APPENDIX....

TECHNICAL CONDITIONS OF CONTRACT (T.C.C.)

TECHNICAL CONDITIONS OF CONTRACT (T.C.C.)

TABLE OF CONTENTS

Clause 1: APPLICABLE SPECIFICATIONS

1.1. OBLIGATORY NATURE OF THE D.I.S. - T.C.C.

1.1.1. The Owner's minimum requirements for the project planning and the Contractor's relative obligations are defined in the Contract Documents.

1.1.2. This volume i.e. the Technical Conditions of Contract (T.C.C.) contains the contractual technical conditions. The Concessionaire (Contractor) shall execute the Project Works in accordance with these conditions and those in the remainder of the Contract Documents.

Specific reference for the individual construction work categories of the project is made in pare 1.6 relative to the necessity of application of each clause of the T.C.C. and the D.I.S.

1.1.3. In the event of conflict between any specific term of the T.C.C. and the European Community legislation, the Tenderer shall notify the Service, by specific letter, within an exclusive deadline being the date of the bid submission.

In any other case:

a. Failure to notify the Service of conflict will result in forfeiture of his right for compensation to any financial claim arising from conflict.

b. If he is awarded the contract assignment he shall be under the additional obligation to cooperate with the Project Owner in harmonizing the conflicting term with the Community legislation. Expenses incurred (if any) in harmonizing conflicts are deemed to be included in the Concessionaires reasonable risk and shall be borne by the Concessionaire.

1.2. COMPLEMENTARY SPECIFICATIONS APPLICABLE FOR THE DESIGN AND CONSTRUCTION PERIOD

1.2.1. For any materials, construction works, quality control (procedure/methods/tests etc.) not covered by:

- The regulations/specifications/codes etc. applicable by the D.I.S. and the other terms of the tender.
- The present specifications i.e. the articles of the present T.C.C. the following shall apply:

the "European Standards" (E.S.) as approved by CEN or the European Committee for Electrotechnical Standardization CENELEC as CEN "European Standards', or as 'Harmonization Documents" (HD) as per the common conditions laid by these organizations.

1.2.2. Complementary to the above the following shall apply in order of precedence.

a. The Common Technical Specifications, i.e. those developed through standard procedures by the member-states of the European Community and purporting to ensure uniform application by all member-states and published in the Official Gazette of the European Community.

b. The *"European Technical Approvals"* (ETA), i.e., the favourable technical estimates on suitability of products to be used judging on the satisfaction of fundamental requirements for construction works as based on inherent product traits and the terms applied for their use. Such (ETA) approvals are granted by the organization assigned with these functions by the member-states.

c. The Standard Technical Specifications of (S.T.S.) of the Albanian Ministry of Infrastructure provided they are not in conflict with Community Legislation.

d. Complementary to the above Specifications the Albanian Organization for Standardization as supplemented by the International Standards Organization (I.S.O.) and the ASTM of U.S.A. specifications shall be applied.

1.3. COMPLEMENTARY SPECIFICATIONS APPLICABLE FOR THE MAINTENANCE PERIOD

1.3.1. Notwithstanding the clause 1.3.2 the complementary specs defined in pare 1.2 shall also apply for the Maintenance Period of the project.

1.3.2. Due to the prolonged duration of the Maintenance Period it is expected that there will be advancement in technology, in materials and equipment for maintenance and operation resulting to the improvement of the related specs and the introduction of new specs.

So the Concessionaire shall apply the specs as stand at the commencement of the related works concerning construction / installations / equipment / procedures / methods, during the Maintenance Period.
Any economic risk emanating from this clause is the Concessionaire’s risk.

1.4. OBLIGATIONS OF BOTH TENDERERS AND THE CONCESSIONAIRE

Attention is drawn to the following conditions:

1.4.1. Without prejudice to pares 1.1, 1.2 and 1.3, the concessionaire shall define in every design the specs to be applied in detail. This should be done not later than the date of the related design submission.

1.4.2. By his submission, every Tenderer acknowledges the fact that all aforementioned specifications are suitable and sufficient for the execution of the Project works and that he undertakes all obligations, risks and charges arising thereby.

1.4.3. Every Tenderer is entitled to propose alternative technical specifications-provided they are not in conflict with the D.I.S., the S.C.C. and the other terms of the tender. The acceptance of the alternative proposals is subject to the Owners approval.

Alternative proposals for the technical specifications shall be fully supported by the relevant documents to be submitted by the bidders.

This right applies for the time period up to the Proposal submittal (Bidding date) and is not applicable if the Tenderer does not make use of this right by the date of his Proposal at latest.

it is also clarified that the Tenderer intending to except this right shall declare:

– whether his proposal constitutes a mandatory condition for his Bid or whether his proposal constitutes simple preference and as a consequence its eventual rejection will not alter his financial proposal

– or whether his proposal is combined with the existence of alternative Bids which correspond to the cases (a) acceptance of his proposal from the part of the Project Owner and (b) rejection of his proposal from the part of the Project Owner

Any proposals made for alternative technical specifications not including the above declarations shall be considered null and void.

1.5. CONCESSIONAIRE'S EXPENSES

All expenses arising from application of the terms of the T.C.C. and the relevant and/or quoted codes / specifications / regulation I norms shall be borne by the Contractor, irrespectively if this is explicitely mentioned or not. The Contractor shall not be borne expenses for a specific activity, if, and only if, the contrary is mentioned clearly and explicitely in a relevant clause of the T.C.C.

1.6. NECESSITY OF APPLICATION OF THE D.I.S. AND I.C.C. CLAUSES IN THE CONTRACT WORKS

1.6.1. The construction works of the present "concession contract' project are classified in the following categories:

1.6.1.1 As far as the application of the technical specifications is concerned

(1) MAIN CONCESSION PROJECT (M.C.P.): These are works of the concession contract whose construction, operation- exploitation and maintenance is being done by the contractor (They refer to the main road work of the contract and the interchange ramps). (For a more detailed analysis see para. 1.4.7 of the D.I.S.).

(2) LOCAL ROADS (L.R.): These are transverse and service roads and other works (beyond the M.C.P.) being constructed by the contractor, though their maintenance will be done by the Project Owner. (For a more detailed analysis see para. 1.4.7 of the D.I.S.).

1.6.1.2 As far as the application of the D.I.S. is concerned

(1) For all works under the present *"concession agreement"* the implementation of the entire D.I.S. is compulsory.

(2) Exceptionally, for the MAIN CONCESSION PROJECT WORKS the application of subchapter 1.14 (PAVEMENTS) of the D.I.S. is OPTIONAL for the Contractor, because in this case clause 100 of the T.C.C. constituting PAVEMENT PERFORMANCE SPECIFICATION is applicable.

1.6.1.3 As far as payment is concerned

(1) LUMP SUM PART: These are works, according to the Project Owner plans. being defined within the limit of contract, for which the contractor undertakes their construction as part of his obligations resulting from the contract, against the "Contract Price" provided by the Project Owner.

(2) PARALLEL WORKS: These are contractual works not in included in the "lump sum part" which shall be constructed by the contractor and be reimbursed separately based on actual quantities of performed works and unit prices, according to clause 19 of the SCC.

The application of the technical specifications for the construction of the "parallel works" is dependent upon the location of works.

Thus. if the "parallel works" are constructed within the MCP works, the MCP specifications shall be applied. If the “parallel works” are constructed within the L.R. works, the L.R. specification shall be applied.

1.6.2. The following table, being the T.C.C. table of contents, provides reference relative to the necessity of application of each clause for the category of MCP works and the LR works.

1.6.3. The necessity of application of the present TCC clauses may be:

- Obligatory
- Optional
- *Not* allowable

for the indicated categories of work (MCP or LR) as shown in next table.

1.6.4. For the case of MCP works, the specifications of the present TCC which are classified, according to the previous paragraph, into the 'optional" works category, are considered to provide the 'concession agreement' contractor the possibility to apply other specifications, according to the requirements of pare 1.2 above. Alternatively, for these specifications, it may be possible to accept application of European Union member-states specifications. In this case such specifications shall be submitted to the Service in order to approve their application in the performance of the MCP works.

TABLE 1-1
NECCESSITY OF APPLICATION OF THE PRESENT T.C.C. CLAUSES IN THE CONTRACT WORKS

Clause T.C.C.	CONTENTS	Main Concession Project	Local Roads
Clause 1	Applicable specifications	+	+
Clause 2	Earthworks for Road Projects (supplements and amendments to STS X1)	O	+
Clause 3	Excavation of foundations for structures and trenches	O	+
Clause 4	Backfilling of foundation and trench excavations	O	+
Clause 5	Contractor's operations / obligations when encountering Public Utility Organization (P.U.0.) utilities in operation	+	+
Clause 6	Concreting	+	+
Clause 7	Formworks	+	+
Clause 8	Waterproofing and drainage of structures	+	+
Clause 9	Bored cast-in-situ and caisson piles requiring soil removal (and their caps)	+	+
Clause 10	Rigid structure metal guardrails, Type ("S.G.-1")	+	+
Clause 11	Prestress	+	+
Clause 12	Steel reinforcement	+	+
Clause 13	Jetted piles (Small piles)	+	+

LEGEND:
+ Application obligatory
O Application optional
- Application not- atlowable

TABLE 1-1 (cont.)

Clause T.C.C.	CONTENTS	Main Concession Project	Local Roads
Clause 14	**Quarries - Borrow pits - Dumping areas**	+	+
Clause 15	**Precast cement pipes (supplement and partial amendment to STS-T110)**	+	+
Clause 16	**Acceptance of weighed materials**	**O**	+
Clause 17	**Cement**	+	+
Clause 18	**Exposed concrete surfaces (fair - faced)**	+	+
Clause 19	**Electromechanical Installations**	+	+
Clause 20	**Work-site Laboratory**	+	+
Clause 21	**Quality control requirements**	+	+
Clause 22	**Project record documents - Inspection and Maintenance Manual - Operation Manual**	+	+
Clause 24	**Permanent fencing**	+	+
Clause 25	**Pollution - proof coating**	**O**	+
Clause 26	**Cement Treated Crushed Stone (C.T.C.S.)**	**O**	+
Clause 27	**Cement stabilized soil (C.S.S.)**	**O**	+
Clause 28	**Rolled concrete**	**O**	+

LEGEND: + Application obligatory

O Application optional

- Application not- atlowable

TABLE 1-1 (cont.)

Clause T.C.C.	CONTENTS	Main Concession Project	Local Roads
Clause 29	Expansion / contraction joints for bridges	+	+
Clause 30	Bridge bearings	+	+
Clause 31	Metal construction - Corrosion (rust) proofing	+	+
Clause 32	Signs - Delineators of right-of-way (expropriation zone)	+	+
Clause 33	Safety guardrails	+	+
Clause 34	Skid-resistant slurry seal course	0	+
Clause 35	Soil improvement by treatment with cement and lime	0	+
Clause 36	Shotcrete (Gunite)	0	+
Clause 37	Skid -resistant course of asphalt concrete	0	+
Clause 38	Sub-ballast and prepared subgrade layer of railroad works	+	+
Clause 39	"Separation' geotextiles for use in road and railroad works	0	+

LEGEND: + Application obligatory
O Application optional
- Application not- atlowable

TABLE 1-1 (cont.)

Clause T.C.C.	CONTENTS	Main Concession Project	Local Roads
Clause 40	Accuracy requirements regarding elevations and surface evenness for railroad works	+	+
Clause 41	Earthworks for railroad projects (supplements and amendments to STS X1)	+	+
Clause 42	Reinforced fills	+	+
Clause 43	Concrete Road pavements	O	+
Clause 44	Segmental construction	+	+
Clause 45	Grout and mortar	+	+
Clause 46	Epoxy paint protective coating of pipes	+	+
Clause 53	Pavement performance specification	+	-

LEGEND:

	+	Application obligatory
	O	Application optional
	-	Application not- atlowable

Clause 2: EARTHWORKS FOR ROAD PROJECTS

2.1. INTRODUCTION

All terms referred to herebelow are applicable both for works paid for on the basis of unit prices and of measurement of quantities of works performed and for works included under a lump sum for "Design - Build or “concession agreement”.

2.2. GENERAL

All conditions shall apply for the execution of earthworks for road projects, as well as for lining and planting works. Further to these, the terms laid down here below shall also have to be taken into account.

2.3. DEFINITIONS

Earth fills: are those fills that are constructed by laying and compacting earth materials in layer thicknesses allowing to achieve the required compaction degree using the compacting means available and in sections permitting the utilization of high efficiency mechanical equipment.

Rock Fills: are those fills that are constructed by laying and compacting rock materials resulting from rock excavations in layer thicknesses allowing to achieve the required compaction degree using the compacting means available and in sections permitting the utilization of high efficiency mechanical equipment.
The fills consist of the parts shown in TABLE 1.

Pavement Subgrade Layer (PSI.): is the ground or fill material direct), underlying the pavement, formed and compacted according to STS Xi requirements and to the other Tender conditions and extending to such depth that is affected by traffic loads.

NOTES

(1) In fills, subgrade layer also includes any pavement drainage layer construction performed according to the Tender conditions.

(2) In cuts, subgrade layer includes any pavement drainage layer construction required by the Tender conditions and the necessary rock cut levelling layer.

(3) In fill construction aimed at raising the level of existing roads, and provided
that the difference of level between old and new rolling surfaces is less than 60 cm., any old existing asphalt pavement shall be dismantled and removed. The cost of such work shall be included in the fill price and she not be paid for separately.

Clause 49 of this TCC shall apply in the case of “earthworks for railroad project”

TABLE 2-1
FILL PARTS

PART NAME	EARTH FILL	ROCK FILL
Foundation	The part underlying the original ground surface after clearing, grubbing and removal of unsuitable materials and an additional .30m-thick layer above the original ground surface	The lowest 0.30m-thick fill layer in contact with the original ground surface (in case of no unsuitable surface materials) and its underlying part (after any required clearing, grubbing and/or removal of unsuitable materials)
Core	The fill between foundation and crown	The fill between foundation and transition section
Transition section		The part composed of layers whose material gradation meets certain conditions (filters) for avoiding penetration of the crown materials into the underlying rock section. It is lm-thick, unless otherwise defined in the remaining tender conditions
Crown	The fill underlying the pavement subgrade layer (P.S.L.), extending 1.00m below the P.S.L. top surface for pavement intended to traffic categories KO, Kl, K2, K2e and K3, (and 0.80 m for traffic categories K4 up to and including K7)	The fill section overlying the above transition section, constructed of earth materials as in earth fills and constituting (wholly or partly) the pavement subgrade layer

2.4. <u>FILLS</u>

2.4.1. <u>Earth Fills</u>

2.4.1.1. Earth Fill Materials

The selection of materials for the construction of fills and their degree of compaction shall be in accordance with STS X1 (pare 2.9.2, etc.), with the following additions or variations: Excavation materials shall be used first of all for the construction of fills. Borrow materials shall be used upon the Service's written approval, only in case that excavation materials are unsuitable or insufficient or if coordination of cut and fill operations is not possible in accordance with the program of execution of the works. (In the latter case, the Service's written approval shall be required, unless the Tender conditions explicitly provide that the excavation products of a specific road section are not necessarily to be used for fill construction).

It is specifically emphasized that no use shall be made of excavation products such as soil mixed with vegetation material or containing organic matters, creeping clay, etc.

Regarding the construction of fills, earth materials are classified into 5 categories, as shown in TABLE 2.

No category Eo materials (unsuitable) are to be used in fills.
Soils containing soluble sulphates in 503 quantities higher than 1.9gr/lit measured according to the BS 1377/test 10 method, with water/soli ratio equal to 2 : 1, shall not be used anywhere less than 50cm from any concrete construction, or Cement Treated Crushed Stone (CTCS), or Cement Stabilized Soil (CSS).

Materials having an overall sulphate (S03) content higher than 0.5% by weight measured according to the BS 1377/test 9 method shall not be used anywhere less than 50cm from any metal structure.

When the core is liable to exposure to flood waters, materials used for its construction must be exclusively of categories E2, or E3, or E4.

2.4.1.2. *Spreading of layers*

Before spreading the fill material, the ground shall be cleared of unsuitable surface material that shall be replaced with appropriate one in accordance with the instructions of the Service. Such substitution material shall be carefully compacted. The whole fill bearing surface shall be compacted to a density equal to not less than 90% of the maximum density obtained through the modified compaction test.

The modified Proctor E105-86 compaction test to be applied shall be according to

METHOD A: For soil materials with sieve N°4 retained percentage not higher than 7%.

METHOD D: For soil materials with sieve N°4 retained percentage higher than 7%.
Such compaction shall extend to a depth of not less than 40cm and to a width of 2m beyond the toe of the fill, or at least up to the boundary of the right-of-way (expropriation belt) in case of relative width limitations.

Spreading and compaction of the layers of fill shall follow. The layers shall be continuous, parallel to the subgrade surface and of such uniform thickness as to allow achieving the required degree of compaction throughout the layer thickness using the equipment available.

The materials of each layer shall have common characteristics and, if not, they shall be properly mixed using suitable mechanical equipment.
No layer shall be spread prior to ensuring that the underlying layer is in compliance with the requirements. A layer shall not be allowed to be spread on an underlying layer softened by an excess of moisture content.

TABLE 2-2
CATEGORIES OF SOIL MATERIALS
(Excluding materials of rock excavations)

Category of soil material	Material characteristics	Atterberg limits	Max. Density according to modified comp. test kg/rn3	CBR*	Organic material content***	Remarks on suitability consideration for use in fills
El	Soil material with Max. grain size 0 < 200 mm and percentage of grain size 200 > D > 150 mm upto 25%	LL < 40 or LL < 65 and Pl>(0.6LL-9)	> 1.600	>3 and expansion" < 3%	< 2%	Accepted
E2	Max. grain size D < 100 mm Percentage passing sieve No. 200 < 35%	LL < 40	> 1.940	> 5 and expansion" <2%	< 1%	Suitable
E3	Max. grain size D < 80 mm Percentage passing sieve No 200 < 25%	LL < 30 PI < 10	- > 10 and	expansion** = 0	0%	Selected I
E4	Max. grain size D < 80 mm Percentage passing sieve No 200 < 25%	LL < 30 PI < 10	-	> 20 and expansion** = 0	0%	Selected II
E0	Soil material not included in the other categories					Not accepted

LL = Liquid Limit E 105 - 86 Method 5
PI Plasticity Index E 105 - 86 Method 6
No 200 = Sieve No. of the American standard sieve measurements AASHTO : M-92 opening = 0.074 mm
*CBR = California Bearing Capacity Ratio determined according to method 12 of the Specification for Soil Mechanics Laboratory Testing (E 105-86) on samples compacted at the 90% of the maximum density of the Modified Compaction Test (Method 11 E 105-86) at optimum water content after water impegnation of 4 days. In the case of *"cemented"* soils and for earthworks in excavation, the Bearing Capacity of the first soil layer underlying the compacted Pavement Foundation Layer, shall also be estimated using the in-situ CBR test. (Also see para. 1.14.2.(3) of D.I.S. sub-chapter 1.14)
During CBR test
Will be determined by the "wet oxidation" method (AASHTO T 194)

Fills on ground of low bearing capacity shall make the object of special studies and shall be constructed in compliance to the instructions issued by such studies. Special attention shall be made to avoid exceeding the ground's limit of strength through appropriate dimensioning of the thickness of the first layers in order to protect the ground against the loads of fill material transportation vehicles and of compaction equipment
During execution of the works, each layer surface must provide the necessary crossfall to ensure water drainage without risking erosion or excessive soaking of the fill construction.

The Contractor is bound to take all necessary measures in order to protect fills as well as cuttings against the effects of rainwater or of water of other origins (torrents, rivers, groundwater).

Should the moisture content of materials spread be found by means of in-situ tests to deviate from the optimum required for compaction purposes, such materials shall be watered in a manner ensuring uniform distribution of moisture, if a moisture increase is required. If moisture is required to be reduced, then the material shall be dried through aeration, or through mixing with appropriate dry soil materials, or through chemical admixtures such as quicklime, slaked lime or other approved by the Service.

2.4.1.3. *Weather constraints*

Construction of earth fills shall be suspended when ambient temperature is lower than 2°C.

2.4.1.4. Opening to traffic

No traffic must be allowed on fill layers under construction prior to completion of compaction operations. In case this is not possible, then vehicle circulation must be directed in a spread way so as to avoid tyres running on the same tracks and risking to create a rutted road surface. The latter is applicable also on sections where compaction is completed.

2.4.2. Rock Fills

2.4.2.1. Rock *Fill Materials*

2.4.2.1.1. Origin

The materials to be used shall be stone material resulting from rock excavation products. Only exceptionally may they come from borrow pits, following approval by the Service. In such cases excavation sites shall be designated by the Service, or approved by the Service in accordance with the SCC, the Supplementary SCC and the other Tender Documents.

2.4.2.1.2. Rock quality

Sources of rock materials are distinguished into suitable sources, unsuitable ones and those requiring special investigation.

Suitable rock sources comprise granites, porphyrites, granodiorites, diabase gabbros, andesits, basalts, dolomites, marbles and others.

Unsuitable rock sources comprise serpentines, phyllites, anhydrites, gypsum, soluble rocks and rocks generally disintegrating after exposure to weather conditions, or failing to a substantial degree, or subject to pulverization or turning into adverse consistency upon compaction.

Prior to utilizing rock materials in the construction of fills, the Contractor is bound to present to the Service a relevant laboratory investigation study proving the suitability of the rock materials he proposes to use.

2.4.2.1.3. Grain gradation

The material must respond to the following requirements:

a. Its maximum dimension shall not be greater than the 2/3 of the compacted layer thickness.

b. The percentage (in weight) passing the sieve of 1" must be less than 30%, while that passing sieve N°200 must be less than 10%.

These requirements regard compacted materials which shall be sampled for checking observance of the former, given that it is possible for these materials to be altered during spreading and compaction in a way liable to modify their initial gradation.

In addition to the above, the materials' gradation curve shall comply with the following requirements:

Grain dimension (sieve)	% passing in weight
D	90 -
0/4	45 - 60
0/16	25 - 45
D/64	15 - 35

The Service may modify the above limits based on the observations and conclusions reached following construction of the Trial Section (see farther below par 2.4.2.3).

2.4.2.1.4. Grain pattern

The percentage of grains having unsuitable pattern shall be less than 30%. The pattern is unsuitable of grains making good the following relation:

$$(L+G)/2E >= 3$$

where: L= the longest dimension between the grain's two parallel plane surfaces,
G= the minimum diameter of a circular opening allowing passage of the grain,
E= the shortest dimension between the grain's two parallel plane surfaces.

The values of L, G and E may be approximately established and it is not necessary for them to be measured on three directions perpendicular to each other.

2.4.2.2. Construction Stage

2.4.2.2.1. Preparation of foundation surface

Clearing, grubbing and removal of unsuitable materials or of agricultural soil, if necessary, shall take place throughout the required depth, as mentioned in pare 2.3 of STS Xl, prior to commencing spreading rock materials and compaction of same.

Whenever it is necessary to construct a rock fill directly on unstable or disturbed ground, or on soft clay, measures shall be taken for stabilizing or removing such material.

Should rock be found near the fill bearing level, then all material may be removed above the rock and the fill may be spread to rest directly on the rock.

2.4.2.2.2. Production - excavation, loading and hauling rock materials

Before commencing excavation of rock materials, all surface soil or deteriorated/altered and unsuitable surface rock shall be removed. In addition, and throughout the excavation of rock materials, all portion of unsuitable soil turning up in the rock formation shall be removed.

The method of excavation applied shall ensure that the gradation and pattern of the stone material produced lie within the limits set up by this clause (para 2.4.2.1). If necessary, following excavation, portions having unsuitable pattern or dimensions shall be removed or further crushed.

Loading and hauling of excavation materials shall be performed in a manner ensuring that no segregation of the material or deterioration of the grain pattern takes place.

2.4.2.2.3. Spreading

The material shall be spread in consecutive layers of uniform thickness, parallel to the surface of foundation.

The material for each layer shall be dumped on a completed section of the same layer and close to its end (construction front). From this position, it shall be mechanically forwarded to the front of construction and shall be spread beyond in a manner minimizing any risk of segregation. The layer thickness shall correspond to the compacting capacity of the plant available in order to achieve the required degree of compaction.

With reference to the core, the maximum compacted thickness is of 1m, while in the transition sector the thickness must be reduced going up to ensure a gradual progress from the core to the top fill layers.

The following conditions shall have to be observed between two adjoining layers:

$$\frac{I_{15\%}}{S_{85}} < 5, \text{ and } \frac{I_{50}}{S_{50}} < 25$$

where: I x = the sieve opening from which passes x% in weight of the underlying course material.

S x = the sieve opening from which passes x% in weight of the material of the course above.

2.4.2.2.4. Compaction

(1) The compaction method selected must ensure achievement of the required degree of compaction. For this reason, and for each sector of the fill, the material gradation, the layer thickness, the type of compaction equipment

and the number of passes shall be carefully selected. Such variable values shall be specified in relation to the results obtained from the Trial Section, as shown in para 2.4.2.3.

(2) Only towed vibratory rollers or self-propelled vibratory rollers shall be used for compaction, having a static lineal load (cylinder/drum plus borne part of chassis) greater than 25 kg/cm (class V2 and above according to French Specifications for Roadworks).

In addition to these, static road rollers with cylinders bearing rectangular iron bar mesh (grid rollers) may be used with a cylinder static load greater than 80 kg/cm.

(3) The compaction shall be considered as completed when the subsidence measured at the foundation or the core between two successive passes of the compaction equipment referred to hereabove does not exceed 1 cm, or 0.5 cm at the transition section.

The subsidence shall be measured by means of a tester consisting of **a** 40x40cm steel plate, not less than 15mm thick, with a suitable resting surface. The tester type shall be proposed to the Service by the Contractor for checking and approval and shall be sure **to** maintain a horizontal position to the extent possible during operation of the compacting mechanical equipment. Such testers shall be positioned at locations of level control as per par 2.4.2.4 (tolerances of completed surfaces) and shall be removed for re-use after completion of the compaction of the layer being checked.

(4) Alternatively, to the above method of quality control regarding compaction of rock fills, it is possible that the Service, following a Contractor's proposal, may adopt a different method in case it is proved, during execution of the *"trial section"*, that another reliable method can be applied ensuring the works compliance to the abovementioned compaction requirements, having taken into account all parameters involved with the supervision of the works.

(5) If in the course of application of this new method it is found that same method creates credibility problems to the supervising staff in correlating test results to actual compaction, then the Service may request the Contractor to subsequently apply the compaction control method referred to in the above subparagraph (3).

(6) Irrespectively of the stipulations mentioned hereabove, a *"minimum compaction requirements* is established consisting of a minimum of six passes of towed vibrating roller for each layer being compacted, with a static lineal load (cylinder and borne part of chassis) greater than 25 kg/cm (class V2 and above of the French Specifications for Roadworks), or of a static road roller having cylinders with rectangular iron bar mesh (grid rollers), with a cylinder's static load greater than 80 kg/cm.

2.4.2.3. Trial Section

The Contractor shall propose to the Service in writing the construction method he considers most appropriate for each type of material with the purpose of meeting the specifications of this clause. The proposal shall include:

- Features of all mechanical equipment involved.

Method of excavation, loading and hauling rock materials.
Spreading method.
Layer thicknesses, compaction method and number of the equipment passes.

- Experience with the proposed construction method involving similar materials.

With the exception of the case of sufficient experience having been acquired with the proposed method, the Service's approval shall depend on the results of in-situ testing. Such testing shall consist of the construction of a trial section having a volume not less than 3,000 cubic meters, aiming at verifying the suitability of the proposed method or at its re-adjustment accordingly.

During construction of the trial rock fill, gradation analyses shall be specified for the recently excavated and for the spread materials, while gradation analysis and density shall be defined for the compacted material. Representative samples of not less than 4 cu.m. each shall be used for the definition of these values. Not less than 10 tests of each type shall be performed. Sections performed through the mass of the fill shall be inspected for determining the characteristics of the compacted material. Such sections shall be made throughout the layer thickness and have a minimum area of 4 sq.m. Surface distortions of the fill shall be checked using topographical methods after each trip of the compacting equipment, together with the average density of the compacted material.

Judging from the results obtained, the Service shall decide on the approval, modification or rejection of the proposed process.

In case that the materials used indicate a distinct fluctuation of their characteristics, then the Service may decide to request a revision of the working method.

2.4.2.4. *Tolerances of Finished Surfaces*

Finished surfaces of the core and of the transitional part shall be verified by means of level pegs fixed with a 1 cm accuracy along the axis as well as along the edges of cross sections spaced at not more than 20 m.

Differences shall be established between the real limits of pegged stations and their theoretical ones according to the drawings, and terminal algebraic values of such differences shall be determined for sections not less than 100m long.

Positive shall be the differences corresponding to points fixed above the theoretical surface.

The following requirements must be observed

If the mean of terminal values is positive, it must be less than 1/5 of the last layer thickness.

If the mean of terminal values is negative, its absolute value must be less than 1/2 of the last layer thickness.

Half the difference of the terminal values must be less than 5cm for the core surface, and less than 3cm for the transition surface.

In case of failure to meet the first condition as above, then the last layer shall be excavated and a new one shall be constructed with the correct thickness. If the second condition is not met, a new layer shall be constructed with the correct thickness. If the third condition is not complied with, then an untarred course shall be added with a minimum thickness of not less than 15cm over the core, or than 10cm over the transitional part. It shall consist of well-graded material having mechanical characteristics not lower than those of the rock fill, with a maximum size of 10cm or of 6cm respectively.

2.4.2.5. Measurement and Payment

Rock fills shall be paid for in cubic meters (m3) of geometrical volume constructed (see par 2.5), measured on cross-section drawings.

The unit price of rock fill shall be considered to include the additional cost of rock excavation performed in compliance to the measures adopted with the purpose of obtaining suitable stone material.

The crown of the fill (for the case of separate price items) shall be considered to be included in earth fill works, unless otherwise established in the Tender conditions.

2.5. SUBSIDENCE OF FILLS, OF AREA FORMATION FILLS. ETC.

The dimensions, slopes, lines and elevations of road fills or of fills constructed for the formation of areas, etc., shown on contractual drawings are final, namely those of the works after the anticipated settlement of the fill/area formation fill materials and the subsidence of the foundation ground resulting from the loads of the fill.

The Contractor is responsible for supplementing the necessary quantities of material, either once or with successive additions, in order to increase the height or width of fills to the extent required for counterbalancing all kinds of settlements.

The volume lost due to subsidences shall not be paid to the Contractor, who should take into account in his tender the fact that in reality he shall need to construct a real volume of fills (and borrow-pitting) larger than the one resulting from the contractual drawings and documents (geometrical volume).

This loss must be taken into account by the Contractor in the calculation of the real conditions of earthworks balance.

2.6. FILLING MEDIANS AND COVERING SLOPES WITH AGRICULTURAL SOIL (TOPSOIL)

2.6.1. Works to be performed

2.6.1.1. In accordance with the design and/or the Service's instructions, agricultural soil (topsoil) shall be spread on medians of all kinds and on other surfaces or on road fill and cutting slopes with the purpose of creating green areas. The topsoil shall be spread in a single layer with a minimum thickness of .40m for medians and of 0.30m for the slopes of fills and of non-earth cuttings that shall be inclined at v : h <= 1 : 1 according to the tender conditions. The topsoil layer shall be lightly compacted. On road central medians the topsoil thickness shall be as provided for in the Road Standard Plan (R.S.P.).

2.6.1.2. When breaking up existing pavements or the purpose of constructing central medians, the overall thickness of the existing pavement shall be excavated to a depth of not less than .60m, irrespectively of any need for constructing drains, installing utility ducts, etc. This requirement is combined with the need to backfill open trenches or pits (after installing all kinds of ducts together with their surrounding materials) using agricultural soil necessary for root development of plants that shall be planted therein.

2.6.1.3. With reference to this, it should be mentioned that it is PROHIBITED to use for duct surrounding aggregates (sand, transitional fill, drainage course) or concrete in quantities greater than the ones specified in the R.S.P. and the other tender conditions, as these will inhibit the development of green to be planted. To this effect it has to be noted that OPEN TRENCHES OR PITS SHALL BE INSPECTED AND ACCEPTED BY THE SERVICE PRIOR TO BACKFILLING CENTRAL MEDIANS OR SHOULDERS WITH AGRICULTURAL SOIL.

In case of failure to meet the above conditions, the necessary corrective measures shall be applied and only then will open trenches be backfilled with agricultural soil.

2.6.1.4. It is pointed out that it is Strictly Forbidden to use the products of old broken up asphalt pavement in the construction of fills. Such material shall be collected and deposited in dumping areas that shall be finally covered with soil material not less than 0.50 m thick. <u>In the opposite case, the Service is entitled to require full</u> reconstruction of pavement or also impose penalties for poor workmanship affecting the overall protect (stability of the works, planting difficulties, environmental problems, etc.).

2.6.1.5.

1. It is specifically made clear that covering fill slopes with topsoil must be combined with fill raising operations.
2. Furthermore, in the case of cutting slopes higher than 5.0 m and subject to being covered with agricultural soil (according to the tender conditions), such covering operation must be combined with the cutting construction.
3. if, during the construction of sideslopes (in fills or cuts) without the provision of accessible berms, the Contractor proceeds with fill or cutting operations to heights greater than 6.0m without combining same with topsoil spreading on the slopes, then the Service shall require application of the provisions regarding bad workmanship both for the fill/cutting operations and for the spreading of agricultural sail.

2.6.1.6. The agricultural soil (not garden earth) to be used for covering slopes (of fills and/or cuts) and for backfilling medians, widenings, verges, etc., shall be obtained either from "string" deposits created in the course of removal of top agricultural soil or from any other source, the Service bearing no responsibility for the issuance of the required permits by the pertinent Authorities.

2.6.2. <u>Quality of Agricultural Soil</u>

1. The agricultural soil must be of excellent quality, given that it constitutes the basic element enhancing the biological functions of the plants.
2. The agricultural soil shall be selected among the most suitable products of topsoil excavation that shall be concentrated and saved in regular "strings'. Agricultural soil shall by preference be selected among sandy clay products. Should such products fail to be available, then suitable materials of a different consistency may be approved and accepted by the Service.
3. Excavation products intended to be used for agricultural soil must be free of foreign admixtures, such as demolition materials, remains of building construction

(rubble), stones, gravel, lime debris, NaCl, or even remains of plants that are hard to be decomposed.

4. In the case that available excavation products of agricultural soil are judged to have suitable consistency but contain unsuitable admixtures such as the above, it is considered self-understood that such products shall be utilized only after removal of undesirable admixtures by means of any method (even screening).
5. Agricultural soil shall result from surface excavation up to 0.70 m deep and shall have reddish or light reddish appearance.
6. In order for the Service to accept the agricultural soil, the Contractor shall necessarily present sample analysis reports issued by a recognized Soil Institute. The cost of such analyses shall be borne by the Contractor.
One sample per 500 cu.m. of agricultural soil shall be analyzed in accordance with the above, or a minimum of three samples (taken at different depths within the useful thickness of .70m) from each individual source of topsoil material.
7. Samples shall be taken in the presence of the Service's representative from sources intended for use by the Contractor, in suitable numbers depending on the volume of material estimated to be extracted and finally used. They shall be numbered and their positions shall be marked with their respective numbers on a relevant map of the borrow pit area. They shall then be forwarded to the Soil Institute for testing and be accompanied by a representative of the Service. After sample analysis, and provided that this complies with these specifications, the Service's approval shall be granted for the Contractor to haul the agricultural soil onto the works site. Areas of topsoil samples proven unsuitable for use shall be excluded from the map.
8. Should a source of agricultural soil present lack of uniformity in terms of soil characteristics, the number of samples required may be increased according to the Service's sole judgment, while the cost of such analyses shall always be borne by the Contractor.
9. It is hereby made clear that the above numbers of samples are the minimum required and that the Contractor is absolutely responsible for the suitability of the agricultural soil used by him. In case that a source of agricultural soil lying within the works site is found not to comply with the requirements of these specifications, the Contractor shall be bound to remove the unsuitable quantities and replace them with suitable ones at his care, responsibility and cost.
10. Otherwise, regarding the quality of agricultural soil, the locations of and methods used for extracting same, the method of execution, etc., the stipulations of STS X1 (chapter C, paras 1, 2.4, 2.5, etc.) shall apply.

2.6.3.

Following a request filed by the Contractor and the Service's approval regarding minor quantities of topsoil to be used in the works, it is possible for them to be accepted on the basis of only a visual examination performed either on the works site or on the respective borrow area.

2.6.4. Measurement – Payment

a) Filling medians with topsoil

Measurement shall be in cubic meters of real volume, on the basis of cross-sections taken before and after execution and in accordance with the design and the Service's instructions. Payment shall be based on the corresponding price of the price list included in the Contractor's bid for *filling medians with agricultural soil".

b) Covering side slopes with agricultural soil

Measurement shall be in square meters of real area covered with agricultural soil not less than .30m thick. It shall be conducted on the real surface before sideslopes are covered, as specified in the STS X1 (fig.1) and in clause 1610 of the Descriptive Price List for Roadworks (DPLRW) 1975.

Payment shall be based on the corresponding unit price of the price list included in the Contractor's bid for *"covering sideslopes with agricultural earth"*.

2.6.4. The above prices and payments include for the supply of topsoil from any source whatsoever lying on any location, for the excavation of topsoil to the depth specified for each location, for loading/unloading same, for the time lost by haulage vehicles, for hauling the material from any location onto the works site, for spreading the topsoil to the thickness specified by the design or by the Service's instructions, for light compaction, for suitability control, as well as for any other expenditure inherent to the completed work.

Clause 3: EXCAVATION OF FOUNDATIONS FOR STRUCTURES AND TRENCHES

3.1. WORKS TO BE EXECUTED

3.1.1. This category comprises the execution of excavations to any depth for foundations of structures and of trenches not less than 3.0 m wide.

More specifically, it comprises:

a. Excavation of foundations for structures (bridges, retaining walls, etc.) of an area up to and including 100 sq.m. (irrespectively of plan dimensions), or of a width up to and including 3.0m (irrespectively of the plan area).

b. Excavation for trenches intended to the installation of ducts constructed in-situ (i.e. of rectangular, oval, cap-shaped section, etc.), of an excavation width up to and including 3.0 m.

c. Excavation of trenches for the installation of precast pipes for drainage, sewerage (rainwater and wastewater) and other utilities (water supply, telephone networks or watertight ducting, fuel gas, electric power transportation, traffic signalization and for a trench width up to and including 3 m

d. Excavation of foundations to be required for the construction of manholes and of all kinds of other structures.

e. Exploratory digging for spotting pipe ducts, public utility ducts or other underground structures, of an excavation width up to and including 3.0 m.

f. Excavation inside triangular islands of a total area up to 100 sq.m. per individual island for filling in garden earth, and provided that this excavation was not conducted together with the other general excavations. Furthermore, excavation in central medians with an excavation width up to and including 5.0 m for filling in garden earth, and provided that this excavation was not conducted together the other general excavations.

3.1.2. This category of excavations for foundations of structures and trenches does not include:

a. Any diggings, irrespectively of dimensions, areas, etc., likely to be conducted in the presence and under the guidance of the Archeological Service should archeological findings be encountered (such works shall be conducted by the Archeological Service itself, unless otherwise ordered).

In case that such works are executed by the Contractor according to instructions issued by the Service, they shall be measured separately and shall be remunerated on the basis of a Unit Price for New Works (U.P.N.W.).

b. Demolitions and removals of reinforced concrete, that shall be measured and remunerated separately.

c. Removals or excavations of metal parts/remains of old structures and machinery, that shall be measured and remunerated separately.

3.2. PERMITS FOR DIGGING - INSTALLATION OF SIGNS

In case of pipes or ducts to be installed under an existing roadway, the Contractor is bound to obtain a relevant permit from the competent authorities authorizing him to cut through the existing pavement.

After completion of the works, the Contractor shall be bound to restore the pavement to its original condition, according to the Service's instructions. Costs related to the issuance of the permit for cutting through the road pavement shall be borne by the Contractor. Following consultations with the Pertinent Authorities, the Contractor shall also be bound to proceed to the installation of appropriate signs along the road section affected by the works in question. The form and content of such signs must comply with the Traffic Code in force.

Building materials, excavation products, etc. must be stockpiled, stored or removed according to the Pertinent Authorities' instructions, in a manner limiting road traffic obstructions to the extent that is unavoidable.

3.3. SOIL CATEGORIES

3.3.1. From the viewpoint of excavated soils, excavation works to be performed for foundations and for trenches are generally classified into two categories:

a. Earth and semi rock : It includes excavation of sods referred to under pares 1.3.1.1 and 1.3.1.2 of the STS X1.

   This category also comprises the excavation of existing pavements of all kinds (all kinds of asphaltic courses with their bases and sub-bases), as well as removal of flagstone pavings.

b. Rock : It includes excavation of soils referred to under para 1.3.1.3 of the STS X1.

   This category also comprises the demolition of mass concrete structures, of masonry and other similar materials and items not specifically referred to in the contract documents.

3.3.2. Whenever allowed for in the tender documents, a unified single category of foundation and trench excavations may be provided "in all kinds of soils", making no discrimination between the abovementioned categories of "earth and semi rock" and of "rock".

3.4. METHOD OF EXECUTION

The Contractor shall execute all required excavations in any kind of soil, in accordance with the dimensions shown on the drawings, using any means (even with hand labour) he may consider most appropriate and suitable for each particular case. This freedom of choice of the method of excavation does not entitle the Contractor to any right of claim for additional compensation.

No excavation shall be allowed to be conducted to dimensions smaller than the ones shown on the drawings. If, during execution, excavations are performed to dimensions larger than those shown on the drawings, the Contractor's remuneration shall be based on the volume resulting from the dimensions shown on the drawings and defined as THEORETICAL EXCAVATION BOUNDARIES (T.E.B.) (see also pare 3.11 herebelow).

Even in case of an excavation executed by the Contractor to be deeper than shown on the drawings, the Contractor is bound to backfill the excavation without any compensation to its normal depth, either with sand, gravel, concrete, dry masonry, or, finally, with stone masonry, always in compliance with the instructions issued by the Service.

Otherwise, the method of execution shall comply with the STS T50 and T110, unless otherwise specified in these T.C.C. and the other tender documents.

3.5. BED FORMATION

The bed of excavations for foundations of structures and trenches shall be formed in a manner ensuring the required thickness of concrete, the blinding courses, as well as the bases of pipes and ducts as shown on the drawings.

Should excavations be conducted to dimensions greater than foreseen, no compensation shall be paid for additional quantities of concrete or grain material of the duct zone.

Similarly, the contact surfaces of timber bracing with the sides of excavation (in case of the excavation being shored) must be basically shaped to ensure adequate contact of the boards on the excavation sidewalls.

No additional compensation shall be paid to the Contractor for the abovementioned sidewall shaping works, as the related costs are deemed to be included in the unit prices of excavation works.

For the case of foundations for retaining walls, abutments, piers, etc. on earth ground, a compulsory blinding course of B5 class concrete shall immediately follow the excavation to a thickness not less than .10 m. It is emphasized that the excavation shall have to be conducted in a manner avoiding any slackening, softening or in any way loss of strength of the foundation ground.

3.6. USE OF EXPLOSIVES

Explosives shall be used only upon specific written permit issued by the Service in accordance with the legislation in force and with the Service's instructions, but always under the Contractor's sole responsibility.

Should the Service refuse to allow the use of explosives, the Contractor shall not be entitled to raise any claim (for revision of unit prices and/or for extension of deadlines, etc.).

It is for this reason that the prices quoted by the Contractor in his bid are generally valid, irrespectively of the possibility or not to use explosives for slackening the soil tissue or for excavating cuts. etc.

3.7. SURFACE AND UNDERGROUND WATER CONTROL

3.7.1. The Contractor is obliged to carry out excavation work

- either in water or
- in dry

depending on the technical requirements of each situation.

3.7.2. The construction within the trenches and the backfilling shall be carried out in dry conditions.

3.7.3. The Contractor shall carry out pumping works in such a way that there will be no danger of piping and erosion of adjacent soil, in case there are other structures in contact.

3.7.4. The Contractor shall divert the pumped water to adjacent natural outflows.

3.7.5. If they do not exist and if it is possible he must construct suitable ditches. Diversion of pumped water is not allowed to adjacent properties to a closed storm water drainage system, except if the water is free of suspended material.

3.7.6. The Contractor is obliged to take all the precautions so as not to make the existing storm water drainage conditions unfavourable in the area where the works are being carried out.

Some indicative but not restrictive precautions are

- The protection of adjacent properties with temporary embankments.
- The immediate removal of excavated material
- The pumping of water and its diversion with a temporary system to a suitable outflow.

3.7.7. Underground and surface water control shall be carried out at the Contractor's expense and responsibility.

3.8. DIGOUT - LOADING/UNLOADING – HAULING

Digout operations are conducted either by hand labour with the erection of intermediate timber racks (scaffolding), or with mechanical means. During such operations, a passage not less than .50m-wide must be allowed along the trench edge for ensuring the workers circulation and their safety.

Excavation products shall be hauled to any location over the works site according to the Service's instructions for backfilling operations, if suitable, or for use in other areas as fill material, or shall be hauled to any distance out of the works site for spoil in dumping areas authorized by the Police.

Digout, loading/unloading and hauling operations are neither measured nor paid for separately. Related costs are included in excavation prices.

3.9. ORDINARY TIMBER BRACING (HORIZONTAL)

Whenever required by the nature of the soil, the Contractor shall proceed with an appropriate bracing (shoring) of the excavation sidewalls as required by safety regulations. The method and density of timber bracing shall be each time determined by the Contractor or his site representative in consultation with the Service.

The collapse of an excavation sidewall under any circumstances and conditions from braced or non-braced sides and any consequences resulting therefrom (labour accidents, damage to third parties, works damage, etc.) shall be borne solely and exclusively by the Contractor, who is responsible for any legal compensation and restoration of the works damaged and undertakes any legal liability related thereto. The Service has the right to require the Contractor to establish supplementary timber shoring or to reinforce the existing one at such points as may be deemed necessary by the former. Notwithstanding the above right of the Service, the Contractor remains solely and exclusively responsible for the safety of excavations performed.

3.10. TIMBER BRACING BY SHEET-PILE (VERTICAL) DRIVING

If any fine-grained quicksand is encountered in the course of excavations, or other soil either by its own nature or by the presence of groundwater requiring the construction of a continuous sheet-pile barrier or of a Berlin wall prior to the execution of excavations, such work shall be executed by the Contractor in compliance with all rules of good workmanship and in a manner ensuring stabilization of the running ground and maintenance of the excavation clear. If in driving the sheet-piles the required perfect contact between them is not attained and therefore the purpose of the timber bracing is not met, the Contractor is bound to withdraw and re-drive the sheet-piles.

3.11. MEASUREMENTS

3.11.1. General

This clause concerns excavations of any depth for foundations of structures and for trenches not more than 3.0m-wide according to the analysis conducted under par 3.1.1 of this specification.

Excavations to any depth of trenches more than 3.0m-wide are paid for as general excavations.

All categories of excavations are measured in cu.m. of volume defined by the THEORETICAL EXCAVATION BOUNDARIES (TEB). The TEB are measured as follows.

3.11.2. Theoretical Excavation Boundaries

3.11.2.1. Excavation Bed

Bed elevations result from the design of pipes and ducts based on the corresponding road levels of the project longitudinal profile, after deducting the thickness of underlying constructions such as pipe thickness and pipe base thickness or (in case of foundations) the respective thickness of blinding concrete course and/or of any other course foreseen.

For parallel placement of pipes or ducts under differing bed elevations, the bed formation shall be considered graded with horizontal steps and vertical sections between them. The position of the vertical section shall be fixed in a way ensuring minimum volume of excavation, taking also into account pare 3.11.2.2. Bed elevation of foundation excavations for manhole construction equally results from the approved drawings or from the Service's instructions.

3.11.2.2. *Excavation Width*

3.11.2.2.1. For measuring purposes, excavation sidewalls are considered to be vertical irrespectively of the actual slopes obtained. Depending on the type of culvert to be placed therein, the width of excavation is contractually determined for measuring purposes as follows:

a. For prefabricated pipes of sewerage/drainage (rainwater/wastewater) and for water supply and fuel gas ducts, the width results from the pipe external diameter increased on both sides by 0.225 m (on either side).

   The above trench width remains constant irrespectively of the possible provision of the pipe design for the construction of surrounding concrete.

b. For the construction of cast-in-situ (according to the design) rainwater and wastewater ducts and for the application of other sectional features (egg-, mouth-, cap-, box-shaped, etc), the contractual trench width results from the duct width increased by 0.25 m on either side beyond the duct's external dimension.

c. If the approved designs of drainage works establish different excavation widths, the contractual width shall be drawn from such approved designs.

d. For the construction of manholes, etc., the excavation dimensions are determined on the basis of the external dimensions of the manhole to be constructed, assuming the excavation to reach 0.25 m out of the structure external wall.

e. For the construction of structure foundations, etc., the excavation dimensions are defined on the basis of the external dimensions of the foundation concerned, assuming the excavation to reach .25m out of the external side of the work, depending on the type of excavation.

f. For the execution of exploratory diggings aiming at spotting public utility ducts, the contractual width is established at 0.70 m, unless specified wider.

g. For placing ducts of electric power transportation (PPC), or telecommunication network ducts (GT), or water-tight GT ducts, or traffic signal ducts, or underground ducts for the electric bus lines (ILPAP), the width shall be determined on the basis of the duct actual width increased by 0.225 m on either side beyond its external sides (minimum trench width equal to 0.60 m).

h. For digging inside triangular islands with the purpose of substituting garden earth, the contractual excavation area is defined as the actual one for the triangular island or the actual excavated width of the central median.

3.11.2.2.2. For the construction of trapezoidal or other trenches intended to remain permanently open according to the design and/or the Service's instructions, the sides may be calculated sloping according to the design.

3.11.2.2.3. Upper Surface of Excavation

The elevation of the natural ground, possibly modified by the execution of existing works (i.e. existing road) is defined to be considered as the upper surface of excavation accounted for in excavation measurements. Alternatively, and should the excavation be carried out subsequently to the execution of general earthworks (cuttings or embankments), the level of such general formation of earthworks shall be considered to be the upper surface of excavation for measuring purposes.

3.11.3. Distinction between "General Excavations" and "Excavation of Foundations for Structures and for Trenches"

3.11.3.1. The execution of all kinds of excavations for the construction of a project is covered by the following items:

a. General Excavations.
b. Excavation of foundations for structures and for trenches.

No category is thus provided for "general foundation excavations". The following are established instead:

3.11.3.2. When excavations for a particular structure cannot be classified (owing to width or area limitations) under the category of excavations for foundations according to the present specification, then such excavations are divided into:

1. General Excavations,

2. Excavations for foundations and trenches.

3.11.3.3. The LINE OF DISTINCTION (LD) of the above categories results as follows:

a. Side Line of Distinction (SLD)

i. Earth and semi rock

A side line of distinction shall be brought from the highest point of the "Theoretical Excavation Boundary" (TEB), being defined according to Para 3.11.2.2 of these T.C.C., sloping at a ratio of h : b = 3 : 2*

h : b = height to base

The part of excavations comprised between the side TEB and the SLD (excavations in areas of slopes inclined at ratios steeper than v h = 3 : 2) are considered to be contractual foundation excavations.

The remaining part of excavations (excavations in areas of slopes inclined at ratios lower than or equal to v : h = 3 : 2) shall be considered to be contractual general excavations.

ii. Rock

The stipulations mentioned above under (i) shall apply, but the side line of distinction shall be inclined at the ratio of v : h = 2 : 1.

iii. Mixed soils

In the case of mixed soils having their portion of earth/semi rock greater than or equal to 20% and less than or equal to 80%, the side line of distinction shall be sloping at v : h = 1.75 : 1.

Soils of any other consistency, with different portions of earth/semi rock and of rock, shall be classified (from the point of view of inclination of the side line of distinction) to the nearest category (i) or (ii) as above.

b. Lower line of distinction (LLD)

i. It shall be assumed to be 1.0 m above the excavation bed of the "Theoretical Excavation Boundary* and up to its intersection with the ground or to its side line of distinction.

Excavations lying below the LLD shall be assumed, for contractual purposes, to be excavations of foundations.

Excavations lying above the LLD shall be assumed, for contractual purposes, to be general excavations.

ii. It is noted hereby that, in case a structure or culvert is founded at the same level and in extension of a road project general excavations (i.e. retaining walls), and provided that the wall excavations are conducted in the same period as the contiguous general excavations for the road (that is to say, with the exemption of the case of constraints imposing the phased execution of excavations), then the lower line of distinction (LLD) shall be considered to coincide with the respective general excavation line.

iii. In the case of the execution of foundation excavations for a structure construction, with the TEB at a depth (h) less than 1.0m below the surface of the contiguous general excavations (according to the stipulations of the abovementioned sub-para ii), the LLD shall be considered to be at a height (h) above the TEB of the foundation level (namely, to coincide with the general excavation line

3.11.3.4. It is hereby established (with the exception of a specific contrary reference in the other tender documents), that a trench excavation for the construction of a central median around the middle of an existing road and according to the approved cross-section, providing the preservation of the carriageway on either side although possibly supplemented in level, shall be deemed to belong to the category of foundation and trench excavations in spite of a width possibly greater than 3.0m (fixed in this contract to be the limit of trench excavations).

3.11.3.5. It is noted hereby (with the exception of a specific contrary reference in the other tender conditions), that the foundation and trench excavation category is of a general application, even in the case of it being executed on slopes or at the ends of the road formation and on any other place, independently of access difficulties, etc.

3.12. PAYMENT

3.12.1. For a project being tendered by "the unit price" system, payment shall be determined on the basis of the cubic meters of volume resulting from measurements as defined hereabove for the category of excavations under para 3.11.1, multiplied by the corresponding unit prices of the Price List included in the Contractor's Bid.

For a project being tendered on "a lump sum" basis or through "a concession agreement' payment shall be made and in accordance with the other terms of the tender.

3.12.2. Such prices and payments include for:

a. Clearing of shrubs, cutting and uprooting trees of any perimeter and removal of same from the works site to any distance required.

b. Taking of special measures according to the Service's instructions for the preservation of any trees and shrubs, and the effect of difficulties resulting therefrom.

c. Trench and foundation excavation in any kind of soil to any depth and with any means (even with hand labour) and irrespectively of the use of explosives, and removal with any means irrespectively of any intermediate digout of cutting products, loading and unloading, loss of time in loading/unloading and in hauling operations of cutting products:

— Of materials suitable and necessary for the construction of embankments, to locations indicated by the Service, including their spreading.

— Of materials suitable and necessary for backfilling open excavations, to locations indicated by the Service, including their spreading.

— Of materials unsuitable for backfilling or filling operations, or of surplus excavated materials not required for backfilling or filling works, to any distance required for final spoil on dumping areas authorized by the Police, including dumping costs.

d. The identification of suitable and unsuitable excavation products according to the Contractor's judgment and to the Service's instructions and in compliance with the stipulations of the tender documents and of the STS X1.

e. The formation and general smoothing of the bed of excavation and, if required, of its sidewalls.

f. Dealing with any surface or ground water (by constructing temporary arrangements for protecting and facilitating the works construction) with all kinds of required pumping operations, irrespectively of the confronted water flow.

g. Compacting the bed of excavations.

h. All kinds of shoring, (horizontal and/or vertical, etc.), (with the exception of cases explicitly exempted in the other tender documents).

i. All kinds of loading/unloading, hauling, dumping, digout operations until final utilization of excavation products in parts of the works, or their final spoil.

j. Costs of restoring damages.

k. The converted cost of additional excavations beyond those specified under pare 3.11 herein, and the converted cost for filling up any surplus excavated volume below the bed TEB with suitable material as described under paras 3.4 and 3.5 herein.

l. The cost of temporary spanning excavated trenches less than 3.0m-wide with sheet metal or other appropriate building materials, that may be required for restoring pedestrian and vehicular traffic, provided that the latter has no alternative deviation for bypassing excavations in accordance with the judgment of the competent authorities.

3.12.3. Depending on the specifications of the tender documents, it is possible to foresee foundation excavations in the following categories of soil:

a. Earth and semi rock.

b. Rock (measurements thereof shall have to be accompanied by a relevant protocol of rock identification).

c. Any kind of soil (comprising the unified categories of earth/semi rock and of rock).

3.12.4. The above prices and payments shall include for all mechanical means, tools, instruments, controls and tests of all kinds, together with all required professional staff and workers to complete the work, and together with any other cost although not explicitly described but necessary for the complete and skilful execution of the work.

3.12.5. The above prices and payments <u>do not 'dude</u> for :

a. Any additional difficulties in excavating foundations and trenches resulting from the encounter of various ducts in operation and belonging to public utility companies and/or organizations, for which an additional payment is foreseen to the Contractor based on a special measurement and a specific relevant unit price of the price list included in the Contractor's bid.

b. The backfilling of the "duct zone" and of the "transitional fills" with granular material, which is being measured and paid for in accordance with clause 4 of these T.C.C. {pares 4.9.a, 4.9.b, 4.10.1.a and 4.10.2).

c. Backfilling the rest of the excavation (above the "duct zone") with suitable excavation products measured and paid for in accordance with clause 4 of these T.C.C. (pares 4.9.c, 4.10.1.b and 4.10.2).

3.13. RELEVANT SPECIFICATION

The backfilling of trenches, etc., is specified in greater detail in the next specifications of clause 4 of these T.C.C.

Clause 4: BACKFILLING OF FOUNDATION AND TRENCH EXCAVATIONS

4.1. GENERAL

The works specified herein concern backfilling operations, following the works construction, of foundations for structures, of trenches intended to the installation of all kinds of ducts (for rainwater and wastewater drainage, water supply, electric power transportation, telecommunication networks, fuel gas, electric buses, traffic signals, etc.), or of manhole foundations, etc.

In the case that trenches to be backfilled cut through the existing road or are close to it, all works shall be executed in a manner avoiding obstructions to the road traffic and as described hereabove under clause 3.

4.2. SUITABLE SOIL TYPES FOR BACKFILLING PURPOSES

The classification of soils suitable for backfilling trenches intended to duct laying shall be in accordance with DIN 18196, depending on their soil mechanics qualities and their compactibility, as follows:

TABLE 4-1
CATEGORIES OF SOIL COMPACTIBILITY

Category depending on compactibility	Brief description	Classification as per DIN 18196
V1	Non-cohesive to slightly cohesive soils, coarse- and mixed- grained	GW, GI, GE, SW, SI, SE, GU, GT, SU, ST
V2	Cohesive mixed-grained soils	-- GU, GT, SU, **ST**
V3	Cohesive fine-grained soils	UL, UM, TL, TM, TA

Only soils appearing in the above Table may be used for backfilling structure foundations and trench excavations.

Organic soils of the remaining categories of DIN 18196 classification (**HN, HZ, F, OU, OT, OH, OK**) are excluded from use in backfilling foundations and trenches.

4.3. COMPACTIBILITY

The compactibility of soil categories given hereabove under pare 4.2 depends on the grain analysis of the soil, the grain form and the water content. With regard to compactibility, the grain analysis and form are of particular importance in the case of category V1 soils, while the water content and, therefore, weather conditions are less important than in the case of category V2 and V3 soils.

On the contrary, water content is of major importance for compactibility in the case of category V2 and V3 soils.

It is not possible to achieve the required compaction degree when highly moist cohesive soils are involved.

With highly dry cohesive soils, the required compaction degree may be achieved only after substantially extensive compaction operations in comparison with the usual conditions.

It is generally true that the compaction of V1 category soils is easier to achieve than that of categories V2 and V3, owing to the former's limited sensitivity to water and weathering.

Given the requirement to avoid settlements in backfilled excavations, soils used in backfilling trenches for duct laying must in principle be category V1 cohesive soils. Only in case that no such soils are among excavation products available and that relevant provisions are included in the remaining tender conditions, should V2 and V3 category soils be used for backfilling purposes.

4.4. LAYING AND COMPACTION OF BACKFILLING MATERIAL

4.4.1. General

4.4.1.1. With specific reference to pipelines crossing under roads and for reasons of traffic safety, any settlement of backfilling material in duct trenches must be avoided. Appropriately executed compaction must ensure that pavement construction above the duct may be carried out immediately after backfilling of the duct trench and compaction of the backfilled material.

It is not allowed to backfill using materials liable to cause damage to the pipes and their related constructions (mainly ashes and slag), as well as materials subject to subsequent settlement (i.e. organic earth, wood pieces). For achieving normal compaction, it is required to use compactible backfilling material. Should excavation products available not respond to this requirement, they must be replaced with compactible backfilling material.

Backfilling is performed in layers, depending on the mechanical means available for compaction and on the backfilling material used. The layer thickness must be such as to avoid jeopardizing the pipeline stability and to obtain the required compaction degree measured according to the PROCTOR method.

4.4.1.2. The following compaction degrees of layers must be obtained in the area of the "duct zone", (from the trench bed of the duct and up to a level of 0,30 m above the pipe summit)

i. 100% of the STANDARD PROCTOR in V1 category non-cohesive soils (or 103% of the STANDARD PROCTOR in materials of categories GW and GI according to DIN 18196).
ii. 97% of the STANDARD PROCTOR in V2 and V3 category cohesive soils.

4.4.1.3. The following shall apply for backfilling trenches above the duct zone:

a. Pipeline crossing under road pavement

(1) A belt not less than .50m-thick below the lower sub-base surface must be compacted to the following degrees

i. 100% of the STANDARD PROCTOR for V1 category cohesive soils (or 103% of the STANDARD PROCTOR for GW and GI class materials according to DIN 18196).

ii. 97% of the STANDARD PROCTOR for V2 and V3 category cohesive soils.

(2) The belt lying under the one described hereabove [pare a.(1)] and extending up to the duct zone must be compacted to :

i. 95% of the STANDARD PROCTOR for V1 category non-cohesive backfill material (or 97% of the STANDARD PROCTOR for GW and GI category soils as per DIN 18196.

ii. 95% of the STANDARD PROCTOR for V2 and V3 category cohesive backfill materials.

b. Pipelines off pavement

Backfill material from the final ground surface (after any surface arrangement works provided for) and up to the duct zone must be compacted as described in pars a.(2) hereabove.

4.4.1.4. Compaction by mechanical means is authorized up to a level not lower than 75cm above the pipe summit, unless otherwise specified in the work description. The type of mechanical compaction depends on the soil conditions, the bracing effected and the pipe type.

4.4.1.5. No excess loading shall be allowed in the course of the construction works (i.e. running of heavy-duty equipment or vehicles above the backfilled duct), beyond those loads taken into account for the pipe structural design.

4.4.1.6. Special measures must be taken when in aggressive soil or water liable to damage the pipe material or its external protective coating.

4.4.2. Trench Bed and Pine Laying,

Slackening of the trench bed must be avoided.

Slackened cohesive soil must be thoroughly removed prior to pipe laying and replaced with non-cohesive material that should be mechanically compacted.

Backfilling must ensure the most uniform and stable distribution possible of liveand dead loads acting onto the duct.

Duct laying must therefore be performed in a manner safely avoiding their being supported along a single line or on a single point.

Existing specifications for the various duct types (DIN 4033, DIN 19636, etc.) shall apply to this effect.

4.4.3. Shored Trenches for Duct Laying

Backfilling and compaction of backfilling material must be executed in a manner befitting the shoring type each time used.

The adjustment and cooperation of backfilling material with the trench sidewalls must be ensured, irrespectively of the shoring type.

For this reason, and in case of horizontal bracing, its components must be gradually removed in a manner allowing immediate backfilling of the released trench section in layers and compaction of such layers.

Similarly, and in the case of vertical bracing, its vertical components (trench beams, sheetpiles) must be gradually removed, each time to a level allowing immediate backfilling of the released trench section in layers and compaction of such layers.

4.4.4. Duct Zone

(1) The duct zone comprises he space between the trench bed and sidewalls and up to a level of 0,30 m above the duct summit.

(2) In the duct zone, construction and especially compaction requirements of the material to be used for backfilling should be increased, given that they have a substantial effect on the duct's static and dynamic loading assumptions.

(3) As backfilling material, sandgravel should be used complying to the following requirements

a. Material grain size distribution

Sieve diameter	**Percent passing (in weight %)**
40 mm	100%
30 mm	70 - 100%
15 mm	50 - 85%
7 mm	35 - 80%
3 mm	25 - 70%
0,075 mm (No 200)	< 12%

b. The material should be well graded, namely it should be:

D60/D10 >= 5

Where: D60 Sieve diameter that 60% (in weight) of material is passing through

.

D10 Sieve diameter that 10% (in weight) of material is passing through

c. If the percentage (P) of the fine grained material (passing sieve No 200) is 12% > P > 5%, then the fine grained material should have a plasticity index P.I. <= 10%

(4) Each backfilling layer should be compacted separately. Control values for the backfilling height as well as the number of passes are mentioned, as a function of compacting equipment, in table 2 of the present specification.

In the present case a cover height 0,30 m above the duct summit was assumed.

(5) As soon as possible for space reasons, compaction must be done from the trench side towards the duct. Trench backfilling and compaction of the fill material must be done simultaneously from both of the duct to avoid shifting and rising. This should be taken into account especially when there are pipes that could be deformed.

Any existing protective lining of pipes is not allowed to be damaged.

(6)

a. For ducts of external diameter greater than 0,40 m, the duct zone must be filled and compacted in more than two phases of work.
b. For pipe ducts of external diameter D_{ex} greater than 1,00 m, due to the encountered compaction difficulties of the backfilling material, the bottom layer of fill material, of thickness t = $D_{ex}/8$ should be constructed of concrete of B10 class with a minimum thickness t_{rnin}=0,15 m.

4.4.5. Space lying above the Duct Zone

The thickness of individual layers must be selected in a way allowing the compacting equipment used to achieve perfect compaction of each layer with the number of passes required. Table 2 hereof gives regulating values. The information contained in this Table represent mean output values. Under unfavorable conditions (i.e. high water content, provision of shoring), the layer thicknesses given may need to be reduced, while they may be allowed to be relatively exceeded under particularly favorable ones. Only a trial compaction may yield accurate values. Without this, only the highest layer thickness values given in Table 2 shall be allowed for the first layer immediately above the duct zone, with the exception of steel pipes and of ductile iron ones.

4.5. COMPACTION TESTS

4.5.1. Compaction tests of trench backfill materials shall be performed at each distinct zone as mentioned above under paras 4.4.1.2 and 4.4.1.3 according to the STANDARD PROCTOR method. Laboratory compaction tests shall be performed on materials obtained from the products of each trial hole (definition of the PROCTOR curve), as it is possible that laboratory density may vary from hole to hole owing to gradation variations.

For coarse-grained materials, corrections shall have to be made as specified in paras 2.10.2 and 2.10.3 of STS Xl.

4.5.2. The minimum number of compaction tests cannot be less than one test per 100 m of trench length and for each distinct zone of backfill, or for a maximum of 500 cu.m.

4.5.3. If the compaction degrees obtained with the above tests are lower than the ones specified herein, then the Contractor shall need to alter his working method with the purpose of achieving the compaction values specified.

4.5.4. In the case of uniform backfilling material, and if the compaction tests performed as described hereabove under par 4.5.1 prove a satisfactory uniformity, then the Service may issue a written approval, upon the Contractor's request, limiting the number of compaction tests to the minimum required under para 4.5.2 hereabove. This, of course, assuming a detailed follow-up of the compacted layer thicknesses and of the number of passes of the compacting equipment, depending on the type of equipment and the soil category according to the indicative directions of Table 2 hereof.
Such reduction shall in no way release the Contractor of his responsibility for the workmanlike execution of backfilling operations, in compliance with this specification. The compaction equipment as well as the layer thicknesses shall be proposed by the Contractor and are subject to the Service's approval.

4.6. ROAD PAVEMENT RESTORATION (CASE OF DUCT CROSSING UNDER EXISTING ROAD)

After laying the duct in the trench, the latter shall have to be immediately backfilled as mentioned under para 4.4 hereabove and the backfill material must be compacted. The final reconstruction of the pavement shall have to be immediately executed. Its connection to the existing pavement should be obtained using a straightedge and be smooth and compact.

Broken pieces of pavement near the edge must be carefully removed by means of a new cut and, if possible, using a mechanical pavement cutter. Pavement restoration must be of the same consistency and quality as those of the existing adjoining pavement.

If, under exceptional conditions, the final restoration of the pavement cannot be conducted immediately, then the duct trench, once backfilled, shall have to be temporarily sealed with asphalt mix. Should such sealing present any damages, same shall need to be immediate restbred.

4.7. CLASSIFICATION OF SOILS AND OF COMPACTION EQUIPMENT

Description of Equipment		Service weight (kg)	Category of Soil Compactability								
			V 1			V2			V3		
			Suita-bility	Layer thickness (cm)	Number of passes	Suita-bility	Layer thickness (cm)	Number of passes	Suita-bility	Layer thickness (cm)	Number of passes
Light compaction equipment (mainly for duct zone)											
Vibratory compressor	Light Medium	up to 25 25 - 60	+ ' +	up to 15 20 - 40	2 - 4 2 - 4	+ +	up to 15 15 - 30	2 - 4 3 - 4	+ +	up to 10 10 - 30	2 - 4 2 - 4
Blast vibrator	Light	upto 100	0	20 - 30	3 - 4	+	15 - 25	3 - 5	F	20 - 30	3 - 5
Vibratory slabs	Light Medium	up to 100 100-300	I f	up to 20 20 - 30	3 - 5 3 - 5	0 0	up to 15 15 - 25	4 - 6 **4** - 6	 -	-- -	
Vibratory cylinder	Light	up to 600	. +	20 - 30	4 - 6	0	15 - 25	5 - 6	-		-
Medium and Heavy-duty compaction equipment (for use above the duct zone)											
Vibratory compressor :	Medium Heavy	25 - 60 60 - 200	+ +	20 - 40 40 - 50	2 - 4 2 - 4	4- +	15 - 30 20 - 40	2 - 4 2 - 4	1 + +	10 - 30 20 - 30	2 - 4 — *2* - 4
Blast vibrator	Medium Heavy	100-500 500	0 0	20 - 40 30 - SO	3 - 4 3 - 4	4 +	25 - 35 30 - 50	3 - 4 3 - 4	+ +	20 - 30 30 - 40	3 S 3 5
Vibratory slabs	Medium Heavy	300-750 750	+ +	30 - 50 40 - 70	3 - 5 3 - 5	0 0	20 - 40 30 - 50	3 - 5 3 - 5	.. -	- -	
Vibratory cylinders		600-8000	1-	20 - 50	4 - 6	+	20 - 40	5 - 6	-	-	.

Notes **+ = Recommended** **0 = Mostly suitable**

The above data represent medium values of output. Under unfavorable conditions (i.e. high water content, bracing), layer thicknesses given above may be necessarily reduced, while, under particularly favorable ones, it is possible that they may be slightly exceeded. Accurate values may only result through a trial compaction. If a trial compaction is not conducted, then (with the exception of steel and of ductile iron pipes) only the maximum value should be used.

4.8. <u>TRANSITIONAL EMBANKMENT ZONES</u>

4.8.1. The transitional embankments, whenever and wherever planned to be constructed behind bridge abutments and culverts, other han pipe culverts, in accordance with the approved designs and the Service's instructions, as well as behind all kinds of manholes, shall be executed with stone quarry drainage material graded as per clause 8 of the T.C.C. (para 8.4.2) and at dimensions and slopes determined through the design or through the instructions of the Service.

4.8.2. The compaction degree of the transitional embankments is specified as follows:

a. <u>Culvert crossing or manhole, etc. lying under road pavement</u> :

(1) A zone not less than .50m-thick below the sub-base lower surface, must be compacted to 103% of the STANDARD PROCTOR.

(2) The zone lying under the abovementioned zone (1) must be compacted to 97% of the STANDARD PROCTOR.

b. <u>Off pavement culvert or manhole, etc.</u>

All transitional embankment material must be compacted to 97% of the STANDARD PROCTOR.

4.8.3. The stipulations of paras 4.4.2 and 4.4.3 are also applicable in the cases of transitional embankments. Backfilling of excavations for the construction of transitional embankments must be conducted simultaneously from both ends with a view to avoiding any shifting of the ducts, etc.

No damage must be allowed to be caused to any protective coating of the pipes.

If no contrary indications exist, the stipulations of Table 2 shall apply with regard to the compaction of transitional embankments above the duct zone.

The stipulations of above sub-clauses 4.5 and 4.6 shall apply with regard to compaction control and to pavement restoration.

4.9. <u>MEASUREMENTS</u>

a. <u>Backfilling the duct zone</u>

The backfilling of the duct zone shall be measured in cubic meters of completed work as resulting from the theoretical excavation boundaries (TEB) of the bed and sidewalls as these were defined under sub-clause 3.11 hereof and ending upwards at the horizontal plane covering the duct zone, after subtraction of the volume of the duct and of its concrete base, where applicable.

For the case of parallel culvert or duct laying, the definition of the duct zone upper surface shall be according to the approved design .30m above the imaginary tangent line joining the summits of two adjoining culverts or pipes. The maximum gradient of this surface must not be more than 100%.

b. <u>Backfilling of transitional embankments</u>

Unless otherwise specified in the design, the volume of transitional embankments shall be measured in cubic meters of completed work, as defined by:

(1) The theoretical excavation boundaries (TEB) of the bed, sidewalls and upper surface, as these were defined under sub-clause 3.11 hereof.

(2) The transitional embankment upper surface, a horizontal area .50m-wide at the culvert crown, and subsequently a slope inclined by h : v = 1 : 1 up to the point of its intersection with the adjoining TEB.

(3) The external side of the culvert or manhole.

(4) The volume of any overlapping culverts or ducts, as well as that of any concrete base of same shall be subtracted from the volume determined as per (1), (2) and (3) hereabove.

c. <u>Backfilling of the space lying above the "duct zone"</u>

The backfilling of the space lying above the duct zone shall be measured in cubic meters of completed work resulting from the sides of theoretical excavation (as these were defined under sub-clause 3.11 hereof) of the bed that is identified with the duct zone upper surface (described under 4.9.a hereabove). The upper surface of this volume shall be considered to be the upper level of the trench, as formed at the time of backfilling. The backfilling measurement as above shall result following subtraction of the thickness of any pavement or agricultural soil layer, etc., possibly required.

<u>REMARK</u>:

Any volume of backfilling in excess of those measured according to the above sub-paras a, b or c, carried out as a result of the trench excavation having been performed to greater depths, or bed widths, or sidewall slopes, etc., compared to those foreseen by the approved design, shall not be measured or paid for to the Contractor.

4.10. <u>PAYMENT</u>

4.10.1. For a project tender by the "unit price" system, payment shall be determined as follows:

a. <u>For the complete work of backfilling the "duct zone" or the transitional embankment,</u> on the basis of the volume resulting when measured by the method define above (para. 4.8.a and 4.9.b) multiplied by the corresponding unit prices of the contractor's price list.

b. <u>For the complete work of backfilling the space above the "duct zone" with suitable excavation products,</u> on the basis of the volume resulting when measured by the method define above (para. 4.8.a and 4.9.b) multiplied by the corresponding unit prices of the contractor's price list.

4.10.2. The above prices and payments include for the supply of suitable material with the loading/unloading cost, cost of time lost and of haulage to the site from any distance, the work of placing the material around or above the duct (depending on the work) or behind the pipe or manhole etc., the compaction of same in compliance with the specifications contained herein, the cost of mechanical means, materials, tools, professional staff and labour, inspections and tests required for the execution of this work, together with any other cost in addition to those referred to hereabove and necessary for the correct and complete execution of the work.

4.10.3. For a project being tendered on 'a lump sum" basis or through a "concession agreement" payment shall be made in accordance with Para 4.10.1 and 4.10.2 hereabove, however, is conjunction with the requirements of the other terms of the Tender.

Clause 5: CONTRACTOR'S OPERATIONS / OBLIGATIONS WHEN ENCOUNTERING PUBLIC UTILITY ORGANIZATION (P.U.0) UTILITIES IN OPERATION

5.1. CONTRACTOR'S GENERAL OBLIGATIONS

5.1.1.

(1) During excavation operations (general excavations, foundation excavation of structures and ditch excavation) various utilities in operation belonging to companies and/or organizations of public utilities (P.U.0.) may be encountered, which may be aligned in any direction, have any diameter or type of covering and be found at any depth from the ground surface. It is also possible to encounter irrigation ditches above the surface of the ground or dug into the ground, with or without lining.

(2) It is possible, that for some of these utilities, relevant designs of the influence of the works under construction, have been prepared, including various methods for restoring their operation, and/or increasing their capacities to meet increased present demands and/or future requirements. These utilities shall be referred heretofore as "known utilities".

(3) Apart from the "known utilities", other utilities may be encountered for which no restoration designs have been prepared, for any reason (i.e. lack of information regarding the existing conditions, no design in the specific section etc.). These utilities shall be referred heretofore as "unknown utilities".

Also included in the category of "unknown utilities" are sections of "known utilities" which it is found necessary to reconstruct or relocated for various reasons [i.e. modification of levels of the existing utility (in relation to the data taken into consideration in the design of the "known utility") of such magnitude that require greater lengths of variation; existence of obstacles that require greater length of variation etc.) and which sections are located in areas outside the limits (beginning and end) of the "known utility".

5.1.2. For each utility encountered ("known" or "unknown"), that comes within the excavations of the works or is adjacent to them, the Contractor is obliged, at his own cost and responsibility:

a. To verify the nature of the utility and its horizontal alignment and levels.

b. To verify the operation/use of the pipe.

c. To propose for every "unknown utility" -in each case- the preservation or relocation of the utility, or to evaluate the given solution of the *known utility' in relation to the conditions found (possible existence of new obstacles which have not been taken into consideration in the design, horizontal alignment or levels different to those given etc.)

d. To contact and make arrangements with the pertinent P.U.O. for all cases mentioned above and specifically for those mentioned in subparagraph (c)

e. To inform on time the Supervision of the above.

5.1.3.

(1) For every "unknown utility" a decision must be taken of what is to be done with it, always after agreement with the pertinent P.U.O. and the Supervision. Alternatively, this decision may be:

a. To keep it "in operation" for the duration of the excavation and construction, without moving it, or with minor relocation (if this is possible).

b. To keep it "in operation", without moving it, or with minor relocation (if this is possible) for the duration of the works, with only short interruptions of its operation.

c. To relocate it, that is to reconstruct it in another location, thus abandoning the section that lies within the excavation area.

The existing utilities which need to be reconstructed for reasons of increased demand, fall within the category of relocated utilities.

In every case the programme of works of the Contractor must be made known in time and accepted by the pertinent P.U.O.

(2) For every "known utility", a relevant decision will be taken, within the framework of evaluation of the given solution of the design, in relation to the existing conditions, as in the above paragraph 5.1.3.(1).

5.1.4. For all utilities in operation [i.e. of subparagraphs (a) and (b) of paragraph 5.1.3.(1) and the respective utilities of paragraph 5.1.3.(2)] it is necessary for special measures to be taken, during the excavation operations, by using special light machinery, or even excavation by hand, in order to avoid any damage whatsoever.

Note that utilities are considered to be "in operation" when they are to be maintained, or will be in use while excavations are being carried out. Temporary interruption of the use of the utility does not invalidate the expression "in operation".

5.1.5. For all utilities "in operation" according to the above definition, the minimum necessary measures and related works are specified in the following paragraph 5.3.

5.1.6. For the utilities which are to be relocated [i.e. of subparagraph (c) of paragraph 5.1.3.(1) and the respective utilities in paragraph 5.1.3.(2)] the specifications of the following paragraph 5.2 apply.

5.1.7. The Contractor's obligations when abandoned utilities are encountered are those of paragraph 5.2, where it refers to the parts of the utilities put out of use after relocation.

5.2. CONTRACTOR'S OBLIGATIONS IN THE CASE OF UTILITIES THAT ARE TO BE RELOCATED

5.2.1. In addition to his obligations in paragraph 5.1.2, regarding P.U.O. utilities which are to be relocated, the Contractor must also fulfill the following obligations:

a. To carry out (at his own cost and responsibility) a complete study of the shifting of the "unknown utilities".

   In the case that new information result from the in situ measurements, these must be taken into consideration during the finalization of the study for the "known utilities" even if it is necessary to extend the relocated length beyond the geographical limits of the contractual beginning and end of the "known duct".

   NOTE:

   It has been mentioned that the responsibilities of the Contractor include the cost of carrying out the study of relocating any kind of cable (electrical, telephone) although these studies are usually carried out by the pertinent P.U.O. (P.P.C., T.0.). This was to cover the need of these studies being prepared by the Contractor, after the relevant agreement of the pertinent P.U.O., in order to expedite the construction of the works, if they are delayed.

b. To construct the "known utilities" in their new location including their connections *under* (the additional) supervision and instructions of the services of the pertinent P.U.O. Also included in the works of this paragraph are possible "temporary works" which may be necessary to ensure the operation of the existing utilities during the connection of the relocated "known utilities" with the existing ones, as well as the works to restore the conditions which existed in the right of way of the relocated duct, (backfill, reconstruction of the existing pavement-walkways etc.)

   The construction of "known utilities", with the respective necessary sections of "temporary works" and the restoration works of the existing condition of the right of way of the relocated utilities, are included in the obligations of the Contractor for projects that have been tendered with the system "Design-Built" or with the system "Concession Agreement". Otherwise these works are paid on the basis of the unit price schedule of the Contractor's tender (and the P.R.U.P.N.W. for items not included in the unit price schedule) for projects tendered *with* the system with "unit prices".

c. To construct the "unknown utilities" in their new location with their connections under (the additional) supervision and instructions of the services of the pertinent P.U.O. including possible "temporary works" which may be necessary to ensure the operation of the existing utilities during the connection with the existing utilities, as well as the works to restore conditions which existed in the right of way of utilities.,

   The construction of "unknown utilities", with the respective necessary sections of "temporary works" and the restoration works of the existing condition of the right of way of the relocated utilities, for projects that are tendered with the system 'Design-Built" or with the system "Concession Agreement", are classified under the category of "parallel works" and are paid for on the basis of the respective unit prices of the unit price schedule of the Contractor's tender for "parallel works" (and the P.R.U.P.N.W for items not included in the unit price schedule).

For projects that are tendered with the system with "unit prices" the construction of "unknown utilities", with the respective necessary sections of "temporary works" and the restoration works of the existing condition of the right of way of the relocated utilities, will be paid for on the basis of the respective unit prices of the unit price schedule of the Contractor's tender (and the P.R.U.P.N.W for items not included in the unit price schedule)

If the length of the "temporary works" is modified in relation to the existing design of "known utilities", then all additional items of the "temporary works" and the restoration works of the existing condition, are classified as works for the "unknown utilities".

d. NOTE:

(1) It is noted that for some "known utilities" for which the sections to be shifted extend to great lengths outside the main construction zone of the works, some intermediate points of the relocated section of the "known utility", may have been defined as "project limits" of the contract.In such cases the Contractor's obligations include the construction of the section of the "known utility" that is within the limits of the project, while the parts outside the "project limits" will be the responsibility of the Owner, who may proceed with their construction under separate contract(s), or any other way whatsoever, also undertaking the obligation to complete the construction of these sections on time, so that the relocated "known utility" may operate on time respectively.

In this case the Contractor is obliged to prepare on time the design for the relocation of the whole length of the utility (including the sections that are outside the "project limits") up to the points of connection with the existing utility, so that it may be possible to construct the remaining works under the other contract(s).

Unless otherwise specified in the special terms of tender (SCC, etc.) the Contractor shall be reimbursed for the respective designs according to the applicable code for engineering fees.

(2) With the exception of cable works (P.P.C., T.O.), which are carried out by experienced workmen of the respective P.U.O.,the construction works of the variations of "unknown utilities" will be carried out by the Contractor of the main project.

By exception the Owner has the right to split the works of variations of important "unknown utilities" and proceed with the construction of sections that are outside the main zone of the works of the project, with separate contract(s), providing this splitting of the works does not impede the timely completion of the project.

e. Furthermore, the Contractor must satisfy the conditions of the following subparagraphs of this paragraph 5.2.

5.2.2. The utility to be relocated or reconstructed shall have:

a. The same characteristics as those of the utility of the design of "known utilities", or at least as those of the existing utility if it regards "unknown utility", unless the pertinent P.U.O. requires the "unknown utility" to be reconstructed withimproved characteristics in relation to the existing one, in which case the utility to be relocated or reconstructed must have these characteristics.

b. The same capacity as the capacity of the utility of the design of "known utilities", or at least the same capacity as that of the existing utility if it regards "unknown utility", unless the pertinent PILO. requires the "unknown utility" to be reconstructed with increased capacity in relation to the existing one, in which case the utility to be shifted or reconstructed must have this capacity.

c. The materials, protection. support, or marking of location (if required), all approved by the pertinent P.U.O. and the Service.

5.2.3. The connections of the new (repeated) utility at its two ends, will be carried out with extreme care, and if necessary, with an inspection manhole. When no inspection manholes are provided, then the connections will be marked.

5.2.4. The general obligation of the Contractor to provide the Service with "as built drawings" is also applicable in the case of P.U.O. utilities, and the Contractor shall also deliver such drawings to the pertinent P.U.C.

5.2.5. The excavation operations in the area of the utility to be relocated, will not commence before the start o' operation of the new relocated-reconstructed utility. However, if the Contractor wishes he is permitted to commence works in the area of sections of utilities that will be put out of operation, provided the requirements of paragraph 5.3 are satisfied.

5.2.6. After the relocated utility is put into operation, the excavation works will be carried out in the area of the section of utility that is abandoned.

More specifically:

For all types of cables (electricity, telephone) as well as all types of pipes, for water supply, liquids, fuel and gas, the Contractor is obliged to recover with due care from the excavation (in order to avoid any damage whatsoever) all salvaged material which must be delivered to the nearest store house of the pertinent P.U.O., at no extra cost.

For stormwater and sewage pipes no special care is required. However, if it is possible to salvage any useful material the Contractor is obliged to put every possible effort towards this end. The salvaged material will be transported and delivered to the nearest store house of the pertinent P.U.O., at the Contractor's cost and his own responsibility.

5.3. METHOD OF CARRYING OUT EXCAVATION WORKS IN THE AREA OF UTILITIES THAT ARE 'IN OPERATION

5.3.1. Excavation works in the area of P.U.O. utilities will be carried out with extreme care, with very light machinery, or even by hand when there is danger for the utilities, following the instructions of the Supervision, and the Services of the pertinent P.U.O.

5.3.2. In cases of uncovered and hanging utilities, that need to be supported or retained, suitable props will be used for supporting or retaining the utilities (wood, steel, concrete etc.) in such a manner that their safety and continuous operation is secured, during the construction works, as well as after backfilling of the excavation.

5.3.3. For important utilities, a special study for supporting and retaining them shall be carried out, when required (on the Contractor's initiative or by order of the Supervision) and when the adequacy of the support and retaining means is not easily assessed.

5.3.4. When backfilling the excavation in the area of P.U.O. utilities, all the suitable measures must be taken:

a. for the safe support of the utilities.

b. for backfilling with special granular material the "utility zone" and using suitable means and method of work, as described in clause 4 of the T.C.C. for the "utility zone".

c. for the remaining backfilling of the excavation with the suitable materials according to the approved design.

Furthermore, in each case, special protective works shall be constructed, such as protection of the top surface with bricks, or concrete slab etc.

5.3.5. If it is necessary to shift sideways, flexible P.U.O. utilities, this work will be carried out with the maximum possible care, the most suitable means and experienced personnel, in order to avoid any damage whatsoever to the P.U.O. utilities.

5.3.6. If it is deemed necessary during the execution of the work, for reasons of safety, to temporarily interrupt the operation of certain types of utilities (i.e. utilities of T.0, P.P.C. etc) the Contractor must obtain the relevant permission. The Supervision will assist him in obtaining such permission, but will not undertake any responsibility against the Contractor, that it will be possible at all to interrupt the operation, or if it is indeed interrupted, what will be the duration of the interruption, the time of the day, or of the night that it will take effect, etc. The Contractor therefore, when preparing his tender, must consider that during the construction, all encountered utilities will be "in operation".

5.3.7. In cases where it is required or it is foreseen by the design, to cover P.U.O. utilities (existing and remaining in position) with concrete structures, so that the future access to the utilities becomes difficult, and the new works come nearer than 0.50 m from the side of the utility, or 1.00 m from the top surface of the existing underground utility, or less than 2.00 m from the side of an irrigation ditch, then the following measures shall be taken:

1) Carry out excavation with light machinery and/or by hand, until the utility is uncovered down to the depth specified in the design (if this is not specified in the design, then tubular utilities will be uncovered down to half their depth and arched or oval utilities down to the level of the point of the arch generation).

2) Inspect the utility uncovered, to make sure that it is not damaged, or if there is any damage then this is repaired by the Contractor at his own cost and his responsibility.

3) Carry out backfilling with care and use only of light mechanical means according to clause 4 of this T.C.C., in order to form an excavation that has the geometrical shape of the structure to be constructed (before the inspection excavation). Wherever necessary this backfilling will be carried out using forms.

4) In the case that large additional loads are transferred from the new constructions (i.e. bridge abutments, high embankments), then backfilling over the zone of the utility shall be carried out in such a way that necessary resilience under the concrete structure is ensured so that no loads are transferred from the superimposed structure to the utility under it. When the concrete construction is very near to the underlaying or surrounded utility then suitable materials must be provided between the concrete and the utility that will ensure that the above mentioned large loads will not be transferred to the utility (i.e. a layer of expanded polystyrene of suitable thickness will be used etc.).

5) In the case of permanent excavation where support of the utility or the irrigation ditch is required, then the permanent supporting structure shall be constructed as the excavation progresses.

5.4. MEASUREMENT

5.4.1. The difficulties resulting from encountering P.U.O. utilities in operation (paragr. 5.1, 5.2.1.a, 5.2.2 to 5.2.6, 5.3) shall be measured by volume of excavation, in cubic meters, that surrounds the encountered utilities.

5.4.2. The execution of the remaining works of construction of "known" or “unknown” utilities and the relevant contractual obligations of the Contractor, are analyzed in the above paragraphs 5.2.1.b and 5.2.1.c, also taking into consideration the stipulations of paragraph 5.2.1.d.

5.4.3. The volume of excavation, that will be measured to account for the difficulties resulting from encountering P.U.O. utilities in operation, will be defined as follows:

a. <u>Length of the utility</u> is that length within which the Contractor shall execute the excavation works of the project, as well as the excavation works of additional sections in which the Contractor shall carry out relocation-reconstruction works of utilities, and which are within the influence-zone of existing utilities.

b. <u>TOD Surface</u>: will be defined up to one meter (1.00 m) higher than the level of the top surface of the utility. For utilities which have variable top level within the excavation, the shape of the top surface shall be taken as being stepped with horizontal sections and vertical steps. The vertical step shall be defined in relation to the top surface of the utility.

For these steps the volume will be increased according to the rule in the following paragraph. It is noted that when zones that are influenced by two pipes, overlap, then in the respective section the highest top surface is valid.

c. <u>Width influenced by the difficulties</u>: for any direction of the utility in relation to the excavation, will be defined as the width of the utility increased on both sides by 0.25 m (25 cm on each side).

When two utilities meet, with free horizontal distance between them less than 0.25+0.25 = 0.50 m then the total increase for both utilities will not be greater than the actual width that really exists.

d. <u>Bottom surface</u> : The actual surface of excavation according to the approved design will be taken, which will not be greater than two meters (2.00 m) below the level of the bottom surface of the utility.

For parallel utilities that meet and their bottom surfaces are at different levels, the shape of the bottom surface will be defined as that provided for the top surface.

5.4.4. From the volume that is defined according to the previous paragraph 5.4.3 the volume of the P.U.O. utilities shall be deducted.

5.4.5. Measurement according to the above in 5.4.1 and 5.4.3 will be accompanied by a detailed plan with levels of the utilities in scale 1 : 500 (or even more detailed in scale 1 : 100 or 1 : 200 when the number of utilities and other characteristics make it necessary) and by characteristic sections etc. on which all information regarding the utilities encountered will be given (diameter, material of external cover, P.U.O., level of the highest and lowest point of the utilities, width of the utilities, etc.).

5.4.6. The inspection excavations mentioned in paragraph 5.3.7 above, shall be measured and paid for on the basis of the relevant item of the unit price schedule for foundation excavations, as well as the item of the unit price schedule for additional compensation "for compensation of difficulties in excavations resulting from encountering P.U.O. utilities in operation" that are described in this clause of the T.C.C.

5.5. PAYMENT

5.5.1. Payment shall be defined on the basis of the cubic meters that will result from the measurement, as specified above, multiplied by the respective unit price of the unit price schedule of the Contractor's tender and will be paid to him as additional compensation, over and above the payment of the respective type of excavations that are executed (general excavation, foundation excavation for structures and excavation for ditches). Also included in the additional payment for the difficulties of excavations resulting from encountering P.U.O. utilities in operation that cover the works of this specification, are :

a. All extra costs due to excavation difficulties from the use of light excavating machines, difficulties that may lead to the point of excavating by hand, **to** avoid damaging the existing P.U.O. utilities.

b. The additional cost of hauling the material resulting from the excavation, due to the difficulty of using mechanical means, which can even become impossible or prohibitive to the access of any mechanical means, in which case the material resulting from the excavation must be removed by hand and shovel from the area of the utilities and then be hauled and disposed of at the temporary or permanent locations of disposal, according to the specification of general excavations (clause 2 of this T.C.C.) and the specification of foundation excavation for structures and excavation for ditches, including backfilling (clauses 3 and 4 of this T.C.C.)

c. The additional cost of all material and work required for supporting or retaining the utilities, for wear and tear of wood forms, and modification of the retaining method of the sides of the excavation, to adapt it to the requirements of the P.U.O. utilities encountered.

d. The additional cost of repairing possible damage to the utilities during excavation or during backfilling, as well as restoration of the support, cover and protection of the utilities.

e. The additional cost of paragraphs 5.1.2 and 5.1.3 above, for carrying out the study of the relocation of the utility according to paragraph 5.2.1.a and the study for supporting and retaining important utilities according to paragraph 5.3.3 above.

f. The additional cost due to difficulties of:

— Access of materials and machinery

— Operation of machinery that can lead to complete prohibition of operation of such machinery.

g. The additional cost resulting from difficulties of recovering the material used for retaining the sides of excavations, which can lead to complete loss of these material, or highly increased work, necessary to recover these material etc.

h. The additional cost for the application and follow-up of the permits required to perform excavations in the areas of P.U.O. utilities.

It is clarified here that the drawings of utilities and culverts provided are only indicative and possibly are inaccurate or incomplete. The Contractor therefore, is fully responsible to carry out the excavations with extreme care as if there are more utilities or culverts that do not appear on the drawings, and any damages that he will inflict on existing, but not shown on drawings, utilities or culverts, he will be equally obliged to repair on his own responsibility (civil and penal) and cost.

i. The possible delays of the work due to the supervision and control of the excavation works by the competent employees of the pertinent P.U.O. (included in these delays are those due to late arrival of the supervising personnel of the P.U.O. or their time schedule according to the rules of their service, which are things that affect the progress of the work, when the pertinent P.U.O. requires that their employee is present during the execution of the works etc.)

j. The cost of preparing drawings of the encountered utilities, or culverts in the appropriate scale and all the specified information, on the basis of which the measurement of works will be carried out.

5.5.2. Also included in the above price and payment are all mechanical means, tools, material, devices, control and tests, permissions expenses, as well as all technical and labour staff that will be required for the complete work and every other cost, even if it is not particularly specified, but is necessary for the complete and workmanlike execution of the work.

5.5.3. The above price and payment does not include the cost of possible backfilling of the zone of utilities and transition embankments with granular material, nor backfilling of the area above the zone of the utility with backfill material according to the terms of contract. Also it does not include the works for sideways shifting of existing utilities and/or construction of new utilities, nor possible protective works required by some P.U.O. (i.e. protection of the top surface with bricks, concrete slab, or special tapes etc.) These works will be paid for separately.

Clause 6: CONCRETING

6.1. SCOPE

6.1.1. This technical specification regards the execution of parts of the works of lean, reinforced or prestressed concrete prepared with ordinary stone aggregates having an apparent specific gravity equal to 2.40 - 3.00 ton/m3, determined according to testing methods ASTM C 127 and C 128.

6.1.2. This specification does not concern concrete prepared with:

i. any aggregates of lighter or heavier consistency.

ii. admixtures of lighter or heavier aggregates, and

iii. aggregates resulting from the rushing of old concrete.

6.1.3. The present specification does not cover concrete for minor Public Works structures (culverts etc.). being constructed at remote areas, concrete for works or elements less than 10 cu.m in total volume, special concrete not included in clause 12, as well as concrete of bulky projects (dams etc.), architectural concrete, concrete for pavements etc.

6.1.4. Until special specifications are prepared the production and control of the above mentioned concrete (of paras 6.1.2 and 6.1.3) shall be established in the project contract or through a special agreement between the Contractor and the Project Owner.

6.1.5. The present specification totally abrogates concreting technology administered by the STS 504 and partly annuls other relevant work specifications (STS 110, etc.) as to their sector regarding technology and methods of acceptance of concreting works.

This specification is in accordance with the REGULATIONS FOR CONCRETE TECHNOLOGY (R.C.T.) [edition of April 1985 by the Direction of Technical Materials (EK3) - Concrete Sector (EK3a) of the Ministry of Infrastructure].

Further, the present specification includes certain additional requirements or/and additional chapters compared to the R.C.T., which are considered necessary for the Specific projects to be constructed based on the present specification.

6.1.6. This specification comprises rules and provisions for preparing and placing concrete of the desired category and for materials and means required to this effect. The present specification does not include provisions connected with the supply and laying of the ordinary steel rods of reinforced concrete and of the prestressing tendons of prestressed concrete. [It does comprise, however, construction provisions related with the spacing of reinforcing rods, as well as with their cover (see par.6.14.1, 6.14.2, etc. hereof)].

6.1.7. Furthermore, it does not comprise provisions connected with the methods of calculation, the permissible stresses, etc., for which DIN 1045 being in force shall apply (recentmost edition).

6.2. SYMBOLS

f28	=	Conventional test sample strength in general
fck	=	Characteristic strength of concrete
f_m	=	Mean strength of concrete
fa	=	Required strength of concrete
Xn	=	Mean value of conventional strength or of tests from **a** single sampling
Xi	=	Conventional strength of a test from one sampling
S	=	Standard deviation of conventional strengths of **a** number of test specimens
n	=	Number of test specimens

6.3. DEFINITIONS

The following definitions are established for the requirements of this specification:

6.3.1. Conventional compressive strength of test specimen f_{28}

Is the strength of a "conventional" test specimen at the age of 28 days, namely a specimen having dimensions and form as provided for under the present specification, prepared and maintained according to Standards

6.3.2. Characteristic compressive strength of concrete f_{ck}

Is the compressive strength anticipated not to be attained by 5% of the conventional strengths of the total number of specimens that could be prepared from a substantially large concrete quantity, if the whole of this quantity were to be turned into test specimens.

6.3.3. Mean compressive strength of concrete f_m

Is the mean value of the strength of all conventional test specimens that could be prepared from a substantially large quantity of concrete, if the whole of this quantity were to be turned into test specimens? The material ratios for the preparation of concrete of a given mean strength fm are given by the mix design.

The concrete of this "substantially large quantity" as referred to hereabove, must be prepared with the same materials, the same ratios, and the same mechanical means.

6.3.4. Required compressive strength of concrete fa

Is the value of mean strength fm for which the concrete of the works has a certain possibility for acceptance when examined under the compliance criteria of this specification? The material ratios of the mix design must ensure a mean strength of f_m not less than equal to the one required.

6.3.5. Mixture (Mix)

Is the quantity of concrete resulting from a single loading, mixing and unloading of the mixing plant? Such quantity shall be equal to or less than the one allowed by the specifications for the mixer's operation.

6.3.6. Batch

Is the quantity of concrete being evaluated through the test specimens obtained from a single sampling?

6.3.7. Site-Produced Concrete

Is the concrete whose production phases are fully monitored and checked by the Service? That means that the Service can control concrete materials and production equipment, that he is able to alter the composition ratios and the mixing process and can check the ready product at any place (inside the mixer, after unloading, after transportation, etc.). The site concrete may be prepared by the works site or at some distance, in which case it is hauled in truck-mixers.

Following approval by the Service, it may also be prepared in a ready-mix concrete production unit (factory), when the conduct of the aforementioned checking operations is ensured through an agreement.

6.3.8. Factory-Produced Concrete

Is the concrete for which the Service cannot obtain own information regarding materials, composition ratios and production process, but may check only ready product at its place of delivery?

As a rule, factory-produced concrete is ready-mixed (see par. 6.3.9 herebelow).

6.3.9. Ready-Mix (-Mixed) Concrete

Is the concrete being prepared at a distance from the works site and hauled onto it:

i. After full mixing, with trucks or truck-mixers.
ii. After partial mixing, or without water introduction, with truck-mixers.

In the second case water is introduced and mixing is executed during transportation to the works or at the works site prior to delivery.

The ready-mix concrete may be site or factory prepared.

6.3.10. In-situ Concrete

Is the concrete being laid in wet condition onto its final position.

6.3.11. Precast (Prefabricated) Concrete

It concerns transported concrete components produced in a prefabrication factory or at the project site and are installed onto-, their final positions after hardening of the concrete.

6.3.12. Fresh Concrete

Is the concrete that is not yet hardened and may still be processed.

6.3.13. Hardened Concrete

Is the concrete that is hardened to a point not allowing any further processing.

6.4. MATERIALS FOR CONCRETE PREPARATION

6.4.1. General

Concrete is considered an artificial solid stuff consisting of aggregate chippings and grains and of cement mortar surrounding and binding the chippings and grains. Thus, the concrete's main components are aggregates, cement and water.

With the purpose of improving certain qualities of fresh or hardened concrete, various chemical substances are introduced into it quite often, called "admixtures".

All aforementioned concrete materials must comply to the quality requirements described in the subsequent paragraphs.

6.4.2. Cement

6.4.2.1. Cement shall meet the requirements of the Law….. for Cement Regulations for Concrete Works or of DIN 1164, or any subsequent decision that may supplement, amend together with any additional requirements set by the present specification.

6.4.2.2. The following cement types are established according to the abovementioned:

Type I	PORTLAND CEMENT
Type II	PORTLAND POZZOLAN CEMENT, (with pozzolan percentage determined by the unsolved cement residue not greater than 20%).

Type IIa: PORTLAND CEMENT, (with pozzolan percentage determined by the unsolved cement residue as equal to 10%).

Type III POZZOLANIC CEMENT (with pozzolan percentage determined by the unsolved cement residue ranging between 20% and 40%).

Type IV: PORTLAND SULPHATE RESISTANT CEMENT

6.4.2.3. From the strength viewpoint, all above cement types are classified in the following categories:

Category 35

Category 45

Category 55

These categories are established on the basis of the compressive strengths of cement measured at the age of 28 days on mortar test cubes prepared and tested.

TABLE 6.4.2.3: CEMENT STRENGTHS

Strength category (nominative) value)	Compressive strength in N/mm2			
	2 days (minimum value)	7 days (minimum value)	28 days	
			Minimum value	Maximum value
35	**-**	**15**	**25**	**45**
45	**10**		**35**	**55**
55	**15**	**-**	**45**	**limitless**

1 N/mm^2 = 10.2 kg/cm^2

6.4.2.4. The strength limits of table 1 are guaranteed by the producer, with a safety of:

- 90% for the minimum values of 2 or 7 days
- 99% for the minimum values of 28 days
- 90% for the maximum values of 28 days

The producer guarantees 85% of the 28-day strengths with a 100% safety.

6.4.2.5. Cement Hauling and Storing

It is compulsory for all types of cement to be brought onto the works site in special paper bags or metal "silos". In general, during hauling and storing cement must be protected against dampness as well as against harmful admixtures.

Truck-silos and cement silos must contain no residues of different cement types or of lower strength grades, or of other materials. In case of doubt, silos shall be carefully checked prior to refilling.

For delivering to the works site cement in paper bags, these must comply to the following requirements:

i. Display intact the paper bags safety stamp,
ii. Be safely stored until use and be fully protected against dampness or weather conditions.
iii. Storage must be separate for each batch in a manner allowing samplings at any moment and locating test results to clearly defined quantities.

Storage rooms of cement in paper bags must be closed but properly ventilated. Storing should be on wooden floors not less than .30m above the ground, to protect the cement from rain and humidity.

Cement stored in the open air tends to absorb air humidity and carbon dioxide and to form lumps, thus diminishing its hardening capacity. Fine granulated or quick hardening cement are particularly sensitive in this respect. With the exception of extremely dry weather conditions, ordinary paper bags will not ensure adequate protection in the case of prolonged storage, not even under shelter. Special protective measures are required in case of cement storage for long periods or under conditions of extreme humidity.

By following up the condition of cement, the Contractor is bound to make sure of its compliance to regulation requirements prior to its use. The Supervising Service is entitled to do the same.

Any cement damaged owing to age or containing hardened lumps that will not break up on light finger pressure, shall be immediately removed from the works site. Similarly, any cement quantity that does not comply with the P.D. 244/1980 requirements shall be immediately removed from the works site.

6.4.2.6. Upon each cement consignment, packaging features as well as the characteristics shown on the shipping documents (cement type, classification, producer's trade mark) shall be checked to comply with the features of the mix design.

6.4.2.7. For each batch of cement, the Service may order the execution of laboratory testing, to be performed at the Contractor's care and expense. By such tests it shall be sought to compare the cement performance with the regulations regarding the following qualities:

- Measurement of undissolved residue,
- Development of strength,
- Setting performance (commencement and completion),
- Volume stability,
- Milling degree.

For some special applications, it may be asked to check

- Resistance to chemical actions,
- Hydration heating,
- Warming loss,

or additional qualities depending on the works' nature and location.

6.4.3. Aggregates

6.4.3.1. General

Aggregates consist of stone particles, either natural, in which case they are called *"natural or collected'* aggregates, or resulting from rock or natural aggregate crushing, in which case they are called "crushed" aggregates. The particles may have similar or different sizes.

6.4.3.2. Crushed Aggregates

Crushed aggregates must meet the requirements of the Standards "crushed aggregates for ordinary concrete", with the following amendments and additions:

6.4.3.2.1. All three series of standard sieves referred to under Standards are adopted, named as follows:

i. *"German Sieve Series or German Sieves",* those described under DIN 4187 and DIN 4188.

ii. *"American Sieve Series or American Sieves",* those described under ASTM E 11.

German sieves shall bear the symbol #, written in front of the sieve number. American sieves shall bear the symbol N° that shall be written in front of the sieve number up to sieve N°4, while sieves of larger apertures shall be symbolized by the size of the hole expressed in inches. (See also para 6.4.3.2.20 of this specification).

6.4.3.2.2. Sieves of circular holes having diameters of 5mm, 10mm, 50mm, and 70mm.

6.4.3.2.3. 6.4.3.2.3 Tables 2a, 2b and 2c, as well as Diagram I are replaced by Tables 6.4.3.2.3a and 6.4.3.2.3c and by Diagram I of this Specification.

TABLE 6.4.3.2.3a: Compulsory grading limits of mixed crushed aggregates with a maximum dia 30mm

Sieves		Passing %		
Name	Aperture	Sub-Zone D	Sub-Zone E	Sub-Zone Z
0.2'	0.2mm	1-10	10 - 14	14 - 19
Φ 1	1 mm	8-27	27 - 40	40 - 53
Φ 3	3 mm	22 - 44	44 - 59	59 - 70
Φ 5	5 mm	31 - 53	53 - 68	68 - 77
Φ 7	7 mm	37 - 60	60 - 74	74 - 81
Φ 10	10 mm	47 - 70	70 - 81	81 - 87
Φ 15	15 mm	60 - 79	79 - 88	88 - 92
Φ 30	30 mm	95 -100	100	100
Φ 50	50 mm	100	100	100

This sieve has a rectangular hole (sub-clause 5.5 of Standard 1105-408).

TABLE 6.4.3.2.3b: Compulsory grading limits of mixed crushed aggregates with a maximum particle of 1" for the series of American sieves ASTM E-11

Sieves		Passing %		
Name	Aperture	Sub-Zone ID	Sub-Zone E	Sub-Zone Z
0.2'	0. 2 mm	1-10	10 - 14	14 - 19
N° 50	0. 3 mm	3-13	13 - 20	20 - 27
N° 30	0. 6 mm	6 - 23	23 - 34	34 - 44
N° 16	1.18 mm	12 - 32	32 - 47	47 - 60
N° 8	2.36 mm	21 - 43	43 - 58	58 - 69
N° 4	4.75 mm	33 - 56	56 - 70	70 - 78
3/8"	9. 5 mm	51 - 73	73 - 84	84 - 89
1/2"	12. 5 mm	61 - 80	80 - 89	89 - 93
1"	25. 0 mm	95 - 100	100	100
1 1/2"	38. 0 mm	100	100	100

TABLE 6.4.3.2.3c: Compulsory grading limits of mixed crushed aggregates with a maximum grain dia 31.5mm for the series of German sieves DIN 4187

Sieves		Passing %		
Name	Aperture	Sub-Zone D	Sub-Zone E	Sub-Zone Z
0. 2 *	0. 2 mm	1-10	10 - 14	14 - 19
0.25	0.25 mm	2-11	11 - 17	17 - 23
1	1 mm	10 - 30	30 - 44	44 - 58
2	2 mm	18 - 40	40 - 55	55 - 67
4	4 mm	30 - 52	52 - 67	67 - 76
8	8 mm	45 - 68	68 - 80	80 - 86
16	16 mm	70 - 87	87 - 93	93 - 96
31. 5	31. 5 mm	100	100	100

6.4.3.2.4. For the case of concrete with a characteristic strength higher than 12 MPa (120kg/cm2), aggregates shall be brought to the site in not less than three (3) parts (components).

6.4.3.2.5. All aggregate components in a project shall be checked in the same order of sieves as that used in the concrete mix design.

6.4.3.2.6. Sand is defined to be the component passing sieve CD 5, or #' 4, or N°4 by not less than 95%.

6.4.3.2.7. It is not compulsory to use an aggregate component having a maximum grain smaller than the maximum grain of sand, however this is recommended in the case of high strength concrete.

6.4.3.2.8. The most ordinary aggregate components having grains larger than the largest sand grains are "rice", *gravel" (fine, coarse), and "ballast".

6.4.3.2.9. The component next to sand should not be allowed to contain any material passing sieve CD 5, or #.` 4, or N°4 by more than 25%, and should similarly contain no material passing sieve 01, or # 1', or N°16 by more than 2%.

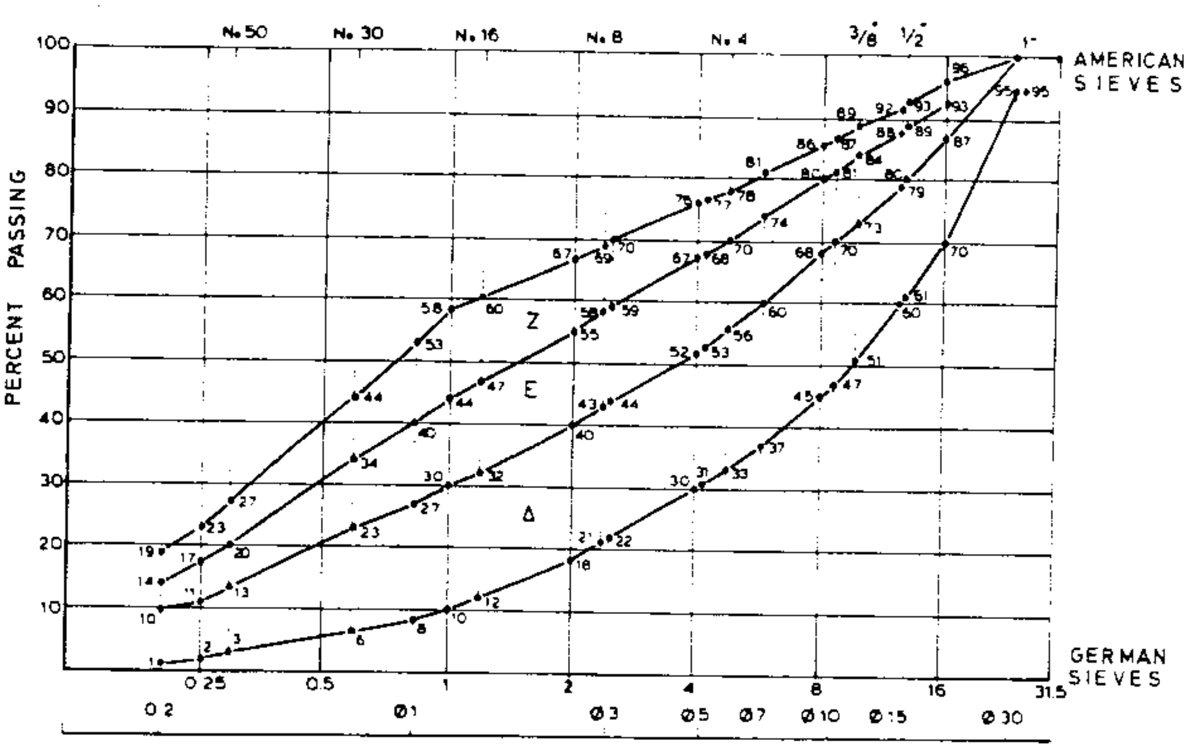

DIAGRAM 1 : GRADING LIMITS FOR AGGREGATES OF MAXIMUM GRAIN PASSING Φ 30, or # 31.5, or 1"

6.4.3.2.10. The percentage of sand grains passing sieve # 0.2" must not exceed :

a) 20% of the dry sand weight, in the case of concrete with a characteristic strength equal to or higher than 30 MPa (300kg/cm^2).

b) 20% of the dry sand weight, in the case of concrete with a characteristic strength lower than 30 MPa (300kg/cm^2).

6.4.3.2.11. 31% of the dry sand weight, in the cases of plain concrete with no special requirements (water-tight, resistant, floor concrete, etc.).

6.4.3.2.12. The aggregate portion passing the American standard sieve N°200 (75pm) is defined as mineral filler and is calculated in accordance with the method ASTM C 117. Mineral filler in sand must not exceed 16% of its dry weight, while the mineral filler in more coarse components (rice, gravel, ballast) should not exceed 1% of their dry weight. For plain concrete without specific requirements, the mineral filler in the sand is permitted to be up to 20% of its dry weight.

6.4.3.2.13. In the case that two different kinds of sand are used, then the requirements of paras 6.4.3.2.9 and 6.4.3.2.10 hereabove apply to the sand mix.

6.4.3.2.14. No permissible upper limit is established for the sand portion passing sieve N°100.

6.4.3.2.15. The grading curve of aggregate mixes intended for reinforced concrete must lie within Sub-zone D of Diagram I.

6.4.3.2.16. If the concrete characteristic strength is lower than or equal to 40 MPa (400kg/cm2), then the Service may specify Sub-zone E of Diagram I as the mix area.

6.4.3.2.17. If an aggregate with a maximum grain of about 50mm is used, then the grading of the aggregate mix must lie within the boundaries of Diagram II of this Specification and of Tables 6.4.3.2.14a, 6.4.3.2.14b and 6.4.3,2.14c.

TABLE 6.4.3.2.14a : Compulsory grading limits of mixed crushed aggregates with a maximum grain cl) 50mm

Sieves		Passing %	
Name	**Aperture**	**Sub-Zone D**	**Sub-Zone E**
0.2'	**0.2 mm**	**1 - 9**	**9-13**
Φ 1	**1mm**	**5-24**	**24 - 36**
Φ 3	**3 mm**	**13 - 37**	**37 - 52**
Φ5	**5 mm**	**20 - 43**	**43 - 60**
Φ7	**7 mm**	**24 - 49**	**49 - 66**
Φ10	**10 mm**	**31 - 57**	**57 - 72**
Φ15	**15 mm**	**40 - 65**	**65 - 79**
Φ30	**30 mm**	**59 - 83**	**83 - 92**
Φ50	**50 mm**	**95 -100**	**100**
Φ70	**70 mm**	**100**	**100**

Sieve with rectangular hole

TABLE 6.4.3.2.14b : Compulsory grading limits of mixed crushed aggregates with maximum grain of 1 IA" for the series of American sieves ASTM E-11

Sieves		Pass ng %	
Name	Aperture	Sub-Zone **D**	**Sub-Zone E**
0.2 *	**0.2 mm**	**1-9**	**9-13**
N°50	**0.3 mm**	**3-12**	**12 - 19**
N3 30	**0.6 mm**	**4 - 20**	**20 - 30**
N° 13	**1.18 mm**	**7 - 29**	**29 - 42**
N° 8	**2.36 mm**	**12 - 36**	**36 - 51**
N° 4	**4.75 mm**	**21-45**	**45 - 62**
318"	9.5 mm	**34 - 60**	**60 - 74**
1/2"	**12.5 mm**	**41 - 66**	**66 - 80**
3/4"	**19.0 mm**	**51- 75**	**75 - 87**
1"	**25.0 mm**	**60 - 84**	**84 - 93**
1 1/2"	**38.0 mm**	**95 -100**	**95 -100**
2"	**50.0 mm**	**100**	**100**

TABLE 6.4.3.2.14c: Compulsory grading limits of mixed aggregates with a maximum grain of 63mm for the series of German sieves as per DIN 4188 and DIN 4187

Sieves		**Passing %**	
Name	**Aperture**	**Sub-Zone D**	**Sub-Zone E**
0.2 *	**0.2 mm**	**1 - 9**	**9 - 13**
0.25	**0.25 mm**	**2-10**	**10 - 16**
1	**1 mm**	**6 - 26**	**26 - 39**
2	**2 mm**	**11 - 34**	**34 - 49**
4	**4 mm**	**19 - 42**	**42 - 59**
8	**8 mm**	**30 - 56**	**56 - 71**
16	**16 mm**	**46 - 71**	**71 - 84**
31.5	**31.5 mm**	**72 - 90**	**90 - 96**
63	**63 mm**	**100**	**100**

6.4.3.2.18. In the case of aggregates with a maximum grain size of about 15mm, the grading of the mixture of aggregates must lie within the bounds of Diagram III of this specification and of Tables 6.4.3.2.15a, 6.4.3.2.15b and 6.4.3.2.15c. In this case, the aggregate may be brought onto the site in two separate parts (sand and gravel).

TABLE 6.4.3.2.15a : Compulsory grading limits of mixed crushed aggregates with a maximum grain diameter of 15mm

Sieves		Passing	%
Name	Aperture	Sub-Zone D	Sub-Zone E
0.2*	0.2mm	1-10	10 - 15
d)1	1 mm	11 - 29	29 - 44
1:1) 3	3 mm	25 - 49	49 - 68
(1) 6	5 mm	37 - 64	64 - 82
t'7	7 mm	49 - 74	74 - 88
CD10	10 mm	62 -100	86 - 95
015	15 mm	95 -100	100
(1330	30 mm	100	100

This sieve has a rectangular hole

TABLE 6.4.3.2.15b : Compulsory grading limits of mixed crushed aggregates with maximum grain size 1/2" for the series of American sieves ASTM E-11

Sieves		Passing	%
Name	**Aperture**	**Sub-Zone❑**	**Sub-Zone E**
0.2 *	0.2 mm	1-10	10 - 15
N°50	0.3 mm	3 - 13	13 - 22
N°30	0.6 mm	8 - 23	23 - 37
N°16	1.18 mm	14 - 34	34 - 52
N° 8	2.36 mm	24 - 47	47 - 66
N° 4	4.75 mm	42 - 68	68 - 84
3/8"	9.5 mm	70 - 91	91 - 97
1/2"	12.5 mm	95 -100	100
3/4"	19.0 mm	100	100

TABLE 6.4.3.2.15c: Compulsory grading limits **of mixed crushed aggregates with maximum grain size of 16mm for the series of German** sieves **as per DIN 4188 and DIN 4187**

Sieves		Passing 9/0	
Name	**Aperture**	**Sub-Zone D**	**Sub-Zone E**
0.2'	0.2 mm	1-10	10 - 15
0.25	0.25 mm	2-11	11 - 18
1	1 mm	12 - 32	32 - 49
2	2 mm	21 - 42	42 - 62
4	4 mm	36 - 63	63 - 80
8	8 mm	60 - 85	85 - 94
16	16 mm	100	100

6.4.3.2.19. The stipulations mentioned in sub-para 6.4.3.2.13 of this specification shall also apply in the cases of sub-zones D and E of Diagrams 11 and Ill.

6.4.3.2.20. The weight portion of mixed aggregates retained between two consecutive sieves of the series of sieves used must be not less than 2%.

6.4.3.2.21. The weight portion of mixed aggregates retained between ***a*** sieve and two sieves after that in the series if sieves used must be not less than 6%.

6.4.3.2.22. The checking of the portion of breakable grains shall be conducted in accordance with the method ASTM C 142.

6.4.3.2.23. In the case of factory produced concrete, as well as in case the Contractor is being supplied aggregates ready from strength a quarry enterprise, the control of the original rock, organic admixtures and sand equivalent may be omitted, if the quarry verifies that his products satisfy the requirements of the present specification.

6.4.3.2.24. In addition to the three series of standard sieves adopted in this specification, according to Standards (as mentioned hereabove under 6.4.3.2.1). other series of standard sieves are also accepted as officially used in the EEC-member countries (i.e. sieve series ISO, etc.). The number of the new sieves used must be such as to enable the grade analysis curves of Diagrams I, II and III to be described with commensurate accuracy (compared with that of the three sieve series accepted by this specification). In such a case, the related tables 6.4.3.2.3a, b and c, 6.4.3.2.14a, b and c, 6.4.3.2.15a, b and c must be adjusted to the mesh characteristics of the new sieves, combined with the curves of Diagrams I, II and III. Appropriate symbols should be used for these sieves, in order to avoid confusion with those mentioned under sub-para 6.4.3.2.1 hereabove.

6.4.3.3. *Naturally Occurring Aggregates*

Naturally occurring aggregates shall respond to the requirements of Standards "Crushed aggregates for ordinary concrete", with the following amendments and supplements:

6.4.3.3.1. The mineral filler of natural sand, determined in accordance with the method ASTM C117, must not exceed 5% of the sand's dry weight.

6.4.3.3.2. Unwashed natural aggregates originating from the sea may be used for the preparation of reinforced concrete provided that their chloride content, expressed in equivalent percentage of dry calcium chloride ($CaCl_2$), does not exceed 1% of the cement weight. With reference to prestressed concrete, it is not allowed to use unwashed natural aggregates originating from the sea.

6.4.3.3.3. In the case of using a mixture of crushed and natural sands, the requirement of sub-para 6.4.3.3.1 still applies with reference to the natural sand.

6.4.3.3.4. In the case of using a mixture of crushed and natural sands, the requirement of sub-para 6.4.3.3.2 is applicable to the sand mixture.

6.4.3.4. *Stockpiling, Sampling and Testing Aggregates*

6.4.3.4.1.

a) The stockpiling of aggregates must be conducted in a way ensuring that

   i. Aggregate particles are not segregated, a condition bound to occur when, for example, a coarse aggregate is dumped from a great height, or when it is raked up.

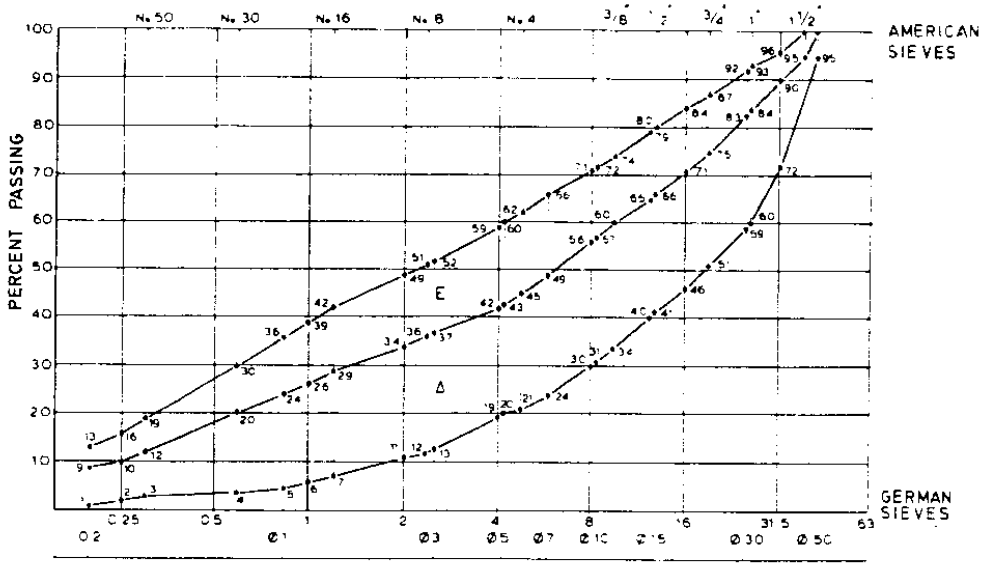

DIAGRAM II : GRADING LIMITS FOR AGGREGATES OF MAXIMUM GRAIN PASSING Φ 50, or # 63*, or 1 1/2"

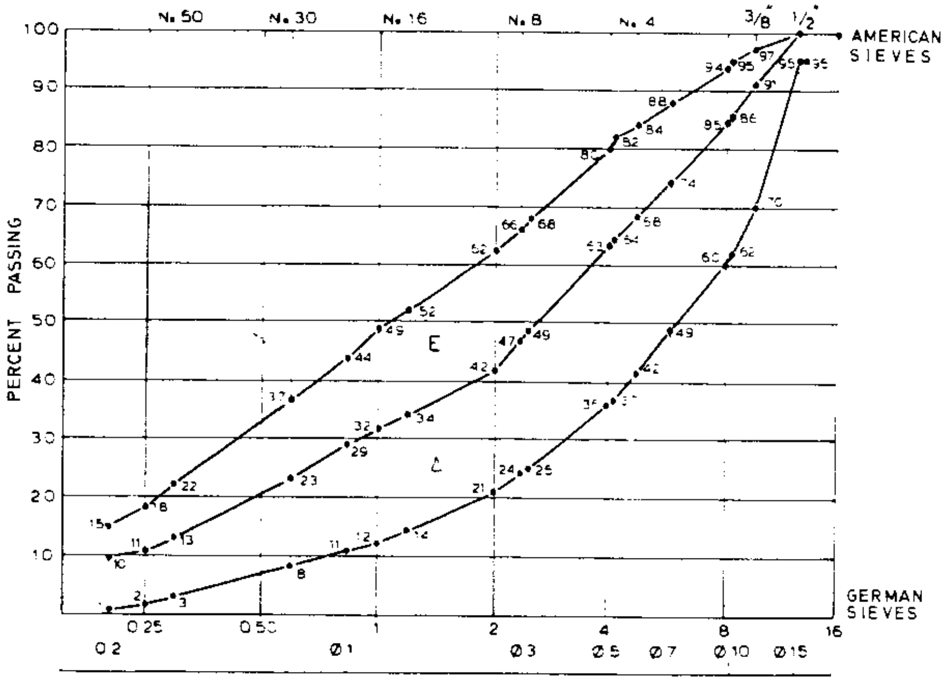

DIAGRAM II : GRADING LIMITS FOR AGGREGATES OF MAXIMUM GRAIN PASSING Φ 15, or # 16*, or 1/2"

* Sieve of square hole of the size indicated (mm)

ii. Mixing of different kinds of aggregates is avoided, a condition likely to occur when, for example, two stockpiles are in contact without intermediate partition.

iii. Aggregates are kept safe against harmful admixtures (earth, wastes, etc.)

b) Floor surfaces of stockpile areas shall be rigid, clean and freely drained, or a coarse of the same aggregate, not less than .30m-thick, must remain unused under the stockpile of each category of aggregate.

6.4.3.4.2. Aggregate sampling from stockpiles shall be conducted in the following manners :

a. When piles are formed from aggregates transferred with a conveyor belt, the sampling shall take place on the belt itself. For each sampling, the belt must be stopped.

Two parallel transversal boards are placed across the belt, with their underside shaped identical to the belt's concave form. The whole aggregate quantity between the two boards shall be carefully collected including all fines for which a brush can be used. The final collective sample of the material shall consist of not less than ten (10) such random samplings.

b. When piles are formed from aggregates brought in on trucks or by means of a crane, the sampling shall be conducted on the stockpiles. The collective sample shall consist of small quantities shovelled from not less than ten (10) random points over the pile free surface. No sampling shall be done from the lowest fifth of the pile height.

6.4.3.4.3. Should test results from such aggregate samples prove to deviate from the requirements of this specification, two more samplings shall be performed and the mean values of test results from the three (3) samplings shall be computed. (With reference to grading tests, the mean values passing each sieve shall be calculated). If these mean values also prove to fall out of the requirements of this specification, then the stockpile sampled is finally rejected.

In case that the discrepancy is limited to the uniformity of grading then the Service is entitled to decline rejecting the stockpile, but

i. to repeat the concrete mix design;

ii. to perform corrective calculations of the design ratios, should there not be time for repeating the mix design, and as long as deviations are confined to stone and gravel sieves larger than Φ 5 or # 4" , or N°4, without however exceeding twice the values referred to the Standards.

6.4.3.4.4. Table 6.4_3.4.4 shows the minimum aggregate sample quantities required for ordinary laboratory tests.

TABLE 6.4.3.4.4: Quantities required for aggregate testing

Test	Minimum required aggregate quantity, in kg		
	Sand	Gravel	Stone
Grading analysis Apparent weight Sand equivalent	20	30	30
Los Angeles abrassion and impact strength test	-	30	30
Disintegration strength (soundness)	10	20	30

6.4.3.4.5. Grading tests shall be resumed after having consumed about 80 cubic meters of stone, 40 cu.m. of gravel and 80 cu.m. of sand, unless larger aggregate quantities are consumed in the course of a single day's spreading operations, in which case the tests shall be resumed prior to beginning each new spreading activity. They shall also be resumed each time that a substantial variation is observed to the slump of concrete without alteration of the component ratios.

The testing of other aggregate characteristics shall be resumed when it becomes apparent that their values are altered or when the source of the aggregate supply is changed.

6.4.3.4.6. Should stockpiles exist that are smaller than those described under sub-para 6.4.3.4.5 and that are supplied on different dates, each one of these piles shall be examined separately.

6.4.3.4.7. Aggregates found unsuitable shall be removed from the works site area.

6.4.3.4.8. In case that the Contractor obtains his aggregate supplies ready from an independent quarry, then the Contractor and the quarrying enterprise producing them shall agree on the grading of aggregates to be delivered to the site with the tolerances provided of the Standards, and such agreement shat be brought to the Service's notice without the latter action releasing the Contractor from any responsibility, as he is solely responsible to the Service.

6.4.3.4.9. Each consignment of quarry aggregates shall be accompanied by a signed note regarding the aggregate grading.

6.4.3.4.10. If the Contractor obtains his aggregate supplies ready from a quarry enterprise and in the case that a grading - according to the quarry note - of delivered batch of aggregates is different than the one agreed to, the Contractor is obliged not to accept this batch of aggregates, for the specific concreting work, since the Service (see pare 6.4.3.4.8) will not undertake any responsibility for the relation between the quarry enterprise and the Contractor.

6.4.3.4.11. If the Contractor obtains his aggregate supply from a quarry enterprise and in case it is realized, after the aggregate batch control to be done by the Contractor, that the material grading is not the one shown on the quarry note, the Contractor is obliged not to accept the aggregate batch for the specific concreting works, since the Service (see para. 6.4.3.4.8) will not undertake any responsibility for the relation between the quarry enterssprise and the Contractor.

6.4.3.4.12. Irrespectively of who produces the aggregates (whether it is the Contractor himself or an independent quarrying enterprise), the Contractor is bound to secure the possibility for the Service to follow-up at the quarry test results of the aggregates produced. Failing this, the Service is entitled to forbid the Contractor's aggregate supplies coming from the said quarry (see also para 6.4.3.4.8)

6.4.3.4.13. Aggregate testing in a project shall be conducted using the same order of sieves as that used for the mix design.

6.4.4. Water

6.4.4.1. Water used in mixing and curing must meet the requirements of Standards.

6.4.4.2. No sea water may be used in the preparation of reinforced concrete, unless provided for in the Special Conditions of the Contract.

6.4.4.3. It is not allowed to use sea water in the preparation of prestressed concrete.

6.4.4.4. Sea water may be used in the preparation of lean concrete with a strength requirement, provided that the required strength is increased by 15%.

6.4.4.5. For calculating the quantity of mixing water (and of any ice), one must take into account the aggregates surface moisture together with any water contained in additives, that shall need to be subtracted from the mixing water quantity established in the mix design.

6.4.4.6. The quantity of mixing water to be added to the mix shall need to be measured with a special automatic measuring device (feeder) fixed onto the concrete mixer.

6.4.5. Concrete Admixtures (Additives)

6.4.5.1. The admixture to be used must be previously approved by the Service.

6.4.5.2. The admixture supplier must provide the Service with the relevant test certificates.

In addition, the supplier is bound to provide the following information :

- Detailed instructions for use;
- Typical ratio and damaging effects in case of a higher ratio application; Chemical definitions of the admixture's principal active ingredients;
- The admixture's chlorium content expressed in terms of dry CaC12 as a weight percent;
- Whether the admixture causes air bubbles;
- Permissible storage time and instructions concerning the required storage conditions;
- Statement referring to the compatibility of admixtures, should there be more than one such admixture used at the same time.

6.4.5.3. The Service is entitled to require a test certificate issued by a recognized laboratory of his own choice. The testing expense shall be borne by the Contractor.

6.4.5.4. The concrete mix design must have taken into account the admixture/s, in case of more than one.

6.4.5.5. In the case that the concrete is to be prestressed or that aluminium fixtures are to be embedded into it, it is not allowed to use additives liable to create chiorium ions.

6.4.5.6. Air entraining agents must comply with the requirements of the specification ASTM C 233 and C 260.

6.4.5.7. Setting accelerators or retarders, viscosity or superviscosity agents or other admixtures must comply with the requirements of specification ASTM C 494 applicable to the respective type.

6.4.5.8. The additive/s shall be added to the concrete mixture at the ratio provided by the concrete mix design. Any variation of such ratio must be previously approved by the Service.

6.4.5.9. Any quantity of an admixture delivered onto the works site shall be accompanied by the supplier's certificate to the effect that its quality is identical to the one used in the mix design.

6.4.5.10. Admixtures and chemical substances intended to the concrete preservation shall be kept in their original packing and shall be weather-proof and protected against extreme temperatures and tampering. With reference to storing, the manufacturer's instructions must be observed.

6.5. COMPOSITION OF CONCRETE

6.5.1. General

The concrete must have been designed and must be prepared in **a** manner allowing it to:

- be homogeneous;
- have sufficient workability to enable it to be spread and satisfactorily compacted with the means available; and
- acquire the strength, toughness and any other additional qualities as required by the project.

6.5.2. Mix Design

6.5.2.1. Obligations

6.5.2.1.1. The ratios of the materials used in concrete preparation shall be determined following a laboratory design of composition. Such mix design is compulsory for all categories of concrete, same as for any concrete of special requirements (watertight concrete, durable concrete, etc.). It is not compulsory with respect to concrete of sublayers, blinding courses and of other auxiliary components of the works that do not participate substantially in the functioning of the project.

6.5.2.1.2. The cost of the concrete mix design shall be borne by the project Contractor, unless explicitly specified otherwise in the Special Conditions of the Contract.

6.5.2.1.3. Upon contract award, the Contractor is bound to conduct the required concrete mix designs (in accordance with this specification and with the tender conditions) using as inputs the kinds of aggregates, cement, water, etc. he shall be actually using in the works according to the project and the tender conditions, and present such designs to the Service. Following their approval by the Service, the material ratios established as above shall constitute the mix ratios to be applied throughout the project in question.

6.5.2.1.4. The laboratories of senior educational institutions, of the Ministry of Infrastructure, as well as private laboratories supervised by the labs of the Ministry of Infrastructure are competent for the conduct of such concrete composition designs.

6.5.2.1.5. The mix design for each category of concrete shall be conducted upon commencement of the works and shall be resumed:

a. For every new source of aggregates;

b. Whenever aggregates present gradings different from the one they had at the mix design (with the exception of sub-pars

c. For every new admixture or every new category of cement used.

6.5.2.2. *Required Strength*

6.5.2.2.1. For data proving a standard deviation value s resulting from not less than 60 consecutive test cubes of varying mixtures obtained with the same materials, the same production facilities and for concrete whose characteristic strength does not deviate more than 7 MPa (70 kg/cm^2) from that of the project under consideration, the required strength shall be calculated on the basis of the relation :

$$f_a = f_{ck} + 1.91\ s \qquad (1)$$

whenever concrete of major projects is concerned (see sub-para 6.13.5), and on the basis of the relation :

$$f_{ck} + 2.05\ s \qquad (2)$$

whenever concrete of minor works is concerned (see sub-para 6.13.4).

The required strength f_a of industrial concrete shall be determined by the factories themselves, but shall not be less than the f_a value determined under 6.12.1.1.4 hereafter.

If the standard deviation value mentioned hereabove has resulted (under the same preconditions as above) from less than 60 test cubes but not less than 15, then this value, prior to being introduced in the relations (1) and (2), shall be multiplied by the respective coefficient given in Table.6.5.2.2.1.

If the standard deviation value, (after being multiplied by the respective coefficient of Table 6.5.2.2.1k results less than 3 MPa (30 kg/cm2), then the value of s = 3 MPa (30 kg/cm) shall be introduced in the relations (1) and (2).

TABLE 6.5.2.2.1: Correction coefficient for standard deviation

Number of test cubes	Coefficient of multiplication
15	1.27
20	1.18
30	1.09
40	1.05
50	1.02
60 or more	1.00

6.5.2.2.2. If no data of standard deviation exist, or that those existing result from less than 15 test cubes, then the calculation of the required strength from the relations (1) and () shall be under the assumption of a standard deviation s = 5 MPa (50 kg/cm) if crushed aggregates are to be used, or s = 6 MPA (60 kg/cm^2) if naturally occurring aggregates are to be used.

6.5.2.3. *Data of the Mix Design*

6.5.2.3.1. The concrete mix design shall be performed with the Contractor's care and responsibility, using aggregates, cement, additives and, possibly, water as those to be used on the works.

The material ratios resulting from the mix design must ensure the following qualities to the mixture :

Workability, to the degree specified in the tender documents or established by the Service upon commencement of the works. If no such degree of workability is specified, then the Contractor is sole responsible for determining the one required, adapted to the project conditions (with adequate margins for fluctuation).

The concrete workability shall be expressed in centimeters of slump, according to the method of the Standards. If no workability degree is specified, then the mix design shall be elaborated for concrete presenting a slump equal to 10 - 12 cm. In addition to slump, flattening may also be specified as described in the testing method of DIN 1048.

However, the references made to slump in sub-paras 6.5.2.4 and 6.8.5 to 6.8.7 inclusive of this specification shall apply also here. VEBE time may also be specified with respect to underwatered mixtures, according to the Standards.

Any additional qualities that may be specified in the tender documents (pumpability, water-tightness, toughness, etc.), or that may be required from the Contractor (Le. pumpability), to the extent feasible with the materials brought onto the laboratory.

A mean strength value of fm equal to or not less than the required one.

Other resistance values or other data required by the Service (bending or bursting resistance, etc.) and/or by the Contractor.

6.5.2.3.2. Should the qualities of concrete referred to under sub-para 6.5.2.3.1 hereabove prove unattainable with the materials produced to the laboratory, the Contractor shall be absolutely responsible for bringing about all necessary changes or even complete substitution of the materials, with the view of achieving the specified qualities, in collaboration with the laboratory.

6.5.2.3.3. Further to material ratios as referred to under sub-pars 6.5.2.3.1 hereabove, the mix design shall also produce the variation curve for the ratio of water/cement (W/C), together with that for resistance, and for a span not less than ± 3 MPa (30 kg/cm) on either side of the mean strength value of fm.

6.5.2.3.4. The quantity of water added to the various material ratios of the mix design shall refer to dry aggregates, same as the marginal values of the ratio W/C indicated under other sub-paras of this specification.

6.5.2.3.5. The Contractor shall be held responsible for the data of standard deviation on which the mix design is based, unless the Service has established a minimum value of standard deviation which the Contractor shall need to adhere to while conducting the mix design.

6.5.2.4. Slump

6.5.2.4.1. The slump value for which the mix design shall be elaborated is to be given in the tender documents, or by the Service in the course of the construction works and in accordance with the special requirements of the project.

6.5.2.4.2. The concrete that is compacted on the site using ordinary vibratory equipment for the construction of structural elements must present a slump of not less than 5cm if prepared with crushed materials, and not less than 3cm if prepared with natural aggregates. Concrete of lower slump values may be used exclusively for the construction of prefabricated components, floors, bulky works or other special structures.

6.5.2.5. Minimum Requirements

6.5.2.5.1. For reinforced concrete of no specific requirements (pars 6.12), the cement content per cubic meter of concrete shall be not less than that specified in Table 6.5.2.5.1.

TABLE 6.5.2.5.1: Minimum cement content (kg/m^3)

Maximum-sized grain of concrete aggregates (mill)	Plastered concrete	Non-plastered - concrete
cD 15, or #16*,or W	310	340
CD 30, or #31.5*, or 1"	_ 270	300
c1) 50, or #63", or 1^1/2"	270	300

Square opening sieves of the size indicated (mm)

6.5.2.5.2. For concrete of no specific requirements (pare 6.12), the ratio Water/Cement shall not exceed the value of 0.70 when concrete is plastered, and the value of 0.67 when it is not plastered.

6.5.2.5.3. When covered with marble lining or painted with any paint, concrete shall be considered to be non-plastered with respect to the requirements of sub-paras 6.5.2.5.1 and 6.5.2.5.2.

6.5.2.5.4. The maximum-sized grain of the concrete aggregates must not exceed 1/3 the thickness of the component to be constructed of such concrete.

6.6. MIXING OF CONCRETE

6.6.1. Aggregates and cement shall be measured by weight parts, while water shall be measured by weight or by volume parts.

6.6.2. Solid admixtures in powder form shall be measured by weight parts, while liquid admixtures shall be measured by weight or by volume parts.

6.6.3. Measurement of aggregates by volume is permitted only with regard to minor projects (sub-para 6.13.4). In such cases, the following shall apply:

a. The required strength shall exceed the characteristic one by 11.6 MPa (116 kg/cm^2) when crushed aggregates are used, and by 13.9 MPa (139 kg/cm^2) in the case of natural aggregates.

b. The quantity of each mix shall correspond to whole bags of cement.

c. Fraction measurement cans (for sand, gravel, stone) shall be marked at the appropriate depths resulting after weighing the fraction quantities of the first mixture and placing them in the above cans.

6.6.4. The mixer equipment must meet with the requirements of Annex B of the Standards. The use of mortar mixers for any category of concrete is prohibited.

6.6.5. The mixing time shall be as indicated in the equipment specifications. In any way, it shall never be less than 1 minute. The mixing time is measured after introduction of all proportioned materials into the mixer. A shorter minimum mixing time is only allowed in case that:

a) The mixer is of turbulent type and a shorter mixing time is provided in its specifications;
b) The uniformity test conducted in accordance with the Standards has proved that a shorter mixing period can be satisfactory.

6.6.6. Aggregates shall be measured with an accuracy of up to ± 3% of their weight, cement with an accuracy of up to ± 2%, water shall be measured with an accuracy of up to ± 2% of its weight or volume, and admixtures with an accuracy up to ± 3% of their weight if in powder form. if admixtures are in liquid or pulp form, they shall be measured with an accuracy of up to ± 3% of their volume.

6.6.7. The ingredients of concrete shall be introduced into the mixing equipment according to their ratios specified in the mix design, after correcting the sand and water ratios on the basis of the aggregates natural moisture content.

The moisture of aggregates shall be checked and the relevant corrections shall be made prior to each concreting operation.

6.6.8. The mixer shall only be loaded after complete discharge of the previous mix.

6.6.9. It is not allowed to add any material to the concrete mix after its discharge from the mixing equipment. It is only permitted to add a super-viscous agent to ready-mix concrete being carried on a truck-mixer. Such addition, however, shall be accompanied by a renewed agitation for a period of 3 minutes.

6.6.10. Mixing of site concrete shall be obtained in the site central mixing plant. Any hand mixing is completely prohibited. Sub-para 6.12.1.2.3 shall apply with regard to mixing of site ready-mix concrete.

6.6.11. A sign with easy-to-read mixing instructions for each class of concrete must be fixed at the mixing site. These instructions shall include:

a. Classification of the concrete strength;
b. Cement characteristics (type and category of strength, cement quantity and content in kg *per* cubic meter of compacted concrete);
c. Aggregate characteristics (category in fraction and quantity);
d. Slump of fresh concrete (or other feature for measuring workability, according to the mix design);
e. Concrete admixtures (type and quantity).
f. The ratio of water over cement (coefficient WIC);
g. Water content.

6.6.12. The concrete mixing equipment (mixers) shall be made in a way ensuring perfect mixing and uniform distribution of the material ingredients throughout the mass of fresh concrete. Mixers shall be equipped with a water storage tank of sufficient quantity as well as with an automatic water batching device (feeder) for each mix. It is appropriate to provide mechanical means for counting the mixing drum rotations to ensure a constant rotation number for all mixes, as well as that the mixer shall not be emptied prior to fulfilment of the required number of rotations. In any case, the drum rotation speed during mixing must be as specified by the mixer manufacturer.

Mixer operators shall be trained and experienced in the production of concrete of even workability

6.6.13. Three main mixer types are distinguished from the viewpoint of their axis direction :

a. with vertical axis;
b. with horizontal axis (non-tilting or tilting mixers);
c. with inclined axis (tilting mixers).

Furthermore, and from the viewpoint of the drive of their mixing power, mixers are distinguished into :

a. turbulent operation mixers;

b. mixers of free fall of the materials by gravity.

6.6.14. No mixer taking a batch smaller than that corresponding to one bag of cement shall be used. Mixers shall not be loaded with mix quantities greater than those warranted by their makers.

In any way, the mixer's output is defined to be the maximum volume of fully mixed concrete that the equipment is capable of producing in a single circle of operation (as distinguished from the mixer's overall geometrical volume and from the sum of the volumes of the mixture's loose ingredients).

6.7. <u>TRANSPORTATION OF CONCRETE</u>

6.7.1. During transportation and until placement, concrete must be protected against rain or against the possibility of its admixture with foreign matters, and must be kept from losing its homogeneity.

6.7.2. In case of transportation by truck or truck-mixer, the stipulations of the Standard re 'ready-mix concrete" shag apply.

6.7.3. If a pump is used, it should not be allowed to alter the mixture homogeneity and workability (see sub-para 6.12.9).

6.7.4. In general, any concrete category could be transported in tubs.

6.7.5. When transported on a conveyor belt, concrete must be cohesive. Suitable arrangements must be provided at points where the concrete drops from the conveyor belt to prevent the mixture from slackening.

6.8. <u>CONCRETE PLACEMENT</u>

6.8.1. Concrete must be discharged as near as possible to its point of final placement, to avoid the need of shifting it by means of shovels or rakes. It is forbidden to move the concrete using a vibrator.

6.8.2. Should unloading not be feasible at the place of placement, then pumps, ramps, conveyor belts or other equipment not endangering the mixture status shall be used for the in-between transportation.

6.8.3. Concrete should not be allowed to drop from a height greater than 2.50m. In such cases, chutes must be used to lower the concrete for placement, or suitable openings must be cut through the formwork at intermediate levels.

6.8.4. It is not permitted to place concrete in two layers for single slabs whose thickness does not exceed 60cm. For slabs more than 60cm-thick, the stipulations of sub-para 6.9.3 shall apply.

6.8.5. Concrete shall be placed in the works with the slump envisaged by the mix design. Nevertheless, and should the work require it, the Service may modify such slump by adjusting the material proportioning according to the instructions given by the mix design.

6.8.6. The concrete slump shall be measured prior to placement, on a sample taken after unloading about one third of the mix or of the truck load, in case of ready-mix concrete (site or factory produced). The slump value shall be the average count of two tests performed on the same sample. This value should not differ by more than 25% from the slump of the mix design (or from that established by the Service on the works site with suitable adjustments of the mix design ratios, or from the slump of the consignment in case of ready-mix concrete). A difference of up to 1cm is permissible for a slump that is less than 3cm, while a difference of up to 4cm is permissible for a slump that is more than 16cm. Should the value measured be found to lie out of the above limits, then two more tests are conducted on a new sample, and the mean value of the four counts is worked out. The four counts must be taken within a period of 15 minutes.

In the case of ready-mix concrete whose unloading was delayed (or for any other reason) the Service does not undertake any responsibility and the Contractor is obliged to comply with the present specification terms.

6.8.7. The Service is entitled to reject a concrete mix or a ready-mix load having a slump greater than the one stipulated under sub-para 6.8.6.

6.8.8. The Service may accept a concrete mix or ready-mix having a slump less than the one stipulated under sub-para 6.8.6, in case this is restored on the spot by an admixture of a super-viscous agent.

6.8.9. If the mix includes an air entraining agent, the air portion must not differ more than ± 1% from the respective percentage of the mix design (or from the percentage of the consignment, in case of ready-mix concrete). The air portion shall be checked according to the method ASTM C 231, and with the same process as the one followed for the slump test (sub-para 6.8.6).

6.8.10. In case of a reinforced concrete element being laid on the ground with steel bars at its lower surface (i.e. a foundation slab), the ground must be covered with a blinding course of an average thickness not less than 50mm.

6.8.11. Site concrete shall be placed as soon as possible after mixing, in order for it to maintain its workability and its composition. The time between adding cement to a mixer containing wet aggregates and placement of the concrete must not exceed one (1) hour during winter, and three quarters (3/4) of an hour during summer.

6.8.12. Ready-mix concrete shall be poured in place, if possible, immediately upon delivery to the job site.

6.8.13. In no case is it permitted for the time between cement introduction to (wet) aggregates in the mixer and the placement of concrete to exceed three quarters (3/4) of the time required up to the start of cement setting.

6.8.14. Formworks shall be carefully cleared from various matters (sawdust, small sticks, straw, paper, cigarette-butts, etc.) before placement of any concrete quantity. Completed sections must be inspected prior to commencement of adjoining ones, and the Service must be advised of any findings capable of unduly affecting the correct continuation of the works. The Contractor is then responsible for defining the method of making good the prejudicial condition to the satisfaction of the Service. Such method shall be subject to the Service's approval.

6.8.15. Placement of concrete is permitted only after inspection and acceptance_ of the formworks and the reinforcement by the Service, and only after fixing any ducts, conduits and other fittings of any kind of installations intended to be embedded in the concrete. During placement of the concrete, it is necessary for a suitable number (at least one) of steel benders to attend for arranging bars and for a suitable number (at least one) of carpenters for watching formwork supports.

In all phases of the works, the Service must be informed not less than 24 hours prior to each concreting operation (in this connection see also sub-pare 7.2.3 of clause 7 of this T.C.C.).

6.8.16. It is not permitted to place concrete under rain. Concrete placement must also be suspended when susceptible to be followed immediately or within the next 24 hours by a downpour.

6.8.17. Furthermore, the Service is entitled to forbid the placement of concrete whenever he judges that prevailing weather conditions in general (sun, heat, cold, rain, snow, winds, etc.) would prevent the regular placement and setting of the concrete.

6.8.18. Placement shall be executed in a manner avoiding movements of the reinforcing bars. The progress rate of placement must be such as to allow the work continuity and smoothness until full completion of the job section scheduled, and so that concrete is always fresh and workable as specified.

6.8.19. Placement shall be in uniform layers with thicknesses depending on the efficiency of the compaction method applied. With the purpose of avoiding formation of horizontal working joints, the placement of concrete must be sufficiently prompt and compaction must be such as to ensure the layers interconnection without any construction joint remaining visible between layers.

6.8.20. It is not allowed to empty the concrete into stacks and to apportion such stacks by means of a vibrator, due to the risk of undoing the mix.

6.8.21. Placement of concrete into special structures or in various special ways provided for in the designs (pouring under water, compressed air casting, shotcreting, grouting, etc.) shall be executed according to specific designs requiring specialized experience and approved by the Service.

6.8.22. The Service's inspection shall precede any concreting operation (see also sub-pare 6_8.15). Such inspection shall regard, without being limited to, the following

- The soundness of formworks and scaffoldings. Formwork and scaffolding compliance with the design shall be checked, together with their good execution. Such control depends on the project importance. In major, difficult and delicate constructions, inspection must be detailed, while in the majority of ordinary building works it may be restricted to visual inspection.

- The uniform coating of formworks with products facilitating their removal, The tightness of joints between formwork sections.

- The compliance of formwork dimensions to the construction drawings.

- The cleanness of formworks and of concreting stage surfaces. The surface condition of reinforcing bars and of prestressing tendons.

- The positioning and sizes (diameters) of steel reinforcement (and of tendons), their fastening, the quality of their tie-ups and the condition of ducts (in case of weldings, the competence of personnel, steel and method applied must be checked).

- The normality of tendon curves within ducts.

- The condition of anchorages, their position and fastening.

- The availability of mechanical equipment likely to be required for adjusting formworks.

- The availability of equipment required for placing and for compacting concrete.

- The good condition of such equipment (required for placing and for compacting concrete).

6.8.23. Prior to each concreting activity, the Contractor shall make sure of the good functioning of the existing equipment, as well as of the availability of supplementary equipment, so that concreting works may be duly completed even in case of serious mechanical breakdown. This latter requirement shall be particularly applicable in the case of major works, and specific reference thereto must be made in the Special Conditions of the Contract, irrespectively of the fact that, in all cases, responsibility lies thoroughly with the Contractor.

6.8.24. Besides, and before starting concrete production activities, the Contractor must have secured the availability of all materials and equipment necessary for finishing and for curing the concrete.

6.9. CONSOLIDATION OF CONCRETE

6.9.1. Concrete must be consolidated by vibration. In case of high slump values of the concrete (more than 20cm) and of small thicknesses of the elements being constructed, vibration may be done through a wood float or stick, following approval by the Service.

6.9.2. The vibrator category (interior mass vibrator, form vibrator, surface vibrator, etc.) and the number of vibrators to be used depends on the form of the element being concreted and on the pouring process and is left to the Contractor's choice, who is also responsible for implementing any instructions of the Service. In special cases, vibrators are specified in the project Tender Documents.

6.9.3. In concrete jobs of substantial thickness, placement shall be in layers not more than 60cm-thick. The layer's upper surface must be made horizontal during placement and not with the use of vibrators. Each layer shall be placed while the previous one is still plastic, in order to avoid the undue creation of working joints.

Distances between consecutive positions of the vibrator must be equal to about 1.5A, where A represents the vibrator's action radius. During vibration, the vibrator's rod shall penetrate by about 5cm through the underlying layer. It is forbidden to vibrate steel bars parts of which lie within already hardened concrete.

6.9.4. External vibration by form or surface vibrators can be applied only when the rigidity and stability of the formwork or metal casing allow it.

6.9.5. Resumption of the vibration of concrete is permitted only in sufficiently plastic concrete allowing the vibrating rod to penetrate the concrete mass through its own weight, namely without any pressure being exerted by the operator.

6.9.6. Consolidation by vibration must be performed under expert surveillance and comply to the following rules:

a. Vibration shall be internal, unless otherwise specified by the Service, as mentioned herebelow.

Vibration with internal mass vibrators shall be supplemented by surface vibrators when formation of a smooth surface is required (pavements, bridge and building slabs).

Form vibrators shall be applied only when the use of internal mass vibrators is unfeasible (very thin sections, thin poles, prefabricated components, etc.).

b. The type of vibrator to be used is subject to the Service's approval.

When charged, vibrators must be capable of transmitting to concrete vibration with a frequency of not less than 3600 shocks per minute.

c. The Contractor must have a sufficient number of vibrators available at the works site, so that each mix may be consolidated immediately after placement inside the forms.

d. The handling of vibrators must provide for the vibration to reach the concrete *at* all points inside the formworks, around reinforcement, at corners, etc.

e. Vibration shall be applied to recently placed concrete. Internal vibrators
shall move slowly in and out of the concrete mass maintaining almost perpendicular positions to the extent possible, with the exception of special cases (shallow sections or places hard to reach). Vibration shall have adequate duration and extent to

achieve perfect consolidation of the concrete, but should not last more than normal for fear of causing segregation of the mix.

f. Surface vibrators shall be applied for as long as required to enable coarse aggregates to sink in the underlying mass of concrete resulting in a uniform sufficiently pulpy appearance to ensure a smooth surface.

g. Form vibrators shall be applied onto formworks in a mariner ensuring satisfactory transmission of vibration to the concrete and shall move in a perpendicular upward direction, parallel to the rising concrete layers. The height of movement shall not exceed that of the concrete being affected by the vibration. Vibrators must be horizontally spaced as provided for under sub-para 6.9.3 hereabove.

h. Vibrating of the concrete must be supplemented by stirring operation with wooden or iron rods near formworks or at points inaccessible to vibrators (corners, etc.) to ensure smooth surfaces and compact concrete.

i. Previously consolidated concrete may be improved through subsequent resumption of the vibration, with the limitations of sub-para 6.9.5. Renewed vibration may close capillary fissures caused by plastic shrinkage, settlement cracks and voids left under horizontal iron bars.

6.10. <u>CURINE OF CONCRETE</u>

6.10.1. Curing is compulsory for all concrete jobs. It begins immediately after placement and shall last for a period depending on weather conditions and on the project special requirements (pars 6.12). This period of time shall in no case be less than seven (7) days.

6.10.2. Curing must create temperature and moisture conditions permitting to hydrate the largest portion of cement in the mixture. For curing temperatures see sub-paras 6.12.7 and 6.12.8 apply. The moisture necessary for curing is secured through the application of:

a. Methods barring or delaying evaporation of the mix water, such as sprinkling the concrete surface with a special waterproofing solution, or covering same with hessian cloth, sand, watertight sheets, etc.

b. Methods of replacing evaporated water, such as sprinkling, flooding, etc.

6.10.3. Unless otherwise specified in the Tender Documents, and unless frost is envisaged, curing shall be conducted as follows :

Immediately after placement, all free concrete surfaces shall be covered with hessian that shall be maintained wet round-the-clock for a period not less than seven (7) days. In this period, workers' circulation and any other activity necessary for the continuation of the works shall be carried out over these hessians. Same method and for the same duration shall be applied to vertical surfaces after form removal.

If the hessian is removed prior to the lapse of fourteen (14) days from the placement of concrete, then, and for the period between 7 and 14 days, the concrete shall be covered with water to surface saturation two times a day, while between 14 and 28 days this shall be done once each day.

6.10.4. The efficiency of the curing method and the general progress of hardening is followed up through test specimens maintained beside the works and equally cured (work test samples-). The strengths obtained by such test samples shall not be taken into account during compliance tests.

6.10.5. Test samples as referred to under sub-para 6.10.4 hereabove are required only for prestressed concrete or under unfavorable weather conditions. However, the Service is entitled to require taking such samples also in other cases, should he need to investigate the performance of a curing method.

6.10.6. The samples of sub-para 6.10.4 shall be taken as duplicates of the 7- or 28-day specimens, according to the method of the Standards.

6.10.7.

a) Should curing be by a membrane formed on the concrete surface by liquid spray, the spray compound must respond to the requirements of specification ASTM C 156 and C 309.

b) Whenever subsequent waterproofing of the concrete surface is foreseen with asphaltic or other coating materials (i.e. waterproofing of bridge carriageways, culverts, etc.), the membrane curing compound shall be approved only if compatible to the waterproofing coat material, and if accompanied by a manufacturer's certificate confirming its compatibility to the foreseen waterproofing method. It is pointed out that working joints shall be moist cured, the use of membrane being excluded in these cases.

6.10.8. Short duration soaking, or, in general, non-continuous round-the-clock water coverage is not considered to be satisfactory curing for young concrete. It may only be applied after the main curing phase, as mentioned in sub-para 6.10.3.

6.10.9. It is indicatively mentioned that the required moisture during curing is ensured by the following methods :

a) Immersion or flooding: Prefabricated components are deposited in water tanks. Regarding floors or building slabs, a single brick (or sand, or earth pile, etc.) is built around the floor or stab perimeter and the whole area is flooded with water. Water must be adequately high to leave no point of the slab uncovered. Usually, 1-2 cm are enough.
b) Soaking: It has to be continuous, by means of revolving sprinklers or fog sprays identical to the ones used for watering.
c) Covering: Straw, sand and plastic sheets are used with the purpose of retarding water evaporation through free surfaces of concrete.
d) Coating: An appropriate liquid compound is sprayed onto free surfaces of concrete forming a thin waterproof plastic membrane.
e) The compound is usually colored to enable checking full coverage by the coating. This method prevents water evaporation as long as the membrane is maintained continuous (with no damage, tear, etc.).

If curing follows the method described under sub-para 6.10.3 hereabove, the hessian can be maintained wet by means of small diameter plastic pipes spread over it, The free ends of pipes are sealed, and water drips through little openings cut through their sides. With this method, water consumption is kept low and no drainage problems are created. The method has proved extremely effective, particularly in the summer months, given that it provides both sun protection and moisture at the same time.

6.10.10. With specific reference to curing by coating, it shall be applied as follows :

(1) The chemical compound turning into wet membrane must be applied with power operated atomizing spray equipment after completion of the concrete surface finishing process and immediately prior to disappearance of the surface moisture shining, and, in any way, before any drying shrinkage or other irregular fissuring becomes apparent.

During heat waves, concrete surfaces must be covered with nozzle-sprayed water until application of the chemical compound, which, however, must not be applied on standing water. In the first seven (7) days after placement of the concrete, any damage caused to the wet membrane must be immediately repaired.

(2) The chemical compound must be applied at the rate of 1 litre per 4 or 5 square meters of surface, unless otherwise specified by the manufacturer, Overflows, potholes, thin sections, steps or interrupted application constitute signs of unsatisfactory work. Throughout its use, the chemical compound possibly containing a coloring substance must be carefully mixed, with the pigment evenly distributed through the spray tank. The solution of the chemical compound must remain applicable (by spray) at temperatures above 25°C and must not be thinned or tampered in any way after its preparation. The manufacturer's instructions must be observed regarding storing, transportation, application, safekeeping and environmental protection.

6.10.11. Hardening Acceleration through Heating

(1) The hardening process of concrete may be accelerated through heating, given that the rise of temperature in the first hours of hardening increases, within certain limits, the strength of young concrete. However, its final strength may be lower than the one the concrete would have attained had it been cured under normal temperature conditions. In such a case, the time of starting heating, the speed of rising temperature, the maximum temperature applied, the duration of heating and the speed of cooling down shall be determinant factors. The success of heat treatment depends on the type of cement, but no general rules can be established to this effect.

Thus, and prior to any application, the method to be used must be tested with trial mixes. It must also be made sure of that heated concrete components shall not be let to dry off too early or too much, or to cool down too suddenly. Heat treatment is liable to affect the qualities of hardened concrete (i.e. ratio of tensile over compressive strength, deflection, properties durability).

(2) Following all the above, it is established that hardening acceleration by heating shall be applicable only if provided for by the design and by the other tender conditions, and following elaboration of a method study (organization, equipment, etc.) and submission of same to the Service for approval.

6.11. FORMWORKS

6.11.1. In the present specification, the term "formwork" is used to imply all kinds of forms (moulds) and of the necessary scaffoldings, irrespectively of their material. Whenever it shall be necessary to distinguish metal or plastic formworks, the terms 'metal casing" or "plastic formwork" will be used.

6.11.2. Formworks must be calculated whenever necessary, and must be erected in a manner enabling them to bear all vertical and horizontal forces developed during construction of the concrete structure, without any recesses or deflections.

It is not allowed to use thin flexible sheets (iron sheets, cartons, etc.) for filling in forms in any position.

6.11.3. Joints between the formwork boards must be sufficiently close to prevent seepage of grout.

6.11.4. Prior to placement, formwork and hardened concrete surfaces being prepared to receive the new concrete (columns, walls, etc.) must be cleared of all foreign matter (wood chips, papers, pieces of polystyrenes, etc.). Absorptive wooden forms (boards, plywood, etc. non-covered with form loosening coatings) shall be soaked to saturation. Hardened concrete surfaces to be covered with new concrete shall also be soaked. No grout is allowed to be spread on such surfaces.

6.11.5. Formwork removal must take place only when concrete has attained sufficient strength to bear all loads exerted upon form removal or to be charged to it up to the age of 28 days, under conditions conforming to those taken into account in structural calculations. Particular attention is required when overhead shutterings are supported by not yet adequately aged concrete components.

6.11.6. Whenever the hardening process is not monitored through sample testing (sub-pare 6.10.4), formworks shall not be removed prior to the dates given in Table 6.11.6. lf, within such periods, ambient temperatures drop below +5°C for longer than 2 hours and up to 24 hours, the time periods of Table 6.11.6 shall be increased by one day.

Generally, if the temperature below +5°C is maintained for 24+1 hours, where k : whole number or 0, and 1 < or = 24, then the time periods of Table 6.11.6 shall be increased by k+1 days, if I > or = 2, and by k days if I < 2.

TABLE 6.11.6 : Days of formwork removal (after placement)

Construction components	Cement type	
	I	II
Sides of beams, slabs, columns, walls	2 days	3 days
Slab and beam formworks	5 days	8 days
Formworks of beams and slabs with longer than 5m spans	10 days	16 days
Safety supports for beams, frames and slabs with longer than 5m spans	28 days	28 days

6.11.7. For the cases of low ambient temperatures, see sub-para 6.12.7 herebelow.

6.11.8. Formwork removal must be effected without shocks and vibrations. First, vertical element forms shall be removed (columns, walls, etc.), and those of horizontal elements shall follow (slabs and beams).

6.11.9. Observance of the days indicated in above Table 6.11.6 does not release the Contractor from his responsibilities regarding any damage that might occur to the concrete structure owing to delays in hardening or to excessive loads being exerted onto such structure.

6.11.10. A specific reference to formworks is made under clause 7 of these T.C.C..

6.12. SPECIAL CASES OF CONCRETE AND PLACEMENT

In the following special concrete types and special concrete placement, the individual provisions of the present clause paragraphs shall apply.

These special concrete types and placement are:

- Factory - produced ready-mix concrete
- Site - produced ready-mix concrete
- Surface wear resistant concrete
- Concrete of reduced permeability
- Chemical action resistant concrete
- Concrete under water
- Concrete under sea water
- Concreting under low ambient temperature
- Concreting under high ambient temperature
- Pumpable concrete
- Concrete of increased strength against surface wear
- Concrete of high strength against surface wear

6.12.1. Ready-Mix Concrete

As mentioned under sub-para 6.3.9, ready-mix concrete can be either factory- or site-produced.

6.12.1.1. Factory Produced Ready-Mix Concrete

The stipulations of Standards shall apply with the following amendments or supplements:

6.12.1.1.1. The term "batch" must be replaced by the term "mixture".
6.12.1.1.2. Footnotes (10) and (14) are deleted.
6.12.1.1.3. The following shall apply in-lieu of sub-clause 3.1 :

The factory shall be responsible for the quality of the concrete ingredients. The materials (aggregates, cement, water, admixtures) shall be tested in accordance with the requirements of this specification. The Contractor is bound to secure the Service's right for communication of the concrete test results *by* the factory, should they be requested by him (the Service). Failing this, the Service shall be entitled to bar any use by the Contractor of concrete coming from the said factory.

6.12.1.1.4. The section of sub-clause 3.2: "In the above designs that such a reduction is feasible", is replaced by the following: "The strength f_m for each mix design shall at least be equal to $f_m = f_ck + 1.64$ s, where f_ck is the characteristic strength of concrete for which this mix was composed and s is its standard deviation, that must have resulted from the testing of specimens of not less than 15 - 60 mixtures". Otherwise, and regarding mix designs, the stipulations of sub-par. 6.5.2.2 of these T.C.C. shall apply.

6.12.1.1.5. Air content and slump shall be checked according to sub-paras 6.8.6 and 6.8.9 of these T.C.C..

6.12.1.1.6. In-situ strength tests to be performed by the Service shall be conducted according to sub-para 6.13.3 of these T.C.C.. On the contrary, the section of the same sub-clause which refers to strength testing data due to be observed by the factory, shall still apply.

6.12.1.1.7. The concrete factory may elaborate its own mix designs at its own laboratory.

6.12.1.1.8. From ANNEX A: "POWER MIXING", the section "Generally, and by order of suitability worn out sections must be replaced" shall not apply.

6.12.1.1.9. The test for "uniformity within the same batch" (mixture) of sub-clause 1.1 of ANNEX B shall be conducted only for concrete that has a slump value varying between 10cm and 15cm.

6.12.1.1.10. The test for the difference in air content mentioned in Table I, "Concrete uniformity requirements", shall be conducted only when an air entraining agent has been added to the concrete. In the same Table, and regarding the slump test, the sentence "For a mean slump value of 10cm", together with the corresponding limit of "2.5cm", are not applicable.

6.12.1.1.11. The Contractor shall secure the Service's right to check the concrete factory supplying the former, for observance of this specification. Otherwise, the Service shall be entitled to bar the Contractor from buying and using in the works any concrete coming from the said factory.

6.12.1.1.12. A quantity of fresh consolidated concrete expressed in tons and cubic meters".

6.12.1.2. Site Produced Ready-Mix Concrete

6.12.1.2.1. Regarding the quality of materials and the mixing equipment and method, the stipulations of the relevant paragraphs of these specifications shall apply.

6.12.1.2.2. Regarding truck-mixers transporting concrete, the relevant stipulations of the Standards shall apply.

6.12.1.2.3. Concrete shall be fully mixed at the concrete mixing plant. No mixing (partial or total) is allowed to be conducted in truck-mixers.

6.12.1.2.4. Sampling for strength testing shall be performed at the concrete mixing plant. Regarding the sampling method and the testing of samples for strength, the stipulations of sub-para 6.13.5 herebelow, 'Site produced concrete for major projects", shall apply.

6.12.1.2.5. Air content and slump tests shall be conducted at the points of concrete unloading by truck mixers, and in accordance with sub-paras 6.8.6 and 6.8.9.

6.12.2. Surface Wear Resistant Concrete

Any concrete exposed to mechanical strain from friction and impact (i.e. expanded vehicular traffic, skidding of objects, solid carrying water flow) without special protective linings or special surface treatment, must respond to the following requirements:

6.12.2.1 The grading curve of the aggregate mix must lie within the lower half of sub-zone D.

6.12.2.2 As long as no viscosity or super-viscosity agents are added, the mixture slump must not exceed 50mm.

6.12.2.3 The concrete characteristic strength shall be not less than 30 MPa (300 kg/cm2) and the cement content not less than 350 kg/m3.

6.12.2.4 The mix design must be such as to ensure minimum sweating. Curing must begin immediately after placement and last not less than 14 days.

6.12.3. Concrete of Reduced Permeability

6.12.3.1. The cement content must not be less than 350 kg/m^3 for concrete of maximum grain size 030 (or #31.5', or 1) and not less than 400 kg/m^3 for concrete of maximum grain size (I)15 (or #16', or $^1/2$").

6.12.3.2. The grading curve of the aggregate mix must lie within sub-zone D and as close as possible to the mean line of this sub-zone.

6.12.3.3. The ratio WIC must not exceed the value 0.58 for cement content of 350 kg/m3 and the value 0.50 for cement content of 400 kg/m3 (with lineal interpolation for intermediate values of cement content).

6.12.3.4. Consolidation must be performed with great care, while curing must begin immediately after placement and last not less than 14 days.

6.12.4. Chemical Action Resistance Concrete

6.12.4.1. Concrete exposed to chemical action owing to aggressive water or soil is bound to meet with the requirements of Table 6.12.4. At the same time, the grading curve of its aggregate mix must lie within sub-zone 0 and as close as possible to the mean line of this sub-zone. Consolidation must be conducted with great care and curing must last not less than 14 days.

6.12.4.2. The requirements of Table 6.12.4 are applicable under mild climatic conditions, for natural water contaminated by chemical substances and standing or running slowly, same as for moist or frequently wet soils.

They are not applicable in the case of sea water (see sub-para 6.12.6), of liquid industrial waste, of solid industrial waste deposits and, generally, of soils having sulphate content greater than 100mg of sulphur ions (S^2-) per kg of air dried soil material. In the above cases, as well as in the case that concrete comes into contact with warm sea water (i.e. desalination plants), special designs shall be required.

6.12.4.3. The requirements of each column of Table 6.12.4 shall apply even in the case of one only of the chemical factors indicated lying within the area described in the same column.

If two or more values of chemical factors of one column lie simultaneously within the upper quarter (regarding pH, the lower quarter) of the aggression limits mentioned in Table 6.12.4, then the aggression degree shall be considered to be the next (worse) of the Table, in which case the respective requirements shall have to be met.

6.12.4.4. The minimum cement quantities indicated in Table 6.12.4 apply in the case of aggregates having maximum grain size c50mm, and shall increase by 30 kg/m3 for aggregates of maximum grain size 015mm,

6.12.4.5. The number of chemical tests required to ensure satisfactory accuracy in the definition of the degree of aggression shall be determined based on the soil or water homogeneity.

TABLE 6.12.4: DEGREE OF AGGRESSION AND REQUIREMENTS REGARDING CONCRETE SUBJECT TO CHEMICAL ACTION

Chemical factors and requirements	Degree of Aggression						
	low				medium	heavy	very heavy
CHEMICAL SUBSTANCES, EXCEPT SULPHATES							
pH (for water only)	**6.5 - 5.5**				**5.5-4.4**	**4.5 - 4.0**	**< 4,0**
CO, mg/l (1) " " "	**15 - 30**				**30 - 60**	**60 - 100**	**> 100**
NH4 mg/1 " " "	**15 - 30**				**30 - 60**	**60 - 100**	**>100**
Mg^2 mg/l " " "	**100 -300**				**300-1500**	**1500-3000**	**>3000**
Degree of acidity (2) (for soils only)	> 20(3)				-	-	-
Requirements							
Class of cement	I or II				I or II	1 or II	I or II
Maximum ratio WIC	0,60				0,55	0,50	0,50
Minimum cement content kern^3	300				330	370	370 and surface protection
SULPHATES							
In the water: $S04^{2-}$ mg/l	**(4) 200**		400	600	3000	**6000**	
In the soil : $S04^{2-}$/mg/kg(5)	1000 2000	4000		6000	12000	-	
Requirements							
Class of cement	**1** or II	I or II	I or II	or IV	IV	IV	IV
Maximum ratio WX Minimum	0,65	0,60	0,55	0,60	0,55	0,50	0,50
cement content kg/m^3	300	300	330	300	330	370	370 and surface protection

(1) Determined by the marble method of Heyer
(2) Determined by the method Baumann-Gully
(3) No aggression exists for an acidity degree below 20
(4) No special measures are required for water containing less than 200 mg/I of $S04^{2-}$.
(5) Determined by the method of DIN 4030 (overall content of sulphates soluble in HCI).

6.12.5. Underwater Concrete

Concrete placed under the surface of non-aggressive water must respond to the following requirements:

6.12.5.1. For more than lm-deep water, concrete shall not be allowed to fall free into the water; instead, one of the following methods shall be adopted :

a) Concrete shall be lowered to placement position within bottom dump buckets that shall open only when the bucket reaches already placed concrete,

b) Concrete shall flow continuously in vertical tremies of sufficient diameter. The lower part of the tremie shall be kept submerged in concrete, while flowing concrete shall supplant that already placed by moving the free surface sidewards and upwards.

c) A pump shall be used with an opening outlet cap allowing concrete to flow only when under pressure.

d) For non-demanding projects, plastic concrete shall be deposited in partly filled cloth bags that shall be lowered onto each other, same like in cement blockwork. Bags are bound to each other by the grout seeping through the cloth weaving.

Combinations of the above placement methods may be applied, depending on the case.

6.12.5.2. When concrete is placed under aggressive water, the requirements of sub-para 6.12.4 must also be observed.

6.12.5.3. Slump must be 15-20cm, cement content must be not less than 350 kg/m3 and the W/C ratio must not exceed 0.60. Cement class I or II may be used.

6.12.5.4. Concrete shall not be vibrated or shifted from the position it has taken after flowing out of the bucket or of the tremie.

6.12.5.5. The mixture-grading curve must lie within sub-zone D and, to the extent possible, near the mean line of this sub-zone.

6.12.5.6. Concrete must have a maximum grain size of 030 (or #31.5. ,or 1"), with the exception of placement in bags, in which case the maximum grain size has no bearing.

6.12.6. Concrete under Sea Water

6.12.6.1. The following shall apply with a view to protecting the reinforcement of reinforced concrete works under sea water, or in contact with sea water, or sprinkled by sea water:

a. Concrete shall meet with the requirements of sub-para 6.12.3: 'Concrete of reduced permeability" having W/C ratio equal to 0.48 and cement content not less than 400kg/m^3.

b. Minimum cover of steel bars shall be 60mm.

6.12.6.2. Should concrete placement take place under sea water, the stipulations of sub-para 6.12.5 hereof, "Underwater concrete", shall also apply.

6.12.7. Concreting under Low Ambient Temperatures

6.12.7.1. In certain class IV regions of the country, as classified in the Standards, the addition of an air entraining agent is compulsory to superstructure concrete not intended to receive a plastering protection, as well as to superstructure or infrastructure concrete being placed in the months between December and February.

6.12.7.2. Concreting must be suspended under temperatures below 0°C. Whenever this is unfeasible, or that the concrete, at the expiry of thermal protection, is anticipated to be exposed to frost conditions, an air entraining agent shall be used.

6.12.7.3. Concreting is absolutely banned under ambient temperatures below -15°C.

6.12.7.4. The quantity of an air entraining admixture must ensure to the mix the air content indicated in the Table 6.12.7.4 :

TABLE 6.12.7.4: Air content in fresh concrete

Concrete of maximum grain size (mm)	Air content %
Φ 15, or #16'', or 1/2"	**4.5**
Φ 30, or #31.5'', or 1''	**3.5**
Φ 50, or #63'', or 1 1/2"	**3.0**

Air content figures of Table 6.12.7.4 must be increased by 1% whenever road pavements are concerned meant to be treated with anti-frost salts.

6.12.7.5. In the course of the winter, while ambient temperatures remain below +5°C, the concrete being placed must have a temperature of not less than 13°C for a maximum grain size of 015** (thin section concrete), not less than 10°C for a maximum grain size of 030" (regular section concrete), and not less than 7°C for a maximum grain size of 050" (broad section concrete). Under appropriate thermal protection, these temperatures must be maintained for the periods indicated in Standards.

6.12.7.6. The durations of thermal protection ensure only concrete durability, not its strength. In the case of prestressed concrete, the development of strength both for the formwork removal and for the application of pretensioning shall be monitored through test specimens maintained in the works just as the works themselves are maintained (project specimens).
When no pretensioning is scheduled, the order of strength required for formwork removal shall be found using project specimens as above, or shall be taken from the Standards.

6.12.7.7. The indications "ordinary cement' and "quick hardening cement" shall be replaced by "cement class I" and "cement class II" respectively.

6.12.7.8. The durations of thermal protection refer to air entraining concrete. For concrete carrying no air entraining agent, these durations shall be doubled.

6.12.7.9. Non-plastered concrete in class IV areas, same as non-plastered concrete exposed to frost temperatures in other regions of the country (bridges, pavements, silos, etc.), must respond to the requirements of sub-para 6.12.3. The minimum cover of reinforcing bars in these cases shall be 50mm.

6.12.7.10. The temperature of concrete that is heated before placement shall not be allowed to exceed 32°C.

6.12.7.11. All costs pertaining to equipment, organization, relevant designs, admixtures, etc., to be required for protecting the concrete against low temperatures, shall be converted and included for in the Contractor's bid prices, unless otherwise specified in the tender conditions.

6.12.8. <u>Concreting under High Ambient Temperatures</u>

6.12.8.1. The temperature of concrete being placed shall not be allowed to *exceed* 32°C under any ambient temperature.

6.12.8.2. Curing shall commence immediately after placement. The method described under sub-para 6.10.3 is extremely effective, as it keeps the concrete surface under shadow and, at the same time, it preserves capillary fissures saturated with water.

6.12.8.3. The Standards contains general instructions for placing concrete under high ambient temperatures.

6.12.8.4. Sub-para 6.12.7.11 hereabove applies also here.

6.12.9. Pumped Concrete

6.12.9.1. With reference to pumped concrete of a characteristic strength less than or equal to 40 MPa (4 0 0 kg/cm2), non-carrying special waterproofing or durability requirements (see paras 6.12.2, 612.3, 6.12.4, 6.12.5 and 6.12.6), the grading of the aggregate mix may be partly or wholly within sub-zone E.

6.12.9.2. The requirement of sub-pars 6.4.3.2.18 does not apply in the case of pumped concrete.

6.12.9.3. In case of the equipment damage or stoppage causing interruption of the pump flow for a period enough to deteriorate the slump value (below specifications) of the concrete in the pump, then such concrete must be rejected.

6.12.9.4. It is not allowed to add water, cement grout or a super-viscous admixture in the pump bucket with a view to improving the concrete viscosity.

6.12.9.5. If the last section/s of the pump outfall pipe is/are perpendicular with a downwards concrete flow direction and an overall pipe length (including any possible final flexible section) exceeding 3m, the concrete discharge point must not be more than 0.50m above the placement surface.

6.12.9.6. The susceptibility of concrete to pumping must be checked at the Contractor's responsibility and expense using trial mixes or special pumping tests. It is emphasized that the Contractor is sole responsible for the production of pumpable concrete, taking into account the nature of the works, the location of the element being concreted, the works execution schedule, the Contractor's mechanical equipment, etc., irrespectively of the fact that the other terms of tender may explicitly specify the preparation of pumpable concrete.

6.12.9.7. It is indicatively mentioned that the use of natural (rounded) aggregates facilitates pumping.

6.12.9.8. Given that the grading of aggregates is a determinant factor to concrete pumpability, all aggregate types must be meticulously checked upon arrival to the works site by conducting more frequent sieving tests (i.e. one sampling for every tenth truck load) in order to ensure conformity of the actual aggregate grading to the one of the mix design.

6.12.9.9. Pumped concrete is usually workable with a slump value greater than 10-12cm

6.12.10. Concrete of increased strength in surface wear

Concrete (without special coating or special surface treatment) being subject to mechanical impact from water in storm sewers having free flow (carrying brought or suspended material) with increased velocities (V < 10 m/sec) shall conform to the following requirements:

(1) The characteristic strength of concrete shall be at least equal to 35 MPa (350 kg/cm2)

(2) The water to cement (WIC) ratio to be used shall not exceed 0.50

(3) Concrete surfaces shall have the least possible bug holes

(4) A wet curing shall be made starting immediately after pouring and lasting at least 7 days.

(5) The aggregate mix gradation curve shall be in the lower half of subzone A

(6) The use of high strength cement (e.g. class 45 or 55) is recommended, in order to use the least possible cement quantity to ensure the required characteristic strength.

(7) The aggregates to be used (coarse or fine) shall have a maximum loss of 25% when tested by the Los Angeles abrasion machine, according to the ASTM C 535 and ASTM C 131 tests.

6.12.11. Concrete of high strength in surface wear

Concrete (without special surface treatment) being subject to mechanical impact from water in storm sewers having free flow (carrying brought or suspended material) at difficult locations (areas of "hydraulic jump", retarding basins) and/or with high velocities (V c 12 m/sec), shall comply to the following requirements :

(1) The characteristic strength of concrete shall be at least equal to 45 MPa (150 kg/cm2)

(2) The Water to Cement (W/C) ratio to be used shall not exceed 0.15.

(3) Concrete surfaces shall be arranged in order to have the least possible bug holes.

(4) A wet curing shall be made starting immediately after pouring and lasting at least 14 days

(5) Special hard aggregates (coarse and fine) shall be used having the following mechanical characteristics :

a. Loss when tested for Los Angeles abrasion (according to ASTM C 535 and ASTM C 131 tests) **LA ≤ 24%**

b. Aggregate Abrasion Value (AAV) (according to BS 812) **AAV ≤ 8**

(6) The above subparagr. (5) and (6) of para 6.12.10 apply as well.

6.13. SAMPLING AND COMPLIANCE TESTS

The stipulations of the subsequent paragraphs regarding sampling and tests apply to concrete of certain characteristic strength. If concrete of two **or more** varying characteristic strengths is placed within the same project, then separate sampling procedures and tests shall be conducted for each category of characteristic strength.

6.13.1. Strength Requirement

Concrete testing shall be conducted with specimens obtained from the mixer's discharge point in the case of site-produced concrete, or, for factory-produced concrete, from the truck discharge. The compression strengths achieved by such samples must satisfy the compliance criteria of sub-para 6.13.6 herebelow.

6.13.2. Form and Dimensions of Specimens (Test Samples)*

6.13.2.1. The contractual specimens intended to compliance tests, as well as the project samples (see sub-para **6.10.4** hereabove) shall be 20cm or 15cm cubes, or cylinders with dia 15cm and height 30cm.

6.13.2.2. Specimens to be used for compliance tests of a project shall be of identical form and dimensions as those used in the mix design. In the case of factory produced ready-mix concrete whose mix design has been performed at the factory, the specimen shape and dimensions shall be specified.

It is not permitted for the same project to take different specimens and subsequently compare their strength following multiplication by conversion coefficients.

6.13.2.3. It is considered that, for other needs, such as early age strength control, not being related to compliance tests, 15cm test cubes at the age of 28 days or more yield strengths that are by 5% higher than the corresponding strengths of 20cm test cubes. It is also considered that the ratio between 20cm test cubes over test cylinders having dia of 15cm and height of 30cm is given by the coefficients of Table 6.13.2.3.

TABLE 6.13.2.3: Coefficients of conversion of concrete strength obtained by 15x30cm cylinder specimens into that of 20cm cube specimens*

Concrete strength of 15 x 30 cm cylinder specimen, in MPa (kg/cm^2)	Multiplication coefficients for converting a cylinder strength into 20cm cube strength
= < 9.2 (92)	1.30
12.8 (128)	1.25

18.4 (184)	1.22
25.4 (254)	1.18
39.5 (395) >=	1.14

*Intermediate values by lineal interpolation.

6.13.2.4. In addition to contractual specimens required for compliance tests, the Service may take more samples for testing strength at younger ages, for monitoring the concrete hardening process, or for other species. tests (see also sub-paras 6.16.5 and 6.16.6 hereof).

The strengths obtained by such tests cannot lead to rejection of the concrete, unless this is explicitly specified in the other terms of tender.

6.13.2.5. No specimens carrying apparent deficiencies due to poor consolidation or to injuries may be accepted to be included in the compliance testing procedure.

6.13.2.6. With the purpose of dealing with the case of sub-para 6.13.2.5 hereabove, it is recommended that one surplus specimen be taken at each sampling operation. If after removal of the specimen moulds it is found that none of them carries any deficiency (in the sense of sub-para 6.13.2.5), then the excessive specimen shall not be taken into account in the compliance tests, however it could be used for testing strength at younger ages.

6.13.3. Factory-Produced Concrete

6.13.3.1. Concrete placed in one day shall constitute one portion and shall be represented by a sampling of six (6) specimens.

6.13.3.2. If more than eleven (11) truckloads of concrete are to be placed, then the Service, but also the Contractor, shall be entitled to increase the number of specimens of a single sampling from six (6) to twelve (12). The cost of testing the additional six (6) specimens shall be borne by the Contractor.

6.13.3.3. If the quantity of concrete to be placed in a single day exceeds 150 cubic meters, the sampling of this portion shall comprise twelve (12) specimens that shall not be taken from consecutive truckloads, to the extent possible.

6.13.3.4. If concreting operations are scheduled to last two consecutive days, then the concrete of this two-day period shall constitute one portion and shall be represented by a sampling of twelve (12) conventional specimens, out of which six (6) shall be taken in the first day.

6.13.3.5. If concreting operations are scheduled to last more than two consecutive days, then the portion of each two-day period shall be represented by a sampling of twelve (12) conventional specimens, unless the number of concreting days is odd, in which case the portion of the last day shall be represented by a sampling of six (6) conventional specimens.

6.13.3.6. If the concreting operations of a two-day period are suspended prior to having taken twelve (12) specimens, then the portion of concrete already placed shall be represented by the first six (6). Any number of specimens taken in excess of the first six shall not be included in the compliance tests.

6.13.3.7. Any concrete quantities placed in two non-consecutive days shall constitute two separate portions and shall be represented by two separate samplings.

6.13.3.8. If the work requires concreting for a period longer than one day without interruption (i.e. as in the case of sliding forms), the concrete shall be divided into imaginary portions depending on construction phasing (i.e. day- or night-placement).

6.13.3.9. No more than one (1) specimen shall be taken from each truckload of concrete for compliance tests. If the concreting operation is to be accomplished with less than six (6) truckloads, then more specimens than one may be taken from the same truck, provided that each one of them is taken after unloading about one (1) cubic meter of concrete subsequently to the previous specimen. The specimens, the truckload of the sampling and the work section concreted by same truckload shall be noted down.

6.13.3.10. 28-day strengths of each sampling of six (6) specimens must respond to compliance Criterion A (sub-pars 6.13.6.2), while 28-day strengths of each sampling of twelve (12) specimens must respond to compliance Criterion B (sub-par. 6.13.6.3).

6.13.3.11. It is not allowed to divide a 12-specimen sampling into two groups of six (6) specimens each, and to test their strengths in accordance with Criterion A.

6.13.3.12. If the 2nd or the 4th Rule of acceptance is not complied to by a single specimen of one sampling, then the strength of the concrete of the sampled truckload is disputed and the procedure of sub-para 6.13.7.1 is applied.

In any other case of non-compliance to one or both Rules of acceptance, the whole concrete portion of that sampling is disputed and resumption of testing is applied according to sub-para 6.13.7.2 herebelow.

6.13.3.13. In the case of factory-produced ready-mix concrete, an authorized representative of the factory may be present during sampling.

6.13.4. <u>Site-Produced Concrete for Minor Works</u>

In the case of a minor work, when preliminary in-situ strength tests are not possible to conduct, the following shall apply:

6.13.4.1. Concrete placed in one day shall constitute a portion and shall be represented by a sampling of six (6) specimens, unless the overall volume of concrete scheduled for placement exceeds 150 cubic meters, in which case the sampling shall comprise twelve (12) specimens.

The Service or the Contractor are entitled to increase the number of specimens from six (6) to twelve (12). In both cases, the cost of the six (6) additional specimens shall be borne by the Contractor.

6.13.4.2. For compliance tests, each specimen shall be taken from a different mix. The specimen, together with the work section concreted by same mix, shall be noted down. No proper or poor mixtures shall be selected. Sampling shall be from random mixtures to be decided by the Service prior to mixing accomplishment.

6.13.4.3. The stipulations of sub-para 6.13.2.4 hereabove apply to specimens not used in compliance testing.

6.13.4.4. The stipulations of sub-paras 6.13.3.10 and 6.13.3.11 apply to compliance tests.

6.13.4.5. If the 2nd or the 4th Rule of acceptance is not complied to by a single specimen from one sampling, then the strength of the mix sampled is disputed and the procedure of sub-para 6.13.7.1 is adopted. In any other case of non-compliance to one or even two acceptance Rules, the whole concrete portion of that sampling is disputed and the resumption of testing follows, as per sub-para 6.13.7.2.

6.13.5. Site-Produced Concrete for Major Projects

The following paragraphs apply to the case of the Contractor being obliged by the terms of tender to install a central concrete production plant and to conduct preliminary tests as per sub-para 6.13.5.1.

6.13.5.1. Not less than a month prior to commencement of the construction works, sufficient quantities of aggregates must be stockpiled at the works site. Between 15 and 60 trial mixes shall be prepared from these aggregates, preferably on different days, according to the material ratios established by the mix design. The precise number of mixtures must conform to one of the "numbers of specimens" given in Table 6.5.2.2.1.

Each mix of concrete may be smaller than the one prepared during construction works, but not less than half the latter quantity. Two twin specimens for testing compressive strength shall be made of each of these mixes (the remaining quantities being used for placement in auxiliary works). If additional tests are specified (tensile, bursting, etc.), then a new pair of specimens shall be prepared for each such test. Thus, two groups of 15 to 60 specimens each shall be gathered for compressive tests and shall be preserved just like conventional specimens. One group shall be tested at the age of 7 days, and the other at the age of 28 days.

The following calculations shall be based on the strengths resulting from such tests:

a. The ratio of the strengths of 7/28 days;

b. The standard deviations of 28-day specimens and the standard deviation
s_π resulting from the multiplication of s' by the coefficient given in Table 6.52.2.1 for the corresponding number of specimens;

c. Possibly other statistical data (i.e. the standard deviation of the 7-day strength).

If such s_π is greater than the standard deviation s on the basis of which the required strength of the mix design was calculated (sub-para 6.5.2.2), then the required strength shall be corrected by application of *the* relation (1) for $s = s_\pi$. If s_π is less than 3 MPa (30 kg/cm^2), the value of s = 3 MPa (30 kg/sq.m) shall be inserted in relation (1). At the same time, and from the curve of water/cement (W/C) ratio and strength resulting from the mix design, the material ratios shall be adjusted so that the mean value f_m may result equal to the new required one. The construction works shall commence on the basis of this corrected value of f_m (or of the old one, in case that the abovernentioned standard deviation of trial mixes is equal to or less than that of the mix design).

6.13.5.2. Concrete placed in one day shall constitute one portion and shall be represented by one sampling. For works placed without interruption, the stipulations of sub-para 6.13.3.8 shall apply.

6.13.5.3. Samplings of the first three days of concreting operations shall consist of twelve (12) specimens each, while samplings of subsequent days shall consist of three (3) specimens. In the case of ready-mixed concrete, the samplings shall be taken at the concrete production plant. Specimens shall have consecutive numbering_

6.13.5.4. Each specimen shall be taken from a different mixture, according to the process of sub-para 6.13.4.2.

6.13.5.5. The terms of tender must provide for an adequate number of specimens to be tested at early ages so that it may be possible to foresee the 28-day strength with satisfactory approximation.

6.13.5.6. The strengths of 12-specimen samplings as per sub-para 6.13.5.3 hereabove must satisfy compliance Criterion C, while the strengths of 3-specimen samplings of the same sub-para must satisfy at least one of Rules 7 and 8 of compliance Criterion D. If a single specimen of a 12-specimen sampling does not satisfy acceptance Rule 6, then the strength of the respective mix is disputed and the procedure of sub-para 6.13.7.1 is adopted. In any other case of non-satisfaction of both Rules of Criterion C (12-specimen samplings), or of non-satisfaction of at least one of Rules 7 and 8 of Criterion ❑ (3-specimen samplings), the respective concrete portion is disputed and the procedure of sub-para 6.13.7.2 is applied.

6.13.5.7. After gathering 60 strength test results of continuous sampling specimens responding to the corresponding compliance Criteria, the mean value of strength X60 and the standard deviation s60 of these tests shall be calculated.

If s60 deviates from the standard deviation s already being used ***by*** more than 0.5 MPa (5 kg/cm^2), then a new required strength shall be calculated for the value of s60 by application of relation (1).

If s60 is found to be less than 3 MPa (30 kg/cm^2), the value of 3 MPa shall be introduced into relation (1). The variation of the required strength shall entail amended mix ratios, same as in sub-para 6.13.5.1, so that the strength f_m results equal, at least, to the required one.

Should X60 be found to be greater than the required strength f_a, the Contractor may request, at his own responsibility, to calculate a new required strength by application of the relation

$$fa = f_{ck} + 1.64\, s_{60} \qquad (3)$$

with the limitation mentioned hereabove regarding the value of s_{60}.

6.13.5.8. If two consecutive samplings fail to satisfy the compliance Criteria (such discrepancies may be provided for of specimens described under sub-para 6.13.3.5), then the mix ratios shall be adjusted in a manner enabling the mean strength fm to become equal to fa resulting from relation (1). If already equal, it shall be increased by 0.41 s, where s is the standard deviation for which the previous discrepancies occurred. fm shall resume lower values after completion of 60 specimens in accordance with sub-para 6.13.5.7.

As mentioned in para 6.13.5.5, failure to meet the compliance Criteria is possible to be provided for young aged specimens. In this case the Contractor may request the adjustment of the mix proportions, immediately after testing these samples.

6.13.5.9. Each time the mix ratios are changed (sub-paras 6.13.5.7 and 6.13.5.8), samplings shall follow the procedure of sub-para 6.13.5.3, with specimens being numbered again from the beginning.

6.13.5.10. Appropriate diagrams shall be kept at the works site showing the serial number of each specimen, the date it was taken, its strength, as well as the average value of each sampling, in a manner allowing to monitor the variation of the concrete quality.

6.13.5.11. Aggregates shall be stockpiled in large stacks (of size and expanse as permitted by the working site area available). After being tested at the stockpiles, they shall be transferred onto the star of the central mixing plant.

<u>It is not allowed to transport aggregates directly from the quarry to the star in the course of concreting operations. with the exception of special cases of limited availability of stockpile area, or following approval by the Service.</u>

6.13.5.12. The stipulations of sub-para 6.12.1 (Ready-Mixed Concrete) shall apply for aggregate weighing installations and for concrete mixing plants.

6.13.5.13. In the case of continuous production, weighing equipment and the general good operation of the complex shall be inspected once every week. When production is not continuous, such inspections shall be at longer intervals, according to the judgment of the Service.

6.13.5.14. The Service shall exert full control at all stages of the construction works (collection of materials, inspection of material quality tickets, laboratory testing of materials, supervision of mixing plant operation, of sampling, of transportation, of placement and curing of the concrete, of possible resumed tests of construction, etc.). This follow-up does not release the Contractor from his responsibility regarding the quality of the materials and of the concrete.

6.13.6. <u>Compliance Criteria</u>

6.13.6.1 <u>General</u>

The criteria mentioned in sub-pars 6.13.6.2 up to 6.13.6.5 inclusive herebelow shall be applied as compliance criteria for each concerned case.

6.13.6.2 <u>Criterion A (for Minor Works)</u>

$X_6 >= f_{ck} + 1.40\ s$ — 1st Rule of acceptance

$X_i >= f_{ck} - 2.5$ MPa — 2nd Rule of acceptance

where :

X_6 = the mean strength of the 6-specimen sampling,

X_i = the strength of each specimen of the sampling,

s = the standard deviation in the sampling as it results from the relation :

$$s = \sqrt{\frac{\sum_{i=1}^{i=6} (X_i - \overline{X}_6)^2}{5}}$$

6.13.6.3 Criterion B (for Minor Works)

X_{12} >= f ck + 1.43 s	3rd Rule of acceptance
X_ι >= f ck - 4 MPa	4th Rule of acceptance

$$s = \sqrt{\frac{\sum_{i=1}^{i=12} (X_i - \overline{X}_{12})^2}{11}}$$

where :

X12 = the mean strength of the 12-specimen sampling,
X i = the strength of each specimen of the sampling,
s = the standard deviation in the sampling as it results from the relation

6.13.6.4 Criterion C (for Major Projects)

X_{12} >= f ck + 1.43.s	5th Rule of acceptance
Xi >= f ck – 4MPa	6th Rule of acceptance

Where:

X12 = the mean strength of the 12-specimen sampling,
X i = the strength of each specimen of the sampling,
s = the standard deviation in the sampling resulting by application of the relation:

$$s = \sqrt{\frac{\sum_{i=1}^{i=12} (X_i - \overline{X}_{12})^2}{11}}$$

6.13.6.5 *Criterion D (for Major Projects)*

$X_{36} >= f_{ck} + 1.50.s$	7th Rule of acceptance
$X_i >= f_{ck} + 1.60.s$	8th Rule of acceptance

where:

X3 = the mean strength of the 3-specimen sampling,

X36 = the mean strength of the 3 specimens of this sampling and of all 33 immediately preceding specimens.

S= the standard deviation of the last group of 60 specimens, or (if the first group of 60 has not yet been completed) the standard deviation of the specimens collected supplemented by the necessary number of same from the last trial mixes until forming a whole of 60.

If the specimens of the trial mixes are less than 24, then the standard deviation shall be calculated on the basis of the 36 specimens collected and of those of all trial mixes, even though the total number of specimens is less than 60.

6.13.7. Resumption of Tests in Hardened Concrete

6.13.7.1. In case a mix or a truck load is disputed the "sentence A" of par 6.13.7.7 is imposed and the section of the works concreted from the portion whose mix or truckload placed is disputed shall be subject to intensive curing for 14 up to 28 days. Such curing shall be by flooding horizontal elements (see sub-para 6.10.9a), and by application of the method of sub-pars 6.10.3 for vertical elements. After the lapse of 14-28 days, three cores with dia up to 10 ± 5 cm and height up to 12.5cm shall be cut off at random locations of the mixture placed or of the truckload disputed. No cores shall be cut off near edges or joints (working or expansion), or from locations of irregular concrete tissue (vacuum bubbles, mix segregation, concentration of fines, etc.)

The cutting and preparation of the cores shall be in accordance with the Standards; however the core height prior to spreading of the levelling grout must not be less than 9.5cm. The conversion of the core strength into strength of conventional specimen shall be conducted according to sub-para 6.13.7.8.

The mean value of the converted strengths of the three cores shall substitute for the strength of the specimen causing the resumed tests as per this sub-para. Should such substitution satisfy the two Rules of acceptance of the respective compliance Criterion, then the strength of the disputed mixture or truckload is deemed to be satisfactory as well. If not, then the whole concrete portion is questioned and the procedure of sub-para 6.13.7.2 herebelow shall be adopted.

6.13.7.2. If the strength of a concrete portion is disputed, the penalty 'A* is imposed entailing adoption of the following resumed testing procedure :

Intensive curing of the disputed portion is performed in accordance with the provisions of sub-para 6.13.7.1 hereabove, unless this is already done so. Twelve (12) cores are then cut off random locations of the said concrete portion (with the assumptions mentioned under sub-para 6.13.7.1). Following conversion of the strengths into conventional specimen strengths according to the provisions of sub-para 6.13.7.8, the applicability of Relation (4) herebelow is examined :

$$\frac{X_{12} - X_{min}}{s} > 2,28 \qquad (4)$$

where: X_{min} **is** the lowest of alt twelve strengths obtained, X12 is the mean strength and s is the standard deviation as resulting from relation (5) herebelow :

$$s = \sqrt{\frac{\sum_{i=1}^{i=12} (X_i - \overline{X}_{12})^2}{11}}$$

If Relation (4) applies, then the mean strength X11 of all core strengths above the value of X min shall be deemed to be the average strength of all cores of this sampling. In case of Relation (4) not applying, then the mean sampling strength X12 of all cores shall be deemed to be the actual average strength.

The mean values X_{11} or X_{12} must respond to the 3rd Rule of acceptance (sub-para 6.13.6.3), where the standard deviation s shall result from relation (5) (for a mean value equal to X_{12}) or from relation (6) for a mean value of

$$s = \sqrt{\frac{\sum_{i=1}^{i=11} (X_i - \overline{X}_{11})^2}{10}}$$

Should the 3rd Rule of acceptance not be satisfied by the mean value X_{11} or X_{12}, then the corresponding concrete portion is considered not to meet with the requirements of this specification, in which case the procedure specified under sub-para 6.13.7.3 shall apply.

6.13.7.3. If, through the testing of sub-para 6.13.7.2 it results that a concrete portion does not respond to the requirements of this specification, penalty **"B"** of para 6.13.7.7 shall be imposed and the portion shall be intensively cured, unless such curing has already been performed. Following this, the strength of this concrete portion shall be estimated through a supplementary number of cores combined with indirect testing methods, and the component or bearing element shall be calculated on the basis of more accurate methods and possibly by the reduction of loads, should the project operation permits so.
A trial loading of components shall be realized whenever possible.

6.13.7.4. If through the tests of sub-para 6.13.7.3 it is proved that the component or bearing element does not carry the required bearing capacity (or if appropriate tests prove that the component or element does not carry the required durability to time or to environmental impacts), then penalty "C" of para 6.13.7.7 shall be imposed and the element is reinforced to the extent required by the safety of the project (provided that esthetic considerations, functionalism and other factors of the works permit it according to the Service's judgment), while all necessary action shall be brought about towards the esthetic restoration of the works.

6.13.7.5. Whenever it is not possible to bring about the reinforcement provided under sub-para 6.13.7.4 hereabove (either due to the peculiar character of the component, or because such reinforcement does not ensure the safety of the works, or because the Service may consider it inappropriate for esthetic, functional or any other reasons to carry out such reinforcement), then penalty "D" of pare 6.13.7.7 is imposed and the respective component or part of the work shall be removed and reconstructed.

6.13.7.6. Competent authorities for performing the abovementioned tests shall be the authorized laboratories of the Ministry Infrastructure. The kind and extent of the tests shall be determined with the collaboration of an engineer specialized in concrete technology, while the strength of the disputed portion shall result from a statistical treatment of the test results.

6.13.7.7. Penalties "A", "B", "C" and "D" are established in the project terms of the tender. Unless otherwise provided for in the project terms of the tender, the penalties "A", "B", "C" and "D" are as follows :

Penalty "A" : All costs of tests specified under sub-paras 6.13.7.1 and 6.13.7.2, and compensations for any delays caused to the progress of the project shall be borne by the Contractor.

Penalty "B" : All costs for the conduct of tests and for the elaboration of designs as per sub-para 6.13.7.3, and compensations for any delays to caused the progress of the project shall be borne by the Contractor.

Penalty "C" :	Refund by the Contractor to the Service of the price of the concrete portion judged unsuitable, if paid for, and payment of the design and execution costs for any reinforcements, in addition to the costs and compensations related to Penalty **"B"**, as well as compensation for any delays caused to the progress of the project.
Penalty "D"	In addition to the costs and compensations provided for under Penalty "B' hereabove, payment of all costs related to the demolition of unsuitable concrete and to the reconstruction of the bearing element or of the necessary part of the works, including compensation for any delays caused to the progress of the project.

6.13.7.8. Cores shall be tested after remaining for a two-day period in a chamber environment. Their strengths shall be converted into 15 or 20cm cube test strengths by application of the coefficients given in Standards, with the distinction that coefficient Kip shall be equal to 0.97 for the cores having a nominal dia of 10cm as provided in this specification, and that curing coefficient Kc shall be equal to 0.94, corresponding to very good curing. If concrete testing is being done by cylinder rather than cube specimens, the conversion factor A3 shall be taken equal to 1. If, for any reason whatsoever, sampling takes place after completing two (2) months from concrete placement, the core strength shall be divided by 1.10, while if sampling takes place after completion of three (3) or more months from concrete placement, the core strength shall be divided by 1.15.

6.13.7.9. If the tests specified under sub-para 6.13.7.2 yield negative results, the Service is absolutely entitled to reject the construction reinforcement and to demand the demolition of the defective portion together with any other affected part of the works and their replacement with sound concrete if this is technically possible.

6.13.7.10. The methodology and test Criteria with the cores of para 6.13.7 concern solely the rechecking of recent concrete whose the contractual specimens did not comply to the corresponding compliance criteria and not the acceptance rejection of recent concrete, on which no compliance tests through contractual specimens have been done. Also they do not concern acceptance or rejection of old concrete of unknown elements as well as the evaluation of its strength.

6.13.7.11. Following the retesting completion, the holes resulting from the cores shall be filled in by the Contractor by suitable concrete (resinous or not) having a reduced shrinkage coefficient and increased cohesion capability to the old concrete.

6.14. CONSTRUCTION DETAILS

6.14.1. Spacing of Reinforcing Rods

6.14.1.1. In sections provided with more than one rows of reinforcing rods, the rods of each row shall be positioned exactly above or exactly behind the rods of the previous or of the subsequent row, and not in the middle of their respective spaces.

6.14.1.2. The free space between consecutive rows of reinforcing rods shall be not less than 2/3 $d_{\alpha\delta}$ while the free space between rods of the same row shall be not less than $d_{\alpha\delta}$ + 5mm, where d_ab is the maximum grain size of the aggregate used. Table 6.14.1.2 herebelow specifies the rod spacing for various cases of maximum grain size.

TABLE 6.14.1.2: Spacing of rod rows and of rods on the same row

'Concrete having maximum grain size	Minimum space (mm) between	
	Rows	Rods on the same row
cD **15, or # 15' ,**	**10**	**20**
X 30, or # 31.5*, or r	20	35
cl) 50, or # 63*, or 1'.4"	35	55

6.14.1.3. The same free spaces are observed also in the case of a bundle of two rods or of tendons. For bundles of more than two rods, the free spaces shall be equal to dab 4 15mm.

6.14.2. Cover of Reinforcing Rods

6.14.2.1. The concrete cover of the reinforcing rods must have a thickness of not less than

— 30mm, for rods with a dia greater than 28mm;
— 25mm, for rods with a dia greater than 22mm;
— 20mm, for rods with a dia greater than 18mm;
— 15mm, for rods with a dia up to and including 18mm.

Same thicknesses apply in the case of tendons (with or without ducts). For dies above 40mm, the cover shall be 40mm-thick.

6.14.2.2. The cover specified under sub-para 6.14.2.1 above applies also in the case of bundles of rods, where the bundle dia shall be considered to be the rod diameter multiplied by $\sqrt{n}$, i.e. ($\Phi \sqrt{n}$), if n is the number of rods in a bundle.

6.14.2.3. In the case of stirrups (or tie-bars), cover shall be considered to be the concrete thickness required to cover such stirrups.

6.14.2.4. The thicknesses referred to under sub-para 6.14.2.1 hereabove apply in the cases of :

a. Concrete of interior spaces, or plaster protected exterior concrete;
b. Concrete permanently submerged in non-aggressive water.

6.14.2.5. For non-plastered concrete freely communicating with the open air (i.e. open sheds, free ground-floor columns-pilotis), the thicknesses of sub-para 6.14.2.1 are increased by 5mm.

6.14.2.6. For non-plastered concrete of :

a. Interior spaces with concentrated steaming (laundries, baths, kitchens, etc.);

b. Intensely moist open spaces;

c. Within normal soil; and

d. Within aggressive environment of low or medium aggression (sub-para 6.12.4),

the thicknesses referred to under sub-para 6.14 2.1 are increased by 10mm each.

6.14.2.7. For concrete in heavily or very heavily aggressive environment (sub-para 6.12.4), the thicknesses of sub-para 6.14.2.1 shall be increased by 20mm.

6.14.2.8. When the concrete characteristic strength is equal to or greater than 30 MPa, the cover values resulting from the above paragraphs can be reduced by 5mm each, without however affecting the minimum thicknesses mentioned in sub-para 6.14.2.1.

6.14.2.9. Same reduction by 5mm, again without affecting the minimum limits set in sub-par. 6.14.2.1, can be brought to slabs or shells, as well as to factory prefabricated components of a concrete characteristic strength greater than 35 MPa.

6.14.2.10. The stipulations of sub-para 6.12.6 shall also apply in the case of sea-side works.

6.14.2.11. In concrete having maximum grain size greater than Φ30 or #31.5* or 1" the thicknesses of para 6.14.2.1 shall be increased by 5 mm.

6.14.3. Working Joints

6.14.3.1.

a. Shortly after concrete placement, working joints shall be brushed by wire brush to remove grout and free aggregate grains.
b. The same effect may be obtained by sandblasting or other treatment suitable for removing the top layer of cement grout and disclosing coarse aggregates to a mean depth of 5mm, in this process, concrete surfaces other than those of the joint must be protected against any damage.

6.14.3.2. Before renewed concrete placement, joints shall be cleared of any foreign matter and washed with pressure water. During concreting, joints must be saturated without however any water being retained in their surface cavities. No grout coat shall be allowed on the joint surface.

6.14.3.3. In case of vertical joints, concreting shall commence at the joints. With regard to horizontal joints of concrete walls, a thin layer shall first be spread along the overall joint, that shalt be carefully vibrated.

6.14.3.4. Working joints shall be almost perpendicular to the spreading direction.

6.14.3.5. In works having watertightness requirements the development of working joints shall be avoided. However in cases where such joints exist, these shall be coated with epoxy resin before placing the new concrete. Maintenance at the joint locations shall be done with special care.

6.14.3.6. Working joints shall be formed where concrete placement is interrupted for practical reasons. The number of such joints must be limited to the minimum possible, as tensile and shear resistance at them is low and, therefore, the concrete bearing strength in their area proves to be substantially reduced. In addition, concrete at such locations risks to be pervious owing to inadequate construction techniques, in which case the reinforcement corrosion protection is weakened. To the extent possible, working joints must be near sections of reduced stresses, or where other factors require the provision of a joint. In case of partly submerged works, no horizontal joint should be formed at the level of the water fluctuation.

6.14.3.7. Work stoppages and formulation of construction joints shall be as shown in the drawings, unless otherwise instructed by the Service.

6.14.3.8. Stipulations similar to the ones of this sub-paragraph (6.14.3) shall apply in the case of unwanted working joints, for example due to weather conditions.

6.14.3.9. Where, in the opinion of the Service, the connecting surface between the two concreting operations is of primary importance to the structural operation of the work, the new layer shall be bound onto the old one by application of an epoxy resin (binder), in accordance with the instructions of the Service and after approval by him of the relevant binding material.

The cost of the additional resulting binding operation shall be borne by the Contractor.

6.14.3.10. The approval of the Service must be obtained prior to the formation of any working joint that is not provided for in the approved detailed drawings.

6.14.3.11. <u>Horizontal construction joints</u> shall be as shown in the approved drawings.

The concrete used in the top 0.50m, whose upper surface shall be construction joint to the subsequent course, must carry a slump not exceeding the nominal slump value fixed by the mix design, excluding its supplement (for tolerances).

The top layer of the concrete must be consolidated using vibrators introduced vertically at close points and withdrawn gradually after remaining at each point for exactly as long as necessary to achieve proper consolidation of the concrete: no excess of grout must appear on the concrete surface, but again no coarse grades of the aggregate mix must remain visible to disturb the evenness of the surface. Concrete surfaces close to the formwork inner side must be lightly tamped with an appropriate tool in a manner allowing for the formation of an edge, after form removal, responding to the line and level wanted. Hardened concrete surface shall present numerous irregularities not less than 5mm- and not more than 30mm-wide.

After fastening the new formwork tight into position, the new concrete must be spread onto well prepared horizontal construction joint surface, without dropping the material from a height greater than 0.50m.

Subsequently, the concrete must be consolidated with vibrators introduced at close points, avoiding to touch the hardened concrete underneath.

6.14.3.12. <u>Vertical construction joints</u> must be at positions shown on the approved drawings, including any shear keys required, as per same drawings.

6.14.3.13. If, for any reason whatsoever, it is not possible to spread a whole uninterrupted horizontal course, it shall be finished at a vertical bulkhead so that, upon resumption of the work, all upper concrete surfaces may be horizontal.

6.14.3.14. In the case of a temporary stoppage of concrete spreading operations, the material placed, if sufficiently hardened to maintain its form, must be cleared (using wire brush etc.) to a depth allowing the appearance of firm concrete (see sub-para 6.14.3.1).

6.14.3.15. In the case of an unforeseen interruption of concreting operations in-between two predetermined construction joints, the exposed face must be covered with a grout layer to form a clear horizontal line on the concrete surface. Upon resumption of concrete placement, the grout layer must be cleared away (with wire brushing, sand blasting, etc.).

6.14.3.16. In construction joints of inclined surfaces the formation of feather edges must be avoided. Suitable block out forms must be used in such cases to ensure a minimum thickness of new concrete not less than 0.15m.

6.14.4. Concrete Embedded Fixtures

6.14.4.1. Pipes or other fixtures causing no harm to concrete through chemical or physical process may be embedded into it, with the exception of the cases mentioned in the subsequent paragraphs.

6.14.4.2. No aluminium pipes or fixtures shall be allowed in contact with concrete, unless coated or covered with appropriate materials preventing aluminium/concrete reactions or any steel/aluminium electrolytic reaction.

6.14.4.3. No drains or other fluid discharge pipes shall be allowed to be embedded in concrete columns.

6.15. CONCRETE SURFACE FINISHING WORKS

6.15.1. General

6.15.1.1. Concrete surface finishing works are distinguished into:

a. Concrete surface finishings required after form removal.

b. Plastic concrete surface finishings, regarding form-free surfaces on which any required processing is executed while concrete is still "plastic".

6.15.1.2. The design engineer of a structure is responsible both for its satisfactory performance in the life course it was designed for as well as for its appearance.

6.15.1.3. *Types of Finishing Works regarding Formed Concrete Surfaces*

Five types of finishing works are generally envisaged for concrete surfaces resulting after removal of formworks :

Finishing work type "A"

Finishing work type "B"

Finishing work type "C"

Finishing work type "D"

Finishing work type "E".

The characteristic features of such finishing works are described in detail under sub-paras 6.15.2 to 6.15.6 inclusive of the present specification, combined with the formwork characteristics and with the working methods anticipated for achieving the required properties of the concrete.

Should concrete be foreseen to remain unplastered, various requirements shall arise regarding selection of the finishing type combined with the location of the surface and with other factors referred to herebelow. More types of unplastered concrete surface finishing works may be envisaged, to be separately specified for each case.

6.15.1.4. *Selection of Finishing Work for Formed Concrete Surface*

To a large extent, the selection of finishing is subjective, however the following must be taken into account in the course of such selection:

- The cost of the finishing work;
- The ease for achieving a high quality finishing;
- The variation of appearance owing to the effect of weather, age or use;
  The convenience of maintenance.

The types of surface finishings are fixed in the other terms of tender, or, if not applicable, they are given by the Service in the course of the construction works.

6.15.1.5. *Quality of Surface Finishing*

Finishing works should ideally present no unwanted color variation or physical discontinuity. However, such degree of perfection can never be achieved. Surface defects due to poor spreading may turn up on final faces, therefore spreading and consolidation are determinant towards obtaining a high quality of finished concrete surfaces. Concrete production must be such as to limit the chances of subsequent stains appearing on the surface. Attention leading to this result is required at various stages of the concrete production, in addition to attention required for ensuring the desired strength and durability.

6.15.1.6. *Formworks*

The absorption capacity of formwork surfaces affects the depth and evenness of concrete coloring. Depending on the desired quality of concrete finishing, formwork surfaces must cause no stains or chemical reaction to concrete. Prior to concrete placement, they shall receive a fine even coat of appropriate material to facilitate detachment and removal. Form joints shall be watertight.

6.15.1.7. *Concrete Mix*

The mix shall be adequately coherent to minimize water movement with relation to solid ingredients. Aggregate colors and grading, as well as mix ratios may have a direct dependence on the appearance desired.

6.15.1.8. *Transportation, Placement and Consolidation*

The methods of transportation, spreading and consolidation shall be such as to minimize segregation of the mix and to ensure effective consolidation. To the extent possible, concrete consolidation must be continuous during spreading, using adequately effective internal vibration in a manner eliminating air bubble formation by new layers of concrete.

6.15.1.9. *Curing and Protection*

Concrete shall be cured in a firm and even manner and shall be protected against mechanical damage (i.e. impact), or against soiling (i.e. protruding rods).

6.15.1.10. *Organization*

Only conscientious and skillful workers under sufficient surveillance may achieve high quality surfaces. Therefore, the Contractor must secure availability of suitably qualified staff and supervise them with particular attention in order to make sure of rendering the required high quality surfaces of unplastered concrete, where specified.

6.15.1.11. *Surface Finishing Types for Plastic Concrete*

Two types of finishings for form-free concrete surfaces are envisaged :

Plastic concrete finishing type 'ΠA"

Plastic concrete finishing type "ΠB"

6.15.1.12. Construction details shown in the approved drawings shall be adopted for concrete surfaces lying in the ground or to be backfilled. in certain cases, and following the Contractor's request, the Service may approve or the design may provide for the possibility of eliminating formworks altogether and of placing concrete into direct contact with the ground.

6.15.2. Requirements for Formed Concrete Surface Finishings

6.15.2.1. *Place of Application and Type of Finishing*

(1) The type of finishing to be required for formed concrete surfaces depends on the character of the structural element (column, beam, floor slab, wall, staircase), its position in the work and the provision for it to receive additional finishing treatment or not (with mortar, tiles, painting, etc.).

(2) In any case, the type of surface finishing shall be clearly specified.

(3) Unless otherwise specified in the tender conditions, the unit price for concrete building in compliance hereto shall include for the converted cost of preparing formed concrete surface finishings considering formworks of type "A".

6.15.2.2. *Color Control*

When even coloring of the concrete surface is required, each material used must be firmly obtained from the same source (aggregates, cement, any additives, water). The Contractor bears full responsibility for ensuring supplies of all quantities required for the work execution from the same source. Aggregates must be durable with relation to time and free of any polluting agents liable to cause soiling. Mix ratios and grading, particularly that of the fines, must be maintained constant. Substitution of ply-wood for boards and vice-versa must be avoided in large formwork panels. Furthermore, particular attention must be paid to the uniformity of curing methods applied, as these may affect the coloring.

6.15.2.3. *Agents to Ease Formwork Removal*

Agents meant to ease away the removal of formworks must be selected suitable for the purpose they are to serve. No variation of such material shall be allowed when unified visible surfaces are concerned. The easing agent application shall be even, not permitting contact of same with the reinforcing bars or prestressing tendons. If the concrete surface is intended to further finishing (mortar, tiles, painting, etc.), compatibility of the easing agent to such finishing must be ensured.

6.15.2.4. *Curing of Concrete*

The concrete texture, coloring and durability against aging are affected by the curing applied. When appearance constitutes an important criterion, then the method of curing, including the time required for formwork removal, must be selected with particular attention and be approved by the Service. Concrete sections intended to identical surface finishing must be subject to identical curing.

6.15.2.5. *Protection of Finishing Works*

Fine (high quality) finishings are susceptible to injuries after formwork removal and require special protection in areas exposed to such risks. In the case of presence of such risks, in the opinion of the Service, the latter may require the Contractor to take additional protective measures, without this entitling the Contractor to claim any compensation or deadline extension.

6.15.3. Description of Types of Finishing Works for Formed Concrete Surfaces

(1) FINISHING WORK TYPE "A"

This finishing is obtained through the use of correctly shaped forms made of sawn boards with watertight joints. The concrete surface shall reflect the timber grain patterns, including joints. It may also show minor deficiencies (cavities) caused by water or air trapping, but the surface must be free of voids, spongy spots and major deficiencies.

This category comprises finishes of invisible formed surfaces and, therefore, rough spots would not be particularly undesired. In this case, concrete surface requires no treatment after form removal other than patching defective concrete, filling in holes due to form ties and ordinary curing.

(2) FINISHING WORK TYPE "B"

This finishing is obtained through the use of correctly shaped forms made of sawn boards. The surface shall show lightly reflected grain patterns of timber and joints. Metal casings or forms of other suitable material may be used alternatively. Minor deficiencies (cavities) may turn up caused by air or water trappings, but the surface must be free of voids, spongy spots and major deficiencies.

In areas where holes left by form ties are to remain as characteristic features of the concrete surface, the recessed exposed end of the tie section left in the concrete must be subjected to special treatment. In areas where holes of form ties are not to remain as characteristic features of the concrete surface (this condition shall generally apply unless otherwise specified in the tender documents), the cavities left by form ties must be filled in the way described under sub-para 6.15.5 for repairing other holes and defects.

This process is the same as the one described for surface finishing works of type "A", with the exception that grout may, according also to the Service's instructions, contain a portion of white cement so that the final color of the treated section may identify with that of the remaining surface. Same applies to the texture of the treated section. Prior to implementing repair works on the structure itself, trial mixes of mortar and white cement shall be prepared and left to dry so that the color desired may be obtained and approved by the Service. Curing of the concrete shall ensue according to generally acceptable practices.

(3) FINISHING WORK TYPE "C"

This type of finishing assumes the preparation of high class concrete having a characteristic strength of fck>= 15 MPa (150 kg/cm2), as well as the use of properly shaped hard and smooth surface forms. Concrete surfaces must be smooth with precise and clear edges. Only minor surface deficiencies are tolerable, while spots are barred, same as color deteriorations due to the application of agents to ease the removal of forms.

The stipulations mentioned hereabove for finishing work type "B" shall apply in relation to holes left in the concrete by form ties.

(4) FINISHING WORK TYPE "D"

This finishing is obtained after first producing type "B" finishing on carefully consolidated high class concrete having characteristic strength fck > 25MPa (250 kg/sq.cm) and placed in properly shaped forms. Surface improving treatment shall ensue, i.e. diligent washing and filling of surface deficiencies with mortar of cement and fine aggregate.

Every effort shall be made towards obtaining even coloring of the concrete. Attention must also be paid to the selection of the formwork easing out agent and to ensuring a stain-free surface, bearing no signs of color variation.

The stipulations mentioned hereabove in relation to finishing work type "B" shall apply also here with respect to holes left by form-ties.

(5) FINISHING WORK TYPE "E"

This type of finishing is obtained after first producing type "C" finishing work, followed by filling up all surface deficiencies with specially prepared mortar of cement and fines, while concrete is still maintained fresh. Every effort must be made to ensure a unified coloring of the concrete surface. After appropriate curing, the surface shall be rubbed, where necessary, with a view to rendering it smooth and even.

The stipulations mentioned hereabove in relation to finishing work of type "B" shall also apply here with respect to holes left by form-ties.

6.15.4. Identification of the Types of Formed Concrete Surface Finishes Fitting the Various Parts of the Works

6.15.4.1. As aforementioned, the responsibility for selecting the appropriate type of finishing befitting the various parts of the works lies with the design engineer. Such finishing types shall be established in the approved design and/or the tender documents of the project.

6.15.4.2. Unless otherwise specified in the tender conditions, the construction of concrete works includes TYPE "A" surface finishing.

As mentioned before, major deficiencies may cause rejection of constructed concrete. However, minor deficiencies as well as ensuring strength duration shall require corrective operations in the manner prescribed under sub-para 6.15.5 herebelow. Unless otherwise specified, the unit prices in the Contractor's tender shall include converted costs for TYPE "A" surface finishing.

6.15.4.3. Unless otherwise specified in the tender conditions, in the case of roadworks and appurtenant structures, the boundary between TYPE "A" finished surfaces and any surfaces requiring high-class finishes (types "B" to "E" inclusive) shall lie 0.50m below final ground surface to be formed by this contract. Such boundaries shall constitute the delineation of high quality finishing works used for measuring any relevant special payment (unless otherwise specified).

6.15.4.4. For special cases requiring surface finishes of exceptional quality, the extent and character of the works of each kind of finishing shall be specially prescribed, together with the materials for constructing special formworks and/or the characteristics of the finishing work with methods and acceptance criteria described in detail.

Unless otherwise specified in the tender conditions, such types of surfaces are, as a rule, measured and paid for separately. In such cases, an additional criterion for checking compliance of the works shall be set : to check compliance of the surface finishing to the special finishing specifications. In case of non-acceptance of any exposed surfaces, the whole construction may be required to be demolished and reconstructed at the Contractor's expense to make it comply with the contract conditions, or other penalty may be imposed according to the tender conditions.

6.15.5. Correction of Minor Deficiencies in Surface Finishing Works of TYPE 'A"

Any irregular projections jutting out of concrete surfaces shall be eliminated immediately after formwork removal. Holes left after removal of form-ties shall be cleaned, fully soaked with water for a minimum of three (3) hours and carefully filled with cement mortar.

Any standing water must be removed prior to application of the cement mortar.

Such mortar shall contain cement and fine sand passing a 0.65mm mesh mixed at the same ratios as those used for the concrete being finished, as well as sufficient water to provide thick and cohesive coating. The mortar must be subjected to pre-shrinking by ensuring its mixing not less than one (1) hour prior to application, and by remixing it immediately before application with no additional water.

While the mortar applied still remains plastic, it shall be rubbed methodically with hessian and a mixture of cement and fines, same as hereabove described but with no water. This operation shall aim at filling voids flush to adjoining concrete and at ensuring uniform texture and coloring for the whole surface. Concrete curing shall ensue as standard practice.

Defective surfaces of minor extent (those of major extent constitute adequate reason for the structure rejection) shall be restored by demolition of the defective portion and by substitution of new concrete bound to the existing one by means of key arrangements in the form of "dovetails" or "anchors". Concrete used for repair works (patches) shall be more dry than usual and shall be fully thrashed, while attention shall be made to remove any water excess prior to final treatment.

Concrete curing in repair works described as above arid surface treatment shall be performed in accordance with sub-para 6.10 of this specification. Expansion joints must be free of any laitance.

6.15.6. <u>Deficiencies of Surface Finishes after Form Removal</u>

6.15.6.1. No iron fixtures shall be allowed to a depth up to 40mm from final exposed concrete surface, with the exception of items required and purposely made to be fixed on the surface.

6.15.6.2. No effort must be made to correct any deficiencies, or to finish formed concrete surfaces before inspection by the Service. The Service must particularly inspect areas showing spalling effects in order to determine whether these are surface deficiencies or structural defects. In the latter case, these shall be corrected according to processes suggested by the Contractor and approved by the Service.

6.15.6.3. Cut out areas and cavities must be carefully cleaned and treated with edges almost perpendicular to the concrete surface, repair requiring surfaces must be rubbed with cement grout and filled with cement mortar of the same ratios as those of the concrete being restored. Mortar must be properly consolidated to completely fill the cavity and must be finished to a surface texture identical to that of the adjoining surfaces.

6.15.6.4. Any efflorescence grown on the concrete surface shall have to be removed according to the Service's instructions using a 10% solution of muriatic acid, and the resulting surface shall be carefully washed with pressure water immediately after frothing has ceased.

6.15.7. <u>Surface Finishing_ Works on Plastic Concrete</u>

6.15.7.1. *<u>Plastic Concrete Finishing Work of TYPE "1-1A"</u>*

6.15.7.1.1. Non-formed concrete surfaces shall be finished *by* work of type FA. They shall be formed flat like ordinary consolidated concrete surfaces after being thrashed with an appropriate straightedge, and turned into forms and shapes as shown in the drawings. Evenness testing with a 3m straightedge must not reveal irregularities more than 10mm-deep. For consecutive positions of evenness testing, the straightedge must not be transposed by more than half its length each time.

6.15.7.1.2. Unless otherwise specified in the tender documents with respect to surfaces scheduled to be covered (floor formation or earth spreading, etc.), and with the exception of the construction of waterproofing courses, the price of concrete shall include for converted costs of type hA surface finishing of plastic concrete.

6.15.7.2. <u>Plastic Concrete Finishing Work of TYPE "ΠΒ" (smoothing process)</u>

6.15.7.2.1. For all surfaces of bridge and culvert decks scheduled to be laid with a waterproofing membrane, the plastic concrete shall be finished by smoothing process (finishing type ΠΒ).

In addition, all surfaces scheduled to remain exposed to use (i.e. parapets, wall crests, concrete footpaths, etc.) shall be finished by smoothing process (ns). Concrete pavements and parallel gutter surfaces, merging lanes, etc., that shall be used by traffic shall be exempted from this provision, as a separate specification shall aim at creating suitable surface texture to resist skidding (nonslip finish).

6.15.7.2.2. Unless otherwise specified in the tender documents, all bridge and culvert deck surfaces, as mentioned hereabove, shall be scheduled to receive type ne finishing of plastic concrete (smoothing process). The unit price of the respective concrete class shall include for the converted cost of such finishing work.

6.15.7.2.3. Concrete surfaces shall be smoothed to type ΠΒ finishing while concrete is still adequately plastic to be able and be finished true to the desired form, elevation or texture. Treatment may be by screeding or floating using various equipment (bull floating, mechanical floating, hand floating, troweling, power troweling)., with edges and joints wrought with a suitable tool to render a dense surface, free of holes, detached aggregates and air bubbles.

6.15.7.2.4. Such processes shall be applied in a manner allowing for the upper surface of plastic concrete to acquire qualities as follows:

a. <u>For bridge and culvert decks</u> :

No corrugations more than 5mm-deep must be revealed when surface is tested using a 3m-long straightedge.
Surfaces shall be subjected to treatment with a wood float.

b. <u>For safety parapets :</u>

No corrugations more than 5mm-deep must be revealed when surface is tested using a 3m-long straightedge.

Surfaces shall be subjected to treatment with a steel float until free of any trowel marks.

6.15.7.2.5. Screeds must be adequately resistant to be able and maintain the concrete surface true to the specified section and evenness. Prior to final screeding operations, the screed rails and supports must be fixed to precise specified elevations, and, if necessary, tested and accordingly regulated.

6.15.7.2.6. Type ΠΒ finishing of plastic concrete on bridge and culvert decks must be performed according to the following process:

a. Immediately after concrete placement and vibration, the surface must be treated using a suitably designed screed with straight edges, or a vibrating screed, to respond to the desired section and treatment quality.
b. The concrete surface must not be subjected to early or excessive treatment for fear of mortar and fines unduly coming up to the surface.
c. The screed rails shall be fixed on the forms and be regulated true to the slab form and thickness. They shall be parallel and close to the transversal construction joint formed by the previously placed section of the bridge superstructure.
In this way, screeds and floats may be operated from the actual section being placed, and not from the previous one that is already hardened. Screed rails must be fixed at a distance not more than 500mm from any construction joint.
d. Striking off equipment must be operated parallel to the superstructure axis, with simultaneous forward and sideward movements blocking ends from rising above end forms or rails in the process. A slight excess of concrete must be continuously maintained along the whole face of construction.
Upon the equipment reaching the end of its course, such excess must be removed and not be incorporated into formed concrete.
e. Immediately upon completing concrete formation and consolidation works according to the abovementioned provisions, the surface must be made uniform by means of floating. Wherever possible during this operation, "footbridges- must be used with a view to minimizing pedestrian circulation on plastic concrete.
Floating must be by staggered movement parallel to the superstructure axis, with gradual transposition from one end of the section being placed to the other. Particular attention is drawn to maintaining true crown and section of the deck. Any excess of water or other foreign matters created as a result of the preceding operations must be removed and not be incorporated into the concrete.
f. Hand tools should be used with a view to obtaining uniformity of consolidation, evenness and smoothness of the concrete surface between screed rails and the previous section of superstructure. Furthermore, all irregularities liable to appear in the concrete and on its surface must be restored during removal of the rails.
g. Soon after completion of floating operations and removal of the water excess and while concrete is still plastic, the accuracy of the surface formation must be tested both transversally and parallel to the bridge axis using a 3m-long straightedge. The straightedge must move along its direction not more than 50% of its overall length each time.
h. Screed testing and further floating must continue until the whole slab surface shows no visible imperfections and the slab is true to treatment level and elevation. Maximum permissible deviation from the straight edge is fixed at 5mm for the overall 3m-long edge. Any cavities detected must be immediately filled with recently mixed concrete, consolidated, treated true to form and subjected to new finishing. Any bumps must be removed and their area must be subjected to new finishing.
i. The final finish required on the bridge deck surface (to be followed by a waterproofing course and then by a layer of asphaltic concrete) is equivalent to a wood float finish to elimination of corrugations and depressions more than 3mm-deep.
j. In the case of slab decks or box culverts envisaging equal type n8 finishing for the top surface of the culvert deck, the above process refers to floating along the culvert axis.

k. The final finish required for the surface of safety parapets corresponds to a steel float finish to elimination of corrugations, depressions or readily visible float marks.

6.15.7.2.7. With respect to type ΠΒ concrete finishes, the Contractor may propose other processes than those hereabove described. Such Contractor's proposals may be accepted if, in the opinion of the Service, they aim at the same targets as those specified hereabove and if their result is at least as good as the one that would be yielded by the processes described hereabove.

6.15.7.2.8. Adding water to the concrete surface with the purpose of promoting finishing is barred, unless deemed imperative by the Service due to detrimental drying conditions. In such a case, additional water should be provided using appropriate sprinkling equipment.

6.16. QUALITY CONTROL

6.16.1. General

6.16.1.1. All concreting operations are subject to the Service's control, a work that the Contractor is bound to try and facilitate. The Service's jurisdiction covers all construction stages, preparation, production method, qualities of component materials, etc.

6.16.1.2. Quality control aims at proving the competence of the work for the purpose it is intended to serve.

6.16.1.3. All systematic testing of the materials, construction methods and finished products shall be conducted by the Contractor who bears full responsibility for the quality, appearance, safety and durability to age of the works under construction. All costs for tests as above are borne by the Contractor.

6.16.1.4. Any testing conducted by the Service shall not release the Contractor in any way and for any reason whatsoever of his responsibility for the good performance of the works.

6.16.1.5. The Service has jurisdiction over all issues regarding specific parts of the work, as these may result from and be referred to hereunder, or over other issues not explicitly mentioned but necessary to the full, competent, safe, esthetic, etc., execution of the works.

6.16.1.6. The Service is entitled to interrupt any concreting operation if the Contractor fails to comply with the terms hereof or of other specifications governing all project construction according to the tender conditions, as well as with specific instructions and guidelines issued by the Service.

6.16.1.7. The Service is entitled to order the demolition of any part of concrete works constructed in deviation of this specification and of the tender conditions or proved, following specified inspections or tests, to deviate from design requirements and from the Contractor's contractual obligations, either due to poor workmanship, or to utilization of defective materials, or due to damages caused by insufficient care or guidance, etc. Such demolition shall be executed even if the Service were aware of the defective performance or if same were due to the Service's negligence in providing supervision to the work.

6.16.1.8. Any cost or damage resulting from such demolition shall be borne by the Contractor, unless the defective work were performed in accordance with a written instruction issued by the Service in amendment to the Contractor's contractual obligations.

6.16.1.9. The quality control referred to hereunder concerns the "external quality control" performed by the Service independently of the "internal quality control' performed by the Contractor on his own account and aiming at ensuring acceptance of the materials, workmanship and constructions by the Service.

6.16.1.10. In certain cases, it is possible for the Service to rely on the results of the Contractor's internal quality control (to the extent and for the period desired) to substitute for the external quality control. Such may be the case, for example, of the Contractor having installed a suitably equipped concrete testing laboratory on the site of the works (with the required equipment, qualified and auxiliary staff, etc.) and of the Service considering, in his absolute judgment, that the tests and measurements are conducted in accordance with the regulations and in an unimpeachable way.

6.16.1.11. Once again it is emphasized that the Contractor is sole responsible for the quality of the concrete (namely, its strength, its performance with aging, its durability against weather conditions and chemical action, and, generally, for all requirements referred to under the other terms of tender).

6.16.2. Actions of Quality Control

6.16.2.1. The quality control extends to comprise the following regular controls of materials, construction methods and finished products :

a. Controls by measurement :

- testing of materials in view of their acceptance;
- checking dimensions of formworks, reinforcement, prefabricated components, etc.

b. Visual inspections :

- reconnaissance of the materials;
- inspection of compliance certificates;
- checking the compatibility of measurements to the methodology adopted;
- checking the competence of equipment and staff;
- inspecting formworks, reinforcement, spreading of concrete, etc.

6.16.2.2. Controls by measuring instruments as well as visual inspections are referred to under individual sections of this specification. Further to such references, the stipulations mentioned herebelow as actions of quality control shall also need to be observed.

6.16.3. Acceptance of Factory-Produced Concrete

a. Prior to placement of factory-produced concrete, the factory producing it must present to the Contractor a consignment ticket for each concrete consignment indicating :

- the name of the factory;
- the characteristic number of the consignment form;
- the date and registration number of the truck;
- the name of the Contractor;
- the project and the site of the works;
- the quantity of concrete in cubic meters;
- the time of shipment and the shipper's signature;
- the characteristic strength (in accordance hereof);
- the concrete slump (or other workability measurement data, if otherwise provided for under the tender documents);
- the type and strength category of cement used;
- the water/cement ratio (coefficient WJC) for use in reinforced and prestressed concrete.

b. In addition to the above, the following information must be supplied, also according to the present specification:

- the minimum cement content;
- the maximum aggregate size;
- any admixtures used.

c. Furthermore, space must be provided on the ticket for adding the following, upon arrival of the concrete to the works site :

- time of arrival of the ready-mixed concrete to the works site;
- time of completion of the concrete placement.

6.16.4. Acceptance of Prefabricated Components

The consignment ticket must certify that fabrication, marking and handling of the prefabricated components is in accordance with the requirements of the order. The following information must be provided:

- dates of fabrication and consignment;
- characterization markings for each component of the order.

6.16.5. Curing Method Control (with test samples)

In all cases instructed by the Service, as well as in cases of specific mention in the tender documents, "work test samples" shall be taken in accordance with sub-paras 6.10.4, 6.10.5 and 6.10.6 with a view to testing the efficiency of the curing method.

The cost of such samples shall be borne by the Contractor. These samples shall be taken as twins of those required for the 7- or 28-day tests.

6.16.6. Hardening Progress Control (with test samples)

a. For all cases of prestressed concrete construction (same as in the cases of weather conditions deemed unfavorable in the opinion of the Service), "work test samples" shall be taken (in accordance with sub-para 6.10.4 hereof) with the purpose of determining the strength of concrete at ages corresponding to particularly important construction phases.

b. Particularly important phases in the course of the construction works are the following :

- removal of formworks;
- partial pre-tensioning;
- final pre-tensioning;
- charging of loads.

c. Such tests are also useful when adverse effects may be envisaged in the course of the construction works due to low ambient temperatures.

d. If particularly important construction phases are envisaged during concrete treatment, and if the concrete strength needs to be tested at ages corresponding to such construction phases, the following hardening test samples shall be taken and tested. For each concrete portion and for adequately spaced and particularly important phases of the construction works.

Test samples in equal numbers and as twins to conventional samples, in accordance with sub-pares 6.13.3 and 6.13.5 hereof, unless their number is otherwise specified in the terms of tender of the project.

e. In the case that only one particularly important construction phase is envisaged for each portion of concrete, it is recommended to take not less than two groups of "work test samples" in equal numbers and as twins to the conventional samples of sub-paras 6.13.3 and 6.13.5.

The first set of samples shall be tested at the age the concrete is anticipated to yield the required strength. In case the first strength test does not yield the required results, the second set of samples shall be tested at a subsequent moment.

f. For calculating the strength of a concrete portion at a certain age, the average strength of hardening test samples shall be taken in each case. However, the fact should be taken into account that, as regards structural members with dimensions substantially differing from those of the samples, it is possible to find a hardening degree in deviation of the respective samples, due for example to differing heat development in the mass of concrete.

6.16.7. Concrete Strength Tests for Early Contractor's Payments

Should the Contractor seek payment for concreting works before the lapse of the 28-day period, or if this is provided in the tender conditions, samples shall also be taken for 7-day testing (normally cured as per DIN 1048), equal in number and from the same mixes as conventional samples intended to the usual 28-day tests.

6.16.8. Works Log-Book

6.16.8.1. A works log-book shall be kept on the field (falling within the Contractor's obligations not entailing payment). With reference to sizable projects, the following information must be recorded in such log-book:

- measurements of ambient temperatures;
- dates of concreting and of formwork removal;

- acceptance of materials and ingredients;
- test and measurement results;
- the concrete mix being used (cement class and aggregates);
- positioning inspections and verifications for reinforcing rods and tendons;
- concrete temperatures (when concreting under very cold weather);
- important instructions received on the field;
- description of occurrences (incidents).

6.16.8.2. In case of less sizable projects, it is possible to reduce the amount of information being recorded in such log-book, upon the Contractor's request and the Service's approval.

6.17. MEASUREMENT

6.17.1. Measurement for each category of concreting operations shall *be* based on the actual volume of concrete in cubic meters of completed work (unless otherwise fixed in the specifications and other tender conditions relevant to the specific works the concrete is being used for), as resulting from the dimensions of the various segments according to contractual drawings, tender conditions, Standard Technical Specifications for the specific works each category of concrete is being used for, etc.

6.17.2. The volume of concrete placed without using formworks shall be measured on the basis of dimensions shown on the drawings, without accounting for any excess of concrete poured due to the lack of forms.

6.17.3. The volume of any voids created by pipes or boxes surrounded by concrete according to the design and aiming at reducing the concrete volume shall be deducted from the volume of concrete.

6.17.4. The volume of chamfered or rounded corners shall not be deducted from the volume of concrete, same as the volume of metal fixtures embedded in the concrete. Similarly, the volume occupied by pipes embedded in the mass of piers or retaining walls for drainage or protection of same shall not be deducted from the volume of concrete.

6.18. PAYMENTS

6.18.1. The amount of payment shall be determined on the basis of the cubic meters resulting from quantity surveying as described hereabove, and multiplied by the unit price corresponding to each kind of concreting work and included in the price list of the Contractor's bid.

6.18.2. The unit prices given in the price list of the Contractor's bid and the respective payments for each category of concreting work shall comprise

a. The supply of all kinds of materials required and their haulage to any distance (including handling, waiting time of transport vehicles and loss of time, for whatever number of repetitions until concrete placement), and the incorporation of same materials (aggregates of any grade and of any maximum grain-size, water, cement of any type or strength category and to any required quantity, any required viscosity or super-viscosity compounds or stabilizing agents and, for the case of ready-mix concrete, any required admixtures for preserving the concrete workability, as well as any additive to the mass of concrete), the cost of execution of all construction works (formworks, scaffoldings, converted costs of sliding superstructure bogies, sliding or climbing forms for piers, bogies and other devices for cantilever construction, prefabrication, transportation and erection of prefab components onto the works, required supplementary field works for constructing the works according to the designs, concrete mixing and transportation to the works, placement, consolidation, curing), the elaboration of concrete mix designs and the preparation of trial mixes prior to the commencement of samplings and tests in accordance with the provisions of this specification, surface finishing work of TYPE NA" as per sub-para 6.15.3.(1) for formed surfaces, and repair of imperfections according to sub-para 6.15.5 hereof.

For non-formed surfaces, the unit prices and respective payments shall include for the cost of finishing plastic concrete of TYPE nA, with the exception of top surfaces of bridge and culvert decks (slabs or boxes), safety barriers, wall crests, etc. (according to sub-para 6.15.7), for which they shall include the cost of finishing plastic concrete TYPE nB (with floating).

b. All costs for constructing new accesses to serve the project, or for improving any existing access (both for concrete works and for other construction works) to be used in the transportation and mechanical erection of prefabricated components or for building same directly on their final position, in moving the required construction plant in and out of the works, the converted cost of aggregate producing plants, concrete mixing plants, weatherproof systems for sheltering materials, heating systems and/or other methods for concreting with hot or cold water and under frost (together with the converted cost for the elaboration of designs related to the concrete protection when concreting with hot or cold water or under frost conditions).

c. Any damages caused by any reason or to any segment of the works or of machinery, etc., owing to causes not covered by the provisions regarding force majeure, and other costs required by the technical designs of the works with the view of formulating the work segments true to the detailed dimensions shown on the drawings.

d. The converted cost (materials and labour) of cylindrical or otherwise shaped items, of diameter conforming to the designs, of suitable material not harmful to concrete, as approved by the Service, suitably strong and generally made to withstand moisture generated deformities and all structural and dynamic loads up to full setting of the concrete, together with any required diaphragm reinforcement, the installation of such items according to the designs, and their total loss as they shall be considered to remain permanently embedded in the concrete.

e. The converted cost (materials and labour) for the formation of rectangular or otherwise shaped items according to the design for constructing load bearing elements with box-shaped voids of suitable material, quality and strength, not harmful to concrete and capable of withstanding structural and dynamic loads until full setting of the concrete, with respective diaphragm reinforcements, with provision of partial or total loss of the materials forming the box-shaped voids according to the design and the character of the segment being concreted, depending on the possibility of recovering the materials used in forming the box-shaped voids, according to the design and the other tender conditions.

f. The converted cost (materials and labour) for the installation of non-reinforced drainage pipes in piers and retaining walls, as directed in the design of each work.

g. The converted cost (materials and labour) of expanded polysterene to be used in the formation of joints.

h. The costs that may be required during the construction of the works as a result of ratio variations in relation to the specifications hereof or to the ratios of the mix design.

6.18.3. The abovementioned prices and payments shall include for all mechanical means, tools, materials, instruments, all kinds of inspections and tests, and for all professional and labour staff to be required for completion of the work, together with any other expense required for the complete and good performance of the works, although not explicitly described.

6.18.4. It is specifically pointed out that, in the case of non-compliance to concrete conformity criteria or to other criteria established in the tender conditions, the resulting tests, samplings, inspections, designs, trial loadings, etc., shall be borne by the Contractor irrespectively of whether the constructed work shall be finally accepted or not, in which case the Contractor may need to reconstruct the work in compliance with the contract, while the Service may in parallel and according to his absolute judgment require imposition of contractual penalties or the Contractor's forfeiture due to any resulting delay (see also sub-para 6.13.7).

6.18.5.

a. Normally, payments for concrete works are effected only after conducting 28-day compressive strength tests, and after ensuring compliance to the concrete conformity criterion. Should additional concrete conformity criteria be established, the respective tests must precede related payments that shall be effected only after ensuring compliance to such additional criteria.

b. If conformity criteria are not met, related payments shall remain pending until issuance of decisions regarding acceptance of the works.

c. It is possible to effect payment for concreting works before the lapse of 28 days, if requested by the Contractor and provided that samples are taken for testing the quality of concrete at an earlier age. Such samples shall be normally cured same as the 28-day samples. They shall be taken in equal numbers and shall be made of the same mixtures as conventional samples for 28-day testing, and shalt be tested for compressive strength not before the lapse of 7 days from concrete placement. For enabling the use of 7-day test samples, the mix design must have previously established a relation for strength development based on tests not less than at 7 and at 28 days.

The results of 7(or more)-day compressive tests shall be compared to the results of this relation of strength development set by the mix design, in order first to establish whether the conformity criterion of compressive strength is met and subsequently to decide on effecting early payments. However, and in any way, the compressive strength conformity criterion shall remain ever the means of testing normally cured 28-day conventional samples for compressive strength.

d. For minor quantities of concrete and for works of secondary importance, it is possible to effect payments prior to the lapse of 28 days and without the realization of compressive tests, in the absolute judgment of the Service.

6.18.6. The above prices and payments do not include (unless otherwise specified) for the cost of finishing high quality formed concrete surfaces (types B, C, 0, E and other special types of forms) that shall be measured separately and paid for under special prices of the price list included in the bid.

6.19. TRANSITIONAL PROVISIONS FOR TESTING METHODS AND SPECIAL SPECIFICATIONS

6.19.1. As referred to under sub-para 6.1.3 hereabove, the present specification was based on the REGULATION FOR CONCRETE TECHNOLOGY, as approved by the Resolution …….. of the Ministry of Infrastructure. Such Regulation was compiled by a group of experts and was published …….

6.19.2. Already, the Draft of that Regulation mentioned the fact that the specifications were scheduled for publication by the Directorate of Technical Materials (EK3). The present specification has repeatedly referred to the respective specifications ASTM, DIN, on which the specifications …. are based.

Upon completion of the processing and publication of the specifications ……they shall be considered ipso jure to be in force instead of the respective specifications ASTM, etc., that are mentioned in the text.

6.19.3. Table 6.19.3 shows the correspondence of testing methods and of special specifications applicable during the transitional period of switching over from the specifications ASTM and DIN to the unified specifications ……

TABLE 6.19.3 CORRESPONDENCE OF TESTING METHODS AND SPECIAL SPECIFICATIONS (STANDARDS)

No of Standard	Corresponding other Standard	Subject
	ASTM C 127	Definition of specific gravity and of absorption capacity of coarse aggregates
	ASTM C 128	Definition of apparent specific gravity of fine aggregates
		Preparation and curing of concrete specimens
		Testing of standard concrete specimens for compressive strength
	ASTM C 117	Definition of fines smaller than 75mm in aggregates (by wet sieving)
	ASTM C 142	Definition of clay lumps and of brittle grains in aggregates
	ASTM C 233 and C 260	Special specification for air-entraining compounds in the concrete
	ASTM C 494	Special specification for chemical admixtures to concrete
		Slump cone test
		VEBE test
	ASTM C 231	Testing air content in fresh concrete with the pressure method
	ASTM C 280	Definition of possible inter-action between aggregates and the cement alkalis (method of mortar rod)
	ASTM C 403	Definition of setting time for concrete mixes through penetration resistance
	ASTM C 156 and C 309	Special specification for liquid compounds forming concrete curing membrane
	ASTM C 40	Organic admixtures to fine aggregates for concrete

TABLE 6.19.3 (Cont.)

N° of Standard	Corresponding other Standard	Subject
	ASTM C 642	Definition of specific gravity, moisture absorption and voids in hardened concrete
	ASTM C 627	Definition of inter-action between aggregates and cement alkalis (chemical method)
	DIN 1048	Flattening test
	ASTM C 136	Grading analysis of aggregates
	ASTM C 88	Resistance of aggregates to weathering (soundness), using 1
	ASTM C 29	Definition of apparent gravity and of voids in aggregates
	ASTM C 232	Concrete sweating test
	ASTM C 123	Definition of low specific gravity grain content in aggregates
		Quality control of water used in concrete
	ASTM C 309 and **C 156**	Testing concrete curing compounds
	ASTM C 295	Rock examination of aggregates
	ASTM C 469	Static modulus of elasticity of concrete
	ASTM C 215	Dynamic modulus of elasticity of concrete
	ASTM C 152	Concrete creep
	ASTM C 157	Drying contraction
	DIN 1048	Concrete permeability
	ASTM C 457	Microscopic definition of air voids
	ASTM C 496	Test of bursting strength on concrete specimens
	ASTM C 597	Measurement of transmission speed for supersonic vibrations through concrete
	ASTM C 805	Impact measurement on concrete
	ASTM C 131	Abrasion and impact resistance (Los Angeles)
	ASTM ❑2419	Sand equivalent
	DIN 4030	Overall content of sulphates, soluble in HCI
	ASTM C 87	Effect of organic admixtures on the strength of fine sand mortars

Clause 7: FORMWORKS

7.1. GENERAL

7.1.1. Description of the Works

7.1.1.1. The works described herein comprise all formworks and scaffoldings required for each concreting operation of the bearing structure.

7.1.1.2. The term "formwork" is used in this specification to imply all kinds of forms (moulds) and the necessary scaffoldings, without respect to their material of fabrication. Whenever it is necessary to distinguish metal or plastic formworks, the terms "metal casing" or "plastic form" shall be used.

7.1.1.3. There are three main reasons for the use of scaffoldings and formworks : they give shape to concrete, they provide means for ensuring the required formation and appearance of surfaces, they support the bearing member until its coming of age to bear its own loads.

7.1.1.4. Without limitation, the works comprise the furnishing of materials, the structural calculations and the detail drawings, all necessary fittings, form and anchor sockets, cement mortar fillings, fixtures for fastening various embedded items, and inspection of formworks.

7.1.1.5. Scaffoldings and formworks shall be made of metal, wood or other matter as approved by the Service. Furthermore, the shape, dimensions, quality and strength of the various segments of scaffoldings and formworks shall need to be approved by the Service. Such approval does not release the Contractor of his full and absolute responsibility (under both criminal and civil code) for the good and safe construction of scaffoldings and formworks in compliance with the tender conditions.

7.1.1.6. Whenever it is specified that the expenditure for a work includes for the cost of scaffoldings and forms, or whenever a special price is provided for scaffoldings and forms, the price of the Contractor's bid shall be deemed to include for all costs required for the design and construction of scaffoldings and forms, in accordance with the stipulations hereof, in a manner enabling them to withstand any action during construction and ensuring compliance with the drawings (irrespectively of any wear of material that would be necessary).

7.1.1.7. In connection with the most important parts of the works, the Contractor shall be bound to submit (if not included in the design) a special design for scaffoldings and forms, formworks of bogies for cantilever construction, sliding bogies for in-situ placement (without requiring scaffoldings), etc.

7.1.2. Relevant Works

Clause 6 of these T.C.C. (CONCRETING) either makes reference to this specification, or is mentioned herein under various paragraphs as a relevant specification.

7.2. DESIGNS OF SCAFFOLDINGS AND FORMS

7.2.1 General

7.2.1.1. A formwork comprises bearing elements and planking and is supported by a scaffolding (or stands directly on the ground).

7.2.1.2. Scaffoldings and formworks shall be erected in a manner ensuring with safety their resistance to loads that may be imposed during construction operations. Such loads and actions are mainly due to the circulation of workers, the fastening of reinforcements, the placement and consolidation of concrete (with particular emphasis to the horizontal component of the pressure exercised by fresh concrete), the weight of any structures intended to rest on them, the transfer of loads during pretensioning, the wind, the variations of temperature, the settlements. The selection of scaffolding and form is of great importance. Most errors and accidents are generated by the inadequacy of scaffoldings and formworks.

7.2.1.3. The strength and stability of the scaffoldings must be justified on the basis of calculation methods appropriate to the materials the former are made of. It is indicatively mentioned that clause 3.3 of DIN 1045/1972, together with DIN 4420 shall govern the design and erection of scaffoldings. Other relevant regulations may also apply, following approval by the Service.

7.2.1.4. Deformations of scaffoldings and forms must lie within accepted construction tolerances and not cause unfavoulable effects to the works performance. Any required superelevation shall result from the design, unless otherwise specified.

7.2.1.5. In the case of simple constructions, the erection of scaffoldings and forms may be executed by application of recognized and acceptable experimental rules, but always under the guidance of experienced personnel.

Such experimental rules mainly refer to the realization of

- correct fixing on appropriate ground,
- ties safely transmitting the forces of compressed members,
- suitable arrangement of wind braces (struts).

It is, however, pointed out that the Service is entitled to require the Contractor to perform a design of formworks and scaffoldings for any segment of the works. The latter shall in any case remain sole responsible for the formworks and scaffoldings, even in the case of the Service not having made use of his right as above to require a design for forms and scaffoldings.

7.2.1.6. Scaffoldings and forms must be compatible to the anticipated concreting method and speed (i.e. in the case of walls and columns more than 3.0 m-high, the speed of concrete placement must be adjusted to the strength of the form and vice versa), the method of vibration (i.e. in case of form vibration for the consolidation of concrete, heavy energy losses must be avoided at support points - elastic support of formworks), the requirements due to prestressing (prestressing causes deformations and load transmissions), and to concrete curing and possible heat treatment (see sub-para 6.10.11 hereof).

7.2.1.7. The formwork must be designed in a way averting losses of concrete material during placement. Watertightness of joints may be ensured by correct and direct contact between planking members which may be specially formed to this end. Joint covers may be used in special cases.

7.2.1.8. In the case of permanent forms to be incorporated in the structure as functional members, the resistance of same to age must be previously tested. if nonfunctional members, then their harmless properties must at least be secured. Interior cavities (such as voids left to reduce a slab's weight) may be formed through the insertion of permanent filling items that must have no bearing to the structure's performance.

7.2.1.9. Form-tie arrangements across the mass of concrete must not affect it in any way. Embedded supports of reinforcing rods must affect neither resistance to age, nor appearance (i.e. rust traces or water penetration).

7.2.1.10. Finally, formworks must be properly designed to allow their easy removal without causing any damage to concrete.

7.2.1.11. The design of formworks shall be elaborated by a licensed Civil Engineer. If a formwork design is not included in the project design, then the former shall be performed by a competent Civil Engineer of the Contractor's staff, in relation also, to the stipulations of sub-para 7.2.1.5 hereabove.
Such a design must also take into consideration any existing safety regulations concerning workers in construction works.

7.2.1.12. In the case of the scaffoldings being erected to stand on a grade other than that of the foundations, the Contractor shall secure such support by using piles or by applying other appropriate method capable of assuming the anticipated loads.
When submitted, the design of scaffoldings shall be accompanied by relevant details together with their structural calculations, all signed by the licensed design engineer.

7.2.1.13. Special concreting methods and special categories of concrete may introduce special requirements for the respective formworks. The following are special concreting methods :

- shotcrete,
- injected concrete,
- concreting under water.

Some categories of concrete (pumped concrete with setting decelerators or viscosity compounds) are liable to cause thrusts higher than those of ordinary concrete, and this must be taken into account.

7.2.2 Detail Drawings

7.2.2.1. The Contractor is bound to prepare detail drawings for all important parts of the works requiring designs of formworks and scaffoldings.

7.2.2.2. Drawings shall be clear and shall provide supplementary instructions in a manner ensuring availability of all necessary information for the exact and correct assembly of formworks and scaffoldings, not requiring additional verbal clarifications. The information provided shall cover the following issues :

a. Sizes, locations and assembly of all members in relation with each other as well as with adjoining construction elements.

b. The quality and class of the materials scheduled to be used for the various parts of the work as well as for their interconnection.

c. Precise description of all related items and accessories in order to facilitate their accurate recognition on the field.

d. Details regarding the necessary supports, with the following clarifications :

    (1) Materials, dimensions and positions of external shoring, braces and other supporting elements, necessary for maintaining vertical and lateral stability, as well as resistance to sideways displacements.

    (2) Details and sizes of structural connections between the various members.

    (3) Materials, dimensions and positions of the scaffolding foundations and of load bearing elements.

e. Details of forms in which concrete shall be placed.

f. The order, method and speed rate of concreting operations based on the structural design of the formworks.

g. Special methods of erection, positioning and dismantling.

h. Sufficient information regarding loads, torque and deflections to facilitate the inspection and verification of formworks and scaffoldings by the Service.

7.2.2.3. The detail drawings shall be signed and stamped by a licensed Civil Engineer, and they shall bear clarification to the effect that the technical specifications and regulations are complied with.

7.2.2.4. All parts of the works requiring detail designs on the field shall be mentioned in detail, and such designs shall be submitted in time to the Service for his approval.

7.2.3 Acceptance of Formworks

7.2.3.1. The Contractor bears full responsibility for inspecting concrete formworks and scaffoldings. For this reason, and irrespectively of the inspection carried out by the Service (see sub-clauses 6.8, 6.16, etc. of specification clause 6 regarding CONCRETING of this T.C.C.), the Contractor is bound to appoint a licensed Civil Engineer for inspecting formworks and scaffoldings prior to any concreting operation, who shall thereupon issue a certificate in which :

a. The object of the inspection conducted shall be described in detail.

b. It shall be certified that formworks and scaffoldings are constructed in accordance with the last revision of the approved drawings and with any supplementary instructions, or

c. It shall be certified that any recommended braces are fixed in place.

d. Such certificate shall be on the site office at the disposal of the Service for any required review.

7.2.3.2. 7Any justified suggestions by the Service shall be taken into consideration and complied with by the Contractor in the framework of his obligations for the performance of the works without additional fee. In the opposite case, the Contractor is not released of his full responsibility, should the Service fail to make use of his right as above.

7.2.3.3. A signed copy of the above certificate of formworks acceptance shall be submitted to the Service prior to each concreting activity.

7.3. MATERIALS

7.3.1 Scaffoldings

Scaffolding materials shall respond to the requirements of modern scaffolding technology for construction works (sawn lumber, suitable steel profiles, steel tube scaffoldings, etc.).

7.3.2 Forms for Exposed Concrete

7.3.2.1. These refer to concrete categories with high quality surface finishing (TYPE B, C, D or E), according to sub-clause 6.15 of clause 6 (CONCRETING) of these T.C.C..

7.3.2.2. Identical materials, or materials creating similar concrete surface texture or coloring shall be used for completing each load bearing element.

7.3.2.3. Plywood : it shall be of the BETOFORM type with a plastic lining on at least one side (facing concrete). Sheets shall be solid, without wear, with perfect edges.

7.3.2.4. Steel sheets : not less than 1.6 mm thick.

7.3.2.5. Lumber (used only for surface finishing of TYPES B and ID) : it shall consist of suitable sawn boards planed on the side facing concrete, as well as along the side ends forming longitudinal joints with perfect edges and no signs of wear.

7.3.3 Forms for Non-Exposed Concrete

7.3.3.1. These refer to concrete categories with surface finishing of TYPE A, according to sub-clause 6.15 of clause 6 (CONCRETING) of these T.C.C.

7.3.3.2. Sawn lumber of rectangular sections shall be used, same as plywood, sheet metal or other material capable of retaining concrete without mortar leaks or deflections (see also sub-para 6.11.2 hereof).

7.3.4 <u>Lumber</u>

It shall conform to standard AASHO M 168 or to other applicable standard of West Germany.

7.3.5 <u>Steel</u>

It shall conform to standard ASTM A 36 or better.

7.3.6 <u>Wedges, Hooks</u>

They shall conform to Canadian standard C.S.A. B 111, or to other applicable standard of West Germany or of the United States of America.

7.3.7 <u>Bolts and Nuts</u>

They shall conform to standard ASTM A 307 (Grade A) with hexagonal heads and nuts, or to standard AASHO M 164 (ASTM A 325) for heavy-duty bolts.

7.3.8 <u>Non-Recoverable Forms</u>

Wherever it is impossible to use recoverable forms, the use shall be permitted of non-recoverable ones (that shall be abandoned). Such forms shall be of adequately resistant and solid materials, so that they may maintain their form without excessive deflections during placement and hardening of the concrete, and that they may have no harmful effect on the concrete after placement or even throughout the construction's life cycle.

7.4. <u>INNERSIDES OF FORMWORKS</u>

7.4.1. They shall be fabricated from properly assembled panels tightly joined together, sufficiently rigid to avert detrimental deformities and mortar leaks. Exposed concrete surfaces must be free of joint evidence.

7.4.2. Panel joints shall be properly adjusted to avoid any differentiation of deformations and mortar leaks along same.

7.4.3. Any corrugations on the concrete surface due to form deviations shall not exceed 3mm or 11270 of axial distances between nails, ties or other supports.

7.5. ACCESSORIES

7.5.1 Form Ties

7.5.1.1. They shall be subject to removal up to a depth of at least 40mm from the surface of concrete. The removable part of the tie shall consist either of a plastic cone, or of other cone-shaped material.

7.5.1.2. The removable tie part shall leave inside the concrete mass a clear, properly shaped hole, free of broken edges.

7.5.1.3. Tie sizes and spacings shall be fixed in a manner permitting the assumption of pressures foreseen to be generated during placement of the concrete, as well as owing to vibrating activities.

7.5.1.4. The use of wire ties, or of ties breakable during removal is FORBIDDEN.

7.5.1.5. The layout of ties shall be uniform and symmetrical.

7.5.2 Tie Sealing Caps

Exposed tie ends in recess within holes left in forms shall be sealed with plastic heads or plugs of bound cement mortar. The cap or plug shall be recessed by not less than 6mm in relation to the surrounding concrete surface. The use of exposed tie holes and other details (position, etc.) is specified in the SCC and the other tender documents, depending on the case, and as provided for in the approved drawings. [When the formation of exposed tie caps is not specified, same shall be sealed according to sub-para 6.15.3 of clause 6 (CONCRETING) of these T.C.C.].

7.5.3 Compounds Easing off the Removal of Forms

7.5.3.1. They shall be compounds containing ingredients of chemical action when joined to the free lime of concrete, producing a kind of water insoluble soap impeding setting of the concrete membrane in contact with the form.

7.5.3.2. Such compounds must be colorless, leave no stains and cause no damage to the final surface of concrete. The continuation of their use shall depend on the results, satisfactory or not, of their initial application on concrete of foundations. (Refer also to sub-clause 6.15 hereof).

7.5.4 Fillets for Corners or Grooves

Plastic or wooden fillets shall be used for corner chamfers and/or for constructing grooves at any length possible and of cross-sections as per the detail drawings and/or the instructions of the Service.

7.6. CONSTRUCTION OF FORMWORKS

7.6.1 Erection

7.6.1.1. Setting out and elevations shall be checked prior to the erection of formworks, with a view to ensuring true erection to the dimensions shown on the drawings.

7.6.1.2. Formworks shall be fabricated and erected according to detail drawings, so that the concrete product may agree with the indications of the drawings regarding form, dimensions, positions and elevations, within the bounds of permissible deviations (tolerances).

7.6.1.3. Formwork joints shall be rectilinear and watertight. The number of joints shall be maintained to the minimum possible.

7.6.1.4. Forms shall be adjusted as perfectly as possible to existing concrete surfaces, and their contact with same shall be absolutely watertight.

7.6.1.5. Grooves, openings, recesses, etc. shall be constructed as shown on the drawings, irrespectively of any damage they may be causing to formworks and scaffoldings, without any additional fee, as it is clarified that all kinds of wear are converted and included for in the prices of the Contractor's bid.

7.6.1.6. Chamfer fillets shall be fixed along corners according to the drawings and/or the Service's instructions for all cases of exposed concrete, without any provision for additional payment.

7.6.1.7. All horizontal joints shall be inspected for mortar leaks.

7.6.1.8. Form ties shall be fixed exclusively on positions as shown on detail drawings. Should no detail drawings be provided, the positioning of form ties shall be in compliance with sub-para 7.5.1 hereof, under the instructions of the Contractor's competent Civil Engineer, responsible for formworks.

7.6.1.9. Surface repairs shall be according to sub-clause 6.15 of clause 6 (CONCRETING) of these T.C.C., with the purpose of ensuring the required surface quality as well as adjustment to the required thickness and permissible deviations.

7.6.1.10. Formworks and scaffoldings shall be regularly inspected in the course of concreting operations, which shall be interrupted in case of detection of deformities on formworks and scaffoldings. Such defective areas shall be restored in accordance with a relevant suggestion by the Contractor and following the Service's approval.

7.6.1.11. Re-use of formworks and/or scaffoldings shall be subject to the Service's approval which shall be issued after a related inspection.

7.6.1.12. The fixing on the ground and the erection of scaffoldings and formworks must be executed by qualified staff and according to the drawings and specifications. Particular attention must be paid to the formulation of joints, in order to secure static balance on all construction phases, correct transmission of stresses, and resistance to buckling, toppling and lateral instability.

7.6.1.13. Inner sides of forms shall be carefully cleaned prior to concrete placement. Cleaning openings must be provided, particularly at the toe of columns and walls, the generation of cantilevers, and the invert of high beams.

7.6.1.14. Shortly before concreting, forms shall be coated with a suitable compound to facilitate formwork removal (see sub-para 7.5.3 hereof). Such compound shall be subject to the approval of the Service. It shall be laid in uniform uninterrupted courses. Concrete must be placed the earliest possible after application of the compound easing form removal, while the latter retains its effective action (to this end, directions for use and other details issued by the manufacturer must be presented to the Service).

7.6.1.15. Formwork erection shall be in a way permitting formwork removal without hammering concrete surfaces or causing other damage to concrete.

7.6.1.16. Formwork surfaces shall be flat or slightly cambered, as specified, so that concrete surfaces may be delivered, after formwork removal, completely flat or with the specified curvatures.

7.6.2 Permissible Deviations

Formworks shall be firmly fabricated to ensure construction of concrete elements with the following maximum permissible deviations from the dimensions of the drawings:

7.6.2.1. Foundations :

— concrete sectional dimensions	-12 mm + 50 mm
— top elevation	up to 12 mm
— eccentricity	up to 30 mm

7.6.2.2. Deviation from the setting out of pier axes:

— at foundation crown	up to 8 mm
— at pier crown	up to 12 mm

7.6.2.3. Deviation from the perpendicular, or from the specified slope, of lines and surfaces on the sides of piers, between the crowns of foundation and of pier

1 : 500 (but not more than 30mm from the crown of foundation to the crown of the pier).

7.6.2.4. Deviation of the abovementioned elements from the specified elevations :

— crown of pier	up to 8 mm
— crest of the road deck at the place of piers	up to 8 mm

7.6.2.5. Deviation of concrete sections from the specified dimensions

— thicknesses of pier walls	– 8 mm + 12 mm
— external pier dimensions	-12 mm + 20 mm
— beam thicknesses	- 8 mm + 12 mm
— deck slabs	– 3 mm + 5 mm
— total height of structural member	– 5 mm + 8 mm
— overall deck width	up to 20 mm

7.6.2.6. Differences in size and location of sidewall openings: up to 12 mm

7.6.2.7. Deviation from the setting out of the axes of beams or of walls in deck caisson sections : up to 20 mm

7.6.2.8. Deviation from the perpendicular, or from the specified slope, of wall or sidewall surfaces of the deck bearing structure : 1 : 300

7.6.2.9. Deviation of plane surfaces from the straight, measured with a 4m-long straightedge in all directions :

- pier walls, beams, slabs and wals of load bearing elements, and plane surfaces in general : up to 10 mm

7.6.3 Embedded Items - Openings

7.6.3.1. Openings of specified form shall be constructed where required for the passage of tubes, pipes, ducts and other items through concrete.

7.6.3.2. Items to be directly embedded into concrete shall be accurately positioned and fixed in-place.

7.6.4 Maintenance and Preparation of Formworks

7.6.4.1. Handling of forms shall be in a suitable manner to avoid wear on surfaces in contact with concrete.

7.6.4.2. Wear shall be properly repaired as approved by the Service, while materials which, in the opinion of the Service, shall not be in a position to render the required finish quality on concrete surfaces shall be replaced.

7.6.4.3. After each use and new concrete placement, forms shall be cleaned and coated with a compound easing away formwork removal, according to the manufacturer's instructions.

7.6.4.4. The compound easing away formwork removal shall not be permitted to be in contact with hardened concrete surfaces, with the steel reinforcement, or with other items embedded in the concrete.

7.6.5 Removal of Formwork

7.6.5.1. Generally, sub-clause 6.11 (Formworks) and sub-clause 6.16 (Quality Control) of clause 6 (CONCRETING) of these T.C.C. shall apply.

7.6.5.2. Formwork undersides and scaffoldings supporting post-tensioned members shall not be allowed to be removed prior to full application of post-tensioning.

7.6.5.3. Forms shall be removed only after fulfilment of the preparation procedures for application of protection during curing and for the protection of concrete.

7.6.5.4. Loosening of forms and scaffoldings shall be performed in conformity to the phases envisaged in the design, diligently, with a view to avoiding shocking and damaging the concrete surface (clear!), statical forces shall be applied).

7.6.5.5. The stipulations mentioned hereabove under sub-clause 6.11 of clause 6 of these T.C.C. shall apply in the cases of structures built of prefabricated components and supplemented with cast-in-situ concrete, when the strength of such structures depends on development of strength of the concrete in-situ.

7.6.5.6. In the case of using sliding or climbing farms, shorter deadlines may be applied than those shown on table 6.11.6, in compliance with a special study to be submitted by the Contractor and approved by the Service.

7.6.5.7. Removal of scaffolding columns must be executed in a manner avoiding the development of stresses exceeding those permitted, and so that the load bearing structure may be gradually and uniformly charged.

7.6.5.8. Formworks of columns, piers and walls must be removed prior to removing those of beams and slabs resting on the former.

7.6.5.9. It is generally established that removal of formworks and scaffoldings shall not be allowed to take place without prior approval of the Service with respect to the time and method of removal.

7.6.6 Safety Columns

7.6.6.1. With a view to ensuring limited deflections caused by creep or drying contraction, safety columns must remain or be added immediately after removal of the formworks. Same applies in the case of prefab component structures referred to under sub-para 7.6.5.5 hereabove.

7.6.6.2. Safety columns must be left in place for as long as possible, even more so in the case of structural members assuming immediately after formwork removal a large portion of their loads considered during design calculations, or in the case of members whose forms and scaffoldings were removed too early (see also table 6.11.6 of clause 6 hereof).

7.6.6.3. Safety columns of consecutive floors must be precisely superimposed.

7.6.6.4. For slabs and beams with spans up to about 8m-long, it suffices to install safety columns halfway under the spans. Greater numbers of safety columns are required for longer spans. No safety columns are usually needed for slab spans less than 5m-long.

7.6.6.5. No safety columns shall be installed when it is concluded from the design that they are not required, or when the design, to be submitted by the Contractor and approved by the Service, proves that their provision may result in an unfavorable effect to the structural system of the project.

7.6.6.6. In any way, it is pointed out also here that the project Contractor remains absolutely responsible for any occurrence related thereto.

7.6.7 Inspections and Tests of Formworks

7.6.7.1. Accomplished formworks and scaffoldings shall be inspected and tested according to the provisions of sub-para 7.2.3 hereof.

7.6.7.2. The stability and safety of columns, fastenings, wedges, joints and other accessories shall be made sure of.

7.6.7.3. After fulfilment of inspections and tests, the Service shall be notified for him to perform the final inspection prior to concrete placement (see also sub-clause 6.8 of clause 6 of these T.C.C.).

7.6.7.4. Further to the stipulations of sub-para 6.8.2.2 of clause 6 (CONCRETING) of these T.C.C., the Service's inspection shall also regard the following aspects :

— Suitable preparation of the form surfaces with the purpose of responding, in addition to anything else, to the type specified of concrete surface finishing.
— The required cover of reinforcing rods.
— The fixing of embedded items.
— The fixing of form-ties going through the mass of concrete.

7.6.8 Loading of Structural Members following Recent Removal of Formworks and Scaffoldings

7.6.8.1. Particular attention is required when the use of structural members, mainly floors, cannot be barred in the first days following construction or following removal of formworks and scaffoldings.

7.6.8.2. In no way must it be permitted to reject or to accumulate or to dump stones, timber, etc. in unacceptable quantities on recently constructed floors.

7.6.9 MEASUREMENT - PAYMENT

No payment of fee is provided to the Contractor for any works related to scaffoldings/formworks, including the furniture of necessary materials, the use cf machinery and equipment, any transportation, removal, cleaning, preparation, coating with removal easing compound etc. for completed work, including the design of scaffoldings/formworks, their inspection etc., given that all costs fcr scaffoldings and formworks are converted and included in concrete prices fc' TYPE A surface finishing, while additional payment is provided for surface finishing of better qualities (TYPES B, C, D and E) covered by tie corresponding item of the price list included in the Contractor's bid.

Clause 8 : WATERPROOFING AND DRAINAGE OF STRUCTRURES

8.1. GENERAL

8.1.1.

a. The present specification regards insulation of bridges, underground works (constructed by application of the "cut and cover" method), culverts, retaining walls and manholes. It does not apply to tunnels constructed by underground boring operations, in which case clause 50 of the TCC shall apply.

b. Clause 63 of T.C.C. applies for waterproofing of metal bridge decks.

8.1.2. The waterproofing system (materials, construction method, tests) must be proposed by the Contractor in time and must meet the requirements of this clause. It shall be subject to the approval of the Service.

8.1.3. Any protective course required shall be laid immediately after placement or spreading of the bonding material of the waterproofing course.

8.1.4. Temporary protection shall be provided to recently waterproofed bridge decks against any damage to the waterproofing system, whenever materials must be deposited on the bridge or traffic requires to use the bridge and the waterproofing material does not have the necessary mechanical strength.

8.1.5. Appropriate details shall be provided for waterproofing edges, expansion joints and around openings, so that water may not penetrate between the waterproofing course and the waterproofed surface. Furthermore, drainage points on bridges shall have suitable arrangements (flanges) for adjusting the waterproofing course, draining filtration water and regulating the elevation of their inlet. Special waterproofing measures shall be taken for anchor bolts on footpaths, if required. All abovementioned operations shall be in accordance with the provisions of DIN 18195, part 9.

8.1.6. Membranes shall be overlapped according to the manufacturer's instructions, and whenever their ends are at low points, the waterproofing course shall be terminated vertically in a suitable recess not less than 7cm high.

8.1.7. Surfaces subject to waterproofing shall be finished as directed by the manufacturer of the system scheduled for use.

With specific reference to the application of special waterproofing membranes or asphalt saturated felt (sub-paras 8.2.4, 8.2.5, 8.2.6 and 8.2.7), the concrete surface shall be graded with troweled mortar 2cm-thick of a cement ratio equal to 600kgicu.m., or, preferably whenever practicable, with a special concrete surface processing equipment prior to hardening, when the surface ceases "shining" and may be walked upon.

The final surface subject to waterproofing (substrate) shall meet the minimum requirements of construction tolerances established by the T.C.C.. Waterproofing operations may begin only after acceptance of the substrate by the Service.

Surfaces shall be flat but not smoothed away, dry and absolutely free of oil, paraffine, silicone, dust and any loose material cleaned away just prior to application.

8.1.8. The application of special waterproofing membranes shall be protected by a - course of cast-in-situ asphalt, or of asphaltic concrete or of concrete not less than 5cm-thick. The final layer of waterproofing membrane shall need to have suitable mechanical strength allowing circulation of rubber-tyred (compulsory) or crawler-track bearing (optional) mechanical finishers. The Contractor shall submit to the Service a statement by the membrane manufacturer to the type of finisher that may be used.

8.1.9. No waterproofing operations shall be executed when ambient temperatures are below 5°C.

8.2. WATERPROOFING TYPES AND THEIR DESCRIPTION

8.2.1. Steel-Trowel Plaster 1.5cm-thick (on concrete surfaces, except those referred to under sub-para 8.2.2)

The surface shall be protected by application of 1.5cm-thick steel-trowel plaster consisting of 650kg and 900kg cement mortar of ordinary cement . The plaster shall be applied in three coats: the two first, dash and sand float finish respectively, with cement ratio 650kg per cubic meter of dry sand, and the third one, steel-trowel finish with 900kg cement per cu.m. of dry sand, followed by cement dusting for obtaining smooth surfaces, plane or curved, and otherwise as specified in STS 44, STS T87 and clause 2350 of the 1975 Descriptive Price List for Roadworks (D.P.L.R.W).

8.2.2. Steel-Trowel Plaster 2.0cm-thick (on interior surfaces of sewers and manholes)

The surface shall be covered by 2.0cm-thick steel-trowel plaster of 650kg and 900kg ratio of ordinary cement and otherwise as specified under sub-para 8.2.1.

8.2.3. Asphalt Coat Insulation (STS T110)

The concrete or cement plaster surface shall be treated with a twin coat of LANCOL type asphalt insulating material, or of other approved type, to the quantity required, and otherwise as specified under sub-clause 9.23.1 of the STS T110.

8.2.4. Insulation by 2-ply Asphalt Felt and Cement Mortar (STS T110)

Concrete surfaces of horizontal bridge decus / crown culverts shall be insulated by a 2-ply asphalt felt, 2 -thick and weighing between 2.20 and 2.50 kg/sq.m, to be protected by a 2c 'thick course of cement mortar with a cement ratio of 600kgIcu.m. as fixed in the technical design or the tender conditions or the Service's written instructs ns issued in the course of the works, that shall be executed according to STS T110 and according to the technical design and the tender conditions, and otherwise as specified under sub-clause 9.23.2 of the STS T110.

8.2.5. Waterproofing with Two Plies of Special Membranes

(1) The bridge and crown culverts deck shall be waterproofed by the application of two special waterproofing membranes conforming to the German regulations "Strassenbrucken Richtzeichnungen -Dichte 4 - Februar 1979 (Strassenbau A-Z, 809-1981)", as follows

a. Asphaltic prime coat with special asphaltic compound type "Villas Pormex Extra B-20" or similar on dry and clean concrete surface (rate of application about 0.4kg/sq.m.).

b. Asphaltic adhesive coat (compatible to the primer) of improved artificial compound type "ViVox Isovill" or similar (rate of application about 2.5 to 3.0kg/sq.m.).

c. Application on the adhesive of bituminous waterproofing sheet reinforced with fiberglass, weighing about 3.5kg/sq.m., type *Villas lmmun-GW B-18 S" or similar (the work at this stage is performed by pouring the asphaltic adhesive and by subsequent rolling of the bituminous waterproofing sheet).

d. Final placement of bituminous binder sheet reinforced with fiberglass textile and protected on its upper side by an aluminium foil covered with oxidized asphaltic material, the overall sheet weighing about 3.9kg/sq.m., of type "Villas Combiral GW B-66" or similar (the sheet shall be fixed in-place using a blow-torch). Sheet fixing shall be initiated at the lowest point of the deck. Overlapping of both waterproofing and protective sheets shall be 0.10m between 1.0m-wide bands and 0.15m across them.

in all other respects (overlapping, temperatures, weather conditions, construction method, etc.) the drawings and DIN 18337 shall apply, together with "Merkblatt" regarding bituminous courses on concrete bridges and construction guidelines.

(2) Another waterproofing method for bridges / crown culverts using two special membranes acceptable by BE-27 (under acceptance certificate N° 75/4) is as follows:

1. One brush coat on clean and smooth concrete surfaces (3mm maximum sudden grade difference) of "Primer Bitu-thene".
2. Application of self-adhesive membrane (hard plastic textile with adhesive, elastic and asphaltic material on one side and dry asphaltic binder coat on the other) "Bitu-thene heavy-duty grade". (Overlapping 0.10m between bands and 0.15m across).
3. Protection of above membrane with one coat of "Bitu-shield".

Other special membranes may be accepted by the Service, products of EU-member countries, Austria, Switzerland, USA or CANADA approved by competent governmental authorities in their countries of origin for waterproofing bridge decks and ensuring (in accordance with certificates to be submitted to the Service) impermeability, elasticity, long duration and mechanical strength not less than the one specified hereabove under this paragraph.

8.2.6. Waterproofing with One Layer of Special Membranes

8.2.6.1.

(1) Bridge / crown culverts deck waterproofing shall be with special waterproofing membranes ECB type "Carbodur" of CARBOFOL or similar, composed of three or four plies, ensuring waterproofing and, at the 'same time, protection against mechanical damage. The work shall be executed as follows :

a. Prime coat of asphaltic emulsion (primer) applied at the rate of about 300gr/sq.m.

b. One coat of bituminous binder compatible to the primer material (i.e. 85125), applied at a rate depending on the quality of concrete surfaces but not less than 2.5 kg/sq.m. This application shall be after the primer has fully dried.

c. Affixing single sheets "Carbodur A" (four sandwiched consecutive plies) of CARBOFOL on the binder coat and parallel to its application over the area of the bridge deck, and single sheets "Carbodur B* (three sandwiched consecutive plies) under sidewalks, triangular ditches and, generally, under concrete structures or under fill, in contact with the ground.

(2) Affixing shall be by progressive unfolding of the sheet rolls on the binder. Application of waterproofing sheets shall be along or across the bridge axis.

(3) Sheet affixing shall be initiated at the lowest point of the deck. Overlapping along seams shall be about 8cm between bands and 12cm for "Carbodur ATM, or 20cm for "Carbodur B" over sheet ends, using a bituminous binder. The least possible binder overflow shall be pursued along lap ends."Carbodur B" sheets under concrete footpaths shall extend by not less than 0.20m out of the kerb and beyond drainage routes of the bridge deck. Prior to affixing "Carbodur A" sheets over the bridge deck, the part of "Carbodur B" protective geotextile protruding out of the footpath shall be removed.

8.2.6.2. Another acceptable waterproofing method consists of using soft PVC membranes of type AG "Trocal" membranes of Dynamit Nobel AG or similar, laid in accordance with the manufacturer's instructions. Under sidewalks, triangular ditches and, generally, under concrete structures or under earth fill, when in contact with soil, the membrane shall be protected by means of T.S. protection sheets, or corresponding sheets for membranes of other manufacturers.

8.2.6.3. The Service may accept other special membranes, made of ECB or soft PVC products of EU-member countries, Austria, Switzerland, U.S.A. or CANADA, if approved by the competent governmental authorities in their countries of origin for waterproofing heavy traffic bridge decks, and if ensuring (on the basis of certificates to be presented to the Service) impermeability, elasticity, duration and mechanical resistance at least equal to those of the membranes specified hereabove under this paragraph.

8.2.6.4.

(1) For bridges and crown culverts the minimum total thickness of bituminous covering in pavement area is equal to 0.10m., when a special class waterproofing system membrane is used, which is suitably manufactured so there is no risk of it being damaged during the construction of the bituminous layers.

(2) If the membrane of the waterproofing system does not fulfill the above requirement, then an additional -protective layer" shall be constructed, with minimum thickness 0.02m, consisting of asphalt and sand (or other suitable material according to valid specifications of the E.E.C. member-countries or the A.A.S.H.T.0./A.S.T.M. specifications), to protect the membrane during the construction of the bituminous layers.

In such case, the minimum covering thickness above the waterproofing membrane shall be 0.12m.

The construction of the aforementioned additional 'protective layer' can be omitted if it is replaced by a concrete layer for the protection of the waterproofing membrane or/and the formation of a sloped bridge deck. In the latter case, the concrete layer will fulfill the requirements of pare 8.2.9.2

(3) For bridges that belong to roads which are constructed by reinforcing their pavement in stages, the following shall be carried out :

a. Bridges with visible surface joints : For bridges with visible surface joints, the joints shall be placed at their final level and consequently no future reinforcement of the pavement in stages, along the length of the bridge, is foreseen.

Therefore, the requirements of sub-par. (1) and (2) are applicable.

b. Bridges and culverts with non-visible joints or dummy-joints or no joints : In these structures the future reinforcement of the pavement is also constructed in the area of the bridges/culverts, so the required minimum covering shall be now equal to 0.10m. or 0.12m. (according to the above), increased by the thickness d of the future pavement reinforcement.

8.2.6.5.

(1) For walkways of bridges and crown culverts it is possible to construct "flexible" type of paving (surfacing).

The same is also valid for the surfaces of median islands and of lateral planted strips that are paved in the areas of bridges and crown culverts.

(2) For walkways etc., it is not necessary to construct the "protective layer" for the waterproofing membrane, as there is no requirement of direct construction on it, of bituminous layers by rolling hot.

8.2.6.6.

(1) For the case of *"Pedestrian Bridges"* the same requirements for the waterproofing membranes apply.

(2) If the membrane to be used is suitably manufactured to withhold application of an asphalt layer by hot rolling, then the planned asphaltic layer may be constructed at its appropriate thickness.

(3) If the membrane to be used does not cover the above requirement, then :

a. If surfacing by hot rolled asphaltic layer is applied, the construction of a *"protective layer'* having a minimum thicken of 0.02 m. made of sand - asphalt or other similar material shall be made before.

b. If surfacing by paving slabs or other material not envisioning hot rolled asphalt layer is applied, it is not required, to construct a *"protective layer"*.

8.2.7. Waterproofing of Railway Bridges

Waterproofing of the surface of concrete constituting the base of ballast on railway bridges shall be with the use of membranes as per sub-paras 8.2.5 or 8.2.6 (depending on the system which has been specified), but the waterproofing construction shall need to be protected by a course of B15 concrete, not less than 7cm-thick, reinforced across mid-thickness with a galvanized iron mesh of dia 2 - 3mm rods and a 5 x 5 cm maximum aperture.

Over railway bridges, the waterproofing course shall be terminated in a suitable groove along the ballast encasing concrete parapet, not less than 30cm-high (see S.R.P. - Standard Road Plan).

Payment for B15 concrete membranes and for galvanized iron mesh shall be according to the corresponding items of the Price List.

8.2.8. Waterproofing of Sheetpile Linings

Waterproofing of the exposed (visible) part of sheetpiles linings shall be by special plastic membranes type 'Delta-MS-Drain" that shall cover the whole interval between piles plus two bands not less than 0.25m-wide, one on each of the adjoining piles.

Alternative waterproofing methods can be secured by the use of other appropriate plastic membranes, specially designed by their manufacturer for such cases (with the provision of special grooves ensuring the discharge of filtering water without risking blockage). Or, by a combination of special textile filter made of "Typar" or "Dupont" or similar type polypropylene weighing not less than 200gr/sq.m. and covering the interval between piles plus the two 0.25m-wide bands on each of the adjoining piles, with not less than four special drainage pipes of soft reinforced PVC type "Alive Drainage Channels" of internal flow section equal to 18-19sq.cm. each to match pressure and water flow conditions, in order to stop the passage of groundwater to the visible side of the concrete wall lining the sheetpiles.

Appropriate fastening shall need to be applied according to the instructions of the manufacturer of the special plastic membranes, of the textile filters and of any special drainage pipes used (depending on the alternative solution applied) that shall have to be fixed in-place in compliance with the supplier's directions with suitable quick setting cement and/or clips, using shotcrete (gunite), etc.

In addition, the surface of piles shall need to be cleaned in a way ensuring adherence of the lining concrete onto the concrete of piles (this may be obtained by grinding or even by sandblasting the pile surfaces), and steel reinforcement of _the piles shall need to be exposed where rectification is foreseen of special bent tie-rods embedded in the piles, or welding is provided of the steel bars of lining onto those of the piles, or other appropriate connecting method.

Finally, the lower end of the waterproofing system shall be connected to the drainage water discharge system.

8.2.9. Membrane Waterproofing of Horizontal Structural Members under Earth Fill

8.2.9.1. Membrane waterproofing for horizontal members of underground works (i.e. bridges / culverts under fill, tunnels constructed by the 'cut and cover" method), backfilled with earth and any agricultural topsoil resulting from environmental arrangement works, shall be as follows :

a. One sheet of protective fleece (non-woven geotextile) weighing not less than 300 gr/sq.m., indicatively of type "Trocal Type P", shall be laid free on the surface of the horizontal member.

   Adjoining sheets shall overlap by 0.30m.

   For the purposes of this operation it suffices to treat the upper surface of the horizontal member with plastic surface finish of Type ΠA (No "grinding" needs to be done in the upper surface).

b.

   (1) A soft PVC membrane of the type used in tunnel construction, not less than 1.5mm-thick, indicatively of type “Trocal T”, is laid on the protective fleece (geotextile).

   The soft PVC membrane shall need to have the following properties, in accordance with DIN 16938 :

   — Tensile strength (test as per DIN 53455): >= 15 N/mm^2

   — Deformation upon breaking (test as per DIN 53455): >= 200%

   — Resistance to extensive tear (test per DIN 16726,para 5.8.2) (additional requirement in relation to DIN 16938) > 80 N/mm

   — Pressure during tear test (4 bars/72 h) (test per DIN 16726, para 5.11) : should present no escape of material

   — General condition of the material air and variation of dimensions after 6 hours under temperature of 80°C (test per DIN 16726, para 5.13) : i should let out no bubbles ii <= 2%

   — Resistance to cold folding (test per DIN 16726, pare 5.14) : should show no cracks at -20°C

(2) Alternatively, and in-lieu of the soft PVC waterproofing membrane, a sheet of waterproofing geomembrane of modified ethylene isopolymer" (ECB) may be used, not less than 2.0mm-thick, of heavy- duty strength (>= $14N/mm^2$), of indicative type "Carbofol CHD".

c. On the waterproofing membrane :

(1) In the case of using a soft PVC membrane, a second sheet of protective fleece (non-woven geotextile) weighing not less than 300gr/sq.m., of indicative type "Trocal Type P" shall be laid free. Sheet overlapping shall be 0.30m.

(2) In the case of using an ECB membrane, a plain Nylon sheet 20G-thick (0.20mm) shall be laid free. Nylon sheet overlapping shall be 0.30m.

d. Any waterproofing membrane (referred to hereabove) must have qualities enabling it to be classified as 'irootproor (resistant to root penetration), according to DIN 4062, and shall be accompanied, to this effect, by a relevant certificate issued by its manufacturer.

e. Waterproofing membrane sheets shall be joined by MANDATORY DOUBLE SEAM, using a suitable special machine for autogenous soldering, while seams shall be tested for watertightness by OVERPRESSURE, using a pressure gauge. The watertightness of seams shall be tested in the presence of the Service and a relevant acceptance protocol shall be worded and signed. Lack of such protocol shall constitute lack of material quantity surveying document. Sheet overlapping shall be not less than 0.10m.

f. The ends of waterproofing membranes shall be properly fixed using suitable special reinforcing parts (i.e. laminated, with metal strengthening plates), in accordance with the special drawings of the waterproofing membrane manufacturer, combined also with the respective waterproofing of vertical surfaces as described herebelow under sub-para 8.2.10.

g. Watertightness at points of pipes or other items going through the membrane shall be ensured by special arrangement constructed in accordance with relevant drawings provided by the manufacturer.

8.2.9.2. The above waterproofing arrangement shall be protected by a B15 concrete course not less than 7cm-thick, reinforced by a galvanized iron mesh fixed halfway through the course thickness. The mesh shall be of dia 2 - 3mm rods, with a 5 x 5 cm maximum aperture. The protective course of concrete shall bear expansion joints spaced at 4.00m intervals in both directions.

8.2.10. Membrane Waterproofing for Vertical Surfaces of Underground Works

8.2.10.1. Membrane waterproofing of vertical surfaces in underground works (i.e. tunnels constructed by the "cut and cover" method), and for the case of limited water filtering quantities, shall be constructed by ensuring continuity from the waterproofing layers of horizontal members (dealt with hereabove under sub-para 8.2.9), as follows :

a. A protective sheet of mechanically bonded, needlepunched, polyester non-woven geotextile shall be fixed at and suspended from the top of the vertical surface, weighing not less than 300 gr/sq.m., of indicative type "Trocal Type P".
Through 0.30m-wide laps, the geofextile is joined into a unified surface reaching down to the toe of the waterproofing surface (where a drainage pipe is fixed for draining the structure). Vertical concrete surfaces shall be treated with finishing work of Type A.

b.

(1) Following this, a soft PVC waterproofing membrane used in tunnel construction, not less than 1.5mm-thick, of indicative type “Trocal T”, is suspended from the top of the vertical surface. The membrane shall be joined to constitute a unified sheet and shall reach down to the toe of the waterproofing surface (up to the drainage pipe). In accordance with DIN 16938, the soft PVC membrane shall need to carry the following properties :

— Tensile strength (test as per DIN 53455)	: >= 15 N/mrn^2
— Deformation upon breaking (test as per DIN 53455)	: >=200%
— Resistance to extensive tear (test per DIN 16726,para 5.8.2) (additional requirement in relation to DIN 16938)	: > 80 N/mm
— Pressure during tear test (4 bars 172 h) (test per DIN 16726, para 5.11)	: should present no escape of material
— General condition of the material and variation of dimensions after 6 hours under temperature of 80°C (test per DIN 16726, para 5.13)	: i. sould let out no air bubbles : ii <= 2%
— Resistance to cold folding (test per DIN 16726, para 5.14)	: should show no cracks at -20°C

(2) Alternatively, and in-lieu of the soft PVC waterproofing membrane, a sheet of waterproofing geomembrane of "modified ethylene isopolymer" (ECB) may be used, not less than 2.0mm-thick, of heavy-duty strength (>= 14N/mm2).

c. On top of the waterproofing membrane and up to the lower level of waterproofing, a protective/drainage sheet of mechanically bonded, needlepunched, non-woven polyester geotextile shall be fixed with free suspension, weighing not less than 600gr/sq.m., of indicative type "Terrafix 600" by NAVE, and meeting the specifications mentioned herebelow :

— Minimum strip tensile strength (as per DIN 53857) : 1.5kN/10cm

— Maximum elongation deformation (as per DIN 53857) : 50%

d. All waterproofing membranes referred to hereabove must carry properties enabling them to be classified as "rootproor (resistant to root penetration) according to DIN 4062, and shall be accompanied by certificates relevant to this effect, issued by their manufacturer.

e. Waterproofing membrane sheets shall be joined by MANDATORY DOUBLE SEAM using a suitable and special autogenous soldering equipment, while the watertightness of seams shall be tested by OVERPRESSURE, using a pressure gauge. The watertightness of seams shall be tested in the presence of the Service, and a relevant protocol of acceptance shall be worded and signed. Lack of such protocol shall constitute lack of substantial measurement document. Sheet overlapping at joints shall be not less than 0.10 m-wide.

f. Appropriate special strengthening parts (i.e. laminated, with metal reinforcing plate) shall be used at the edge formed between the horizontal member and the vertical surface, in accordance with the special drawings provided by the waterproofing membrane manufacturer.

g. A special construction to ensure watertightness shall be implemented at points of pipes crossing through the waterproofing membrane, according to the special drawings thereto provided by the membrane manufacturer.

h. Construction joints shall be covered by waterproofing PVC tape ("Waterstor") of appropriate width, in accordance with the Standard Road Plan (S.R.P.)

i. The external protective/drainage sheet of geotextile weighing 600gr/sq.m. referred to under sub-para c hereabove may be applied in the case of limited quantities of filtration water and for a work height not exceeding about 6.00m (allowing backfilling through 'tipping"), provided that the backfilling shall be executed with granular material of "transitional fir, according to sub-clause 8.4 hereof.

8.2.10.2. Should backfilling be executed by "tipping from a height greater than 6,00m, and/or that the maximum grain size of backfilling material exceeds 80mm, then a heavier type of protective polyester geotextile must be applied (weighing more than 600gr/sq.m.), or even a lighter polyester geotextile (say 300 gr/sq.m.) that shall be subsequently protected by the construction of a brickwall.

8.2.10.3. In the case of backfilling with a non-draining material, or that water filtering quantities exceed those originally anticipated, then the construction of a special sheet should be envisaged of increased draining capacity (i.e. "Secudraen or similar), in accordance with a special design.

8.2.11. Waterproofing of metal bridge decks

For waterproofing of metal bridge decks reference is made in clause 63 of the T.C.C.

8.3. WATERPROOFING OF EXPANSION AND CONSTRUCTION JOINTS

Waterproofing of expansion and construction joints along the bridge deck and on piers, wing walls, retaining walls, culverts and other structures shall be in accordance with the corresponding Standard Road Plan (S.R.P.) and with clause 29 of the T.C.C..

8.4. DRAINAGE OF STRUCTURES

8.4.1. The drainage of structures shall be done in accordance with the relevant Standard Road Plan (S.R.P.) and with sub-clauses 1.11 and 1.13 of the Design and Investigations Standards (D.I.S.).

8.4.2. As special and transitional embankments behind walls and end piers, and pavement drainage layers are defined the following :

a. For a work of a minimum thickness less than 0.15m, the construction material shall comply to the STS 0 150, grading B or C, but with a percentage passing screen N°200 equal to 3-10%.

b. For a work of a minimum thickness equal to or exceeding 0.15m, its construction material shall comply to STS 0 150, grading A, or to the stipulations of the preceding sub-para a.

c. In all other respects, the STS 0 150 shall apply.

Clause 9: BORED CAST-IN-SITU AND CAISSON PILES REQUIRING SOIL REMOVAL (AND THEIR CAPS)

9.1. GENERAL

The November 1976 version of DIN 1054 describes general basic principles for pile foundations, while the provisional regulation of DIN 4014, version of September 1977, describes those related to caisson piles.

9.1.1. Soil Data

All soil information available shall be handed over to the Contractor. However, and unless otherwise specified in the tender conditions, the Contractor shall be bound to conduct supplementary soil surveys, at his initiative and expense, with the purpose of verifying the design soil data. Should any discrepancies result from such supplementary surveys, the Contractor shall submit his proposals related thereto to the Service who shall base its decision on its exclusive judgment. In all cases, the Contractor shall be sole responsible for the timely conduct of the supplementary soil investigation programme, as well as for the submission of any proposals for coping with resulting situations. In formulating his work programme, the Contractor must take into account the fact that, (unless otherwise specified), the Service shall need not more than thirty (30) calendar days to make a decision.

9.1.2. Definitions

Bored east-in-situ piles that are constructed following removal of soil, having a shaft dia. greater than 0.50 m and a base dia. not less than 1.00 m, shall be called caisson piles. Caisson piles shall be considered to be indiscriminately implied along with others whenever the terms of piles or cast-in-situ piles are used in this specification.

9.1.3. Construction Method

Not less than one month prior to commencing pile construction works, the Contractor is bound to submit to the Service the following for the latter's approval:

a. A detailed description of the pile construction method. In all cases, the proposed method must be such as not to create safety problems or cause excessive noise and nuisances to adjoining structures.

b. A detailed list of the equipment he proposes to use.

c. The technical staff composition, to be headed by a foreman of certified experience in the execution of piling works, along with the name of his deputy who must also have same qualifications.

d. A method for testing the sequence of concreting operation in the piles being constructed (see also sub-clause 9.6.2).

9.1.4. Work Execution Programme - Pile Register

The Contractor must submit to the Service for approval a programme showing the sequence and duration of excavation and concreting operations for the construction of piles, in a manner ensuring that no damage is caused to adjoining piles. On a daily basis, the Contractor shall keep the Service informed of the work programme for the next day. The Contractor shall keep a detailed register with all relevant data for each pile constructed. A copy of such register shall be submitted to the Supervising Service, signed by the foreman of the pile construction company in-charge of the operations and by the Contractor.

9.1.5. Setting-out of Pile Positions - Tolerances

(1) The setting-out of the pile axes shall be executed by reference to the most reliable lines as per the design (for bridge foundation piles, the setting-out is usually referred to the road centreline, while for building works the setting-out of piles usually depends on the building lines or street lines).

(2) Prior to construction, each pile position is secured by appropriate means. Following construction, the actual pile centre shall not be permitted to deviate from the theoretical position by more than 75mm in each direction. On the other hand, and for vertical piles, the maximum permissible deviation of the pile axis from the perpendicular shall be by n = 0.015 (= 1 : 66.7). For inclined piles, the maximum acceptable deviation of the axis from the slope specified is by 1 : 25.

(3) Violent and subsequent repairs of constructed piles shall not be allowed.

(4) The pile diameter must not be less than the one specified by the design and by the other tender conditions.

(5) Piles found to be defective at any time and for any reason shall be subject to rejection by the Service, while all restoration costs related thereto shall be borne by the Contractor.

9.1.6. Supervision of Pile Construction Works

In the course of pile construction works, the foreman in-charge or his deputy representing the pile construction company must attend the site on a permanent basis on behalf of the Contractor.

A relevant form shall need to be regularly filled at the works site for each pile constructed, and shall be daily brought to the attention of the Service by the Site Engineer or by his representative. The form shall be in accordance with the Table 1 that follows

TABLE 1 :
REGISTER OF CAST-1N-SITU PILES

Company• ....

Works Site ....

Pile Drawing ....

Cast-in-situ Pile No'

Pile Category:

Compression/Traction Pile

STRATA SEQUENCE

Meters below borehole level	Meters above natural ground (datum)	Soil formation and its composition	Grounwater	Data fur the boring equipment and the pipe casing from ....in to, ...in
f 0	❑	borehole	level	

1. Pile Characteristics

1.1 Pile diameter............cm (external casing dia.)
1.2 Pile base diameter ....cm
1.3 Pile base height .... cm
1.4 Pile inclination ....
1.5 Pile head ....m below borehole level
1.6 Lower edge of pile base ....m below borehole level
1.7 Pile length ....in (figure 1.6 minus figure 1.5)
1.8 Borehole void ....m
1.9 Depth of pile adhesion to bearing stratum .... m

2. Boring Operation

2.1 Cutting ring external diameter ....cm
2.2 Depth of borehole excluding base.....................m below borehole level,
Depth of borehole including base ....m below borehole level
2.3 Quantity of bored material (calculated on the basis of 2.1 and 2.2 figures):
Shaft .... liters
Base .... liters
Total .... liters
2.4 Test of vertical position and of borehole bottom elevation:
- after boring completion ....m below borehole level
- after under-reaming................m below borehole level
- before casting concrete ....m below borehole level

3. Pile Reinforcement

3.1 Longitudinal reinforcement ...., dia .. mm, BS................
3.2 Transversal reinforcement (coils) ...., dia ......mm, BS...........
3.3 Thread pitch ....
3.4 Frame height
Above the pile head ....m
Below the pile head .... m
Total ....m
3.S Joints (welded)

4. Pile Concrete

4.1 Strength category: B..............., Concrete class: BI/Blil ....,

Cohesion KIII/fluid concrete.

4.2 Site prepared concrete/Ready mixed concrete Cement

4.3 category. Supplier factory.

4.4 Cement quantity .... kg/cu.m.

4.5 Concrete aggregates (maximum size)

4.6 Water/Cement ratio (WIC = water weight/cement weight) Concrete

4.7 admixtures

5. Casting of Concrete

5.1 Water table inside borehole casing upon commencement of concreting operations ....m below borehole level

5.2 Concrete supply hose (dia ....cm/supply bucket)

5.3 Proof of concrete quantity used ....

6. Work Execution Periods

Work stages	Weather conditions	Temperature VC	Duration from	to	Date	Signature
		Boring				
Stoppage						
Under-reaming						
Concreting						

7. Deviation of Actual Pile Position from the Specified one (measurements i inside borehole) sec drawing.

Pile head ex

ey =

Pile slope An%

K. Remarks and Peculiarities :

Foreman In-Charge of Piling Operations **Site Engineer**

9.1.7. Preliminary Action

(1) The Contractor is bound to erect work platforms at each pile-cap location, at no extra payment. Such platforms must be horizontal, fixed not less than 50-70cm above the level of cutting-off of the piles. They must withstand normal wear due to the various pile construction plant.

(2) The positioning of the protective casing must be checked by the Contractor and approved by the Supervising Service.

9.2. PILE CONSTRUCTION MATERIALS

9.2.1 Pile and Pile-Cap Concrete Materials

(1) Unless otherwise specified herein, all concrete preparation materials shall be as specified in clause 6 hereof, entitled Concreting (clause **6.4).**

(2) Cement shall be type I, or II (and IIa), or III, or IV**,** and of suitable strength category to achieve the required concrete qualities for the works of this specification. The cement type and strength category shall result from the concrete mix design on the basis of a well-documented proposal.

(3) Aggregates shall be according to the specification of clause 6 hereof. Concrete mixes both for piles and for pile-caps must not contain aggregates larger than those having a dia equal to 32mm. It is possible in this case to use also natural aggregates (rounded, not crushed), otherwise complying to the aggregates of clause 6 hereof, in accordance with **a** well-founded proposal of the concrete mix design. Aggregates shall consist of three sizes, (two for stone ***and*** one for sand). They shall lie within sub-zone ❑ of the tables of clause 6 hereof.

(4) Water shall be from normal water supply network. Otherwise, the relevant provisions of clause 6 hereof shall apply.

(5) Should any concrete admixtures be required, they shall be determined through the concrete mix design that shall need to be performed for pile concrete according to sub-clause 6.5 of clause 6 hereof.

(6) With regard to storing, sampling, quality control etc. of concrete preparation materials both for piles and for pile-caps, the provisions of clause 6 hereof shall apply.

(7) Should factory prepared concrete be used in accordance with **the** provisions of the present specification, then the stipulations of clause 6 hereof shall apply.

9.2.2 Properties of Pile Concrete

(1) Piles and caisson piles shall be constructed of a concrete category having a characteristic strength not less than 25 MPa (250 kg/sq.cm.) in accordance with clause 6 hereof and otherwise in accordance with DIN 1045 (the recentmost version in force).

(2) Cement content should not be less than 400 kg/cu.m. of concrete for cement of any type and any strength category. In any way, maximum cement content should not exceed 500 kg/cu.m. of concrete.

(3) Concrete slump must exceed 100mm, usually in the order of 200-220mm.

(4) The concrete mix design (see sub-clause 6.5 hereof) to be performed in view of pile concrete preparation must make a special provision for ensuring the appropriate mix viscosity in order to avoid blockages of concrete supply hoses used in pile construction. Sieving tests must be executed prior to acceptance and stockpiling of aggregates to check compliance of their grading to that specified by the concrete mix design. This will make sure of achieving normal flow of hose-supplied concrete, as required for pile construction.

(5) The concrete mix design must also provide a concrete strength development curve by means of sample testing conducted at least at both 7 and 28 days (such specimens to be normally cured in accordance with DIN 1048), together with a water/cement ratio curve according to sub-clause 6.5.2.3.3 of clause 6 hereof.

9.2.3 Properties of Pile-Cap Concrete

(1) Pile-caps shall be constructed of a concrete category having a characteristic strength equal to 15 or 25 MPa (150 or 250 kg/sq.cm respectively), in accordance with clause 6 hereof, depending on the specifications of the approved technical design.

(2) Irrespectively of the strength category, the value of cement content must lie within upper and lower limits as specified for pile concrete under sub-clause 9.2.2(2) hereabove.

(3) The concrete slump must suit the individual conditions of the specific pile-cap construction work (density of reinforcing rods, concreting under water, etc.), but, generally, the concrete shall be prepared to belong to the categories of "plastic" and "semi-fluid" concrete (having a slump greater than 3cm).

(4) According to clause 6 hereof, it is established that, for pile-cap construction works, the Contractor shall be bound to perform and submit to the Service a concrete mix design, as mentioned in above sub-clause 9.2.2(5).

9.2.4 Quality Control of Concrete

(1) The compression strength of regularly cured 20cm cube specimens tested at 28 days shall be used as quality control criterion for acceptance of pile and pile-cap concrete.

(2) The distinction of concrete "portions" in accordance with sub-clauses 6.13.3 and 6.13.5 hereof shall apply for testing compliance of pile concrete. However, and in addition to this, the distinction of concrete portions shall be based also on the following :

a. Further to the condition of maximum concreting volume of sub-clause 6.13 hereof, not more than the first ten (10) piles of the project shall be considered to constitute a unified portion of concrete to be sampled in accordance with the stipulations of sub-clauses 6.13.3 and 6.13.5 hereof for testing concrete compliance at the age of 28 days. Additional samples shall be taken from the same mixes for normal curing and subsequent testing at 7 days for comparison with the strength development curve supplied by the concrete producing factory (in case of using ready-mix), or resulting from the preliminary tests referred to under sub-clause 6.13.5.1 hereabove (in the case of site produced concrete). (As a rule, the provision of sub-clause 6.13.4 for site produced concrete for minor works" shall not be applicable in this case, unless specially instructed in writing by the Service, or that a relevant condition thereto is included in the tender documents).

b. After the first ten piles, subsequent portions of concrete shall be constituted by not more than 25 consecutive piles each time. In accordance with the stipulations of sub-clauses 6.13.3 and 6.13.5 hereof, each one of such portions shall be sampled with the purpose of conducting 28-day concrete compliance tests. The specimens shall be drawn from fresh concrete according to the provisions of clause 6 hereof. Should the concrete mix vary in the course of pile construction works, or that concrete be supplied from different sources, such operations shall be conducted as if a new, different project is concerned each time.

c. For each category of concrete strength, not more than the first pile-cap of the works (taking also into account the condition of maximum concrete volume as per sub-clause 6.13 hereof) shall be deemed to constitute **a** unified concrete portion, for which the provisions of sub-clause 9.2.4(2) hereabove shall apply regarding required samplings and tests.

d. Further to this, and for each category of concrete strength, not more than three (3) subsequent pile-caps shall be deemed to constitute **a** concrete portion, for which the stipulations described as above under sub-clause 9.2.4(2)b shall apply with regard to required samplings and tests.

(3) The above process of portion definition shall commence anew after each variation of the concrete mix, or change of concrete supplier, as if a new project were concerned.

(4) Clause 6 hereof shall apply with regard to all other concrete quality control activities.

9.2.5 Production of Concrete

Clause 6 hereof shall apply.

9.2.6 Steel Reinforcement

9.2.6.1. Pile Reinforcing Rods

The quality of steel reinforcement shall be as described on the drawings. During bending and subsequent concreting operations, reinforcing bars shall be cleared of all surface rust. Crossing rods shall be carefully tied with wire, A unified reinforcing frame shall be constructed for the whole pile length. The frame design geometrical characteristics shall be achieved and secured by means of provisional auxiliary supports necessary for the shape-up of a solid frame. Overlapping of longitudinal rods shall be in accordance with DIN 1045/1972. Stirrups shall tightly encircle longitudinal rods. The required cover of reinforcement and symmetrical positioning of the frame inside the borehole shall be obtained with the use of special spacer blocks. Welding of reinforcing rods shall be permitted only if performed according to DIN 4099.

9.2.6.2. Pile-Cao Reinforcing Rods

The general requirements for steel rods of reinforced concrete shall apply.

9.2.7 Mechanical Equipment - Provisional Protective Casino

The Contractor shall provide all the required mechanical equipment and installations for the construction of cast-in-situ piles, together with sufficient quantities of protective pipe casings during excavation and the necessary equipment for casing withdrawal. No compensation shall be paid for any pipe casings that may not be possibly recovered. Casings bearing obvious wear or fatigue signs shall not be accepted.

9.2.8 Drilling Fluid

(1) Bentonite suspension may be used as drilling fluid following the Service's approval for securing the hole sides.

(2) Supply.

Prior to being mixed with water, bentonite brought onto the works site shall be tested for compliance with specification DFCP 4 of the Oil Companies Materials Association.

For each bentonite powder consignment, the Contractor shall require the supplier to provide a quality certificate indicating the properties of the quantity received. Such quality certificates shall be deposited with the Supervising Service. The supplier must indicate the fluctuation breadth both for apparent viscosity and for gel strength of particles in the water.

(3) Mixing.

Bentonite shall be carefully mixed with clean water to create a suspension that shall ensure stability of the borehole sides for the period necessary to place concrete and construct the pile.

The water temperature for mixing the bentonite suspension and for using it in the pile hole must not be less than 5°C.

If salted or aggressive groundwater is encountered, special protective measures shall be taken as proposed by the Contractor to secure an appropriate suspension for the construction of piles.

(4) Testing.

a. Prior to commencement of the works, the Contractor shall propose to the Supervising Service the frequency of drilling fluid tests and the sampling method. Such frequency may vary according to the consistency of the test results.

b. Suitable devices shall be used for carrying out bentonite suspension trial tests.

c. The density of newly prepared bentonite suspensions shall be measured once daily to control the suspension quality. (The gauging equipment must be regulated to ensure an accuracy of 0.005 grlcu.cm).

d. Bentonite suspension in a pile borehole shall also be tested for density, viscosity, shear strength and PH' value. Test results for average soil conditions should lie within the limits indicated in Table 2. Tests shall be repeated until achieving a consistent correspondence of results to the working method applied. The mixing process must take into account all addition of fresh or previously used bentonite suspension, together with any procedure for removing foreign matters from previously used suspensions. When results prove adequately consistent, shear strength and PH tests may stop, while density and viscosity tests may continue at a frequency to be agreed upon with the Supervising Service.

   In case of modification of the working method applied, shear strength and PH tests shall be repeated for a period conforming to the provisions hereabove.

e. Notwithstanding all the above, the Contractor shall remain sole responsible for maintaining the characteristic properties of the bentonite suspension within the pile borehole. Depending on local conditions, the Contractor may modify the characteristics indicated in Table 2 herebelow, following a well-documented proposal. On the basis of a similar justified proposal, he may also propose to modify the testing methods applied. Any modification of characteristics or of testing methods shall be subject to the Service's approval.

f. Should a bentonite suspension be intended for re-use after completion of a pile concreting operation, appropriate means must be available at the works site for releasing such suspension of any foreign matter, i,e. sand removers for removing sand and coarse aggregates. Special attention shall be attached to removing unwanted fines while making sure of maintaining the characteristics of Table 2 herebelow in the mixture of fresh and re-used suspensions.

(5) Depending on local conditions, the Contractor may opt to use a different drilling fluid, following a documented proposal by a specialized pile manufacturer meeting with the Service's approval. It is, however, clarified that the Contractor shall be sole in bearing both criminal and civil liability for selecting the drilling fluid that shall be used in the performance of the works. In view of using any new drilling fluid, the Contractor shall be bound to submit proof of the latter's successful application in similar works, together with the methods of performing quality control for same.

T A B L E 2

CHARACTERISTICS OF BENTONITE SUSPENSION IN A PILE BOREHOLE UNDER AVERAGE SOIL CONDITIONS

Measured Property	Result Fluctuation for 20°C	Testing Method Applied
Density	Lower than 1.10 gricu.cm	Mud Density Balance
Viscosity	30 - 90 sec (d) or less than 20cP (c)	Marsh Cone Method Fann Viscometer (a)
Shear Strength or Gel Strength 10'	1.4 - 10 N/sq.m 4 - 10 N/sq.m	Shearometer Fann Viscometer (a)
PH	7.5 - 12 (b)	PH indicative tapes, Beckman apparatus, etc.

(a) When Fann Viscometer is specified, then the suspension sample must first pass through a BS screen N'52 (0.3mm) prior to performing the test.

(b) Special attention is required for PH values exceeding 10.2, as the suspension may lose its properties. It is recommended that PH values for suspension water vary between 7.00 *and* 8.50.

(c) cP = Centipoise (a hundredth of poise): unit for measuring viscosity, 1cP = 1m Pas.

(d) The time of Marsh cone evacuation usually varies between 38 and 41 seconds.

9.3. <u>BORING HOLES FOR PILE CONSTRUCTION</u>

9.3.1 <u>General</u>

(1) With the purpose of avoiding any damages, it is not permitted to bore holes for pile construction in the vicinity of other recently concreted piles, when their concrete is still workable, or of pile boreholes still without concrete.

(2) Boring products shall be hauled in accordance with the Service's instructions either within the works site area (for provisional deposits or for using in fill construction), or to any distance to be dumped on sites authorized by the Police Department.

9.3.2 Boring Equipment

The type of boring equipment must be suitable in view of the specific soil and groundwater conditions. The selection of appropriate boring equipment shall be based on the criterion of averting the loosening of ground consistency around the pile perimeter and under its foot. It is a fact that such slackened conditions are often observed after the lapse of some time, therefore rapid boring equipment should be preferred, while the effort must be to minimize time between boring completion and concreting operations. Should the borehole sides be secured through drilling fluid overpressure, such condition must not be substantially affected by the removal of the cutting equipment, as this acts as a ram during withdrawal of the boring machine.

9.3.3 Boring with Provisional Protective Pipe Casing

(1) Provisional protective pipe casings are used either throughout the hole or along sections requiring protection of the sides. The casings must bear no conspicuous surface deformities. In order to ensure smooth concreting operation, their internal surface must be free of all protruding parts or dried staff from previous concreting.

(2) Even in the case of sides secured by another method, a small casing section shall be used at the top of the hole to ensure local support and to stop surface materials from falling within.

(3) Provisional pipe casings along boreholes aim at protecting the surrounding ground against turning slack in the course of the boring process. They are mandatory when bored ground is unsafe and may subside or collapse, even when a supportive drilling fluid is used.

(4) When boring below groundwater table, water or other supportive drilling fluid (usually bentonite suspension) overpressure shall be maintained constant inside the borehole, in order to avert hydraulic breakage of surrounding soil towards the interior of the hole and to safely block entry of isolated soil portions due to ingress of groundwater into the bored pile hole.

(5) Depending on the nature of the ground, the pipe casing shall more or less precede the boring, in order to avoid slackening of the bottom material in the course of boring. For soft cohesive or non-cohesive soils, specifically fine sand or silt below groundwater table, the casing must necessarily precede by about half the borehole diameter. When soil tends or is observed to heave up from the bottom, the casing precedence or the supportive drilling fluid overpressure must be increased. if the soil nature does not allow furthering the casing precedence, then the fluid overpressure must be increased, possibly by extending the casing with additional pipe sections fixed even above the ground. In stable and cohesive soils, it is not always possible for the pipe casing to precede the boring, but then again it is not quite necessary.

(6) The boring machine should not precede, but the casing should follow immediately after boring. In order to achieve this and obtain penetration, sufficient vertical driving force must be applied onto the pipe casing in addition to torque.

(7) It is not permitted to drive the provisional protective pipe casing into the ground with the method of hydraulic underexcavation (using excavation under water pressure).

(8) If, at the end of boring, the pile base does not require widening, the ground must be cleared to the bottom of the casing in order to avoid slackening of the ground under the pile base during casing withdrawal. Given that, in this condition, the borehole bottom is exposed to the risk of going slack due to the removal of ground load corresponding to the pipe casing precedence, concreting of the pile should follow immediately after bottom clearing. With a view to avoiding slackening of the pile surrounding ground when boring is accompanied by pipe casing, the boring machine precedence to the bottom of the casing must be maintained the least possible. Pipe casing is not permitted to be driven using hydraulic underexcavation.

9.3.4 Boring without Pipe Casing

The protective pipe casing may be omitted when boring through stable ground. When boring without casing through loose soil strata tending to collapse, the hole sides must be supported by means of drilling fluid overpressure. In this case, it may be useful to drive a casing in a posteriori.

The construction of bored piles without using casings may cause slackening of surrounding non-cohesive soils, particularly natural gravel or stone, or a superficial softening of the borehole sides in cohesive soils. In the case of bentonite suspension being used as supportive drilling fluid, it is possible that the pile strength may be adversely affected due to the formation of a filter layer. Given that slackening or softening of the surrounding ground may be accelerated with time in boreholes without casings, concreting operations must follow immediately after boring. A casing of a few meters must be provided for protecting the top section of the borehole against subsidence caused by surface activities.

9.3.5 Widening of Pile Base

The present specification makes no provision for piles with widened base.

9.3.6 Drilling Fluid Overpressure

(1) If drilling fluid is used with the purpose of retaining borehole sides, its surface level must be such as to overcome the soil and groundwater pressures, and, anyway, not less than 1.00m above the groundwater table.

(2) In the case of boreholes without casings, the drilling fluid overpressure required for supporting hole sides shall mainly depend on the type of the protective fluid, the borehole diameter, the nature of the ground, particularly its strength, and, in the case of non-cohesive soils, on its grade analysis.

(3) In the case of a high groundwater table, it may prove necessary to extend the pipe casing well above the ground surface in order to obtain the required overpressure. When boring under free water, this condition shall apply to the water surface instead of the natural ground surface.

(4) When boring without casings, the above reasons shall make it necessary to drive at least a few pipes through the upper part of the borehole to exceed the ground surface, in order to achieve the required overpressure inside the borehole.

(5) The precise gauge of overpressure and the appropriate supportive drilling fluid must be reliably selected in each case by the pile Contractor on the basis **of** his experience.

9.3.7 Obstructions during Boring

(1) In the case of sudden loss of the drilling fluid, the borehole must be immediately backfilled with suitable material and recompacted. Boring may be resumed in the same location only following the Supervising Service's instructions.

(2) When removing boring obstructions, any loosening of the natural ground must be avoided. A pile may not rest on an obstacle lying over the pile theoretical base.

(3) Abandoned boreholes must be properly backfilled with suitable soil or concrete and carefully compacted.

9.3.8 Water Pumping off Boreholes

No water pumping shall be allowed off boreholes unless a provisional pipe casing has been driven in up to stable soil. impeding substantial water quantities from filtering into the hole through other strata, or unless it is otherwise proved (and approved by the Service) that the pumping may have no adverse effects onto the surrounding subsoil and adjoining land sites.

9.3.9 Protection against Pollution caused by Bentonite Suspension

(1) All necessary steps shall be taken aiming at avoiding diffusion of bentonite suspension or other drilling fluid over the site area, with the exception of the pile hole immediate vicinity.

(2) All disused bentonite suspension (or other drilling fluid) shall be immediately removed from the works site.

(3) Bentonite suspension or other drilling fluid shall be rejected to any distance from the works, over sites authorized by the Police Department and approved by the Supervising Service.

9.3.10 Testing Ground Sections

The ground performance during boring process shall be closely followed. Each pile must be driven to a depth reaching bearing stratum. Soil strata as encountered must be shown in the pile record forms in order to allow checking and completion of ground sections. Should the subsoil nature under piles give rise to any doubts, a supplementary soil investigation shall have to be conducted according to a programme prepared by the Contractor and approved by the Service, to be paid for under a separate fee.

9.3.11 Borehole Clearing

Upon completion of boring, the bed of the hole shall be cleared of all loose remainings and consolidated by ramming. A small quantity of aggregates or dry concrete mix may be used.

9.3.12 Borehole Inspection

Before the reinforcement frame positioning and before concreting, the borehole shall be inspected both by the Contractor and by the Supervising Service. Dry boreholes having diameters up to 0.75m shall be inspected from the ground surface. For dry boreholes of diameters greater than 0.75m, the Contractor shall be bound to provide (without additional fee) suitable equipment for lowering staff (the Contractor's or the Supervising Service's) into the hole with the purpose of carrying out proper inspection of same. From the point of view of safety precautions, all equipment and measures applicable in the course of hole inspection shall comply to the British Regulation C.P.2011 (Safety precautions in the construction of large diameter boreholes for piling and other purposes).

9.4. STEEL REINFORCEMENT OF PILES

9.4.1 General

(1) The provisions of DIN 1045/1972 shall apply with regard to preparing and positioning reinforcements, unless otherwise specified in DIN 4014/Part 2 (preliminary draft of September 1977), the provisions of which supersede those of DIN 1045/1072.

(2) Reinforcement design requirements must be strictly observed as per par. 5 of DIN 4014/Part 2 (preliminary draft of September 1977).

(3) The unified prefabricated one-piece reinforcement frame shall be positioned immediately after completion of boring.

(4) Pile reinforcing rods must protrude above the final level of pile heads (after cutting off of the pile head) by not less than the length required for the reinforcement satisfactory adhesion onto concrete, with a view to ensuring anchoring of each pile into the pile-cap.

(5) Stirrups shall not be allowed to be less than dia. 8mm, or to be spaced at more than 25cm.

9.4.2 Formation of the Frame of Reinforcement

The frame must be adequately rigid to avoid deformation during transportation and positioning. Special spacer blocks must be provided, unless a minimum concrete cover of 5cm is secured by the pipe casing. Anchoring of reinforcing rods must comply with DIN 1045/1972, pare 18.3. Appropriate measures must be taken, i.e. incorporation of iron blade cross supports, to ensure steady positioning of the frame in the course of the casing extraction.

9.4.3 Interconnection of Reinforcing Rods

Interconnection of reinforcing rods must be avoided to the extent possible. Should such interconnections be finally performed, they shall be subject to the constraints of para 18.4 of DIN 1045/1972.

9.4.4 Quantity Surveying - Payment for Pile Reinforcement

Unless otherwise specified in the terms of tender, pile reinforcement shall be measured and paid for under the items related to steel reinforcement, according to the general clauses regarding steel reinforcement of the price list included in the Contractor's bid.

9.5. PILE CONCRETING

9.5.1 General

(1) Unless otherwise herein specified, the specification of clause 6 hereof shall apply with regard to concrete preparation and transportation. The provisions of sub-clauses 9.2.1, 9.2.2, 9.2.4 and 9.2.5 hereof shall apply with respect **to** the composition of the concrete mix, the materials required for its preparation and its quality control.

(2) Concreting must be assumed the earliest possible after completion of boring and positioning of reinforcement. Pile concreting shall be carried out in a continuous operation, without interruption or construction joints. In exceptional cases of brief concreting interruptions, delayed setting compounds must be used in order to avoid any damaging effects.

With the exception of the Supervising Service's explicit instruction to the opposite, concreting shall not be allowed to commence if attaining completion appears doubtful for any reason whatsoever. For the same reason, the Service may impede the conduct of boring operations at a progress rate faster than that of concreting. Under each case, namely concreting under water or in dry conditions, the Contractor shall be bound to submit for the Service's approval a detailed description of the concreting method envisaged (see sub-clause 9.1.3 hereof).

(3) In the course of concreting, it must be ensured that the envisaged mix and degree of workability reach up to the bottom of placement without segregation or pollution of the concrete, and that the concrete column is not interrupted by any narrow passages. It is for this reason that, even for concreting under dry conditions, a concrete supply hose or pumping hose must be used, reaching the borehole bed at the beginning of the concreting operation.

(4) The advisability of internal vibration must be investigated with respect to areas of workability of concrete as specified under sub-clause 9.2.2 hereof, due to the risk of concrete segregation.

9.5.2 Borehole Concreting under Dry Conditions

Concrete shall be poured through a hose and funnel, whenever required, to avoid disturbing the hole sides and the frame of reinforcement. On the other hand, appropriate steps must be taken to avoid segregation of concrete ingredients and washing out of aggregates. Furthermore, the level of concrete must be maintained above that of the lower end of the provisional protective casing during the latter's parallel and phased withdrawal.

9.5.3 Borehole Concreting under Water or under Drilling Fluid

(1) With regard to this concreting operation, the stipulations of sub-clauses 6.12.5 and 6.12.6 of Concreting specification, clause 6 hereof, shall apply accordingly.

(2) It is, however, specifically mentioned that concreting shall be in accordance with a recognized method to be presented by the Contractor for the Service's approval (see sub-clause 9.1.3 hereof).

(3) The following are also pointed out in this respect

a. The concreting hopper and hose must be in good condition and watertight.

b. Prior to beginning concrete placement, it must be made sure that no mud concentration or mud polluted drilling fluid (i.e. muddy bentonite suspension) lies on the borehole bed. A suitable sampling device shall be used to sample the bentonite suspension at the pile base. Concreting shall be blocked if the sample specific gravity is found to exceed 1.25 gricu.cm. In such case, the Contractor shall be bound to improve or replace the bentonite suspension to enable it meet its specified characteristics.

c. Particular attention shall be attached to avoiding any concrete damage caused by water pumping or by reduction of the groundwater table during concreting or soon after it.

d. Throughout concreting operations, a sufficient quantity of concrete shall be maintained in the concrete supply hose, with the purpose of ensuring that its pressure exceed that of water or of the drilling fluid.

e. The internal diameter of the concreting hose shall not be less than 150mm for concrete of a maximum grain size equal to 20mm, or less than 200mm for concrete with a 32mm maximum grain diameter.

f. The concreting hose must carry a minimum of protruding elements to allow its manoeuvering through the frame of reinforcement without causing any damage. Similarly, the hose must carry no protrusions on its internal surface.

g. Special measures must be taken to avert direct contact of concrete first introduced into the borehole with water or drilling fluid (i.e. by means of a water displacement "valve" operating through the concreting hose).

9.5.4 End of Concreting Operations

(1) Concreting shall be carried on for not less than 0.30m to 0.60m above the final pile heads, to allow for future removal (the fact remaining that the last amount of concrete shall always be left virtually unconsolidated, uneven and defective from all viewpoints).

(2) In the case that the final level of the pile heads **fixed** in the design is found to lie below the groundwater table, the Contractor shall be responsible for submitting to the Service his proposals for dealing with the matter prior to the commencement of concreting operations. Concreting of the specific pile shall proceed to the point that the remaining part, after cutting off **the upper** head section, may be above the groundwater table, unless other appropriate steps have been taken by the Contractor as approved by the Service.

(3) The upper section of the pile hole, not being concreted, shall be filled temporarily with suitable granular material of negligible plasticity (i.e. sand, gravel or concrete stone) and properly compacted to the plant working floor level or not less than 0.50m below it, in a manner ensuring the works continuity and safety.

9.5.5 Withdrawal of the Provisional Casing

(1) The withdrawal of the provisional protective pipe casing shall be performed gradually and while concrete is sufficiently workable to avoid concrete being carried upwards during the extraction. Furthermore, such withdrawal operation shall need to be carried out slowly, at a uniform speed and with due care to avoid the creation of any voids in the mass of concrete, of any cracks to the concrete column, or narrowings of the pile section.

(2) A sufficient amount of concrete should be inside the casing (not less than lm-high) in the course of withdrawal, to overcome the soil or groundwater or drilling fluid pressure and thus avoid the formation of a narrowing in the concrete section and of concrete mixing with mud or other soil material.

(3) Vibrating extractors of the provisional casing may only be used following the Service's approval, which can be withheld if in his opinion :

a. Prohibitive noise and disturbance conditions are caused to users of adjoining properties.

b. Safety risks are created to utility networks and to adjoining structures.

9.6. QUALITY CONTROL OF CONSTRUCTED PILES

9.6.1 Checking the Borehole Bed Providing Pile Seat

(1) An amount of fine material may be concentrated on the borehole bed between its final cleaning and beginning of concrete placement (considering the time period required for lowering the frame of reinforcement into the borehole and fixing it in place), depending on the nature of the bored ground, the groundwater conditions and the pile depth. If the pile is allowed to rest on such loose ground, an inadmissible subsidence may follow the pile loading extending up to the point of the pile foot encountering the bearing stratum it was originally designed for.

(2) In this case, the Service may instructor the Contractor may propose and the Service may approve to incorporate throughout the pile length two (from top to bottom) steel pipes of dia. not less than 3', preferably 4", after taking into account the resulting reduction of the pile section and the corresponding effect onto its bearing capacity.

(Such action may thus have a cost effect in the case of small diameter piles, due to the substantial impairment of the pile section).

The lower ends of the two pipes shall be plugged with concrete or plastic caps to block concrete coming up through the steel pipes. The pipes must be absolutely straight, and an effort shall be made to maintain them straight throughout the concreting operation by protecting them from any kind of blow.

(3) Upon completion of the pile concrete placement, the pile bottom ground shall be sampled by means of borings performed through the steel pipes. Should any loose ground material be found under the pile base, such material shall be properly removed'. The vacuum thus left shall be filled in by grouting procedure, and then the two steel pipes shall be replenished either with grout or with fine concrete. The bottom corrective process is thus completed.

(4) In case of such works not being provided for in the project Bill of Quantities, they shall be paid for to the Contractor through the compilation of a Protocol for the Regulation of Unit Prices for New Works (P.R.U.P.N.W.) and the corresponding amount shall be recovered from Contingencies.

9.6.2 Controlling the Continuity of Pile Concreting Operations

(1) Along with the submission of information regarding the pile construction method to be applied (see sub-clause 9.1.3 hereabove), the Contractor shall be bound to present to the Service also his proposed method for controlling the continuity of pile concreting operations without causing any damage to the works (non-destructive methods, integrity tests) by using y-rays, sounding methods, etc.

Such method must be formulated in collaboration with a specialized consultant.

(2) The Contractor is bound to present the method of controlling the continuity of pile concreting operations even in the case that no such work was provided for in the Bill of Quantities and the Price List of the Contract (unless otherwise specified in the tender conditions).

(3) In the case that the execution of such works is provided for in the contract documents, the Service shall retain his right either to implement the whole programme to the quantities indicated in the project cost estimate, to reduce it by not more than 25%, to increase it depending on the project requirements, or, finally, to eliminate it altogether.

(4) If no such works are provided for in the contract documents, they shall be executed either according to the Service's instructions, or upon the Contractor's proposal and the Service's approval. In this case, payment of the works shall be effected on the basis of a P.R.U.P.N.W. and shall be charged to the item of Contingencies.

9.7. REJECTION OF DEFECTIVE PILES

(1) It is hereby emphasized that all necessary precautions must be taken during concreting to avoid problems related to incomplete sections (i.e. narrowing formation, concrete mixing with soil, etc.). For this reason, the whole operation must be continuously supervised by an experienced engineer or foreman.

(2) In addition, the quantities of concrete used must be continuously compared to those theoretically required for the various consecutive levels of the pile construction.

(3) In all cases, the Contractor shall be sole responsible for the wholeness of the construction.

(4) When sufficient evidence is provided to the imperfect construction of certain piles (i.e. based on test results as per sub-clause 9.6.2 hereof, or on concrete consumption data as compared to theoretical ones), same piles shall be subject to rejection depending on the opinion of the Service, and all resulting additional costs or loss of time shall be borne by the Contractor.

9.8. CUTTING OFF OF PILE HEADS

The cutting off of the head of the piles shall be to the levels established on the drawings, following the pile concrete having acquired the desired strength. Attention must be made to avoid causing any damage to the protruding parts of the reinforcing rods.

9.9. TRIAL LOADING OF PILES

9.9.1 General

(1) The Contractor is bound to execute one or more trial loadings on operational or non-operational piles, according to the Service's instructions. An extra payment is provided for the work of trial loading.
(2) The construction of operational or non-operational piles that shall be subject to trial loading tests shall be paid for in accordance with the applicable contract prices.

9.9.2 Trial Loading of Non-Operational Piles

Non-operational piles shall be constructed at positions as instructed by the Service and by application of the same methods as those used for operational ones. In order to make possible the deduction of precise conclusions regarding the relation between load and settlement as well as the bearing capacity, a maximum trial load may attain twice the value of the corresponding design load.

Such conclusions will allow verification of the design assumptions, or may entail their appropriate revision. Trial loads shall be executed prior to the construction of operational piles.

9.9.3 Trial Loading of Operational Piles

After completion of the pile construction, the Service may order the execution of trial loading on any operational pile, under separate payment. The level of loading may reach 150% of the operational load, while the Service shall issue special instructions as to the duration of application of each loading step.

In all cases, the arrangement made for the imposition of trial loads, together with the arrangement and the types of gauging instruments shall be recommended by the Contractor and approved by the Service. However, the load staff shall be any material to be used in subsequent construction stages (i.e. concrete aggregates), with the purpose of minimizing additional expenses. Finally, the Contractor shall present and evaluate the results of trial loadings executed.

9.10. EXCAVATIONS FOR PILE-CAP CONSTRUCTION

(1) Such excavation works shall concern the construction of pile-caps. Excavation levels are shown on design drawings.

Excavation works shall need to be conducted very carefully in order to avoid causing any damage to constructed piles, as well as to any public utility networks to be preserved under pile-caps or through their mass.

The sideslopes of excavations shall be vertical or inclined, always safe against falling ground, while their dimensions shall be such as to allow the normal conduct of operations necessary for the remaining pile-cap construction. Special attention shall be required when excavating close to adjoining structures, where a phased operation may be called for with simultaneous provisional shoring works for protecting adjoining building properties.

In such cases, the Contractor must submit for approval his proposals regarding the safe execution of the works. The bed of the excavation shall be cut horizontal and be maintained dry, unless water pumping causes appurtenant problems connected with the safety of sideslopes **or** of adjoining properties. Thereupon, the Contractor must submit to the Service his proposals for dealing with the situation.

(2) Clauses 3, 4 and 5 hereof shall apply in connection with the method of excavation, quantity surveying and payment for pile-cap excavation works.

(3) It is specifically clarified that the calculated volume of pile-cap excavation shall comprise the volume of the backfilled portions of non-concreted pile boreholes [see sub-clause 9.5.4(3)], as well as the volume of cut off pile heads [see sub-clause 9.5.4(1)].

9.11. CONCRETING PILE-CAPS

9.11.1 General - Preliminary Works

(1) The provisions of sub-clauses 9.2.1, 9.2.3, 9.2.4 and 9.2.5 hereof shall apply with regard to the required materials, concrete and quality control methods for same.

(2) The horizontal (or stepped) and dry bed of the excavation is covered with a lean concrete layer of B5 characteristic strength, to be used as working floor for the main pile-cap concreting operation.

(3) According to the design and the rest of the tender conditions, any waterproofing of the said surface shall follow after hardening of same.

9.11.2 Concreting of Pile-Caps

(1) All works shall be executed in compliance with the structural drawings, the dimensions and concrete qualities being strictly observed as specified therein.

(2) Concrete placement shall be taken up only after acceptance of formworks and reinforcement by the Service, to be conducted in accordance with the stipulations of clause 6 hereof.

(3) A steel-bender must necessarily attend concrete placement operations to perform any reinforcement corrective job that may be required.

(4) The floor of the blinding layer must be properly cleaned and sufficiently watered prior to beginning concrete placement.

(5) Concrete placement shall be assisted by frequent knockings onto the forwork external surfaces.

(6) Vibrators shall be used for the consolidation of concrete, unless the Contractor believes (and the Service agrees) that there is risk of the concrete being segregated, in view of the workability span selected. Consolidation shall be assisted by tampering on formworks.

(7) The upper surface of pile-caps shall be generally finished with plastic concrete of TYPE ΠΑ (unless otherwise specified in the tender documents), in accordance with sub-clause 6.15.7 of clause 6 hereof.

(8) Concreting interruptions must be avoided. They shall be allowed only following an approval by the Service, who shall indicate the related location, the duration permitted and the method of connecting fresh onto previous concrete. This shall generally require scraping of the previously laid surface, cleaning and washing off of the remains according to sub-clause 6.14.3 of clause 6 hereof.

(9) The specification of clause 6 hereof regarding concrete shall apply in all other respects, unless otherwise specified in this sub-clause.

(10) If, in accordance with the design and the other tender conditions, it is deemed necessary to block any upward movement of existing groundwater through the mass of pile-caps and the superstructure of piers, or towards columns, etc., all external surfaces of pile-caps shall be insulated, following removal of formworks, by application of a material conforming to the design, or, in absence of a relevant specification, of the Contractor's choice following approval by the Service.

9.11.3 Quantity Surveying - Payment for Pile-Cap Concrete

Blinding and main pile-cap concrete shall be measured and paid for as described in clauses 6.17 and 6.18 hereof for the respective work item mentioned in the Contractor's price list.

9.12. REINFORCEMENT OF PILE-CAPS

9.12.1 General

The stipulations of new DIN 1045/1972 shall apply with respect to bending and positioning of the steel reinforcement. Steel reinforcement of concrete must comply to steel categories, diameters, dimensions and forms as shown on the design drawings. Reinforcement shall be fixed in place only following acceptance of the formworks. Reinforcing rods shall be carefully and properly positioned, solidly tied at all crossing points with N°5 or larger wire, depending **on** the rod size and location. Hooks, if required, shall be of normal size and form. Special efforts shall be made to keep all reinforcing rods straight, to position them accurately and fasten them rigidly, to maintain their position steady during concrete placement and tampering, particularly where bars are negative (upper side), and to secure their adequate cover with concrete. Where necessary, provisional or permanent supports (rivets, check-pins) shall be provided.

Prior to commencement of concrete placement operations, the Service shall inspect fixed reinforcement for acceptance, ensuring its compliance to bending schedules as compiled by the design engineer and checked by the Contractor, or, in absence of such schedules, to bending schedules as compiled by the Contractor. Bending schedules shall be signed by the Contractor and reviewed by the Service for approval. Such approved schedules, including weights, shall constitute quantity surveying data accompanying acceptance certificates for inconspicuous works.

Protruding dowels shall be treated with protective paint.

9.12.2 Measurement - Payment for Pile-Cap Steel Reinforcement

Steel reinforcement of pile-caps shall be measured and paid for by steel rod category, in accordance with the general reinforcement items of the price list included in the Contractor's bid.

9.13. MEASUREMENT OF PILE CONSTRUCTION WORKS

(1) The measurement for pile construction works shall be conducted as follows, also according to the provisions hereof :

a. Installation - Removal of Equipment

It includes the installation on an appropriate location, as instructed by the Service, of the complete plant and other equipment necessary for the construction of bored (cast-in-situ) piles following removal of soil [in accordance with sub-clause 9.1.3(b)], and the removal of same plant and equipment after completion of the pile construction operations. Intermediate assemblies and disassemblies of the plant and equipment, as may be required prior to the completion of the works, shall not be accounted for.
The installation and removal of the plant and equipment shall be measured apiece, for lumpsum payment.

b. Pile Boring

Measurement shall be in lineal meters, per pile diameter. Actual borehole lengths shall be measured, as realized for the construction of respective piles, finally accepted. Borehole lengths shall be calculated from base level as envisaged by the design (or as modified during construction upon approval by the Service) to the level of the natural ground, as this shall be at the beginning of the pile boring operations (and as approved by the Service). No boring shall be measured in excess of the base level envisaged by the design or of its approved amendment.

c. Pile Concreting

Measurement shall be in lineal meters, per pile diameter and per category of concrete strength.
Actual lengths of concreted and finally accepted piles shall **be** measured. Pile lengths shall be calculated from base level as envisaged by the design (or as modified during construction upon approval by the Service) to the final level of concreted pile head envisaged by the design (or as modified during construction upon approval by the Service). No concrete volume shall be measured in excess of the approved base level, nor the cut off part of the pile head.

d. Backfilling Pile Boreholes with Granular Material

Measurement shall be in cubic meters of completed backfill of pile hole with granular material, following completion of concreting works, to the ground surface or just below it, according to sub-clause 9.5.4(3) hereof.
The pile nominal diameter shall be contractual diameter for the hole backfill, while the pile head final level (below which the pile concrete shall be calculated) shall be base level for the backfill.

REMARK :

Excavation, removal, etc. of this material to be subsequently performed during excavations for pile-cap construction shall be measured under same item as all other pile-cap excavations. Same applies to the volume of non-measured concrete of the cut off pile head.

(2) Works measured as abovementioned shall be considered to comprise the whole spectrum of works related to pile construction. Piles of the same diameter shall be measured under the same item, irrespectively of differences in the nature of ground encountered during boring, their location, depth, inclination, ground- or artesian water, the use of provisional protective casing or of drilling fluid, and irrespectively of difficulties in securing access to the site, in boring, driving in, extracting, concreting, pumping, etc.

(3)

a. In the case of a provision for the construction of bored piles (with removal of soil) belonging to more than one categories (i.e. varying diameters, inclinations, etc.), the item of "installation and removal of plant and equipment" shall refer to the overall plant and equipment required for the construction of all categories of bored piles with removal of soil.

b. If, due to the necessity of constructing large quantities of bored piles with removal of soil, is deemed necessary to bring on site more than one groups of similar pile construction equipment, this shall be considered only in cases provided for in the terms of tender (SCC, cost estimate, etc.), otherwise it shall be considered that the additional installation and removal of the extra equipment is reducely included in the measured quantities of the other pile construction works.

The same applies also for the case where, due to different geotechnical conditions, and is deemed necessary to bring on site different groups of pile construction equipment (e.g. pile construction equipment for soft soils and pile construction equipment for very hard soils).

9.14. PAYMENT FOR PILE CONSTRUCTION WORKS

(1) In accordance with measurements executed, pile construction works shall be paid for under four distinct work items, as follows :

a. Installation/Removal of Plant and Equipment

Payment shall be based on the respective lumpsum price of the price list included in the Contractor's bid, and shall be effected by half upon completion of the plant installation in full (in accordance with the provisions of sub-clause 9.1.3.b hereabove), and by the other half upon completion of the plant removal that shall take place after the completion of pile construction works.

b. Boring Holes for Pile Construction

Payment shall be based on borehole length, measured in lineal meters as hereabove defined under sub-clause 9.13.1(h) and multiplied by the respective unit prices of the price list included in the Contractor's bid.

c. Concreting Piles

Payment shall be based on the length of concreted piles, measured in lineal meters as hereabove defined under sub-clause 9.13.1(c) and multiplied by the respective unit prices of the price list included in the Contractor's bid.

d. Backfilling Pile Borehole with Granular Material

Payment shall be based on the volume of granular material, measured in cubic meters as hereabove defined under sub-clause 9.13.1(d) and multiplied by the respective unit price of the price list included in the Contractor's bid.

(2) The abovementioned individual prices and work payments shall include for the following

a. Installation/Removal of Plant and Equipment

1. All costs related to transportation of the complete mechanical plant (frame) and other pile equipment onto the works site, irrespectively of the number of times such transportation shall be effected (should it be required more than once until completion of the works), and irrespectively of the overall length of piles to be constructed.

2. All costs related to removal of the complete mechanical plant and other pile equipment from the works site, irrespectively of the number of times such removal shall be effected (should it be required more than once until completion of the works), and irrespectively of the overall length of piles to be constructed.

3. The converted effect of the cost of a compilation regarding the method of construction, and of submission of same to the Service.

The requirements of previous paragraphs 9.13.(1).a and 9.13.(3) apply herein regarding the quantities to be measured.

b. Boring Holes for Pile Construction

1. The cost of lay days and of overall hiring mechanical plant related to boring pile holes, for the whole period such plant shall be on the site including all kinds of delays, irrespectively of the length of individual piles and of the overall length of piles to be constructed.

2. The cost of transferring the relevant mechanical plant from one position to another over the same pier, or from one pier to another, irrespectively of the number of such transfers, of the individual and the overall pile length, until completion of the whole work.

3. The cost of boring the required hole to measurable length, depending on the diameter specified, in the manner described herein, irrespectively of the nature of the ground encountered during boring, the depth, location and inclination, ground- or artesian water, the use of provisional protective casing and/or of drilling fluid of suitable consistency, the difficulty of providing access, of boring, etc.

4. The cost for the supply, transfer onto the works site, mixing, using, loss and consumption of any quantities of drilling fluid (i.e. bentonite suspension or other), for the case of using such method, of suitable quality and properties for boring pile holes, along with taking appropriate measures and construction of appropriate structures for storing, feeding the hole, avoiding environmental pollution, removal and disposal of remains or disused quantities onto sites authorized by the Police Department or approved by the Service.

5. The cost for the supply, transfer onto the works site, driving in, extraction and removal of suitable provisional protective casings, for any stretch of the borehole such casing may be applied, including wear and/or total loss due to impossibility of extracting same, or for any other reason.

6. The cost for loading, lay days of hauling vehicles, removal of excavation (bored) products and dumping of same onto sites approved by the Service within the area of the works site, or haulage to any distance from such site onto areas authorized by the Police Department and approved by the Service, including the cost of depositing same on such areas.

7. The cost for compiling a record form for each pile, in accordance with relevant stipulations herein described.

8. The cost for any pumping that may be required, and for dealing with surface, ground or artesian waters.

9. All costs related to restoration of utility networks and/or of adjoining structures that may be damaged as a result of pile construction works.

c. Concreting Piles

1. The cost for hiring and for lay days of mechanical equipment related with pile concreting operations, throughout the duration such equipment shall be on the works site including all kinds of delays, irrespectively of individual and of overall length of piles to be constructed therewith.

2. The cost for transferring such equipment from one position to another within bounds of the same pier, or from one pier to another, irrespectively of the number of transfers, and of individual and overall pile length until completion of the works.

3. The cost of preparing the necessary setup, working floors, etc., required for the pile concreting operations.

4. The supply of all required materials (aggregates, water, cement, admixtures) and the mixing of the required quantity of concrete, or the supply of ready-mix concrete of suitable quality meeting specified requirements, all kinds of handling and transportation to the position of placement and concreting of piles in compliance with the method herein specified, its subsequent curing, etc., as described in the present clause or under clause 6 hereof regarding concreting.

5. The additional cost for concreting not less than 0.30m to 0.60m over and above the pile head final level (being upper end to measurable pile length), to be later demolished, including the cost of demolition performed in a manner safeguarding protruding dowels.

d. Backfilling Pile Borehole with Granular Material

1. The cost for the supply, handling and transportation of suitable granular material having negligible plasticity (i.e. sand, grit, concrete stone or their mix) from any distance onto the works site, including lay days for transportation vehicles, any intermediate unloading and their final depositing.

2. The cost for backfilling holes with such material to suitable level, in consecutive courses and to appropriate compaction degree aiming at avoiding collapsing sides of excavation and at ensuring continuous operation of plant allocated to pile and pile-cap construction and to appurtenant works (irrespectively of the type of plant to be required for these works, of having to deal with surface or groundwater, etc.).

3. The cost for loss of granular material as above due to compaction, and to the difference between the actual hole diameter and the nominal one constituting basis of measurement, etc.

(3) The above prices and payments include for all mechanical means, tools, instruments, controls and tests of all kinds (with the exception of those separately mentioned herebelow), as well as for all professional and skilled/unskilled personnel to be required for the completion of the work,

together with any other cost relevant to the execution of an impeccable work, although may be not explicitly herein specified.

(4) The above prices and payments do not include (unless otherwise specified in the tender documents) for the following works :

a. Steel reinforcement for piles, to be separately measured and paid for as per relevant steel reinforcement items of the price list included in the Contractor's bid. (See also para. 9.4.4)

b. Steel pipes of appropriate diameter embedded in the piles and related boring, grouting etc., as specified under sub-clause 9.6.1 hereof regarding quality control of the pile base.

c. The execution of controls for ensuring continuity of pile concreting operations, as referred to under sub-clause 9.6.2 hereof.

d. The execution of trial loading on non-operational andior operational piles.

e. Any additional costs required for dealing with aggressive groundwater, possibly entailing the need for using cement type IV.

f. The cost of any supplementary soil survey to be required in compliance with the programme approved by the Service, according to sub-clause 9.3.10 hereof.

(5) Works regarding excavations, concreting (with or without reinforcement) and steel reinforcement for the construction of pile-caps are covered by the present and other specifications, but shall be measured and paid for under separate items of the price list included in the Contractor's bid [taking into account the special remarks of the present specification, i.e. see sub-clause 9.10.3(3) and remark of sub-clause 9.13.(1)d hereabove].

Clause 10: RIGID STRUCTURE GUARDRAILS TYPE 1 ("S.G.-1")

10.1. GENERAL

10.1.1. The works described herein include construction of metal guardrails for structures (bridges, culverts and adjoining retaining walls), as well as for sections of transition between rigid guardrails and flexible ones.

10.1.2. The specification is based on guardrails for structures, type BN4 of the French Standards (GC 77), as follows :

Guardrails type BN4 - Edition of October 1977

Transition between guardrail BN4 and flexible guardrail -Edition of June 1980.

10.1.3. Rigid safety guardrails for bridges and culverts dealt with under the present specification shall be hence designated type "5.G.-1".

10.1.4. Their field of application is determined by the technical designs of the corresponding structures (beginning and end of guardrail, transition sections, etc.). It is pointed out that type "5.G.-1" (without including sections of transition to flexible guardrails) should apply to lengths not less than 25m, even in the cases of short-spanned bridges. See drawing S.S.-08 of the Standard Road Plan - S.R..P. (Applicable edition - revision).

10.1.5. Further to rigid guardrails of type "S.G.-1" dealt with under the present specification, other types of traffic safety barriers may be provided for structures, such as

- Metal safety guardrail for crest culverts (type other than "S.G.-1").
- Metal safety guardrail for motorway central median on bridges of unified carriageways (without median gap formation) at the same grade.
- Other types of metal safety guardrail on crest walls, for sections not directly adjoining to bridges (for which "S.G.-1" type guardrail may be provided by the design).
- Metal safety guardrail for bridges and adjoining walls on roads of limited traffic and of relatively low "hazard index" (guardrail types other than "S.G.-1" shall be applied).
- Concrete structures guardrail (type NEW JERSEY or similar).

Barriers of the present sub-clause (as well as any other similar) shall comply with construction specifications relevant to them.

General drawings for typical "S.G.-1" type guardrail and for its transition to adjoining flexible safety guardrails are attached at the end of the present specification clause, in this volume. It is pointed out that the transition drawing concerns utilization of horizontal open metal sections whose supporting method is specifically patented in France.

However, the Contractor may be entitled to formulate a transition detail of his own (similar to the abovementioned) for the case of using horizontal bars of closed metal sections.

10.2. TYPICAL RIGID METAL STRUCTURE GUARDRAIL TYPE "S.G.-1'

10.2.1 General Directions - Description

10.2.1.1. Typical safety guardrails type "S.G.-1" shall comply to the respective drawing accompanying the present specification clause, with construction details as per project design drawings, or, in their absence, as per - shop drawings to be prepared by the Contractor. Guardrail erection comprises the following;

a. supply and erection of frames of anchoring onto the structure (anchor details shall comply to the respective drawing attached to the present specification);

b. supply, erection and adjustment of the guardrail elements;

c. supply and placement of anchor embedding concrete.

Posts shall be vertical, equally spaced for each project at intervals between 2.30m and 2.60m.

10.2.1.2. "S.G.-1" type guardrails operate by noded embedding of posts onto the structure.

The requirements mentioned in the D.I.S. (pare 1.15.2.2.10.2) apply with regards to vehicle impact loads and the anchoring arrangement.

10.2.2 Quality of Materials

10.2.2.1. *Quality of Steel*

Posts and horizontal bars of both closed and open sections shall be steel type E24-2, according to French Regulation NF A 3 5-5 01 (or of similar technical characteristics in case of materials complying to EEC-member state or USA standards).

Steel shall be class I, in accordance with the provisions of sub-clause 3.1.1, chapter III of Document 4 of CPC (or of similar standards of EEC-member slates or of USA).

10.2.2.2. Bolts

10.2.2.2.1. Bolts for connection on to the structure

They shall include four (4) bolts H, M22-80 at the front face of the guardrail and two (2) bolts H, M16-60 at its back. These shall be mild steel, category A40, according to French standards NF E 27-311, class 4-6, or of similar EEC or USA standards.

Their fracture strength shall be 450 +- 50 N/sq.mm. A dia.18 and dia.12.5 fracture notch shall be provided respectively, according to the guardrail drawings.

10.2.2.2.2. Bolts for interconnecting guardrail components

They shall comply with the respective French standards NF E 27-113, 27-311 and 27-350 (or similar EEC or USA standards).

10.2.2.3. Weldings

Weldings shall be performed in accordance with the specifications of document 66 of CPC, chapter II (or similar EEC or USA standards).

10.2.2.4. Quality of Concrete

Guardrail embedding concrete shall be class B25 or better (in case the structure concrete is better than class 625) and shall be placed under the same conditions as for the structure.

The volume of concrete required for embedding guardrails shall be not less than 0.050cu.m. per post (see also sub-clause 10 4.3).

10.2.2.5. Corrosion Proofing

Corrosion proofing of guardrails including bolts shall be ensured by hot galvanizing executed in workshops approved by the Service.

A minimum 500gr/sq.m. protection shall be required per single face (i.e. 70 pm) plus or minus 50gr/sq.m., according to standards NF A 91-121, 91-122 and NF E 27-016 (or similar EEC or USA standards). A higher degree of corrosion proofing may be provided in the tender documents for special cases.

Depending on the galvanizing unit, particular attention shall be paid towards ensuring free circulation of cleaning and subsequently of galvanizing bath fluids between segments, in order also to avoid distortion. Prior to assignment of galvanizing services, and certainly prior to executing galvanization in an industrial setup, the Contractor shall be bound to obtain me Service's written approval. The Service shall need to satisfy himself of the observation of requirements hereof by inspecting the galvanizing installations.

Should guardrail materials be supplied ready to install from the local and/or the international market, the Contractor shall present to the Service adequate proof of the manufacturer's organization. Upon the Service approval, the Contractor shall submit duly certified invoices making proof that the respective quantities of materials were purchased from the manufacturer concerned by the approval granted. Such invoices shall constitute documents which shall accompany the request for payment of this item of work.

Attention is hereby drawn to the difficulty involved in galvanizing steel with a silicon percentage exceeding 0.04%.

10.2.3 Method of Execution of the Work

10.2.3.1. Shop Drawings

10.2.3.1.1. Shop drawings of guardrails, their end sections and of any transition to the bridge approach retaining setup shall be submitted by the Contractor to the Service for approval not later than sixty (60) working days prior to the scheduled date of commencement of their construction works, provided that such drawings were not included in the technical design handed to the Contractor by the Service.

10.2.3.1.2. Similarly, the Contractor shall be bound to submit to the Service for approval a drawing showing the precise locations of post embedding not later than thirty (30) working days prior to commencing construction of the bearing slab for the structure in question, provided again that such drawing was not included in the technic& design handed to the Contractor by the Service.

10.2.3.1.3. It is pointed out that the abovementioned drawings (two sub-clauses immediately preceding) to be prepared by the Contractor must comply to this specification and to its relevant typical drawings referred to under the S.R.P.

10.2.3.1.4. The Service shall return such drawings to the Contractor together with its related remarks, if any, not later than fifteen (15) working days following their submission.

10.2.3.1.5. Any corrections required thereto shall be performed by the Contractor within the deadline fixed by the Service.

10.2.3.2. Construction and Assembly

The Contractor shall proceed with the cutting and assembly of all elements. For the cases of horizontal curves having radii less than 100m, horizontal bars shall be bent in a manner observing installation tolerances as herebelow provided.

Bars shall be joined together using coupling sheaves. Attention shall be made to provide not more than one joint between two consecutive posts. Quite exceptionally, and if difficulties are encountered in obtaining supplies of adequately long bar segments, it is possible to permit two joints in the same panel, one of which should be along the smaller bar. This allowance, if granted, should be provided in the tender documents.

The guardrail elements shall be first assembled and then fixed in place and adjusted in plan and elevation. The vertical positioning of posts shall be checked with a tolerance of 0.5cm for their overall height.

Post embedding shall not be finalized unless previously inspected by the Service for observance of the requirements hereof.

Sheaves shall be provided at expansion joints of horizontal bars, as well as at end sections of structures, to permit free expansion and contraction of adjoining segments. The joint gap thus allowed shall be calculated on the basis of prevailing temperatures during erection and of the expanding/contracting length of segment. Such joints must be capable of assuming impact forces, if any.

Guardrail setting out tolerances, both in plan and elevation, cannot exceed one (1) centimeter of deviation from theoretical alignment for the overall length of each unified section, irrespectively of any unevenness on the base surface.

Post embedding concrete shall be produced, hauled and placed under the same conditions as concrete for the main structure.

The surface of post embedding concrete shall be shaped in a manner facilitating the water flow off the post base.

10.2.3.3. Final Treatment of Protected Surfaces

Surfaces requiring final treatment as of injuries sustained or of weldings performed at the works site shall be properly cleaned to remove any grease, rust etc. and shalt subsequently receive a coat of zinc rich paint in dry environment.

The thickness of such coat shall not be less than the paint thickness of adjoining surfaces.

If injured surfaces bound to receive such additional treatment exceed 20% of the overall guardrail surface, then the final paint treatment shall extend over the whole surface, in order to ensure homogeneity of coloring.

10.2.3.4. Tightening Anchoring Bolts

Anchoring bolts shad be tightened by torque application equal to 150 Nm for the four frontal bolts and to 50 Nm for the two rear ones. The Contractor shall be bound to use a suitable dynamometer equipped clamp for performing this work.

10.3. TRANSITION BETWEEN RIGID METAL STRUCTURE GUARDRAIL TYPE "S.G.-1" AND COMMON FLEXIBLE METAL GUARDRAIL.

10.3.1 General Directions - Description

The transition from a typical rigid metal safety guardrail type "S.G.-1" **to a** common flexible metal guardrail shall be in full compliance to the relevant drawing attached to the present specification and to shop drawings accompanying the respective design, or, failing this, to be prepared by the Contractor.

The supply and installation of individual segments for the section of transition shall be as follows :

a. A 4.50 m-long open section bar 85x70x3, and a 6.50m-long open section bar 100 x 100 x 4.

b. Two 1.50 m-long bar reinforcements (one each for bars of 100 x 100 and of 85 x 70).

c. An open section end bar 100 x 100 x 4 cut in two pieces, respectively 2.75 m- and 0.75 m-long, subsequently welded to form **a** 15° angle, an internal reinforcement and an assembly item.

d. Eight typical sliding items, each 4.315 rn-long and one piece of variable length.

e. Twenty-one (21) metal spacers for bar separation (in plan).

f. A wheel guide consisting of one 5.50m-long 0125 with respectve supports.

g. An end piece for sliding item of flexible guardrail.

h. One or two 0125 posts (depending on the specific case), welded on a 250 x 200 x 14 base plate.

i. Ten or eleven or twelve posts each consisting of one C125 and of one U100 Or C100 piece, each one 2.00m-long

   - five 2.00 m. long C125 posts (one of which shall be for connecting the wheel guide)
   - four 2.00 m. long C100 or U100 posts.

j. For sliding pieces, one special tie is required at post N°6, two special ties at posts N°4 and N°8, and one special tie for the end sliding piece. (Drawings show posts of the transitional section numbered in relation to the last guardrail post type "S.G.-1", which shall be numbered as N°0, while the former posts shall be N'1, 2, 3 etc.).

k. An adjustable bar tie to be used at post N'0 of guardrail type `S.G.-1".

l. Seven stirrups 200mm-long and three stirrups 330mm-long, typical or expansion-type according to the Service's instructions (see sub-clause 10.3.3.1 herebelow).

m. The complete set of bolts ensuring connection of the abovementioned items, as specified in the drawings attached to the S.R.P. accompanying the present specification.

10.3.2 Quality of Materials

10.3.2.1. Quality of Steel

With the exception of sliding pieces and posts, steel items constituting the transition section shall be steel type E24-2 in accordance with the French Regulation NE A 35-501 (or of similar technical characteristics for materials manufactured in compliance with EEC-member state or USA standards).

Steel shall be category I, in accordance with the specifications of clause 3.1.1, chapter III of document 4 of the CPC (or of similar standards of EEC-member states or USA).

Depending on the individual case, posts shall comply with the following French specifications (or with similar EEC-member states or USA standards).

Type	Section	Quality of steel	Characteristic dimensions as per
GS2 or GCU	UAP 100 or UPN 100 or C 100	Steel E24-1 as defined in Regulation NF A 35-501	Regulation NF A 45-255 Regulation NF A 45-202 General dimensioning specification of the Commission of European designs
GRC, GCU and plate base	C125 x 62.5 x 25 x 5		the drawing

10.3.2.2. *Sliding elements*

The spacing system type A or B and the bolting of the above components must comply with those of structures approved in France by the Decision dated 3.5.1978 or better.

If the Contractor intends to have such pieces manufactured in Albania or in another country, he shall need to present to the Service samples manufactured by the manufacturer he intends to use for review and approval. In this case, the Contractor must allow adequate time so that, should such samples be rejected by the Service, he may be in a positron to get his supplies from another source.

10.3.2.3. *Bolts*

With the exception of the provisions of the preceding sub-clause 10.3.2.2, bolts shall be in accordance with the relevant regulations NF E 27-113, 27-311 and 27-350, for class 5.8 (or with similar EEC-member state or USA standards).

10.3.2.4. *Weldings*

Weldings shall comply with the specifications of document 66 of the CPC, chapter II (or with similar EEC-member state or USA standards).

10.3.2.5. *Corrosion Proofing*

With the exception of items mentioned under above sub-clause 10.3.2.2, corrosion proofing of the components of transitional sections in guardrails, including bolts, shall be ensured by hot galvanizing executed in workshops approved by the Service.

A minimum protection equal to 500gr/sq.m. of single face shall be required (namely 70pm) plus or minus 50grisq.m., in compliance with regulations NF A 91121, 91-122 and NF E 27-016 (or similar EEC-member state or USA standards). A higher degree of corrosion proofing may be specified in the tender documents for some special cases.

Depending on the unit performing galvanization, special attention must be made to ensure free circulation of cleaning and subsequently of galvanizing bath fluids among treated segments, and to avoid resulting distortions. (The provisions of sub-clause 10.2.2.5 hereabove shall apply also here).

Attention is drawn to the difficulty involved in galvanizing steel with more than 0.04% silicon content.

10.3.3 Method of Execution of the Works

10.3.3.1. Shop Drawings

The positions of the structure expansion joint and of the last "S.G.-1" type post at the structure approach shall be shown on the technical design drawings handed over to the Contractor by the Service. The drawings shall also show connections involving expansion stirrups as well as typical ones.

On the basis of such drawings, the Contractor shall proceed with the preparation of shop drawings regarding guardrail transition (from type ns.c.-1- to adjoining flexible metal guardrail) within deadlines specified in the tender documents. Similarly, the Contractor (in collaboration with the Supervising Service for establishing missing data) shall prepare shop drawings for guardrail transition, even in the case when no structure design data are provided.

Unless otherwise provided in the tender documents, the above shop drawings shall be submitted to the Service sixty (60) working days prior to commencing safety guardrail construction for the adjoining sections.

10.3.3.2. Post Fixing Material

The material in which posts will be embedded shall be subject to inspection and acceptance by the Service.

10.3.3.3. Posts Installation

Posts shall be installed parallel to the sliding elements, on the traffic side of the guardrail.

Installation tolerance in plan of their side facing sliding elements shall be plus or minus three centimeters (+-3cm) in relation to the theoretical position.

The upper edge of sliding elements shall be between 0.65m and 0.80m above average ground or cover level in a 0.50m-wide zone vertical to the sliding elements. Usual height shall be 0.70m.

It is mandatory for the post driving equipment to bear a steel head. The vertical position of the post and of the driving equipment guide must be checked prior to beginning each post driving operation.

In case of "refusal", and before attaining the required level, the Contractor must :

(1) cut the post to the required height following consultation with the Service, if same post is driven at least 70cm in length,

(2) In the opposite case, he must

— either remove the post, bore the obstacle encountered and continue driving (the type of equipment to be used shall have to be previously approved by the Service),

— or remove the post, proceed with excavation and backfilling with sand, and subsequently redrive the post.

The Contractor shag be bound to replace posts bearing folds, cracks, faults, or caved in as a result of the driving process.

10.3.3.4. *Assembly of Sliding Elements*

Sliding elements shall be assembled in a manner ensuring that one's end in the direction of traffic overlaps the beginning of the subsequent element.

Sliding elements type A shall be installed with the longitudinal axis of their bolt holes to the right-hand side of each post and

— vertical to overlapped ends in contact with spacer blocks,

— horizontal to overlapping ends exposed after completion of assembly.

Installation of sliding elements in the opposite way shall not be permitted, except on curved sections having a radius less than 250m.

All fixing bolt heads shall be exposed on the front face of the sliding elements.

The final adjustment of all components in the transition section shall be through loosening, supporting and tightening close of the fixing bolts, excluding any other method.

10.3.3.5. *Tightening Bolts*

Bolts shall be tightened by application of a 150 Nm torque.

10.3.3.6. *Bolt Inspection*

Should the Service detect any errors or insufficient drawing of the fixing bolts on the various components of the transition section, he shall call the Contractor to make the necessary repairs and, if deemed necessary (by the Service), the Contractor shall be required to proceed with a systematic inspection of the overall or of part of the transition system.

10.3.3.7. *Final Treatment of Corrosion Proofed Surfaces*

Surfaces bound to receive final treatment as a result of injuries sustained or of site executed weldings shall be properly cleaned to remove any grease or rust, etc. and subsequently coated 1.4,th a zinc rich paint, in dry environment.

The thickness of such pant coat shall be not less than that of the adjoining surfaces.

10.4. MEASUREMENT – PAYMENT

10.4.1. Unless otherwise specified in the Special Conditions of Contract and/or the price list, the works of the present specification shall be paid for per kilogram of guardrail weight, for work fully completed in accordance with these specifications. Such weight shall be calculated on the basis of the design drawings and of typical weights of individual components, bolts, etc.

10.4.2. Such prices and payments shall include for converted values of all supplies of materials (including the reflectorizing elements, according to clause 33 of the T.C.C.), labour involved, use of equipment, transportation, approach, fixing, adjustments, corrosion proofing, final treatment, etc. Furthermore, they shall include for charges related to patents (in case some of the materials to be used by the Contractor are covered by same), and for any additional cost necessary for the completion of the guardrail construction.

10.4.3. The present specification provides for control of the quality and of the volume of concrete needed for embedding posts onto the structure. However, payment for such concrete shall be as for the respective class of concrete involved in the construction of the structure, without any differentiation between embedding and surrounding concrete.

10.4.4. Similarly, this specification shall provide control for local and general anchoring reinforcement as described under sub-clauses 10.2.1.2.a and b hereof, but payment for such reinforcement shall be by application of price items provided for payment of the respective reinforcement categories of the principal structure work.

10.5. DRAWINGS ATTACHED TO THIS SPECIFICATION

The present specification is accompanied by the following drawings:
……………………….

Clause 11 : PRESTRESS

11.1. DESCRIPTION

The present specification refers to the prestress of structural elements *made* of precast concrete or cast-in-situ concrete, in relation to the supply, placing and tensioning of the prestressing steel, in accordance with the prescriptions of the specific standards and the other conditions of contract.

The works comprise also the supply and installation of the auxiliary parts which are necessary for each particular prestressing system used, including the tendons ducts, the anchoring devices, the protection of the tendons by grouting after tensioning etc. In case of cast-in-situ concrete, the term 'structural element" used in the present specification, refers to the concrete that is to be prestressed.

The present specification does not refer to the tensioning of bars having a diameter more than 8 mm, or having an area of more than 50 mm^2. Moreover, this specification does not refer to SUSPENSION CABLES.

11.2. MATERIALS

11.2.1 Prestressing Steel

According to the present specification, the prestressing steel shall be :

- High-tensile steel wires
- High-tensile steel wire ropes

11.2.1.1. High-Tensile Steel Wires

a. General

High-tensile steel wires shall be in accordance with specification BRITISH STANDARD SPECIFICATION 2691 "STEEL FOR PRESTRESSED CONCRETE" and shall additionally satisfy the following requirements :

- The minimum diameter of the wires shall not be less than 5,0 mm and for non-circular cross-sections the minimum cross-section shall not be less than 30 mm^2.
- The wires shall be of OPEN HEARTH PROCESS or ELECTRIC FURNACE produced steel, cold worked either by drawing or by re-rolling. Electrically welded splices shall not be permitted.
- A thermal or therno-mechanical after-treatment shall be applied to the wires by tempering for internal stresses relief (STABILIZING, THERMALIZING).
- The wires shall have a smooth or a prescribed ribbed surface, and shall be clean, dry and without factory-induced scaling.

Note: The wires may have smooth or ribbed surfaces and circular or non-circular sections

Tolerances shall not exceed +2,0% or -1,0% of nominal diameter (for non-circular cross-section wires tolerances of the cross-section area shall not exceed +4,0% or -2,0%).

b. <u>Strength properties</u>

Strength properties of the wires shall be as follows :

- The minimum (tensile) rupture strength shall be as specified by the Technical Design and the other conditions of contract.
- The yield point corresponding to 0,2% strain (0,2% proof stress) shall be equal to 85% to 95% of the True Rupture (tensile) Stress (T.R.S.).
- The rupture strain (strain at failure), measured on a specimen with length ten times its diameter (10d test specimen) shall be at least 5%.
- Decrease of cross-section at rupture: The decrease of the true cross-section at location of rupture shall be at least 30%.
- Fatigue strength: Steel shall be able to sustain without rupture at least 2 million load cycles imposing stress equal to 55% of T.R.S. and 70% of the characteristic I.R.S.
- Relaxation : In a relaxation test under an initial stress equal to 65% of the characteristic T.R.S. and under normal temperature, the stress loss shall not exceed 4% after 1.000 hours of test.
- Bend test : The number of bending operations 900 + 900 round a former with a diameter of 10 times the wire diameter shall follow the following rules:
  - Simple wire test specimen minimum 10
  - Test specimen on which a notch (0,1 mm deep, at 600 angle, and 0,03 mm curvature angle) has been engraved (During testing the specimen shall be installed in a way allowing the notched section to be tensed during the first 900 bending) approxim. 3

c. <u>Particular requirements</u>

<u>Suitability for head shaping:</u>

In case that the prestressing system to be employed necessitates the shaping of heads at the wires, the suitability of the wire for head formation shall be checked by random spot checking prior to delivery of the wires at the site.

<u>Straight shape:</u>

Wire freely unwinding on a level and smooth concrete floor shall keep the shape of a practically straight line.

<u>Ribs:</u>

If required, the wire surface may have small ribs with height not exceeding 0.1mm. The ribs shall not affect substantially the mechanical properties of smooth wire

d. Certificates and information

General characteristics about the quality of the delivered wire :

The wire manufacturer shall submit test certificates, which shall prove that the strength requirements as per para 11.2.1.1.b are fulfilled.

Factory certificates :

Factory certificates containing the following data shall be submitted at each delivery :

— With each coil the (tensile) rupture strength.

— With one coil for every twenty coils :

  - The true wire diameter
  - The specified yield point
  - The rupture strain
  - Bend tests

— Additional data

Beyond the general certificate and the factory certificates, the wire manufacturer shall submit the following additional data :

  - Stress-strain diagram
  - Modulus of elasticity
  - The proportional limit (0.05 $^{0}/_{00}$)
  - Relaxation rates :
  - Stress loss from an initial stress equal to 0.60, 0.70 and 0.80 of the characteristic Tensile Rupture Strength (IRS) under normal temperature after 1,000 hours of test.
  - Results of corrosion tests.

REMARK :

The Contractor of the project shall be absolutely responsible for the provision of all above certificates and data. In case of missing data, the Service as per its absolute judgement, shall have the right to deny the use of the corresponding prestressing wire in the project.

11.2.1.2. High Tensile Steel Wire Ropes

The wire ropes to be used shall not have a cross-section of less than 30 mm^2 and their individual wires shall not have a diameter less than 3,0 mm.

The high tensile wire ropes shall be in accordance with specification ASTM A 416, 1974 edition or more recent, and shall not have electrically welded splices. The steel cross section of the wire rope shall not differ more than 0,005 sq. inches from the nominal steel section shown in table I of the above mentioned specification ASTM 416.

11.2.1.3. *General Requirements*

General :

The wires shall be straightened, if needed, to achieve equal stress at all wires or wire clusters or at tendons parallely located that shall have to be simultaneously prestressed, or when it will be necessary to secure the proper placement in the tendons ducts.

When shaping of heads at the wires is prescribed, the heads shall be shaped by cold upsetting symmetrically to the wire axis. The heads shall have to be able to ensure the minimum guaranteed (tensile) rupture strength of the wire. The use of head shaping methods that cause cavities to the wires shall not be permitted.

Protective measures during transportation and storage :

Prestressing steel shall be safeguarded from damaging, rust and other effects of corrosion during the whole period between it is produced at the factory until it is protected through grouting or embedded in concrete. Presence of visible rust or other effects of corrosion constitutes reason for rejection by the Service. Prestressing steel shall be packed in containers or other similar methods of packing suitable for transportation to ensure protection from damaging and corrosion during transportation and storage. Each bundle of prestressing steel of any type shall bear a well fastened label on which will be listed the bundle number, the length, the diameter and the tensile rupture strength. Prestressing steel delivered on site without the above characteristics shall be rejected by the Service. Inside the packaging of the steel shall be included an anti-corrosion substance (against rust or other corrosion effect) or, in case the Service allows so, it might be applied directly on the steel surface. The anti-corrosion substance should not adversely affect the steel or the concrete or the bond between steel and concrete. Any packing damaged by any cause shall be

immediately replaced or repaired and brought to their original status.

The transportation packing shall bear a legible notice stating that the crate (or any other package) contains high tensile steel and also mentioning the care that must be taken handling the crate and the type, kind and quantity of the anticorrosion substance used, the date it was included, safety instructions and instructions for use.

Protective measures after placement :

After placing of the prestressing steel in the structural element no electric welding shall take place and no electric welding machines shall be grounded through the formworks or through steel reinforcement. All pre-tensioned reinforcement shall be cut-off without leaving protruding ends, level with the concrete element surface, and the exposed ends of the prestressing steel together with a concrete area of 2,5 cm around the rein-forcement shall be painted with a thick layer of rich zinc paint after prior cleaning. Cleaning shall be effected with wire brush or sand blast to remove fouling and residues not solidly bonded to the steel or concrete surfaces. Paint shall be well shaken at the time of application and shall be carefully applied at each cavity at the prestressing tendons.

11.2.2 Anchorages and Stress Distribution

All tendons tensioned after the concrete hardening, shall be fixed at their ends through suitable approved anchor devices of permanent type, in accordance with each pretensioning system requirements.

11.2.3 Tendon Ducts

Ducts of prestressing steel shall be manufactured of ferrous metal sheathing, leak proof to grout and shall be correctly placed in shapes shown in the drawings approved by the Service. In all ducts or anchor devices shall be connected pipes or other suitable devices to carry out the grouting after tensioning. Ducts shall be reliably secured in position to avoid displacements.

After placement in the formworks, the ends of the tendon ducts shall be always covered in the most appropriate way, in order to avoid intrusion of water or other dirt. In the case that the prestressing steel shall be inserted after concrete is placed, the ducts shall be cleaned with air or hosed and cleaned with air, immediately before insertion of the prestressing steel. All ducts of continuous spans shall be provided with air vents at the locations of supports (high points of ducts) and at additional points that eventually are shown on the drawings. The vent pipes must have a minimum diameter of 1/2". The connections to the ducts shall be effected through metal structural fasteners and will allow for the possibility of grouting through the vent pipes as well as the possibility to seal the vent pipes. The protruding ends of the vent pipes shall be cut after the grouting is completed.

All ducts (unless otherwise prescribed in the conditions of contract) shall consist of stiff galvanized ferrous "metal". Connecting pieces that are placed to connect the above stiff ducts to the anchorages need not necessarily be galvanized. The above stiff ducts can be used in prestressed simply supported elements as per the Contractor's judgement. The stiff ducts may be manufactured either with electrically welded ends or by forming the ends in an interconnected shape. Galvanizing of electrically welded ends is not considered as necessary.

Rigid ducts should have the necessary strength so that their correct geometric shape is maintained during concreting and they should not become distorted when stepped upon by workmen. The connections between parts of stiff ducts shall be correct metal junctions that shall not cause deflection point at the joints. The connections shall be protected with waterproof tape.

11.2.4 Cement Grouting

In accordance with DIN 4227, Part 5, 1979 edition.

11.3. CONSTRUCTION REQUIREMENTS

11.3.1 Implementation of Prestressing

The prestressing steel shall be tensioned with hydraulic jacks in a way that it will be ensured that the prestressing force of the tendons shall not be inferior to the one shown on the drawings. Unless otherwise specified or shown on the drawings, the average service load stress of the prestressing steel shall not exceed 55% of the specified minimum (tensile) rupture strength of the prestressing steel.

The maximum temporary tensile stress (stress at jack) of the prestressing steel shall not exceed 70% of its specified minimum (tensile) rupture strength. The prestressing steel shall be anchored under such stresses (initial stresses), which will allow that at the final redistribution, the service load forces will not be inferior to the ones shown on the drawings, but in any case the initial stresses shall not exceed the 60% of the specified minimum (tensile) rupture strength of the prestressing steel.

In order to define the prestressing force at the jack, every jack that shall be used for the tendons tensioning, shall be, without fail equipped with a pressure gauge and if possible with a dynamometer. The pressure gauge shall be equipped with a precision pressure reading disk and each jack with its pressure gauge shall have been properly checked and calibrated as a whole, in order to ensure the accurate measurement of the prestressing forces.

If a dynamometer is used as well, it will be properly calibrated and equipped with a gauge by which it will be possible to define the prestressing force of the prestressing tendon.

It is not permitted to use the dynamometer to measure forces inferior to the 10% of its maximum capacity to measure forces. In accordance with the above, the approved calibration charts of the hydraulic jacks, that shall be used for the tendons prestressing may be checked by the Service before and during the execution of the prestressing.

The method of prestressing adopted for each case of tensioning after concrete hardening shall be such, as to continuously measure the inflicted prestressing stress in relation to the measured extension of the prestressing steel.

A prestressing log shall always be kept for each interim phase of the prestressing and for each prestressing tendon. In this log shall be noted the location of the tendon, the date and time of prestressing, the jack number and any eventual problems faced during prestressing, the pressure readings and the force reading (when there is a dynamometer), in relation to the corresponding readings of the steel extensions. The prestressing logs shall be signed by the responsible engineer of the Contractor for the prestressing (however the Contractor of the Project shall also absolutely assume the civil and penal liability) and by the representative of the Supervising Service.

The calibration of the hydraulic jacks shall be repeated every six months, as well as whenever the measurements of the prestressing forces and the corresponding extensions are incompatible by more than 5%. The calibrations shall be subject to approval.

Eventual repairs of the pistons, replacement of sealing gaskets, or modifications to the lengths of the hydraulic pipes shall constitute reasons to repeat calibrations. No additional compensation shall be approved for the initial or subsequent calibrations or for the use of the original reference scale.

In case that the tendon force measured through the prestressing force, and the corresponding extension differ by more than 5% the tendon shall be released and the method to determine the origin of the error shall be studied. The Service shall be kept informed about the origin of the error and proposals for its elimination shall be submitted, in order that the measured forces be within permissible limits.

Prestressed tendon length eventually in surplus shall not be cut off prior review of the diary by the Service and prior the relevant instruction is issued by the Service. Cutting off of excessive length shall be performed as close to the anchorage as possible, without however inflicting any damage to it. If an acetylene torch is used, the cut off shall be effected at least 50 mm from the anchorage.

11.3.2 Cement Groutings

In general DIN 4227, Part 5, 1979 edition is in effect in connection with the following

The mixing of the grout shall be effected by use of a mechanical mixer with a horizontal retrogressive movement, with sufficient power to abruptly generate a vortex in the mixture.

Auxiliary equipment to perform accurate measurements of the quantities of the

liquid and solid components of the mix, shall always be present on site.

Initially in the mixer shall be poured the quantity of water for the mix followed by the cement. After at least two minutes of mixing, or as per the suppliers instructions, the additives shall be poured in, in the proportions defined by the grouting mix design. Mixing shall continue for at least three minutes until a uniform mass has been formed.

Groutings shall be effected within thirty minutes of the moment of pouring the additives, and the grout shall be continuously stirred until the time of the grouting. For as long as no grouting takes place, the grout shall recirculate within the pumping circuit.

The grouting shall be effected by means of a pumping equipment with positive displacement, capable of producing at least a 1MPa pressure at the exit. Between the pump's outlet and the inlet of the tendon's duct, a pressure gauge shall be installed, equipped with a complete reading scale to measure up to 2MPa max.

Prior entering the pumping equipment, the grout shall pass through a filter (sieve) of max 3 mm aperture, installed in a way allowing easy cleaning.

Entrance of the grout into the pump shall be effected by gravity through a funnel shaped vessel, constantly kept half-filled to avoid pumping air into the tendon duct.

During mixing or pumping the grout temperature shall be kept between 10° and 20° Celsius.

For three days after grouting or until the grout has reached a maturity factor of 10000 C.h., the temperature of the coldest concrete member should not drop below 5° Celsius. As maturity factor is defined the result of the multiplication of the degrees above -10° Celsius by the grout hardening period in hours.

Whenever high ambient temperatures contribute to fast setting of the grout, the means to keep the grout's temperature at low levels shall be provided on site, in order to avoid formation of zones during grouting.

Whenever during or immediately after grouting frost conditions prevail, means to

adequately protect grout from frost in the ducts shall be made available.

To minimise leakage of water from the pump, its pressure shall be maintained close to 0,5 MPa and shall never exceed 1,4 MPa. If, due to reduced fluidity of the grout, it is constantly required to keep the pump pressure above 1,0 MPa, the grout shall be discarded. Its remixing shall not be allowed.

Prior to grouting, all vents at high points and anchorages shall be opened. Grout shall be allowed to be discharged from vents at highest and intermediate points until any water or air eventually entrapped into the duct are evacuated. The vents shall be sealed or shut by any suitable method. The remaining openings shall be sealed by the same method.

If during grouting the pressure exceeds the one recommended by the specifications, then it is possible to execute the grouting through any vent, sealed or ready for sealing, while grout flow is maintained towards one direction.

If this procedure is followed, the vents shall be equipped with sealing valves. In ducts where eventually the grout flow towards one direction cannot be maintained, then thorough washing with water shall take place.

Grouting shall continue along the whole length of the duct having a continuous flow at the outlet, until eventual visible bursts of water or air at the outlets stop and until velocity of flow of grout entering the duct equals the velocity of the grout discharging. Inlet and outlet hoses shall remain sealed until setting of the grout.

An adequate quantity of water as well as a pumping equipment shall be provided stand-by, having the capacity to produce a 2 MPa pressure at the outlet, for eventual need to thoroughly wash a duct partially grouted, whenever, for any reason grouting cannot be successfully completed.

11.3.3 Repairs and Cleaning of Concrete

After the completion of grouting and the setting of the grout, all vent hoses shall be cut off, all anchorage cavities shall be cleaned using sand blasting and one coat of epoxy glue shall be applied to the exposed surfaces of the anchorages and the prestressing steel, as well as to the concrete surfaces.

The epoxy substance shall consist of two components. it shall be cured by watering until it hardens, and it shall be specifically suitable for bonding freshly casted with hardened concrete. A supplier's certificate shall be submitted to the Service, by which it will be certified that the epoxy substance proposed shall behave in a satisfactory way under the temperature conditions foreseen to prevail during the execution of the works.

Cement mortar shall be applied at the cut off points and into the cavities of the anchorages prior to the hardening of the epoxy glue. Such application shall not take place at the anchorages located on horizontal surfaces of the bridge deck, where repairs shall be effected using concrete of the same class as for the remaining structure.

The mortar for repairs at the ducts cut off points and at the anchorage cavities, shall consist of cement and sand to the same proportions as used in the concrete to be repaired.

The repairs on the horizontal concrete surfaces of the deck and on concrete surfaces (except the ones intended to receive fair faced finishes type B, C, D, or E) shall be finished until they become level with the concrete surface surrounding them.

Repairs to the concrete surfaces intended to receive fair faced finishes (type B,C,D or E) shall be effected slightly in recess, in order that the repair area to be defined by the straight lines that will surround the recess.

Grout discharged on openings shall be well scrubbed off.

11.4. MODIFICATION OF SYSTEM OF PRESTRESS BY THE CONTRACTOR

The Contractor may, if he so wishes, submit to the Service a proposal to use an alternative system of prestress, other than the one prescribed in the drawings, as well as the pertinent calculations, under the condition that the proposed alternate system shall satisfy the following requirements :

(1) The system of prestress shall comply with the material specifications hereof.

(2) The net prestressing force, all losses taken into account shall not be less that the one of the system prescribed in the drawings.

(3) The rupture strength of the tendons shall not be inferior to the one of the system prescribed in the drawings.

(4) The tendons distribution shall be in general in accordance with the distribution shown in the drawings.

(5) The concrete stresses and the stresses of the steel elements at all cross sections and during all stages of the construction shall not exceed the permissible stresses stipulated in the specifications.

(6) The Contractor shall prepare a new structural design, according to the requirements of all elements for which the implementation of the new prestress system is proposed.

(7) The Contractor shall submit, for checking by the Service, complete detail drawings, and structural calculations including the temporary and permanent losses.

Clause 12: STEEL REINFORCEMENT

12.1. SCOPE

The work covered by this clause consists of the provision of all installations, labour, materials and equipment and of the performance of all works related to the provision of steel reinforcement for concrete intended to permanent structures. The Contractor shall provide, cut, bend and fix in place all reinforcing bars as shown on the drawings or as instructed by the Service, and shall prepare steel reinforcement drawings as herein defined.

12.2. MATERIALS

Steel reinforcement shall be new, clean, straight and free of rust. Unless otherwise instructed, all reinforcement shall consist of ribbed bars meeting the requirements of DIN 488 concerning ribbed bars class 42/50 RU or 42/50 RK and concerning mesh of bars class 50/55 GK or 50155 PK or 50/55 RK. Bars shall be plain circular whenever shown on drawings to be class St I. Reinforcing bars shall comply to the above standards, or to equivalent standards and specifications in use as approved by the Service. Steel reinforcement shall be stockpiled on supports, or shall be safeguarded in any other way against contact with the ground.

12.3. TESTS

The Contractor shall submit to the Service two (2) certified copies of all reports on tests performed in the manufacturer's workshops or in any other certified laboratory, in accordance herewith. Certified copies of reports shall be submitted to the Service prior to consignment of the materials on the works site.

12.4. WORK PERFORMANCE

Generally, the performance of the work shall be of high quality, conducted in compliance to the recentmost and best standard methods.

12.4.1 Cutting and Bending

Reinforcing bars may be straightened at the factory or on the works site. Cutting and bending shall be in accordance with an approved standard method, using recognized mechanical means. Bending of by heating bars shall be excluded, unless specifically authorized by the Service.

12.4.2 Fixing In Place

Reinforcing bars shall be fixed in place as shown on the drawings or as instructed by the Service. During fixing, bars shall be measured along their axis, unless otherwise specified. Free space left between parallel bars shall not be less than one and half time (1%) the bar diameter, and anyway never less than 25mm, unless specifically approved by the Service.

Once fixed, reinforcing bars shall be inspected for compliance to design requirements regarding size, form, length, welding, position and quantity.

Prior to fixing, bar surfaces, as well as surfaces of any bar supports shall be cleaned to remove mill scale, loose rust, dirt, grease or other foreign matter deemed unacceptable by the Service. Mill scale that can only be removed through intensive canvas rubbing or similar process shall be unacceptable.

Once fixed, reinforcing bars shall be kept clean until embedded in concrete. Reinforcing bars shall be fixed in place exactly as shown on the drawings or as instructed by the Service and shall be properly fastened to avoid displacement during placement of concrete. Special care shall be provided to avoid any disturbance of steel reinforcement already embedded in concrete. With the purpose of supporting steel bars, the Contractor may use chairs, metal hooks, metal spacers or other satisfactory steel or concrete bolsters as authorized by the Service. Supports shall be adequately resistant to maintain reinforcing bars in place throughout concrete placement operations.

Supports shall be used in a way ensuring that no damage, fading or erosion be caused to concrete. When necessary to avoid ugly stains on exposed concrete surfaces, bar supports shall be concrete or stain-free metal. Minimum net cover of main reinforcing bars to the surface of concrete or other surfaces shall comply to the drawings or to the Service's instructions. If approved by the Service, concrete cover of stirrups, spacers and similar secondary reinforcement may be reduced by their own diameter.

12.4.3 Tying

Tying of steel reinforcement shall be as shown on the drawings or as instructed by the Service, or as shown in relevant standards proposed by the Contractor and approved by the Service. Tying of overlapping bars may be applied if bars are either rigidly tied together, as approved by the Service, or adequately spaced to allow embedding of the overall sections of both overlapping bars in concrete.

Frontal welding of bars in lieu of overlapping shall need to be authorized by the Service, and then comply to the requirements of the recentmost ACI Code 318. Furthermore, welding shall be in accordance with applicable AWS standards. Weldings shall be subject to standardized tests, as described in Operators Qualifications of AWS.

Low hydrogen electrodes (AWS E-7015-16) shall be used for welding reinforcing bars. Weldings shall utilize the overall strength of the smaller bar (they shall reinforce the strength of the smaller bar). They shall provide for adequate overlapping enabling stress transfers onto bars through the welding connection. Adjoining sheets of reinforcing mesh shall overlap by not less than fifteen (15) centimeters, with their ends rigidly tied to each other by means of wire or standard clips.

12.5. PROTECTION OF STEEL REINFORCEMENT FOR FUTURE USE

Any exposed reinforcing steel intended for future embedding in concrete shall be protected against oxidation by covering with a thick tar-impregnated canvas, as instructed by the Service. Steel thus protected shall be carefully cleaned prior to embedding in concrete.

12.6. ELABORATION OF DETAILED BENDING SCHEDULES

12.6.1 Shop Drawings to be Prepared by the Contractor

The Contractor shall prepare all shop drawings for reinforcing steel. Such drawings shall include bar placement, bar bending, bar schedules and other drawings as required to facilitate fabrication and fixing in place of the reinforcing bars.

Shop drawings of reinforcement shall be based on the Final Design to be elaborated by the Contractor and approved by the Service. Such drawings are finalized on the works site by adjustment to conditions encountered on the spot during implementation.

12.6.2 Submission of the Contractor's Shop Drawings for Reinforcement

The Contractor shall submit to the Service for review, approval and registration all detailed drawings and factory documents, together with transparencies of detailed drawings for bar placement, bar bending, bar schedules etc., as performed by him for all steel reinforcement, not less than thirty (30) calendar days prior to placement of reinforcement, unless otherwise specified by the Service.

Clause 13 : JETTED PILES (SMALL PILES)

13.1. FIELD OF APPLICATION AND SCOPE

13.1.1. The present clause is to serve as a basis for the design, construction and evaluation of the bearing capacity of non-prestressed jetted piles (piles by in-situ grouting of concrete and composite piles), of circular or similar sections and diameters less than 300mm. The minimum required diameter for piles constructed by in-situ grouting of concrete is 150mm, while for composite piles it is 100mm. Piles are constructed vertical or inclined and, as a rule, they bear axial loads. They shall transfer their loads onto subsoil mainly through lateral friction whenever not founded on rock.

13.1.2. Jetted piles are applicable both for short duration works (not more than two years) and for works of long duration.

13.1.3. Basic principles ruling pile foundations as described in DIN 10 54 (edition of November 1976, chapter 5) shall generally apply,

13.1.4. The present specification is based on DIN 4128, edition of April 1983.

13.2. SYMBOLS

The symbol of a jetted pile (Verpressfahls) is as follows Jetted Pile DIN 4128-V

13.3. DEFINITIONS

13.3.1 A Jetted Pile (Constructed by Grouting of Concrete)

13.3.1.1. A jetted pile is a pile constructed by in-situ grouting of concrete, or a composite pile with prefabricated components. The pile by in-situ grouting of concrete is reinforced throughout its length with bars of steel suitable for structural works. The pile shall be made of concrete (clause 6 hereof).

13.3.1.2. The composite pile bears all along a continuous prefabricated bearing component of reinforced concrete or steel. The bearing component is sunk within a hole bored through the foundation ground, or is driven by ramming into the ground with a widened toe, i.e. like a ram sunk jetted pile. The hole may be filled with grouting concrete prior to the sinking of the pile. The grouting material surrounds the bearing component all along in the foundation ground. The load is distributed over the whole pile length or part of it, depending on the achieved bond between the bearing component and the grouting material.

13.3.2 Internal and External Bearing Capacity

13.3.2.1. The internal bearing capacity of a jetted pile is defined on the basis of the strength of its materials of construction.

13.3.2.2. The external bearing capacity of a jetted pile shall depend on the strength of the foundation ground supporting the pile.

13.3.3 The Length of Load Distribution

The pile load is distributed over the length of the pile section transferring the pile force onto foundation ground.

13.3.4 Pile Diameter

The pile diameter corresponds to the external diameter of the auger of the core sampler tube, or of the cutter fixed at the lower end of the pile driven by percussion. For piles constructed with external slurry circuit, it may be considered that the pile shall be by 20mm wider than the diameter of the core sampler tube.

13.3.5 Grouting. Subsequent Grouting Operations

By grouting is meant the operation during which the material being jetted in is under a pressure higher than the hydrostatic pressure. The pressure is applied in-situ by compressed air or fluid.

By the term of subsequent grouting the operation is designated during which one or more infusions follow cement setting or hardening, after the first operation.

13.4. RECONNAISSANCE OF THE FOUNDATION GROUND

Before going ahead with pile construction, the soil consistency and the groundwater situation shall be investigated to sufficient depth under the feet of the piles, in compliance with the recommendations of DIN 1054 (November 1976 edition, chapter 3).

Strength properties of non-cohesive soils shall need to be determined by means of in-situ measurements using competent devices such as the Terzaghi statical penetrometer, vibrating penetrometers and pressiometers.

With regard to cohesive soils, the grade analysis, cohesion index Ic, uniaxial compressive strength and shearing strength of soil formations shall have to be determined.

With regard to rock and soft rock, the survey methods to be applied shall need to allow drawing conclusions as to the strength of the rock mass, its permeability and water sensitivity, in addition to determining the sequence of strata, the rock formations constituting them and their strengths.

it shall need to be investigated whether any properties of the groundwater and of the foundation ground are liable to cause damage to concrete and to the other pile materials, as well as whether any other properties may be liable to influence the mechanical properties of the supporting fluid.

13.5. SURVEY TO EXPLORE THE EXISTENCE OF OTHER WORKS

Since planning, the depth of any other works existing in the vicinity of the projected pile construction must be investigated together with the dimensions of their foundations, their construction methods and materials and their strength. The existence of any horizontal loads must be particularly verified.

Furthermore, the survey shall extend to investigate whether the structural condition of any adjoining structures may be affected by the pile construction, particularly regarding their sensitivity to strain and vibration. All the above shall be determinant factors towards the selection of the pile construction method to be applied.

13.6. CONSTRUCTION OF PILES

13.6.1 Piles by In-Situ Grouting Operation

The reinforcement of piles constructed by in-situ grouting (jetted piles) shall comply to the recommendations of DIN 1045. With regard to concrete cover of such reinforcement, Table 13.1 hereof shall apply.

Since a minimum cover of reinforcing bars is not secured by the pile construction method, measures shall need to be taken to avoid eccentric fixing of the reinforcement. Same measures shall apply after extraction of the core sampling tube (i.e. by fixing spring spacer blocks), to ensure satisfactory cover in all cases. Such spacers shall be particularly important with regard to piles inclined by more than 15’’ in order to avert the risk of the reinforcement being sunk into fresh concrete.

13.6.2 Composite Piles

The bearing component of the composite pile must be positioned in the hole centre throughout the pile length, by using appropriate spacer blocks.

The regulation DIN 1045 should be consulted with regard to the construction and arrangement of reinforced concrete bearing components. Clause 6 (Concreting) hereof shall apply in respect with concrete technology.

In the case of steel bearing components, these may be of circular section compact rod, hollow pipe or other section. The constitution of such bearing components shall adhere to DIN 1050. In addition to steel categories referred to under the abovementioned regulation, use of other steel categories may be permitted, as approved by the competent material testing commission for civil engineering works in West Germany, having a nominal yield point up to 500 N/sq.mm. Steel bearing components shall require corrosion proofing against rust throughout their length.

Table 13.1 hereof shall apply with regard to concrete cover of bearing components.

13.6.3 Measures against Aggressive Foundation Ground or Groundwater

In the case of the foundation ground or groundwater being aggressive to concrete in the sense of the stipulations contained in DIN 4030 or in working sheet GW 9 of DVGW, the requirements of Table 13.1 hereof shall have to be taken into account.

TABLE 13.1

Minimum Thickness of Concrete Cover for Steel Reinforcement

	Degree of Aggression		
Row No	**Aggressive to concrete as per DIN 4030**	**Allowed aggression to steel as per working sheet GWG of DVGW**	**Concrete cover for Steel reinforcement (1), (5) in mm.**
1.	Non-aggressive		30
2.	Non-aggressive. However, it contains sulphates, therefore it is deemed slightly aggressive to steel (per DIN 4030)	Aggressive, slightly aggressive, or practically non-aggressive (4)	30 (2)
3.	Slightly aggressive		35 (3)
4.	Heavily aggressive		45 (3)

(1) Values applicable to concrete. In the case of cement mortar, same values may be reduced by 10mm.

(2) Cement class IV (sulphate resistant) must be used for the main pile construction.

(3) Pile construction shall be authorized provided that a specialist's report on matters concerning steel corrosion and concrete erosion may certify that the pile bearing capacity shall not be affected by any time-dependent reduction of lateral frictions. Instead of increasing the concrete cover, other protection measures may be taken, in the area lying outside the force transition length (see DIN 1045, December 1978 edition chapter 13.3). Despite that the reinforcement cover shall at least correspond to the values given in row 1, of table 131

(4) Jetted piles intended to short duration operation may be permitted to be constructed in ground heavily aggressive to steel, if proved that the pile bearing capacity may not be affected.

(5) In the case of jetted piles intended to short duration operation, the above values may be reduced by 10mm intended to short duration operation, the above values may be reduced by 10mm.

13.7. GENERAL NOTES ON PILE CONSTRUCTION

13.7.1 Boring the Pile Hole

Boring, ramming (percussion) or vibration may be used for opening holes intended to the construction of jetted piles. Boring products are removed by internal and external flow of the borehole water.

It is not permitted to remove the soil using exclusively borehole water, without any boring tube. A hole must be constructed throughout the length of the borehole, having firm sides and well-designed geometrical characteristics. The hole construction method shall be adjusted to the foundation ground.

In the area of force distribution, pile axes shall be spaced at not less than 0.80m. Such spacing may be reduced only in the case that no damage to adjoining piles is anticipated during construction.

Holes inclined by more than 15° from the perpendicular shall be permitted only when using adequately rigid boring tubes. Piles shall not be allowed to be inclined by more than 80° from the perpendicular.

When boring tubes are relatively rigid, we may as a rule measure the inclination at the upper tube section. Measuring of inclination is of particular importance when pile groups are concerned.

Provided that no damage may be caused to the reinforcement or the bearing component, tube ramming may be permitted to be effected through internal ties, by departure from DIN 4014, Part 1.

When boring below groundwater table, overpressure of the cleaning water or bracing of the borehole sidewalls may be used to avert entry of soil material into the hole.

The borehole must be finally cleaned from remains of bored products.

13.7.2 Grouting

13.7.2.1. Grouting material shall be either concrete or cement mortar. In the course of pile construction, the pressure to be applied in the region of the load distribution shall be not less than 5 bar.

13.7.2.2. Concrete shall be prepared in compliance to DIN 1045, December 1978 edition, chapter 6.5.2, and following the respective technology described under clause 6 (Concreting) hereof. By departure from the regulation, the cement content of concrete shall be no less than 500 kg/cu.m. Similarly, the characteristic strength of concrete shall be no less than 25 MPa (B25). By departure from DIN 1045, December 1978 edition, chapter 6.5.7.1, concrete placed with the sinking tube method, as described also in DIN 4126, Part 1 (for the time being still in draft), may be prepared in accordance with the terms provided for concrete category BI of DIN 1045. If grouting is performed in ground liable to absorb the grouting material, or in fissured ground, the cement content of concrete may be increased.

13.7.2.3. The largest aggregate size must not exceed one half of the concrete cover, or the spacing between reinforcing bars.

13.7.2.4. With regard to piles having diameter less than 200mm, the largest aggregate size shall not exceed 8mm. In the case of cement mortar being used, its ingredients must comply to DIN 1045, December 1978 edition, chapter 6. By departure from DIN 1045, Dec.'78 edition, chapter 2.1.3.1, it is permitted to omit any concrete admixtures. The mortar compressive strength should at least correspond to a concrete characteristic strength of 25 MPa (category B25).

13.7.2.5. Grouting operations in the area of the force distribution shall take place immediately after the hole preparation. Grouting shall proceed gradually upwards beginning from the bottom of the borehole.

13.7.2.6. The grouting material shall be discharged through a metal pipe, an elastic hose, or a tube. During hauling up of the pipe, the discharge outlet must always be no less than 3.0m deep inside the material being jetted in.

13.7.3 Supplementary Grouting Operation

The grouting of supplementary material shall be necessary when the hole is short of being filled according to sub-clause 13.7.2.1.

The arrangement for grouting shall be symmetrically positioned in the pile section. The supplementary grouting material, pressures and quantities to be applied shall need to be adjusted to local conditions. The mix of the supplementary grouting must be such as to allow filling of fissures, if any.

No supplementary grouting should be applied inside piles already loaded.

13.7.4 Construction Log

Construction logs must be compiled for all jetted piles in the course of their construction. Data corresponding to each type of pile used shall be taken from the model attached to annex A, at the end of the present clause.

13.8. QUALITY CONTROL

DIN 1045, Dec.'78 edition, chapter 7 shall be combined to clause 6 (CONCRETING) hereof to apply with regard to the certification of the quality of construction materials. When cement mortar is used in lieu of concrete, compressive strength shall be ascertained by application of DIN 4227, Part 5, a departure from DIN 1045. Two sets of cylinder test specimens (number, etc. complying to clause 6 hereof) shall be taken at the end of each 7-day period, in addition to all other samples, with a view to performing quality control.

13.9. BEARING CAPACITY PLANNING AND CONTROL

13.9.1 Control of External Bearing Capacity

According to DIN 4014, part 1, Aug.'75 edition, chapter 13.1, the pile section serving the transfer of loads must lie within ground of sufficient bearing capacity, to a length not less than 3m.

Within rock or semi rock, the length of pile transferring loads may be reduced, but not to less than 0.50m.

The thickness of ground layer must be re-examined in the case of compressive piles, combined with the likelihood of unwanted settlements being caused to the underlying layers by the pile loads.

In the case of reinforcement of existing foundations, jetted piles may be used (by departure from DIN 1054, Nov.'76 edition, chapter 5.2.1) for the transfer of partial loads, if tolerances are considered for the strain performance of the foundation components.

Permissible pile loads shall be based on trial loadings applied in accordance with the directions of DIN 1054 and of its annex, Nov.'76 edition, chapter 5.8.

Trial loads shall be applied onto not less than two (2) piles, and not less than 3% of the overall number of piles.

Such trial loadings shall be conducted where ground sections indicate the least appropriate ground formation bearing in mind the pile bearing capacity, unless similar trial loadings are conducted for each distinct ground formation.

During the application of trial loads on piles adjacent to operational foundation pile excavations, care shall be taken to apply suitable construction measures for excluding the transfer of lateral friction loads onto the pile excavations. When required that the pile loads be distributed over a limited length of the pile, suitable construction means shall be used to exclude load application onto other areas. Under exceptional cases, the effect of lateral friction shall need to be taken into account through the application of calculation methods.

Should operational piles be used for trial purposes, it shall need to be proved that such test loads may not affect unduly the piles' bearing capacity.

The values of safety factors shall not be lower than those indicated in Table 13.2 herebelow. With a view to defining the permissible pile load, we may begin with the lowest possible value of the trial load.

TABLE 13.2: Safety Factor "n" for jetted Piles

Jetted Piles		"n" (under various loadings as per DIN 1054)		
		1	2	3
Compressive	Piles	2.0	1.75	1.5
Traction Piles :	deviation from the perpendicular by 0° to 45°	2.0	1.75	1.5
	deviation from the perpendicular by 80°	3.0	2.50	2.0

In the case of traction piles deviating from the perpendicular by between 45° and 80°, the safety factor value shall be taken by interpolation between those given in the Table for the 0-45° and 80° angles.

REMARK:

In accordance with DIN 1054, Nov.176 edition, table 8 and with the "Recommendations of the Commission for Bank Protection Works" EAU 1980-E26 of West Germany, in the case of traction piles and for reasons of structural sufficiency and of geometry the values of the above safety factors shall decrease when the pile deviation from the perpendicular increases. As opposed to this view, and always in the case of traction piles, the present clause provides that safety factors increase with the deviation from the perpendicular, due to a more profitable exploitation of lateral friction. In comparison with jetted anchorings (DIN 4125, parts 1 and 2), and having given up the principle of taking test samples, this method tries to achieve a comparable level of safety factors.

If results of other trial loadings are available under comparable conditions, application of these trial loads may be eliminated following the Service's approval.

In the exceptional case of the trial loadings being skipped, the marginal values of lateral friction used in Table 13.3 may be applied. It shall not be permitted to take into account the resistance of the pile peak as a supplement.

TABLE 13.3 : Marginal Values of Lateral Friction for Jetted Piles

Ground Formation	Compressive Piles MN/sq.m.	Traction Piles MN/sq.m
Medium size to coarse gravel	0.2	0.1
Sand and grit	0.15	0.08
Cohesive soils	0.1	0.05

The permissible values of lateral friction shall result by dividing the marginal values of lateral friction by the factors "n" of Table 13.2.

Axial displacements of pile heads up to 10mm must be envisaged for individual piles of an overall length up to 10m under conditions of permissible loadings.

Elastic and permanent displacements are included in these values.

13.9.2 Internal Bearing Capacity

Dimensioning of piles constructed by in-situ grouting of concrete shall be in accordance with DIN 1045. Prior to dimensioning composite piles other than these (i.e. by grouting of cement mortar), the possibility of using such piles must be proved and certified.

For concrete grouting piles, the limitation of pile fissure size must be certified according to DIN 1045, Dec.'78 edition, chapter 17.6.2 for "very small" fissures envisaged.

In the case of composite piles, we may act depending on the case of using concrete or cement mortar for corrosion proofing.

Other means may also be used for corrosion proofing, if proved to provide equal protection with that of concrete or cement mortar in the long term and under similar loading conditions.

13.9.3 Buckling Safety Control

If, according to DIN 18137, part 1, or according to DIN 4096, the shearing strength of badly drained cohesive ground proves to be less than 10 KN/sq.m., a buckling safety test must be conducted for column with no lateral support, in supplementing DIN 1054, Nov.'76 edition, chapter 5.2.10.

13.9.4 Bending Strain

In addition to DIN 1054, Nov.'76 edition, chapter 5.3.3, the lateral compressive strain must be taken into account, depending on the recommendations of DGEG

"Lateral compression of piles due to movement of soft cohesive soils".

With the purpose of avoiding bending strain of individual piles caused by undue eccentric loading, the pile layout must be designed in a manner ensuring that such eccentric action may be considered harmless to the individual pile.

Note :

This, for example, would mean arrangement of no less than three (3) piles or of two (2) rows of piles under a unified load

13.9.5 Safety of Stability and of Strain Performance for the Overall System

Tests must be conducted as to the stability and the strain performance of the overall system.

The tests shall be in accordance with the directions contained in the regulation DIN 1054, part 1, Nov.'76 edition, chapters 5.2.3 and 5.3.

The regulation DIN 4125, part 1, June'72 edition, chapters 5.6 to 5.8 shall be adhered to when jetted piles are used for anchoring purposes.

In the cases of variable compression or traction, i.e. in the cases of the piles being subject to fluctuating dynamic loads, the conditions of trial loading must be equaled to those of the piles' future operation status, in addition to the usual trial loading applied for the determination of marginal loads. The number of dynamic loads (fluctuating traction and compressive loads) applied in the course of the trial, should suffice to enable the drawing of positive conclusions, namely that the increase of the pile strain has gradually been reduced to zero.

In the case of traction loads increasing from zero up to a marginal value always positive, the conduct of the above trial (requiring progressive elimination of the strain) may be omitted when the contribution of fluctuating traction loads to the overall service load of the pile is less than 50%.

13.10. MEASUREMENT OF SMALL PILE CONSTRUCTION WORKS

(1) The measurement for small pile construction works shall be conducted as follows, also according to the provisions hereof

a. Equipment Mobilization - Demobilization

It includes the installation on an appropriate location, as instructed by the Service, of the suitable complete plant and other equipment necessary for the construction of small piles, and the removal of same plant and equipment after completion of the construction operations. Intermediate assemblies and disassemblies of the plant and equipment, as may be required prior to the completion of the works, shall not be accounted for.

The mobilization - demobilization of the plant and equipment shall be measured apiece, for lumpsum payment.

b. Small construction (without reinforcement)

Measurement shall be in lineal meters, per small pile diameter. Actual bored lengths shall be measured, in which concrete has been injected [and the eventually planned precast bearing element has been installed (for the case of composite small piles)] for the construction of small pile receiver. Small pile lengths shall be calculated from base level as envisaged by the design (or as modified during construction upon approval by the Service) to the level of the natural ground, as this shall be at the beginning of the small pile construction operations (and as approved by the Service). No small pile construction shall be measured in excess of the base level envisaged by the design (or of its approved amendment).

c. Small pile reinforcement

Measurement shall be made in kilograms of steel reinforcement weight being installed on site before concrete injection, or which is included in the precast bearing element made of concrete or steel. The weight shall be calculated from the detailed bar bending schedules included in the approved engineering design, or (in case of lack of such schedules), from schedules which the contractor is obliged to prepare and submit for the Service’s approval prior to the start of construction.

The bar bending schedules shall be conducted based on the design drawings and shall include in full detail the dimensions, diameters/cross-sections, No of bars, partial and total steel bar lengths and weights per I.m. and cross-section according to the official weight schedules of the German Regulations (DIN 488 if steel bars for reinforced concrete are concerned, DIN 1025 if molded steel St 37 of standard I cross-section etc.). The schedules shall be signed by the Contractor and the Service, following reinforcement delivery which shall be checked during installation in the project site.

The above approved schedules of the installed reinforcement together with their weights constitute the reinforcement measurement which shall accompany the delivery protocols of obscured works.

During measurement, the weight of the additional elements used to ensure the installation and holding of the reinforcement in the planned position within the small pile course shall not be considered.

(2) Works measured as abovementioned shall be considered to comprise the whole spectrum of works related to small pile construction. Small piles of the same diameter shall be measured under the same item, irrespectively of differences in the nature of ground encountered during boring, their location, depth, inclination (as specified in pare 13.7.1 here of), ground- or artesian water, and irrespectively of difficulties in securing access to the site, in boring, driving in, extracting, concreting, pumping, etc.

Depending on encountered type of soil it is possible to classify small piles into two categories (with different small pile diameters in each category)

- Small pile construction in any kind of soil with retaining of borehole side (by means of casing and/or drilling fluid).

- Small pile construction in any kind of soil without retaining of borehole sides (by means of casing and/or drilling fluid).

However, it might be possible that these two categories may be unified into one according the Price List and/or the other terms of tender.

(3) In the case of a provision for the construction of small piles belonging to more than one categories the item of "installation and removal of plant and equipment" shall refer to the overall plant and equipment required for the construction of all categories of small piles.

13.11. PAYMENT FOR SMALL PILE CONSTRUCTION WORKS

(1) In accordance with measurements executed, small pile construction works shall be paid for under three distinct work items, as follows :

a. Installation/Removal of Plant and Equipment

Payment shall be based on the respective lumpsum price of the price list included in the Contractor's bid, and shall be effected by half upon completion of the plant installation in full, and by the other half upon completion of the plant removal that shall take place after the completion of small pile construction works.

b. Small Dile Construction (without steel reinforcement)

Payment shall be based on constructed linear meters as derived from the measurement for the various small pile diameters and eventual classification into categories (depending on the need or not to retain the borehole sides) as hereabove defined under sub-clause 13.10.(b) and multiplied by the respective unit prices of the price list included in the Contractor's bid.

c. Small pile steel reinforcement

Payment shall be based on the kilograms of reinforcing steel weight, as derived from the measurement, as hereabove defined under sub-clause 13.10.(c) and multiplied by the respective unit prices of the price list included in the Contractor's bid.

(2) The abovementioned individual prices and work payments shall include for the following :

a. Mobilization/Demobilization Plant and Equipment

i. All costs related to transportation of the complete mechanical plant (frame) and other small pile equipment onto the works site, irrespectively of the number of times such transportation shall be effected (should it be required more than once until completion of the works), and irrespectively of the overall length of small piles to be constructed.

ii. All costs related to removal of the complete mechanical plant and other small pile equipment from the works site, irrespectively of the number of times such removal shall be effected (should it be required more than once until completion of the works), and irrespectively of the overall length of small piles to be constructed.

iii. The converted effect of the cost of a compilation regarding the method of construction, and of submission of same to the Service.

b. Small Pile Construction (without steer reinforcement)

i. Small pile boring

1. The cost of lay days and of overall hiring mechanical plant related to boring small pile holes, for the whole period such plant shall be on the site including all kinds of delays, irrespectively of the length of individual small piles and of the overall length of small piles to be constructed.
2. The cost of transferring the relevant mechanical plant from one position to another over the same pier, or from one pier to another,

irrespectively of the number of such transfers, of the individual and the overall small pile length, until completion of the whole work.

3. The cost of boring the required hole to measurable length, depending on the diameter specified, in the manner described herein, irrespectively of the nature of the ground encountered during boring, the depth, location and inclination, ground- or artesian water, the difficulty of providing access, of boring, etc. and with the provision to classify in two categories depending on the need or not to retain the borehole walls (by means of temporary protective casing and/or boring through the use of a drilling fluid of appropriate composition e.g. bentonite slurry).
4. The cost for the supply, transfer onto the works site, mixing, using, loss and consumption of any quantities of drilling fluid (i.e. bentonite suspension or other), for the case of using such method, of suitable quality and properties for boring small pile holes and for stabilizing the boring walls, along with taking appropriate measures and construction of appropriate structures for storing, feeding the hole, avoiding environmental pollution, removal and disposal of remains or disused quantities onto sites authorized by the Police Department or approved by the Service.
5. The cost for the supply, transfer onto the works site, driving in, extraction and removal of suitable provisional casings for stabilizing the boring walls (in case this method is required to be used), for any stretch of the borehole such casing may be applied, including wear and/or total loss due to impossibility of extracting same, or for any other reason.
6. The cost for loading, lay days of hauling vehicles, removal of excavation (bored) products and dumping of same onto sites approved by the Service within the area of the works site, or haulage to any distance from such site onto areas authorized by the Police Department and approved by the Service, including the cost of depositing same on such areas.
7. The cost for compiling the construction protocol for each small pile, in accordance with relevant stipulations herein described.
8. The cost for any pumping that may be required, and for dealing with surface, ground or artesian waters.
9. All costs related to restoration of utility networks and/or of adjoining structures that may be damaged as a result of small pile construction works.

ii. <u>Concreting Small Piles</u>

1. The cost for hiring and for lay days of mechanical equipment related with small pile concreting operations, throughout the duration such equipment shall be on the works site including all kinds of delays, irrespectively of individual and of overall length of small piles to be constructed therewith.
2. The cost for transferring such equipment from one position to another within bounds of the same pier, or from one pier to another, irrespectively of the number of transfers, and of individual and overall small pile length until completion of the works.
3. The cost of preparing the necessary setup, working floors, etc., required for the small pile concreting operations, as well as the installation / driving of the precast bearing element made of reinforced concrete or steel, regarding the construction of composite piles.
4. The supply of all required materials (aggregates, water, cement, admixtures) and the production of the required quantity of concrete

(injected concrete), meeting specified requirements, all kinds of handling and transportation to the position of placement and injecting concrete for the construction of the small pile trunk, in compliance with the method herein specified, its subsequent curing, etc., as described in the present clause or under clause 6 hereof regarding concreting, including the expense for lay days and occupation of the suitable mechanical equipment for injecting the concrete.

5. The supply to the job site of the precast bearing element made of reinforced concrete (without the value of steel reinforcement being paid for separately) for the composite piles.
6. The expense for the supply, production and injection of the required complementary concrete which is necessary in cases where the small pile hole has not been completely filled with injected material, according to the present specification, including the expense for lay days and occupation of the suitable mechanical equipment for injecting the material.

c. Small pile steel reinforcement

i. The expense for the supply, loading - unloading, idle time from truck lay days, transportation to the job site from any distance of the steel reinforcement planned to be installed in the small piles, on site during small pile construction or during the fabrication of the precast bearing elements made of precast concrete if it concerns construction of composite piles, as well as the expense of temporary storage of steel reinforcement in a suitable place protected against weather conditions, until the reinforcement use in the project.
ii. c2. The expense of cleaning the reinforcing bars from detrimental and undesirable substances (such as rust, greasy substances etc.), arrangement of the eventually planned from the approved design reinforcing grid made of steel rods of suitable cross-section, reinforcement installation (bars or grid) within the small pile hole, fixing and holding the reinforcement into its proper position during material injection, including the expense of supply and installation of elements (metal or plastic) at appropriate locations to ensure holding the reinforcement at the desirable location.

(3) The above prices and payments include for all mechanical means, tools, materials, instruments, controls and trial loadings the number of which is specified in para 13.9.1 hereof, the construction (material and workmanship) of the trial small piles the number of which is specified in para 13.9,1 hereof and according to the methods described hereinabove, for all professional and skilled / unskilled personnel to be required for the completion of the work, together with any other cost relevant to the execution of an impeccable work, although may be not explicitly herein specified.

(4) The above prices and payments do not include (unless otherwise specified in the tender documents) for the following works :

a. The execution of additional trial loadings on non-operational or operational small piles beyond those specified in para 13.9.1 hereof.

b. Any additional costs required for dealing with aggressive groundwater, possibly entailing the need for using cement type IV.

ANNEX "A" TO CLAUSE 13 OF THIS T.C.C.
TABLE OF CONTENTS OF CONTRUCTION LOG FOR JETTED PILES

1. <u>GENERAL PROJECT DATA</u>

   1.1 Contracting company

   1.2 Job site

   1.3 Pile drawing N" ....

   1.4 Pile reinforcement drawing N° ....

   1.5 Drawing of pile placement

   1.6 Description of the pile construction method

   1.7 License N° ....

   1.8 Drilling equipment (auger, ram)

   1.9 Boring tube (external and internal diameter)

   1.10 External diameter of auger (or of pile foot)

   1.11 Stay

   1.12 Borehole cleaning (compressed air/water/slurry/external/internal)

   1.13 Discharge of the grouting fluid (through elastic hose, metal pipe, boring tubes)

   1.14 Grouting pump

   1.15 Grouting through air/fluid

   1.16 Category of strength of the concrete/cement mortar

   1.17 Mix analysis

      1.17.1 Cement : type, strength category, weight ratio per unit of volume

      1.17.2 Aggregates : largest grain size, weight ratio per unit of volume

      1.17.3 Admixtures : (concrete admixtures) type, ratio to cement in weight

      1.17.4 Additives : (concrete additives) : type, weight ratio per unit of volume

      1.17.5 Water/cement ratio (coefficient WIC)

      1.17.6 Result of compliance test

   1.18 Jointing of reinforcing bars : (overtopping/welding) or jointing of bearing component : muffs, clamps.

2. INDIVIDUAL PILE DATA

2.1 General

2.1.1 Pile N° ....
2.1.2 Pile diameter
2.1.3 Inclination to the perpendicular
2.1.4 Elevation of the pile head in relation to the borehole ground level. Works site datum
2.1.5 Pile length
2.1.6 Pile hole
2.1.7 Pile section of load distribution

2.2 Sequence of ground formations as per DIN 4014, part 1, Aug:75 edition, annex, or Boring ram log as per DIN 4026, Aug.'75 edition, annex.

2.3 Pile reinforcement (or bearing component)

2.3.1 Length of reinforcement (or length of bearing component)
2.3.2 Position of reinforcement (or of the bearing component) in relation to the drilling level and the absolute site level or datum.
2.3.3 Joints of reinforcing bars

2.4 Grouting, supplementary grouting

2.4.1 Measurement of grouting pressure applied along the pile section of load distribution (grouting pressure at pump outlet)
2.4.2 Grouting quantity pumped through each valve
2.4.3 Total volume of grouting material jetted in

2.5 Pile construction periods

2.5.1 Boring time (or period of ram use)
2.5.2 Reinforcement (or fixing of the bearing component)
2.5.3 Grouting
2.5.4 Supplementary grouting

2.6 Remarks/specific issues

2.7 Signatures

2.7.1 Chief drill operator
2.7.2 Site agent
2.7.3 Service's representative

2.8 Date

ANNEX “B” TO CLAUSE 13 OF THE T.C.C.
RELEVANT REGULATIONS AND OTHER INFORMATION

DIN 1045 Plain and reinforced concrete / Dimensioning and construction

DIN 1050 Steel in civil engineering works / Calculations and structural layout

DIN 1054 Foundation ground - Permissible loads

DIN 1080 Part 1 : Definitions - Symbols and units in civil engineering works - Basic principles

DIN 4014 Part 1 : Ordinary bored piles (construction, dimensioning, and permissible loads)

DIN 4026 Ram driven piles (construction, dimensioning and permissible loads)

DIN 4030 Testing water/soils/gases aggressive to concrete

DIN 4096 Foundation ground. Blade test (instrument dimensions, working method, evaluation)

DIN 4125 Part 1 : Soil and rock anchors. Provisional anchors in loose rock (dimensioning, construction and testing)

DIN 4125 Part 2 : Soil and rock anchors. Permanent anchors by grouting. (Permanent anchors) *in* loose rock (dimensioning, construction, testing)

DIN 4126 Part 1 : Reinforced concrete retaining walls and reinforced concrete retaining walls cast in-situ under continuous concreting operation (construction and execution)

DIN 4227 Part 5 : Prestressed concrete. Grouting of cement mortar

DIN 18137 Part 1 : (Preliminary Regulations) Foundation ground : Testing soil samples. Determination of shearing strength Definitions and basic conditions for conducting trial tests.

EAU (1980) Recommendations by the working commission "Bank protection" of the company DGEG (1981), 6th edition. Ernst & Sohn Publishers.

DVGW-(working sheet GW9)
Note on the evaluation of corrosion risks of iron and steel in the ground. ZFGW Publishers, Frankfurt am Main

Recommendations by AK5 of the company DGEG "Strain of piles under lateral compression due to movement of soft cohesive soils", Geotechnik 1978, page 100 ff.

Clause 14 : QUARRIES - BORROW PITS - DUMPING AREAS

14.1. QUARRIES

14.1.1 General

14.1.1.1. It is pointed out, that with regard to financial charges and limitations related to installation operation and environmental protection, the following shall apply in this contract : Law …….

14.1.1.2. This clause is applicable to common quarries and/or mines of aggregates (for the preparation of concrete, other technical constructions, road pavements, common asphaltic works, etc.),as well as quarries and/or mines of skid-resistant aggregate materials for the construction of special skid-resistant wearing courses (bituminous or concrete).

14.1.1.3. Aggregates may be supplied from :

a. Existing quarrying enterprises

b. "New Quarries" that will be installed and run by the Contractor (on new sites or on sites of old quarries that are out of operation).

14.1.1.4. In the case of aggregates supplied from existing quarrying enterprises, the Service shall not interfere with the Contractor's choice, other than the quality control requirements of materials (which must comply absolutely with the requirements of the specific contract) and the environmental protection requirements regarding the existing installation.

14.1.1.5. In the case of aggregates supplied from "new quarries" that will be installed and operated by the Contractor (in accordance with subparagraph 14.1.1.3.b above) the following paragraph 14.1.2 shall apply in this contract, which refers indicatively and not by way of limitation, to the legislation in force, regarding selection of the location of suitable material and issue of operation permit for the new quarry.

14.1.1.6. It is noted that the term "new quarries" in this specification refers to new quarry sites as well as restarting operation of old quarries that are now out of operation, in accordance with paragraph 1 of clause 9 of the J.M.D. 69269/5387/24-10-90.

14.1.1.7. In all cases the Contractor's offer includes all costs of constructing and maintaining the roads that may be required for access and transportation of materials drawn from any source, and the cost of any additional transportation, or unfavorable land renting conditions, purchase of rock outcrops or quarries, uncovering, exploitation, and output of such quarries, etc.

14.1.1.8. Furthermore the Contractor's offer includes any costs related to the development of the available site (according to the needs of the Contractor and under the limitations of the Approval Decision of Environmental Conditions, the existing legislation, and the Competent Authorities), the connection works to existing roads, the protection, the necessary transfer, the restoration of public utility networks and installations, any consequential damages to adjacent buildings, cultivations, adjacent areas etc.

14.1.1.9. Operation permit for new quarries will be granted only for the requirements of the project, and after completion of the works the Contractor shall cease all quarrying activities, he shall take all the necessary measures and execute the related works as provided by the legislation in force (Law …..) for the purpose of restoring the environment. Similar actions shall be carried out in the area of the worksite installations.

14.1.1.10. Any operation permit issued by the Service, for new quarry and site installations, shall be for EXCLUSIVE USE FOR THE CONSTRUCTION WORKS OF THE PROJECT of the specific contract. The use of the installations, or the drawing of aggregates etc. for other projects or the execution of other works shall be prohibited.

In case this prohibition is not respected, the Service has the right, according to L.1650/86, to impose fines on the Contractor based on evaluation of the environmental damage caused, the use of Public materials for private purposes, and/or other reasons, or even to order the immediate interruption of operations of the quarry, or any other installations, the Contractor being automatically responsible to restore the quarry environment, according to the E.I.S. for the section he has exploited. In this case the Service assumes no responsibility for any financial consequences or delays that the Contractor may suffer, who shall be considered to be solely responsible, due to the violation on his part of the restrictions hereby defined.

14.1.1.11. In the case where the Contractor intends to install and operate a new quarry, for the period of time until the new quarry starts to operate and if the programme of works provides for operations that require the use of aggregates, then the Contractor is obliged to purchase the aggregates from existing quarrying enterprises.

14.1.1.12. The Contractor shall be solely responsible for the good quality of the rock quarried and the processing that it will undergo, in order that it obtains the characteristics required by the technical specifications and the other terms of the contract; for the quantities that may be drawn (provided that the good operation of the installations is ensured in compliance with this specification and with the conditions of the operation permit issued to him in accordance with the provisions in force).

In accordance with all the above, and during the preparation of his offer for participating in the tender, the Contractor must inspect the sites he intends to use for quarrying of rock and for his worksite installations, and to conduct all surveys he deems necessary (even borings) in order to document UNDER HIS OWN RESPONSIBILITY, the suitability of the quality of the rock, the adequacy of deposits, the possibility of installing the required facilities, the possibility of arranging the site in compliance with environmental requirements and the requirements of successful economic exploitation, etc.

He shall furthermore have ensured alternative locations for site installations or for the supply of aggregates, in the case of reversal of facts for any reason whatsoever in relation to initial estimates regarding the possibility of installing and of successfully operating a quarry with full observance of the restrictions and obligations imposed by this specification, the other terms of the contract, the legislation in force, etc.

14.1.1.13. If in the course of the preliminary investigation, conducted by the Contractor, prior to the formulation of his proposal, or even during the execution of the works, the quarry site or any other installation or operation or stockpiling area etc. is proved to be inadequate or unsuitable, or to have become unsuitable, the Contractor shall be bound to locate, at his own care and expense, a new site appropriate for the installation of the facilities required by him, or for the transfer of the installations erected and/or operated by him, in order to comply with the following requirements.

a. The execution of all works must comply with the specifications.

b. The time-limits fixed are considered not to be affected by any problems arising from the above situation.

c. The unit prices and/or the lumpsum price are not to be affected by such situation, even in the case where the Contractor has to install a quarry and/or other installations on such locations that render work more difficult, or prolong transportation trips, or even if he has to purchase aggregates from the open market and from any distance.

14.1.1.14. If the contract provides for a Quality Control Firm, then all the quarries must be approved by the Firm.

All tests and controls shall be carried out either by the Quality Control Firm, or in the presence of its representative.

All submissions to the Supervision shall be accompanied by test certificate(s) of the Quality Control Firm, with reference to the suitability and the required quantity.

14.1.2 Operation of *"new quarry"*

14.1.2.1. Regarding the location of suitable materials and the issue of a permit for "new quarry", indicatively but not by way of limitation, the following stipulations of the legislation in force, shall apply :

Law …….

14.1.2.2. The Environmental Impact Study that will be submitted by the Contractor must also include the laboratory test results of an investigation programme that he must have conducted in compliance with the provisions of the D.I.S. and/or the other special conditions of contract.

14.1.2.3. The results of the relative investigations and laboratory tests are considered necessary for the Service to determine (besides other consequences and views regarding the operation of the quarry) the suitability of the materials to comply to the specified requirements of execution of the project works.

14.1.3 <u>Quarry selection methods by the Contractor</u>

14.1.3.1. The tender conditions of all contracts shall specify the quarry selection method by the Contractor, which may be one of the following two :

a. Free selection of quarry method.

b. Selection of quarry, following preselection by the Service.

These two methods are analyzed in the following paragraphs 14.1.3.2 and 14.1.3.3.

Should the tender conditions make no special reference to the selection of quarry method to be applied for the contract, then the free selection of Quarry method shall be applicable, according to case (ay above of this paragraph.

14.1.3.2. *<u>Free selection of quarry method</u>*

In application of this method the Service shall NOT hand over to the Contractor any quarry or mine for obtaining the required aggregates for the execution of the project.

The Contractor therefore, shall obtain all the necessary suitable aggregates from existing quarrying enterprises or by installing and operating a "new quarry", or quarries, under the provisions and restrictions of the legislation in force (according to paragraph 14.1.2 above.)

According to this method the Owner of the project shall NOT undertake any obligation to expropriate land areas suitable for the production of materials to be used by the Contractor.

The Contractor therefore, in the case of new quarry, shall have to locate and use suitable sources of aggregate materials either by renting or by purchasing the suitable sites

It is assumed therefore, as contractual term, that the Contractor's bid price and/or lumpsum price, includes all the required additional expenses for any reason whatsoever, for the supply of the necessary aggregates from private sources or for renting or purchasing land areas for their production, or even any surcharges that may be required due to the simultaneous exploitation of certain sources (with other previous or following contracts, including the related surcharges required for the timely and workmanlike execution of the work), having taken into account all the commitments and restrictions imposed by the environmental protection.

14.1.3.3. *<u>Quarry Selection following preselection by the Service</u>*

(1) According to this method, all the provisions of the above paragraph 14.1.3.2 are also applicable, but in the case of new quarry the Service shall have conducted an indicative preliminary investigation at some sites, that are in principle considered as satisfying the requirements of this specification.

Such sites are designated as PRESELECTED SITES FOR NEW QUARRIES (P.S.N.Q.) and shall be explicitely mentioned in the tender conditions.

(2) It is however pointed **out** that the Service SHALL NOT ASSUME ANY RESPOS1BILITY for the suitability of rock deposits in the P.S.N.Q., the agreement of the competent authorities with regard to the suitability for granting operation permit, the compliance with this specification, the transversal slopes, the necessary layout arrangements, the excavation to reveal clear rock, the connection of the quarry site and the worksite with access road to the existing road network, the accessibility to the necessary public utility networks, the successful location in relation to the work being executed, the causing of disturbance and/or damage (positive or consequential) to any adjacent properties, buildings, installations, etc.

(3) In the case of P.S.N.Q., if they are finally selected by the Contractor for the installation and operation of a new **quarry,** under his sole responsibility and provided that they may be finally accepted, in compliance with the stipulations regarding new quarries of this specification, the Contractor shall have to squire <u>at his own cost</u> the site required for the quarry, as well as for the worksite, either by renting or by purchasing the appropriate locations.

(4) In contrast to the free selection of quarry method, it is specified that for this method and specifically for the P.S.N.Q. the Service may initiate expropriation procedure on behalf of the Government, with temporary allocation of the land to the Contractor for use during the execution of the works. After completion of the works any expropriated land areas shall devolve to the Government for its own use.

The costs related to such expropriation shall be borne by the Contractor, who shall deposit in advance the necessary amount to the Service, to allow the fulfillment of the expropriation and the taking over of the land in question.

(5) For quarries of skid-resistant aggregates, or other quarries of special-property aggregates, the Service, following the Contractor's request, may initiate expropriation procedure as if it were for P.S.N.Q., even though these sites were not mentioned in the tender conditions. For these quarries the conditions set for the P.S.N.Q. shah also be applicable.

(6) For any other sites for new quarries [except for the P.S.N.Q. and those mentioned in the previous subparagraph (5)], the Service shall assume no responsibility to promote any expropriation procedure.

(7) The procedure of expropriation of necessary land areas for P.S.N.Q. shall commence after the issue of Decision of Approval of Environmental Conditions which shall grant operation permit for a knew quarry" in accordance with paragraph 14.1.2 above.

(8) The Service shall assume no responsibility regarding time limitations for completion of the expropriation procedure, however it is understood that the Service shall assist the expedition of such procedure through the formalities in force.

(9) If required by the programme of works, the Contractor shall be obliged to obtain the necessary aggregate material from existing quarrying enterprises, for the period until completion of the expropriation and

provided that the required land area affects the operation of the quarry and the necessary installations.

(10) In this case the Contractor's bid prices and/or lumpsum price shall include converted, the expenses mentioned in paragraph 14.1.3.2 above, as well as the expenses incurred for the completion of the expropriation mentioned in the above paragraphs 14.1.3.1(4), (5) and (7).

14.1.4 Monitoring of the quality characteristics of aggregates

14.1.4.1. The Contractor shall be solely responsible for the good quality and compliance of any materials entering into any kind of works with the specifications and the other conditions of contract [hardness, grain size grading, plasticity, water absorption, sand equivalent, aggregate abrasion value, polishing stone value, resistance to abrasion by Los Angeles machine etc.], as it is understood that by signing the contract he has assumed responsibility for the perfect construction of the works using the best accepted materials, while any testing conducted by the Service shall not release him from this responsibility, irrespective of the results.

Should therefore, some sources of materials prove in the meanwhile unsuitable for the production of accepted materials, the Contractor who has to monitor such developments, is obliged to seek other suitable sources. The above constitutes a contractual obligation of the Contractor and belongs to his exclusive responsibility.

14.1.4.2. Production of aggregates for concrete, road pavements and asphaltic mixes, shall be continuously monitored, sampled and tested for hardness, grain size grading, plasticity and water absorption. Control test sheets shall be filled in to this effect and material consignment protocols shall certify that the materials were tested and found in compliance with the specification.

14.1.4.3. In the case of using site produced concrete, the quality control of the aggregates (paragraph 6.4.3 of clause 6 of the T.C.C. etc.) shall be supplemented with the following requirements :

(1) The overall quantity of aggregates required for concreting each independent section of the works, or part of pier, wall, section of culvert, etc., scheduled for concreting in one shift, shall be stockpiled prior to the commencement of the concreting works, in the storage area at the worksites and/or the contractor's camps (provided such locations shall be authorized by the Service for aggregate stockpiling), if the site available is not adequate. These aggregate materials shall be continuously visually monitored.

(2) if pumped concrete is to be used, screening test (to test the grain sized grading) shall be performed on not less than one out of ten consignments, same as on all suspect consignments. In cases of non-pumped concrete, class B15 or lower, screening tests may be performed on one out of twenty consignments and on all suspect ones.

(3) All aggregate consignments shall be initially deposited separate from the general stockpile until results of the representative sample screening test prove satisfactory and conforming to the grain size grading specified by the design mix and the other conditions of contract, in which case the aggregates that were stocked to the side shall join the general stockpile of each category of aggregates.

(4) Should the screening tests prove the non-compliance to the specified grading, the Contractor is obliged to remove the unsuitable quantity of aggregates. Supplementary samplings and tests may be performed in order to identify and remove the whole unsuitable quantity.

(5) Since the above operations are liable to directly affect the rate of progress of aggregate stockpiling, the Contractor shall make sure of adopting in the materials supply and production programme, an appropriate rate of aggregate deliveries to allow for adequate time as required for testing, and he shall carry out all works related to the haulage and stockpiling of materials, identification and removal of unsuitable materials.

14.2. BORROW PITS

14.2.1. The provisions of the above paragraphs 14.1.1.1, 14.1.1.7, 14.1.1.8, 14.1.1.12, 14.1.1.13, shall accordingly apply also in the case of borrow pits with respect to the quality of the borrow materials and to the costs included in the unit price and/or the lump sum price, regarding borrow pits.

14.2.2.

(1) The Owner of the Project shall not hand over to the contactor any borrow pit or mine for the drawing of the required borrow materials that must have the quality characteristics in compliance with the specifications and the other tender conditions, for the execution of the work. The Contractor therefore, shall make sure to locate and use suitable borrow pits (or mines) observing also any environmental constraints imposed from the other tender conditions, either in public land (provided it is allowed to grant him with permit to exploit and draw the required quantities, in accordance with the provisions in force and the restrictions of the tender conditions), or by renting or purchasing of suitable private land areas, or even by purchasing from existing enterprises selling borrow materials.

(2) Consequently the Contractor's bid price and/or lump sum price for the works, shall include all the required additional expenses for any reason whatsoever, for the supply of the necessary borrow materials from existing enterprises selling such materials, or for renting or purchasing land areas for the drawing of borrow materials, or even any surcharges that may be required due to the similtaneous exploitation of certain sources (with other previous or following contracts, including the related surcharges required for the timely and workmanlike execution of the work), having taken into account all the commitments and restrictions imposed by the environmental protection, in accordance with the legislation in force as also specified for the quarries in the previous paragraph 14.1 of this specification.

(3) Furthermore the Contractor's bid price and/or lump sum price shall include for any costs incurred for the extraction or purchase of borrow materials

from streams and/or river beds, or other sites, to be paid to local authority enterprises, that have the exploitation of the borrow pits, or to local authorities, to which fiscal rights for drawing borrow materials from certain sites have been ceded.

14.2.3. In general, the Owner of the Project DOES NOT assume any responsibility to expropriate land areas suitable for use as borrow areas or mines for the drawing of materials by the Contractor. It is however possible, following a request by the Contractor, to promote compulsory expropriation of certain land areas to be used as borrow areas, in accordance with the legislation in force.

Such expropriation shall be effected on behalf of the Government with provisional release of the land to the Contractor for the duration of the construction of the works. After completion of the Project any expropriated land areas shall return to the use of the Government.

It is pointed out that prior to the initiation of the expropriation procedure of borrow areas in accordance with the above, a relevant sampling and investigation must have been carried out that proves the suitability of the material for use in the works of the contract, according to the specifications and the other tender conditions.

14.2.4. Expropriation costs as per above paragraph 14.2.3 shall be borne by the Contractor, who shall deposit in advance the necessary amount to allow the fulfillment of the expropriation and the taking over of the land in question.

14.2.5. Paragraphs 14.1.3.3(7), (8) and (9), concerning expropriations, shall also apply accordingly in the case of borrow pits and borrow materials.

14.2.6. It is hereby clarified that in this case the Contractor's bid prices and/or lump sum price shall include converted, the expenses mentioned in paragraph 14.2.2, as well as the expenses incurred for the completion of the expropriation mentioned in paragraph 14.2.4 above.

14.2.7. Furthermore to the above, and in combination with the other tender conditions, the terms of the following paragraphs shall also apply.

14.2.7.1. For the borrow materials to be approved, the Contractor shall notify in writing the Service of his intention to use the specific "sources of borrow materials" (borrow pits). Within five (5) days from the notification samples shall be taken and suitability tests shall be carried out. After that, and not later than twenty (20) calendar days from the notification of the sites, the Contractor shall submit to the Service a technical report regarding the borrow areas, which shall comprise :

(1) Topographic plans of the borrow areas with an estimate of the quantities
that will be extracted from each site.

(2) Laboratory tests results.

(3) Evaluation report of the above results and of the proposed construction methods, i.e. the materials compliance to the specifications, thickness of layers, compaction equipment that will be used, optimum moisture content and the relative PROCTOR

curve, materials classification into categories (according to the categories used in the tender conditions of the contract) etc.

(4) An excavation study of the borrow pit, when it regards borrow areas on Public land and specially in stream beds, that will show

- Minimization of environmental disturbance and the method of restoration.
- Ensuring of hydraulic requirements (ensuring of the necessary section, bridgings, elimination of erosion dangers, etc.)

(5) Supplementary information regarding the necessary investigation in borrow areas are given in chapter 4 of the D.I.S. and in other special conditions of the contract.

It is noted that the provisions of this paragraph 14.2.7.1 are also applicable accordingly to borrow pits that shall be indicated by the Service, whether they will be used only for drawing borrow materials or for production of aggregates by crushing.

14.2.7.2. The Service is obliged, within 15 calendar days from the submission of the borrow pit technical study, to evaluate the study from the technical point of view (approve, modify, reject) so that the above technical study becomes a part of the Environmental Impact Study that will be prepared by the Contractor and shall be accordingly submitted for approval.

14.2.7.3. It is further noted that the Environmental Impact Study must give full details regarding the ownership of the area where the proposed borrow pit is located, in order to evaluate any consequences of the (temporary) occupation of the public area, or the land expropriation on behalf of the Government, at the Contractor's cost.

14.2.7.4. In the case of using borrow materials from existing enterprises selling borrow materials, then the technical study that will be submitted will show that the area, where the materials will be drawn from, is in accordance with the tender conditions, and then the need of preparing an Environmental Impact Study shall depend on the necessity of "up-dating or expanding existing works and activities, when there are essential modifications in relation to their impact to the environment".

14.2.7.5. The Decision of Approval of Environmental Conditions shall be issued within the time limits set by Law ....

14.2.7.6. If an expropriation procedure is required, then this will be initiated immediately after the issue of the Decision of Approval of Environmental Conditions.

14.2.7.7. The Contractor is obliged to proceed to the following, without any separate compensation :

- Remove any top soil surface materials or intermediate layers of unsuitable materials. Any material suitable for restoring the affected area shall be collected to be used during the phase of restoration works.

- Dump any unsuitable materials to locations approved by the Authorities, or if permitted, use them in backfilling borrow areas.

- If technically required to make selection of borrow materials.

- Conduct extraction of borrow material arid shape the slopes and bed of excavations in such a way that borrowing turns into hydraulic management of the stream (if the borrow pit is a stream) or it causes the minimum possible disturbance to the natural environment.

- Restore the natural environment and green, if the borrowing activities involved destruction of shrubs and trees, and to execute any works and take any measures for restoration as provided in the Decision of approval of Environmental Conditions, regarding the area of the borrow pit.

All above costs shall be included converted, together with all other expenses and costs mentioned before in this specification in the unit prices and/or the lump sum price of the Contractor's offer.

14.2.8. The requirements of the previous paragraph 14.1.1.14 (regarding the Quality Control Firm, if any) are also applicable to the borrow pits.

14.3. DUMPING AREAS

14.3.1. The dumping of any surplus materials resulting from excavations, any excavation materials found unsuitable for use in fills and any other waste material of any type, which will not be used for restoring the affected areas, shall be carried away by the Contractor at his own cost and responsibility, in areas designated in the special terms of tender. Should the special terms of tender not include any deposit areas, or the planned areas are not sufficient, then the additional required areas shall be selected on the following basis, in order of priority :

a. By the competent authority for the environment

b. By the Supervising Service of the Project

c. By the Contractor himself, following a proposal he will submit, in accordance with the conditions of the following paragraphs 14.3.7 and 14.3.8.

14.3.2. Besides transportation to any distance (or to a specific distance, if there is such provision in the special conditions of tender) and spreading of the materials in the dumping areas, the Contractor shall, with no additional compensation, construct the necessary infrastructure works and compact as required to stabilize the materials, so that the resulting areas are accessible by vehicles and suitable to be developed as recreation areas, sports grounds or similar. The only works remaining for the final development should be the following :

- Any special top surface earthworks, in combination with any structures that may be constructed.

- Any excavation for foundations (for buildings, wags, pipes of public utility networks, and similar works) including the related technical works and the backfilling of the remaining materials from the volume of the excavation.

- Spreading of the surface agricultural soil and its planting.

- Construction of road pavements (bituminous, concrete, or unpaved), walkway pavements etc.

- Any other special constructions that are not classified as general earthworks (and the related works of supporting them),

in order that the "restoration works" included in the terms of the approved environmental study, are considered completed.

All the above costs are deemed to be included by conversion, in the unit prices and/or the lump sum price of the Contractor's offer.

14.3.3. According to article 5 of the J.M.D. 69629/5389/90, it is hereby defined that due to the importance that the works related to the dumping areas have for the environment, they are considered to be classified into works and activities of GROUP II, CATEGORY A of clause 4 of J.M.D., 69269/5387/90 and it is considered necessary to conduct an ENVIRONMENTAL IMPACT STUDY (E.I.S.), which shall satisfy the requirements of table 2 of article 16 of the J.M.D. Furthermore, the E.I.S. shall include a TECHNICAL STUDY with all necessary attachments (plans, photographs, report about the hydraulic requirements by construction of necessary culverts etc.) as well as a RESTORATION STUDY of the dumping area, that must be approved by the Service.

It is pointed out that the Environmental Impact Study must give full details regarding the ownership of the proposed dumping area, in order to evaluate any consequences from the occupation of public area, or the expropriation of private land on behalf of the Government (see also paragraph 14.3.12 below).

In the case that dumping works are considered of minor importance (due to small volume of surplus materials, special location of the works etc.) then, provided it is explicitly stated in the special conditions of tender (S.C.C. etc.), the preparation of an E.I.S. may not be required for the specific contract.

14.3.4. In the case that inactive quarries are going to be used as dumping areas, for which Environmental Impact studies have been made in the "Restoration Measures", then the Contractor is obliged to proceed with the dumping works in compliance with paragraph 14.3.2 above, applying the approved terms of the "restoration measures" according to the issued Decision of Approval of Environmental Conditions.

14.3.5. In the case that dumping works are carried out in part or in whole in inactive quarries and/or other sites for which no E.I.S. has been prepared, then the Contractor shall himself prepare the necessary E.I. Study(ies), according to paragraph 14.3.3 above. The preparation of E.I. Study(ies) belongs to the group of works for which no separate compensation is provided for the Contractor, and therefore the latter must include converted such costs in the unit prices and/or the lump sum price of his bid.

14.3.6. As soon as the contract becomes active and if the dumping areas provided for in the special terms of tender are not sufficient to cover the project needs and in case that the contractor cannot ensure dumping areas for the surplus volumes at appropriate spaces of his own choice (that shall be approved by the pertinent Authorities), then he shall submit a written request to the Service, determining the required complementary volume for the dumping areas and requesting the Service to propose dumping areas for the complete volume of deposits (if no dumping areas are included in the special terms of tender) or for the required complementary volume for deposits.

The Service in collaboration with the competent environmental authorities, shall prepare a table of the proposed dumping areas, of Public ownership preferably inactive quarries that are the property of the Government, where there will be mention of the roughly estimated quantities of materials that may be dumped along with any environmental terms under which the dumping works are to be performed (itinerary of trips, possibly the gross/net load of the loading trucks, traffic restrictions during times of common rest, covering of the load of excavated material/waste to be dumped with special sheets etc.), stating whether there is an approved E.I.S. and related Environmental Conditions, or whether there is no such study, in which case, according to the previous paragraph 14.3.5, it is necessary for the Contractor to prepare the E.I.S.

14.3.7. In the case that the above table with the estimated volumes of materials that may be dumped is not adequate to cover the needs of the project, then the Contractor shall submit on time a supplementary table of proposed dumping areas, along with the estimated volumes of materials that may be dumped, accompanied by the relative E.I.S., in accordance with paragraph 14.3.3.

By priority, it is preferable that such sites are areas that belong to the Government, but private areas may also be included, when by comparison the costs and any environmental disturbances from the dumping operations (i.e. to avoid occupying forest areas and other sensitive areas), are in favor for the use of dumping sites in private areas.

14.3.8. The Contractor shall include in his supplementary table, the volumes of materials that must be removed from the project (including a margin of safety) and the volumes that may be dumped in the new proposed sites, which must cover over and above the needs of the project, thus giving the Service the possibility of selecting alternatively one (or some) of the proposed sites.

14.3.9. The issue of the Decision of Approval of Environmental conditions shall be made within the time limits set by Law ……. The same Decision shall grant approval to use one or more Dumping Areas for the Project needs.

14.3.10. In the case that the above approved areas as dumping sites, include areas that are private, then the necessary expropriation procedure shall also be activated for the favour of Public.

14.3.11. If there is no explicit mention in the special terms of tender to the contrary, then the expropriation costs for the dumping areas shall be done in favour of the Public and all the pertinent expenses shall be borne by the Contractor.

Clause 15: PRECAST CEMENT PIPES

Supplementary to the S.T.S. T110 and the G.G.G. issue No 253 B/84 specification, it is defined that the following quality control shall be carried out on precast cement pipes (reinforced or non-reinforced) that are to be used in the construction of the works, prior to acceptance and delivery by the Supervising Service to allow them subsequently to be used in the project :

15.1. Two percent (2%) of the total quantity of cement pipes (reinforced or non- reinforced) of each individual diameter that are to be used, and not less than 5 specimens per diameter, shall be taken as samples for testing at the facilities of recognized laboratories according to the tender conditions, all at the Contractor's care and expense.

The specimens of cement pipes shall be taken in random fashion, from the Contractor's fabrication site, or from the quantities of pipes delivered at the site (when the Contractor is obtaining his supplies from a cement pipe factory), as described in paragraph 4.3.1.1.6.1.2.1.A.5 of the S.T.S T110. Such specimens shall be made available by the Contractor at no cost for the carrying out of tests.

The conditions of this paragraph regarding cement pipe samples are applicable for the cement pipes that are constructed according to the S.T.S. T110 (reinforced or non-reinforced) as well as for the reinforced vibrated or centrifugal stormwater or sewage cement pipes that are constructed according to the specifications.

15.2. Concrete compressive tests (paragraph 4.3.1.1.6.1.2.1.A.3 and 4.3.1.1.6.1.2.2.A.2 of the S.T.S. T 110) shall be conducted in supplement, when the cement pipes are constructed by the Contractor at the site of the works, but shall not constitute a criterion for the acceptance of the pipes by the Service.

15.3. The strength test of precast cement pipes in antidiametric compression load according to the "three points loading method" shall constitute an acceptance criterion for the cement pipes. In these tests, the strengths provided in the respective specifications of the pipes shall be obtained [i.e. Table I of page 94 or Table II of page 95 of the S.T.S. T110 for non-reinforced pressure fabricated cement pipes, Tables I, II, Ill and IV of pages 100,101,102, and 103 of the S.T.S. T110 for reinforced pressure fabricated cement pipes, Tables 5, 6, 7 and 8 for vibrated or centrifugal stormwater and/or sewage cement pipes according to specification EA2a/02/44/0.1.1 dated April 4, 1984 (G.G.G. Issue No 253 B/84)]

15.4. Non-reinforced pressure fabricated cement pipes shall be accepted in accordance with the conditions of paragraph 4.3.1.1.6.1.2,1.A.1 of the S.T.S. T110 (testing and retesting), according to specification A.S.T.M. C-14.

Complementary and beyond the acceptance criterion of the non-reinforced pressure fabricated cement pipes, which is the strength against external load, the criteria of water absorption, water permeability and hydrostatic testing shall apply, in accordance with S.T.S. T110.

Furthermore, for non-reinforced pressure fabricated cement pipes, the acceptance criteria of dimension tolerances as per paragraph 4.3.1.1.6.1.2.1.8 of the S.T.S. T110 (Table III of page 99) shall also apply.

15.5. Reinforced pressure fabricated cement pipes shall be accepted in accordance with the conditions of paragraph 4.3.1.1.6.1.2.2..A.1 of the S.T.S. T110 (testing and retesting) according to specification A.S.T.M. C-76 with the exception of permeability that will be conducted according to specification DIN 4035.

Complementary and beyond the acceptance criterion of the reinforced pressure fabricated cement pipes, which is the strength against external load, the criteria of water absorption, water permeability (waterproofing) shall apply, in accordance with S.T.S. T110.

Furthermore, for reinforced pressure fabricated cement pipes, the acceptance criteria of dimension tolerances as per paragraph 4.3.1.1.6.1.2.2.8 of the S.T.S. T110 shall also apply.

15.6. Reinforced vibrated or centrifugal stormwater and/or sewage cement pipes of the specification EA20/02/44/0.1.1/4-4-84 (G.G.G. Issue No 253 B/84) shall be accepted according to the conditions set out in the respective specification.

15.7. For the testing of the protection with epoxy paint of reinforced vibrated or centrifugal sewage cement pipes, the specification of clause 64 of the T.C.C.

Clause 16 : ACCEPTANCE OF WEIGHED MATERIALS

16.1. If the scope of the Contract includes acceptance of materials following weighing operation (for cast iron materials, iron item, etc.), the Contractor shall make sure of issuing a triplicate weighing and acceptance protocol, indicating :

1. The type of material (precoated slip-resistant chippings, cast iron products, etc.);
2. The dimensions of the truck wagon;
3. The truck license plate numbers;
4. The location of supply;
5. The site of deposit;
6. The loading time;
7. The time and place of unloading;
8. The net weight; and
9. The truck deadweight, etc.

16.2. The abovementioned triplicate protocol shall be signed by the Service's competent official/s attending the weighing operation, as well as by the Contractor or the Contractor's representative.

Furthermore, and during unloading onto the works site, the above weighing card shall be signed by the Service's official/s and by the Contractor or his representative.

16.3. Each truck load must necessarily be accompanied by the above mentioned weighing card.

16.4. The abovementioned weighing cards and acceptance protocols shall need to be followed by a detailed quantity survey and drawings showing placement of the materials (namely, concerning cast iron items, the positions of their placement, etc.).

Such installation drawings shall need to be construction drawings as approved by the Service.

16.5. The Service shall compile a material acceptance protocol based on the above weighing cards, acceptance protocols, detailed quantity surveys and construction drawings.

Clause 17 : CEMENT

17.1. The types of cement to be used in this contract shall comply to the provisions of the Law ……… and shall be in accordance with the documented proposal of the concrete mix design.

With the exception of cement type IV, any type of cement to be required for the works in accordance with the regulations and the tender conditions shall be used without entailing any financial surcharge or any need for extension of deadlines, etc.

17.2. Should unfavorable groundwater conditions be encountered, namely chemical substances aggressive to concrete and requiring the use of cement type IV, the following shall apply :

a. For works remunerated under a lumpsum price, any need for using cement type IV shall not entail modification of the said lumpsum price, while the additional cost must have been included in converted form in the Contractor's economic proposal.

b. For works remunerated on the basis of unit prices quoted and of quantities of completed work, any requirement for using cement type IV (to be satisfied following a documented proposal by the Contractor and approval by the Service) shall entail payment to the Contractor of the additional cost incurred by the delivery of cement type IV onto the works site, to be made upon the compilation of a Protocol for the Regulation of Unit Prices for New Works (P.R.U.P.N.W.).

c. The need for cement type IV does not constitute ground for extending the deadline of the completion of the works.

17.3. Cement to be used shall be recently produced, delivered to the works and stored in special metal silos. Should simultaneous use of more than one cement type and/or category be anticipated in accordance with the schedule of execution of the works, separate installation of distinctly labelled silos shall be provided for the various cement types. In the case of minor quantities of cement, these may be allowed, if approved by the Service , to be delivered to the works in paper bags bearing intact safety labels and to be stored, until use, in storerooms providing full protection against moisture and weather conditions.

17.4. Storerooms containing cement in paper bags shall be closed but well ventilated. Stockpiling of bags shall be on wooden floor not less than 0.30m above the ground in order to keep the cement safe from rain and humidity.

17.5. Similarly, forecasts must be made on time so that sufficient cement quantities be always available at the site to secure smooth progress of the works and to avoid any shortage. It is particularly emphasized that the Contractor shall be sole to bear any consequences from such situations causing any delay to the works progress.

17.6. In addition, the Contractor shall be bound to store each cement consignment separately in a manner allowing for samplings to be made at any moment and for subsequently identifying results with clearly defined quantities. Any batch of cement damaged from age, or containing lumps hardened to the extent of not breaking up with a light finger squeeze, shall be immediately removed from the works site.

17.7. The Service shall be entitled to require laboratory tests of cement for each 50 ton consignment, according to the provisions of P.D. 244/1980, at the Contractor's care and expense. Such tests belong to Test B category, in conformity to sub-clause 21.2 hereof.

17.8. Any unsuitable cement quantity, or quantity not complying to the above stipulations shall be immediately removed from the works site.

17.9. The provisions of clause 6 hereof shall also apply.

Clause 18 : EXPOSED CONCRETE SURFACES (FAIR-FACED)

18.1. The quantities of concrete surfaces intended to receive surface finishing Type C shall be separately surveyed (measured) and a respective work item shall be included in the price list concerning the Contractor's extra remuneration for achieving a high quality of formed concrete surface finishing (Type C).

18.2. The following supplementary requirements are established or emphasized further to those mentioned hereinbefore with respect to concrete surfaces scheduled to receive Type C finishing (in accordance with sub-clause 6.15 and with clause 7 hereof) :

a. Surface finishing Type C on exposed concrete surfaces shall be performed with special attention using metal casings or special ply-wood lined forms (Betoform type or similar) for achieving absolutely smooth surfaces free of joint or other marks or imperfections (refer to sub-clause 7.3.2 hereof).

b. The most advanced relevant technology shall be applied on this matter with an extremely reduced number of consecutive applications of the Betoform used, with extreme attention in the preparation of the metal casings, application of special agents to facilitate form removal, utilization of special ties in scaffolding erection and in form assembly to ensure absolute accuracy in the work execution, according to the drawings, etc.

c. In addition to the above, a great deal of attention shall be given to obtaining the appropriate mix of the concrete (with possible use of quality improving admixtures) and to ensuring perfect vibration combined with precise positioning of reinforcing bars using special plastic inserts to secure firmness of the bar positions during vibration, with the purpose of achieving absolutely smooth and unified appearance of exposed concrete surfaces finished as per Type C.

d. It is emphasized that, with a view to achieving a unified color and appearance of the exposed concrete surfaces, a detailed concrete mix design shall need to be performed prior to commencing concreting operations. Such mix shall be maintained constant throughout concreting, using standard sources of aggregates and cement, etc.

e. It is possible to use different materials of formwork construction for surfaces of varying structural components, such as:

   i. Forms of special reinforced ply-wood panels bearing plastic lining (Betoform or similar).
   ii. Metal casing not less than 1,6mm-thick, in accordance with clause 7 hereof.

   No simultaneous use of class (I) and (II) materials as above shall be permitted in assembling forms for the construction of a unified structural element.

f. The surfaces listed herebelow shall be considered to constitute parts of an integral structural component requiring the use of unified form material (wood or metal), application of the same form removal easing agent, standard curing of concrete during construction (see also sub-clauses 6.18 and clause 7 hereof) and unified other action with the purpose of achieving identical overall characteristics for the surface finishing work (Type C) :

   i. overall exposed surface of a bridge deck;
   ii. all exposed surfaces of abutments and throughout the length of adjoining retaining walls (for their sections specified to receive Type C surface finishing);
   iii. all exposed surfaces of piers;
   iv. the overall length of each individual wall.

g. Plastic lined ply-wood panels (Betoform or similar) must have clear edge formation free of damage, chippings, breakings, surface cavities, discolourings that may, in the opinion of the Service , affect the color of the concrete surface finishing. All panels deemed unsuitable in accordance with the above shall be disqualified from being used in formwork construction. If, notwithstanding the above, they are still found to be used, they shall be ordered to be removed during the formwork final inspection to be conducted prior to concreting, irrespectively of any resulting conditions of having to replace reinforcing bars, to remove scaffolding, delays, etc., as it is clarified that the Contractor shall be sole responsible for the strict observance of the conditions mentioned above aiming at achieving the required high quality of concrete surface finishing.

h. Wherever decorative grooves are to be used on the concrete surface, they shall be accurately fixed as required by the design and shall be made of altogether new, smooth-planed wood battens, or of special plastic sections of precise dimensions as provided by the design and/or in accordance with the Service 's instructions, free of damage, etc., as mentioned in the previous sub-clause. It is important to use suitable form easing off agents also for decorative groove battens, as hereabove mentioned.

18.3. It is pointed out that any detected deviations in the performance of such works by the Contractor from the specifications regarding surface finishings, tie construction technology, formwork and other tolerances (clause 7 hereof), and other tolerances shall incur the imposition of all penalties provided by the regulations in force, depending on the case and at the Service's sole judgement, while the following measures may also be taken alongwith

a. Removal of the concrete portion found not to comply with the surface finishing work foreseen, according to the requirement of para. 6.16.1.7 etc. of clause 6 of the TCC, or
b. Imposition of penalties up to <u>tenfold</u> the Service 's price for achieving the planned finishing of formed concrete surfaces, or
c. Obliging the Contractor to perform steel troweled cement plaster at his care and expense, for the case that he did not perform or he has improperly performed the planned surface finish type ns, according to clause 6 of the TCC (para. 6.15.7.2).

Clause 19 : ELECTROMECHANICAL INSTALLATIONS FOR OPEN AIR ROADWORKS

19.1. GENERAL

19.1.1 Scope

Electromechanical installations, for open air roadworks refer to :

a. Roadworks (road lighting, irrigation, telecommunication). The requirements for lighting open air roadworks are also applicable for lighting of RR station plazas. Also the requirements for roadworks irrigation are applicable, similarly, for railroad works as well.

b. Toll stations

c. Building structures related to road installations (toll stations, roadworks exploitation and maintenance centers)

They do not include E/M installations for tunnels.

19.1.2 Specification General Terms

Miscellaneous materials, equipment, instruments, apparatuses and plant used for the project, or incorporated in it, shall be in compliance with :

a. "European Standards" approved by the European Electrotechnical Standards Commission (CEN/CENELEC)

b. In addition to the foregoing and for those items for which European Standards do not exist, the "Common Technical Specifications" published in the European Communities Official Gazette.

c. Specifications complementary to the above.

Items not covered by the above standards shall comply with relevant approvals issued or to be issued during the procedure of European Technical Approvals (refer also to article 1 of the TCC).

Where in this article a specific standard is referred to hereinafter, such standard shall be generally applicable, except for the stipulations in controversy to standards /specifications under (a) through to (c) above, in which case the latter shall prevail.

19.2. ROAD LIGHTING

19.2.1 Steel Lighting

Provision is made for steel lighting poles, having a height of 9m, 10m, 12m, 14m and 15m. Tapered poles of decreasing octagonal or circular section shall be used. Irrespective of the poles structural and/or dynamic analysis requirements, the minimum steel sheet thickness shall, in all cases, be 4mm. Longitudinal seam, if any, shall be straight, invisible, watertight, of continuous electrical (not induction) welding applied on chamfered steel sheet, in accordance with the regulations, excluding the use of spirally seamed sections.

Tapered poles not more than 12m high are allowed to be formed with one lateral joint. Additional lateral joints may be allowed for longer poles, one for each additional 6m long section. The diameter of the surcumscribed circle at the top of poles shall not be less than 60mm and the length of its end shall conform to the tables of EN 40-2 pare 7.

Lateral joints shall be formed by continuous, invisible, watertight, butt welding, reinforced, where required by the calculations, by the insertion of an inner lap plate of the proper thickness, ensuring structural continuity, overlapping both adjoining pole sections by not less than 0.20m, welded at both ends inside the pole.

At an appropriate height from its base the pole shall have an access opening sufficiently sized to allow the installation and connection of the pole's fuse box. The access opening dimensions shall be selected from the table for metal openings dimensions of EN 40-2 pars 4. The minimum opening dimensions shall be 300 mm height by 85 m width. The minimum distance between the access bottom and the pole base shall be 60 cm. An internal reinforcement shall be provided for restoring the pole strength in the area of this opening by the introduction of a lap plate of the proper thickness welded all along its edge onto the pole sheet metal, unless it can be documented by the calculations that the pole strength in that section, where there is an opening, lies within the allowable limits. In case of using a strengthening plate, its edge shall overlap by at least 0.20 m in the pole of ordinary section, on each side of the opening edges.

The access opening shall be covered by an appropriate door made of a plate having the same thickness and shape with the rest of the pole, which when closed shall not extend beyond the pole plate. Its fixing on the pole shall be done by bronze bolts flush with the plate and their construction shall ensure robust and steady fixing on the pole.

The external and internal surfaces of the steel poles shall be protected by hot dip galvanizing having a weight complying to the pertinent clause of the TCC (clause 31) and the other terms of tender (SCC etc.). Alternatively, and only for the internal surface of the steel poles protection by using an asphaltic primer will be accepted.

The lighting pole shall be fixed on a suitable base, incorporating the anchor-bolts required for its fastening. Subsequent to fastening the pole on its base, the base surface shall receive its final treatment, namely covering nuts with grease or vaseline, and final grouting with cement mortar.

19.2.1.1. Steel Lighting Poles 9m or 10m-high

The lighting pole shall be supported by a 20 mm-thick steel baseplate, 400 mm x 400 mm safely welded onto it. It shall have four (4) vertical stiffening blades, 15 mm-thick each, in the form of rectangular triangles, 90 mm-base and 200 mm-height. The baseplate shall have a central 100 mm-dia hole for cables and earthing conductor access, together with four (4) oval shaped 30 mm x 54 mm holes (by exception to the circular holes presented in figure 8 of EN 40-2) for pole fixing, by means of 24 mm dia anchor bolts.

The four (4) 24 mm-dia anchor bolts shall be embedded Into the concrete base on a length not less than 500 mm each, and shall have suitably threaded upper ends, protruding 150 mm each above the base surface. They shall be installed on the corners of a 300 mm-side square (bolt axial spacing), secured by means of 4Nos 30x30x3 mm angle iron sections, welded onto the bolts' lower ends (along the four sides of the square) and in addition, 2Nos diagonal ones welded just below the threaded upper end.

Exposed parts of the 4Nos anchoring bolts, and an additional length of 100 mm (from the embedded part), along with the respective nuts (2Nos for each anchor bolt) and washers, shall receive centrifugally applied hot dip galvanizing protection (as provided for in standard NF E 27-005). average and to specification NF A 91-122] equivalent to 375gr of zinc coating per m2 of galvanized surface (53 gm).

19.2.1.2. *Steel Lighting Poles 12m-high*

The lighting pole shall be supported by a 20 mm-thick steel baseplate, 400 mm x 400 mm safely welded onto it. It shall have four (4) vertical stiffening blades, 15 mm-thick each, in the form of rectangular triangles, 90 mm-base and 200 mm-height. The baseplate shall have a central 100 mm-dia hole for cables and earthing conductor access, together with four (4) oval shaped 33 mm x 60 mm holes (by exception to the circular holes presented in figure 8 of EN 40-2) for pole fixing, by means of 27 mm dia anchor bolts.

The four (4) 27 mm-dia anchor bolts shall be embedded into the concrete base on a length not less than 800 mm each, and shall have suitably threaded upper ends, protruding 150 mm each above the base surface. They shall be installed on the corners of a 300 mm-side square (bolt axial spacing), secured by means of 4Nos 30x30x3 mm angle iron sections, welded onto the bolts' lower ends (along the four sides of the square) and in addition, 2Nos diagonal ones welded just below the threaded upper end.

Exposed parts of the 4Nos anchoring bolts, and an additional length of 100 mm (from the embedded part), along with the respective nuts (2Nos for each anchor bolt) and washers, shall receive centrifugally applied hot dip galvanizing protection (as provided for in standard NF E 27-005), average coat thickness [in compliance to standard ISO 1461-1973 (F) and to specification NF A 91-122] equivalent to 375gr of zinc coating per m2 of galvanized surface (53 pm).

19.2.1.3. *Steel Lighting Poles 14m or 15m-high*

The lighting pole shall be supported by a 20 mm-thick steel baseplate, 500 mm x 500 mm safely welded onto it. It shall have four (4) vertical stiffening blades, 15 mm-thick each, in the form of rectangular triangles, 130 mm-base and 200 mm-height. The baseplate shall have a central 100 mm-dia hole for cables and earthing conductor access, together with four (4) oval shaped 33 mm x 60 mm holes (by exception to the circular holes presented in figure 8 of EN 40-2) for pole fixing, by means of 27 mm dia anchor bolts.

The four (4) 27 mm-dia anchor bolts shall be embedded into the concrete base on a length not less than 800 mm each, and shall have suitably threaded upper ends, protruding 150 mm each above the base surface. They shall be installed on the corners of a 400 mm-side square (bolt axial spacing), secured by means of 4Nos 30x30x3 mm angle iron sections, welded onto the bolts' lower ends (along the four sides of the square) and in addition, 2Nos diagonal ones welded just below the threaded upper end.

Exposed parts of the 4Nos anchoring bolts, and an additional length of 100 mm (from the embedded part), along with the respective nuts (2Nos for each anchor bolt) and washers, shall receive centrifugally applied hot dip galvanizing protection (as provided for in standard NF E 27-005), average coat thickness tin compliance to standard ISO 1461-1973 (F) and to specification NF A 91-1221 equivalent to 375gr of zinc coating per m2 of galvanized surface (53 pm).

19.2.1.4.

(1) Alternatively, for all the pole heights described above, poles being supported on steel plates without stiffening supporting blades may be accepted provided that :

a. The poles are industrial products and their production industry holds a quality assurance certificate, according to standard ISO 9000 (or *EN* 29000) relative to the operation organization of the enterprise.

b. They are accompanied by the test certificate, according to EN 40-8 standard from an internationally recognized or State Laboratory.

(2) The base plate thickness, the diameter and length of the anchor bolts shall be selected based on detailed calculations, according to EN 40-6 and EN 40-7.

19.2.2 Steel Lighting Poles Foundations

Foundations for steel lighting poles (9.0 m, 12.0 m and 14.0 m high) shall be constructed on the medians, the roadside or on sidewalks, and shall be prefabricated from reinforced concrete, incorporating cable draw pits. Fabrication and installation details for these foundations are provided in the Standard Road Plan (SRP).

Whenever construction difficulties are encountered, the light poles may be constructed on sheet piling or on walls. Details for this type of construction are given in the Standard Road Plan (SRP).

Overpass lighting poles shall be installed outside the safety barriers. To this effect, the Contractor shall be at liberty to either apply the relevant details illustrated in the Standard Road Plan (SRP) or, alternatively, any other method, subject to Service's approval.

19.2.3 Luminaire Brackets

Luminaire brackets shall be supplied and installed in accordance with the instructions of the Ministry of Infrastructure which stipulates that :

Single or twin luminaire brackets shall be fitted on lighting poles. Brackets shall be formed from galvanized steel pipes as per DIN 2440, and shall be fastened onto the pole tops by means of a special construction funnel, made of stainless steel, fixed with stainless bolts or screws, of appropriate diameter, or with a reducer of appropriate dimensions.

The brackets steel pipe diameter (0), for the various horizontal projection (d) lengths, as well as the distance between luminaire center and pole axis, shall be as follows :

- For	d<=2.50 m	shall be 2" dia steel pipe 3.65 mm wall thickness
- For	2.50<d<=3.00 m	shall be dia steel pipe 4.05 mm wail thickness
- For	d> 3.00 m	shall be 3" dia steel pipe 4.05 mm wail thickness, fitted with a 12 mm dia steel tie bar

The bracket base (funnel) shall be made of suitable diameter galvanized tube pipe, to ensure safe fitting onto the pole's top section.

The bracket outer end, shall be formed as a suitably designed metal socket to hold the lighting fixture (luminaire).

Socket length and diameter shall be suitable, to fit the proposed fixture, as appropriate.

Prior to installation, the bracket and funnel or reducer shall be protected by hot dip galvanizing having a weight complying to the pertinent clause of the TCC (clause 31) and other terms of tender (SCC etc.). Prior to galvanization, funnel welding onto the bracket shall be appropriately treated. Each bracket arm shall consist of a single continuous pipe section. Brackets constructed by jointing (welding) of more than one pipe sections shall not be allowed.

The brackets horizontal projection shall be straight, where astheir vertical projection shall be sloping according to the proposed luminaire requirements, and which shall range between 5 and 15 degrees.

19.2.4 Lighting Poles Fuse Boxes

Pole fuse boxes shall be in conformity with Law ………. stipulating that :

A fuse box shall be installed inside each pole for power supply to the luminaire(s). The box shall be made of cast aluminum alloy, and shall have in its lower part a divided receptacle, with three holes for the access of cables up to NYY 4x10 mm2, and two holes in its upper part for the access of cables up to NYY 4x2.5 mm2, along with respective metal glands.

The box shall contain heavy-duty terminals to ensure firm contact to the conductors.

Terminals shall be base-fixed, and shall be suitably insulated against the box walls. Complete fuses shall be provided, along with brass bolts for fixing onto the box walls with nuts, washers etc., as well as for connecting earthing copper conductor and luminaire earthing wire.

The box system shall be fixed with two bolts on a suitable base inside the pole and shall close by means of a suitable cover fixed onto the box with two brass screws. The cover shall have a peripheral gasket seal, firmly fixed around its edges for perfect closure.

19.2.5 Bracket-mounted Luminaires and Lamps

Road lighting luminaires shall, generally, be of the bracket-mounted type, and shall together with lamps, meet specification requirements, as follows :

Luminaire	Technical Specification
a. Sodium high-pressure 150W	**0.Φ - 4**
b. Sodium high-pressure 250W	**0.Φ - 5**
c. Sodium high-pressure 400W	**0.Φ - 6**
d. Sodium low-pressure 90W	**0.Φ - 7**
e. Sodium low-pressure 135W	**0.Φ - 8**
f. Sodium low-pressure 180W	**0.Φ - 9**
g. Sodium low-pressure 1x135W+1x9OW	**0.Φ- 10**

It is clarified that in connection with high-pressure sodium bracket-mounted luminaires, bulb or tubular type lamps can be used.

19.2.5.1 Underpass Luminaires

Luminaires for underpasses shall be of the wall-mounted type, suitable for use in connection with underpass or tunnel lighting.

Their housing shall be made of aluminum alloy casting or, alternatively, of hot pressed aluminum sheet not less than 2 mm-thick, with smooth surfaces and corrosion proofing, in compliance with the sodium high-pressure bracket luminaires specification.

The luminaire shall incorporate a specular reflector to ensure assymetric light distribution. The reflector shall be made of polished or anodized chemically pure aluminum (99.9% grade), or, alternatively, of high grade stainless steel sheet. Reflector position shall be adjustable.

Luminaire front surface shall be covered by a dust repellent (to avoid getting dirty) hardened glass cover, not less than 5 mm-thick, tightly fastened on its frame by means of gaskets.

Frame shall revolve on two hinges of special manufacture, and shall be fixed on the housing through quick-coupling devices. Housing and cover construction shall ensure protection not less than IP66 as per IEC 144.

In a separate housing space, other than that reserved to the lamp, the luminaire shall have an electrical gear compartment accommodating all electrical apparatus such as ballast, ignitor, capacitor, lamp holder, anti-spark device. This compartment shall ensure protection against heat released from the lamp. High-pressure sodium luminaires specification requirements shall apply with respect to the electrical gear compartment and the luminaire's electrical apparatuses. Luminaire Internal wiring shall be made by use of conductors 2.5 mm2 cross-section.

The luminaire shall have a terminal for the connection of 2Nos four-conductor cables, section not less than 4 mm2 each, 2Nos cable fastening clamps, and a cable access equipped with glands not less than Pg 21.

The luminaires design shall be suitable for accommodating tubular high pressure sodium vapour lamps 70, 100, 150, 250 or 400W capacity. With regard to lamps, the stipulations of para 4.6 of Specification 0.0 - 5 shall be applicable.

Provision shall be made for wall-, ceiling- or corner-mounted luminaires. To this effect, they shall be accompanied by a pair of wall-mounted corrosion-proof metal rails. Luminaire shall be fixed on the rails by means of 4Nos screws.

Specification 0.Φ - 5 requirements shall generally apply to the luminaire phototechnical characteristics, tests and schedule (questionnaire), except that such luminaires shall not be of the cut-off type.

19.2.6 Power Supply Network

An underground power supply network shall be supplied to connect each pillar to the respective lighting poles. Burned cables shall be protected inside ductwork.

Ducts used for cables access shall be PE 90 mm nom dia, NP 6. Ducts shall be placed at a depth of about 70cm. Should particular mechanical strength be required of the ducts (due to documented special conditions), the network shall be constructed of heavy-duty galvanized steel pipes to ISO Medium grade (green label), 2.5" nom dia.

When cables are crossing over a bridge, ducts shall again be constructed of galvanized steel pipes, 2.5" nom dia, to ISO Medium grade (green label) positioned within the bridge sidewalk. Ducts shall branch-off to the lighting poles by means of special design metal boxes. Similarly, special metal boxes of 6' dia with specific expansion arrangement shall be provided at the bridge expansion joints. Roadway lighting cables shall be accommodated inside the steel pipes.

A spare duct shall always be provided at road crossings, while in these cases ducts shall be embedded in reinforced concrete, according to the details given in the Standard Road Plan (SRP). Duct ends shall always terminate in cable draw pits.

In the case of underpass lighting installations, referred to in sub-clause 19.2.5.1 above, cables access between luminaires shall be effected by means of plastic conduits of internal diameter double the cable external diameter, but not less than 30 mm, positioned in the formwork prior to concreting. Necessary items for luminaire fixing shall also be embedded in concrete (cables junctions shall be effected inside the luminaire).

The underground distribution network shall consist of cables type NYY, with a cross section of 4x10 mm2. Each duct shall contain a single road lighting feeder cable. In case provision is made for the design and installation of a facility allowing uniform illumination level reduction (REDUZIERUNGSALTUNG), an additional control wire shall be provided for the automatic changeover into the reduced level status. An irrigation control valve supply cable may be accommodated in same duct.

Without exception, feeder cables shall be connected onto lighting pole fuse boxes. Thus the cable entering the pole shall be connected to the fuse box and subsequently exit to continue with the next lighting pole feeder.

Spare cable length of not less than 1.0m shall be provided in the manhole embedded at each lighting pole base.

The supply of each road lighting luminaire from the respective fuse box shall be effected by NYM type cable, 3x1.5 mm2 section.

For underpass luminaires feeding, NYY type cables shall be used with sections according to the calculations.

Cable draw pits shall be provided to facilitate cable pulling throughout the underground network. Such draw pits shall in all cases be embedded in the road lighting poles prefabricated bases. At road crossings, individual draw pits shall be provided, for access to the first luminaire in a row, etc. Construction of such individual draw pits shall be in compliance with the details given in the Standard Road Plan (SRP).

Special form draw pits, duly adjusted to local requirements, shall be provided for cables accommodation in specific cases (le over bridges etc.).

19.2.7 Earthing

An underground bare stranded copper conductor, 25 mm2 section, running parallel to the road lighting poles feeder cable (in common trench) shall be provided for earthing the road lighting installation.

Pole fuse boxes shall be connected to the earthing conductor by means of a bare copper conductor, 6 mm2 section. The two conductors shall be firmly connected in the pole base draw pit, crossed by the earthing conductor, using special clamps.

The earthing conductor shall, furthermore, be connected inside the pillar to the totally enclosed distribution boxes.

Finally, the earthing conductor shall be connected to earthing plates provided at the end of each feeder line, as well as at each pillar location.

Earthing plates shall be 500x500x5 mm copper plates, installed underground, at a depth of 1.00m.

19.2.8 Lighting Feeder Pillar (Metal)

Pillars shall be in compliance with the specifications providing that :

Pillar cabinets shall be divided into two separate sections : the PPC meter and the AFRC apparatus (Audio Frequency Remote Control) shall be installed in one section, whereas watertight distribution enclosures comprising all feeders switching and protection instruments shall be accommodated in the other.

(Note : No PPC meter is required, in the case of projects tendered applying

the "CONCESSION CONTRACT' system, should the pillar be fed with low voltage from a stepdown substation supplied and installed by the Contractor).

Fully automatic operation shall be provided, on-off switching orders being given from the AFRC apparatus and executed by means of suitably provided contactors, after the switch and fuse of each departing feeder.

Pillars construction shall be of the industrial type, with IP54 protection, suitable for outdoor installation. Pillar cabinets shall be made of scaled sheet metal, 2 mm thick.

Pillars shall externally be 1.45 m-wide, 1.30 m-high and 0.35 m- deep. They shall consist of two separate compartments, closing with separate doors, and shall be divided internally by a steel sheet partition 2 mm-thick.

The left side compartment shall be 0.60 m-wide, and shall be designated for the PPC meter and AFRC. The other, shall be 0.85m-wide, and shall be designated for the electrical distribution apparatus.

The steel sheet partition shall feature 4Nos 26 mm-dia holes along its upper part, for cable passage.

Pillar doors shall close tightly at all points with the pillar main body, to avoid rain penetration inside the pillar.

A standard painted letters label shall be provided and installed on the outer face of the right side compartment door (distribution compartment), with the inscription "Ministry of Infrastructure", dimensions to be provided by the Service.

Label position shall be such that each row of lettering Is symmetrical to the vertical door axis.

Letters shall be applied by two coats of white emulsion paint.

Each pillar shall stand on a concrete base, grade B120, vide a peripheral 40x40x3.5 mm angle iron frame. Triangular shape steeisheet stiffeners shall be welded at the frame four corners, with fixing holes for fastening anchor bolts embedded in the concrete base. Pillar removal shall be made possible by unfastening these bolts.

Pillars shall be factory assembled and shall provide ample room for cables access and connection between the network operation instruments.

Particular attention shall be attributed to their aesthetic, symmetrical appearance.

For the purpose of installing PPC instruments in the PPC compartment, a 2 mm-thick galvanized iron fixing-plate shall be provided, fixed by means of bolts and nuts on U-shaped channels, 30x20x2 mm, formed from 2 mm-thick steel sheet. The channels shall be fixed on the pillar back plate.

Fixing plate shall be 0.60 m-high and 0.40 m-wide. Channels shall be fixed on the right and left side edges of the compartment.

For the purpose of installing distribution enclosures in the distribution compartment, a 2 mm-thick galvanized iron fixing plate 1.10m-high and 0.60m-wide shall be provided and installed, in exactly the same manner.

Keys, locking method and other construction details shall be indicated on the relevant drawing, due for submission. Keys and locks shall be made of brass. Two separate locks and respective keys shall be provided, one for the PPC compartment, the other for the distribution. Identical pairs of locks and keys shall be provided for all pillars, pertaining to this contract.

Totally enclosed distribution enclosures (boxes) comprising feeder switching and protection apparatus shall be provided and installed in the right side pillar compartment.

Distribution shall consist of a watertight cast aluminum alloy or moulded polycarbonate GRP enclosure. Boxes shall be fire-proof, suitable for outdoors and sea moisture conditions.

Enclosure dimensions shall be designed in accordance with VDE 0660 and shall provide sufficient room for the various distribution accessories.

Enclosures shall feature suitably glanded holes of appropriate size, for the access of the PPC power supply and remote control cables, as well as for the exit of cables to the distribution network.

The upper distribution enclosure shall contain :

Main switch to DIN 49290, main fuses to DIN 49522, main remote control contactor to VDE 0660, part-time lighting contactor (if provided), timer switch to DIN 40050, power socket to DIN 49462, operation indicator lamp and automatic miniature-type circuit breakers to VDE 0611.

The lower distribution enclosure(s) shall contain bus bars (100A and 300 mm-long) and the cables-departure apparatus, to the network.

Distribution enclosure(s) shall in all cases be of appropriate symmetrical appearance, its construction complying with the following general requirements :

a. In case of underground PPC power supply, feeder entry shall be effected from the bottom side. In opposite case, entry shall be from the upper side, through suitably glanded opening.

b. Internal wiring shall be skillfully assembled (both from technical and aesthetic aspects). Single-core cables shall follow short and straight runs, shall be properly connected to the instruments and their ends shall be provided with terminals where required.

c. Network and distribution cables shall be connected by means of heavy-duty sliding clamps, and shall be suitably sized to carry maximum current loads, as per respective instruments ratings, without any risk of failure.

Subsequent to sandblasting to Swedish Standard SIS 055900 of 1967, grade SA-3 and a coat of corrosion-proof epoxy primer, the pillar and all internal accessories shall receive two further coats of epoxy paint (color to be selected by the Service). Overall coating dry film thickness shall not be less than 0.4 mm-thick.

19.3. IRRIGATION

19.3.0. General

All irrigation equipment (isolation valves, filters, reducers, solenoid valves, air release valves etc.) hall be suitably sized for installation in manholes/chambers, according to the drawings approved.

19.3.1 Isolating Valves. etc.

1. The cut-off apparatuses which shall be required to isolate the branches of the water supply main shall be manual cast-iron gate valves, of 16 atm. operating pressure, threaded or flanged.

2. The cut-off apparatuses which shall be required in the air release and drain chambers of the "primary network" (see para 1.16.8.1.(4) of the I/1.5.) shall be fullway ball valves, bronze, threaded, of 16 atm. operating pressure.

3. The cut-off apparatuses which shall be required in the "secondary" and "tertiary network"(') (see para 1.16.8.1.(4) of the D.I.S. (in the I.H.C., V.H.C. F.H.C. etc.) shall be fullway ball valves, bronze, threaded, of 10 atm., nominal pressure for the case of a "primary network" pipe of class 10 atm. and 16 atm. for all other cases. The operating pressure of the cut-off apparatuses located downstream of the pressure reducers is set at 10 atm.

19.3.2 Water Filters

The water filters (strainers) shall be "Y" shaped, suitable for operating pressures up to 16 bars (for water temperatures up to 400C). They shall be made of brass, cast iron or steel painted with epoxy paint after a special anticorrosive treatment and will have flanges according to DIN 2501 at the inlet and outlet.

In the filter body a differential pressure gauge shall be adapted which shall be connected via holes in positions before and after the filtering element for measurement of the pressure drop during the checking of filter blockage.

The filtering element shall be a cylinder made of corrugated stainless steel sheet (of quality at least AISI 304, or equivalent), with hole diameter 0,75 mm (except otherwise specified), or disk body 120 Mesh, suitable for retainment of micro particles, sand and other sediment materials and shall have low level of pressure losses. The filter shall have a cap with easy opening for taking away the retained elements, which shall have a special outlet for quick cleaning through a 3/4" ball valve.

19.3.3 Water Pressure Reducers

Through the water pressure reducers a constant network pressure shall be ensured at their outlet (with preregulation capability), regardless of inlet pressure variation. The reducers shall be suitable for clean water and 16 bars operating pressure (for water temperature up to 400C). They shall have a body made of brass or cast iron and their operation shall be through spring, or through three-way pressure regulation valve (pilot) without external energy.

The diagphragm shall be either metal resistant to corrosion, or nontoxic elastic suitable for potable water, whereas the spring shall be of stainless steel.

The reducer shall allow diaphragm repairs without removal from the network and having small pressure losses.

It shall carry a pressure gauge at its outlet and the outlet pressure should be able to be regulated from 1 to 12 bars.

For diameter up to 02" (50mm) the reducers shall be adapted to the network through threading, whereas for the diameters larger than 02", through flanges by DIN 2501.

Generally the reducers shall be of small dimensions for their easy placement in manholes.

Before each pressure reducer a water filter (strainer) shall be installed. This filter can be omitted in case it is embedded in the reducer.

19.3.4 Irrigation Solenoid valves

Irrigation solenoid valves are tele controlled valves and normally dossed, shall have strength for operating pressure 10 bars (for water temperature 400C) and shall be threaded. The valves shall have a body made of brass, or cast iron, with epoxy paint, or high strength plastic and their parts which contact water shall be of material resistant to corrosion. The valves shall be with diaphragm, or with "heart - elastic mantle" cross section and their elastic material shall be of suitable composite type. Their inlets arrangement shall be in a straight line or angle, whichever facilitates installation.

The solenoid valves shall carry a solenoid, of operating voltage 24V, 50 Hz, of limited power, not more than 6 VA for the hold condition and 10 VA for the rush condition and their solenoid shall be made of corrosion-resistant material. The solenoid valves shall be accompanied with an at least 1,0 m-long connection wire and with all their auxiliary equipment (tubes, filters, etc.).

The solenoid valves should also fulfil the following requirements :

a. Have a flow reduction (regulation) system.

b. Have a hand opening system.

c. Valve maintenance shall be done without needing to disconnect it from the network.

d. Have low pressure losses, which shall not exceed the 0,6 bars for the nominal design flow.

e. All metal parts shall be made of stainless materials.

If the design requires to preceed the placement of the pressure reducer before the solenoid valve, it is possible to omit the regulator, if it is embedded in the solenoid valve. In this case the adapted reducer should have a pressure gauge of 0-10 bars for indicating the outlet pressure.

Before the solenoid valve, or group of solenoid valves, a water filter shall be installed.

19.3.5 Air Release Valves

1. Dual function air release valves shall be provided for air in taking (vacuum breaking) and air releasing of the irrigation "primary network" [see para 1.16.8.1.(4) of the D.I.S.]. Operating pressure shall be 16 bar. They shall be made of cast iron (with epoxy heat treated paint), with suitable threaded or flanged connection, diameter not less than 50 mm.

2. The air release valves installed at the ends of the irrigation lines([3]) shall be dual function, i.e. suitable for air intake and air release, of 10 atm. operating pressure, cast-iron (with epoxy heat treated paint) with suitable threaded or flanged connection, diameter not less than 25 mm.

19.3.6 Irrigation Water Distribution Manifolds

Water distribution manifolds provided and installed in irrigation control chambers shall be seamless steel tubes to DIN 2448, of appropriate length, with welded caps, equipped with the necessary nozzles for connecting incoming and outgoing pipes as well as air release/vacuum valve (for head manifoldes). All nozzles shall be made of seamless steel tube pieces of suitable diameter (as required in each case) with threaded ends. Subsequent to fabrication, manifoldes shall be hot dip galvanized, in accordance with sub-clause 31.3.a(2) hereof.

19.3.7 Safety valves

The safety valves (pressure relief valves) shall allow the quick relief of network pressure in case the pressure exceeds the pre-regulated one, protecting the network. The minimum regulated pressure shall be 0,5 bars.

The safety valves shall have strength for operating pressure 16 bars (for water temperature up to 400C) and should be potable for unclean water.

For diameters up to Φ2" (50 mm) they shall be threaded with brass body, whereas for diameters larger than Φ2" they shall have cast iron body and shall be flanged according to DIN 2501.

The valves shall be either of "spring type" with stainless steel spring and with suitable metal diaphragm resistant to corrosion, either they shall be equipped with special quick reaction 'pilot'. In the latter case the diaphragm shall be made of not toxic elastic material suitable for potable water, whereas the spring shall be stainless AISI 304.

The placement of valves could be done "in series" (e.g. case of valves of "pilot type"), or shall be of 'angle type" in which case they shalt be adapted laterally to the piping with a "T" (e.g. case of "spring type" valves).

The valves shall be able to be subjected to diaphragm repairs without disconnecting them from the network and they should have low pressure losses.

Before each safety valve a water filter (strainer) shall be installed. This filter could be omitted in case it is embedded in the safety valve.

19.3.8 Hydraulic injector of fertilizers - chemicals

The injector shall be hydraulic, that is it shall be based on the VENTURI phenomenon and shall operate with the network pressure, to which the addition of fertilizers and/or chemicals takes place, and shall be connected at a bypass of the main irrigation duct.

The entire arrangement (injector, piping, connections, etc.) shall be made of special plastic material of high resistance to fertilizers and/or chemicals, without movable parts so that practically it should require absolutely no maintenance and shall be able to withstand operating pressure 10 bars.

If mentioned differently in the special terms of tender (S.T.C., Price Catalog, etc.), the injector fertilizing pump shall be able to suck at most, with constant concentration, during the application, approximately 300 litres per hour of water solved fertilizers and/or chemicals, at a pressure approximately 8 bars.

The hydraulic injector shall comprise the VENTURI arrangement, the piping for connection to the water network and the suction tank of fertilizer and/or chemical material, the valves of isolation or cutoff (regulation) of flow, the arrangement of automated (but hand) stopping of its operation when the fertilizer level, inside the container, falls below the suction level, as well as the ventilation arrangement.

19.3.9 Fire Hydrants Quick Couplers

At specific locations, within the irrigation network, fire hydrant chambers shall be provided, i.e. chambers with suitable connecting outlets for the supply of water to fire fighting vehicles. Such chamber outlets shall be equipped with suitable quick couplers for the purpose of connecting fire vehicles hoses. Quick couplers shall be made of aluminum or brass, 2,5" dia and shall be of suitable design to allow connection of the respective fire vehicles hose coupler.

19.3.10 Irrigation Network Chambers

The irrigation network design makes provision for various types of chambers (irrigation control, Irrigation outlets, air release valves drain, fire hydrant couplers etc). Chambers shall be constructed in accordance with the details provided in the SRP.

19.3.11 Power Supply

The power supply network between each pillar and the supplied solenoid valves shall be constructed underground. Valve power cables shall generally run in the ducts used for roadlighting cables access.

In case irrigation provision is made for a motorway section without roadlighting, an underground duct network shall be provided together with irrigation cable draw pits in accordance with sub-clause 19.2.6 above (individual chambers).

In this case, cable drawpits spacing shall not exceed 50m.

Control valve feeding cables shall be type NYY, sized according to respective calculations. Two-, three-, or four- core cables shall be supplied and installed (is

for serving one, two or three control valves, with common return wire).

Cables shall be jointed at irrigation control chambers, In cast iron or aluminum alloy watertight boxes, sized 100x100 mm approximately, 55 mm-deep, with three entries, containing a heavy-duty terminal for the connection of up to five distribution conductors of up to 4 mm2. Access openings to the junction boxes shall have suitable metal glands.

19.3.12 Irrigation Pillar Cabinet (metal)

The electric section of an irrigation network shall be generally supplied with power from the roadlighting pillar, as stipulated in above sub-clause 19.2.8.

However, pillar dimensions specified under above sub-clause 19.2.8 should be verified, in order to ensure that control valve electrical supply apparatus described herebelow, can be accommodated in the pillar. If available room is found insufficient, the pillar shall have to be constructed suitably larger.

For the power supply of electrically controlled irrigation valves, pillars should contain the following :

a. A watertight enclosure with a 25A single pole switch (PACCO type) and a 25/10A fuse.

b. An electronic irrigation controller([5]) installed in a watertight enclosure, Hardie HR 6200/59 E type or equal, with the following features :

i. Single-phase supply 220V, 50Hz.

ii. Capacity of six (6) stations and possibility of receiving two independent programmes.

iii. Energy storage with charging system and nickel-cadmium rechargeable battery not less than 72 hours capacity, so that, in case of power failure :

 – the programme memory be preserved, and
 – the "clock" continues operating (with no irrigation taking place during the power failure) thus allowing the programme to continue running immediately upon power resumption.

iv. Programming cycle shall be not less than 7 days with the possibility of irrigation day selection and, furthermore, a select-a-day type programme (i.e. irrigation every 2nd, 3rd or 4th day). In case there is no select-a-day feature available, the programming cycle must be not less than 28 days.

v. Repeated irrigation sequences, not less than 3 times a day per station, with flexible starting time selection (or at least once every quarter of an hour).

vi. Irrigation duration selection should be made with one-minute accuracy, its length being up to five hours per day (refer also to Note under viii below).

vii. Two station simultaneous irrigation possibility, as planned in the two separate programmes.

viii. Power feeder for each station, of 26.5V, 50Hz with a power of not less than 8VA.

Note :

If the irrigation period permitted by the controller each time is less than 5 hours (in no case less than 99 minutes), then, additional stations shall be connected to the above relays (ie No 3 and No 5 shall be connected to No 1, while No 4 and No 6 shall be connected to No 2), so that a total daily irrigation period of up to 5 hours may be achieved.

c. A watertight enclosure comprising a single-phase, dry transformer of 100VA, 220V/26.5V, 50Hz 2Nos 2A fuses for the protection of departing lines, 2Nos contactors with coil suitable for feed voltage of 26.5V, 50Hz, each with 2Nos contacts suitable for the connection or disconnection of not less than 6A current, lifespan not less than 1,000,000 connections.

d. A frame made of angle iron sections for incorporation of all above features and for fastening of the distribution onto the pillar back plate.

In case an Irrigated motorway section is not provided with illumination, then the watertight distribution shall contain only those items defined under sub-clause 19.3.10. Pillar dimensions shall be as defined under sub-clause 19.2.8, but the PPC meter section shall not include the AFRC apparatus.

19.4. TELEPHONES

(1) Underground ducts for the passage of telephone cables shall be PE, 90 mm ext. dia, PN6. Ducts shall be placed in 80cm-deep trenches in accordance with SRP. Should specific mechanical resistance is required for the ducts (due to justified special conditions), the duct network shall be constructed of heavy-duty galvanized iron pipes (ISO Medium-grade, green label).

A spare duct shall always be provided at road crossings in accordance with sub-clause 19.2.6 above.

Telephone cable draw pits (GT chambers) shall be fabricated in compliance with the detail drawings provided in the Standard Road Plan (SRP).

(2) Eventual ductwork provided for immediate or future installation of a wired automation system, for which reference is made in subchapter 1.17 of the DIS (pare 1.17.4.3.7), shall be constructed in a similar manner, in the case of projects tendered with the "CONCESSION CONTRACT" system (and/or in other cases, if relevant provision is made).

19.5. TOLL STATION PLAZAS OR AREA ILLUMINATION

19.5.1 Mobile Headframe High Masts

High masts shall be 20 to 35m high (preferably in four sizes ie 20, 25. 30 and 35m).

High masts shall be used for the illumination of toll station plazas, as well as for difficult-shape highway interchanges roadlighting, requiring a special illumination arrangement (floodlighting) and other special cases.

Prior to placing any high mast orders, the Contractor shall submit for Service's approval the pole's structural calculation, according to the DIS stipulations (subchapter 1.17). The following requirements should, additionally, be satisfied.

High masts shall be made of hot extraction steel sheet, in lengths not shorter than 10m each.

Mast sections shall have the form of a tapering prism or cylinder and shall be slide-jointed, wedged into each other, or with sliding joints.

Joint overlap shall be equal to 1.5 times the pole diameter (at the joint height). Steel sheets shall be seamed preferably along a section edge.

The lowest mast section (trunk) shall be supported, seamed on a steel baseplate. The baseplate shall be reinforced with lateral stiffeners and shall have holes for anchor bolts passage.

Subsequent to fabrication, each high mast section shall be hot dip galvanized according to article 31 of the TCC and other Tender Conditions, coating density being in all cases not less than 1000 gr/m2 (140 pm). In situ weldings shall in no case be permitted. Pole wall thickness shall be not less than 4 mm, regardless of the static and/or dynamic structural analysis requirements.

Suitable stiffenings shall be provided in weak areas (eg access opening) for reinforcing the high mast strength.

Provision shall be made by the mast top for suspension of the mobile (raising and towering) headframes, on which luminaires shall be installed. Subsequent to completion of the high mast erection, the headframe shall be capable to slide along the full height, between the mast head and its base, and shall be composed of sections enabling its dismantling (when on ground) for maintenance purposes. Luminaires fixation system on the high mast headframe shall ensure the possibility of illumination distribution adjustment, in one or more directions, enabling the orientation of required number of luminaires towards any zone and their firm fastening in the desired direction. Notwithstanding the limitations and requirements mentioned above, with respect to high mast sections galvanizing, the headframe integral system shall be hot dip galvanized to BS 729/1971.

Suitable arrangement shall be provided by the pole base, for fixing a mobile lifting device, comprising reduction gearbox and drums for the purpose of lowering and lifting the mobile head by means of stainless steel wire ropes. Dimensioning of such ropes shall satisfy a safety factor SF=6.

The mobile system shall be operated by means of an electric motor connected to the hoisting system, supplied from an electric socket provided in the electrical distribution installed within the pole base. Motor operation shall be effected from an independent remote control, enabling, during the head lowering or raising phase, a distance of not less than 5m between the operator and the pole base. The raising and lowering device capacity shall not be less than two times the mobile headframe deadload, and the maximal permissible winding torque shall be clearly indicated. The access opening, accommodating the mobile unit connection arrangement shall be securely locked, by means of a suitable safety lock.

By the pole top a suitable locking system shall be provided, so that the headframe is safely locked in position, avoiding permanent tension to the wire ropes.

Pulleys used, shall be structurally calculated and shall be suitable for application in conjunction with the wire ropes.

Luminaires (floodlights) power supply cables shall depart from the totally enclosed distribution enclosure provided by the pole base and shall be suitably selected (of the flexible, non-twisting type), free of tension or wear during the headframe lowering or raising.

19.5.2 High Mast Bases

The high mast bases shall be cast in situ reinforced concrete grade B15, with the necessary reinforcement St III satisfying cracking and strength requirements, etc.

Dimensioning of such bases shall result from structural calculations, effected In accordance with the DIS [pare 1.17.2.11(8) etc.).

Prior to concreting, the anchor bolts system shall be placed in each base. Botts sizing shall result from the high mast and base structural analysis.

Anchor bolts shall be interconnected into a rigid cage by means of welded angle iron bars. Such cage shall be positioned in the base formwork, so that subsequent to concreting, its 20 cm-long upper part, remains protruding above the base. Anchor bolts upper part shall be threaded in a length of 15 cm. The upper part shall, furthermore, be hot dip galvanized, in a length not less than 30 cm.

Subsequent to high mast positioning and final vertical adjustment, the void between pole base and baseplate underside shall be grouted with cement mortar. The anchor bolts part above the mast baseplate shall be vaseline or grease coated.

A PVC cable access duct, 140 mm nom dia, PN4, shall furthermore be embedded in the pole base. This pipe shall connect the center of the base upper face with the base side from which power supply is to be effected.

19.5.3 Floodlights

Floodlights, installed on high masts, shall be provided, for area or toll station plazas lighting.

Floodlights shall be of the asymmetric narrow beam type, suitable for the installation of 1No high-pressure sodium lamp, 400W capacity, or 2Nos HP sodium lamps 400W, or 1No HP sodium lamp 1000W.

Floodlight shall be suitable for outdoor installation, protection 1P55 to IEC 598, capable of operating continuously in + 350 C ambient temperature. Construction materials shall be free of tear and wear due to adverse weather conditions.

The floodlighting housing shall be made of pressure-cast aluminum alloy with smooth outer surface.

Floodlight reflectors shall be made of polished or anodized chemically pure aluminum (99,99% grade), and shall generate an asymmetric narrow beam on the vertical plane, as specified above.

Floodlight support shall be of robust construction, hot dip galvanized, equipped with a built-in protractor to be used for aiming purposes. Floodlight fixing on the high mast mobile headframes, shall be effected by means of a suitable anti-vibration securing arrangement, whose design shall ensure tight-locking, in spite of extensive vibrations, oscillations etc.

Fixing bolts and nuts as well as all floodlight metal parts shall be made of high grade corrosion-resistant materials (stainless steel) or, alternatively, shall receive highly efficient corrosion protection (cadmium coating, paint etc.).

Floodlight toughened glass-plate cover shall be not less than 5 mm-thick, securit type, specially treated for resistance to high temperatures developed in the floodlight inner part, or the ambient (outer side) low temperatures. Glass covers shall be fixed in a non-detachable manner, hinged and locked on the floodlight housing.

For the purpose of fixing the tubular lamp, a vibration-proof porcelain lamp holder, type E40 shall be provided in the floodlight inner space.

Cable entrance shall be effected via an appropriate gland, suitably fixed on the floodlight housing.

Each floodlight shall be accompanied by the relevant starting apparatuses, separately delivered, for installation in a watertight enclosure by the high mast base.

Such apparatuses shall comprise :

a. Ballast

It shall be suitable for high pressure sodium vapour lamp, of the same capacity of the lamp 1,000 W or 400 W, 220V, 50Hz, constructed to VDE 0712, its cold status losses not exceeding 60W.

b. Power factor correction capacitor

The capacitor shall achieve power factor (cosφ) not less than 0.85. It shall be constructed to VDE 0560, with a discharge resistance and shall be suitable for operation in conjunction with the floodlight ballast.

c. Starter

It shall be electronic, of the automatically switched-off type.

19.5.4 High Pressure sodium lamp. 1kW

The lamp to be used in the floodlights shall be tubular type high pressure sodium vapour, 1,000W capacity.

It shall be suitable for 220V, 50Hz, shall provide 125,000 Im luminous flux and shall have a lifespan exceeding 8,000 hrs.

it shall be suitable to screw into a E40 type lamp holder.

19.5.5 High pressure sodium_Jamps, 400W

These lamps shall also be of the tubular type.

19.5.6 Watertight Distribution Enclosures In sigh Masts

All floodlights installed on high masts shall be electrically supplied from a watertight distribution enclosures (boxes), installed by the base of each high mast.

Each watertight distribution enclosure shall contain :

a. Incoming power main switch.

b. Floodlights feeders, each one comprising power switch and fuse. Each feeder shall supply the flood-light vide its starting apparatuses, installed in a watertight enclosure, located also by the pole base.

c. A 3-phase feeder, equipped with fuse and load switch feeding in a power socket outlet for the supply of the mobile headframe lifting device.

In conjunction with watertight enclosures the stipulations of pare 19.2.8 of this TCC shall apply.

19.5.7 High Mast supply Pillars

High mast supply pillars shall have an adequate number of feeders, equal to the number of supplied high masts. Pillar construction details as well as the construction of watertight distributions (enclosures) contained therein, shall be in accordance with pare 19.2.8 of the TCC.

19.5.8 Power Network - Earthings

The stipulations of pares 19.2.6 and 19.2.7 of the TCC shall be applicable.

19.6. TOLLS SAFETY-OPERATION VISUAL SIGNING

19.6.1 General

Provision shall be made for luminous signs with the indication 'OPEN-CLOSED as well as toll-island-edge and or fog luminous indication for the tolls safety and operation visual signing.

In order to enable nationwide standardization of relevant luminaires, both luminaires types are subject to Service's approval.

19.6.2 “OPEN-CLOSED” Sign

"OPEN-CLOSED" luminous signs shall be provided and installed by the canopy fronts, at locations corresponding to each toll lane (between two consecutive islands), indicating to the motorists toll lanes available for use, by means of a red cross (x) and/or a green arrow.

Each relevant luminaire shall consist of :

a. Robust construction, waterproof, metal stainless steel casing. Luminaire front shall be covered by a transparent acrylic sheet, size 55x55cm approx. (or larger), fixed on the housing by bolts and nuts. The luminaire back shall be its access door, hinged on one side on the casing via stainless steel hinges, locked on the other side, for easy opening. The door shall also have holes for luminaire's ventilation.

b. 2Nos luminous sources each containing a cold-cathode glass discharge tube and a converter. One luminous source shall be a green arrow and the other a red cross. The 2Nos luminous sources shall be totally independent. The symbol color depends on the gas contained in each tube as well as its internal coating. Each tube shall *be* provided with an anti-vibration seating. The symbols shall be superimposed (being totally independent), both well centered within the luminaire space and shall satisfy the CIE 148 (TC16) requirement.

Luminaires shall be suitable to operate at 220V, 50Hz, and shall be 250VA approximately.

19.6.3 Anti-fog Luminaire

Provision shall be made for an alternating operation anti-fog luminaire to be installed on each island edge (nose light, or anti-fog beacon). This luminaire shall consist of :

a. A GRP housing, with a waterproof transparent cover on its front surface.

b. Flashing lighting system, consisting of a "NEON" tube, accommodated In a large reflector (200 mm dia approx.).

A synchronizing arrangement shall be provided for all anti-fog lamps simultaneous operation.

The luminaire shall be suitable for 220V, 50Hz, power 100VA approx.

Luminaires shall be accommodated in suitable hatches formed on the RC Island noses. Formation of the hatch shall be achieved by means of a suitable polyethylene form embedded in the concrete. According to the Manufacturer' s drawings, the concrete nose design shall be such as not to allow any luminaire protruding parts.

19.7. BUILDING WORKS INSTALLATIONS. TOLL STATIONS, TUNNELS. TOLL BOOTHS

19.7.1 Plumbing Installations

19.7.1.1 Pipeworks

Water distribution networks shall be made of copper tube material SF-CU F37 to 1787, in straight sections, with fittings suitable for capillary jointing.

Shut-off valves shall be of ball type.

Underground water supply or irrigation networks shall be made of HDPE,

19.7.1.2 Electric Waterheaters

Electric waterheaters shall comply with RD 69/14.2.70 for "safety regulations for the construction of storage type electric waterheaters".

Each waterheater shall be provided with a thermometer, a thermostat range up to 900 C, safety valve and shall be strongly insulated. The insulation shall be covered by a steel sheet, coated with heat-treated paint. Waterheater shall be suitable for single phase 220V or 3-phase 380V, 50Hz power supply.

19.7.2 Drainage Installations

19.7.2.1 Pipeworks

Drainage pipeworks shall be constructed of uPVC pipes and fittings to DIN 8061/8062 and/or NHS 9-71 series 2, PN4 at 20° C. Underground pipeworks within buildings shall be embedded in concrete.

External underground sewerage and storm water drainage networks shall be constructed from PVC pipes to DIN 19534 (brown color).

Stormwater downpipes (downspouts) shall be made of heavy type galvanized iron pipes, "green label", in accordance with the Standards.

19.7.2.2 Waste and Foulwater Lifting Pumps

Provision shall always be made for the supply and installation of two pumps, in principle the first as duty-pump and the other as standby. Pumps shall be with vertical shaft, centrifugal, specially designed for handling sewerage or slightly contaminated wastewater.

Pump impeller, and casing shall be cast iron. Shaft, bolts etc. shall be stainless steel.

Pumps shall operate in 380V, 50Hz. They shall be sliding on guide rails, their discharge outlets being tightly adjusted to permanently installed discharge pipe.

Provision shall be made for a fully automatic operation system.

19.7.2.3 Sanitary Fittings

Except for sinks that shall be made of stainless steel, all sanitary fittings (washbasins, WC pans, shower trays, urinals etc.) shall be vitreous china.

Provision shall be made for at least one drinking water cooler per building, and in large buildings at least one cooler per floor.

In sanitary rooms hand dryers shall be provided.

Remaining sanitary fixtures shall be chromium plated brass or stainless steel.

19.7.3 Firefighting Facilities

19.7.3.1. Water Firefighting Pipeworks

Water firefighting networks (firehose cabinets, sprinkler heads etc.) shall be constructed from galvanized iron pipes, "green label" as per Standards.

19.7.3.2. Firehose Cabinet

Firehose cabinets shall be wall-mounted, or recessed or semi-recessed metal closets.

Closets shall be constructed from DKP steel sheet 1.5 mm thick, fully reinforced as required at supporting locations including equipment, doors etc. They shall receive two coats of rustproofing graphite primer, followed by two further oil paint coats, color to be selected by the Service.

Doors shall have rigid frames, heavy duty hinges and easily operating, aesthetically pleasing locking bolts, approved by the Service.

Each firehose cabinet shall contain :

a. A 2" dia special type shut-off valve made of brass, with vertical seat and operating gear, "Fire Service" type.

b. A stainless steel hose rack, on which a robust construction flexible hose shall be folded.

c. A 2" dia brass pipe ("trunk") threaded at both ends, for connection to the valve of subclause (a) and to a STORTZ-type quick coupling.

d. Flexible firefighting hose 1.75" nom dia, made of synthetic fibres internally rubber lined (1 mm minimal thickness), 25m long, with rust proof metal quick couplings installed on both ends.

e. An aluminum adjustable dia and mist nozzle, approved by the Service.

19.7.3.3. Sprinkler Heads

Sprinkler heads to be used should be approved by (at least) one internationally recognized Testing Authority, such as UL or FM (USA).

Each sprinkler head shall be activated in the "ordinary" temperature range, ie between 1350 F (570 C) and 1700 F (770 C).

The element plugging the sprinkler head outlet shall be simply formed, of either the fragile bulb or of the "melting" type, maintenance free and quick acting.

Sprinklers heads shall have a 1/2" orifice and shall be threaded for their connection to 1/2" water supply pipes. Under a pressure of 10 psig (0.7 bar) they should deliver a flow of not less than 17.9 gpm. Operating pressure shall be at least 10 bar.

19.7.3.4. Fire Stations

Each fire station consists of a cabinet similar to that of the firehose cabinets, in which the following special Firefighting Tools and Equipment are accommodated:

a. 1No personal gas-mask with toxic gases filter.

b. 2Nos protective helmets.

c. 2Nos battery operated torch lights.

d. 1No safety blanket (inflammable).

e. 1No shovel.

f. 1No axe.

g. 1No pick-axe.

h. 1No burglary crow-bar.

1. 1No hatchet**.**

Every third fire station shall, additionally contain an extra respiratory device.

19.7.3.5. Portable Fire Extinguishers. 6kg

CO2 portable fire extinguishers shall be provided, 6kg contents net capacity. Each extinguisher shall be delivered filled and shall consist of the container made of aluminum or low carbon content steel sheet, tested to 250bar (3626psi) rated 60bar working pressure (870 psi) approved by its country of origin competent authority, (e.g. for the USA, Department of Transportation), equipped with a press-on or trigger type brass valve, rubber hose and delivery nose (funnel) made of hard plastic material.

Effective (shooting) time shall be 25sec approx. to a distance of 2,5 to 3,0m. The container shall be equipped with a manometer and shall have a suitable wall-mounting base.

19.7.3.6. CO2 Automatic Firefighting Systems

Where provision is made for automatic firefighting systems (except water systems), e.g. at computer halls, these shall be operated with the CO2, designed and constructed in accordance with NFPA Standard No 12 (Carbon Dioxide Extinguishing Systems).

19.7.3.7. Fire Detection Cables

Fire detection installation wiring shall be effected either using NYM type cables installed in steel conduits or with armored cables type LiYCY.

19.7.3.8. Fire Detection Equipment

For large buildings (e.g. Service and Maintenance Centre) the fire detection installation shall be fully addressable, whereas for smaller buildings it shall be of conventional technology.

Fire detection installation and equipment shall be in compliance with the National Standard of its country of origin (e.g. BS 5839 for the UK).

19.7.4. HVAC Installations

19.7.4.1. Hot and Chilled Water Piping Networks

The hot and chilled water piped networks shall be constructed up to 2" nom dia from carbon steel seemed pipes, "green label" to ISO/R65/Medium duty. For larger diameters seamless pipes shall be used to ISO/11336 or alternatively DIN 2448.

Condensate drainage piping networks shall be constructed from galvanized steel pipes "green label". For the control and isolation of branches ball valves shall be provided.

All pipeworks shall be insulated by means of prefabricated insulating shells of "closed cellular structure".

19.7.4.2. Radiators

They shall be made of steel, pressure rated not less than 4bar.

19.7.4.3. Local Fan-coil AC Units

Each fan-coil AC unit shall comprise :

a. Fans section : equipped with one or more double inlet centrifugal fans on a common shaft with a single phase electric motor 220V, 50Hz. Operation shall be noiseless (at medium speed not to exceed NC-30).

b. Filter : 1" thick, metal, washable.

c. Coil unit : with copper tubes and aluminum fins, to operate on chilled water as a cooler in summertime, and on hot water as a heater in winter.

d. Condensate collection pan.

e. Control apparatus for the unit, such as 3-speed switch, thermostat switch, automatic WINTER-SUMMER changeover thermostat switch, electrically operated 3-way valve, isolating valves etc.

Local fan-coil AC units shall be of horizontal or vertical installation with or without cabinet, depending on installation location.

19.7.4.4. Split type packaged AC Units

These units can be designed for cooling only (split type packaged air conditioners) or cooling and heating with cooling cycle reversing (split type heat pump).

These units shall consist of :

a. Indoors unit comprising a fan and its motor, a cooling or cooling-and-heating coil and a condensate collection pan, additional electric element (when required for heat pumps) filter and a cabinet covering all above components.

b. Outdoors unit comprising compressor and its motor, condenser, axial fan with its motor, coolant container, operation reversing valve (for heatpumps).

c. Coolant pipeworks and electric cabling between the indoors and the outdoors units.

d. Automatic operation and control instruments.

Units shall be suitable for single-phase operation, 220V, 50Hz.

19.7.4.5. Central Air Conditioning Units

These shall be of horizontal or vertical arrangement and in a double skin with insulation they shall contain :

a. Fans section with one or more centrifugal fans, outlet velocity not exceeding 8mIsec, motor speed 1450rpm 3-phase, suitable for 380V, 50Hz and a movement transmission system with pulleys and drive belts.

b. Coils section with a heating coil, a cooling coil, operating on hot and chilled water respectively, water or vapour humidifier and condensate collection pan. Coils shall have copper tubes and aluminum fins, and the face velocity on the coils shall not exceed 2,5m/sec.

c. Filter boxes with prefilter (EU-3) and bag filters (EU-5).

d. Mixing boxes (where required) with dampers.

e. Attennation boxes with industrial type silencers.

Each unit shall be fully equipped for automatic operation.

19.7.4.6. Ducts

Ducts shall be constructed of high quality galvanized steel sheets, complying with SMAGNA or to BS 2989.

Steel sheet thickness to be used shall be defined for each duct section, in function of the cross section largest side, in accordance with the following table :

X-section largest side	Steel sheet thickness
Up to 30 cm	0.60 mm
From 31cm up to 75 cm_	0.80 mm
From 76cm up to 135 cm	1.00 mm
From 136cm upwards	1.25 mm

Both supply and return ducts, located in non airconditioned spaces shall be fully insulated.

19.7.4.7. Air Outlets

Supply and return air outlets shall be aluminum-made, square or rectangular, type and design to suit the case.

19.7.4.8. *Fire Dampers*

When ducts cross through walls or floors, separating different fire compartments, fire dampers shall be installed of the 'fire curtain" type, rated not less than 1.5 hrs.

19.7.4.9. *Chillers*

Chillers shall be air cooled, completely automatic operation, each equipped with a minimum of two independent refrigeration units, one duty the other standby.

Each chiller shall comprise :

a. Electric motor driven - compressor with freon-22 coolant, with "semi-closed" type compressor, equipped with piston system allowing it to start in load-free condition, with adjustable capacity at no less than four stages. Electric motor shall be 3-phase, suitable for 380V, 50Hz, equipped with starters allowing it to start under reduced voltage.

b. Air cooled condensers with copper tubes, aluminum fins and electrically driven axial fans.

c. Water coolers of the "shell-and-tube" type, with copper tubes.

d. Coolant pipeworks and equipment system, comprising the totality of fittings and instruments required (eg solenoid valves, filters etc).

e. Automatic control and balancing instruments for system operation.

19.7.4.10. *Boilers*

Boilers shall produce hot water 850 C, shall be steel construction, of the smoke-tube type, suitable for operation by burning light diesel oil.

They shall provide for triple combustion gases passage and efficiency not less than 85%.

Each boiler shall have a two-stage forced-draft burner suitable for light diesel oil, completely automatic operation, 3-phase, 380V, 50Hz.

19.7.4.11. *Diesel Oil Tanks*

Tanks shall be metal construction, cylindrical shape, in accordance with DIN 6608 (underground) or DIN 6616 (above ground).

Tank capacity should be sufficient to allow 20 days operation under full load. 19.7.4.12 Circulating Pumps

"IN-LINE" type circulating pumps shall be provided, with aligned suction and discharge outlets.

They shall be equipped with 1450rpm electric motors, suitable for 220V, 50Hz, or alternatively 380V, 50Hz.

19.7.4.12. Fans

Discharge (and In some cases Supply) fans shall be of the type required in each case (centrifugal, wall mounted axial, duct mounted axial, roof mounted etc).

They shall be equipped with 3-phase electric motors suitable for 380V,50Hz. Very small fans may, alternatively, be provided with 220V, 50Hz single-phase motors.

Discharge velocity should not exceed 8m/sec.

19.7.5. Electric Power Installations

19.7.5.1. Electric Wiring

Electric wiring for lighting and power shall be with either type NYA (VDE 0250) wires, in plastic or steel conduits, recessed or surface mounted, or alternatively with NYM (VDE 0250) type cables in plastic or steel conduits or on cable trays, or in channels or surface mounted on suitable supports.

Electric lines feeding distribution panels as well as motors power supply lines shall be constructed using NYM or NYY type cables installed in conduits, or on metal cable trays.

Power distribution lines construction shall comply with the Indoors Electrical Installations Regulation.

Plastic and/or steel conduits and respective fittings shall be approved by the Ministry of Industry.

Cable trays shall be made of perforated steel sheet 1 mm thick (for 100 and 200 mm width) and 1,5 mm thick (for 300 and 400 mm width). Larger width trays shall be made of 2 mm thick plate.

Bare copper conductors for earthing lines shall be In accordance with VDE 0255/51 and VDE 0265/52 and shall be installed in conduits or on cable trays or surface mounted on suitable supports.

19.7.5.2. Switches - Sockets etc.

Switches, sockets etc. shall be square shaped, white, recessed type.

Light controlling switches shall have a 10Amps minimal rating, (for both dry and wet areas), whereas "schuco" type socket outlets shall be provided, rated 16Amps.

19.7.5.3. Lighting Fixtures

Lighting fixtures to be used shall be mainly of the fluorescent type.

Their housing shall be made of 0.7 mm-thick cold extraction steel sheet (DKP) electrostatically coated and heat treated in suitable oven.

Lighting fixtures accessories (lamp holders, ballast, starters, capacitors etc.) shall be heavy type, VDE approved, fixed on the fixture housing by means of suitable receptacles.

Fluorescent lamps to be used shall be of the new type, with high efficiency and lifespan, Philips type TLD, light color equivalent to Philips No 84 color, or approved equal.

With respect to lighting fixtures types to be used, the following stipulations shall, generally, apply :

a. In clean rooms (offices etc.) louvered type, ceiling or false ceiling mounted lighting fixtures shall be used.

b. In less clean spaces, prismatic cover type lighting fixtures shall be used.

c. In wet areas waterproof cover (or with waterproof lamp sockets) fixtures shall be used.

d. In large height spaces (workshops, warehouses etc.) industrial type lighting fixtures shall be used with high pressure sodium lamps.

Safety (emergency) light fixtures shall be self-powered, equipped with a minimum of 1.5 hrs-duration batteries and a 6W fluorescent lamp.

19.7.5.4. *Outdoors Lighting*

Buildings surrounding areas (access roads, parking areas) shall be illuminated with 9m-high lighting poles and bracket mounted luminaires with high pressure sodium lamps, in compliance with paras 19.2.1.1 and 19.2.5 of the TCC.

19.7.5.5. *Metal Distribution Panels*

All lighting panels as well as small size electric motor panels shall be suitable for recessed or semi-recessed or wall-mounted installation. of the well-known 'stab" type (Stabverteilungen) by Siemens (or approved equal), suitably protected to DIN 40050/IEC144 in accordance with the installation spaces particular requirements.

In composing such panels, following provisions should be made :

a. At each panel entrance a load switch shall be provided along with power fuses and operation indication lamps with fuses.

b. Feeders to lights and socket outlets shall *be* protected with miniature type circuit breakers.

c. Socket feeders shall be grouped and protected through an EFCB (earth fault circuit breaker).

d. Motor feeder lines shall be equipped with load switches, fuses, starter-auto motor protection breaker (direct-on-line starters for motors up to 5hp capacity, star-delta starters for larger motors) operation push buttons, indication lamps, ammeter with changeover switch and hours-run counter.

Panels equipment should comply with following specification, where applicable:

a. Miniature type circuit breakers shall have nominal current 6Amps to 25Amps and shall be suitable for up to 380V (AC). They shall be suitable for switching-off current of not less than 1.5 kA according to VDE 0641 and 0643.

b. Threaded type fuses shall be of the E2 type with porcelain base to DIN 49510, 49511 and 49325, plug to DIN 49360 and 49365, fusion cartridge to DIN 49360 and DIN 0635.

c. Knife-type fuses: for currents exceeding 100Amps, knife-type fuses shall be used in accordance with DIN 43653.

d. Load switches: for currents up to 100Amps rotating type load switches shall be used, "Pacco" or "Rail mounted" type. For currents exceeding 100Amps knife-switches shall be generally used.

All panel instruments shall originate from a single well-known electrical equipment manufacturer.

19.7.5.6. Medium Voltage Switchboard 20kV

Medium voltage switchboard general technical characteristics are as follows :

a. Highest operating voltage	24 kV
b. Rated voltage	20 kV
c. Rated current	>400 A
d. Rated breaking capacity	>250 MVA
e. Earthing test voltage (1')	>50 kV
f. Impulse test voltage (SW)	>125 kV
g. Control voltage	100 V AC

It is anticipated that for the size of buildings provided in this project, the installation of a single transformer shall, in general, be sufficient. To this effect the medium voltage switchboard shall contain :

a. A 3-phase, 400Amps rated current, under load-operated switch, with following characteristics :

I.	Operating voltage	20/24 kV
II.	Earthing and phase to phase voltage capacity in 1'	50 kV
III.	Short circuit breaking capacity	> 12,5 kA-1'
IV.	Making capacity	> 31,5 kA
V.	Impulse to earth and phase to phase voltage capacity	12,5 kV
VI.	Operation	Dependent manual operation

b. 3Nos medium voltage 20kV fuses of suitable current for the transformer size.

c. 3Nos single phase cable terminals complete with all necessary fittings, suitable for the termination of 20kV single phase cables.

d. An earthing switch for cables earthing, with following technical characteristics:

   i. Short rated nominal current 9.65 kA, lsec and
   ii. Short circuit making capacity (peak) 18.4 kA

   The switch shall be independent, manually operated.

e. Cable voltage control arrangement, with capacitor voltage distributors per phase, for voltage indication at the cable terminals, by means of Led indication lamps.

The switch shall be provided with a suitable arrangement that shall cause circuit disruption, in case of fusion of one single medium voltage fuse. It shall be, furthermore, equipped with an operation coil for remote control disruption when 220V voltage (approx.) is applied and with auxiliary contacts (2S+2o).

19.7.5.7. *<u>20kV/0.4kV Power Transformer</u>*

A power transformer shall be provided with following characteristics :

a.	Rated capacity	According to the building load
b.	Frequency	50 Hz
c.	Rated voltage	2010.4 kV
d.	Vector group	DY 11
e.	Impedance voltage at 75^0 C temperature	6% to IEC
f.	Ambient temperature	40o C
g.	Insulation class	24 kV
h.	Losses	DIN 42511

The transformer shall be indoors type, 3-phase and shall comply with VDE 0532 and IEC 76 specifications.

Transformer shall be supported on 4Nos two-directional wheels in accordance with DIN 42511.

The transformer shall be oil-type in accordance with VDE 0370 specifications.

Cooling shall be effected by means of a special transformer cooling oil and the radiator fins shall be heavy duty to withstand transport hardships.

Transformation ratio (tapping) shall be externally adjustable by at least -+ 5% in steps of 2.5% when transformer is unloaded (-5%., -2.5%, 0%, +2.5%, +5%). Transformers shall have copper losses, under full load, as stipulated in DIN 42511.

Transformer shall be protected by means of a dual-float Buchholz-type relay. The first float switch shall provide an audio signal (horn) and the second shall isolate the transformer, cutting-off medium voltage supply through the remote control of the medium voltage switch in the medium voltage switchboard (refer to previous par 19.7.5.7).

19.7.5.8. 20kV Cables. N2YSY

Medium voltage cables (20kV) interconnecting the PPC meter to the MV Switchgear as well as the latter to the 'primary' power transformer MV side, shall be 3Nos single-phase copper cables, of extra strong thermoplastic insulation (insulation rating 20kV), 95 mm2 section, type N2YSY.

19.7.5.9. "Cubicle" type Switchboards

The main low voltage distribution switchboard for the building as well as eventual large size motor control panels (e.g. air conditioning control panel) shall be of the free standing "cubicle' type, metal made, suitable for floor installation, with front access via suitable doors. Each board shall be an integral complex consisting of a number of cubicles.

For these panels the following features shall be provided :

a. At the entrance from the transformer, provision shall be made for an automatic air circuit breaker.

b. At the entrance of all other cubicle type distribution panels provision shall be made for load isolators and fuses.

c. All feeders shall be equipped with load switches and fuses. In particular departures feeding motors shall be additionally equipped with a starter-automatic motor protection switch, operation push buttons, Indication lamps changeover switch, ammeter and hour-run meter.

19.7.5.10. *Standby DG-set*

The standby DG-set shall have sufficient capacity to satisfy the loads referred to in the BIS, due consideration being given to the starting of motors and with a minimal spare capacity of 25%, and under the following conditions :

a. Output : 3-phase, (polar) voltage 400V, phase voltage 230V, 50Hz, with neutral.

b. Fuel : 'Diesel" fuel as available in the market.

c. Installation space ambient temperature (consequently temperature of combustion air to the diesel motor) :

Winter -4^0 C

Summer $+40^0$ C

d. Installation altitude : 250m above sea level.

e. Full-load takeover time : 15sec.

The DG-set should be capable to withstand under full load a 10% overload, for a 1-hour duration every 12hrs of operation, in accordance with DIN 6270.

PG-Set Components : The emergency standby DG-set shall comprise the following :

a. The diesel engine (prime mover).
b. The alternator.
c. The flexible coupling connecting the above and their common base.
d. The automation control of the diesel - generator set and load changeover system.

Prime Mover : Diesel engine shall be 1500rpm, with sufficient power to move the alternator under full load in the conditions stipulated above. The prime mover shall be closed circuit water cooled, equipped with a complete fan-radiator water cooling system.

The prime mover shall, preferably, have removable cylinder jackets and shall contain the following :

a. A speed (rpm) regulating system.

b. A lubrication system (with pump and oil cooling radiator).

c. A fuel system (via pumps, filter etc.).

d. A starting electrical system (starter motor, batteries, battery charger etc.).

e. Cooling system (with closed-circuit water, pump, radiator etc.).

f. Combustion air-system (with filter).

g. Exhaust gases disposal system (with silencers etc.).

h. Diesel engine indicator instruments, such as :

- cooling water thermometer and pressure gauge lubricating oil thermometer and pressure gauge speedometer
- hour-run counter fuel level indicator

Alternator (generator) : The generator shall be 3-phase, synchronous, self-regulated, self-excited, brushless type. The exciter shall be on the generator shaft. Both generator and exciter shall be brushless without any other moving contacts, subject to tear and wear. Maintenance shall mainly consist on bearings lubrication and cleaning from eventual fouling.

The generator shall yield at its poles the required power with a power factor cosφ = 0.8, for 400 C ambient temperature and 250 m altitude above sea level.
The voltage at the generator poles shall be 400/231V, 50Hz at 1500rpm, with star connection and outgoing neutral. Generator efficiency shall be not less than 90% for 100% loading and power factor cosφ = 0.8.

The generator shall, generally, comply with VDE 0530 standards and shall be suitable for use in a DG-set.

Following indication instruments shall be provided, in conjunction to the generator :

a. 1No voltmeter,

b. 1No 1-position voltmeter selector switch

c. 3Nos ammeters with the respective current transformers.

d. 1No frequency meter.

e. 1No power factor meter (cosφ).

f. 1No DC voltmeter, for the starting battery.

g. 1No DC ammeter, also for the battery.

Flexible coupler - Common base : The diesel engine (prime mover) and the alternator shall be closely coupled with a suitable flexible coupling and shall be installed on a common metal base. The base shall be accompanied by suitable high-effectiveness, anti-vibration springs, excluding the risk of vibration transmission to the building.

Automation. Control and Load Changeover System : The DG-set shall be equipped with an Electronic Voltage Surveillance System, with following functions :

a. Automatic start of the set subsequent to a power failure or PPC network inadequacy or transformer(s) failure and automatic load take-over, with the time-delay required for the PPC network.

b. DG-set operation surveillance.

c. Automatic DG-set cut-off in case of problem (lubricating oil low pressure, coolant water overheating, prime mover over speeding, alternator overload, voltage deviation, fuel shortage).

d. In case of starting failure, automatic starting procedure repetition, for a duration of 8sec approximately, up to a total of 3 consecutive times, with intermediate 8sec pauses.

e. Locking of the starting automation, subsequent to three unsuccessful starting trials.

f. Automatic load changeover to the PPC supply, subsequent to PPC network restoration, DG-set load free operation for a duration between 0 and 5 minutes (timer adjustable) and, finally, stoppage of the set and return to the standby status.

Load changeover between the PPC and the DG-set supply shall be effected via a 4-pole changeover switch, installed at the DG-set automatic control panel.
Automatic control and changeover system shall be equipped with indication lamps and operating instruments (eg mode selection switch OFF-AUTO-MANUAL-TEST).

19.7.5.11. *Uninterruptible Power Supply System (UPS)*

The UPS shall comply with following regulations :

a. Regulations requirements in general (Indoors Electrical Installations Regulation, PPC and GT Regulations).

b. German VDE and DIN Standards in general, or the respective regulations of its country of origin, in case the latter are more severe.

c. IEC International Regulations.

The UPS system shall comprise the following main components :

a. Rectifier with adjustable silicate thyristores.

b. Batteries for the DCIAC voltage converter supply, in case of PPC network failure.

c. Static converter DC to AC, of the required capacity.

d. Electronic Changeover Switch (ECS) suitable for the total power capacity of the UPS installation.

UPS capacity shall be suitable to cover with a 20% margin the prescribed loads.
Its total efficiency shall exceed 85% under the nominal load. Batteries shall be maintenance free, waterproof, suitable for rapid discharging. Batteries nominal voltage shall correspond to the DC/AC converter input voltage. They shall have suitable capacity so as to enable 100% supply of the UPS consumers cumulative load for not less than 15 min.

19.7.5.12. *Earthing*

An earthing ring, with a galvanized steel strip, to DIN 48801, 30 x 3.5 mm cross-section, installed in a 60cm-deep trench, at a distance not less than 1.5m from the building, shall be provided for the earthing of each building.

The flat steel strip shall be held in vertical position on special supports to DIN 48833, provided at 2m spacings approximately.

At the substation, (where provided) an earthing bar for the main installation components shall be installed (neutral, metal parts etc.). This bar shall be connected to the building peripheral earthing ring.

In case a metal canopy is provided above the toll collecting facilities, it shall be earthed by means of a hot galvanized bare copper conductor, 50 mm2 cross-section, installed in a 60cm-deep trench along the canopy perimeter. The earthing ring shall be connected to the canopy metal columns, by means of a copper conductor of identical section.

The Administration Building and the canopy earthing rings shall be interconnected in order to achieve a lower earthing resistance.

Subsequent to completion of the earthing installation, earthing resistance shall be measured through a specially provided instrument (earth resistance metering apparatus) or otherwise, as provided for by the Indoors Electrical Installations Regulations (volt-ammeter method). Earthing resistance should not exceed 1,0 Ohm. Measurements shall be effected in summertime on dry soil. In case measured resistance is in excess of 1,0 Ohm, suitable earthing electrodes shall have to be added in order to reduce earthing resistance value to the stipulated limit.

Earthing electrodes shall, indicatively, be of the Copperweld type, 3/4" dia, 2.4m-long, or approved equal.

Electrodes shall have a steel core, thermally or electrolytically copper-coated.

19.7.6. Low-voltage Installations

19.7.6.1. *Telecommunication Installation Lines*

Telecommunication lines shall be constructed using indoors-type telephone cables, with PVC thermoplastic insulation and aluminum shield. Cables shall be JY(st)Y type with copper conductors 0.60 mm dia.
Cables shall be installed in plastic or steel conduits or alternatively in closed type (covered) metal trays.

19.7.6.2. *Data lines*

They shall be constructed with cables as indicated by the computer supplier.
In case provision is made for an integrated cable system for both telecommunications and data, it shall be possible to use multiple unshielded twisted pairs cable (UTP), 100 Ohm. Such cables shall comply with the "Commercial Building Telecommunication Wiring Standard" EINTIA-568.

19.7.6.3. *Telephone Exchange*

The exchange shall be automatic, fully electronic, suitable for internal and external communication. Its size (city exchange lines, internal extensions, number of simultaneous communications) shall depend on the size of the building served, providing all features available to modern electronic automatic telephone exchanges.

Electrical and connection components of the telephone exchange shall allow satisfactory direct compatibility with the automatic Public Telephone Exchanges, used in Albania.

The automatic telephone exchange shall be equipped with a complete power supply system, from the city network. Such system shall consist of cylindrical element Pb batteries, sufficient for 24hrs-operation without recharge, an automatic battery charging facility of parallel operation, supplied from the city network with single-phase, 220V, 50Hz and all necessary auxiliary equipment such as indicating instruments protection apparatus, switches etc.

The exchange shall be accompanied by one (1) "operator console" facility, to which all incoming calls shall be normally transferred.

The "operator console" shall be button operated and shall be capable of executing all above described operations.

19.7.6.4. *Telephone Sets*

Telephone sets for buildings shall generally be of the desk type, button operated, suitable for internal and external communication through the automatic telephone exchange. Toll booth telephone sets shall (most probably) be of the wall mounted type, and shall be defined subsequent to discussion with the booth manufacturer.

In order to ensure compatibility of the telephone sets with the apparatuses of the automatic Public Telephone Exchanges, used in Albania, the operational characteristics of their selection system should be as follows :

a. Selection disc speed : 9.25 up to 10.75 pulses per second.

b. Pulses ratio : between 1.3 and 1.9 : 1.

c. Consecutive digit-call interval discounting the time required for the digit selection by the consumer, (ie ineffective disc return time) : not less than 0.200 sec.

19.7.6.5. *Telephone Installation Earthing*

In case the foundation earthing resistance of the building is equal or lower than 1 Ohm, provision shall be made for protection earthing of the telephone exchange and the metal telephone distribution frame, by means of a suitable connection to the main earthing conductor of the building.

For the telephone exchange operation earthing, provision shall be made for an independent earthing system, consisting of an insulated copper conductor (NYA 25 mm2) and 3Nos vertically installed in the ground copper coated steel earthing electrodes, Copperweld type, 3/4" dia (19 mm), 2m-long each, positioned on the corners of an equilateral triangle.

Earthing resistance achieved shall be less than 1 Ohm.

19.8. ORDERS FOR EQUIPMENT, APPARATUSES ETC

19.8.1. General.

In order to avoid misunderstandings on equipment and apparatuses technical characteristics, it is stipulated that prior to placing any orders the Contractor shall be obliged to submit for approval :

a. A list containing equipment, apparatuses, plant, materials and other items intended to be ordered, accompanied by the respective illustrative leaflets, operation diagrams, efficiency charts and other manufacturer's data, proving that such items are "in principle" in accordance with the contractual stipulations.

b. Suitable scale general drawings, indicating the proposed plant/equipment layout within the spaces provided, as well as their respective outer dimensions and weights, in order to demonstrate installation possibility within the proposed spaces.

The Contractor shall be obliged to submit a sample, for any material requested.

19.8.2. Road Lighting Luminaires

Prior to placing any orders for road lighting luminaires (bracket mounted or floodlights) and lamps and in order to ensure their technical characteristics in relation to those provided in the project's Engineering Design, the Contractor shall be obliged to unfailingly submit following data in the form of manufacturer's official original documents, duly stamped and signed by both the Contractor and the luminaires and lamps Manufacturers :

a. Detailed technical leaflets, pamphlets, prospectuses etc.

b. Utilization coefficient curves.

c. Polar distribution diagrams in two planes, parallel and perpendicular to the luminaire longitudinal axis.

d. lsolux curves.

e. Time related luminous flux reduction curves, for the offered lamps and lifetime curve.

f. Lamp technical leaflet (prospectus) with a graphic illustration of the transmission spectrum, with the lamp's nominal luminous flux after 100hrs of operation.

In case the technical characteristics of the luminaires and/or lamps offered are in variance to those of the project Engineering Design, the Contractor shall be obliged to prepare and submit new phototechnical calculations and a new Design Report, demonstrating that the DIS requirements are satisfied, without altering the installation characteristics, as derived from the project's original Engineering Design.

The Contractor shall, furthermore, be obliged to submit the following :

a. Technical leaflet (prospectus) incorporating the ballast technical characteristics, in accordance with the stipulations of pare 5.1.10 of Standard Specifications 0.0-5 and 0.0-6, mentioned above.

b. Electronic starters technical leaflet (prospectus) in accordance with the stipulations of pare 5.1.11 of Standard Specifications 00-5 and 00-6, mentioned above.

c. Duly filled-in, signed and stamped by both Contractor and Manufacturer, Luminaires and Lamps Schedules (questionnaires) in original form, as contained in Standard Specifications 0.0-5 & 0.0-6, mentioned above.

With respect to lighting fixtures and lamp tests to be effected, the stipulations of para 6 (subclauses 6.1 through to 6.7) of the above mentioned Standard Specifications 0.0-5 & 0.0-6 shall apply. Specimens and tests cost shall be borne by the Contractor.

19.9. EQUIPMENT AND INSTALLATION TESTS

19.9.1. Plant Tests

All main equipments or apparatuses intended for the project, such as power transformers, emergency standby DG-set, uninterruptible power supply system, MV and LV switchgears, and any other equipment or apparatus, as deemed appropriate by the Service, shall be subject to performance tests.

Tests shall be attended by the Supervision or, alternatively, by the Quality Control House (QCH), in case one is appointed.

Tests shall be effected at Manufacturer's premises, but also on site (subsequent to their installation) so as to verify certain main characteristics of the plant.

Tests shall be effected in accordance with recognized international standards (DIN, VDE, BS, CIE recommendations etc).

19.9.2. Building Installations Tests

Subsequent to their completion and prior to handover of each project section, building installations shall be duly tested.

Installations tests, adjustments and commissioning. shall be effected in accordance with the Albanian Regulations in force (e.g. Indoors Electrical Installations Regulation) or other international standards.

19.9.3. Networks And Equipment Marking

Networks of all installations shall be duly marked by using colored tapes and sticker letters. Equipment shall also be marked with agreed identification (reference) letters and numbers, as these are indicated on the installation drawings.

Clause 20 : WORKSITE LABORATORY

20.1. CONTRACTOR'S GENERAL OBLIGATIONS

20.1.1. The contractor is obliged to install and maintain in operation a suitable laboratory on the site of the works to carry out the tests for monitoring and controlling the quality of construction of the project, in accordance with the specifications and the special terms of the Project tender.

The minimum required equipment for the worksite laboratory of the Contractor is specified in paragraph 20.2 of this clause.

The equipment shall remain in the laboratory until all relevant works are completed.

20.1.2. The equipment of the worksite laboratory must ensure the possibility of carrying out the following

- At least the most frequent tests and checks of quality control.
- All the geometry checks.
- All sampling of materials and structures.
- All measurements related to in-situ tests.

20.1.3. The equipment shall be at the disposal of the staff of the Service, whenever requested, in the case where it is necessary to use the worksite laboratory to carry out additional tests.

20.1.4. An experienced laboratory engineer, approved by the Service, shall be in charge of the laboratory for the duration of the execution of the works. He will be assisted by an adequate number of technical and labour staff of the required specialization. The laboratory staff shall be occupied exclusively with the quality control of the project.

20.1.5. The Contractor is obliged to build and furnish at a suitable location, approved by the Service, a temporary installation of a minimum covered area of 200 m2 and of suitable free height, so that inside this covered area and completely independent of it (by providing new internal walls independent of the external walls, and a second roof independent of the general roof of the covered laboratory area) to build the room where the concrete test specimens will be kept and cured as specified in the following paragraphs.

This room of the worksite laboratory must be provided by the Contractor with all the minimum necessary installations (in addition to the equipment of the laboratory). This room shall be demolished by the Contractor after the completion of the works.

20.1.6. After completion of all the project works, the whole installation may be demolished at the Contarctor's discretion.

At the delivery time of the project to the Owner (after expiration of the Concession Period) the tender terms, regarding remaining installations, shall be applicable,

20.2. MINIMUM EQUIPMENT FOR THE WORKSITE LABORATORY

20.2.1. Notwithstanding the provisions of paragraph 20.2.4 the minimum equipment for the laboratory must be sufficient to execute the tests that are to be carried out more than once (1) every two working days :

— During construction or installation works that last one month at least,
— or during material deliveries (on the worksite) whose consumption is such that does not allow each lot to remain for longer than 15 calendar days.

20.2.2. The worksite laboratory equipment may be increased as the Contractor may see fit. For every increase the Service shall be notified regarding the type of equipment and the estimated period of use of such equipment.

20.2.3. The worksite laboratory equipment may be reduced following proposal of the Contractor and approval by the Service, after completion of the relevant works or material deliveries.

20.2.4. The minimum equipment for the worksite laboratory must be adequate and suitable to execute the following tests, even though the requirements of paragraph 20.2.1 are exceeded :

a. Soil Mechanics

1. Natural moisture

2. Description and classification (liquid limit, plastic limit, grain size analysis with sieves and areometer).

3. Determination of apparent weight and soil compaction (dry and with natural moisture) with the sand method, or other approved method).

4. The compaction controls shall be carried out by comparing the density achieved in-place with the optimum density as defined by the PROCTOR test (STANDARD or MODIFIED according to the specification) for the specific sample.

b. Concrete

1. Workability test

2. Grain size grading analysis of aggregates

3. Sampling and curing of test specimens for the compression strength measurement

4. Compression strength test

c. <u>Sampling</u>

1. Cutting and taking samples of any type of materials and any type of structures/equipment.

2. Marking and handling/packing samples.

d. <u>Insitu tests</u>

1. Deformations measurements.

2. Direct or indirect force measurements.

e. <u>Geometrical measurements</u>

1. Measurement of dimensions precision and allowed tolerances

2. Measurement of precision of the geometry of the construction works in space and comparisons to the allowed tolerances.

3. Geometrical deformations.

20.2.5. The Contractor shall also construct a wet room of suitable dimensions for the storage and curing of the concrete specimens, that will be designed by a specialist scientist of the contractor.

The room shall be suitably equipped to provide the required environmental conditions.

20.2.6. The worksite laboratory must also be provided with :

a. Complete records of all information regarding the Quality System and the Quality Control.

b. Library of all specifications regarding the Quality Control of the Project, on the basis of which the Quality Control is carried out.

Clause 21 : QUALITY CONTROL REQUIREMENTS

21 GENERAL TERMS

21.0.1 The present clause is applicable in the construction of both road and railroad projects.

21.0.2 From the viewpoint of contractual correspondence of works in road and in railroad projects, and for the application of quality control provisions referred to under the present specification, it is hereby established that :

a. The quality control to be applied on the *'prepared subgrade"* of railroad works is identified as corresponding to that applied on the *"Pavement Subgrade Layer"* (P.S.L.) of roadworks.

b. Clause 47 hereof shall apply with respect to precision requirements in elevations and in surface evenness of the railroad *"prepared subgrade*

c. The quality control to be applied on the *“subballast layers”* of railroads (including any required *"foundation”* and *"filtering'* layers) is identified as corresponding to that applied on road pavement works (sub-base, base with mechanical stabilization) for roadworks.

d. Clause 47 hereof shall apply with respect to precision requirements in elevations and in surface evenness of the railroad *"foundation layer"* (together with any *¨filtering layer").* If the provision of a *“filtering layer”* is required in a railroad project, from the viewpoint of quality control, such filtering layer shall be treated generally as a foundation layer, with the exception of grading tests for which the requirements referring to the *"pavement drainage layer"* shall apply.

21.0.3 It is noted that clause 2 hereof shall apply with regard to road earthworks construction, while clause 49 hereof shall respectively apply to the execution of railroad earthworks.

21.0.4 The provisions of this clause shall apply to projects tendered for under both the *"DESIGN - BUILT"* system and the method of “UNIT PRICES”. It is also applied for projects being tendered by a *"CONCESSION AGREEMENT"* system.

21.0.5 Quality control for material and construction is being specified herebelow as well as partially in the pertinent clauses of the TCC. If the requirements are in conflict, then the ones considered by the Service as being the most strict shall apply.

21.1. DISTINCTION OF QUALITY CONTROL CATEGORIES

21.1.1 The quality control of materials and construction is distinguished into :

(1) CONTROLS TYPE "A" : The Contractor sees to it that all such controls are conducted and bears all costs related thereto, with the purpose of verifying the performance quality of his own work, of regulating production, managing his relations with suppliers, etc. The frequency of such controls and their extent rest with the Contractor's judgment. The Contractor shall not be paid any extra fee for these controls, irrespectively of the fact that the Service may make use of their results for any other purpose.

A complete record shall be regularly kept of these results at the job site and they shall be at the disposal of the Service whenever they may be requested until the final delivery of the project.

(2) CONTROLS TYPE "B" : These controls shall be made by the Contractor at his expense, and the Service awareness. The Service has the right to be present during the performance of the controls and also to interfere and demand the application of the specified quality control as well as additional controls. These controls are independent of CONTROLS TYPE ‘A' and constitute a minimum requirement of proof that the materials used, the methods applied and the works constructed conform to the relevant specifications.

The kind and frequency of such controls are established in the specifications, the present specification (namely paras 21.2.5, 21.2.8, 21.2.9, etc.) and the other tender documents. Wherever not clearly defined, the time for the execution of such controls must be as appropriate. Appropriate is the time when risks of poor workmanship accumulation or even construction work not complying to the targeted excellent quality are minimized and when additionally it facilitates and makes intervention improvements more efficient.

Results of such controls constitute supporting documents for interim and final payments, as hereinafter established. The importance of these controls is so significant that any omission of same may lead to the imposition of irrevocable penalties, as hereinafter established. Achieving acceptable results from these controls, or accepting penalties imposed for omission of same does not release the Contractor of his obligation to deliver a perfectly constructed work, as hereinafter described.

The stipulations of sub-clause 21.2 hereof shall apply with regard to the controls of this category**.**

(3) CONTRQLS TYPE "C" : They shall be conducted through the care and at the expense of the Service. These controls are deemed to be an undisputable right of the Service and aim at controlling materials and works either in a preventive manner, or as a supplement to CONTROLS TYPE "B", or even after completion of the construction works of a section or of the overall project with a view to verifying satisfaction of regulation/specification requirements.

Since the extent and frequency of such controls rests fully with the Service, their costs shall not be borne by the Contractor. However, the Contractor shall be bound to offer his prompt services in facilitating the Service in the conduct of these controls, assisting it whenever required.

The stipulations of sub-clause 21.3 hereof shall apply with respect to the controls of this category.

(4) CONTROLS TYPE "D" : These controls refer to the verification of the geometrical characteristics of materials and of construction works and are conducted with the care of the Contractor or of the Service, in case of the Contractor's negligence, their costs being fully borne by the Contractor. Such controls *aim* at verifying compliance to the approved drawings and the specified tolerances.

The stipulations of sub-clause 21.5 hereof shall apply with respect to the controls of this category.

(5) CONTROLS TYPE "E" : These controls refer to a macroscopic inspection of materials and of construction works under the care of the Service. The purpose of these controls is obvious.

It is pointed out that, should the Service detect any apparent divergence from the regulations or specifications or any obvious signs of poor workmanship, it shall be entitled to order, through the Supervision, the immediate suspension of the works and the execution of CONTROLS TYPE "B" and "C". Should such controls prove the Service's intervention to be unjustified, then the Contractor shall be entitled to an extension equal to the work break for all deadlines subsequent to such suspension of the works only for the affected section. However, and should such controls prove defective materials and construction works, the Contractor shall be bound to fully restore such defective works, without any entitlement for extension of deadlines.

21.1.2 In case there is a provision to assign a Quality Control Firm(s) (Q.C.F.) as consultants to the Service for the project construction the following shall apply :

(1) All controls shall be executed or be attended by the Quality Control Firm(s).

(2) All programs for tests / controls shall be approved by the pertinent Q.C.F. for each case.

(3) Wherever the present clause makes reference to the Service or the Supervision, without making specific reference to any eventual Q.C.F., it is considered that the Service may be substituted by the Q.C.F. *for* any matters for which it has been authorized by the Service.

(4) The quality control of the works does not in any way relieve the Contractor of his construction responsibility, as he is solely and uniquely responsible for the quality and the suitability of the works and materials.

21.2. CONTROLS TYPE “B”

21.2.1. General

All stipulations mentioned herebelow shall be deemed to regard the quality control work described in the heading of the present sub-clause. All costs for CONTROLS TYPE "B" shall be borne by the Contractor.

21.2.2. Responsibility for the performance of CONTROLS TYPE “B” and Procedure for their Instruction

All responsibility for the execution of CONTROLS TYPE "B" is vested with the Contractor. The control execution shall be ordered by the Contractor. In case of Contractor negligence, the Service may order the execution of controls. In every case the order shall be registered in the Project Diary, or shall be announced in writing.

An order document issued by the Contractor (e.g. to a Testing Laboratory) shall be also sent to the Service.

An order document issued by the Service is addressed to both the Contractor and the agency performing the control.

In any case, such order shall define the kind and object of the control, the place to be sampled, the testing laboratory, the time for commencement of sampling and the time for commencement of the laboratory testing work.

Representatives of both the Service and the Contractor shall attend both sampling and lab testing operations. Non-attendance of the Service's representative shall not alter the control programme. Should the control fail to be executed for any reason whatsoever (with the exception of an explicit written instruction by the Service), any delay observed in the execution of the control and any ensuing delay in the performance of the works shall by no means constitute justification for an extension of deadlines, nor shall it be reason for non-imposition of the penalties provided under sub-clause 21.2.10 hereof.

With a view to allowing ample notification time to the other party and enable him to assign a representative for attending sampling and the rest of the control operations, the control order must precede the testing date by not less than two (2) working days. This condition shall concern all controls of the same nature that are spaced by more than 48 hours. For all other cases constituting series of similar controls spaced between them by up to 48 hours as a result of their nature or of the works progress, the order shall concern the whole series of the controls. In such a case, the order shall define all above mentioned features for each individual control.

21.2.3. General Control Programme. Specialized Staff and Equipment of the Contractor Detailed Control Programs

The Contractor shall be bound to submit a general control program, together with the project programme, and a study regarding the organization of sampling operations and of the other phases of control work, accompanied by a staff list compiled after consideration of the output of the constructional effort, according to the project program. More specifically, it is pointed out that such staff shall need to be suitable and sufficient in number to satisfy the requirement of parallel execution of a variety of all the different items of work in the project.

(1) More detailed control programs shall be submitted to the Service at least two months before starting the relevant works. These programs shall be accompanied by the same elements as for the general control program.

(2) The Contractor shall be responsible and bear the costs for all transportation of test samples to the testing laboratory. The Service reserves the right to be present during sample transportation to the testing laboratory.

21.2.4. Testing Laboratories

Laboratory tests that can be conducted at the field lab, shall be conducted there. All other tests shall be performed in a laboratory(ies) to be selected according to a procedure specified in the Special Terms of Tender or (in case such procedure has not been specified) according to a proposal to be submitted by the Contractor for a qualified laboratory, subject to the Service's approval.

21.2.5. Frequency of CONTROLS TYPE "B"

The minimum number of CONTROLS TYPE "B" anticipated to be executed and borne by the Contractor is described under sub-clause 21.2.9 herebelow for the various kinds of works.

Should the number of tests provided by the present clause be less than that specified in the S.C.C. or the specifications established in the D.I.S. and the present T.C.C., the greatest required number shall prevail.

The Service reserves the right to increase such frequency :

- to the extent required by the specifications, in the case of deviation from desired results,
- up to 30% of the overall cost of tests/controls, even if there is no apparent need to that,

without variation to the basic condition for the tests/controls to be executed at the Contractor's expense. In the case that the cost of tests/controls required by the Service exceeds 30% of the overall cost, the amount in excess shall be reimbursed to the Contractor on the basis of the procedure for payment of "PARALLEL WORKS'.

The total expense for test/controls shall be the one estimated by the Contractor in the Contract (e.g. cases where it is required to determine the test/controls expense for projects being tendered by the "DESIGN - BUILD- system or by the "CONCESSION AGREEMENT' system). Should it not be required to determine the total expense for tests/controls in the contract, then the Contractor will make a pertinent calculation of the expense based on performed quantities through the use of appropriate unit prices according to the procedure for payment of parallel works, during the project construction.

CONTROLS TYPE "B" (sampling, test execution) shall concern, depending on the case, the period of normal supply of materials, production of materials, execution of construction works, and not the period of preparatory operations when the multiple tests performed towards the proper regulation of production shall concern the Service, but shall constitute part of the Contractor's quality control (CONTROLS TYPE "A") (unless otherwise mentioned explicitly in the specifications and the other tender documents) for which reference is made in para. 21.1.1.(1) hereof.

21.2.6. Record of CONTROLS TYPE "B" (RC-B)

21.2.6.1. The Contractor shall be responsible for and bear all costs related to saving up all data regarding the quality control conducted through CONTROLS TYPE "B" in the Record of

CONTROLS TYPE (RC-B). Such data shall include without being limited to the following :

(1) Copy of the General Programme (as per sub-clause 21.2.3).

(2) Copy of the order to perform the control (namely, of the Diary page or of the relevant document).

(3) Copies of correspondence related to partial controls, if any.

(4) Extracts of topographic maps and of other suitable diagrams for the identification of the position concerning each control.

(5) Copies of sampling protocols or of in-situ tests (as per sub-clause 21.2.7 hereof).

(6) Copies of results of laboratory or in-situ tests, together with relevant comments.

(7) Summaries of control results for each series of quality control, section of completed work, quantity of material tested, or quarry, etc.

(8) Any supplementary data deemed useful by the Service or by the Contractor.

21.2.6.2. The individual sheets of the RC-B shall be bound periodically by the Contractor at his own cost into handy volumes (i.e. of 200 sheets), after numbering all pages. Each volume shall comprise an analytical table of contents.

21.2.6.3. The RC-B shall be kept at the Supervision office of the job site. The Contractor may keep a full or partial copy of the document. The RT-B constitutes an indispensable supporting document to be attached to the Protocol of Provisional Acceptance.

21.2.6.4. The data of the RC-B shall be correlated to those of quantity measurement data and shall be applicable in either direction.

21.2.7. Positions and Records of Sampling and of In-Situ Tests

21.2.7.1. The Service and/or its consultants (e.g. Quality Control Firm) shall be called to indicate the place of sampling in connection with all tests requiring such sampling. It is hereby established that samples shall be taken from places presenting the most unfavorable picture with regard to the quality performance of the works.

A sampling record of a suitable form shall then be compiled by the Contractor.

21.2.7.2. The stipulations referred to under the previous sub-clauses shall accordingly apply to all in-situ tests.

21.2.8. Applicable Specifications

21.2.8.1. It is considered obvious that all materials to be used in all kinds of construction works shall be of excellent quality and shall be subject to quality control with the purpose of ensuring their conformity to the technical specifications and to the tender conditions with regard to their physical and chemical properties.

21.2.8.2. The requirements of the D.I.S. and the regulations and specification mentioned thereof, as well as in the present T.C.C. shall apply in principle for the execution of the works and controls (sampling - testing). The same applies for the materials and the material control.

21.2.8.3. With regard to work items not covered by the above specifications and regulations mentioned above, the following shall apply :

a. With regard to concrete, DIN 1048 and 1084.

b. For all other works reference is made in clause 1 of the present T.C.C.

21.2.9. Minimum Frequency of CONTROLS TYPE "B"

The minimum number of tests/controls shall be as follows :

21.2.9.1. *Materials for Fill and for Pavement Subgrade Course land/or for Prepared Subgrade in Railroad Works)*

i. Earth Fills

For each consecutive quantity of not more than 5000cu.m. of excavated earth material to be used in the construction of fills, or each time that there is an apparent macroscopic variation of soil characteristics in cuttings or in borrow-pits, the following tests shall be conducted aiming mainly (further to soil classification) at obtaining the necessary information towards adjusting fill construction to material properties and to the quality control of same.

a	Natural moisture	1 test
b	Liquid and plasticity limits	1 test
c	Grade analysis with sieves	1 test
d	Proctor modified compaction test (AASHO-T 180 methods A and C) (maximum dry densities, cor-responding optimum moisture contents, compaction curves)	1 test
e	Minimum number of tests per borrow-pit (tests a to d as abovementioned)	Tests in 3 pits

ii. Rock Fills

Continuous visual inspection shall be carried out for rock cutting products intended for use in road fill construction works, stones shall be removed if their size exceeds 2/3 the compacted layer thickness defined on the basis of the trial section tests mentioned in sub-clause 2.4.2.3 hereof.

With respect to rock cutting products intended to the construction of railroad fill works, maximum rock size is defined to be equal to 1/2 the compacted layer thickness defined on the basis of the trial section tests (see sub-clauses 49.4.1.3 and 49.4.8 hereof).

It shall be required to construct a trial section of a volume not less than 3000cu.m. prior to the commencement of roadworks rock fill construction subject to the tests described under sub-clause 2.4.2.3 hereof (or, respectively, of sub-clause 49.4.8 hereof for railroad works).

iii. Pavement Subgrade layers (and/or "Prepared Subgrade" of Railroad Projects)

The same shall apply as under above sub-para (I), but with a greater frequency of tests.

For each quantity of not more than 1000cu.m. of excavated material :

a	Natural moisture	1 test
b	Liquid and plasticity limits	1 test
c	Grade analysis with sieves	1 test
d	Proctor modified compaction tests (same as for embankments)	1 test
e	Minimum acceptable number of tests per borrow-pit (tests a to d as above)	Tests in 3 pits

21.2.9.2. Compaction Controls – Tests

a	Cut formation or fill foundation, every 150 m, or less in the case of an independent road branch section	1 test
b	Earth or rock fills, pavement subgrade layers (or "prepared subgrade" in the case of railroad works) for each consecutive 500cu.m. of compacted volume	1 test
c	Mechanically stabilized sub-bases and bases, drainage courses (or "subgrade", "foundation layer and any "filtering layer for railroad works), for each course, every 150 m of a road branch or of a railroad	1 test
d	Backfilling of duct placement trenches, for the area above the duct zone, every 100 m along the trench and for each distinct zone of back-fill material, or for each consecutive quantity of not more than 100cu.m. of compacted volume	1 test
e	Asphaltic courses, every 150 m of road branch	1 test
f	Granular material of "duct zone", for every consecutive quantity of 100cu.m. of compacted volume	1 test
g	"Transitional fills", for each structure or for every consecutive quantity of not more than 150 cu.m. of compacted volume	1 test

21.2.9.3. Aggregate Grade Analysis Tests

a	Concrete aggregates, road pavement (mechanically stabilized), transitional fills, "subgrade" and "foundation layer* of railroad works and asphaltic concrete work, every 300 cu.m. of compacted volume (see also sub-clause 6.6.2.2.2.c hereof),	1 test
b	Aggregates for drains, drainage courses, "filtering layer" of railroad works, shotcrete or other special construction works (class B25 and above), fine concrete, every 150 cu.m.	1 test
c	Hard aggregates for skid-resistant course (slurry seal of clause 39 and pre-coated chippings of clause 40 hereof), every of 50 cu.m.	1 test
d	Hard aggregates for skid-resistant course of clause 43 hereof, every 100 cu.m.	1 test

21.2.9.4. Plasticity and Sand Equivalent Tests

a	Concrete aggregates, for each quantity of 300cu.m. of completed construction work, transitional fills	1 test
b	Aggregates for road pavements (mechanically stabilized), for "subgrade" and "foundation layer" of railroad works and for asphaltic courses, every 500 cu.m. of compacted volume	1 test
c	Aggregates for drainage courses, "filtering layer" of railroad works, shotcrete, every 150 cu.m.	1 test

21.2.9.5. Rock Soundness and Resistance to Abrasion and Impact (Los Angeles)

For all aggregates of a single source	5 tests

21.2.9.6. Asphalt Content Test and Grade Analysis of Asphaltic Mix

For every 3-hr production	1 test

21.2.9.7. Control of Characteristics of Asphaltic Concrete according to Marshall

For every daily production	1 test

21.2.9.8. Testing Sand Equivalent of Aggregates for Asphaltic Mixes during Production of the Latter

For every daily production	1 test

21.2.9.9. Factory Produced Concrete

In the case of using factory-produced concrete, the supplier shall hand over to the Contractor for each concrete quantity delivered a consignment card on which all features mentioned under sub-clause 6.16.3 hereof shall *be* entered.

For each consignment to the works site	1 consignment card

21.2.9.10. Conventional Concrete Specimens (for testing compliance to requirements of sub-clause 6.13 hereof) (Specimens E)

Such specimens shall be taken only with regard to concrete categories of a characteristic strength fck >= 10 MPa (100kgisq.cm.) (categories 1310 and above) as follows :

a. Factory-produced concrete :

Sampling shall be conducted in accordance with sub-clause 6.13.3 hereof. (The Contractor shall prepare and submit to the Service schedules showing distinction of PORTIONS of the works that shall be tested separately with regard to the related compliance criteria of sub-clauses 6.13.3.10 and 6.13,3.11 hereof).

b. Site-produced concrete for minor works :

Sampling shall *be* conducted in accordance with sub-clause 6.13.4 hereof. (The Contractor shall prepare and submit to the Service a schedule showing distinction of PORTIONS of the works that shall be tested separately with regard to the related compliance criteria of sub-clause 6.13.4.4 hereof).

c. Site-produced concrete for major works :

Sampling shall be conducted in accordance with sub-clause 6.13.5 hereof. (The Contractor shall prepare and submit to the Service a schedule showing distinction of PORTIONS of the works that shall be tested separately with regard to the related compliance criteria of sub-clause 6.13.5.6 hereof).

Note:

For each group of conventional specimens representing a PORTION of concrete, an extra specimen shall be taken as per sub-clauses 6.13.2.5 and 6.13.2.6 hereof,

21.2.9.11. *Specimens for Testing 7-Day Strength (Specimens EA)*

The greatest of the frequencies provided for in clause 6 of the T.C.C. (which is based on the Albanian Regulation for Concrete Technology) and the German Regulation (DIN), shall be implemented.

21.2.9.12. *Specimens for Testing the Progress of Hardening (Specimens ΠΣ)*

The same requirements mentioned in previous para. 21.2.9.11 shall apply.

21.2.9.13. *Specimens for Testing the Efficiency of the Curing Method (Specimens AΣ)*

The same requirements mentioned in previous para. 21.2.9.11 shall apply.

21.2.9.14. *Acceptance of Precast Cement Pipes*

The relevant specification of clause 15 of the present T.C.C. shall apply with regard to the acceptance of precast cement pipes.

21.2.9.15. *Quality Control of Galvanizing Applied to Metal Items*

Clause 31 hereof shall apply with regard to the quality control of galvanizing.

21.2.9.16. *Quality Control of Cement Treated Crushed Stone (C.T.C.S)*

The provisions of sub-clause 26.8 hereof shall apply. Furthermore, sub-clause 26.9 shall apply with regard to test specimens. The anticipated construction of a TRIAL SECTION in accordance with sub-clause 26.5 hereof is pinpointed.

21.2.9.17. *Quality Control of Cement Stabilized Soil (C.S.S.)*

The stipulations of sub-clause 27.15 hereof shall apply. The provision regarding construction of a TRIAL SECTION in accordance with sub-clause 27.12 hereof is hereby pinpointed.

21.2.9.18. *Quality Control of Rolled Concrete*

The stipulations of sub-clause 28.10 hereof shall apply, supplemented by the respective sub-clauses of clause 26. The provision regarding construction of a TRIAL SECTION in accordance with sub-clause 28.6 hereof is hereby pinpointed.

21.2.9.19. *Quality Control of Shotcrete*

Further to the control of aggregates as referred to under sub-clauses 21.2.9.3 and 21.2.9.4 hereabove, the quality control of preparation shall also apply as described under sub-clause 42.6 of the present T.C.C.

21.2.9.20. *Quality Control of Soil Improvement with Cement and Hydrated Lime*

The stipulations of clause 41 hereof shall apply. The provision regarding construction of a TRIAL SECTION in accordance with clause 41 hereof is hereby pinpointed.

21.2.9.21. *Quality Control of Skid-resistant Aggregates*

a	Aggregate Abrasion Value (A.A.V.) (BS 812 : PART 3 : 1975) For all aggregates from the same source	5 tests
b	Polish Surface Value (P.S.V.) (BS 812 : PART 3 : 1975) For all aggregates from the same source	1 test
c	Flakiness index (85 812 : PART 105.1 : 1985)	1 test

21.2.9.22. *Supplementary Quality Control for Asphaltic Courses*

The supplementary quality control shall be executed, together with any TRIAL. SECTION provided for under subchapter 1.14 of the D.I.S.

21.2.10. Penalties for Ensuring the Performance of Quality Control

21.2.10.1. If, during interim quantity surveying and by comparison of the quantities of executed works to the corresponding number of tests executed, it would result that the above number of tests is inferior to that specified under sub-clause 21.2.5 hereof, the Service shall be entitled to consider as non-completed the works (according to his own judgment) for which tests are insufficient, until the required number of tests is completed at the Contractor's expense and responsibility with regard to any delays, restoration works, etc. that may ensue.

Irrespectively of the above, the Contractor shall be charged a penalty amounting to 250 ECU for each missing test.

21.2.10.2. A copy of the table provided for under sub-clause 21.2.6.1.(7), shall necessarily accompany the required supporting documents of each payment. Omission of such table shall be interpreted as lack of substantial quantity surveying evidence.

21.3. CONTROLS TYPE "C`

21.3.1. Extent of the Service's Right and Obligations of the Contractor

The Service shall have the right to order an unlimited number of tests of any kind, on any type of material or section of the construction works (see also sub-clause 21.5.6 hereof). With respect to this right of the Service, the Contractor shall bear the following obligations :

a. To make arrangements for and bear the costs of the execution of the controls ordered by the Service, within the limits of control frequencies as described under sub-clause 21.2.5 hereof.

b. To assist the Service, if requested, in the execution of any additional controls, by making his specialized personnel and equipment available to him. The Contractor shall be entitled to remuneration for such services that shall be viewed upon as works paid for on the basis of unit prices for quantities executed.

c. To facilitate the execution of controls by the Service or by other parties possibly engaged by the Service to this effect, in accordance with the relevant provisions of the tender documents.

d. To restore any sample holes opened in the works, or any other disturbances caused by sampling or by in-situ testing. The Contractor shall be entitled to payment of compensation for such restoration works, provided that the corresponding controls be in excess of the frequency specified under sub-clause 21.2.5 hereabove.

e. To attend sampling and testing operations when advised beforehand thereto, according to the procedure of sub-clause 21.2.2.

21.3.2. Notification of the Contractor regarding the Execution of Controls and Communication of Results

It is not necessary to notify the Contractor with respect to all controls conducted at the expense and care of the Service. With specific reference to controls for which the Contractor's assistance is sought, the Contractor shall be notified in accordance with the provisions of sub-clause 21.2.2.

The Service is obliged to communicate to the Contractor the test results for the materials and/or structures independently whether these fall within the limits of the specifications - structures or should any deviations are observed.

In each case, communication of results shall be fulfilled the earliest possible.

21.4. THE CONTRACTOR'S RIGHT FOR REPETITION OF TESTS

21.4.1. For the case of controls/tests of sub clause 21.3 (CONTROLS TYPE "C") the Contractor is entitled to request that a second sample (counter-sample) be taken along with its identical principal one, to be packed and forwarded to the Service's laboratory at the same time with the latter sample. In the case of controversy and of any objection raised by the Contractor (to be immediately recorded in the project Record), a new laboratory test shall be conducted onto the counter-sample in the presence of the Contractor's representative, the result of which shall be binding to the Contractor (even if the test is not attended by him). In case of dispute, the Contractor shall be allowed to carry on with the construction works in the interim period prior to finalization of the tests, at his own risk and having assumed explicit obligation to remove any defective work that might be ascertained.

21.4.2. In addition, the Contractor shall have the right to request repetition of tests that may have led to unfavorable results and that were conducted by the Service without notification to the Contractor. The tests shall be repeated in the presence of the Contractor following his due notification according to the provisions of sub-clause 21.2.2. The costs of such test repetition shall be borne by the Contractor.

21.5. CONTROLS TYPE “B” (Geometrical Tests)

21.5.1. General Terms

With regard to geometrical controls which include control of the shape and dimensions aiming at ensuring observance of shape, dimensions and of other geometrical requirements as specified in the design and in the other tender documents, the stipulations of sub-clause 21.2 hereabove shall apply, unless explicitly specified otherwise in the present sub-clause and in sub-clauses 21.5.2 to 21.5.6 that follow.

The Record of CONTROLS TYPE "D" (RC-D) referred to herebelow shall be maintained similarly to the Record of CONTROLS TYPE "8" (RC-B) dealt with under sub-clause 21.2.6 hereabove. The former shall constitute indispensable supporting document to be attached to the protocol of provisional acceptance of the works.

All CONTROLS TYPE "D" shall be conducted by care of the Contractor who shall be bound to execute same irrespectively of the presence of the Service's representative. The Supervisory staff shall have the right to conduct spot checks with the assistance of the Contractor's staff and equipment. The costs for the occupation of such staff and equipment together with that of any minor materials required shall be borne solely and exclusively by the Contractor.

in the case of deviations exceeding tolerances as established by the specifications, the Supervision shall order interruption of the works until suitable materials are produced on the site, or until correction of the construction works. The provisions of sub-clause 21.6 shall apply in case of delayed ascertainment of deviations in embedded materials or constructed work.

21.5.2. CONTROLS TYPE "D" for Materials I Precast Sections

21.5.2.1. The control of material and precast section dimensions is distinguished into:

a. Control of the quality and of the physical and mechanical properties of the materials, beyond those specified in the remaining chapters of the present clause, the remaining clauses of the present T.C.C. and/or the regulation / specifications to which reference is being made in these clause, the clause of the D.I.S. and the other tender documents.

b. Control of the correct dimensions and their compliance to the approved design (including any approved design revisions)

21.5.2.2. For the controls of this category and for the material and/or precast sections :

(1) ribbed reinforcing steel bars (which includes control of geometrical characteristics of the ribs);

(2) circular pipes of all kinds and of any material (controls for verification of sectional circle, of specified relation between wall thickness and diameter, of specified joint configuration, of specified internal-external insulation, etc.);

(3) Metal elements (controls for ascertaining shape, dimensions, anticorrosive protection etc., as provided for in the design or the specifications).

(4) All kinds of wire and tendons (as indicatively and not exhaustively : prestressing cables, suspension, bonding of pile heads), as well as accompanying material (pipes, protective casings, anchorage elements etc.).

(5) All kinds of metal material, standard profiles, metal sheets etc. to be used for the metal parts of the construction (including controls to confirm evenness, faultless surfacing/edges plus sections as required, for the metal sheets to be welded, anticorrosive protection intended by the design etc.).

(6) All kinds and sorts of metal connectors (including the control of anticorrosive protection as prescribed in the specifications etc., besides the controls and checks of dimensions etc.).

(7) All kinds and sorts of wires/cables for the erection of electric lines and transmission lines of low, average, medium, high voltage including all related works.

(8) Piles of any nature/kind

(9) All kinds and sorts of wire ropes

(10) Every kind or sort of material for traffic signs/signalization, luminous or not

(11) Protective railings of all nature, safety parapets and guard rails, etc.

(12) Precast elements and sections of all kinds for the construction of the project (concrete, steel, etc.).

(13) Material of every other nature to be incorporated in the project. the following shall need to be done at the Contractor's care and expense :

a. application of the procedure for the Service's notification provided under sub-clause 21.2.2;

b. to process the control results and to compile control protocols providing the following information, without limitation to same :

- nature and source of materials, site of their provisional storage,
- date of control test,

- the names of testers representing the Service and those representing the Contractor
- size of portion tested,
- number of samples tested,
- test results per item and sample tested, in form of schedule,
- average value and standard deviation;

c. keeping of particular Record for CONTROLS TYPE “D”-Materials (RC-D/Materials) from the abovementioned protocols, by analogy to the provisions of sub-clause 21.2.6.

21.5.3. <u>Special Requirements for Precast Elements Control</u>

21.5.3.1. Precast elements should be controlled as against :

a. their accuracy of fit with each other

b. their correct geometry, i.e., avoidance of any distortion or twisting due to either their manufacturing or to transport mishaps.

c. their clear and correct numbering to avoid errors, and orientation markings with regard to the construction, the location and position they are intended for

d. the dimensions of their particular elements and their conformity to the engineering design, the specifications and other tender documents

e. correctness and accuracy of their connection holes, or holes for future cablings, etc.

f. correct lifting devices necessary for their transfer to their final placement, in compliance with the construction drawings or/and the technical requirements of the Supervisor.

g. any other data (such as, due absence of all ill-treatment, damage, etc.).

21.5.3.2. The Contractor is under the obligation to carry out at his care and expense the above-listed controls. He is also obliged to cooperate with the Supervisor's staff for the execution of such controls, being always free of any charge to the owner of the project.

With controls of sub para (a) and (b) of the previous paragraph in particular, the Contractor is obliged to suggest in time the most appropriate ways of performing the controls. As an indication only, not exhausting the list of proper ways, such ways are :

a. juxtaposition of adjacent sections (in the Site) or

b. construction of standard profile corresponding to the contact surfaces of suitable material, so as to avoid dimension inconsistencies and subsequent alterations.

In case (b) the cross-section shall bear all holes and the control shall be made by juxtaposition and comparison to the corresponding contact surfaces.

21.5.3.3. All above-mentioned controls are ruled by the corresponding provisions of Clause 21.5.2 with regard to procedures, records and control files kept.

21.5.4. CONTROLS TYPE "D" for Structures

21.5.4.1. Earthworks. Road Paving. Asphaltic Works

A levelling operation shall be conducted for each course of fill or embankment work, pavement subgrade or pavement drainage course, paving and asphaltic works, in order to verify the response of the constructed surface to design and specification requirements.

The same applies to "prepared subgrade", "subballast", "foundation" and “filtering layers” when railroad construction works are concerned. The relevant clauses 47 and 49 hereof shall also apply.

Paving construction works comprise the construction of pavements using Cement Treated Crushed Stone (C.T.C.S.), Cement Stabilized Soil (C.S.S.) and rolled

concrete, all dealt with under clauses 26, 27 and 28 hereof respectively.

The results of the levelling operation shall be filed with a separate Record for CONTROLS TYPE “D”- Eartwks. Pavmt. Asphlt. (RC-DIE.P.A.), subject to the provisions of sub-clause 21.2.6. Such results shall be used as quantity survey information and generally for measurement of inconspicuous works. Similarly, they shall apply to excavations, only with regard to final excavation surfaces.

The “straightedge control” shall be done for the regularity of the asphaltic layers (parallel and perpendicular to the road centerline according to the applicable specifications) as well as the calculation of the Irregularity index' of waving along the road centerline by a suitable "smoothness meter" (e.g. BUMP-INTEGRATOR type).

21.5.4.2. Concrete Structures

Complete geometrical control shall be conducted by dimension verifications and by levelling operations at the following stages of the construction works :

- excavation of foundations;
- erection of formworks, prior to reinforcement placement;
- completion of construction, after formworks removal.

The results of such controls shall be filed with a separate Record for CONTROLS TYPE "D"-Concrete (RC-D/Concrete) that shall be subject to the provisions of sub-clause 21.2.6. They may also be used as quantity survey data.

21.5.4.3. Inconspicuous Construction Works

With regard to inconspicuous construction works, such as sewer pipes, cable ducts etc., compliance to geometrical characteristics specified by the design and the Service's instructions shall be verified, in addition to other specified controls as well as for their location in relation to the one planned for in the design. The Contactor is oblidged to safisty the Service requirements.

The results of such controls shall be filed with a separate Record for CONTROLS TYPE "D"-Inconspicuous Lengthwise Structures (RC-D/Incsp. Leng, Str.) that shall be subject to the provisions of sub-clause 21.2.6.

21.5.4.4. *Visible Construction works of completed project sections*

(1) The visible construction works of completed project sections shall be thoroughly checked as far as their planned location, geometrical shape, and generally the form / elevation and geometry (based on the approved design and its eventual modification, the dimensions and the terms of tender).

(2) The following shall be used as criteria for control and acceptance :

a. For distances between kerbs, along stretches of non-parallel kerbs : +-0.02 m

b. For the constant distance between parallel kerbs : +-0.01 m

c. For kerb edge lines, handrail tubes, corrugated sheet metal of safety guardrails [types ,M.B, S.G (except S.G-1), according to clause 33 hereof], and for rigid guardrails type S.G.-1 :

maximum offset deviation from the mean line of the construction (both in horizontal and vertical sense) +-0.01 m

(3) The results of such controls shall be filed with a separate Record for CONTROLS TYPE "D"- Visible Lengthwise Structures (RC-D/Vis.Leng.Str.), that shall be subject to the provisions of sub-clause 21.2.6 hereof.

21.5.4.5. *Inconspicuous construction works to support / hand future ducts_ or other project subsidiary works*

The requirements mentioned for visible construction works shall apply for all these construction works (see para. 21.5.4.4 hereof).

21.5.5. Frequency of CONTROLS TYPE “D”

21.5.5.1. The minimum frequency of geometrical controls shall be the greatest between the ones mentioned below and those mentioned in the T.C.C. and the regulations referenced in the T.C.C., according to para. 21.2.5 above.

21.5.5.2. Regarding testing of materials as per sub-clause 21.5.2.1, the tests shall concern not less than 2% of the pieces contained in a single portion of the material, and in any way not less than ten (10) samples.

21.5.5.3. In connection with the controls described under sub-clause 21.5.4.1 hereabove, the density of level check-points shall be not less than the following :

(1) For Roadworks

a. At each cross-section, maximum distances between check-points :

for the lower courses of fill	15 m
for the upper courses of fill and for pavement course	10 m
for asphaltic courses	5 m

b. Maximum distances between cross-sections:

for earthworks and road pavement	20 m
for asphaltic courses	10 m

c. As a supplement with regard to rock fills, sub-clause 2.4.2.4 of the present T.C.C. shall also apply.

d. With specific reference to road pavement works using Cement Treated Crushed Stone (C.T.C.S.), Cement Stabilized Soil (C.S.S.) and rolled concrete, the density of controls and the tolerances of the completed surface are further established by the respective clauses 26 (26.6 and 26.8.8), 27 (27.13, 25.15.4 and 27.15.7) and 28, combined with clause 27, (28.8, 28.10 and further 27.15.4 and 27.15.7) of the present T.C.C.

(2) For Railroad Works

All abovementioned references shall apply and, furthermore, clauses 47 and 49 hereof, but with a higher priority degree than with regard to roadworks.

21.5.5.4. Construction works shall be subject to the controls of sub-clauses 21.5.4.2 and 21.5.4.4 in their overall extent. With reference to particularly lengthy construction works, controls shall be in the form of spot-checks to not less than 30% of the overall length of the construction works.

21.5.5.5. The controls of sub-clause 21.5.4.3 shall be in the form of spot-checks to not less than 20% of the overall construction length.

21.5.6. Geometrical Controls Conducted by the Service. at his Expense

The stipulations of sub-clause 21.3 hereof shall apply similarly also to the geometrical controls.

21.5.7. Penalties Aiming at Ensuring the Performance of CONTROLS TYPE “D” (Geometrical)

The provisions of sub-clause 21 .2.10 shall generally apply, with the exception of penalties imposed for omission to conduct certain controls, in which cases the following shall apply :

(1) For omission of the test described under sub-clause 21.5.2, and provided that the test cannot be subsequently conducted since the materials are already embedded, the value of such embedded materials shall be reduced by 2%.

(2) For omission of the tests described under sub-clause 21.5.4.1, an irrevocable penalty of 1 ECU per check point (levelling) shall be imposed.

(3) For omission to verify the geometrical features of formworks, an irrevocable penalty equal to 1% of the value of concrete shall be imposed.

(4) For omission of the tests described under sub-clause 21.5.4.3, an irrevocable penalty shall be imposed equal to 1% of the certified value of works for which the respective tests were omitted.

(5) For neglegence in performing the controls referenced in para. 21.5.4.4 the stipulations of para. 21.1.1.(4) above shall be applied.

21.5.8. Notification and Attendance of the Service's Representatives

In accordance with the provisions of sub-clause 21.2.2, the Contractor shall be responsible for notifying the Service with regard to all tests to be conducted as per sub-clause 21.5.2.

21.6. RELATIONSHIP BETWEEN QUALITY CONTROL AND CONTRACTOR'S LIABILITY REGARDING QUALITY AND PERFECTION OF THE PROJECT MATERIALS AND OF CONSTRUCTION WORKS

21.6.1. The quality control of all categories conducted in connection with the project shall not release the Contractor of his responsibility, since he is solely and fully responsible for the quality and completeness of materials and of construction works, as well as for the safety of the construction works, for which he is also solely and fully responsible.

21.6.2. In the case of quality control results that fail to satisfy specification requirements, action shall be brought forward for the rejection of defective works in accordance with the provisions in force and the terms of the Tender Documents.

21.6.3. For each case referred to under sub-clauses 21.4 and 21.6.2, the Contractor shall be bound to keep a record of tests similar to that provided under sub-clause 21.2.6. Such record shall constitute an indispensable supporting document that shall be attached to the Protocol of Provisional Acceptance of the Works.

Clause 22 : PROJECT RECORDS - INSPECTION AND MAINTENANCE MANUAL - OPERATION MANUAL

22.1. PROJECT RECORDS

22.1.1. Regardless of the tendering system; the Contractor is obliged to keep records of the Project at his own cost and responsibility, which he will submit to the Service. In its final form this record should include the following :

(1) An inventory table including a summary of the individual works, installations, equipment etc. that constitute the whole project.

(2) A complete set of drawings of the project with the dimensions that were actually applied, which should include but not be restricted to : Horizontal plan, longitudinal profile, typical sections of the road/railroad works (with analysis of the structural configuration of the individual sections of the pavements or the types of superstructure-infrastructure of the railway works), sections and details of the whole of the works as well as of the individual parts of the works in appropriate scales that will illustrate the position, the form, any special characteristics and the conditions of their functionality.

These drawings shall be provided for every type of road, railroad and their related works (i.e. main traffic works, bridges, culverts, retaining walls, tunnels, noise pollution protection works, subsurface drainage works, drainage works (stormwater and wastewater), water supply/irrigation works, electromechanical installation works (street lighting, irrigation, any pumping stations etc.), cable ducts, P.U.O. works, and other individual works that are included in the whole project).

(3) Document including information regarding bench marks along with indicative drawings of their location.

(4) Document with summaries of all field or laboratory investigations (geotechnical investigations, geological investigations and studies).

(5) Document with all Quality Control tests and procedures including copies of the relevant certificates of the Chartered Quality Control Firm(s) [if there is provision for such Q.C.F. in the special conditions of the Tender].

(6) A descriptive report of the main stages of the work, the methods applied, the difficulties encountered, etc.

22.1.2. The project records shall be compiled in Albanian or in English, properly numbered and classified in folders, and shall be submitted to the Service in seven (7) copies. All text shall be typed and bound in volumes. In projects tendered by a "CONCESSION AGREEMENT' the project record with its complete data shall be also prepared and submitted in the English language in the same number of copies.

22.2. INSPECTION AND MAINTENANCE MANUAL

22.2.1. PROJECTS TENDERED BY A 'CONCESSION AGREEMENT'

22.2.1.1. The Contractor is obliged at his own care and expense to deliver to the Service a complete and detailed Maintenance Manual for the Project (of all types of construction works, including fixed and mobile equipment etc.). The degree of completeness and detail shall be to the satisfaction of the Supervision.

The Manual shall include all instructions and execution methods for the satisfactory and efficient maintenance of the project, which should include but not be restricted to :

(1) Maintenance instructions regarding time periods, material, equipment, etc. for each element of the construction.

(2) Instructions manual for the necessary inspections and controls that have to be carried out periodically in the future.

(3) Instructions manual for the maintenance and operation of the various sections of bridges, tunnels, toll stations and of all fixed and mobile equipment.

(4) Instructions manual for the inspection and maintenance that should be carried out in the stormwater and subsurface drainage works that are constructed by the Contractor, in the context of his obligations resulting from the Contract.

(5) Detailed Technical Reports and instructions regarding the methods for restoring and repairing future wear and damage.

22.2.1.2. Specifically for the instructions manual of maintenance and operation of the installations, it is noted that at the end of each chapter of instructions a complete table shall be given, including all machinery contained therein with their characteristics and manufacture information (name of manufacturer/supplier, type, model, size, serial number, capacity, proposed spare parts, etc.). The printed installation and maintenance instructions of the manufacturer shall also be attached.

22.2.1.3. During the concession period the Contractor shall have to update the maintenance manual, taking into consideration the development of technology and particularly international practices.

The Service reserves the right to indicate such updates.

22.2.1.4. The Contractor shall always apply the latest up-to-date methods and measures for the maintenance of the Project, that are meant to increase the safety of the Project and of its users, even though they may not be included in the Maintenance Manual.

22.2.1.5. The Maintenance Manual updated according to the above and enriched based on the Contractor's experience which resulted from the Project operation during the Concession Period, shall be delivered to the P.O. by the Contractor during the project delivery after the expiration of the Concession Period.

Further, during the project delivery the Contractor shall deliver to the P.O. the following:

(1) A volume including statistical data for the maintenance works (quantities of materials by category, personnel by discipline and involvement time,

machinery by category and occupation time etc.) analyzed for at least the last 10 years.

The statistical data volume shall also include economic data for the maintenance works (expenses *per* category of material, personnel, machinery, spare-parts, consumables, etc.) with a time analysis for the period that the statistical data are provided.

(2) A proposal for organizing the maintenance for the period that the P.O. will undertake the operation - maintenance of the works after the project delivery to him by the Contractor.

(3) A proposal for immediate maintenance action and a proposal for the supply of the required material - machinery for the maintenance to cover the need of the first year that the Project operation - maintenance will be undertaken by the P.O.

The above data shall be prepared in way facilitating the P.O. to further organize the maintenance of the Project, either by the Public being undertaking the operation - maintenance, or alternatively, by awarding a new "Concession Agreement".

22.2.2. PROJECTS TENDERED BY THE "UNIT PRICE' OR BY THE "DESIGN - BUILD" SYSTEM

22.2.2.1. The Contractor is obliged at his own care and expense to prepare and submit to the Service a detailed and complete manual for the works maintenance, according to the requirements of paras 22.2.1.1 and 22.2.1.2.

22.2.2.2. The project maintenance manual shall correspond to the manual of Phase B according to the requirements of para. 22.2.1.3 above. The project maintenance manual incorporating all the comments and the instructions of the Service, whatever Consultants (Quality Control Firm(s), project design and/or construction Consultants), and the Insurance Companies, shall be submitted by the Contractor before the issue of the certificate for completing the works of the Design Construction period.

22.2.2.3. The terms of paras. 22.1.4 and 22.1.5 apply also for the case of the Maintenance Manual.

22.3. OPERATION MANUAL

22.3.1. For the projects tendered by a *"CONCESSION AGREEMENT"* the Contractor shall hand over a complete and detailed Operation Manual of the Project. The degree of completeness and detail shall be to the satisfaction of the Supervision.

22.3.2. This manual shall comprise two parts :

i. Regulation for the Project operation.

ii. Operation instructions regarding the staff that will operate and exploit the Project.

22.3.3. Part I shall refer to the relations between the users of the Project and shall include all information regarding its use by the users, i.e. rights, restrictions, etc. It will also include all instructions and specifications on actions to be taken in case of emergency (interruption of operation due to failure, accidents, incidences of partial interruption of operation due to maintenance works, failure of signalization or VMS systems, etc.)

It shall further include basic information pamphlets that will be distributed to the users, with suitable and adequate information to familiarize the users on how to use the Project and what to do in emergency cases.

Part I shall be properly structured into chapters.

22.3.4. Part II shall include all instructions for the use of the fixed and mobile equipment of the Project, as well as the necessary actions of the competent staff for every situation, i.e. under normal operation conditions and in emergency conditions.

The manual shall be structured in chapters by work groups.

Special chapters of the manual shall provide information regarding the police or other authorities that are involved in the operation of the Project. The contents of these chapters - before the submission of the Manual to the Service - must be adopted by the relevant Authorities.

22.3.5. During the concession period the Contractor shall update the operation manual, on the basis of any developments regarding :

- Legislation in general,
- Regulations - Instructions for traffic safety and operation of the installations /equipment of the Project, for each case,
- technology trends

adapting it also to :

- any new systems (installed in the Project for regulating / controlling traffic circulation, collection of toll fares etc.)
- the experience gained progressively during the operation of the Project.

The Service reserves the right to suggest such updates. The Contractor shall always apply the latest and up-to-date methods and measures for the operation of the Project, that are meant to increase the safety of the Project and of its users, even though they may not be included in the Operation Manual.

22.3.6. All the requirements mentioned in pare 22.2.1.5 concerning the Manual and other data regarding the maintenance, which the Contractor is obliged to deliver to the Project Owner after the expiration of the Concession period, apply similarly in the manual and other respective data concerning the operation of the Project.

Clause 24 : PERMANENT FENCING

24.1. GENERAL

24.1.1. The present clause concerns the construction of fences (high, medium, or combined with safety barrier) blocking entry to vehicles and pedestrians through to the motorway and to interchange ramps. Application fields for each type of fencing are determined in the Design and Investigations Standards (D.I.S.).

24.1.2. The work comprises the supply of all materials onto the job site, together with all works required for the full and proper completion of construction, as analytically described in the Price List.

24.2. HIGH FENCING 2.26 M. HIGH

24.2.1. The wire fabric of the fence shall be galvanized, N°17, 5 x 5 cm square mesh, with wire diameter of 3mm, weighing 2.36 kg/m2, 1.94m-high. On each side of the wire fabric there shall be a reinforcing galvanized wire No. 19, with wire diameter 3,6 mm. Fixing of this wire on the posts shall begin 2 cm above the ground surface (natural or as graded in the frame of roadworks, depending on the fence location).

24.2.2. Post spacing shall be 3,0 m at most. For fixing of posts holes shall be opened of 70 cm. total depth. The bottom 55 cm high section of holes, shall have a 25 cm diameter and their top 15 cm high section, shall have a 60 m. diameter.

24.2.3. Posts shall be made of reinforced concrete (centrifugal or vibratory) of minimum grade B35, 3,00 m. height, and shall be fixed on ground with 55 grade concrete. The concrete of posts shall be "water tight" and of "high frost resistance", as those defined in DIN 1045188 (para. 6.5.7.2 and 6.5.7.3 respectively). The shape of posts shall be truncated cone (or truncated pyramid) for circular section or of regular octagon 1 hexagon shape, drawn in a circle with diameter (base / apex) 13/10 cm. For the case of posts of rectangular cross section the posts shall be of truncated pyramid shape with square section, with side (apex / base) 13/10 cm, or prismatic with rectangular cross section with minimum dimension 12 cm. The main reinforcement of posts shall be constant throughout the posts length and shall be at least 6 4) 10 St I in case of circular, octagonal or hexagonal cross section, and 4 as 8 St III in case of rectangular (and square) cross section. As distribution reinforcement rings or rectangular stirrups (for the case of rectangular section posts) shall be used 4) 4 St I every 0,35 m. throughout the post length.

In addition to the above requirements in sizes, reinforcement and characteristics of concrete and reinforcement, as additional acceptance criterion of the posts. the 'failure moment' (Mj) in the upper clamped surface (2,30 m. from the top) should obey the relationship :

$$Msd >= 3{,}75 \text{ KN.m}$$

Testing of posts shall be done in a laboratory, according to the tender terms, for a number of posts N which shall correspond to a 0,5% percentage of their total number. The minimum number of tested posts of each individual sampling shall be Nmin = 2 pieces

The posts to be tested shall be taken at random from the posts brought to the project site.

Testing of Mj shall be done with gradual application of concentrated load (F) at 2,20 m. distance from the upper clamped surface (0,10 m. from the top) and the failure, in each tested post, shall occur for F >= 1,70 KN. If one of the tested posts fails for F < 1,70 KN the batch is rejected.

24.2.4. The fence upper brim shall be supplemented with three rows of double galvanized barbed wire N°13 (dia.2mm). The lowest row shall be spaced 10 cm from the wire fabric. Wire spacing shall be 10 cm. Wires shall be tied to the posts through 10 mm dia. holes.

24.2.5. In order to tie and reinforce the wire fabric fixing, three additional galvanized wires No 19, 3.6 mm in dia, shall be installed (two diagonal per segment plus one horizontal at mid-height of the wire fabric). These wires (as well as the edge wire fabric wires) shall be tied to the posts through galvanized wires No 17 (3 mm dia) which will run through 10 mm dia holes.

24.2.6. 3.0 m.-long post bracing struts shall be constructed at max 60 m intervals to reinforce the fencing.

24.2.7. Wire fabric and barbed wire galvanization (to be done HOT) shall have a minimum weight of 210 grlm2. It is pointed out that after delivering the wire fabric to the site a sampling will be made to check the galvanization according to clause 31 of the T.C.C. and the other terms of the tender. Following the acceptance of the wire fabric, which will be done by signing a protocol, installation of the wire fabric will be done.

24.3. MEDIUM HEIGHT FENCING

24.3.1. TYPE "A" (1.46m-high. with _wire fabric. 5x5cm square mesh)

(1) The wire fabric of the fence is galvanized, N°17, 5x5cm square mesh, with wire of diameter 3mm, weighing 2.36 kg/m2., 1.20m-high. On each side of the wire fabric there shall be a reinforcing galvanized wire No. 19, with wire diameter 3,6 mm. First fastening onto the post at 2cm above the ground surface (natural ground or as graded in the frame of roadworks, depending on the fence location).

(2) Posts shall be spaced at not more than 2.50 m. 40 cm-deep holes shall be opened in the ground for post embedding. The lower 30cm-long part of the hole shall have 20cm diameter, while its upper 10cm-long part shall have 40cm dia.

(3) Posts shall be made of reinforced concrete (centrifugal or vibratory) of minimum grade B35, 1,90 m. height, and shall be fixed on ground with B5 grade concrete. The concrete of posts shall be *"water tight"* and of *'high frost resistance"*, as those defined in DIN 1045/88 (para. 6.5.7.2 and 6.5.7.3 respectively). The shape of posts shall be truncated cone (or truncated pyramid) for circular section or of regular octagon / hexagon shape, drawn in a circle with diameter (base *I* apex) 12/9 cm.

For the case of posts of rectangular cross section the posts shall be of truncated pyramid shape with square section, with side (apex base) 12/9 cm, or prismatic with rectangular cross section with minimum dimension 9 cm. The main reinforcement of posts shall be constant throughout the posts length and shall be at least 6 CD 8 St I in case of circular, octagonal or hexagonal cross section, and 4 0 8 St Ill in case of rectangular (and square) cross section. As distribution reinforcement rings or rectangular stirrups (for the case of rectangular section posts) shall be used 0 4 St I every 0,35 m. throughout the post length.

In addition to the above requirements in sizes, reinforcement and characteristics of concrete and reinforcement, as additional acceptance criterion of the posts, the *'failure moments* (Msd) in the upper clamped surface (1,50 m. from the top) should obey the relationship :

Msd >= 2,40 KN.m

Testing of posts shall be done in a laboratory, according to the tender terms, for a number of posts N which shall correspond to a 0,5% percentage of their total number. The minimum number of tested posts of each individual sampling shall be Nmin = 2 pieces.

The posts to *be* tested shall be taken at random from the posts brought to the project site.

Testing of Msd shall be done with gradual application of concentrated load (F) at 1,40 m. distance from the upper clamped surface (0,10 m. from the top) and the failure, in each tested post, shall occur for F >= 1,70 KN. If one of the tested posts fails for F < 1,70 KN the batch is rejected.

(4) The fence upper brim shall be supplemented with three lines of double galvanized barbed wire N° 13 (dia. 2 mm). The lowest of the above three lines shall be 8 cm below the fabric upper edge, while the three lines shall be spaced at 8 cm from each other. The three wires are tied onto posts through 10 mm diameter holes.

(5) In order to tie and reinforce the wire fabric fixing, one additional wire No 19, 3.6 mm in dia. shall be installed at mid height of the wire fabric.

This wire (as well as the edge wire fabric wires) shall be tied to the posts through galvanized wires No 17 (3 mm in dia) which will run through 10 mm dia holes.

(6) 1.90m-long post bracing struts shall be constructed at 60m intervals to reinforce the fencing.

(7) Wire fabric and barbed wire galvanization (to be done HOT) shall have a minimum weight of 210 gr/m2. It is pointed out that after delivering the wire fabric to the site a sampling will be made to check the galvanization according to clause 31 of the T.C.C. and the other terms of the tender. Following the acceptance of the wire fabric, which will be done by signing a protocol, installation of the wire fabric will be done.

24.3.2. TYPE "B" (1.62m-high. special wire fabric of rectangular mesh),

Alternatively, MEDIUM HEIGHT fencing may be constructed (at the same unit price as that indicated for TYPE "A") under the following variation of TYPE "B" for the MEDIUM HEIGHT fencing :

(1) Wire Fabric

a. Special road fencing wire fabric shall be used of rectangular mesh type URSUS by BEKAERT, 1.60m-high, MEDIUM type 160/23/5 M with the following characteristics :

— 23 horizontal steel wires (the two extreme ones having diameter of 2.50mm, the other 21 being 2.00mm dia.) with high carbon content (0.45-0.50%) and tensile strength 1200/1400 N/sq.mm. [the 16 lowest spaces being 0.05m each, then 3 spaces of 0.10m each, then two spaces of 0.15m and finally at the upper end one space of 0.20m].

- Vertical wires of 1.90mm diameter, with low carbon content (<=0.10%) and with tensile strength of 400/500 N/sq.mm.

- In accordance with DIN 1548, galvanizing weight shall be not less than:

  - for horizontal wires of 2.00mm dia. >=210gr/m2.
  - for horizontal wires of 2.50mm dia. >=230gr/m2.
  - for vertical wires of 1.90mm dia. >=240gr/m2.

b. Sampling and testing of galvanization according to clause 31 of the T.C.C. and the other terms of the tender, shall be done after delivering the wire fabric to the site. Following the acceptance of the wire fabric, which will be done by signing a protocol, installation of the wire fabric will be done.

(2) Fence Height

The fence height shall be 1.62m.

(3) Spacing of Posts and their fixing

Post spacing shall be 2.50 m. max. Holes having a total depth of 45 cm shall be drilled to embed posts. The lower 35 cm high portion of the hole shall have 20 cm dia where their upper 10 cm portion shall have 40 cm dia.

(4) Posts

Posts shall be made of reinforced concrete (centrifugal or vibratory) of minimum grade B35, 2,10 m. height, and shall be fixed on ground with B5 grade concrete. The concrete of posts shall be "water tight" and of "high frost resistance", as those defined in DIN 1045/88 (para. 6.5.7.2 and 6.5.7.3 respectively). The shape of posts shall be truncated cone (or truncated pyramid) for circular section or of regular octagon / hexagon shape, drawn in a circle with diameter (base / apex) 12/9 cm.

For the case of posts of rectangular cross section the posts shall be of truncated pyramid shape with square section. with side (apex base) 12/9 cm, or prismatic with rectangular cross section with minimum dimension 9 cm. The main reinforcement of posts shall be constant throughout the posts length and shall be at least 7' 8 St I in case of circular, octagonal or hexagonal cross section. and 4 (1) 8 St lit in case of rectangular (and square) cross section. As distribution reinforcement rings or rectangular stirrups (for the case of rectangular section posts) shall be used 0 4 St I every 0,35 m. throughout the post length.

In addition to the above requirements in sizes, reinforcement and characteristics of concrete and reinforcement, as additional acceptance criterion of the posts, the *failure moment' (Msd) in the upper clamped surface (1,60 m. from the top) should obey the relationship :

Msd >= 2,40 KN.m

Testing of posts shall be done in a laboratory, according to the tender terms, for a number of posts N which shall correspond to a 0,5% percentage of their total number. The minimum number of tested posts of each individual sampling shall be Nmin = 2 pieces.

The posts to be tested shall be taken at random from the posts brought to the project site.

Testing of Msd shall be done with gradual application of concentrated load (F) at 1.40 m. distance from the upper clamped surface (0,20 m. from the top) and the failure, in each tested post, shall occur for F >= 1,70 KN. If one of the tested posts fails for F < 1,70 KN the batch is rejected.

(5) Wire Fabric Fastening - Fencing Reinforcement

Wire fabric fastening shall be done in at least three points on each post (at the edges and at midheight) through galvanized wires No 17 (3 mm dia) which will run through 10 mm dia holes intentionally provided in the posts.

2.10 m-long posts bracing strats shall be constructed at max 60 m. intervals to reinforce the fencing.

(6) Alternative wire fabric system

Alternative wire fabric systems shall be accepted for TYPE "B" fences provided that they may ensure characteristics that shall not fall short of the fabric described hereabove (minimum galvanizing weight, rupture strength of wires, maximum openings not exceeding those mentioned hereabove and suitable fabric knitting or welding so that the fabric may not be disorganized in case any wire is cut and pulled out).

In such a case, the minimum height of the fence and the post characteristics shall remain unchanged in relation to those described hereabove in sub para. (1) to (5).

24.4. COMBINATION OF FENCE AND SAFETY GUARDRAIL (S.F.G.-6)

This type of fencing is specified under sub-clause 33.2.6 of clause 33 of the present T.C.C.

24.5. LOW WALL WITH FENCING (M.D.-3 AND M.D.-3a)

24.5.1. This item concerns the complete construction of low wall made of class B 15concrete which separates two adjacent road projects (motorway or interchange ramps with service road) and a wire fabric fence fixed on the wall. The wall is 0.60 m wide and 0.80 m. high above the sidewalk of the upper road.

24.5.2. Wire fabric shall be made of galvanized wire No 7, 5 x 5 cm square mesh, 3 mm wire diameter, 2.36 kg/m2 weight, 1.00 m. high.

Three horizontal galvanized wires shall be installed per segment (top, bottom and mid-height). These wires shall be No 19, 3.6 mm in diameter.

24.5.3. The wire fabric Is being fixed on steel posts of U-section, having dimension 120 x 55 x 5 mm, 1.05 m long (similar to the posts of common safety guardrails). The installation of the wire fabric fencing is being done towards the side of the service road.

24.5.4. Posts are being installed at approximately 2.00 m. intervals and the post centerlines lie at a distance of 0.125 m. from the service road side face of the low wall. (The post face lies at a distance of 0.065 from the low wall face). There is a 140 x 140 mm, 5 mm thick, steel plate welded at the bottom of each post. This plate has 4 corner holes of suitable diameter, constructed at 25 mm from edge to centerline (in both directions) in order to fix the post on the concrete through anchor bolts.

24.5.5. Fixing of posts shall be made through four anchors at the four plate corners with hot dip galvanized anchors (galvanization thickness >= 45 pm).

Anchors shall be metallic plugs HSA type, or chemical plugs HILT/HIT C-100 type, or other of similar bearing capacity behavior to impact and time resistance, for which reliable proof shall be ensured through experimental data on the anchors to be used, which also will be supported by calculation methods developed by their manufacturing company and by suitable equipment for their installation (perforation, fixing, etc.).

24.5.6. Anchoring calculation (anchor diameter, anchoring depth, anchor spacing, anchor distance from adjacent concrete surface, etc.) shall be done for a static horizontal load of 1 KN/m excreted at the fence top.

24.5.7. Posts and steel plates shall be corrosion protected by HOT DIP GALVANIZING according to clause 31 of the T.C.C. and the other terms of the tender. Galvanization shall be done after welding of posts to the plates.

24.5.8. In the case of low wall and fencing on a road having high longitudinal slope (to such a degree that the fence wire fabric cannot follow the slope of the low wall top surface, if this follows the slope of the steep road), then a stepping arrangement for the low wall top surface (and the fencing) shall be made.

In such a case, of a stepping arrangement, the following restrictions apply :

a. Maximum “step” height cannot be more than 0.30 m.

b. Minimum low wall height at the “step” vicinity cannot be less than 0.70 m.

c. The common post height at the step vicinity (or of the post being founded on the lower surface, if two posts are installed) shall be equal to 1.05 + h (m).

24.5.9. In the areas where (future) noise control barriers are to be constructed, PVC CD 315 mm of series 51, sleeve pipes shall be embedded throughout the entire height of the low wall, spaced at 4.0 m., in order to receive the future piles (e.g. through the use of AUGER) on which the noise control barriers will be founded.

At the initial stage, where no noise control works are constructed, the PVC sleeve pipe shall be filled with sand and its top will be plugged by class B15 concrete, 0.10 m. thick.

24.5.10. In the case where no future noise control barriers are foreseen, then PVC sleeve pipes will not be installed, and in this case "the low wall with fencing (without provision for future noise control barriers)" shall be designated as M.D.-3.

24.5.11. On the contrary, the designation M.D.-3a is being referred to low wall with fence' (having provision for future noise control barriers).

24.5.12. Expansion joints shall be constructed according to what is mentioned in D.I.S. (pare 1.11.4 of subchapter 1.11). At the vicinity of the expansion joints double fence posts shall be constructed.

Clause 25 : POLLUTION-PROOF COATING

25.1. In accordance with the tender conditions, a pollution-proof coating is provided for application on certain exposed (visible) concrete surfaces.

25.2. Pollution-proof coated surfaces must not permit firm adherence of any matter(paper, plastic, etc.), while any kind of paint must be easily removable with pressure water or with water solution of an ordinary detergent purchased in the free market.

Such coating material must have a duration of not less than three years, must not affect the surface texture in a negative manner, be completely colorless and remain so with the passage of time, contain no toxic substance and cause no harm whatsoever to the concrete surface.

25.3. It is indicatively mentioned that a work of this type may include the following :

a. a first coating application of the substance M.T.M 77 and, subsequently,

b. Two coats of the substance M.T.M. PA 78.

However, the Service can assume no responsibility as to the efficiency of the above substances. Should these be applied, it must be pointed out that the application of an overall number of three coats, as hereabove described, is considered to be a minimum requirement for the provision of a pollution-proof coating.

25.4. It is hereby made clear that acceptance of the pollution-proof coating can only take place after the lapse of a period of thirty (30) months from the certified completion of the work, and only provided that such work conform to the conditions mentioned hereabove.

25.5. The following method is anticipated to be applied with the view of coping with this latter condition

c. Immediately upon the Contractor's installation on the works site, he shall execute samples with various pollution-proof materials and methods of application on concrete surfaces subject to local conditions identical to those of the work execution proper.

d. Tests shall be performed on such samples after a period of two (2) years (and while the project construction works are still carrying on), with the purpose of drawing conclusions as to the suitability of the sample work executed as above.

e. The work shall then be executed as per the sample proved to be most effective (in the opinion of the Service), without the Service assuming at this stage any responsibility.

f. The work shall be accepted by the Service at a later date, in compliance to the previous sub-clause

Clause 26 : CEMENT TREATED CRUSHED STONE (C.T.C.S)

26.1. DEFINITION

The term "cement treated crushed stone" implies a homogeneous mix of stone aggregates, cement, water and eventual admixtures used in road pavement construction after proper consolidation.

26.2. MATERIALS

26.2.1. Cement

Cement shall comply to the requirements of the Law for Concrete Works.

The use of cement type Ii or III is particularly recommended.

No cement of a strength category superior to 35 is to be used.

26.2.2. Aggregates

Aggregates shall be sand gravel resulting from the crushing of rock boulders or from the crushing of naturally occurring gravel quarried in river/torrent beds or mine extracted. Aggregates shall comply to the requirements of paragraphs 2, 3 and 4 of the Standard Technical Specification (STS) 0 155, modified as follows:

- The required grade analysis shall comply to the limits of grade E (maximum grain size 25.4mm) of Table 1 of the STS 0 155.
- Use of grade D material (maximum grain size 31.7mm) shall be permitted following approval by the Service, provided that it be proved through trial works that no segregation of the mixture is risked with the final aggregate/cement mix and by the use of the haulage and spreading equipment available.
- Wear due to friction and impact as determined on the basis of the standard method Los Angeles AASHTO : T-96 shalt not exceed 40%.
- Aggregates shall be of continuous grading. 95% of the grade analysis tests to be conducted in the course of the construction works must lie within zones centered on the curve used in the mix design, with the following breadth of the respective zones : +-6% for each fraction of those passing sieve N°4, +-4% for those passing sieve N°40, and +-2% for the fraction passing sieve N°200.
- Should the above requirement for grading uniformity not be adhered to, the aggregates shall be divided into suitable fractions (i.e. ballast, grit, sand) and shall subsequently be mixed anew in the hatching plant conforming to the required ratios.

— 75% by weight of the grains retained by sieve N°4 must bear not less than two crush resulting surfaces.

26.2.3. Water

Water used in mixing and curing shall comply to the requirements of the Standards concerning plain concrete.

26.2.4. Admixtures

Retarding admixtures may be used following the Service's approval and a relevant laboratory survey, with the purpose of extending the period allowed to the mix consolidation, particularly in hot weather.

It is emphasized that such consolidation period depends on ambient temperatures and is slashed by almost half for temperatures twice as high.

Mean ambient temperature between hours 11 : 00 and 15 : 00 shall be taken as representative temperature. The laboratory survey shall include the effect of the admixture for the period that the mix is still workable (namely, it can be satisfactorily spread, graded and compacted) under various ambient temperatures. The usual values of time extension vary between 6 and 10 hours, depending on the method of spreading and the spreading and consolidation plant used.

Admixtures must conform to the requirements of pare 4.5 of the "Regulation of Concrete Technology" and to the Special Specification EK 308.

26.3. MIX DESIGN

The mix composition, i.e. the ratios of cement and water, the required grading and, eventually, the amount of the admixture, shall be established through the mix design that shall also yield the density required from the mix at the completion of the consolidation period.

The mix design shall be submitted by the Contractor to the Service in time for approval.

The relationship density/moisture of the mix shall be calculated in accordance with the standard compaction test BS 1924:1975 Test 4, or with the test BS 1924:1975 Test 5 (by vibrating hammer).

The grade analysis of aggregates shall lie within bounds of the zone specified under sub-clause 26.2, while the aggregate/cement mixture shall have a value for C not less than 0.83, where :

$$C = Y_d \, [1 - L/Y_G + L/Y_L]$$

and Y_d = density of the dry mix
Y_G = density of aggregates
Y_L = density of cement
L = cement ratio in the aggregate/cement mix

The cement ratio shall be fixed in a manner ensuring that cube samples of 150mm side, prepared in accordance with the process of sub-clause 26.9, may satisfy not less than one of the following compressive strength requirements :

age of 7 days :	7 MPa
age of 90 days :	10.5 MPa

In no case shall it be allowed for the cement ratio to be inferior to 3.5% by weight of dry aggregates.

The strength requirement at the age of 90 days is applicable only for the case of using special cement of a high pozzolana/fly ash content. In such cases, the mix design must include a special research regarding the progress of strength and, more specifically, it must produce values of the ratio of 7-day over 90-day strengths resulting as average values from not less than 15 specimen tests at each age with the same aggregates and mix composition (grading, cement/water ratio) as those to be used in actual construction works. The value of this ratio of strengths shall be used in the 7-day control of construction works.

If required, the Service may modify the mix design in the course of construction following the necessary laboratory testing, with a view to improving the quality of the works.

26.4. WORK EXECUTION

26.4.1. Planning

To a large extent, success of the works implementation depends on their correct planning. Such planning would include definition of the following:

a. properties of the materials;
b. periods of renewal of supplies, related to the progress of construction;
c. mixing method, as well as methods of transportation, unloading, spreading and compaction;
d. material storage sites and location of the central mixing plant;
e. compatibility of mixing capacity with transportation, spreading and compaction capacities.

26.4.2. Preparation of the Storage Area and of Mix Preparation Areas

Storage and preparation areas shall be subject to the necessary treatment (mechanical consolidation, local ground processing with hydraulic binders). Vehicular traffic areas shall receive special attention (service roads of storage areas and around the central mixing plant and weigh-bridge).

Drainage shall be carefully studied in relation to :

— the overall site ground configuration,
— the location of the various storage areas and preparation zones, and must be ensured during utilization of stored materials.

26.4.3. Supply and Storage of Materials

26.4.3.1. *Aggregates*

Aggregates shall be stored and stockpiled in a manner avoiding all possible segregation or contamination.

These conditions are satisfied by means of horizontal layers enabling frontal withdrawal. Grading homogeneity of the various aggregate sizes is obtained in this way.

At the works commencement, stockpiled quantities must be adjusted to the quarry production capacity and to the rate of progress of the works.

Direct deliveries to the production facilities without prior storage shall be excluded.

In the case of minor projects, it shall be necessary for the whole required quantities to be stored in advance of the commencement of the works. In major projects, a satisfactory safety margin shall be required for the mix production needs.

In exceptional cases, shall it be accepted for a mixing plant to be directly supplied from the quarry crusher sieves, subject to quality control and to ensuring the appropriate grade analysis.

26.4.3.2. *Cement*

Cement in bulk shall be stored in silos whose number and capacity shall be determined by the anticipated daily consumption plus an extra margin depending on the regularity of supplies and on the capacity of the means of transportation.

26.4.3.3. *Admixtures*

Admixtures shall be stocked and stored in compliance to the instructions of the manufacturers.

26.4.3.4. *Water*

Water shall be stored in tanks. If the water is coming from a water supply network, it is recommended that it be stored in a water tank as an interim stage.

26.4.4. Mix Preparation

The mix shall be prepared at a central mixing plant of continuous or periodic operation ensuring separate !patching of aggregates, cement, water and eventually admixtures at the ratios and with the tolerances defined in sub-clauses 26.2.2 and 26.3 hereof.

The mixing shall be executed using means that shall ensure full homogeneity of the mixture of aggregates, cement and water. Water is usually added after complete mixing of cement with aggregates and in quantities ensuring that, during compaction, the mix moisture shall respond to that recommended by the mix design. To this effect, the variation of water content during execution of the works shall be taken into account

In periodic operation plants, no entry of new batches of materials shall be permitted into the mixing drum prior to its complete clearing from previous contents. Batches of solid ingredients shall be measured by weight, while those of liquid ones (water, admixtures) by weight or by volume.

Discharge of the drum into haulage vehicles shall last no more than 5 seconds and shall be performed from no greater a height than 2.00m.

Continuous operation plants shall be equipped with special arrangements for continuous control and registration by weight of the flow of solid ingredients and for the automatic regulation of mixing ratios according to flow indications.

In the case of periodic mix discharges from a continuous operation drum, discharged quantities shall correspond to the production of not less than thirty (30) seconds. Discharge operation shall last no more than 5 seconds and shall be performed from a height no greater than 2.00m. In the case of continuous evacuation onto a conveyor belt, the mix shall first be driven into a funnel-like storage skip of a capacity equal to no less than 10% of the plant hourly production. At the point of the mix discharge from the conveyor belt into the skip, a special arrangement shall be provided aiming at averting mix segregation and ensuring evacuation capacity of 10 tons in less than 15 seconds.

Irrespectively of the type of mixing plant, cement and water batching shall be subject to a tolerance not exceeding +-0.3% of the weight of dry aggregates.

Minimum overall production capacity of the mixing plant must be 60cu.m/hour. However, plants of greater production capacities are recommended. (Continuous operation plants are considered advantageous from this point of view).

26.4.5. Acceptance of Underlying Course

No spreading work shall be permitted to go ahead prior to the control of the underlying course with regard to density, surface evenness, elevations, gradients and crossfalls as provided by the design and the relevant specifications. kJ deviations shall be made good conforming to the respective specifications, so that they may comply with tolerance permissible limits.

26.4.6. Mix Transportation

The mix is usually hauled on tipper trucks. Absolutely strict measures shall be taken during haulage of the mix to reduce segregation, contamination with foreign matters and moisture variation to the least possible. In hot weather, or for hauling distances envisaged to result in losses of moisture, the mix shall be protected with tarpaulin or other suitable cover.

26.4.7. Unloading and Spreading of the Mix

Upon its acceptance and directly prior to spreading the cement treated crushed stone, the surface prepared to receive the latter course shall be sprayed with sufficient water and be maintained moist but devoid of pools.

Unloading and spreading shall comply to requirements imposed with a view to avoiding segregation and contamination of the mix material.

Spreading and compaction shall be executed in a single layer. Prior to compaction, the layer thickness must be such as to allow for the compacted course to achieve the required thickness, gradients, crossfalls and surface evenness. It shall have to be borne in mind that in no case shall it be permitted to supplement a lacking course by adding any thin layer after compaction.

Spreading and compaction operations shall be implemented over the whole width of the new carriageway, separately for each direction. Should the spreading plant not suffice to cover the whole width in one course as above, spreading shall be executed in strictly successive adjoining lanes, any delay from one lane to its adjoining one not permitted to exceed maximum 1 hour. This period shall be slashed down to 30 minutes in hot weather, when ambient temperatures exceed 30°C. The addition of a retarder admixture during the period specified by the special study (sub-clause 26.2.4 hereof) may result in easing out and extending such time limitations.

Should it be imposed by construction conditions (traffic regulation or construction of other necessary works etc.), it may be permitted to construct only part of the overall width of each carriageway direction, following the Service's approval. A longitudinal joint shall need to be provided in such cases, as per sub-clause 26.4.9 hereof.

The spreading plant scheduled for use in the works shall need to be approved by the Service prior to commencement and must be capable of spreading the material without permitting segregation of the mix, to a uniform thickness, in a manner ensuring that the final compacted course achieve the required thickness, evenness of surface, gradients and crossfalls.

With specific reference to base courses, spreader-finishers shall be used, slip-form-pavers, or autograders.

The feeding of such equipment must not be frequently interrupted and must be combined, whenever required, with a mechanical arrangement ensuring proper distribution of the mix in front of the spreading equipment, or with a feeding arrangement.

Ordinary graders may be used in sub-base construction. Their number shall depend on the required rate of spreading.

26.4.8. Compaction

Compaction shall be executed in single layers. Since the future performance of the layer largely depends on the quality of compaction achieved, same shall be performed with great diligence using suitable equipment with the purpose of obtaining the required degree of compaction within predetermined time brackets.

The density of the compacted layer must not be less than 97% of the maximum laboratory density obtained by the modified compaction method (BS 1924:1975 Test 4) specified through the mix design (sub-clause 26.3). Densities shall be tested in accordance with sub-clause 26.8.6 hereof.

If no retarder admixture is used, the compaction operation must be completed within 3 hours when ambient temperatures are below 25°C, while they shall need to be completed within 2 hours when temperatures are above 25°C. If retarder admixtures are added to the mix, the compaction period may be extended by such time as will be recommended by the respective mix design for the prevailing range of ambient temperatures.

26.4.8.1. Compaction Equipment

Compaction shall be carried out by vibrating rollers carrying a vibrating load exceeding 30kg per cm of the drum circumference, as well as by rubber-tyred rollers of 3 tons per wheel, with internal tyre pressure varying between 0.3 and 0.9 MPa.

The Contractor shall be entitled to propose other types of compacting equipment for approval. Their application shall be subject to the Service's approval, provided that it be proved in the trial operation (sub-clause 26.5) that the required degree of compaction can be achieved within the predetermined time brackets and that the course surface achieved satisfies evenness requirements.

In all cases and prior to the commencement of the works, the Contractor shall be bound to submit to the Service a full study based on equipment performances establishing the required number of plant as well as the required number of respective trips for achieving the necessary degree of compaction. Such design shall be verified and modified according to the results of check measurements performed along the trial section.

26.4.8.2. Compaction Process

Compaction operations shall commence without delay and immediately after spreading. They shall proceed from the lowest points of the layer in an upward direction. Consecutive roller trips shall need to be of slightly varying lengths.

Compaction is recommended to begin with one or two trips of a light roller equipment or of non-vibrating vibrator roller. Following completion of the compaction with vibrator and/or rubber-tyred rollers, the final formation of the pavement surface shall take place with one or two light roller trips for eliminating any tracks left by heavier equipment.

Particular attention shall be paid to achieving full compaction along zones adjoining to longitudinal and transversal working joints.

Edge compaction shall also need to be carried out very carefully. With a view to achieving satisfactory compaction results along the course edges, it is recommended that shoulder construction be assumed parallel to the spreading of cement treated crushed stone, and that compaction for both works proceed simultaneously in three consecutive stages. In the first stage, the non-vibrating roller travels by 1/3 of its width over the shoulder and by 2/3 over the treated mix. In the second stage, the non-vibrating roller travels exclusively over the treated mix compressing it sideways onto the shoulder. The third phase r' constitutes the normal compaction procedure.

In case of the shoulder construction preceding that of pavement layers, attention must be given to providing frequently spaced openings across shoulders permitting the discharge of rainwater, if any. Should it prove impossible for the shoulder construction to go alongside that of the treated pavement course as mentioned hereabove, and that no satisfactory compaction of the pavement edges can be secured by other methods and/or means, it is then recommended that the pavement course be constructed with a width increased by 25cm.

The course thickness cannot be supplemented after completion of compaction works. For the same reason, it shall not be permitted to repair any 'bumps" found on the pavement surface by having a grader cut such bumps away after completion of the compaction operations. This method would tend to cause a local disintegration of the compacted course while surplus material is transferred onto "lower lying" spots in thin layers failing to achieve a satisfactory adhesion onto the compacted course surface.

Surface repairs shall be performed prior to the completion of compaction. In particular, they shall be performed after precompaction with a light roller or a non-vibrating vibrator roller.

Upon completion of the compaction works, the pavement course surface shall look closely tied, bear no roller ruts, no loose grains or thin layer separation, nor any spots of clear mix segregation.

26.4.9. Working Joints

Joint construction methods shall need to be approved by the Service and shall make sure that joint end surfaces be made vertical.

Transversal joints shall be provided when the works progress is interrupted for a period exceeding two (2) hours in the case of ambient temperatures below 30°C, and for a period exceeding one (1) hour in ambient temperatures above 30°C. In the case of a retarder admixture, the above time brackets may be extended by the time envisaged in the special study (sub-clause 26.2.4). In addition, transversal joints shall be constructed at the point of stoppage of each day's work.

Longitudinal joints shall be provided in the case of the construction being carried out in fractions of the overall width, and only when works of adjoining strips differ by 1 hour or 30 minutes in ambient temperatures below or above 30°C respectively.

26.4.10. Curing of the Course

Upon completion of the compaction works, the pavement course shall be protected against loss of its water content through evaporation. This operation is of great importance, aiming at allowing the pavement to achieve the required strength and to form a resistant surface layer ensuring its connection onto adjacent pavements. Two cases are distinguished:

1. Sub-Base Course

If a base course of cement treated stone is scheduled for construction on this surface, curing of the latter shall aim at creating suitable conditions for ensuring satisfactory binding between the two courses, further to holding back water evaporation.

Two possibilities exist in these cases :

a. Base construction follows after a short period (12-24 hours). Moisture is preserved by means of frequent water sprinkling using tank-wagons.

b. Base construction follows after quite some time.

The sub-base surface then receives a cationic bituminous emulsion coating (PH>=4) of not less than 400gr of asphalt (residual) per square meter, followed by gritting chippings sized 14-20mm in quantities of 7-8 liters/sq.m. to be compacted with a rubber-tyred roller. This work is carried out soon after sub-base construction, so that the mix workability be not reduced to a degree impeding partial insertion of the chippings into the treated mix.

The treated course surface shall be maintained moist by consecutive sprinkling until application of the abovementioned bituminous coating.

2. Base Course

The bituminous coating as described hereabove under 1.b shall be applied in this case, with the difference of using smaller chippings sized 4-6mm. In case of courses intended to serve substantial construction traffic, the coating shall need to be repeated a second time to ensure surface reinforcement.

Courses constructed as above shall remain closed to heavy-duty vehicular traffic (including the Contractor's vehicles) for a period not less than 7 days, and to light traffic for a period not less than 3 days, and this only if a protective layer has been applied. Spreading of pavement courses thereupon shall not be embarked upon before the lapse of 7 days, with the exception of the case under 1.a hereabove.

26.5. TRIAL SECTION

No less than ten (10) days prior to the commencement of the main construction works, a trial section shall be implemented over an area of not less than 500 sq.m. with the same materials, mix composition, equipment and personnel as those used for the main works. The purpose of this trial section shall be to test generally the suitability of methods to be applied and of equipment and mix composition to be used. It is recommended that such trial section comprise both a transversal and a longitudinal joint. Decision on the siting of the trial section shall rest with the Service. Should tests finally prove satisfactory, the trial section may be incorporated in the Contractor's main works.

All the various tests provided for under sub-clause 26.8, "Quality Control", shall be conducted over the trial section. Particular attention shall be attributed to the uniformity of the course thickness, its strength, compaction and achievement of the required surface evenness.

Should tests prove non-compliance to requirements, the necessary corrective action shall be taken immediately in the mix preparation plant and the spreading and compaction work systems, or, if necessary, the mix composition shall need to be modified. A new trial section shall be constructed upon completion of the corrective action.

26.6. TOLERANCES OF THE COMPLETED SURFACE

Level pegs shall be fixed with 1mm precision in accordance with the drawings along the centerline and edges of cross-sections spaced at not more than 20m. The completed course surface shall then be related to the theoretical one established by the heads of pegs.

Al no point shall the completed surface be permitted to exceed or fall short of the theoretical one by more than 1/5 the envisaged course thickness. When tested with a 3m-long straightedge, both parallel and at right angle to the road centerline, the completed surface shall not deviate by more than 10mm at any point.

In no case shall it be permitted for the course thickness to be supplemented by the addition of a new thin layer. Should the surface level of the cement treated stone course fall short of the theoretical one in excess of acceptable tolerances, one of the following solutions shall be applied in compliance to the Service's instructions

- increase of the thickness of the course to be constructed above, or
- reconstruction of the defective section.

26.7. WEATHER CONDITIONS

Construction of cement treated crushed stone courses shall proceed only when ambient temperatures under shade exceed 5°C with no documented fear of frost. When ambient temperatures are in ascending course, the above minimum temperature may be reduced to 2°C.

26.8. QUALITY CONTROL

26.8.1. Scope of the Quality Control

The scope of the quality control shall extend to cover the following :

- materials to be used in the works,
- mix ratios and preparation,
- testing the course bearing surface,
- spreading operations,
- compaction,
- curing,
- geometrical characteristics.

26.8.2. Testing of Materials

26.8.2.1. Purpose

Ensuring that the materials to be used satisfy the specification requirements hereof both at their source and on the works site where they are to be used, so that any tampering likely to occur during quarrying, loading, hauling and unloading be eliminated.

26.8.2.2. Procedure

26.8.2.2.1. At the source

- Aggregates.

- Verification of face exploitation conditions as provided for *by* the Special and Supplementary Conditions of Contract and by the other tender conditions.

- Checking the removal of topsoil or other unsuitable layer prior to beginning a quarry or mine exploitation.

- Verification of the rejection of unsuitable veins.

- Representative sampling of rock material in accordance with the Service's instructions for conducting the following tests :

    - Prior to works commencement, and if material variations are envisaged

      1 analysis of sulphate content,
      1 analysis of organic matters content.

    - For each consecutive quantity of 750 cubic meters, or once daily, if smaller quantites are used :

      1 grade analysis,
      1 percentage of elements with 2 or more fracture surfaces,
      4 sand equivalents.

    - For each consecutive quantity of 4500 cubic meters, or once weekly, if smaller quantities are used

      1 definition of Atterberg limits,
      1 clay lumps content.

    - For each consecutive quantity of 15000 cubic meters:

      1 test of wear due to friction and impact (Los Angeles).

26.8.2.2.2. <u>At the central plant</u>

- Aggregates

Inspection of unloaded piles and rejection of those bearing visual evidence of agricultural soil, organic matters or lumps exceeding the maximum acceptable size, marking of the piles presenting irregular appearance in relation to material from an approved source, namely coloring differentiation, excessive plasticity etc.

Sampling of the marked piles with a view to repeating tests performed at the source.

- Admixtures

Certification by the manufacturer according to pare 4.5.9 of the Regulation of Concrete Technology to the effect that the quality of the admixture is identical to the one used during the preparation of the mix design.

- Water

Prior to the commencement of the works and also in the case of a source variation, verification of the water compliance to the requirements of sub-clause 26.2.3 hereof.

26.8.2.2.3. Interpretation of Results

The results of tests conducted on aggregates at the source or at the central plant (in case of need to repeat same) must conform to the requirements of the present specification document.

26.8.3. Control of Mix Ratios and Preparation

26.8.3.1. Purpose

Verification that the materials of which the work consists are mixed at the ratios designated by the mix design.

26.8.3.2. Procedure

— Aggregates

Verification of the mix aggregate grading conducted prior to cement mixing, for each consecutive prepared mix quantity of 500 cubic meters, or once daily in case of lower production.

— Mixture

Regarding the mix prepared, it is established as follows :

PORTION :

the quantity of mix produced daily at the central mixing plant

SAMPLING :

5 random samples taken at the mixer discharge with the purpose of determining moisture content.

5 random samples taken at the mixer discharge with the purpose of preparing one test specimen from each. After regular 7-day curing, the five specimens shall be subject to compressive strength tests.

— Cement

Verification of the cement quantity used in each portion.

— Central Plant

Semi-weekly verification of the accuracy of scales and of batching mechanisms for water and admixtures. For volume ratios, such checking shall be conducted at the mixer discharge by blocking the flow of the remaining ingredients.

26.8.3.3. *Interpretation of Results*

— Aggregates

The results of grade analyses conducted on the aggregate mixture shall comply with the requirements of sub-clauses 26.2.2 and 26.3 hereof.

— Mixture

The moisture content of all mixtures must comply to the percentage designated by the mix design, increased by the amount needed to counter losses likely to be incurred during transportation and spreading and by the amount of tolerance as per sub-clause 26.4.3 hereabove.

Failing this, ratios shall be modified accordingly. Plain 7-day compressive strength must be equal to or exceed 9 MPa on each of the test specimens. However, lower results by up to 0.6 MPa may be accepted if the mean value of the overall sampling group remains equal to or above 9 MPa. Should cement with high pozzolana/fly ash content be used, application shall be made of the 7- and 90-day strength ratio established in the mix design with regard to the definition of the permissible strength limit.

— Cement

The quantity of cement used must be such that the ratio may lie within limits of tolerances determined in the mix design and under sub-clause 26.4.4.

26.8.3.4. *Remarks*

A constant follow-up of the central mixing plant shall be necessary to enable immediate interruption of the production in case of irregularities and with the purpose of verifying the minimum permissible mixing time.

26.8.4. Control of the Bearing Surface

26.8.4.1. *Purpose*

Verification that the surface intended to bear the cement treated crushed stone course complies to density requirements and is to the required elevations, gradients and crossfalls. lf, in the opinion of the Service, general irregularities are evidenced on such surface possibly caused by heavy-duty traffic or by heavy rainfall, the testing shall need to be repeated.

26.8.4.2. *Procedure*

— Visual inspection.

— Monitoring results of the passage of a loaded truck over the surface.

- Repetition of density tests as established by control regulations for works similar to the bearing surface, along sections where disintegration of compaction is estimated to have occurred.

- Verification of surface and particularly of cross-section geometrical characteristics.

- Removal of spoil deposits.

26.8.4.3. *Interpretation of Results*

The same interpretation criteria shall be applied to the conduct of tests as those required for the construction of the bearing surface.

26.8.4.4. *Remarks*

Visual inspection is of particular importance to this test.

26.8.5. Control of Spreading Operations

26.8.5.1. *Purpose*

Follow-up and verification that spreading is in compliance to the requirements of sub-clause 26.4.7.

26.8.5.2. *Procedure*

- Monitoring ambient temperatures.

- Counting transportation time.

- Taking five random samples for the definition of moisture content.

- Control of the geometrical characteristics of the course during spreading and verification of the course thickness using a metal graded ruler to insert into fresh concrete.

26.8.5.3. *Interpretation of Results*

The limitations established herein (sub-clauses 26.8, 26.4.7, 26.4.8, 26.4.9) shall apply with regard to ambient temperatures.

Prior to compaction, the course thickness must be such as to allow for achieving the required final one after completion of compaction, bearing always in mind that in no case shall it be permitted to supplement the thickness by subsequently adding thin layers of material.

Upon commencement of compaction operations, the mix moisture content shall be either equal to or less (by not more than 1%) than the optimum moisture content concluded in the mix design (sub-clause 26.3).

26.8.5.4. Remarks

Visual inspection all along the carrying out of spreading operations shall be of particularly great importance, given the characteristics of these operations.

26.8.6. Control of Compaction

26.8.6.1. Purpose

Measuring the lapse of time between cement addition into the mix and completion of compaction of the same mix.

The following are established with regard to the work section subject to control :

PORTION :

An overall area of 3000 square meters of compacted course, or the part constructed in one day.

If the daily output exceeds 3000sq.m. (but is less than 6000sq.m.), then such daily output shall be divided into two approximately equal parts, each of which shall constitute a separate portion.

SAMPLING :

Five (5) samples in all, taken at random from each portion. Each one of the samples shall be tested for

- moisture content,
- density,
- course thickness.

26.8.6.2. Interpretation of Results

If retarder admixtures are used, mean times shall need to be either equal to or less than those referred to under sub-clause 26.4.8 hereof and in the special study (sub-clause 26.2.4).

Dry densities measured on the compacted course shall have to be either equal to or higher than those established under sub-clause 26.4.8 hereof.

Notwithstanding the above, test results from a unified sampling group may be accepted even if found lower than the required ones by not more than 2%, provided that the mean values resulting from the overall sampling group remain equal to or higher than the values established under sub-clause 26.4.8 hereabove.

Course thickness shall not be permitted to fall short of the contractual one by more than 15mm. If a thinner course is detected at one point, verification tests shall become more dense in that area with the purpose of identifying the whole extent of course having insufficient thickness. Should the course thickness be found to fall short of the specified one by more than 15mm, then the whole area of defective course shall need to be reconstructed.

26.8.6.3. *Remarks*

Other means may also be used in measurements of density and moisture content, such as apparatuses of radioactive isotopes, compressed air densimeters, calcium carbonate bottle etc., provided that they be satisfactorily graded following previous comparison tests and a documented correspondence be established between such methods and those officially referred to in the technical specifications for in-situ soil mechanics tests E106-86. In the case of using radioactive isotope apparatuses, the number of tests shall be doubled.

26.8.7. Control of Curing

26.8.7.1. *Purpose*

Verification of meeting the requirements hereof during application of the curing coating.

26.8.7.2. *Procedure and Interpretation of Results*

Control regulations corresponding to the Standard Technical Specification (S.T.S.) A 222 shall apply.

26.8.8. Control of Geometrical Characteristics

26.8.8.1. *Purpose*

Verification of adherence to geometrical characteristics regarding surface evenness, accuracy of elevations, gradients and crossfalls.

26.8.8.2. *Procedure*

Characteristic points of the road centreline shall be verified by readings spaced at 20m in addition to other points (tangent points of horizontal and vertical curves), using pegs fixed to the specified levels with an accuracy of 1mm. Width and crossfall shall be verified by means of pegs fixed at cross-section edges.

Verifications based on the road centerline shall aim at spotting irregularities in the carriageway width, the longitudinal profile and transversal slopes. Whenever deviations are suspected to exceed tolerances, the 3m-long straightedge shall

26.8.8.3. *Interpretation of Results*

Road sections shall be certified acceptable only when surface evenness, elevations, gradients and crossfalls are found to comply to those specified for the specific course (base or sub-base) by the Special and Technical Conditions of the Contract.

Irregularities found to exceed the respective tolerances shall be restored by the Contractor in compliance to the Service's instructions.

Following compaction of restored sections, density tests shall be resumed on them, same as verification of geometrical characteristics.

26.9. PREPARATION OF TEST SAMPLES

Moulds shall be cubes of 150mm side (according to the requirements of method ZK-304). For sample preparation, moulds shall be arranged on a rigid base. The mix shall be brought to consolidation in three equal layers using a vibrating electric hammer with a power of 600-700W and an operation frequency of 25-45Hz (the vibrating hammer shall be controlled according to the method provided in BS 1924:1975 Tests Note 2).

Consolidation shall be by a square slab of 7500-14000sq.mm. fixed at the end of the vibrating hammer stem. Each layer shall be consolidated through vibration and compacted through simultaneous vertical pressure of 300-400N (30-40kg) lodged on the hammer for a period of 40 +-5 seconds, in a manner ensuring compaction of the layer by simultaneous vibration and pressure. Prior to spreading the next layer, the previous compacted layer surface shall be scarified to a depth of about 5mm by means of a sharp tool.

The final layer shall be compacted and made flat to an even surface ensuring the sample height at 150mm.

The fresh sample density shall be determined as the quotient of the difference in weight between full compacted and empty mould divided by the mould nominal internal volume. With a view to achieving precision and uniformity in density determination, formation of the mould final surface shall be by a 155x155mm metal slab set on the top of the full mould and vibrated with the vibrator hammer until touching the four corners of the mould walls.

If deemed necessary, the Service may instruct the sample preparation to be by other methods, as i.e. Proctor density test samples to be by the modified compaction test method BS 1924 : 1975 Test 4.

Following preparation, samples shall be covered with moist hessian for about 24 hours until mould removal. After this, they shall be stored in plastic air-tight bags having lightly soaked internal surfaces.

Laboratory samples shall be preserved in a moist curing chamber according to the method ZK-303. Similarly, samples taken at the works site shall be preserved in the field laboratory, in a curing chamber of temperatures varying by not more than required under method IK-303.

Compressive tests of samples shall be conducted in compliance to method EK-304.

26.10. TREATED CRUSHED STONE OF SPECIAL MIX FOR IMMEDIATE OPENING TO TRAFFIC

If required to be immediately opened to traffic, the cement treated crushed stone shall be of special composition lending a high degree of stability to the fresh mixture.

Mix selection shall be based on the same criteria as those used in roller concrete (clause 28).

A special study shall be conducted with a view to selecting a suitable composition ensuring high initial stability. To this effect, samples shall be prepared using the casings of the CBR test with density equal to 97% of the maximum laboratory density foreseen under sub-clause 26.3 and with the optimum moisture provided. Directly after preparation, samples shall be subject to the CBR test (E)(105-85 method 12), free of any surcharge. The resulting CBR value must exceed 65.

In all other respects, mix preparation, transportation, spreading and compaction

shall be in accordance with the requirements of the previous sub-clauses.

Curing coating shall be applied immediately after completion of compaction. It shall consist of a bituminous emulsion coat (PH>5) applied at the rate of 600gr of residual asphalt per square meter and accompanied within not more than 5 minutes by gritting chippings of 2-6mm (N9 10 to N° 31/3) at the rate of 4-6 Its per sq.m., and by roller compaction. In case of heavy anticipated traffic, an additional bituminous coat with gritted chippings shall need to be constructed as above.

Unless otherwise specified in the tender conditions, payment for the construction of cement treated crushed stone courses of special composition shall be by the establishment of special unit prices per cubic meter of the specific construction work.

26.11. QUANTITY SURVEYING

Work measurement shall be per cubic meter of fully constructed work (labour and materials), since, further to methods of checking the course thickness as such mentioned hereabove, same shall also be verified by levelling operations conducted on the course bearing surface and, subsequently, on the final course surface, according to the stipulations of the relevant sub-clause concerning "tolerances of the completed surface".

26.12. PAYMENT

Payment shall be made per cubic meter of fully constructed compacted course measured in accordance with the previous sub-clause. It shall include for all costs of the supply of the required material quantities and of the qualities specified herein, of the mix production in a central mixing plant, for hauling, spreading, compacting, sprinkling of water and curing with bituminous emulsion, gritting chippings and rolling, for all necessary transportation and lay-days, together with all related costs (labour and materials), even if not explicitly mentioned but required for achieving a fully completed work.

Clause 27 : CEMENT STABILIZED SOIL

27.1. DEFINITION - GENERAL REQUIREMENTS

Cement stabilized soil is the uniform mixture of soil with cement, water and, possibly, admixtures that is laid to a specified thickness, is compacted and cured (protected from loss of water and from damage due to external factors) for a specified length of time and provides courses that are homogeneous and durable.

The layer construction of cement stabilized soil shall be carried out in accordance with STS 0.164, subject to the modifications and additions that are set out in the following.

27.2. CONSTRUCTION MATERIALS

27.2.1. Cement

Cement shall conform to the requirements of the Law…..

More specifically, the use of cement type II or III is recommended. No cement of a strength category exceeding 35 is to be used in the works.

27.2.2. Water

Water for mixing and curing shall conform to Standards

27.2.3. Admixtures

In order to extend the time allowed to the mix compaction, especially during periods of high temperatures, retarding admixtures may be used in the mix, following the Service's approval and the elaboration of a relevant laboratory mix design.

It is emphasized that the length of time allowed to compaction depends on the ambient temperature and is reduced by approximately half when temperature doubles.

The average ambient temperature between the hours of 11 : 00 and 15 : 00 shall serve as a representative temperature. The laboratory design shall also investigate and determine the effect of the admixture on the length of time during which the mix is workable (can be satisfactorily spread, graded and compacted) at various ambient temperatures. The usual extension of time allowed to compaction is from 6 to 10 hours, depending on the method of laying and on the plant involved with spreading and compaction.

Admixtures shall conform to the requirements of Para 4.5 of the "Concrete Technology Regulation" and to Special Specification ZK 308.

27.2.4. Soil Material

Soil to be stabilized may be naturally occurring soil or material resulting from a quarry, river or torrent mine, crushed or otherwise, conforming to the following requirements :

27.2.4.1. Grading

The grading of the material shall fall within the limits of Table 1 :

TABLE 1 : LIMITS OF GRADE ANALYSIS

AASHTO Sieve: M-92		
N°	Mesh Opening mm	Percentage passing by weight
2"	50.8	100
1"	25.4	95 - 100
3/4"	19.05	45 - 100
3/8"	9.5	35 - 100
N° 4	4.76	25 - 90
N° 10	2.00	20 - 75
N' 30	0.59	8 - 50
N° 40	0.42	6 - 40
N° 50	0.297	6 - 35
N° 200	0.074	0 - 15

0 - 20 in the case of crushed material

The basic consideration for the selection of a material is the extent to which it is susceptible to convenient mixing in a central mixing plant. Also, the degree of homogeneity of the resulting mix. Sandy or sand-gravel soils with low clay fines content are usually the most suitable ones.

27.2.4.2. Liquid Limit

The liquid limit shall be less than 35.

27.3. MIX DESIGN

The Contractor shall submit to the Service a mix design for approval, sufficiently in advance of construction. Such mix design shall determine :

a. The ratio of cement required.

b. The moisture of the soil cement mix at compaction.

c. The required density of the compacted mix

The cement content is determined as necessary to ensure for the mix a 7-day minimum strength of 3.0 MPa when compacted at optimum moisture content, in accordance with the standard compaction testing procedure (BS 1924 or AASHTO T-134), in samples prepared in a Proctor test mould.

Furthermore, the average strength of five test samples after 7 days' soaking, in accordance with Test 12 of BS 1924, shall be not less than 80% of the average strength of five samples cured in the normal manner. The samples shall also show no cracking or swelling as a result of soaking.

The cement content shall be no less than 3% by weight of the dry soil.

If required, the mix design shall include a special investigation regarding the use of a retarding admixture. During the period of construction and following the necessary laboratory tests, the Service may implement modifications to the mix design, if necessary and in order to improve the quality of construction.

27.4. MIXING

The mixing of the materials shall be carried out in a central mixing plant of continuous or non-continuous operation that shall ensure the separate measurement of the soil, cement, water and, possibly, the admixture in the ratios specified in the mix design. The plant in question shall further meet the requirements of pare 5.8 of STS 0.164.

Mixing shall be conducted in an equipment ensuring complete uniformity of the resulting aggregate, cement and water mix. Water shall normally be added after thorough mixing of soil and cement, in the quantity necessary to ensure a final moisture content of the mix during compaction that corresponds to the one required by the mix design. To this end, the variation of the water content (due mainly to evaporation but also, possibly, to rain) shaff be taken into consideration.

In the case of a mixing plant with intermittent operation, the introduction of mix components into the mixing bucket shall not be resumed until the contents of the latter have been completely discharged.

Emptying of the mixing bucket into haulage trucks shall be performed from a height not exceeding 2.Om.

Continuous-mixing plants shall be equipped with a device permitting the constant monitoring of the flow of solid materials and the regulation of mix ratios according to the flow readings.

Where the mix discharge from continuous operation mixers is intermittent, said discharge shall be in quantities corresponding to a 30sec minimum production period. The height of discharge shall not exceed 2.Om.

Where the mix discharge is continuous onto a conveyor belt, the mix shall be fed into a special cone-shaped storage bin having a storage capacity at least equal to 10% of the plant's hourly production capacity. At the point where the conveyor belt discharges into the bin, the latter should be equipped with a special arrangement to prevent segregation of the mix components. It shall also have a large-capacity discharge system

Irrespectively of the type of mixing plant, the application of cement and water ratios shall be conducted with a tolerance not exceeding 0.3% of the weight of the dry aggregate.

Minimum total production capacity of the mixing plant shall be 60 cu.m./hour. However, the use of plants of higher production capacities is recommended. (Continuous-mixing plants are advantageous in this respect).

27.5. ACCEPTANCE OF THE UNDERLYING COURSE

No laying or spreading of material shall be allowed to take place before the underlying course has been tested for conformity of its density, surface evenness, elevations, gradients and crossfalls to those of the design and to the respective specifications. Any deviation from the latter shall be corrected in accordance with the corresponding specification, in order that it be brought within acceptable tolerances.

27.6. TRANSPORTATION OF THE MIX

Transportation of the mix is usually carried out with tipper trucks. The strictest measures shall be taken during transportation to ensure maximum restriction of the mix segregation, of soiling through contact with foreign matters and of fluctuations in the moisture content of the mix. In hot weather, or in cases where loss of moisture is anticipated due to the length of the haul, the mixture shall be protected with tarpaulins or with other suitable covering.

27.7. UNLOADING AND SPREADING OF THE MIX

After testing and acceptance (sub-clause 27.5) and immediately prior to the spreading of the mix, the surface on which the course is to be laid shall be sprayed with water to the extent that it be moist but free of pond formations of surface water.

All necessary precautions shall be taken during unloading and spreading to prevent the mix segregation or soiling due to contact with foreign matters.

Prior to compaction, the course thickness shall be as required to ensure a compacted layer of the specified thickness, falls and crossfalls and evenness of surface. It should be understood that under no circumstances shall the increase in thickness of a layer be permitted after compaction by the addition of new thin layers of material.

Spreading and compaction shall be carried out over the full width of the new carriageway corresponding to one direction of traffic. Should the laying plant not be capable of spreading the material over the whole width in one pass, it shall carry out the laying in strips, on condition that adjacent strips be laid consecutively within not more than one hour of each other. This time limit shall be reduced to 30 minutes when ambient temperature is in excess of 30°C. If a retarding admixture is used, the above time limits may be extended by the time period specified in the special laboratory design (sub-clause 27.2.3).

Where necessary for construction purposes (traffic routing or construction of other necessary works, etc.) and following permission by the Service, construction may be carried out over less than the full width of the carriageway allocated to one direction of traffic. In such cases, a longitudinal construction joint shall be formed.

The plant to be engaged in laying the course shall be previously approved by the Service and shall be capable of laying the material without segregation of its components to a uniform thickness, so that, after compaction, the final course shall have the required thickness, the necessary evenness and the required falls and crossfalls.

Ordinary graders may be used in sub-base courses, their number depending on the desired rate of laying.

Where cement stabilized soil is laid in a single course, the compacting plant shall be capable of achieving the specified density throughout the whole thickness of the layer within the time limits set down in sub-clause 27.8. Otherwise, the Service may permit the laying down of the stabilized soil in two (2) courses, each of a suitably reduced thickness, so that the necessary degree of compaction may be achieved with the plant available throughout the whole depth of construction.

In this latte case, the overlying course shall be laid immediately following compaction of the lower course.

In any case, overall compaction shall have been completed within the time limits set down in sub-clause 27.8. Also, given the importance of a solid, monolithic construction with regard to the magnitude of the stresses expected to develop and the fact that the former is jeopardized as a result of construction in layers, the Service's decision to permit the latter method shall need to be adequately justified.

27.8. COMPACTION

Before the commencement of any work, the Contractor shall present to the Service a complete study based on the type of soil and the output of the equipment, determining the number of units, their type and the number of passes they need to carry out in order to achieve the required compaction within the time limits specified in this section. This study shall be verified and modified in accordance with the results of tests and readings that shall be conducted in the trial section.

Compaction shall commence within one hour of the start of mixing and the moisture content of the mix shall be as specified in the mix design, with a tolerance not exceeding +-1% of the weight of the dry mix.

Should any water addition be required, this shall be effected in a manner ensuring the uniform moistening of the materials.

Compaction shall commence in a longitudinal direction, from the lowest edge of each separate strip towards the highest edge of the layer. Each pass of the roller over the section to be compacted shall vary slightly in length.

Special attention shall be paid in order to achieve proper compaction at all edges and in the area of working joints.

During compaction, levels shall be taken and surfaces being formed shall be verified to ensure construction of the proper cross-section.

The compaction equipment being utilized shall be as necessary to ensure that compaction be completed within a period of 3 hours following the introduction of cement into the soil mix. This time limit is reduced to 2 hours should the air temperature exceed 30°C.

Should use be made of a retarding admixture, above time limits may be extended by the period of time designated in the laboratory design (sub-clause 27.2.3).

During the final stages of compaction, overloading of the stabilized soil with very heavy rolling equipment shall be avoided, same as very lengthy compacting procedures. At no point of the construction shall these latter exceed a period of 2 hours from the start of compaction at the point in question.

The required density is specified in the mix design and shall be at least equal to 100% of the density achieved in the standard compaction test BS 1924:1975 Test 3 or AASHTO T-134.

In sections of the construction works where normal compaction equipment is not permitted to operate due to restricted dimensions or to proximity with other works, compaction shall be carried out with the means most suited to each case, in order to ensure densities that are not inferior to those in the rest of the course.

27.9. SURFACE FINISHING

No increase in the thickness of a course shall be permitted after completion of compaction. Final shaping may be carried out with a grader or scraper, but always within the time limits set for completion of the layer, to obtain the specified levels and cross-section.

27.10. CONSTRUCTION OF JOINTS

Construction joints shall be so formed that the edges of the recess be exactly vertical. Their method of construction shall be subject to approval by the Service.

Lateral joints shall be formed whenever work is suspended for more than 3 hours. If the work is carried out in longitudinal strips, and not over the whole width of construction, longitudinal joints shall be formed whenever there is a delay of more than 1 hour between the laying of two adjacent strips.

27.11. CURING AND PROTECTION OF THE LAYER

Upon completion of compaction, the layer shall be protected from loss of water due to evaporation. This is very important in ensuring a layer of the required strength, with a hard-wearing surface conducive to good bonding with the subsequent pavement layers. Applicable measures can be distinguished as follows

1. Sub-base course

   If a base course of sand-gravel treated with cement is to be constructed on this layer, then the purpose of curing is not only to prevent the loss of moisture through evaporation, but also to provide the conditions necessary to a satisfactory bond between the two courses. Two separate cases can be distinguished as follows :

   a. Construction of the base to follow within a short period of time (12-24 hours). Moisture content is preserved through frequent spraying with water tanks.

   b. Construction of base to be carried out after the lapse of some time.
   The surface is coated with an asphaltic emulsion spray (PH>=4) applied at a rate of 400gr of asphalt (residue) per sq.m. This is followed by the application of blinding consisting of 14-20mm of aggregate spread at a rate of 7-8 liters/sq.m. and compacted with a rubber-tyred roller. This work is carried out within a short period of time in order to prevent the workability of the mix from being reduced to the point where the penetration of the aggregate into the stabilized material is no longer possible. The surface of the stabilized course is kept moist through watering until the coating has been applied.

2. Base course

   In this case, an asphaltic coating shall be applied, as described in sub-para lb hereabove, with the difference that the aggregate here is of a smaller size, 4 to 6mm. Should the course need to accommodate substantial construction traffic, a further protective asphaltic coating shall be applied.

   The circulation of heavy vehicles (including those of the Contractor) shall be permitted after at least 7 days from the construction of the courses, while that of light vehicles after at least 3 days and only in cases where a protective coating has been applied. Construction of the successive superior courses shall not commence before the expiration of the same 7-day period, except in the case of sub-para la hereabove.

27.12. TRIAL SECTION

At least ten days prior to commencement of the main works, a trial section not less than 500 sq.m. in area shall be constructed with the materials, the mix, the equipment and personnel that the Contractor intends to utilize in the main works. The purpose of this trial construction is the general testing of methods, equipment and mix composition. It is recommended that the trial section include both a lateral and a longitudinal construction joint.

The actual position of the trial section in the works shall be subject to the approval of the Service and the section in question may be incorporated into the Contractor's main works should the respective tests prove satisfactory.

All possible tests, for which provision is made in sub-clause 27.15 "Quality Control" herebelow, shall be carried out on the trial section. Of special concern shall be the uniformity in the course thickness, its strength, degree of compaction and evenness of finished surface.

Should the tests prove that the cement stabilized aggregate does not conform to the specified requirements, the necessary corrections shall be made immediately at the production plant and to the systems of laying and of compaction. Alternatively, and if proved necessary, the mix shall be redesigned and the construction of the trial section shall be repeated, following implementation of the modifications.

27.13. TOLERANCES IN THE FINISHED SURFACE

Pegs levelled to within a millimeter of the levels shown on the drawings shall be placed along the centerline and at the edges of cross-sections spaced at not more than 20m.The actual finished surface shall then be compared to the theoretical one that shall be defined by the tops of the pegs.

At no point shall the finished surface be more than 1/5 the specified thickness of the cement stabilized soil layer above or below the theoretical surface. Tolerances in the evenness of the finished surface shall not exceed 10mm when checked with a 3m-long straightedge placed paralled or at right angles to the road centerline.

Sections in which the above tolerances are exceeded shall be repaired as follows:

- Scarifying and recompaction of the defective section shall take place only if it can be carried out within existing time limits for the completion of compaction. Should these time limits be exceeded, the defective section shall be entirely reconstructed in accordance with the Service's instructions.
- Under no circumstances can the thickness of a course be increased through the addition of a new thin layer. Should the surface of the cement stabilized soil layer fall below the theoretical level by more than the accepted tolerances, one of the following remedies shall be followed, depending on the Service's instructions :

    - Increase the thickness of the layer to be constructed superior to the layer in question.
    - Reconstruct the layer of the cement stabilized soil.

27.14. WEATHER RESTRICTIONS

Cement stabilization shall be carried out when the ambient temperature in shade exceeds 5°C and that there is no warranted expectancy of frost.

Should the ambient temperature be on the increase, construction work may be carried out when the temperature is as low as 2°C.

27.15. QUALITY CONTROL

27.15.1. Scope of the Control

Items to be the subject of control are as follows :

- Materials to be incorporated in the works Mix ratios and mixing at central plant Control of the bearing surface
- Laying of mix produced at a central plant Compaction
- Geometrical characteristics

27.15.2. Control of Materials

27.15.2.1. Purpose

The purpose of the control of materials shall be to verify that the materials to be used in the works conform to the requirements hereof both at the place of origin and on the works site, so that any variation likely to occur to such materials during extraction, loading, haulage or unloading be avoided.

27.15.2.2. Procedure

27.15.2.2.1. At the place of origin :

- Soil to be stabilized :
    - Checking that the exploitation of the pit or quarry face is in accordance with the provisions of the Special Conditions of Contract, the Supplementary 5CC and the other tender conditions.
    - Checking that top soil and any other unsuitable layer have been removed prior to the start of work on actual exploitation of a mine or quarry.
- Collection of representative samples of the material as the Service may instruct, to be tested as follows :
    - For every 1,000 cubic meters of material, or once a day if a day's consumption is less:
      1 grade analysis test.
    - For every 3,000 cubic meters of material, or once every 3 days if consumption is reduced as above :

1 Atterberg limits determination test.

- For every 10,000 cubic meters of material:
  1 Sulphate content test
  2 Organic matter content test.

27.15.2.2.2. At the works site or point of incorporation :

— Soil to be stabilized :

Piles of material unloaded from trucks are inspected visually and those with an apparent content of topsoil, organic matters or large particles exceeding the maximum acceptable size are rejected. A note is made of those showing a deviation from the appearance anticipated of material from an approved source, such as a difference in coloring, excessive plasticity, etc.

Samples are taken from the piles noted so that tests that were carried out at the place of origin may be repeated.

27.15.2.3. *Evaluation of the Results*

The results of tests carried out on the soil to be stabilized, either at the place of origin or on the site where it is to be used (when repeat testing is necessary) shall be in accordance with the requirements hereof.

27.15.3. Checking Mix Ratios and Mixing at Central Plant

27.15.3.1. *Purpose*

To ensure and verify that the materials mixed in a central mixing plant are in accordance with the ratios specified in the mix design.

27.15.3.2. *Procedure*

— Mix.

The following are established with regard to the production of the mix

Portion : The quantity of the mix produced daily in the mixing bucket of the central plant.

Sampling : Five (5) random samples for the determination of the moisture content. Five (5) random samples from the discharge of the mixing bucket, each to be made up into a test cylinder in accordance with sub-clause 27.3 hereof and to be subjected to a compressive strength test after 7 days of normal curing.

— Cement.

Verification of the quantity of cement used in each portion.

— Central mixing plant.
The accuracy of the batching scale is checked twice a week. If batching is done by volume, weighing shall take place at the point of discharge of the mixing bucket by stopping the flow of ingredients other than the one being measured.

27.15.3.3. *Evaluation of the Results*

The moisture content of each sample shall not differ from the percentage specified in the mix design increased by the percentage necessary to counterbalance losses of moisture during transportation and spreading and the tolerance percentage provided for in sub-clauses 27.4 and 27.8. In the opposite case, the ratio measuring system shall be regulated accordingly.

The 7-day compressive strength of each specimen shall be not less than 3.0 MPa. However, results lower than the required ones by not more than 0.2 MPa shall be accepted in any one sampling as long as the mean value of the results corresponding to the overall number of samples in the group shall remain equal to or greater than the value of 3.0 MPa.

— Cement.

The quantity of cement used shall be such that the resulting ratio do not exceed the tolerance percentage specified in the mix design, within the tolerance limits described under sub-clause 27.4 hereabove.

27.15.3.4. *Remarks*

It is essential that the central production plant be constantly monitored, so that production may be immediately discontinued in the event of any irregularities observed.

27.15.4. Checking, the Bearing Surface

27.15.4.1. *Purpose*

The purpose of verifying the bearing surface shall be to make sure that the top surface of the cement stabilized soil has the required density, evenness and elevations as shown in the drawings.

27.15.4.2. *Procedure*

— Visual inspection.

— Observation of the result from the passage of a loaded truck over the surface.

- Resumption of density tests along sections judged to be disintegrated (decompacted).

- Verification of the geometrical characteristics of the surface, especially with regard to cross-section.

- Removal of any waste material or debris detected.

27.15.4.3. Evaluation of the Results

When conducting testing operations, applicable criteria shall be identical to those governing the construction of a bearing course.

27.15.4.4. Remarks

Visual inspection is very important to this phase of quality control.

27.15.5. Spreading of the Mix

27.15.5.1. Purpose

The purpose is to observe and verify that the spreading of the course is in accordance with the stipulations hereof.

27.15.5.2. Procedure

- Monitoring the ambient temperature.
- Measuring the time required for haulage.
- Checking the layer thickness.
- Rough checking of the geometrical characteristics of the course during the spreading process.

27.15.5.3. Evaluation of the Results

With regard to the ambient temperature, the restrictions of sub-clauses 27.7, 27.8 and 27.14 shall apply.

Transportation time shall not exceed the one set in advance on the basis of weather conditions and of time restrictions as defined in sub-clauses 27.8 and 27.10 hereabove.

The thickness of the layer before compaction shall be as necessary to ensure a compacted course of the specified thickness, bearing in mind that in no case shall it be permitted to increase the thickness by means of additional thin layers after completion of the compaction operations. Thicknesses are usually measured by insertion of a graded metal ruler into the fresh mix.

27.15.5.4. Remarks

Given the special features of the spreading process, visual inspection is of great importance to achieving same.

27.15.6. Checking of Compaction

27.15.6.1. Purpose

The purpose is to verify that the degree of compaction of each layer conforms to the requirements hereof.

27.15.6.2. Procedure

Recording of the time from incorporation of cement into the mix to completion of compaction. Also, of the time taken up solely by the compaction process.

The following are established in the section of the works to be checked:

- Portion :

  A 3000sq.m. area of compacted course, or an area constructed in the course of 1 day, should the latter be less than 3000sq.m. If one day's construction exceeds 3000sq.m. in area, it shall be divided into sections, each of which shall be treated as a separate portion.

- Sampling :

  Five (5) random samples taken from the surface of the portion and checked for moisture content, density and construction thickness.

27.15.6.3. Evaluation of the Results

Times recorded shall not exceed the corresponding specified ones. Dry densities checked in the compacted layer should not be less than 100% of the maximum dry density achieved in the standard compaction test specified in the mix design, at all points of testing. However, in any one sampling, results falling short of the specified ones by up to 2% shall be accepted, on condition that the mean value of the results of the overall sampling group be not less than 100% the dry density of the standard compaction test.

The thickness of the compacted layer shall not fall short of the respective contractual requirement by more than 15mm. If found to be less at any point, then checkings shall be spaced closer with the purpose of fully defining the area of the defective thickness. If the thickness of the layer falls short of the specified one by more than 15mm, the respective section shall be reconstructed.

27.15.6.4. Remarks

In determining field densities and moisture contents, methods may be applied involving the use of radioactive isotope devices (nuclear gauges), air operated density meters, carbonic calcium cylinders, etc., subject to the satisfactory calibration of above equipment for the materials with which they are to be used.

27.15.7. Checking of Geometrical Characteristics

27.15.7.1. Purpose

The purpose shall be to check the finished surface for conformity to contract requirements with regard to evenness, accuracy of levels, falls and crossfalls. Also, for correct thickness of layer.

27.15.7.2. Procedure

The points establishing the axis setting out shall be verified with observations spaced at 20m, same as distinct points (tangent to horizontal and vertical curves), by means of pegs fixed and levelled to within a millimeter of contract requirements. The width and crossfall at above points shall be checked following the fixing of pegs at the edges of cross-sections.

Checkings shall be conducted from points of the road centerline for discrepancies in the width, the longitudinal profile and the crossfalls, while the 3m-long straightedge shall be applied wherever it is suspected that variances may exceed the specified tolerances.

27.15.7.3. Evaluation of the Results

Cross-sections whose geometrical characteristics conform to those specified in the Special and the Technical Conditions of Contract for the type of course in question (base, sub-base, subgrade) shall be accepted.

27.16. MEASUREMENT

The quantities of the works shall be measured in cubic meters of completed construction (materials, labour and equipment). Further to the abovementioned checking of the layer thickness, quantity verification shall also require levelling operations of the bearing surface as well as of the finished top surface of the course being surveyed for quantity, all in accordance with the stipulations of the clause regarding "tolerances of the finished surface".

27.17. PAYMENT

Payment shall be made per cubic metre of fully constructed and compacted course, measured in accordance with the preceding sub-clause. It shall include any and all costs for the supply of materials on site in the required quantity and of the quality specified in this clause for the production of the mix at a central mixing plant, its haulage, spreading, compaction and watering. Also, for curing and protecting the layer by the provision of a coating of asphaltic emulsion properly gritted and rolled and for all necessary transportation and lay-days. Payment shall also cover the cost of any and all work and materials, even if not specifically mentioned, necessary to the implementation of a fully completed construction.

Clause 28 : ROLLED CONCRETE

28.1. DEFINITION

By the term of "rolled concrete" is implied a homogeneous mixture of aggregates, cement, water and, eventually, admixtures (retarder) spread to a predetermined thickness, compacted by means of rollers and cured for a fixed period of time. Rolled concrete differs from cement treated crushed stone mixes mainly by its cement content, while from the concrete of ordinary rigid road pavements it differs by its water content which so much restricts its watery consistence that it can be compacted by roller.

28.2. GENERAL REQUIREMENTS

Rolled concrete construction shall comply to the requirements concerning cement treated crushed stone (clause 26 hereof), as modified and supplemented by the following provisions.

28.3. MATERIALS

28.3.1. Cement

Cement must comply to the requirements of the Law…..

The use of cement class II or Ill is particularly recommended. No cement of a strength exceeding 35 may be used.

28.3.2. Water

Mixing and curing water shall satisfy the requirements of the Law…

28.3.3. Aggregates

Aggregates shall satisfy specification requirements concerning "Treated Crushed Stone Mixes" (sub-clause 26.2.2 hereof), with the following modifications and additions.

The grade analysis of the aggregate mixture with cement shall lie within the limits established by Table 1 herebelow :

TABLE 1 : Limits of the Grade Analysis

Screens (AASHTO M-92)		Passing %		
Identification	Opening mm	Grading 0/20	Grading 0/16	Grading 0/14
1 1/4"	31.7	100		
3/4"	19.0	85 - 100	100	96 - 100
318"	9.5	59 - 81	95 - 100	71 - 95
N° 4	4.76	42 - 63	50 - 69	53 - 73
N° 10	2.0	29 - 47	35 - 50	35 - 51
N° 40	0.42	17 - 28	19 - 31	19 - 30
0.2	0.2	13 - 23		
N° 200	0.074	10 - 20	10 - 20	10 - 20

Grading 0/20 shall be used only when no fear of segregation exists, and only upon the Service's approval. Gradings of low fine contents are generally recommended. In lack of previous experience, the grading suitability shall be verified through testing.

With a view to achieving uniformity of the grading and of the mixture, aggregates shall be supplied in no less than two sizes (i.e. sand and gravel).

It is pointed out that the percentage of fines and their nature shall bear a substantial effect on the mix stability (direct bearing capacity). A relatively high content of coarse ingredients, particularly of material with rounded grains, renders the mix compaction easier to achieve but reduces the mixture's stability. The phenomenon grows even more complex when the effect of the grain size and nature is taken into account with regard to the mixture's water requirement for a specified workability.

The minimum acceptable content of fines in aggregates is fixed so that the CBR value of fresh and recently compacted mixture may not drop below 65 (E105-86 method 12, free of surcharges).

28.3.4. Admixtures

Relevant requirements specified with regard to "cement treated crushed stone" (sub-clause 26.2.4 hereof) shall apply in the case of any admixtures being used, with the following modifications.

The addition of retarder admixtures is mandatory, unless specially permitted otherwise by the Service . The retarder admixture shall allow an extension of the period of the mix workability and, therefore, the mix spreading and compaction according to the prevailing ambient temperature. Under the term of "period of the mix workability" is implied the time period from the beginning of mixing during which the mix is conveniently susceptible of spreading and compaction. Minimum recommended time periods of workability extension are given in Table 2 herebelow.

TABLE 2 : Minimum Periods of Extension of the Mix Workability

Type of Work		Workability Extension (hours)
1.	New pavement or reinforcement of existing one, free of traffic during the execution of works a. across the whole width b. over part of the width	 6 10 *
2.	Pavement reinforcement with simultaneous use by traffic	12*

* If construction of the remaining part of pavement cannot be accomplished within the periods specified, extension times shall need to be further extended.

Further use of admixtures in addition to retarder ones shall be subject to an approval by the Service.

28.4. MIX DESIGN

28.4.1. Laboratory Tests

The most appropriate grade analysis of aggregates is selected in the mix design and the required quantities of cement, water and aggregates are established in order for the mixture to satisfy the requirements of the present Specifications.

The mix design must be conducted in due time ahead, using materials that shall be used in the construction works proper.

Cement content shall not be less than 10% by weight of the dry materials. The required water quantities for the various ratios of aggregates that shall be tried shall be determined as the optimum moisture content in accordance with the modified compaction test BS 1924 : 1975 Test 4, or with the vibrator hammer compaction test BS 1924: 1975 Test 5. Mix compositions presenting the least possible number of voids shall be selected, as being the least liable to moisture variations_ (in the case of the aggregates being susceptible to substantial size variations, the Vabe apparatus may be used following the Service's approval, with an additional load of 9 kilograms).

Cylinder specimens of diameter 100mm and height 200mm must have tensile strength against rupture not less than 3.3 MPa at 28 days.

Quality control shall be made easier if the mix design includes a survey for the definition of the ratio between strengths at 7 and at 28 days. The values of such ratios must be based on not less than 15 strength values at each age. It shall be determined at these ages whether density tests of the course shall be by core sampling. In addition, the dry apparent specific gravity of hardened concrete shall be defined.

Four (4) different compositions shall be selected and three (3) test samples shall be prepared from each one of them under the optimum compaction moisture content in accordance with the modified compaction test BS 1924 : 1975 Test 4, or with the vibrator hammer compaction test BS 1924 : 1975 Test 5.

The composition shall be selected whose test samples shall yield strengths better than 3.3 MPa increased by an amount allowing for the strength of the final construction mix to exceed 3.3 MPa, bearing in mind the variety of strengths obtained from the various parts of the works.

The following shall also be determined for each composition being tested :

- the fresh mix CBR value, free of surcharges (E 105-86),
- the duration of the mix workability.

The limits of aggregate grade analyses in the compositions finally selected may be allowed to vary slightly from those shown in Table 1, if this is deemed necessary and the requirements of the present specification are satisfied.

Upon selection of the appropriate composition of the mixture of aggregates, the sensitivity of such mixture's initial bearing capacity to moisture fluctuations shall need to be investigated. This shall be done by the definition of the CBR value of fresh compacted specimens whose compaction moisture differs from the optimum one by +-0.5%.

Furthermore, the sensitivity of the tensile strength to moisture and density fluctuations shall have to be investigated by the definition of strengths of specimens prepared under :

- moisture content differing from the optimum one by +-0.5%, or
- optimum moisture content, but with densities equal to 95% or to 97% of the maximum density determined through the modified compaction method or the vibrator hammer method.

The conduct of such tests may be omitted, if agreed upon by the Service , provided that sufficient experience be available based on previous use of the same aggregates and cement.

28.4.2. Site Conducted Tests

Such tests are necessary with the purpose of verifying that the concrete designed in the laboratory can be produced by the mechanical equipment available at the works site, and that it can be spread and compacted in compliance to the requirements of the present Specification Document.

Six (6) different mixtures shall be produced from each laboratory selected composition and two (2) samples shall be prepared from each of these mixes to be tested for 7-day tensile strength. The moisture content of each mixture shall be the optimum one reduced by 0.5%.

The mean strength of the group of specimens produced from each mix composition must not be less than 90% of the respective strength of laboratory specimens. Failing this, the necessary modifications shall need to be brought to the mix composition until satisfaction of this requirement.

The tests of sub-clause 28.4.2 may be omitted if the strength is verified in accordance with sub-clause 28.10.1. Similarly, the Service may instruct omission of the strength tests described under sub-clause 28.10.1, in case that the conduct of tests of sub-clause 28.4.2 proves satisfaction of strength requirements.

28.5. MECHANICAL PLANT AND EQUIPMENT

The following plant *and* equipment shall be required for the execution of the works:

28.5.1. Central Mixing Plant

The central mixing plant to be used may be of continuous or of periodic operation. The mixing installation must satisfy requirements regarding "mix preparation" (sub-clause 26.4.4 hereof) of the clause entitled "Cement treated crushed stone".

28.5.2. Spreading Equipment

Spreading shall be performed by the use of equipment ensuring increased precompaction and not liable to cause any mix segregation. Ordinary mechanical graders shall only be used following the Service's written approval.

28.5.3. Compaction Equipment

Compaction equipment shall consist of not less than the following :

— a heavy-duty smooth-drum vibrator roller with a statical load of not less than 30kg/cm applied on the generating line, and

— a heavy-duty rubber-tyred roller with loads not less than 3tons per wheel and with internal tyre pressure not less than 0.8 MPa (8kg/sq.cm).

28.6. TRIAL SECTION

A trial section extending over an area of about 400 square meters shall be constructed not less than ten (10) days prior to the commencement of the main construction works with the same materials, mix composition, plant and equipment and with the same labour as those scheduled to be used in the main construction project. The purpose of this trial construction shall be to test generally the suitability of methods, equipment and composition of the materials. It is recommended that such trial section comprise a transversal and/or a longitudinal joint. The position of the trial section shall be subject to the approval of the Service ; same may be incorporated in the Contractor's main work provided that test results therefrom prove to be satisfactory.

All in-situ tests provided for under sub-clause 28.10 shall need to be conducted over such trial section. More precisely, the following tests shall be executed :

— Not less than ten (10) in-situ density measurements performed at random positions using the equipment scheduled for use on the main project. These tests shall be conducted throughout the course thickness and should possibly yield density values in the lower, medium and upper thirds of such thickness

— Mean densities in the medium and lower third as above must not fall short of 97% and 95% respectively of the laboratory obtained density with the modified compaction test.

— Individual density values may be lower than the above limits by not more than 2%, provided that mean value requirements as above be satisfied.

— It is recommended that a core density measurement equipment be utilized, suitably calibrated to fit the materials used. Twenty (20) tests shall need to be performed in this case.

— Failing this, one of the standard methods shall be applied within two (2) hours from completion of compaction, or otherwise cores cut on the site shall be tested in the laboratory.

Depending on the equipment available for testing compaction, the Service may modify the control procedure with the purpose of achieving the best and most detailed control possible.

— Preparation of ten (10) specimens, one from each truckload, to be tested for tensile strength at the age of 7 days. Their strength must be proved to exceed the required 7-day strength. In addition, the typical deviation of strength values shall be calculated, thus providing a first approximation of the dispersion of results

— In the case of major projects, the Service may use a compliance criterion similar to compliance criterion D (for major works) of clause 6 hereof, where tensile strength shall be tested instead of the compressive one.

The capacity of spreading and compaction plant and equipment, together with the respective methods applied shall be tested over the trial section in order to verify the extent to which the pavement produced can meet with the requirements of the present Specification (tests of spreading and compaction time, surface evenness, course thickness).

Furthermore, verification shall extend to the efficiency of the course curing and protection process. If results prove unsatisfactory, consecutive trial sections shall have to be implemented by introducing appropriate variations to the works constituent characteristics until achieving the required quality standards. If other mix compositions were certified suitable during tests regarding project characteristics, then the first mix that failed as above on the trial section can be replaced by any one of those other compositions, following the Service's approval.

28.7. EXECUTION OF THE WORKS

28.7.1. Mix Preparation

No method of aggregate stockpiling or hauling to the central site stockpiling installation shall be acceptable if liable to cause undue segregation or mixing of different sizes of stone. Appropriate measures shall be taken to avert contamination of aggregates in contact with the ground, as well as to ensure proper drainage of the stockpile area.

No less than 50% of the aggregates required for the overall concrete quantity scheduled for construction shall have to be stockpiled prior to commencing mix preparation works. Cement shall be stored in silos. The minimum storage capacity shall correspond to 2-days' consumption under normal conditions of performance.

Admixtures shall be properly safeguarded against weather conditions as well as against any contamination through strict adherence to the manufacturer's storage instructions. More specifically, bags of powdered products shall be stored in closed shelters on insulated base slabs, namely just like in the case of cement bags.

Fluid admixtures shall be stored in watertight containers, properly sheltered against sun and frost.

28.7.2. Spreading of the Mix

Whenever possible, the mix shall be spread over the whole width of the carriageway. Failing this, the maximum width possible shall be completed while the material on the band first spread is still workable. In the case that no retarder admixture is used, spreading of mix shall not be permitted on adjoining bands after the lapse of more than one (1) hour from the respective phase of work.

28.7.3. Compaction

Certain trips of non-vibratory tandem roller are recommended in a first stage.

Compaction shall need to be fully completed at all points within the time span of the mix workability. The duration of compaction operations shall not be permitted to exceed three (3) hours from delivery of the first batch of mix at a given point, unless retarder admixtures are used.

The course surface shall be maintained constantly moist, specifically under hot and dry weather, by means of fine sprinkling of water that shall be extended to the curing period in order to make sure that the surface shall remain constantly moist, with the exception of pool formation.

With a view to achieving satisfactory compaction at the course extremities, it is recommended that the formation and compaction of shoulders be combined in parallel to that of the concrete. In a first phase, the non-vibratory roller shall cover by 1/3 of its width the shoulder and by 2/3 the concrete surface, then it shall pass exclusively over the concrete, and subsequently the compaction procedure shall follow its normal course.

Should it be impossible to carry out the shoulder compaction parallel to that of the concrete, and that satisfactory compaction of the concrete extremities be not ensured with other methods or means (i.e. by application of provisional lateral moulds), then construction of the concrete course is recommended to be extended by 20cm on either side.

Particular attention must be paid to achieving satisfactory compaction in the region of transversal and of longitudinal working joints (see sub-clause 28.7.5).

28.7.4. Surface Grading

In case that concrete surface grading is deemed necessary, spreading should be in such a way as to ensure that the actual surface be a few centimeters above theoretical levels. Grading could be done by mechanical grader or other plant, following an initial compaction to about 95% of the required one.

Upon completion of grading, compaction shall be resumed with a vibratory roller to be followed by a pneumatic-tyred roller until achieving the required degree of compaction. If necessary after grading, the surface shall receive a very fine and light sprinkling of water under low pressure.

Surplus material scraped during grading must be immediately removed out of the course surface lest it be guided onto "low" points and create thin layers failing to adhere to the underlying course.

28.7.5. Construction of Joints

28.7.5.1. Transversal Joints

Transversal joints for work stoppage shall be provided at the end of each day, or when the works progress is interrupted for a period longer than the mix workability requirement. If no retarder admixtures are used, joints shall be constructed whenever work stoppage exceeds two hours.

Joints shall be made to have even vertical sides, since otherwise such points would risk being broken and raised.

The following method is recommended with a view to facilitating the formation of even, vertical surfaces at work interruption joints and the smooth withdrawal of compaction equipment out of the compacted section:

- A wooden balk or suitably dimensioned board is firmly fixed at the course end and a ramp provided beyond this with gravel or other material.
- Some kind of plastic sheet or other appropriate separation material is recommended to be placed over the surface of the underlying course with the purpose of facilitating removal of the triangular ramp section material.
- The material of the triangular section, together with the balk shall be removed the next day prior to commencing the spreading of concrete.

Following the Service's approval, the Contractor may apply other methods for the formation of joints, provided that they meet requirements for ensuring even and vertical joint surfaces.

28.7.5.2. Longitudinal Joints

Lane construction must be organized in a manner eliminating the need of longitudinal joints. To this effect, and in order to ensure jointing of adjacent lanes, a band about 0.50m-wide shall be left uncompacted, subject to compaction along with the adjoining lane. The constraint relating to the period of workability (sub-clause 28.7.2 hereabove) shall apply.

28.7.5.3. Cutting contraction joints

Transversal contraction joints spaced at 15.0m shall be cut with a cutter to a depth of 5cm at right angle to the road axis or slightly askew at 1:6 in a manner ensuring that the left wheel of the vehicle reaches the joint prior to the right one. Joint cutting shall be within a period from 1 to 3 days. The Service may order that cutting take place earlier or spaced at shorter or longer distances, should this be deemed necessary due to the prevailing weather conditions or as a result of the experience gained from the construction of the first stretches or from other constructions. It is also possible for the Service to order that no joint be cut.

28.7.6. Curing – Protection

Concrete shall be subject to a curing spray upon completion of its compaction. Special polymer base products may be used ensuring not only appropriate preservation of moisture, but also surface hardening.

The quantity applied shall be not less than 400gr/sq.m. Bituminous emulsions having PH not less than 5 may also be used, with a minimum ratio of residual bitumen equal to 600gr/sq.m. These ratios may be modified by the Service, if necessary.

Working (work stoppage) joints shall be subject to an additional spray prior to sealing. Within 5 minutes from application of the bituminous emulsion, aggregates sized between 2 amd 6mm shall be spread on the surface with a ratio varying between 4 and 6 liters per square meter and per rolling trip.

These operations must take place prior to the lapse of 12 hours from completion of compaction. Meanwhile, the surface shall need to be preserved moist by means of fine water sprinklings. The Service may deem it appropriate to reduce the above deadline in the case it is performed under hot and dry weather.

Following the above treatment, and after fission of the emulsion, the concrete course may be opened to traffic. Wearing coat shall not be used before the lapse of 7 days, while it is recommended that such time constraint be extended to one or even two months, particularly under cold weather.

28.8. TOLERANCES OF THE COMPLETED SURFACE

In accordance with the stipulation of sub-clause 26.6 hereof, the surface regularity of each stretch of compacted concrete shall be tested within 24 hours from completion of construction. Should irregularities due exclusively to "high points" (bumps) be detected, same may be corrected by means of scraping with suitable diamond disk saws.

Deviations from theoretical plan data shall not exceed 5cm.

28.9. WEATHER CONSTRAINTS

Concreting shall be avoided when temperatures are likely to drop below 2°C.

28.10. QUALITY CONTROL

28.10.1. Control of Mix Preparation

The uniformity of the mix preparation shall be controlled with the daily conduct of the following tests :

- 5 moisture content tests of the mix,
- 2 grade analyses (with particular attention drawn to the percentage of fines),
- 1 cement consumption test.

— Preparation of 12 specimens from random samples obtained at the mixer discharge and compacted in accordance with the modified compaction method or with the vibratory hammer method. The specimens shall be tested for compressive strength following 28-day curing. The mean value of the compressive strength of the 12 specimens must satisfy the following compliance criterion :

$$x_{12} >= 3.3 + 1.43\ S\ [MPa]$$

where :

S = the typical strength deviation of the sampling, as it results from the function :

$$\frac{\left[\sum_{j=1}^{j=12} (Xj - X10)^2\right]^{1/2}}{11}$$

It is emphasized that the same compaction method as that used in the mix design shall be applied in the preparation of the specimens.

28.10.2. Control during Construction

28.10.2.1. Compaction

This control shall be implemented by the definition of the progress and of the number of roller trips performed over the trial section. To the extent possible, auto-recording instruments of continuous registration shall be used, fixed on the compaction plant with the purpose of controlling the latter's speed, vibration frequency, working time and distance travelled.

28.10.2.2. Density

Tests shall be conducted at various points, with a frequency of one test per 100 square meters of course area if core methods of compaction testing are used, or per 700 square meters if other methods are used.

With the purpose of conducting compaction tests by application of core cutting methods, the mix design must have established the apparent specific gravity of hardened concrete at various ages on samples compacted to 100% by the modified compaction test or by the vibratory hammer method.

28.10.2.3. In-Situ Moisture Content

Tests shall be conducted at various points corresponding to the tests conducted during mix preparation.

Should deviations be found to occur too frequently and exceed tolerances, the Service may deem it necessary to stop spreading operations and reinforce control the next day.

28.10.2.4. *Thicknesses*

Tests shall be conducted at 10m intervals of the average thickness of uncompacted spread material, using a calibrated nail and taking into account the thickness reduction that the material shall be subject to following compaction.

The thickness of the concrete course shall also be verified by core cutting at locations designated by the Service . At no point may the thickness fall short of the required one by more than 15mm. Core cutting holes must be filled with concrete of the same quality as that used in the course construction. Cores shall be used for compaction testing.

28.10.2.5. *Extension of Workability Period*

Temperature shall need to be monitored during spreading and the retarder admixture must be proportioned in accordance with the previous tests.

The period of workability of the concrete may be tested following the Service's instruction by the method of measuring transmission time of sound waves, or by other approved method.

28.10.2.6. *Curing - Protection*

Concrete surface shall be tested prior to the application of curing/protection compound for constant moisture preservation.

No less than one test shall be conducted daily of the quantity of curing compound applied on the concrete surface by collecting and measuring the quantity applied on a given area plate.

28.11. MEASUREMENT

Measurement shall be per cubic meter of full construction (labour and materials), since, after all the above mentioned tests of the course thickness, the latter shall be verified also by levelling the course bearing surface as well as the final course surface according to the stipulations of the sub-clause concerning "tolerances of the completed surface".

28.12. PAYMENT

Payment shall be per cubic meter of fully constructed compacted course measured in accordance with the previous sub-clause and including all costs required for the supply of the materials in the required quantity and of the quality specified herein for the mix production at a central plant, for haulage, spreading, compaction and sprinkling with water and for curing with bituminous emulsion, gritting aggregates and rolling, for all necessary transportation and lay-days, as well as for all costs (labour and materials), although not explicitly mentioned, but required to the complete accomplishment of the work.

Clause 29: EXPANSION/CONTRACTION JOINTS FOR BRIDGES

29.1 <u>JOINTS OF TOTAL DISPLACEMENT EXCEEDING 20min</u>

29.1.1 <u>General</u>

29.1.1.1

As a general rule, road pavement expansion/contraction joints shall be used inthe formulation of joints for road bridges subject to a total displacement exceeding 20mm. They shall be watertight expansion joints of industrial origin (manufactured by specialized factories) and shall have characteristics as required with a view to responding to the following:

a. Displacements as shall be concluded from the design taking into account the most unfavourable combinations possible of loads and displacements defined in the tender documents [i.e. Technical Design, Design and Investigations Standards (D.I.S.), etc.].

b. The load category related to bridges, anticipated to be category SLW 60/SLW 30 for all bridges, culverts, etc.

c. Smooth and quiet passage of vehicles and damping of vibrations, minimizing annoyance to passengers.

29.1.1.2

All necessary measures shall be taken by the manufacturer for ensuring corrosion proofing of the joint and such measures shall be specifically referred to in the Contractor's submission to the Service for approval of the joint system. As a minimum, the corrosion-proofing system shall respond to the local conditions (see relevant clause 31 hereof and the other tender conditions).

29.1.1.3

Together with the joints, the manufacturer shalt provide directions for installation, regulation, maintenance, etc.

29.1.1.4

Skilled technicians shall be used for the installation of expansion/contraction joints on bridges. The technicians shall need to produce their qualification certificates issued either by the joint manufacturer or by the joint dealers.

29.1.1.5

The size of the gap left in the joint during installation shall depend on the mean temperature of the bridge at the same period, as well as on DIN 1072 and on Beiblatt 1 zu DIN 1072.

29.1.1.6

The waterproofing system of the bridge deck shalt be designed in a manner ensuring watertight sealing of the expansion joint.

29.1.1.7

Should a joint be required to withstand also transversal displacements (namely, two-directional displacements), the Contractor shall be bound to produce a relevant certificate issued by the manufacturer to the effect that the specific joint system is capable of assuming such composite displacements.

29.1.1.8

With the exception of embedded parts, all other components of the system shall be accessible for periodic inspections and, if need be, for replacement.

29.1.1.9

In the case of railway bridge construction, respective joints shall conform to the Standard Road Plan (S.R.P.). A rail expansion joint shall be provided at a short distance from the bridge expansion joint.

29.1.1.10

Steel joints with neoprene sealing components shall in no case bear a clearance exceeding 80mm between metal sections (i.e., all types of Tensa-Acme are permitted in joints of types Tensa-Acme and Tensa-Lastic made by Proceq S.A. of Zurich, while in types Tensa-Lastic types F-L 60 shall be allowed together with multiples of 60, namely F-L 120, F-L 180, etc, as well as types F-L 80 and the multiples of 80, namely F-L 160, etc.).

29.1.2 Schedule of Acceptable Joint Types

The following types of expansion/contraction joints shall be acceptable, provided that no counter-indications be created by the structural and dynamic operation system of the bridge.

(1) Rubber/metal joints of type Transflex (manufactured by Expandite, Servicised, Alga, General Tyre and Rubber Company, Gutehoffnungshuette, Man) conforming to the requirements of the anticipated displacements, or similar.

(2) Steel joints with neoprene sealing components of the Rub system by Rheinstahl Union Brueckenbau AG (manufactured by Thyssen or Alga), conforming to the requirements of the anticipated displacements, or similar.

(3) Steel joints manufactured *by* Proceq SA of Zurich with neoprene sealing components of type Tensa-Acme or Tensa-Lastic, conforming to the requirements of the anticipated displacements, or similar.

(4) Steel joints type ❑ with neoprene sealing components made by Maurer Sohne, conforming to the requirements of the anticipated displacements, or similar.

(5) Metal joints type W made by Cipec with neoprene sealing components, conforming to the requirements of the anticipated displacements, or similar.

(6) Rubber/Metal joint type Junta-Span 021 made by CTT/Stronghold International Ltd in compliance to West German regulations, conforming to the requirements of the anticipated displacements, or similar,

(7) Steel joints with neoprene sealing components made by Tesit-Honel, of types Honel (161N, 162N, etc. to 176N), conforming to the requirements of the anticipated displacements, or similar.

(8) Steel joints with neoprene sealing components made by Sollinger Hutte, type WSF, conforming to the requirements of the anticipated displacements, or similar.

Irrespectively of their types, joints must be dimensioned to withstand strain caused by traffic and, specifically, dynamic strain resulting from non-compliant construction (i.e. defective placement, lack of conformity to accurate levels, etc.).

Any joint found to be defective prior to the acceptance of the works shall have to be replaced by the Contractor with a joint of a different type as approved by the Service.

29.1.3 Requirements of Other Types of Joints

With regard to other types of joints that would comply to the requirements of the tender documents, the type to be proposed by the Contractor shall be subject to the approval of the Service, who may require the Contractor to adjust the joint to the complete satisfaction of the former. Further to the stipulations contained in sub-clause 29.11 hereabove, the following specifications shall also need to be observed.

(1) The top level of the sealing components shall be in a recess, lower than the final road surface, while the above components shall be fastened by means of mechanical hooks onto the separating steel beams.

(2) In the case of the application of two or more sealing components, ways shall be provided for ensuring equal distribution of the overall clearnace of the joint among all sealing components.

(3) Sealing components shall be arranged in a way ensuring their self-cleaning, while allowing low compressive stresses.

(4) Watertight plugs shall be provided at the ends of sealing components.

(5) Permanent and firm bearing of mobile steel components, together with a noiseless operation of same shall be ensured through the provision of bearings and prestressed holding sets of poly-urethane or other suitable material.

Consecutive sliding surfaces shall be of PTFE and stainless steel

29.2 JOINTS OF TOTAL DISPLACEMENT LESS THAN OR EQUAL T9 20mm

29.2.1

In the cases of joints of total displacement that would be less than or equal to 20mm, it is possible to use "sunk types of joints" that can be covered with bituminous layers.

29.2.2

In the cases of joints with a total displacement (d1) satisfying the inequality 10mm < di <= 20mm, rubber joints can be used of type Deck Flashing DF6 made by Expandite, or of type Serviseal Type B made by Servicised, protected through a galvanized steel plate of 15 x 200 mm, or other similar joints complying to the requirements of sub-clauses 29.1.1.1 up to and including 29.1.1.7 hereabove.

29.2.3

In the cases of joints with a total displacement (d2), where d2 <= l0mm, the same rubber joints as above may be used (without the steel plate reinforcement) of the same manufacturers Expedite or Serviced, or other similar joints ensuring adherence to the requirements of sub-clauses 29.1.1.1 up to and including 29.1.1.7.

Clause 30: BRIDGE BEARINQS

30.1 ELASTO/METAL BRIDGE BEARINGS

Elasto/metal bridge bearings shall be laminated bearings bound to comply to the following specifications :

30.1.1

Bearings shall be prefabricated to the specified dimensions (width, length and height, with all required consecutive metal plates and elastomer layers), so that to be able and assume the design loads (horizontal and vertical), rotations and displacements, and to allow their replacement by jacking the bridge deck to a height equal to that of the bearing plus 3mm (room shall be provided for jack installation and operation).

Metal plates shall be suitably shaped (with rounded edges, etc.) and embedded in elastomer by means of vulcanizing. All steel plates shall be elastomer enveloped (for rust-proofing).

30.1.2

The following elasto/metal bearings produced by any of the manufacturers mentioned herebelow shall be accepted (provided they meet tender requirements)

(1) Bearings of type Neoarm by F.I.P. SPA Padova, or similar.

(2) Bearings of type Lasto (responding to design requirements) by Proceq SA of Zurich, or similar.

(3) Bearings of type Gumba, by Gumba GmbH of Germany, or similar.

(4) Bearings of type Hercules, by Gutehoffnungs Hutte (former Esslingen), or similar.

(5) Bearings of type ES, ESv, ESd, by Maurer Sohne, or similar.

(6) Bearings of type Vulcanized Laminated Bearings by R.S.C. Equipment Ltd, or similar.

(7) Bearings of type Slide-Block-Type B, by CTT/Stronghold International Ltd (in compliance to West German regulations), or similar.

30.1.3

In view of the envisaged application of other types of elasto/metal bearings (in compliance to the tender conditions), relevant certificates shall be submitted together with a statement by the manufacturer to the effect that any one of the undermentioned regulations is adhered to:

(1) DIN 4141 Sept.1984.

(2) German Regulations re: elastic bearings.

(3) British Standards re : use of elastic bearings on road bridges (Memorandum No802).

(4) Italian Specifications re : elastic bearings (CNR-UNI 10018-72).

Such bearings shall be subject to the Service's approval, who may reject same and require the Contractor to bear necessary adjustments until complete satisfaction of the abovementioned requirements.

30.2 POT BEARINGS

30.2.1

Pot bearings (cast rubber point-type bearings) shall be of industrial production, conforming to the tender conditions and to the technical design requirements with a view to responding to:

- the most unfavorable envisaged combinations of loads (maximum vertical load with respective horizontal ones, maximum horizontal load with respective vertical one, etc.),
- the anticipated turns, the anticipated displacements, by size and direction (firm bearings, bearings mobile in one or in two directions).

30.2.2

Bearings must be appropriately fashioned to ensure any required provisional firm fixing of the bridge deck in the course of construction.

30.2.3

These bearings shall consist of a suitably designed and fabricated steel box containing a plain elastic sheet of neoprene and sealed with the bearing steel cap and with appropriate peripheral watertight insulations.

30.2.4

In mobile bearings, sliding shall be achieved through a suitable metal plate lined with a sheet of polished stainless alloy of chromium/nickel steel sliding over a PTFE slab of appropriate thickness. Pockets of suitable greasing matter must be incorporated in the PTFE slab for ensuring minimal wear due to friction.

30.2.5

The bearings shall undergo corrosion-proofing treatment ensuring at least a minimal satisfaction of related requirements of the project to which they are ncorporated, as such requirements are established in the tender conditions. They shall be supplied together with accompanying directions for installation and regulation.

30.2.6

Also these bearings shall be fashioned and fixed-in-place in a way allowing their removal and subsequent replacement. The superstructure and the piers shall be designed in a manner permitting the installation of jacks for provisional jacking of the superstructure during bearing replacement.

Clause 31 : METAL CONSTRUCTION - CORROSION (RUST) PROOFING

31.1

The specifications of the present clause concern the various metal items anticipated to be constructed under this project and that are not dealt with by other clauses.

31.2

Without limitation to these, the works shall comprise the supply of all materials, their assembly, surface finishing, placement, together with all fittings necessary for the completion of the works in accordance with the drawings of the technical design and with the remaining tender conditions.

(1) Hand railing, safety guardrail and other metal fittings of metal safety guardrails along roads and retaining walls.

(2) Rigid metal safety guardrails for bridges/culverts and other items pertaining to Guardrails for Bridges and Culverts.

(3) Welded metal plates embedded in concrete (i.e. formation of circumference of access hole on reinforced concrete sewer manhole, same as fittings of reinforced concrete manhole covers).

(4) Metal fabrications and corresponding frameworks for all types of manholes on the road, pertaining to utility networks, etc.

(5) Anchorages onto concrete and anchor bolts (i.e. on bases of lighting poles).

(6) Metal items pertaining to sewerage, drainage, irrigation, public lighting, telephone, light signaling, fencing, etc. works.

(7) Any required metal ladders, landings and railings.

(8) Various other metal items for the completion of the works in accordance with the technical design, the tender conditions and the instructions of the Service.

31.3

a. Corrosion proofing of all metal fabrications shall be in accordance with the British Standard BS 5493/1977, depending on the local conditions of exposure and on weather conditions, and depending on the typical time required to the first maintenance service, as follows :

(1) 1st CASE :

EXTERIOR FABRICATIONS EXPOSED TO NON-POLLUTED INLAND ATMOSPHERE - PROTECTION OF EXTRA-LONG DURATION (exceeding 20 years)

[Table 3 - Part 1 of BS 5493/1977 shall apply, particularly its section referring to "very long (20 years or more) typical time to first maintenance].

In accordance with the abovementioned stipulations, application of the following protection method is selected in this case and constitutes an obligation of the Contractor :

i. Hot-dip galvanizing (following assembly) to cover the longest possible sections of the metal fabrications, in relation to galvanizing bath dimensions of important units, with minimum protection thickness of 85 pm (600gr/sq.m.). (See relevant system of specification 581 in BS 5493/1977).

ii. In-situ weldings shall receive a protection of unsealed sprayed zinc to a thickness of 150 pm. (See relevant system of specification SC 2Z in BS 5493/1977).

(2) 2nd CASE :

EXTERIOR FABRICATIONS EXPOSED TO NON-POLLUTED COASTAL ATMOSPHERE - PROTECTION OF EXTRA-LONG DURATION (exceeding 20 years)

[Table 3 - Part 4 of BS 5493/1977 shall apply, perticularly its section referring to *very long (20 years or more) typical time to first maintenance].

In accordance with the abovementioned stipulations, application of the following protection method is selected in this case and constitutes an obligation of the Contractor

i. Hot-dip galvanizing (following assembly) to cover the longest possible sections of the metal fabrications, in relation to galvanizing bath dimensions of important units, with minimum protection thickness of 140pm (1000gr/sq.m.). (See relevant system of specification SB2 in BS 5493/1977).

ii. In-situ weldings shall receive a protection of unsealed sprayed zinc to a thickness of 250 pm. (See relevant system of specification SC 3Z in BS 5493/1977).

(3) 3rd CASE

FABRICATIONS IN SEA WATER SPLASH ZONE OR IN ZONE OF FREQUENT SALT SPRAY - PROTECTION OF LONG DURATION (10 to 20 years)

[Table 3 - Part 9 of BS 5493/1977 shall apply, and particularly its section referring to

In accordance with the abovementioned stipulations, application of the following protection method is selected in this case and constitutes an obligation of the Contractor :

i. Hot-dip galvanizing (following assembly) to cover the longest possible sections of the metal fabrications, in relation to galvanizing bath dimensions of important units, with minimum protection thickness of 85pm (600gr/sq.m.) and thereupon an epoxy paint to a thickness of 150pm. (See relevant system of specification SB1+SK5 in BS 5493/1977).

ii. In-situ weldings shall be protected by unsealed sprayed zinc to a minimum thickness of 100pm and thereupon a protective paint of 60 to 100pm (See specification system SC 10Z in BS 5493177).

Where metal sliding surfaces are foreseen in expansion joints, an asphalt based membrane layer shall be inserted according to a detailed design and specification to be submitted by the Contractor for the Service's approval.

The color of paints shall be selected by the Service from among paints available and/or by mixing of same.

b. The abovementioned specification BS 5493/1977 shall apply in all other respects.

c. Anchor bolts and nuts shall be galvanized in accordance with ASTM A 153, category C, while washers shall be as per category ID. Threading of nuts shall be rewound after completion of no less than 0.38mm-thick galvanizing for dia. 16 to 25mm bolts, and no less than 0.51mm-thick for bolts of dia. exceeding 25mm.

31.4

By departure from the above, lighting poles may be protected by application of an epoxy paint etc., in accordance with the specifications of sub-clause 19.2.1 hereof.

Should such poles receive a hot-dip galvanizing protection as described in the same sub-clause hereof, such galvanizing shall conform to the obligations emanating from the protection method (in accordance with sub-clause 31.3 hereof and the other tender conditions, i.e. the Supplementary SCC, etc.) to be applied to the remaining metal works of this Contract.

Furthermore, special reference is made to anchor bolts of lightning poles in the specification regarding electro/mechanical installations (sub-clauses 19.2.1.1, 19.2.1.2, 19.2.1.3. hereof), that shall also apply in the case of very high poles (required for flood lighting).

31.5

The following provisions shall be observed during the assembly of metal constructions

(1) Items shall be fabricated in accordance with the approved detail drawings and, whenever possible, the dimensions of any related concrete construction shall be verified for the case that any deviation from such specified dimensions may affect the correct placement of the metal item. Pieces shall be assembled to the largest quantities possible for delivery to the works site.

(2) Whenever possible, factory works shall be welded, while site works shall be joined by means of bolts.

(3) Where a smooth and continuous exterior surface is required, welding surfaces shall be ground to complete levelling. (Such are the cases of all exposed surfaces, when no counter-indications to grinding are put forward by the Service).

(4) Supplies shall include all pieces required for the satisfactory anchorage of assembled items onto the construction. Unless otherwise specified in special cases, all manufactured items of anchorage, namely fixing lugs, couplings, slings and struts, shall be of the same material and with the same finishing as those of the respective metal constructions.

(5) All exposed edges (sawn, scissored, or flame cut) shall be ground to remove any borings or sharp edges.

(6) Prior to galvanizing, all surfaces and welded areas shall be completely cleared of any corrosion traces, grease, welding leftovers or other harmful matters liable to be prejudicial to the adherence of zinc.

(7) Pieces to be assembled by means of bolts shall *be* galvanized separately, while edges of adjoining surfaces in welded joints shall be welded to complete sealing of the joint along surfaces requiring galvanizing.

(8) No chemical treatment shall be permitted to galvanized surfaces intended to receive paint.

(9) Metal plates to be embedded, bearing welded pins or anchoring rods, shall be galvanized after their assembly.

31.6

When hot-dip galvanizing is specifically envisaged to provide protection of metal constructions against corrosion, this shall be performed in a workshop approved by the Service.

Depending on the galvanizing unit, special care must be taken to ensure free circulation of fluids in the cleaning bath and, subsequently, in the galvanizing bath among metal pieces, and also to avoid strains.

Prior to assignment of the galvanizing work to an industrial workshop, or prior to assuming galvanizing in his own unit, the Contractor shall be bound to request the Service's written approval thereto. The latter shall then himself inspect the galvanizing setup with a view to making sure of adherence to the provisions of the present specification.
Should materials be supplied complete from expatriate sources, the Contractor shall be bound to submit to the Service documents testifying to the manufacturer's organization and then, after the Service's approval, he shall again submit suitably certified invoices proving that the quantity referred to was indeed purchased from the manufacturer originally approved.

The presentation of such invoices shall also be required in the case of local supplies and same shall constitute supporting documents to be attached to the certification of the relevant work.
Attention is drawn to the difficulty of galvanizing steel with a silicon content exceeding 0.04%.

31.7

It is emphasized that elongated objects, such as :
lighting poles,

- corrugated sheet metal for safety parapets and their posts,
- long guardrail rods,

- steel piping (for parapet handrails, general railing or any other application),
- shall be necessarily galvanized in vertical arrangement units.

31.8

(1) Further to the control of geometrical characteristics and to any other controls required by the specifications, all metal items shall be subject to a quality control regarding galvanizing that shall fall under category B of controls dealt with in clause 21 hereof. Such galvanizing quality control shall be performed in recognized workshops as described under sub-clause 20.4 hereof and in the other tender conditions, at the Contractor's care and expense. Sampling shall be conducted in the following manner

a. Test specimens shall be taken from all metal items brought onto the works site, to a percentage varying between 0.5% and 1.0% of galvanized items from each distinct category (corrugated sheet metal for parapets, guardrail posts, steel piping, steel manhole items, grids for anchoring guardrails and lighting poles, etc.), and no less than 2 pieces from each distinct category.

b. Sampling shall be performed by a three-member committee to be appointed by the Superintendent of the Supervising Office.

(2) The quality control of galvanizing shall conform to the requirements of the French specification NE A91-121 (galvanisation U chaud), in accordance with which :

a. The following tests shall be conducted for corrugated sheet metal, for posts of the various types of safety parapets and for the corresponding items of rigid guardrails for bridges and culverts (long rods and posts), same as for galvanized piping :

- appearance test (aspect),
- adherence test (adherence),
- weight of zinc laid down per surface unit (masse de zinc dtposLe par unit de surface).

b. Two tests shall be conducted for all other metal items :

- appearance, and
- weight of zinc laid down per surface unit.

Clause 32 : SIGNS - DELINEATORS OF RIGHT-OF-WAY (EXPROPRIATION ZONE)

The present clause concerns the construction of Signs, Pavement Markings and Right-of-Way Delineators.

32.1 <u>SIGNS</u>

32.1.1 <u>Regulatory and Warning Sign</u>

They shall be provided in accordance with standards applicable by the Ministry of Infrastructure, as well as with the stipulations of the Design and Investigations Standards (D.I.S.).

32.1.2 <u>Information Signs</u>

They shall be fabricated in compliance to applicable standards, as well as to variations and supplements thereto provided by the Design and Investigations Standards (D.1.5.).

Their supports shall be heavy-duty galvanized steel pipes ISO MEDIUM (green label), designed to resist wind loads as per the above mentioned D.I.S.

Pipe posts for small signs up to 2.5m pole height shall have a minimum diameter of 11/2" and a thickness of 3.4mm.

Pipe posts for larger signs up to 3.3m pole height shall have a minimum diameter of 3" and a thickness of 3.25mm.

In the case of very large roadside sign panels requiring the provision of special lattice or frame supports, the latter shall be fabricated of structural steel of any category specified by the D.I.S., in accordance with relevant structural calculations, with the requirement of a minimum thickness of the section equal to 3mm. Corrosion proofing shall be provided of the type specified for external corrosion proofing of lighting poles as per pare 19.2.7.1 of the T.C.C..

The configuration of the sign support arrangement must be such as to allow easy adjustment of the sign panel thereto and/or replacement of same.
All bolts and nuts to be used shall be galvanized or stainless steel.

32.1.3 <u>Overhead Sign Bridges</u>

They shall be fabricated in compliance to the specifications given in the D.I.S., of structural steel of any category, in accordance with structural calculations, with the requirement of a minimum thickness of section equal to 3mm. Corrosion proofing shall be provided of the type specified for external corrosion proofing of lighting poles as per para 19.2.7.1 of the T.C.C.

The configuration of the sign support arrangement must be such as to allow easy adjustment of the sign panel thereto and/or replacement of same.

All bolts and nuts to be used shall be galvanized or stainless steel.

32.1.4 Roadside Delineators

32.1.4.1

Delineator posts shall have a section of isosceles triangle with a top angle of 30° and an altitude of 10-16cm for full sections and of 12-16 cm for hollow ones. In the latter case, the section thickness shall be not less than 3mm. The triangle angles shall be rounded with curvature radii not less than 1 cm (see S.R.P. R.5.-137). Minimum overall height of the delineator post shall be 1.50 m, while 50cm of it shall be embedded in the ground.

Delineator posts shall be of polyvinylchloride material type PVC-H1. Quality shall be such not being affected by ultraviolet radiation and atmospheric conditions.

Posts shall be uniform white color all over.

32.1.4.2

The reflectorizing elements shall be rectangular, 18 x 4 cm and (unless otherwise specified in the special terms of tender) shall consist of sphere glasses weatherproofed and installed on plastic base (TYPE B). Alternatively, it will be possible to use reflectorizing surfaces made of prismatic reflectorized crystals of acrylic material tightly waterproofed (TYPE A) or microprism cube corner reflecting sheeting (e.g. DIAMOND GRADE type of 3.4).

The coefficient of illuminating intensity for the various types of reflectors shall be measured according to the requirements.

The requirements of TYPE A reflectors are considered to apply also for the DIAMOND GRADE membrane type. The reflectorizing element colour shall be red (for the face right to the direction of traffic) and silver white (for the face left to the direction of traffic).

The reflectors shall be installed on both sides of the delineator (silver white on one side and red on the other) on a black rectangular strip covering the entire cross-sectional surface of the delineator to a width of 25 cm.

For the case of delineators on motorways (or on one-way roads) the installation of reflectors on the back side of the delineators serves the periods when traffic is directed into a single carriageway (e.g. during maintenance).

The reflectors center of gravity shall be 15 to 20 cm below the post top.

32.1.4.3

During delivery a sampling shall be made amounting to 1% of the delivered quantity with a minimum number of 5 posts.

32.1.4.4

The reflectorizing elements of the delineators shall be coverd after their construction for their protection against loading - unloading, transportation and installation.

32.1.5 Fully Reflective Milepost Markers

Milepost markers shall be of type similar to that of specification 11-15 applicable to information signs, with the difference that the reflector part shall have characteristics conforming to the highly reflective membrane Type II as per the specification. Also the dimensions of the sign are being altered (relative to sign 11-15) as relatively mentioned in para 1.15.1.6 of DIS.

The background for motorway milepost markers shall be reflectorized, green in color, and shall have reflectorizing, strength and other characteristics according to the high reflectorization membrane (Type II).
The background for milepost markers on other roads (except motorways) shall be reflectorized, blue in color, and shall have characteristics according to the reflectorizing membrane Type I.

Posts supporting sign panels shall be galvanized steel pipes of dia.11/2" and 3.4mm-thick, with appropriate height to ensure that the bottom side of the milepost marker be 0.60 m above the road final surface.

32.2 PAVEMENT MARKINGS

(1) Pavement markings shall be done through the use of white reflectorized pavement marking paint, according to Specification for the case of non-final surface courses in motorways and ramps (such as in case the pavement is turned over to traffic for a limited period of time, without the final skid-resistant layer being constructed), as well as in roads of the remaining network for which no special instruction was issued for the need to use *"special high quality paint'*. Pavment markings shall be constructed according to the D.I.S.

(2) The quality of the above mentioned reflectorizing pavement is considered unsuitable to be used for final wearing courses (skid-resistant or ordinary) in motorways and interchange ramps.

(3) In final wearing courses of motorways and interchange ramps a *"special high quality pant'* or other pavement marking materials (thermoplastic, phsychroplastic, miscellaneous membranes etc) having higher reflectorization and life duration, for which todate the relative specification has not been finalized yet, shall be used.

Similarly a "special high quality painr etc shall be used in road sections of the remaining network having heavy traffic, for which a pertinent instruction has been issued by the Service.

32.3 DELINEATORS OF RIGHT-OF-WAY

The delineators of the right-of-way (zone of expropriation) shall be made of reinforced concrete class B15 (reinforcing rods 408 + stirrups 06/15). Their dimensions shall be 0.20 x 0.20 x 0.75m.

The delineators shall be embedded in a base of lean concrete class B5, of dimensions 0.40 x 0.40 x 0.50m, in a way ensuring that their tops be 0,40m above the ground.

They shall be prefabricated in order to ensure uniform quality, shape and appearance.

The Contractor shall submit related drawings for approval by the Service.

Clause 33 : SAFETY GUARDRAILS

33.1 COMMON FEATURES OF SAFETY GUARDRAILS

33.1.1 General

In the specifications that follow, safety guardrails are distinguished into Single Face Guardrails (S.F.G.), Median Barriers (M.B.) and Structure Guardrails (S.G.). Steel guardrails and/or the steel components of composite guardrails combined with concrete barriers (NEW JERSEY type) shall be of hot-dip galvanized steel, same as all bolts and nuts used thereto. NEW JERSEY type barriers shall be constructed of concrete class 825. Respective Standard Road Plan (S.R.P.) shall apply to all types of guardrails in addition to the specifications described here below. Wherever guardrails are constructed over structure expansion joints, special construction arrangements shall be provided with a view to covering the expansion joints through special holes drilled in the corrugated sheet metal, possibly additional pieces, sliding arrangements (with internal muffs) over handrails, etc.

Expansion joints and special construction arrangements at end sections of safety guardrails shall be included for in a converted manner in the unit prices quoted for the corresponding typical safety guardrail. Furthermore, the unit price of typical safety guardrails shall include in a converted manner for the additional work required for bending the corrugated sheet metal according to the horizontal curvature, if any, in the place of guardrail construction.

Such bending is mandatory for locations along which the radius of curvature does not exceed 40m.

The formulation of expansion joints shall be in accordance with German Regulations, and the Contractor shall be bound to include relevant construction details in the technical drawings of engineering designs pertaining to structures.

With the exception of Structural Guardrail type S.G.-1, to which special reference is made under clause 10 hereof, the following provisions shall generally apply to all types of guardrails.

33.1.2 Posts

33.1.2.1

Posts supporting metal safety guardrails (with the exception of the *"German Type"* metal guardrails MD-4 and MD-5) shall be steel U sections with dimensions 120 x 55 x 5mm, (unless otherwise indicated for the various guardrail type herebelow), suitably long depending on the type of guardrail as indicated herebelow under characteristic features for guardrails of the various types. Posts shall be subject to HOT-DIP GALVANIZING for corrosion proofing, ensuring a minimum zinc cover of their surface in accordance with the provisions regarding other metal items as described under clause 31 hereof, the Special Conditions of Contract and/or the other terms of tender. The supply of each post shall include for the appropriate galvanized bolt for fixing the spacer.

33.1.2.2

Alternately, for projects tendered through a "CONCESSION AGREEMENT' it might be possible to accept posts having cross-section INP 120 or IPE 120 or UNP 120 instead of the U 120x55x5 posts being referred for the various types of guardrails.

33.1.2.3

Posts for Median Barriers MD-4 or MD-5 ("German Type" posts) shall have an IPE-100 cross-section.

33.1.2.4

On guardrails provided with handrail for which there is a possibility of extenting the posts (by welding), the post extension to support the handrail shall be protected by HOT DIP GALVANIZING, as the remaining of the post is, and the post welding operation shall be done prior to galvanization.

33.1.3 Spacers

(1) Spacers shall be provided on safety guardrails of types SFG-1 up to SFG-7 inclusive, SFG-9, SFG-12, MD-1, MD-2 and SG-2 up to SG-7 inclusive.

Spacers shall be HOT-DIP GALVANIZED steel ensuring a minimum zinc cover of their surface in accordance with the stipulations regarding all other types of metal items under clause 31 hereof and the other terms of tender.

(2) Standard *"light type spacers"* shall be used in single face guardrails (guardrail types SEG-1 up to 5FG-7[1] inclusive, SFG-9, SFG-12, SG-2, 3, 4, 6 and 7). These spacers shall have a U-section 50x65x3 mm. The spacer length shall be equal to 306 mm (equal to the total height of the guardrail corrugated sheet metal). However, spacers up to 320 mm long will be acceptable.

(3) Two standard *"light type spacers"* shall be used on each post of median barriers (barrier types SG-5, MB-1, *MB-2* and MB-7D[2]) having characteristics similar to those mentioned in sub-para (2) above.

In difficult cases (high speeds, unfavorable geometry, high percentage of trucks, it might be possible for the Service to request the use of standard *"heavy type spacers"* instead of *"light type spacers"*. *"Heavy type"* spacers shall have a U-section 80x55x5,5 mm. or 120x55x5,5 mm. *"Heavy type"* spacers length shall be in accordance with sub-para (2) above.

(4) *"German type spacers"* shall be used for median barriers MB-4 or MB-5 type. These spacers shall have a "special section" as shown in the S.R.P. made of a 3 mm. thick steel sheet having a developed width of 435 mm. and length 780 mm. (prior to bending for forming the cross-section). Tolerances for these dimensions shall be according to DIN 1016.

33.1.4 Corrugated Sheet Metal and reflectors

33.1.4.1

The corrugated sheet metal (steel) of safety guardrails shall comply to the following requirements

- Corrosion proofing of the corrugated sheet metal shall be obtained through HOT-DIP GALVANIZING ensuring a minimum zinc cover on its surface in compliance to the stipulations of clause 31 hereof, the SCC and/or the other terms of the tender regarding all other metal items of this contract.
- Sheet metal shall be of special corrugated section [type Armco Flex Beam Guardrail, or Profit "A" of the German Regulations - see [TECHNISCHE LIEFERBEDINGUNGEN FUR STAHLSCHUTZPLANKEN AN BUNDES-FERNSTRASSEN (TL-SP 1972)].
- Following extrusion, the sheet shall be 80mm-wide, 306mm-high and 3.0mm-thick. Tolerances shall be as provided by DIN 1016.
- Sheets shall be fabricated in standardized pieces not less than 4.31m-long (in order to ensure the required extra length for overlapping), however the length measured (when measurements are per lineal meter) shall be the effective length estimated equal to 4.00m.
- Sheet metal shall be of industrial production, excluding all recast steel. Sheets shall be continuous, free of welded seams, brand new material which has never been reused.
- All standard pieces of sheet metal shall bear connection holes that must be drilled prior to galvanizing. The holes shall have semi-circular ends with dimensions 20 x 40mm.
- Standard pieces of sheet metal shall also bear fastening holes spaced at 2.00m that must be drilled prior to galvanizing. Again, they shall have semicircular ends with dimensions 20 x 60mm.
- If the sheet metal is to be used in the construction of specially reinforced safety guardrails with densely spaced posts at 1.333m, holes shall be also spaced at 1.333m drilled by an industrial method prior to galvanizing, same as for holes mentioned hereabove.

33.1.4.2

The work related to the galvanized corrugated sheet metal shall further include the following :

a. The supply of suitable galvanized connecting bolts (2x4 pcs M16 per unit of effective length equal to 4.00m), to connect the sheet metal sections to each other,

b. The supply of reflectors on a galvanized steel plate base, red on the one side silver - white on the other. The reflectorizing elements (unless otherwise specified in the special terms of tender) shall be of a normal trapezoid shape, have base dimensions 40 and 110 mm and a height of 60 mm (reflectors type I), or circular shape with reflectorizing surface of approximately 50 cm2 and shall consist of glass spheres water tight and installed on a plastic base (reflectors TYPE B) which shall be fixed on a metal plate at least 1 mm thick, galvanized according to the corrosion protection requirements for the rest of the metal guardrail.

The illuminance intensity coefficient for the various types of reflectors shall be measured according to the specification “Technical Instructions for Safety Guardrails”. The requirements for TYPE A reflectors are considered to apply also for the membranes of DIAMOND GRADE type or similar.

On each face of a safety metal guardrail (for the central median barriers there are two faces) a double reflector (one face red and one face silver-white) shall be provided (unless otherwise specified in the special terms of tender).

The reflectors shall be installed at 12 m maximum spacing. For the case of safety guardrails being constructed on projects with poor geometric characteristics and restricted visibility conditions, the reflectors spacing along the guardrail shall be a function of the visibility conditions, according to the requirements of para. 1.15.1.5 of subchapter 1.15 of DIS concerning delineators (tables 1 and 2). In this case rounding of the given spacings may be done, so that the reflectors may be installed at the locations of the guardrail posts.
The metal plate on which the reflector is fixed shall have a suitable fixing arrangement (groove instead of circular hole) so that it will be fixed on the central fixing bolt of the sheet metal, in a way that its replacement will not require removal of this bolt.

c. Alternatively, at difficult location of central median safety guardrails (on road sections with increased pollution risks) it is possible that supplementary rectangular reflectorizing elements will be required (TYPE II reflectorizing elements) being fixed by special support, on the upper guardrail section, according to the draft specification "Technical Destruction for Safety Guardrails" According to this, each face of the reflectorizing element TYPE II shall bear two rectangular reflectorizing surfaces, of yellow color, having each a surface of at least 50 cm2.

The requirements of sub-para 33.1.4.2.b above shall apply in all other respects.

33.1.5 Handrails (and fastening of same)

(1) Whenever required (with the exception of SG-9 and SG-10 guardrail), handrails shall be galvanized heavy-duty steel pipe iso medium (green label) of dia. 21/4". In plan, the handrail axis shall be fixed at a distance of 0.14m from the front of posts (away from the corrugated sheet metal). In elevation, the handrail shall be fixed in a manner ensuring that its top be 1.10 m-high above the adjacent used surface (road or sidewalk).

An extension of the post shall be required for fixing the handrail to its correct position for SFG-4, SFG-12, SG-2, 5G-3 and 5G-6 types of gurdrail, being a U-section of dimensions 120 x 55 x 5mm (similar to the post section). The post extension shall be inclined towards the outside (according to the Standard Road Plan (S.R.P.) and its connection to the post section may be done by electrical welding. Construction of posts is one section (without extension) is desirable. In the upper post section a hole suitable for letting the handrail through shall be provided, which shall be drilled prior to galvanization.
Above the handrail and at a distance of 5 cm. from it, the post shall be rounded and its flanges shall follow such rounding with a view of creating a unique curved surface on the upper side.

(2) For Structure Guardrails SG-9 and SG-10 the handrail constitutes an operative part of the guardrail which contributes to withhold vehicles and is being constructed by a 0140 mm. galvanized steel pipe. For other details the provisions of paras 33.4.9 and 33.4.10 below shall apply.

33.1.6 Structure Guardrail anchoring

(1) Anchoring of (rigid) metal Structure Guardrail -1 (SG-1) on bridges and walls shall be developed according to clause 10 hereof and the pertinent S.R.P. drawings accompanying the specifications of SG-1.

Their calculation shall be done according to the requirements mentioned in para. 1.15.2.2.10.2 of D.I.S.

(2) Anchoring of other metal type Structure Guardrails (SG-4, SG-5, SG-6) shall be done through suitable "anchoring grids" which shall comply to the following

a. To ensure withholding of the impact load for which the posts are calculated.

In the case of industrially produced *"anchoring grid"* the official results of pertinent tests in recognized laboratories are being accepted.
For other cases the Service may request to its sole judgement, to perform tests in laboratories conforming the possibility of the anchoring grid to withhold the design loads.

b. To ensure the possibility of vertical adjustment on-site.

c. To be provided with INTERNAL TREADS (female) on which the fixing
bolts (male) of the post support plate will *be* bolted, after concreting. A REVERSE ARRANGEMENT (through extensions and nuts) WILL NOT BE ACCEPTED.

d. To at least ensure the corrosion protection provided for by clause 31 of the T.C.C., the S.C.C. and or the other terms of the tender.

e. To provide suitable thermoplastic plugs for temporary protection of the grid holes to prevent concrete from entering during casting and thermoplastic covers to protect the nut heads after tightening.

f. To ensure requirements of industrial precision for the dimensions and the construction details in order to avoid problems during the guardrail assembly phase.

(3) For the construction of concrete safety barrier in the form of "low wall" (S.G.-7), this shall be done as "cast-in-place" through the use of formwork and their arrangement shall be monolithically connected to the wall.

(4) For the construction of "composite' structure guardrails on walls_(S.G-8) [through the arrangement of their lower portion of concrete (NEW JERSEY type) and their upper portion in the form of railing] their development shall be monolithically connected to the wall and constructed as "cast-in-place through the use of formwork.

(5) For the construction of concrete barriers (NEW JERSEY type) on bridges (S.G.-9), the concrete shall be casted-in-place monolithically connected to the bridge bearing element (by lineal gripping) with provision of a predetermined crushing surface and loadings according to the requirements mentioned in para

1.15.2.2.10.3 of D.I.S. The need to construct suitable joints, spaced according to the design calculation, for this type of barriers is hereby noted.

(6) For the construction of concrete barriers (NEW JERSEY type) on walls (S.G.-10), the concrete shall be tasted-in-place monolithically connected to the wall with provision of a predetermined crushing surface and loadings according to the requirements mentioned in para 1.15.2.2.10.3 of D.I.S.

33.1.7 Construction of Metal Guardrails

The horizontal alignment of metal guardrails must necessarily respond to the respective Standard Road Plan (S.R.P.) depending on the road project under consideration (motorway, interchange ramps, secondary roads, etc.), and on the specific section of the project (cutting, fill, with or without side ditches, etc.). It must also respond to the remaining specifications and tender conditions.

The vertical alignment of sheet metal guardrails shall be such as to ensure that the top level of the corrugated sheet be 0.75m above the adjacent usable surface.

For Road Guardrails, being installed on an inclined motorway central median, a suitable adjustment of the vertical corrugated sheet metal installation shall be made, in order to deal with the vertical track of the diverted vehicle (reference is made to the German Regulations Richtlinies fur Passive Schutzeinrichtungen an Strassen - R.P.S., figures 15, 16, 37, 38, 39, 40, 41, 81 etc.).

In guardrails supplied with handrail, the top level of the handrail shall be 1.10 m. above the adjacent usable surface (with the exception of S.G.-9 and S.G.-10, in which the special, heavy duty, handrail shall be at 1.14 m. height). For bridges having very big height, the handrail-railing shall be raised, according to the approved design, in order to avoid the fear and giddiness feeling created to certain people from big heights.

Following the erection of posts, the guardrail and its relevant spacers shall be tied onto the posts using suitable bolts. Threading shall comply to the respective regulations NE E 27-113, 27-311 and 27-350, class 5.8 (or similar specifications of EEC-member countries or of the USA). Bolts shall be tightened by application of a torque equal to 150 Np and shall be tested in accordance with sub-clause 10.3.3.6 of clause 10 hereof.
The installation of the reflectors mentioned in the previous para. 33.1.4.2 shall be made together with the installation of the corrugated sheet metal.
Adjoining corrugated sheets shall be assembled at the vicinity of each post so that the latter may constitute the axis of the overlapping sections of the two sheets. All heads of fastening bolts shall be on the front face of guardrails. The final regulation of all components of the assembly shall be by loosening, supporting and tightening of the fastening bolts, excluding any other method. The provisions of the previous sub-clause 33.1.4 shall also apply with respect to bolt drawing.
It is also noted that the assembly of adjoining corrugated sheets must ensure that, in the overlapping section, the overlying (superior, to the road side) sheet must be the one first encountered in the direction of traffic.
All weldings required shall comply to the specifications of volume 66 of the CPC, chapter II (or similar specifications of EEC-member countries or of the USA).

Surfaces requiring final treatment as a result of damages caused or of site performed weldings shall be properly cleaned of grease, rust, etc. and shall receive a zinc-rich paint coat applied under dry conditions. The thickness of such coat shall be no less than equal to that of the adjacent surfaces, in accordance with clause 31 hereof, with the 5CC and the other terms of the tender.

33.1.8 Construction of Concrete Guardrail

1. Concrete SFG and MB guardrails shall be constructed of cast-in-place concrete class B25, through the use of a special equipment with sliding metal form (GOMACO type or similar, heavy duty).

2. In road sections where storm water is accumulated towards SFG or MB guardrails and there is a need to construct drain inlets (e.g. S.F.G.-8, S.F.G.-13, S.F.G.-6, S.F.G.-7), then the storm water drain hole or the recess *("nest")*, depending on each arrangement case, shall be done, on the Contractor's chaise, either through the use of a suitable metal form, or through the use of a removable material after the guardrail construction (e.g. polysterene).

3. In the vicinity of drain inlets, it is possible for the contractor to make use of precast guardrail sections at least 3,0 m. long, provided that suitable measures are taken for the connection (and joint waterproofing) of the precast section with the adjacent *"cast-in-place"* sections

4. Before the construction of *"cast-in-place"* guardrails commences a non-operative trial guardrail section shall be constructed. This trial section aims to ensure the suitability of the concrete mix design, the organization set-up and the suitability of the mechanical equipment to be used for the construction (concrete flow, equipment with sliding metal form for pouring-compaction). It is pointed out that the concrete mix design is mandatory, its expense constitutes a contractor's obligation for which no additional fee is provided and shall be done taking into consideration the type of equipment to be used (e.g. excess of fine sand percentage beyond the appropriate quantity may lead to extreme slump or to extreme deformations of the fresh concrete.

   Concrete safety guardrails S.F.G.-8, S.F.G.-11 and M.B.-6 type shall be reinforced with two 012 St III reinforcing bars, installed at 0.15 and 0.30 below their top, according to the competent S.R.P. Respectively, S.F.G.-13 and M.B.-7 guardrails shall be reinforced with four 012 St Ill reinforcing bars installed at 0.15, 0.30, 0.45 and 0.60 below their top according to the competent S.R.P.

   Reinforcement is of vital importance for the stability ensuring the barrier continuity and is required to be installed at the location shown on the drawings with possible allowance +-3 cm. At locations of bar extensions an overlapping of 0.50 m. is required.

   Following a contractor's request, the Service may approve the replacement of the St Ill reinforcing bar with wire ropes consisting of 3 galvanized wires each 4 mm in diameter. In this case, suitable arrangements shall be provided (guide pipes and/or installation of a guide within the formwork of the laying equipment) in order to maintain the wire ropes at their desirable positions (avoidance of sinking during guardrail concrete placement).

5. In order to avoid flecking due to early concrete hardening the barrier must be protected during construction by spraying its entire surface with a liquid creating a membrane according to clause 6 hereof (sub-clause 6.10).

6. The construction of drying contraction joints is not considered necessary. The expansion joints provided at bridge locations shall be applied also to the safety barrier.

7. Concrete S.G. shall be constructed "in-situ" through the use of formworks, with class B25 concrete (S.G.-7, S.G.-8 and S.G.-10) with the exception of S.G.-9 for which concrete class 845 is required.

8. Concrete barrier surface finishes shall be type r according to clause 6 hereof.

   Surface finishes of the barrier upper surface being constructed with ordinary concreting through the use of wood forms shall be ΠΒ, also according to clause 6 hereof. (Such cases may appear for example in guardrail S.G.-8, S.G.-9, S.G.-10, S.F.G-10).

9. Guardrail construction, in the form of "low war (S.G.-7) shall be made of reinforced concrete class B25 through the use of wood forms and with surface finish requirements type Γ and ΠΒ according to clause 6 hereof.

10. The construction of the NEW JERSEY concrete barriers includes also the supply and installation of rectangular shape reflectors having an area of approx. 50 cm2 which shall consist of weatherproof glass spheres installed on a plastic base (unless otherwise specified in the special terms of tender).

    On each face of a NEW JERSEY concrete safety barrier (for median barriers there are two faces) a double reflector (one side red and one side silver white) shall be provided (unless otherwise specified in the special terms of tender).

    The two reflectorizing surfaces shall be at an approximate angle of 30°.

    The reflectors shall be installed at maximum 12 m spacing along the guardrail. For guardrail sections installed on projects with reduced visibility conditions, the reflectorizing elements spacing shall be reduced according to the requirements of sub para. 33.1.4.2 .b above.

    Fixing of each reflectorizing element on the concrete shall be done by at least two expansion bolts.

    Alternatively, it will be possible to use reflectorizing surfaces made of prismatic reflectorizing crystals of acrylic material tightly weatherproofed, or by special microprism cube corner reflecting sheeting (e.g. DIAMOND GRADE type of 3M).

    The requirements of para. 33.1.4.2.b above apply in all other respects.

33.1.9 Tolerances

Irrespectively of any irregularities occurring in the underlying bearing surface, tolerances in the geometrical characteristics of guardrail construction, (both horizontally and vertically), shall not exceed 1cm from the respective theoretical alignments, throughout the entire length of each unified section.

33.2 SINGLE FACE GUARDRAILS (S.F.G.)

33.2.1 Single Face Guardrail-1 (S.F.G.-1)

It concerns a single-face metal safety guardrail consisting of 1.75m-high steel posts having a U 120x55x5 cross-section spaced at 4.00m and embedded in the ground to a depth of 1.10m, spacers and the specific corrugated sheet metal.
Posts shall be embedded in the ground by the opening of suitable holes (in diameter and depth) using rotational boring (removal of soil), to be backfilled with sand (with the exception of a 0.20m-thick top layer that shall be filled with the same material as that of the final course of the surrounding works, e.g. agricultural soil) and suitably compacted (with vibrating plate) following erection and adjustment of the posts.

Clause 34 : SKID-RESISTANT BITUMINOUS WEARING COURSE (By insertion of pre-coated chippings of suitable hard rock aggregate)

34.1 GENERAL

34.1.1 Definitions

The method for constructing a skid-resistant course by the "insertion of chippings" basically consists of evenly spreading asphalt-coated and almost equally sized chippings of suitably hard aggregate, and of incorporating such surface dressing into the road pavement.
Chippings are evenly spread by a special equipment accompanying the finisher and are incorporated into the hot asphaltic mix/bedding during final compaction, thus creating the desired coarseness of the road wearing surface and covering a substantial part of such surface with an aggregate of superior quality.

34.1.2 Scope – Applications

The present technical instructions concern the construction of a skid-resistant course with "inserted chippings", namely a course of dense bituminous concrete of ordinary aggregates, usually limestone, upon which pre-coated with asphalt and almost equally sized chippings of suitable hard rock are evenly distributed immediately after the course spreading and prior to compaction, and are finally incorporated into the course through compaction.
As this method results in savings of the required hard rock aggregate quantities, it is usually selected for application in areas where the cost of transportation of materials would entail a substantial rise in the overall construction cost.
Compared with skid-resistant bituminous concrete courses, the method of "inserted chippings" presents the disadvantage of a portion only of the road pavement surface being covered with an aggregate of superior quality, and, furthermore, of the difficulty in creating and maintaining a uniform wearing surface due either to uneven initial spreading of the inserted chippings, or to their gradual detachment and coming off. In order to achieve a successful construction of this kind, it is absolutely necessary to strictly observe all relevant requirements (coating of chippings, cleanliness of same, adherence to temperatures, etc.) and to conduct a systematic quality control.
The advantages of the method consist of the possibility to obtain a sufficient macro-structure on a watertight surface course of a high bearing capacity.

34.2 CONSTRUCTION MATERIALS

34.2.1 Chippings

With regard to skid-resistant road surface dressings constructed with chippings inserted on carpets of limestone (most usually) aggregates, the creation and preservation of the pavement surface characteristics (micro-structure and macro-structure) depend almost entirely on the properties of the chippings themselves. The chippings shall result by crushing rock of excellent mechanical properties, shall be extremely clean and shall have appropriate shape of grain.

34.2.1.1 *Grade Analysis*

The chippings shall respond to the grading scale described in the Table that follows

TABLE 1
Grade analysis for nominal size of chippings 10 - 14 mm

Square hole screen aperture (BS)	Passing % (by weight)
28.0 mm	
20.0 mm	100
14.0 mm	90 - 100
10.0 mm	0-15
6.3 mm	0 - 3
0.6mm	0 - I*
0.075 mm (N°200)	0 - 0.5

34.2.1.2 *Cleanliness and Shape of Grains*

Chippings shall result by the crushing of rock having mechanical characteristics as herebelow specified and shall be free of noxious admixtures (clay lumps or flour, organic or other soft and brittle materials). In the case of chippings produced by the crushing of pebbles naturally deposited in rivers or torrents, such pebbles should be of a size retained by a screen having an aperture three times the upper limit of the nominal size of chippings, so that it may be ensured that no less than 90% of the chippings retained by the screen of 6.3mm (1/4") may have at least one crush resulting side, while 75% of them may have two or more such sides.

The shape of chippings shall be as close as possible to the cubic form and shall be controlled through the determination of the flakiness index (as per standard method BS 812/1985, para 105.1), which must never exceed the value of 25.

34.2.1.3 *Mechanical Properties*

Requirements regarding the characteristic mechanical properties of chippings intended for insertion as above are fixed in relation to the anticipated traffic volume, which is either established through the pavement design, when new construction works are concerned, or based on existing traffic conditions, when it comes to the maintenance of existing pavements and are being specified in the project terms of tender.

34.2.1.4 *Bituminous Binder for the Pre-Coating of Chippings*

The coating of the chippings shall be performed in a permanent installation with clean hot bitumen of type 60/70.

The bitumen shall meet with the requirements of specification ASTM D946.

The ratio of bitumen shall be established at the laboratory. The optimum ratio shall be determined as the minimum amount of bitumen allowing the formation of a fine but continuous asphaltic wrapping around all chippings, without entailing any risk of forming agglomerated lumps of chippings during production and storage. With regard to materials having a specific gravity in the range of 2.6-2.8 and normal porosity, this ratio usually varies between 1% and 1.5%, while it may attain the value of 2% when it comes to low specific gravities and raised degrees of porosity.

In the case of using hygrophilous aggregates, an adhesion improving agent should be added to the bitumen, same as in other special cases to be determined by the Service. The type and precise ratio of the improving agent shall be fixed at the laboratory.
Instructions are given herebelow (see sub-clause 40.3.1) regarding correct application of the bituminous coating and storage of chippings, together with laboratory testing methods and pre-coating quality requirements.

34.2.2 Asphaltic Concrete – Bedding for Chipping Insertion

34.2.2.1 Aggregates

Limestone aggregates may be used for the construction of the asphaltic concrete course to form the base for the insertion of chippings. However, in the case of envisaged heavy traffic it would be preferable if aggregates of more appropriate mechanical characteristics were used.
Coarse aggregates must be produced by rock crushing into cube-like forms and must be extremely clean (no clay lumps, organic and other brittle grains). If resulting from the crushing of pebbles, no less than 50% of the grains retained by the screen of 4.75mm (N°4) must have at least one crush-produced side.

Grade Analysis (of the overall aggregate mill

Square			Passing %
12.50	mm	(1/2")	100
9.50	mm	(3/8")	80 - 100
4.75	mm	(N° 4)	55 - 75
2.36	mm	(N° 8)	35 - 50
0.60	mm	(N°30)	18 - 29
0.30	mm	(N°50)	13 - 23
0.15	mm	(N°100)	8 - 16
0.075	mm	(N°200)	4 - 10

34.2.2.2 *Bituminous Binder*

Clean bitumen type 40/50 shall be used for the production of the bituminous mix, or type 60/70 for colder regions of elevations exceeding 500 m.

The asphalt must satisfy the requirements of specification ASTM D946.

For aggregates with a grade analysis shown as above and with an apparent specific gravity in the region of 2.65, the ratio of bitumen usually varies between 6% and 6.5%.

The precise ratio shall be fixed at the laboratory during the conduct of the asphalt mix design.

34.2.2.3 *Mix Design*

The ratios for the introduction of aggregates (coarse, fines), the precise ratio of bitumen and of the adhesion improving agent (if necessary), together with the mechanical characteristics of the bituminous mix shall be fixed at the laboratory according to existing provisions regarding ordinary asphaltic concrete for wearing courses (S.T.S. A265).

34.3 CONSTRUCTION

34.3.1 Pre-Coating and Storage of Chippings

The pre-coating of the chippings is executed in a special mixer provided with specific devices for the accurate checking of the quantity of bitumen as well as of temperatures.

On their way out of the drier. chippings shall be fed into the mixer under temperatures varying between 130°C and 170°C.

Bitumen shall be added at a temperature not exceeding 165°C, and thus the maximum temperature of the pre-coated chippings on their way out of the mixer shall not exceed i 70°C.

The mixing time usually ranges between forty (40) seconds and one (1) minute.

Additional precautions taken with the purpose of averting both the oxidation of the bitumen and the formation of agglomerated lumps by the chippings are as follows :

a. Soaking of the chippings with water immediately upon their discharge from the mixer and stirring up of same by means of a mechanical shovel.

b. Piles up to lm-high on a clean surface.

Pre-coating of the chippings must be conducted no less than 2 days prior to commencing their insertion and a special attention must be paid to avoiding their being contaminated (with dust, rock flour, fine sand, etc.) during storage and transportation, a fact that is bound to affect adversely their adhesion and holding onto the bituminous subgrade.

34.3.1.1 Pre-Coating Quality Control

The bituminous binder shall be tested for any possible overheating and "burning" of the bitumen, while the sufficiency of coverage of the chippings shall be inspected, all with the purpose of ensuring satisfactory adhesiveness of the pre-coated chippings.
Such testing shall be conducted with the method of heated sand, as this is described under the standard method of BS 598 part 3/1985 (para 5). The weight of sand retained during this definition, expressed in grams per kilogram of chippings, shall need to be :

– for chippings of 14/20 mm 40 gr/kg,
– for chippings of 10/14 min 50 gr/kg.

In addition to the above, and during the visual assessment of the coverage with sand, the percentage of grains presenting less than 50% coverage must not exceed 7.5%.

34.3.2 Production and Spreading of the Bituminous Mix

Bituminous mixes intended to the insertion of chippings are produced at the same central plant as that used for ordinary bituminous mixes, in accordance with the conditions and the limitations referred to under the Standard Technical Specification (S.T.S.) A265.

In view of the fact that such bituminous mixes contain a relatively increased percentage of sand (less than 2nim sized grains), attention must be paid to the natural moisture content of the sand and necessary precautions must be taken (covering) with the purpose of ensuring that any fluctuations of moisture content remain minimal.

The need is emphasized for the observance of temperatures.

Any careless increase of temperature during mixing operation must be avoided for fear of the bitumen being tampered. At the same time, the necessary precautions must be taken for containing thermal losses during transportation of the bituminous mix, so that minimum required temperatures may be adhered to in the course of spreading thus ensuring satisfactory compaction as well as adhesion of the chippings.

The minimum temperatures required to be observed during spreading depend on the type of the bitumen used, the course thickness and the prevailing weather conditions. In the usual cases of course thicknesses ranging between 3cm and 4cm, the minimum temperatures required during spreading are as follows :

– for bitumen type 80/100 : 130°C,
– for bitumen type 60/70: 135°C,
– for bitumen type 45150: 140°C.

Operations shall be interrupted in the occurrence of rainfall, of strong wind blowing and of low temperatures (below 10°C).

34.3.3 Spreading of Pre-Coated Chippings

The spreading of the pre-coated chippings is performed by a special self-propelled plant/spreader which follows the finisher at a distance of about 10 meters. Among the various types of spreaders, those with wheels moving out of the lane being worked upon (i.e. Bristowes spreader) are preferable.

Chippings must drop from a reduced height to ensure their even distribution, while the speed of the spreader plant must be about equal to that of the finisher of the bituminous mix.

This operation requires extreme care in order to ensure even distribution of the chippings. Special attention shall be drawn to the zones of longitudinal joints, usually presenting the highest degree of unevenness.

With regard to transversal joints, the bituminous mix finisher must be withdrawn from the lane being worked upon immediately after reaching the working joint, so that the spreading of the chippings may follow without delay.

34.3.3.1 Spreading Ratio

The optimum quantities of chippings spread per square meter of road surface for the two nominal sizes of chippings 10-14mm and 14-20mm and for an aggregate of apparent specific gravity ranging between 2.60 and 2.70 are as follows:

Nominal Chipping Size (mm)	Spreading Ratio (kg/sq.m.)
10 - 14	7 ± 1
14 - 20	10 ± 1

In the cases of materials with different specific gravity and different grain form or size, the precise ratio of spreading per square meter of surface shall he established at the laboratory in accordance with the standard method BS 598: part 3 : 1985 (para 6).

The ratio of "dense" spreading is established with this method, in which chippings shall be in contact to each other on a single-grain course.

The work spreading ratio must not be less than 70% of the "dense" spreading.

34.3.3.2 Control of the Spreading Ratio

In the case of using a mechanical spreader, the definition of the spreading ratio of pre-coated chippings shall be conducted according to the procedure described under the standard method BS 598: part 3: 1985 (para 6.3), while in the case of manual spreading the ratio shall be calculated on the basis of the weight of chippings used divided by the area of the pavement surface covered with them.

34.3.4 Compaction

34.3.4.1 General

With compaction, the warm bituminous mix course with chippings spread on its surface must achieve the required density and mechanical strength for fulfilling structure requirements of the road pavement. On the other hand, compaction must also lead to desired surface characteristics and ensure anchoring of the surface chippings.

In order to achieve the above, a competent selection of compaction equipment shall be required, together with strict observance of temperatures and perfect coordination for the preparation and haulage of the bituminous mix and for the teams of finishing, spreading of chippings and compaction operations.

34.3.4.2 Insertion of Chippings onto the Underlying Bituminous Mix Course

This operation follows the spreading of the chippings and is executed with a roller of smooth cylinders weighing 8-10 tons each, equipped with a wheel watering arrangement for averting adhesion of the chippings onto the wheels.

One roller pass is usually sufficient to ensure satisfactory insertion.

At the phase of the chipping insertion, it is important that temperature be not above 140°C for bitumen type 40/50, or above 135°C for type 50/60, in order to avoid the undesired full sinking of the chippings, as well as that it be not below 120°C, because adhesion onto the underlying bituminous mix course would Then risk being unsatisfactory.

34.3.4.3 Final Compaction

After initial compaction aiming at the insertion of chippings, intensive compaction of the bituminous concrete follows in accordance with the regulations and the requirements for ordinary bituminous concrete of closed type (see S.T.S. A265). Smooth cylinder rollers (plain or vibratory) may be used for ensuring a satisfactory degree of compaction, or even rubber-tyred rollers, as long as the latter do not cause separation of the chippings to a substantial extent.

With a view to achieving a smooth wearing surface and to replacing any dislocated chippings, a roller with smooth cylinders weighing 8-10 tons shall be used at the final phase and prior to the temperature dropping below 80°-85°C.

34.3.5 Opening to Traffic

Appropriate cleaning must precede the opening of the road surface to traffic in order to avoid that any chippings be hurled away if not properly inserted into the underlying bituminous course. In no case should traffic be allowed on the road prior to the temperature dropping below 50°C. In case of emergency, this may be achieved by spraying the road surface with water.

It is also advisable to impose a reduced speed limit in the first days of the road operation with the purpose of eliminating any risks of loose chippings being detached and hurled away.

34.4 QUALITY CONTROL

34.4.1 Control of Materials

General principles applicable to ordinary bituminous mixes (see S.T.S A265, paras 6 and 7) shall apply to the control of materials used in the preparation of the bituminous concrete.

Attention is particularly drawn to the mechanical characteristics and other properties of the chippings, whose quality shall be determinant factor to surface characteristics of the skid-resistant course.

A summary of the laboratory tests to be performed is given herebelow :

a. Bituminous Binder

The provisions of S.T.S. A200 combined with specifications ASTM D946 and ASTM D3381.

b. Chipping

— grade analysis	BS 812 : part 103/1985
— filler (finer than 0.075mm)	ASTM C-117
— grain form (flakiness index)	BS 812: part 105.1:1985
— polished stone value (PSV)	BS 812 : part 3: 1976
— aggregate abrasion value (AAV)	BS 812: part 3 : 1975
— wear as per Los Angeles (LA) :	ASTM C-131

c. Bituminous Concrete

The controls of the materials used in the preparation of the bituminous concrete shall be conducted in accordance with the provisions applicable to ordinary bituminous mixes (S.T.S. A265).

34.4.2 Controls during Construction

a. Chippings

—	pre-coating quality	BS 598 : part 3: 1985
—	bitumen ratio	AASHTO T-164
—	spreading ratio	BS 598 : part 3: 1985

b. Bituminous Concrete

The controls for the good operation of the central production unit, for the mechanical characteristics and for the homogeneity of the bituminous concrete produced shall be in accordance with the provisions regarding ordinary bituminous mixes under para 7 of the Standard Technical Specifications (S.T.S.) A265.

Attention is drawn to temperature control during pre-coating of the chippings, production of the bituminous concrete, as well as in the course of the operations of spreading/insertion of chippings and of compaction. The procedure of standard method BS 598 : part 3/1985 (Appendix A) is recommended to this effect.

34.4.3 Controls and Requirements with regard to the Final Course

Upon application of the final compaction, the bituminous course shall be tested for verification of compliance to the following general requirements and to the special requirements contained in the work contract.

Elevation

– The final elevation shall comply to the design longitudinal section of the road alignment combined with the specified camber falls or crossfalls. No deviations from these shall be allowed if exceeding ±6mm.

Evenness

– Corrugations or other local irregularities detected with a 4m-long straightedge placed parallel to the road axis shall not exceed 5mm.

– Deviations found with a 3m-long straightedge placed at fight angle to the road axis shall not exceed 3mm.

– In cases of major projects, longer corrugations as well as the overall driving comfort shall be measured by means of a hump-integrator type gauge. With this method, the index of irregularities must not exceed 140cm/km.

Thickness

– The course thickness shall be verified by the sampling of cores at a frequency of no less than three core samples per 4000 square meters of the road surface.

– The mean value of all thickness measurements shall be equal to or exceed the thickness specified in the works contract.

- No single value shall be allowed to deviate from the specified thickness by more than ±10%, unless otherwise specified by the Service in cases of new pavements added onto existing underlying bituminous courses.

Degree of Compaction

- The mean value of the compaction degree for types 1 and 2 shall not fall short of 98%, while no single compaction value shall be less than 95%.

- Tests are conducted according to the ASTM D1188 method on the same specimens sampled for thickness verification, after removal of the pre-coated chippings.

Surface Structure

- The mean depth of structure of the final surface shall be tested either by the sand method as per BS 598: part 3/1985, or by the ASTM E965-83 method, or by any other approved method no more than 7 days after completion of the construction and prior to the road being opened to traffic.

- Tests for each separate lane shall be conducted on points spaced at no less than 50m and lying at distances of no less than 30cm from the edges of the road pavement.

- The recommended minimum mean depth of structure for roads with average speed of traffic exceeding 80km/hr is 1.5mm.

Clause 35 : SOIL IMPROVEMENT BY TREATMENT WITH CEMENT AND LIME

35.1 DEFINITION

The improvement in the mechanical properties of soil resulting from its being mixed with relatively small quantities of lime and/or cement, compacted at optimum moisture content and cured for a specific length of time is known as soil treatment (improvement of soil by treatment) with lime and/or cement.

35.2 MATERIALS

35.2.1 Cement

Cement shall conform to the requirements of the "Cement Regulation for Concrete Works".

35.2.2 Lime

Lime shall be of common, commercial, industrially produced type delivered in paper bags or in bulk to a silo.

35.2.3 Water

Water for mixing and curing shall conform to Standards.

35.2.4 Soil

Soil material shall be fine-grained, clayey soil with a high plasticity or swelling factor and a low content in large-size stones.

Stones larger than 7.5 cm in diameter constitute a source of problems in mixing and in the grading of layers. Also, they may cause damage to the mixing plant. Stones larger than 7.5 cm shall be removed.

35.3 MIX DESIGN

Depending on the type of soil and on the degree and type of improvement sought for its mechanical properties, the mix design determines the composition of the mix, i.e. the ratio of the stabilizing agent or agents (lime or cement) and the moisture content of the mix during compaction.

Unless different or additional requirements are specified by the Special Conditions of the Contract or by the other tender documents due to the special nature of the works or of the properties of the soil to be used, the mix of soil and stabilizers compacted to 100% of the standard compaction test density (E 105-86 method 10) shall have a CBR value at 7 days

(3 days' curing in an airtight plastic bag and 4 days' soaking) of not less than 5% and a swelling of less than 2%.

The minimum ratio of lime is 2%, white that of cement is 3%, both of the dry weight of the soil material.

35.4 CONSTRUCTION

1. Construction of the course shall be carried out in accordance with STS 0 164,with the following modifications or additions :

2. When both lime and cement are used as stabilizing agents, the addition of the lime to the mix shall precede that of the cement, so that the former may assist in the fragmentation of the soil.

3. The spreading of lime or of cement on the course of soil to undergo improvement, the watering, mixing and compaction shall all be carried out as specified in STS 0 164 (para 6.1). Spreading of cement or lime shall not take place during periods of strong winds that could carry away substantial quantities of the stabilizing agent. If the Service sees fit in such cases, he may instruct suspension of the works for the duration of the unduly windy period in question.

4. During the mixing of soil and lime, water shall be sprinkled uniformly over the mix, as necessary to ensure a uniform moisture content equal to the optimum for compaction, or slightly below the optimum, in order to facilitate the fragmentation of the soil and the soil/lime mixing process.

5. Should a degree of fragmentation as defined in para 6.1 of the STS 0 164, equal to 60%, not be achieved after 4 passes of the stabilizing equipment, work shall be stopped and the course shall be rolled with one pass of a smooth drum statical roller weighing 2.7 tons per meter of drum width, or with one pass of a rubber-tyred roller weighing 1.0 ton per wheel. Sealed as above, the course under treatment shall be kept moist for 72 hours. To this end, it shall be watered once or twice a day, if necessary.

6. At the end of the above 72-hour period, the material shall be scarified and, if necessary, it shall be sprinkled uniformly with water to the point of reaching optimum moisture content.

   Fragmentation tests shall be carried out (3 tests per 200 cu.m. of treated soil) and, as long as the degree of fragmentation is not less than 60% and that a uniform mix has been achieved, compaction of the course shall commence (in case of treatment with lime alone), or the specified quantity of cement shall be spread over the course (when cement and lime are combined for achieving soil improvement).

   Should the degree of fragmentation be less than the one specified, the Contractor shall need to make use of heavier equipment for crushing and mixing.

7. Should work on the trial section (see section 15 herebelow of this sub-clause) prove that the Contractor's equipment is capable of ensuring the specified degree of compaction without waiting for the lapse of the abovementioned 72-hour period, and also should the soil treatment process include the use of cement, the latter may be applied directly after the mixing of lime with soil, subject always to the time restrictions of section 10 herebelow.

8. In all cases, the addition of cement to the mix shall not be undertaken if the degree of fragmentation does not exceed 60%. Furthermore, the moisture content of the mix shall not fall short of the optimum by more than three (3) percentage points.

   Water shall be added uniformly during mixing in the form of fine spray, in accordance with para 6.1.4 of STS 0 164, to ensure optimum moisture content for the mix and to make up for any losses due to evaporation.

   Before work on compaction commences, the mix shall have acquired uniformity and shall be at optimum moisture content with a degree of fragmentation of not less than 80%.

9. Lime shall not be left exposed to the open air for a period exceeding 6 hours.

   To this end, the time elapsing between start of mixing and start of compaction (whether temporary, to seal a course as in section 5 hereabove, or final) shall not exceed 6 hours.

10. When mixing with lime, or with lime and cement, has been thoroughly carried out, grading and compaction shall be undertaken in accordance with paras 6.15 and 6.16 of STS O 164.

    The mixing operation shall be completed within no more than 2 hours from the addition of cement.

    Work on compaction shall follow immediately without delay and shall be completed within a period of time not exceeding 2 hours. Total time from the addition of cement to the mix up to the completion of compaction shall not exceed 4 hours for an ambient temperature in excess of 26°C, and 6 hours for temperatures falling below 26°C.

11. The completed course shall be protected from loss of moisture. It shall be either watered at frequent intervals, or covered with a layer not less than 10cm-thick of material belonging to the next (superior) course, or covered with waterproof plastic sheeting overlapping by not less than 30cm at edges and positioned in a safe manner against the wind blowing it away, or sealed with an asphaltic emulsion coating in accordance with para 6.4 of STS O 164.

    Traffic shall not be allowed on the completed course for at least 4 days.

12. The thickness of the compacted course of soil treated with lime or with lime and cement shall not exceed 25 cm. Should the thickness proposed for improvement exceed 25 cm, the soil treatment shall be carried out in layers 10 cm to 25 cm thick.

13. When the depth of the soil to be improved by treatment is considerable, and in order to comply with the thickness limitations imposed by the preceding section (sub-clause 4.1.4, section 12), the soil shall be excavated leaving at the bottom a 25cm-thick layer of material for treatment. Excavated material shall be stacked along either one or both edges of the strip undergoing treatment, or in accordance with the Special Conditions of the Contract (SCC) or with the Supplementary SCC, or with the other tender conditions. The soil in this course shall then be scarified, to be followed by the spreading of the lime and by the mixing, as specified in sections 2, 3, 4, 5 and 6 of this sub-clause.
    When the specified soil treatment involves the use of cement, the latter is applied (section 8 hereabove) following a thorough mixing of soil and lime and subject to

the degree of fragmentation having reached 60%. Otherwise, the procedure set forth in sections 5 and 6 hereabove shall be followed.

The course is then graded and compacted.

The course is maintained moist through frequent watering or is covered with the soil that is to form the next (superior) course. The thickness of such covering shall be not less than 10 cm. Before the covering is applied, the surface of the compacted course shall be adequately watered.

In the above manner, the course shall be protected against loss of moisture and against the effects of traffic in accordance with section 11 hereabove.
At the expiration of the specified period, work may commence on the treatment of the overlying course.

14. The following verification controls shall be conducted in the course of soil improvement works

    a. Verification of the thickness of scarified soil.

    b. Verification of the soil natural moisture content prior to the addition of water.

    c. Verification of fragmentation prior to the start of compaction, for every section. At least 3 fragmentation tests shall be conducted on random samples of the mix for every section due to be compacted and for at least each quantity of 100 cubic meters of soil that has been improved by such treatment.

    d. For each section in which cement or lime is to be used, and for at least each quantity of 100 cubic meters of soil to be treated, not less than 3 checks shall be conducted of the quantity of lime or of cement being added.

       Where a mechanical distributor is used, a plastic sheet or tarpaulin or a suitable open container of known surface area shall be placed on the course surface, and the quantity of stabilizing agent spread on it shall be collected and weighed following the pass of the distributor.

       Where the stabilizing admixture is distributed from bags opened on the spot, verification tests shall focus on the accurate positioning of bags over the course surface.

    e. Verification of the thickness of the mix course using a suitable ruler. Checking shall be continuous, in order to ensure that the compacted course thickness is as specified.

    f. Verification of the observance of time restrictions set down in sections 9 and 10 hereabove.

    g. At least three tests for moisture content of the mix carried out prior to starting compaction on random samples taken from each section to be compacted and for each quantity of not more than 100 cubic meters of mix prepared.

h. Three random samples shall be taken from the mix that is ready for compaction or from each quantity of not more than 100 cubic meters for the preparation of an equal number of specimens compacted to 100% of the standard compaction test.

   Such specimens shall be cured and tested as specified under sub-clause 41.3. After 7 days, the CBR value of these specimens must be no less than 5%, while their swelling must not exceed 2%.

i. At least three density tests shall be carried out daily on each quantity of 100 cubic meters or on each section that is to be compacted. The mean value of the densities checked shall be no less than 100% of the one achieved in the standard compaction test, while no single test result shall be accepted if less than 98% of same.

   The thickness of the compacted course shall be also checked during density testing. No deviation in excess of 2.5cm shall be permitted.

j. Verification of adherence to requirements regarding curing of the course.

15. No more than ten (10) days prior to embarking upon the construction works, the Contractor shall prepare a trial section of either 250 square meters or 60 cubic meters (whichever provides the largest area) using the actual soil to be treated, the stabilizing agents in the specified ratios, the maximum course thickness to be actually constructed and the plant and personnel to be employed in the implementation of the main soil treatment works. All verifications and tests specified in this clause shall be carried out to ascertain the Contractor's ability to construct (with the plant available with him) the course to the specified degree of fragmentation, density, CBR values, uniformity of mix and, in general, according to all requirements of this clause and of the other tender conditions.

    No work may commence on the main project before the Contractor obtaining the Service's approval to this in writing. Such approval shall be granted only upon satisfactory conclusion of the tests on the trial section, and this shall be no later than 10 days after the completion of the trial section.

    Should such tests prove satisfactory, the trial section shall be allowed to be incorporated into the Contractor's main works.

35.5 MEASUREMENT AND PAYMENT

The Works shall be measured in cubic meters of fully completed construction unless otherwise provided for in the Special Conditions of the Contract and the other tender documents.

Course thicknesses shall be determined from levels taken over the surface of the subgrade and, subsequently, over the final surface of the treated course.

Payment shall be made per cubic meter of fully completed and measured course and shall include for all and every cost for quarrying, scarifying and piling the soil along either one or both edges of the strip being treated, its removal therefrom and spreading into position in the works as specified in the drawings. Also for supplying on site cement, lime and water and for mixing, fragmenting, compacting and curing. Also for any temporary compaction necessary to seal the course and for rescarifying and mixing after 72 hours. For all necessary transportation and lay-days and for every cost (for work or materials) specifically mentioned or otherwise, necessary to the full and proper completion of the works in accordance with the requirements of the present clause.

Clause 36 : SHOTCRETE (GUNITE)

36.1 SCOPE

The work covered by the present clause includes the supply of all labour, materials and equipment, as well as the execution of all works required with a view to producing and applying shotcrete (gunite) on the works, as shown on the drawings of the approved design or as designated by the Service.

36.2 DEFINITIONS

By the term of "shotcrete" is implied the concrete applied on a surface by ejection through a gun (nozzle) in a manner permitting the formation of a layer of concrete on the said surface. By the term of "bouncing" are implied the shotcrete ingredients that bounce back from the surface of application and are not finally incorporated in the layer applied.

36.3 GENERAL

The methods and execution of the work required for the implementation of shotcrete shall conform to the best modern practice and be as herein specified. Shotcrete shall be applied onto the works at the times and to the extent, places and thickness as shown on the drawings or as herein specified or as suggested or approved by the Service, depending on the existing conditions and on the rock conditions.

36.4 MATERIALS

Shotcrete shall consist of cement, fine and coarse aggregates, water and approved admixtures, as herein specified. Cement, water, aggregates and admixtures shall comply to the requirements of the present clause as well as to those of the Technical Specifications clause regarding concrete.

Coarse and fine aggregates shall conform to the grade analysis given herebelow, unless otherwise approved by the Service.

Size of American standard screen of square hole	Fine Aggregates	Coarse Aggregates	
		Size N°8 up to 3/8"	Size N°4 up to 3/4"
2"	-	-	100
3/4"	-	-	90 - 100
1/2"	-	100	-
3/8"	100	85 - 100	20 - 55
N° 4	95 - 100	10 - 30	0-10
N° 8	80 - 100	0-10	0 - 5
N°16	50 - 85	0 - 5	-
N° 30	26 - 60	-	-
N° 50	10 - 30	-	-
N° 100	2 - 10	-	-

The water content of aggregates at the moment of their introduction into the mixture shall be less than 5% of the weight of the kiln dried aggregates. The air used for the pneumatic ejection of shotcrete shall be clean and free of any oil traces. A quick setting agent shall be added to shotcrete, such as Sigunit of Sika manufacturer, or a similar approved admixture. A further number of admixtures may be used by the Contractor upon the Service's approval, in order to meet requirements of specifications ASTM C494.

36.5 SHOTCRETE MIX DESIGN

The class of shotcrete to be used at each specific point of the works shall be determined by the Service. Cement, aggregate and admixture ratios required for each class of shotcrete shall be proposed by the Contractor and approved by the Service.

Aggregate ratios for each class of shotcrete shall conform to the recommendations of ACI 214, with a view to achieving the specified crushing strengths, as given herebelow

Class of shotcrete	Grade analysis of coarse aggregates	Minimum crushing strength (l_c_Wcm^2)	
		8 hours	28 days
1	3/4" - N°4	40	285
2	3/8" - N°8	40	285
3	Fines only	40	285

The minimum crushing strength shall be deducted from cube crushing test results, as described herebelow. No shotcrete mix shall be used in the works unless previously approved by the Service. Mix ratios shall be amended to comply to the Service's instructions, with the purpose of confining "bouncing" action to the minimum possible.

The Contractor shall keep the Service informed on any such amendment of mix ratios.

36.6 SHOTCRETE QUALITY CONTROL

With a view to obtaining approval for the proposed mix design, the Contractor shall execute no less than three (3) sample bays with each mix for tests to be conducted by the Service at least thirty (30) days prior to the commencement of any shotcrete application onto the works or prior to the approval of a new admixture or when a new equipment is proposed for use. Also when, in the opinion of the Service, shotcrete is scheduled for application in compliance to the specifications hereof. In general, three (3) test bays shall be required per fifty (50) cubic meters of scheduled shotcrete application, with the purpose of conducting the typical quality control.

The three-bay sets, each for the approval of a mix design and for the typical quality control, shall result by one downward spraying onto a horizontal surface, one spraying onto a sloping or vertical surface, and one upward spraying onto an overhead horizontal Sample bays for the quality control of shotcrete and for determining the competence of proposed admixtures shall be executed as herein specified and conforming to the Service's instructions. The Contractor shall make available all required installations, equipment, materials and the necessary labour and shall conduct all relevant operations with a view to obtaining representative sample bays of the proposed quality of shotcrete. Sample bays shall be executed inside approved square wooden frames of lm side and 10em-deep having rigid base and being safely fixed on a rock surface similar to the one proposed for shotcreting or on a different approved surface, after wetting the frame and by spraying shotcrete on to the surface enclosed by it in the manner herein specified and using the same mixing and application equipment as that proposed for use in the works. All bays, no less than 8cm-thick, shall be executed in the presence of the supervisory staff and be left undisturbed where applied until final setting of the shotcrete.

Sample bays and the frames used shall be transferred by the Contractor to the site laboratory immediately upon final setting and in a safe manner in order to avoid any damage. The Service shall establish the crushing strength of the shotcrete by the crushing of 10cm diameter cores drilled through the sample bays directly prior to the tests. Six (6) 10 cm diameter core specimens shall be drilled from each bay perpendicular to the bay surface about 48 hours after spraying of the shotcrete. Drilling of the cores shall keep off any existing reinforcing rods and be at distances no less than 10cm from the bay edges. Specimens shall be stored with their ends covered and tests shall be conducted in compliance to the specifications ASTM C-192. Specimens shall be crushed as follows :

- 1 sample core at the age of 3 days,
- 2 sample cores at the age of 7 days,
- 3 sample cores at the age of 28 days.

Whenever required by the Service, a set of two 10 cm diameter core specimens shall be drilled out of selected places of shotcrete application and shall be crushed at the age of 28 days, same as specimens from the sample bays. Holes left by the core taking shall be filled manually with a suitable mix similar to the one of the shotcrete sampled.

Crushing strength requirements shall be deemed to be met for each set of two samples aged 28 days, if :

a. the crushing strength of each sample is proved to be equal or greater than that specified for the age of 28 days, or

b. their average crushing strength is equal or greater than that specified for the age of 28 days, and the two values differ by less than 20% of the average strength.

If the tests conducted by the Service prove that the shotcrete fails to meet specified requirements, the Contractor shall be bound to take the necessary measures as instructed by the Service, including: interruption of shotcrete application complying to the mix tested, a series of mix tests aiming at proving the acceptability of the mix proposed, sampling of in-situ test specimens by the Contractor in the form of 10 cm diameter cylinders, etc.

Any amount of shotcrete that proves to be non-compliant to a specification requirement shall be demolished and replaced in accordance with the Service's instructions.

36.7 PLANT AND EQUIPMENT

Prior to the plant and equipment related with the conduct of shotcrete operations being forwarded to the works site, the Contractor shall advise the Service about the manufactures and models of all relevant items he proposes to use, together with all other machinery required for shotcrete construction. All such equipment and plant shall need to be approved by the Service.

All plant and equipment required for the preparation, mixing and application of shotcrete shall be maintained clean and in good operating condition throughout the duration of the construction works. Preparation and mixing plant shall comply to relevant requirements of the present clause of the Technical Specifications.

Shotcrete application equipment shall be of sufficient capacity allowing to minimize delays in excavation and other works. The equipment shall provide for the full and uniform mixing of the quick setting agent directly prior to application.

The Contractor shall ensure the supply of the shotcrete application equipment with sufficient quantities of air and water, as specified by the equipment manufacturer and in accordance with the Service's instructions. If the operation of the shotcrete application equipment fails to satisfy the Service, the Contractor shall proceed with all necessary repair work or replacements. The Service may order stoppage of shotcrete application until compliance of the Contractor to the former's instructions.

In all areas of excavations, the Contractor shall ensure the availability of sufficient equipment for the application of shotcrete on any front. of excavations, as established in the present Technical Specifications.

36.8 SPECIAL TRAINING OF OPERATORS

Gun operators shall have adequate previous experience in the application of shotcrete with coarse aggregates, or shall be working under the direct guidance of a foreman or trainer having such experience. Upon the Service's requirement, each work team shall prove its acceptable experience in the application of shotcrete by the performance of such work on vertical and overhead test bays prior to the commencement of application operations proper.

Acceptable shotcrete application shall consist of dense concrete of uniform consistency free of substantial gaps of bounced materials as well as of obviously weak pockets of non-adhering layers. Gun operators shall be shooting concrete of uniform cohesiveness and with the largest possible moisture content that can be permitted without causing problems of layers being detached from the rock. The gun shall be held at a specified position and distance in a manner ensuring that the beam of the fluid material hits the rock surface from the shortest possible distance and at right angle. The completed work shall not be allowed to feature gaps of bounced materials or pockets of aggregates. Bounced

36.9 SHOTCRETE_APPLICATION IN COLD WEATHER

No shotcrete application shall be permitted when ambient temperatures drop below 0°C. In such cases, the Contractor shall take all necessary precautions for shotcrete to be maintained at a temperature above 0°C for no less than five (5) days after application.

36.10 SURFACE PREPARATION

When shotcrete application is scheduled for execution onto excavation surfaces resulting immediately after boring or blasting, such surfaces shall be prepared first by lightly disengaging and throwing away all loose materials, in accordance with the Service's instructions. Fractured and faulty clay materials shall be removed to a depth fixed by the Service for allowing sound shotcrete application. Subsequently, all surfaces scheduled for shotcrete application shall be properly cleaned with compressed air or water jetted thereupon or with other means approved by the Service with the purpose of removing any remains of dust, mud, debris, oil, loose pieces, together with any other injurious substances.

When water leakages are found through the rock proposed for shotcrete application and that the water ingress cannot stop solely by the application of shotcrete, such amount of water shall be moved away from the area by blocking its vein, or shall be diverted by means of drain pipes, collectors or other approved means, thus ensuring that the shotcrete remain unaffected by the action of water either through infiltration, hydrostatic pressure or erosion.

Any shotcrete application scheduled for superposition of a subsequent layer shall be first let to attain initial setting and then cleaned from all surface cement discharges, loose materials, dirt or other injurious matter and bounced materials using ordinary brooms, water pressure or other means approved by the Service. Subsequent layers shall be applied prior to the final setting of previous shotcrete application.

At any time during surface preparation, the Service may instruct the Contractor to apply shotcrete on single surfaces prior to proceeding with the remaining surface preparation.

36.11 MIXING AND APPLICATION

36.11.1 Mixing

Prior to mixing, the quantities of shotcrete ingredients shall be checked by weighing. Aggregates shall be fully mixed, free of water, before being introduced into the shotcrete application plant. Cement shall be added no sooner than one (1) hour prior to implementation. Any mixtures prepared but failing to be applied within one (1) hour from the introduction of cement shall be discarded. The quick setting agent shall be added at the precise specified ratio.

36.11.2 Application

The class of shotcrete shall be as ordered by the Service. Shotcrete shall be applied exclusively in the presence of the Service's representative and only where instructed or approved by the Service.

Delays of shotcrete application in relation to each circle of advancement of underground excavations shall depend on the conditions of the exposed rock, as approved or as instructed by the Service.

Shotcrete application on open air surfaces shall not be executed if, in the Service's opinion, such work cannot be successfully performed due to adverse weather conditions, unless the whole area of the works execution may be sufficiently covered for protection and appropriate curing conditions can be ensured throughout the required curing period.

Any reinforcing rods shall be fully covered by shotcrete. The minimum cover shall be 15 mm from the surface of the rock and 25 mm from the final surface of the shotcrete. Care shall be taken to ensure that no voids are left in the back of the reinforcing rods.

The Contractor shall develop processes and operations to the satisfaction of the Service, with a view to ensuring :

- minimum bouncing effects,
- avoidance of gaps left by bounced materials on the completed shotcrete surface,
- the smoothest final surface possible,
- avoidance of cavities in the mass of shotcrete,
- minimum number of cracks caused by setting contraction,
- satisfactory adherence of the shotcrete onto the rock or other surface,
- qualities presenting maximum possible strength against frost.

Flow of the material from the gun (nozzle) shall be continuous and even, while the rate of application on any surface shall be uniform. Any loose projections, sand pockets, moist areas or other defects shall be removed and restored as herein specified.

After commencement of shotcrete application operations on any area, the Contractor shall be bound to establish, in close collaboration with the Service and as part of the procedure of initial application, shotcrete application processes that shall ensure the production of first quality results, with a minimum degree of bouncing effects.

Such processes may include minor amendments to the mix ratios, if necessary, the definition of acceptable surface formation, course thicknesses and the quantities to be ejected from the gun (nozzle) per unit area of the rock or per tunnel length unit, as required by the Service.

The quantities of shotcrete to be ejected from the gun shall be determined on the basis of the mean thickness of shotcrete shown on the approved design drawings, or as required by the Service following correct measurement of the bouncing effect. Since shotcrete application processes are established, the subsequent operations shall be conducted accordingly.

If required by the Service, a course thickness in any area shall be verified either by the penetration of a rod immediately upon completion of the shotcrete application, or by the fixing of nails of predetermined length onto the rock prior to application, or by any other means approved by the Service.

Shotcrete shall be applied by consecutive layers and each layer shall be structured with various passes of the gun over the working surface in a unified continuous operation. If, for any reason whatsoever, flow from the gun is discontinued, such gun shall be held by the operator far from the working surface until a continuous flow is resumed.

The gun shall be held at a distance from the working surface ranging between 60 cm and 150 cm. In general, it shall be held at right angle to the surface of application. However, when shotcrete is applied onto a mesh reinforcement, the gun shall be held even closer and tilted at a slight angle in order to facilitate incorporation of the mesh and removal of the bounced material.

In the case of class 3 shotcrete application with a total thickness exceeding 25 mm on vertical or overhead surfaces, shotcrete shall be applied in two or more layers, each with a thickness not exceeding 20 mm. With regard to class 1 and 2 shotcrete application, the thickness of each single layer shall not exceed 50mm, while in altogether fiat or slightly inclined surfaces the individual layer thickness shall not exceed 90 mm.

If the total thickness of shotcrete exceeds 80 mm, the mesh shall be fixed about half-way and shall be anchored onto the underlying course by means of anchor bolts_

When shotcrete is applied onto vertical or steeply sloping surfaces with the exception of vaults or tunnels, application shall commence at the lowest point and the shotcrete course shall be structured in horizontal bands until coverage of the whole surface. The ends of shotcrete surfaces not scheduled to receive any further layer shall be formulated into clear lines sloping at 45° in relation to adjoining surfaces.

In the case of weepholes bored through the rock surface for drainage purposes, or of instruments fixed on rock surfaces scheduled for shotcrete application, the Contractor shall take all necessary precautions to avoid blocking of such holes or damaging the said instruments.

When shotcrete application is to take place near existing structures, the Contractor shall ensure that no damage is caused to such structures and shall make all necessary arrangements for protecting their surfaces against and prior to such operation.

In areas where seepages of groundwater from joints or springs is affecting the works, the Contractor shall install drain pipes and shall seal continuous joints prior to proceeding with the shotcrete application. if moist spots appear on surfaces of set shotcrete, the Contractor shall bore holes of limited depth with the purpose of relieving pressures.

Any defective spots on shotcreted surfaces presenting problems of poor compaction or of lack of cohesion, indicating dryness (segregation), voids, sand pockets, swellings or inadequate compressive strength shall be cleared of the shotcrete applied and a new course of shotcrete shall be applied over an area no less than 30x30cm, as approved by the Service.

No blasting operations of underground works shall be permitted for a period of two (2) hours from application of shotcrete within a distance up to 30 m from the front of operations.

36.12 BOUNCING EFFECTS

Bounced materials shall be removed and rejected prior to the application of subsequent shotcrete layers or of shotcrete on adjoining surfaces, as instructed by the Service. Bounced materials shall not be re-used. Special attention shall be given to avoiding accumulation of bounced materials along the joints of walls to floors, both in underground and in open air constructions.

The Contractor shall make all effort possible to minimize the effects of bouncing. Should bouncing be deemed by the Service to be excessively pronounced, the latter may require the Contractor to review mix ratios or application processes or to take any other measures deemed necessary by the Service in order to restrict bouncing to a reasonable percentage, which should not exceed 15% or 35% for open air or underground excavations respectively.

36.13 CONSTRUCTION JOINT$

Construction or working joints shall be as approved or required by the Service, sloping at 45° in relation to the adjoining surface of shotcrete application, with clear-cut edges. Prior to shotcrete application on the adjoining surface, the sloping part and adjacent shotcrete shall be prepared as specified under sub-clause 42.10 hereabove.

36.14 REPAIR WORKS

Before application of any subsequent shotcrete layer, each layer previously applied shall be inspected for any existing gaps (swellings) in a manner as it may satisfy the Service.

The Contractor shall be bound to repair all areas presenting air or sand pockets or faults, or being detached, as well as any other area of shotcrete judged defective by the Service, by removal of the defective shotcrete up to the sound rock or shotcrete surface, by preparing the surface as herein specified and by re-application of shotcrete in a mariner satisfactory to the Service.

36.15 CURING

Upon appearance of the first dry spots on the surface of any shotcrete layer, such layer shall be sprayed with water no less than once every four (4) hours or shall be otherwise cured in a manner satisfactory to the Service for a period of at least seven (7) days. No membrane curing shall be accepted unless approved by the Service.

Clause 37 : SKID-RESISTANT COURSE OF ASPHALT CONCRETE

37.1 GENERAL

37.1.1 Definitions

The skid-resistant course of asphalt concrete is a wearing course of high mechanical strength and, at the same time, of excellent surface characteristics.

The asphalt concrete used in the construction of the skid-resistant course is a strictly controlled asphalt mixture produced hot in a permanent plant of hard rock aggregates and clean asphalt for hot application (spreading).

37.1.2 Scope - Applications

The present technical instructions concern the construction of a skid-resistant wearing course of asphalt concrete with loose or dense composition, as well as the construction of porous bituminous carpets. Skid-resistant courses herein described are applicable to new constructions, as well as to final wearing courses in the renewal and maintenance of existing road pavements. Targets achieved include the construction of skid-resistant wearing courses and, at the same time, increase of the pavement bearing capacities of major roads with demanding requirements and relatively high traffic volumes.

Compared with the chipping insertion method, the advantage of the skid-resistant asphalt concrete courses is a safer assurance of a uniform wearing surface. In the case of application on existing road pavements, and given that the course is usually of limited thickness, the adequacy of the existing pavement bearing capacity must be ensured and a proper preparation of the bearing surface must precede.

In the usual cases of existing pavement deterioration, namely in the occurrence of perspiration, surface irregularities and excessive surface polishing, an effective preparation method consists in the mechanical scraping of the pavement with a special equipment creating a coarse surface (cold milling).

37.1.3 Selection Criteria for the Type and Thickness of Construction Courses

The mixtures of the skid-resistant bituminous courses are distinguished into three types

TYPE 1 : Asphalt concrete of dense composition **with** nominal maximum grain size of 12.5 mm or 9.5 mm.

Applicable mostly to urban roads where almost static loads make it necessary for the concern to focus on the increase of the bearing capacity and on sealing the construction.

Under type 1, surface structure achieved is of limited depth.

TYPE 2 : Asphalt concrete of loose composition with nominal maximum grain size of 12.5 mm or 9.5 mm.

Applicable to urban or trunk roads of relatively higher speed limits, where the interest focuses on achieving satisfactory surface characteristics, in addition to reinforcing the construction.

TYPE 3 : Asphalt concrete of porous composition with nominal maximum grain size of 12.5 mm or 9.5 mm.

Applicable to high speed trunk roads mainly concerned with achieving a satisfactory macro-structure in addition to the rapid drainage of runoff water through the porous carpet. It shall be necessary to ensure watertightness and sufficient bearing capacity of the underlying road pevement courses. The life span of asphalt concrete courses of porous composition is short if compared to the closer types 1 and 2, unless improved binders are used (i.e. asphalt-rubber).

Regular thicknesses usually applied, as recommended for the three types of asphalt concrete, are as follows :

TABLE 1

Type of Asphalt Concrete	Normal course thickness for application
Types 1, 2 and 3 with nominal maximum grain size of 12.5 mm	4 cm
Types 1, 2 and 3 with nominal maximum grain size of 9.5 mm	3 - 4 cm

37.2 CONSTRUCTION MATERIALS

37.2.1 Aggregates

The total of aggregates used in asphalt concrete preparation is distinguished into coarse material retained by screen N°8 (2.36 mm), fine material passing screen N°8, and filler passing screen N°200.

37.2.1.1 Coarse Aggregate

In bituminous courses, the coarse fraction c! the aggregates is usually the determinant factor to the formulation of the pavement surface characteristic properties (micro-structure and macro-structure). For this reason, the coarse material must consist by 100% of aggregates with excellent mechanical characteristics, a high degree of cleanliness and appropriate form of the grains.

37.2.1.1.1 Grade analysis of the coarse fraction (for types 1 and 2)

Screen aperture of square mesh (ASTM)_	Nominal maximum grain size		
	12.5 mm (1/2")		9.5 mm (3/8")
	Passing %		
19.0 mm (3/4")	100	100	-
12.5 mm (1/2")	90 - 100	90 - 100	100
9.5 mm (3/8")	40 - 70	40 - 75	85 - 100
4.75 mm (N° 4)	0 - 15	5- 25	10- 30
2.36 mm (N° 8)	0 - 5	0- 10	0- 10
1.18 mm (N°16)	-	0- 5	0-5

NOTE :

The above limits do not constitute a quality criterion but are given only as an assistance for the cases when hard rock aggregates are used exclusively for the coarse fraction.

37.2.1.1.2 Cleanliness and form of the grains

The coarse fraction shall result from the crushing of a rock having the specified mechanical characteristics and shall be free of injurious admixtures (clay lumps or flour, organic or other soft brittle materials). Should it result from the crushing of pebbles, these must be retained by a screen with a hole three times the nominal maximum grain size, and :

- for types 1 and 2 : no less than 80% of the grains retained by screen N°4 shall have at least one crushed side:
- for porous carpets : no less than 90% of the grains retained by screen N°4 shall have at least one crushed side, while 75% of the grains shall have two or more such sides.

Grains shall have a cube-like form to be controlled by the definition of the flakiness index in accordance with the standard method BS 812/1985. This definition is conducted on material retained by the screen of 6.3 mm (1/4") and the resulting index value must be less than 30%

37.2.1.1.3 Mechanical properties

Requirements regarding characteristic mechanical properties of the coarse aggregate material are related to the anticipated traffic volume, which is established either by the pavement design, with regard to the construction of new works, or by the existing traffic conditions, when it comes to the maintenance of existing road pavements and are specified in the project terms of tender.

37.2.1.2 *<u>Fine Aggregate</u>*

The fine fraction of the overall aggregate (passing screen N°13 and retained by screen N°200) shall consist of angular crushed grains, free of clay and other injurious admixtures. In the cases of heavy and of very heavy traffic, it is preferable for the fines to be of the same source as that of the coarse material.

If a lower cost material is used for reasons of economy, this may be of limestone or other consistency, but of resistant crush resulting grains.

37.2.1.3 *<u>Filler (or Mineral Filler)</u>*

The filler mentioned herein (material passing screen N°200) is the fine material that is added as a separate ingredient to the asphalt concrete, if required, with the purpose of supplementing the grading of the aggregate mixture.

It may be mineral powder or a powder of other source (slag), hydrated lime, cement, fly ash or any other suitable mineral matter, sufficiently dry at the time of application to ensure free flow without creating accumulations.

Grade Analysis of Filler

Square mesh screen (ASTM)	Passing %
600 m (N° 30)	100
300 m (N° 50)	90 - 100
75 m (N° 200)	70 - 100

Filler shall contain no clay or organic matter, and shall have no plasticity (unless it is cement or hydrated lime).

37.2.2 <u>Bituminous Binder</u>

Pure asphalt shall be used for asphalt concrete production. It shall comply to the requirements of specification S.T.S. A 200, or to those of ASTM D946 when it comes to asphalt types not envisaged under the former.

The type of asphalt to be used shall be determined by the Service depending on the climatic conditions of the project area, the type of the course under construction and traffic characteristics and volumes.

Depending on the altitude of the project area, the recommended types of asphalt are as follows :

Altitude	Type of Asphalt
H < 500 m	40/50
500 < H < 1000 m	60/70 or 80/100*
H > 1000 m	80/100*

* Application of the type 80/100 is envisaged only when construction is conducted in the winter months and no high traffic

37.2.3 Adherence improving Agent (water repellent)

An agent for improving adherence of aggregates onto asphalt shall be added in the cases when hydrophilous aggregates are used, or in special cases to be determined by the Service.

The type and precise ratio of such agent shall be established by the laboratory through the immersion-compression test.

37.3 ASPHALT CONCRETE MIX

37.3.1 Mixture of Aggregates

37.3.1.1 Grade Analysis

The overall mixture of aggregates may result by the synthesis of two or more partial fractions, or may be delivered to the asphalt concrete production unit and applied without prior segregation and re-composition, provided that its uniformity and standard grading are assured.

The grade analysis of the overall mixture of aggregates (coarse, fines and filler) shall have to lie within the limits established by Table 2, depending on the type of asphalt concrete desired and on the nominal maximum grain size.

The selection of the grade analysis (nominal size) and of the type of asphalt concrete, as described also under sub-clause 43.1.3 hereabove, shall be based on the road category, the course thickness and the desired surface structure.

With regard to types 1 and 2, the portion (%) of the overall aggregate mix passing screen N°8 is a substantial feature to the works site control, given that it constitutes the border line between coarse and fine fractions. Aggregate mixes containing the maximum permissible percentage passing screen N°8 provide a final pavement surface of relatively fine texture, while gradings closer to the minimum permissible percentage passing screen N°8 are likely to yield a relatively coarse surface. When it comes to porous carpets (type 3), the fine fraction must be limited precisely to the portion required for the jamming of coarse grains.

The grading limits shown in Table 2 shall apply provided only that the specific gravities of coarse and fine aggregates do not differ by more than 5%. In the cases of differences exceeding 5%, the limits shown in the Table shall need to be converted according to the specific gravities.

37.3.1.2 Strength against Weathering (Soundness)

The percentage of loss by weight, as established by the standard method AASHTO T-104 (using sodium sulphate) must not exceed 9%.

37.3.1.3 Sand Equivalent

The sand equivalent defined according to the standard method AASHTO T-176 on the mixture of aggregates (prior to the introduction of bitumen and of the supplementary amount of filler), must exceed the value of 55.

37.3.2 Bitumen Ratio

Table 2 shows ratios of bitumen over the total weight of the asphalt concrete, and in relatively broad limits, covering the cases of using aggregates with specific gravities ranging between the values of 2.50 and 2.80.

The possibility may arise when aggregates with specific gravities lying within or out of the above limits, or with high or low porosity, require bitumen ratios that lie beyond the bounds outlined in Table 2.

TABLE 2

Screen Size square mesh (ASTM)	Type 1 Dense Mixture		Type 2 Loose Mixture		Type 3 Porous Carpets	
	Nominal Maximum Grain Size					
	12.5 mm	9.5 mm	12.5 mm	9.5 mm	12.5 mm	9.5 mm
	Percentages passing respective screens of square mesh					
19.0 mm (3/4")	100	-	100	-	100	100
12.5 mm (1/2")	90-100	100	85-100	100	90-100	100
9.5 mm (N°3/8)	-	90-100	60-90	85-100	60-100	90-100
4.75 mm (N° 4)	44-74	55-85	20-50	40-70	15-40	30-50
2.36 mm (N° 8)	28-58	32-67	5-25	10-35	4-12	5-15
1.18 mm (N°16)	-	-	3-19	5-25	-	-
0.30 mm (N°50)	5-21	7-23	0-10	0-12	-	-
0.07 mm (N°200)	2-10	2-10	-	-	2-5	2-5
Ratio of bitumen by weight over asphalt mix	4-11	5-12	4-11	5-12	41/2-8	5-81/2

The precise ratio of bitumen is determined on the basis of a laboratory design, combined with the experience gained by the use of similar aggregates and of asphalt mix of the same type.

37.3.3 Permissible Deviations from the Mix Design

The uniformity of the asphalt mix produced and the application of the mix design shall be controlled by the testing of no less than three samples, and on the basis of the average values obtained therefrom.

The maximum permissible deviations of aggregate grading percentages and of the bitumen ratio from the respective design figures are presented in Table 3. Further to these, no single sample deviations shall be allowed to exceed the same limits increased by 20%.

TABLE 3

Screen size	Tolerance over % passing
12.5mm (1/2") and above	± 8
9.5 mm (3/8") and 4.75 mm (N° 4)	± 7
2.36 mm (N° 8) and 1.18 mm (N°16)	± 6
0.60 mm (N°30) and 0.30 mm (N°50)	± 5
0.075 mm (N°200)	± 3
Ratio (by weight) of bitumen contained in the mix	± 0.4

NOTE :

If, by application of the above tolerances, the resulting curve falls out of the limits prescribed in Table 3, this may not constitute ground for rejection of the material.

37.3.4 Characteristics of the Asphalt Concrete

The definition of the ratios of aggregates aiming at achieving the desired grade analysis shall be followed by the definition of the optimum bitumen ratio. With regard to types 1 and 2, this shall be conducted on the basis of the Marshall method, while for type 3 (porous carpets) the mineral oil process developed in the USA by the Federal Highways Authority (FHWA) shall be adopted. The Marshall method shall be applied to type 2 provided this is feasible in view of the specific grading, otherwise the same procedure shall be followed as for type 3.

The Marshall characteristics, the voids, as well as the criteria for controlling hydrophily by application of the immersion-compression test are presented in Table 4 herebelow :

TABLE 4

Characteristics	Type 1	Type 2	Type 3
N° of thumps on each side of the specimen	75	75	50
Stability at 60°C N (Newton)	8000	6000	-
Strain of samples (mm)	2-4	2-5	.
Air pockets °A of compacted asphalt concrete	3-5	5-15	15 minimum
Minimum ratio of strengths at immersion-compaction test	0.8	0.7	0.5'

Test samples of porous carpets are prepared with a compressive load of 140kp/cm^2 (2000psi) and by mixing aggregates with bitumen following heating to optimum mixing temperature

37.4 CONSTRUCTION

37.4.1 Production of Asphalt Concrete

Asphalt concrete intended to the construction of skid-resistant courses shall be produced at a central asphalt mixing plant (see S.T.S. A265 page, para 4).

3cm- to 4cm-thick courses of asphalt concrete are cooling off rather rapidly, for this reason their mixes are prepared at temperatures relatively higher than those corresponding to the production of asphalt mixes intended to courses of ordinary thicknesses.

Furthermore, and in the case of using hard bitumen particularly in denser types, production temperatures that shall need to be observed are higher than those for a bitumen of a more advanced degree of permeability (80/100).

The following mixing temperatures are recommended for the three types of asphalt mixes (temperatures at the mixer discharge point) :

Type of Bitumen	Type of Asphalt Concrete	
	Types 1 and 2	Type 3 (porous carpets)
40/50	132 - 177°C	110 - 127°C
60/70	130 - 16°C	110 - 127°C
80/100	125 - 163°C	-

It is emphasized that any excess off the above limits must be avoided during the mixing of aggregates with the bituminous binder, in order to save any risk of the latter being tampered.

No substantial thermal losses shall be allowed curing transportation of the asphalt concrete from the production plant to the place of spreading, so that it may be ensured that the specified minimum temperatures for normal spreading and compaction of the wearing course be adhered to.

It is recommended that a small quantity of si: cone (i.e. a polymer of dimethyl-siloxane) be added to the bitumen at a ratio of about t5 cu.cm./ton with the purpose of fending off frothing of the hot bitumen upon coming in contact with water, as well as for averting segregation of the asphalt mixture and for ensuring easy unloading and spreading of same, particularly those mixes of the loose types 2 and 3. It shall not be permitted to use oil in order to facilitate the unloading of asphalt mix transportation vehicles

37.4.2 Binding Coating

In view of the fact that skid-resistant carpets are of limited thickness, application of a binding coat shall be required. In order to avoid the creation of a skidpery surface between the carpet and the underlying bearing course, it is recommended that the binding coat be constituted of a reduced quantity of bituminous emulsion, so that no more than 300,gr/sq.m. of this binder are finally left on the surface.

Aiming at achieving a homogeneous coating over the whole area, it shall be necessary for the application of the binder to be implemented with an asphalt spreader and a thinned bituminous emulsion with 30% bitumen content.

(An emulsion of 60% bitumen content shall be carefully thinned with the addition of 100% of water -instructions being requested from the emulsion manufacturer-with the purpose of obtaining an emulsion of 30% bitumen content).

37.4.3 Spreading of the Asphalt Concrete

The minimum temperatures required to be observed during the spreading of the asphalt concrete shall depend on the type of the asphalt mix, the type of the bitumen used, the course thickness and the prevailing weather conditions, and shall be determined by the Service.

The usual limits for spreading temperatures are as follows

Type of Bitumen	Type of Asphalt Concrete	
	Types 1 and 2	Type 3 (porous carpets)
40/50	120 - 145°C	90 - 120°C
60/70	120 - 140°C	90 - 120°C
80/100	120 - 135°C	-

37.4.3.1 *Weather Constraints*

Spreading operations shall be interrupted in the case of rain, of strong winds and of low ambient temperatures (namely below 10°C). Specifically regarding porous carpets (type 3), the ambient temperature shall need to exceed 20°C.

37.4.4 Compaction

Asphalt mixes of the types 1 and 2 shall be compacted in compliance to the provisions of specifications S.T.S A265, para 5.3.

Porous carpets in particular shall be lightly rolled with an 8-10 ton, smooth cylinder roller. Usually 1-2 passes shall be enough.

Excessive compaction, or compaction subsequent to the cooling off of the asphalt concrete is bound to lead to the crushing of aggregates.

37.5 QUALITY CONTROL

37.5.1 Control of Construction Materials

The general principles applicable to ordinary asphalt mixes (see S.T.S. A265, paras 6 and 7) shall apply to the control of construction materials.

Attention is particularly drawn to the quality of coarse aggregates on which mainly depend the surface characteristics of skid-resistant courses.

The laboratory controls conducted are summarized as follows :

a. Bituminous binder

The provisions of S.T.S. A200 combined with those of the specifications ASTM D946 and ASTM D3381.

b. Aggregates

Further to the tests specified under S.T.S. A265, the following controls shall be applied :

form of grains (flakiness index)	BS 812/1975
polished stone value (PSV)	BS 812/1975
aggregate abrasion value (AAV)	BS 812/1975

c. Asphalt concrete

Air pockets in asphalt mixes of loose composition ASTM D3203. Mix design for porous carpets in accordance with the method FHWA-RD-74-2.

d. Final surface

Surface structure - in accordance with the standard method ASTM E965-83 (sand method).

37.5.2 Operation of the Asphalt Concrete Production Plant

The control for good operation of the central production plant and for uniformity of the asphalt mix produced shall be conducted in accordance with the provisions regarding ordinary asphaltic mixes of S.T.S. A265, pare 7.

37.5.3 Controls and Requirements regarding the Final Course

Following final compaction, the asphalt course shall be tested for compliance to general requirements as mentioned herebelow. or to the specific requirements referred to in the project contract.

Elevation

— The final surface shall conform to the longitudinal section of the engineering design combined with the specified camber fall or crossfall, with any deviations from the above not allowed to exceed ±6 mm.

Evenness

— Any corrugations or other local irregularities detected by application of the 4 m straightedge parallel to the road axis shall not exceed 5 mm.

— Any deviations found with the 3 m straightedge applied at right angle to the road axis shall not exceed 3 mm.

— In the case of major projects, longer corrugations and the overall driving comfort shall be tested by application of the bump-integrator type gauge. With this method, the index of irregularities shall be less than 130 cm/km.

Thickness

— The thickness of the course shall be tested by the cutting of cores with a frequency of no less than three (3) cores per an area of 4000 square meters.

— The mean value of all thickness measurements must be equal or exceed the thickness specified in the contract documents.

— No single thickness value shall deviate from the specified thickness by more than ±10%, unless otherwise instructed by the Service with regard to resealing existing asphalt courses.

Compaction degree

— The average compaction degree for types 1 and 2 shall not fall short of 98%, and no single compaction test result shall be less than 95%.

— Tests shall be conducted according to the method of ASTM D1188 on the same samples cut for thickness testing.

Surface structure

— The mean depth of structure of the final surface shall be verified either by the sand method or by other approved method no more than seven (7) days after completion of the construction and before opening the road to traffic.

- Tests for each band shall be spaced at no less than 50m from each other and at distances not less than 30 cm from the edges of the road pavement.

- The minimum average depth of structure recommended and envisaged by the design shall be :

for type 1	1.0 mm
for types 2 and 3	1.5 mm.

NOTE:

Final requirements regarding surface structure of the above asphalt concrete types shall be formulated following systematic measurements conducted in the course of the first stage of application. it is for this reason that the Supervisory services must supplement the file of laboratory test results with measurements of the mean depth of surface structure.

37.6 MEASUREMENT AND PAYMENT

The stipulations referred to under para 8 of the S.T.S. A265 shall apply with regard to measurement surveying and to payments to be effected to the Contractor.

BIBLIOGRAPHY

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Clause 38 : SUB-BALLAST AND PREPARED SUBGRADE LAYER OF RAILR❑AD WORKS

38.1 SUB-BALLAST

Sub-ballast construction shall comply with STS O 155 with the following modifications or additional stipulations :

38.1.1 Materials

(1) The sub-ballast material shall consist of grade C, D or E crushed stone (gravel and sand), which shall satisfy the following resistance requirements :

—	Los Angeles abrasion value	< 25%
—	Microdeval Humid Test value	≤20

(2) It is necessary to ensure the following requirements :

a. Compatibility of the various superstructure layers. To this end the application of the TERZAGHI filler criteria shall be checked (see para. 2.9.56 STS X-1). This rule shall be strictly applied in case of non-cohesive material.

b. Avoiding the *"pumping"* phenomenon (rising of fine material and its intrusion into the ballast) for the case of infrastructure made of cohesive material.

General application filter rules, for both cohesive and non-cohesive material, have been described in volume D 117/RP 21 for this requirement.

(3) In practice, the subballast layers, being in contact with fine material subgrades (silty or clayey), shall consist of material which include a satisfactory percentage of grains of non-cohesive material having a size of less than 0.2 mm.

This can be achieved by the application of either one of the following methods

Method A:

The subballast layer consists of a simple sand gravel layer with approximately 20% fine sand (grain size smaller than 0.2 mm.).

Method B :

The subballast layer consists of two layers as follows :

I. The upper subballast layer section, being in contact with the ballast, consists of crushed sand-gravel, well graded, complying to the following uniformity and curvature coefficient requirements

— Uniformity coefficient $C_u = \frac{d60}{d10} > 6$

— Curvature coefficient $C_c = \frac{(d30)^2}{d60.d10}$ $1 < C_c < 3$

where d10, d30 and d60 are the grain sizes (in mm) for which 10%, 30% and 60% (by weight) respectively of the material has a smaller size.

II. The lower subballast layer section consists of a sand-filter layer.

III. The geotextiles may improve the filter properties and the subgradebearing capacity (relative volume ORE D 117 RP 24).

(4) The present subballast layer specification applies for the case of an "upper section" subballast layer, according to para. 45.1.1.(3).b.1 above.

38.1.2 Production - Haulage - Placement

The production, storage, haulage and placement of the material shall be effected in a way minimizing the risk of segregation and contamination. It is recommended that placement be effected using a special spreader-box.

38.1.3 Compaction

Compaction shall be implemented under conditions of optimum moisture content uniformly distributed within the mass of the material and shall continue until a density not less than 100% of the Proctor Modified Test is achieved, (E-105-86 Method 0). Compaction shall be implemented in layers so that at the end of compaction operations, layer thickness shall be not less than 0.15 rn provided that repetitive compaction tests prove that the necessary degree of compaction is achieved throughout the entire thickness and that requirements of level accuracy and of surface evenness specified in article 47 hereof are satisfied.

The modulus of deformation (Ev2) resulting during the second loading, during the slab loading test (according to the DIN 18134 or NF P94 117.1 standards) shall be Ev2 > 120 MN/m2.

38.2 PREPARED SUBGRADE

Construction of the prepared subgrade layer shall comply with STS 0 155 and according to the requirements mentioned above for the "subballast layer' with the following modifications or additional stipulations

38.2.1 Materials

The material shall consist of grade C,D or E crushed stone (gravel and sand), having Los Angeles wear values for abrasion and impact 5 27, and Microdeval humid Test 5 22.

38.2.2 Production - Haulage - Placement

The production, storage, haulage and placement of the material shall be effected in a way minimizing the risk of segregation and of contamination.

38.2.3 Compaction

Compaction shall be implemented under conditions of optimum moisture content uniformly distributed within the mass of the material and shall continue until a density not less than 98% of the Proctor Modified Test is achieved, (E-105-86 Method D). Compaction shall be implemented in layers so that at the end of compaction operations, layer thickness shall be not less than 0.15m provided that repetitive compaction tests prove that the necessary degree of compaction is achieved throughout the layer thickness and that requirements of level accuracy and of surface evenness specified in article 47 hereof are satisfied.

Clause 39: "SEPARATION" GEOTEXTILES FOR USE IN ROAD AND RAILROAD WORKS

39.1

Geotextiles for use in road and railroad works to separate two soil layers (including superstructure and infrastructure layers) having different physical properties (grading, consistency, density) shall be manufactured of synthetic or other fibers, as a thin permeable membrane, and shall satisfy the requirements stipulated in the present clause. Separation geotextiles shall be used to permanently avoid mixing of the two materials.

39.2

Prior to placement of geotextiles, the Contractor shall submit certificates proving that the geotextile to be used is able to successfully resist for a period of at least 40 years the effect of the materials of the layers that it will separate.

39.3

Geotextiles shall be protected from eventual mechanical or chemical effects during transport, storage, placement and covering. Geotextiles bound to be damaged by exposure to light, shall be continuously covered until placement. Exposure to light shall not exceed five hours.

39.4

Out of the total quantity of the geotextiles to be used, the Service shall retrieve in the presence of the Contractor five samples which will be tested in accordance with the tender conditions at a 'recognized laboratory'. Sampling and testing of the geotextiles belong to category B tests in accordance with clause 21 hereof (sub-clause 21.1.2). Sampling shall be effected in accordance with sub-clause 46.7 below and testing in accordance with subclauses 46.8, 46.9 and 46.10 herebelow.

Geotextiles shall :

a. Resist tensile loading of at least 2.5 kNm with 5% axial tensile normal unit strain under a "wide strip" tension test carried out as per sub-clause 46.8.

b. Allow the flow of water in both directions transversely to the principal plane, with a velocity of at least 10 $lt/m^2/sec$ under constant water head difference (pressure) of 100 mm, measured as per sub-clause 46.9.

c. Pores distribution shall be such that, O_{90} value as defined in sub-clause 46.10, be between 100 pm and 300 pm.

39.5

Overlapping at the locations of geotextile sheets splices shall be not less than 300 mm.

39.6

The geotextile sheets shall be laid on surfaces free of protrusions or bumps, with no sharp edges or angles that may damage the geotextile during placement and covering or during operation.

Placement of the geotextile shall be effected in a way ensuring its continuous contact with the surface it is laid on, without voids or protrusions. Immediately after placement, the geotextile shall be covered with a protective layer of material, and until completion of such protective layer, no piece of equipment or vehicle likely to damage the geotextile, shall be allowed to circulate on unprotected surfaces.

39.7

Samples of geotextiles shall be kept clean and dry until testing. Prior to evaluation of pore dimension and tensile strength, the samples shall be brought to a "state of equilibrium" at 20 ± 2° and relative humidity 65 ± 5%. Dry specific density of the geotextile shall be given in gr/m2.

39.8

"Wide strip" tensile strength test shall be effected as follows :

a. Test samples shall be 200 mm wide and 100 mm long along direction of testing.

b. To evaluate the characteristic tensile strength, not less than five geotextile samples shall be tested along their two principal directions, in accordance with their structure.

c. Strain shall be imposed at a rate of 10% ± 3% per minute.

d. As characteristic strength shall be defined the average value, reduced by 1.64 times the standard deviation. This characteristic strength corresponds to the value below which it is expected that no more than 5% of the tests will fall.

39.9

Water velocity shall be measured as follows :

a. Geotextiles shall be tested in unloaded condition at a constant pressure equal to 100 mm column of water.

b. Flow shall be uni-directional.

c. Geotextile area of test shall be of circular shape, having a 50-100 mm diameter.

d. Geotextile shall be immersed in clean water for one hour prior to test.

e. Water to be used in permeability tests :

    i. Shall be as free of air as possible, and shall be supplied from a storage tank and not directly from the city network.

    ii. Shall have a temperature between 10^0 C and 25° C. Flow velocity shall be converted to the one corresponding to 15° C using the standard functions relating water viscosity to temperature.

f. Quantity of water that flowed through shall not be less than two liters, or alternatively, duration of permeability measurement shall be in excess of 15 seconds.

g. Permeability shall be measured in liters/m2/second (It/m2/sec). Testing report shall also present the average value of measurements and the standard

39.10

Pore distribution and 090 value shall be defined as follows :

a. Pore distribution shall be defined by using the geotextile as a sieve to establish the retained percentage of a set of glass pellets. The number of sets and the diameter of the pellets of each set (being in accordance with BS 6088) is so selected as to cover all expected pore openings.

b. The cumulative curve of frequencies of percentages of retained particles against their diameter is sketched. Value corresponding to 90% retained expresses 0_{90}

c. At each sieving a quantity of at least 100 gr is sieved for 10 min through a geotextile piece fixed at the frame and bottom of a sieve with 300 mm diameter and sieve aperture of 10 mm.

d. The sieve equipment has a vibration frequency of 50 Hz and maximum vertical displacement 0.75 mm.

e. As O_{90} value is defined the average value of results of tests in five different

Clause 40 : ACCURACY REQUIREMENTS REGARDING ELEVATIONS AND SURFACE EVENNESS OF RAILROAD WORK

The prepared subgrade layer, the foundation layer and the sub-ballast layer shall be constructed in a way ensuring that their surface shall have the levels, gradients and transverse slopes shown in the design drawings, with the tolerances shown in the following table :

TABLE 1-40 : TOLERANCES OF LEVEL ACCURACY

Layer	Level tolerance (mm)
Prepared subgrade	± 25
Foundation	± 20
Sub-ballast	+ 0 - 15

Level control shall be effected at points located on a grid of 10 m along by 3 m across. The above requirements shall be considered to be satisfied as long as no more than one out of ten level checks or one only level check at any transverse grid line diverges from the values of the Table. In addition, the measurements beyond the limit shall not deviate by more than 5 mm from the tolerance limits.

Further to accuracy requirements, surface evenness of the layers shall be verified using a 3 m straightedge at right angle to the axis of the railroad track.

The maximum permissible divergence of these checks is given in the following table

TABLE 2-40 : TOLERANCES OF SURFACE EVENNESS

Layer	Maximum permissible divergence (mm)
Prepared subgrade	20
Foundation	15
Sub-ballast	10

Straightedge checks shall be taken at a frequency of 100 checks for every 1,000 m of length; 25 of these checks shall be taken at 3 m intervals, or at a distance of 3 m from the level control grid lines.

Clause 41 : EARTHWQRKS FOR RAILROAD PROJECTS [Supplements and Amendments to STS X-1]

41.1 INTRODUCTION

All terms hereinbelow are applicable both to works paid for on the basis of unit prices and of measured quantities for completed works, and to eventual works covered by "lump-sum prices" or by -concession agreement".

41.2 GENERAL

The specifications shall apply to the construction of earthworks for railroads as well as of lining and planting works. Further to the stipulations, the following clauses shall be taken into consideration :

41.3 DEFINITIONS

41.3.1 Earth fills

Fills made of earth material placed and compacted in layers of such thickness that, using the available mechanical equipment, the required degree of compaction is achieved, and in a stretch of such magnitude as to allow use of mechanical equipment of high performance.

41.3.2 Rock fills

Fills made of rock materials originating from rock quarrying, placed and compacted in layers of such thickness that, using the available mechanical equipment, the required degree of compaction is achieved, and in a stretch of such magnitude as to allow use of mechanical equipment of high performance.

Fills consist of the parts listed in TABLE 49-1.

41.3.3 Superstructure

The primary load-bearing layer that accepts and distributes the train loads and is subject to rehabilitation at regular intervals. Superstructure comprises, beyond the sleepers and tracks, the ballast and the sub-ballast (including, eventually, necessary additional foundation and filtering layers).

41.3.4 Infrastructure

Layer immediately below superstructure, composed of soil or fill material, placed and compacted in accordance with the requirements hereof and the other tender conditions (STS X-1 etc.).

41.3.5 Prepared subgrade

The upper layer of the sub-grade, compacted to a higher degree and occasionally made of higher class material than the infrastructure. The purpose of the prepared subgrade layer is to increase the bearing capacity of the sub-grade upper layer.

TABLE 41-1: COMPONENTS OF FILLS

DESIGNATION	EARTH FILLS	ROCK FILLS
Foundation	The section situated below the original ground surface, after cleaning, grubbing and removal of unsuitable materials, and an additional layer of 0,30 m. over the original natural	The lower layer of the fill, with 0.30 m. thickness, adjacent to the original ground surface (whenever there are no unsuitable surface materials) as well as the layer below, (after eventually necessary cleaning, grubbing and/or removal of unsuitable materials)
Core	The section of the fill between foundation and top of the fill	The section of the fill between foundation and top of the fill
Transition section		That section of the fill where the grading of the materials composing it, satisfy certain requirements (filter) in order to avoid penetration of the material of the top into the rocky section underneath. Its thickness shall be 1m. unless otherwise specified in the other tender terms
Top of the Fill	The section of the fill below the *"prepared subgrade layer"* ranging to a depth (from the upper surface of the *"prepared subgrade layer")* equal to 1.00 m.	The section of the fill above the transition section that is made of earth materials as in earth tills and is coinciding with the *"prepared subgrade layer"*

41.4 FILL

41.4.1 Materials for fill and for prepared subgrade layer

41.4.1.1

(1) The selection of the material for the construction of fills and "prepared subgrade layer" as well as their degree of compaction shall be effected in accordance with the stipulations of STS X-1 (clause 2.9.2 etc.) with the following additions or modifications

(2) Construction material shall be obtained in principle from excavation products. Use of borrow material shall be allowed upon written approval of

the Service, only in case the former material is unsuitable or in insufficient quantities, or in case that coordination between excavation and fill works is impossible in accordance with the time schedule of the works (in this case a written approval of the Service is necessary, unless it is explicitly specified in the tender conditions that

(3) Soil material containing soluble sulphuric salts in concentration, expressed as 503, higher than 1.9 gr per liter measured in accordance with BS 1377 test 10, with a water to earth ratio 2 : 1, shall not be used in locations less than 50 cm away from concrete structures, or from Cement Treated Crushed Stone (C.T.C.S.), or Cement Stabilized Soil material (C.S.S.).

(4) Material with total sulphuric salts contents expressed as SO3, higher than 0.5% in weight measured in accordance with BS 1377 test 9 shall not be used in locations less than 50 cm away from metal structures.

41.4.1.2

Soils can be classified in the following categories, according to the POSSIBILITY OF THEIR USE as FILL MATERIAL or PREPARED SUBGRADE LAYER :

(1) Soils NOT ALLOWED TO BE USED for the construction of fills or "prepared subgrade layer".
These are the following, according to Table 41-2 :

a. *"Unsuitable"* material (QS◦ category) subcategories 0.1 until 0.6 inclusive

b. *"Poor'* material PS_I category) subcategories 1.1.a and 1.2

(2) Soils WHOSE USE IS CONDITIONALLY ALLOWED for the construction of "prepared subgrade layer- (only in cut areas) or of fills :

I. These are the following, according to Table 41-2 :

a. *"Poor"* material (OS_I category) subcategory 1.1.b
b. Material of subcategories 1.3, 1.4 and 1.5
c. Material of subcategories 2.1 and 2.2

II. CONDITIONS for allowing use of the above material are as follows :

a. Moisture content of material of subcategories 1.1.b and 1.3 shall satisfy the following constraints :

i. In 80% of quality control tests, the following relations shall be satisfied :
$W_{op} - 2\% < W < W_{op}$

ii. In 100% of the tests, the following relations shall be satisfied :
$W_{op} - 3\% < W < W_{op} + 1\%$

where W_{oo} = Optimum moisture content at the Proctor Modified Test.

W = Moisture content of the sample

b. Material would be used in fills of small to medium height (H ≤ 10m)

c. The "top of the fill" (crown) shall be made with material of higher category.

(3) Soils ALLOWED TO BE USED IN ANY CASE for the construction of fills or of "prepared subgrade layer' :
These are the following, according to Table 41-2 :

a. Material of subcategory 2.3

b. “Good” material (category 0S3) of subcategories 3.1 and 3.2

41.4.1.3

The maximum grain size of the material used shall not exceed half the layer thickness and in any case it shall be smaller than 600 mm for fill layers and then 200 mm for "prepared subgrade layers".

41.4.1.4

In case that earth fills are placed on humid soil, then the lower layer of the earth fill (foundation) shall be made of material category QS3 to a height of not less than 0.30 m above the natural ground level.

41.4.1.5

For rock fill material, additional reference is made herebelow in sub-clause 41.4.2.

41.4.2 Additional Requirements for Rock Fill Materials

41.4.2.1 Origin

The material for use shall be stone from excavation in rock. In exceptional cases, and upon approval by the Service, material may come from borrow pits. In these cases, the excavation locations shall be designated by the Service or shall be approved by the Service in accordance with the S.C.C., and the other tender conditions.

41.4.2.2 Rock quality

(1) Rocks from which fill material is quarried are classified into "suitable', "unsuitable" and those for which "additional study is required' (e.g. marl, schist, chalk etc.).

(2) "Suitable" materials comprise granite, porphyrite, granite-diorite, gabbro, diabase, ophite, andesite, basalt, dolomite, marble e.a., taking into consideration the requirements of Table 41-2 (Definition of Los Angeles and Microdeval values) (subcategories 1.5, 2.3 and 3.2).

(3) "Unsuitable" material comprise serpentine, phyilite, granodiorite, anhydrite, gypsum, soluble rock and in general rock that disintegrates when exposed to weather conditions, or easily breakable, pulverizable, or acquiring adverse characteristics when compacted (Sub-categories 0.4 and 1.2 of Table 49-2).

(4) In order to use rock material for fills, the Contractor shall submit to the Service a laboratory study, supported by laboratory tests and classification in

accordance with Table 41-2 requirements. The study shall prove that the rock material intended to be used is suitable and classified in the specific sub-category of Table 41-2.

TABLE 41-2

CATEGORIES AND SUBCATEGORIES OF SOIL MATERIAL FOR RAILROAD WORKS

Sub category s/n	GEOTECHNICAL CHARACTERISTICS	Hydrogeological and Hydrological conditions(9)	Soil material category	Comments as to materials suitability for fills
0.1 0.2 0.3 0.4 0.5 0.6	Organic material (organic substances content >= 30% b.w) Fine-grained soil material, expanded, moist and therefore non compactable [Percentage(1) of material passing sieve No 200(2)) higher than 15% b.w] Thixotropic soils (e.g. sweeping clay) Soluble soils (e.g. soils containing mineral salts or gypsum) Polluting material (e.g. industrial waste) Mixtures of soil materials with organic substances (Content of organic substances >5% and < 30% b.w.)	-	QS_n	Unsuitable
1.1.a 1.2	Soil material comprising a percentage(1) passing sieve No 200(2) higher than 40% b.w. 1. Having a L.L. > 35 2. Having a L.L. <= 35 and not satisfying the additional requirements of sub-category 1.1.b. Rock subject to easy wheathering (e.g. marl, decomposed schist, chalks having a low density (yd < 1.7 t. m^3) and a high degree of pulverisability)	-	QS_1	Poor
1.1.b	Soil material comprising a percentage(1) passing sieve No 200(2) higher than 40% b.w. with a L.L. <=35 and additionally having: - Maximum density(6) > 1.7 t. m3 - CBR(7) > 5 - Expansion (per CBR test) < = 2% - Organic content(8) <= 2%	-	QS_1	Poor

TABLE 419-2 (Cont.)

Sub category s/n	GEOTECHNICAL CHARACTERISTICS	Hydrogeological and Hydrological conditions[9]	Soil material category	Comments as to materials suitability for fills
1.3	Soil material comprising a percentage(1) passing sieve No 200(2) between 15% and 40%	Bad	QS_1	Poor
1.4	Rock subject to easy wheathering (e.g. non decomposed schists or chalks having a low density (yd < 1.7 t/m^3) and a low degree of pulverisability)			
1.5	Soft rock (e.g. Microdeval humid test index(4) MDE > 40 and Los Angeles loss L.A.(3) > 40)	Good	QS_2	Average
2.1	Soil material comprising a percentage(1) passing sieve No 200(2) between 5% and I5%	Bad	QS_2	Average
2.2	Soil material of poor gradation (having a Cut[5]1 5 6i and comprising a percentage passing sieve No 200(2) less than 5% b.w.			
2.3	Medium hard rock (Microdeval humit test index(4)(25 < MDE 5 40 and Los Angeles 30 < L.A.(3) 5 401	Good	QS_3	Good
3.1	Soil material comprising a percentage(1) passing sieve No **200(2)** less than 5% b.w.	-	QS_3	Good
3.2	Hard rock (Microdeval humid test index(4) MDE 5 25 and Los Angeles loss L.A.(3) 530)			

NOTES :

(1) The percentages mentioned refer to the portion of the soil material having grain size smaller than 60 mm.

(2) Sieve No 200: American series of standard sieves AASHTO : M-92 with aperture diameter of 0.074 mm.

(3) L.A. : L.P.C. Modes Operatoires HG 18 (Los Angeles Test). AFNOR NF P 18-573.

(4) Microdeval humid test : L.P.C. Modes Operatoires HG 16 (Essai Microdeval), AFNOR NF P 18-572

(5) Cu: Grading uniformity coefficient. Cu=d60 d10 where d60 and dIO the sieve aperture diameters in mm corresponding to percentages passing of 60% and 10% by weight respectively.

(6) As per the modified compaction Proctor test E105-86.

(7) Value of the California Bearing Ratio (C.B.R.) specified in accordance with method 12 of the **Soil** Mechanics Tests Specification (E 105-86) on samples compacted at 95 % of maximum density as per the Modified Compaction Test (Method **11** E 105-86) with optimum moisture content and following 4 day soaking in water.

(8) Shall be defined using *"liquid oxidation"* method (Method AASHTO T194).

(9) Hydrological and Hydrogeological conditions shall be defined *as "good"*, in accordance with the stipulations of sub-clause 49.5 of the present clause.

41.4.2.3 *Grade Analysis*

The material shall satisfy the following requirements :

a. Maximum particle dimension shall be not less than 112 of the compacted layer thickness and, in any case, it shall be smaller than 600 mm (see sub-clause 49.4.1.3).

b. It shall contain less than 30% b.w. material passing 1" sieve and less than 10% material passing sieve No 200 b.w.

These requirements shall apply to compacted material from which samples shall be obtained in order to establish that the requirements are satisfied, since during placement and compaction the material may undergo changes modifying the initial grade analysis.

Moreover, the material's grading curve shall satisfy the following requirements :

Grain Dimension (sieve)	% passing by weight
D	90 - 100
D/4	45 - 60
D/16	25 - 45
D/64	15 - 35

The Service may modify the above limits, according to the conclusions and observations from the construction of the Trial Section (see following sub-clause 49.4.9).

41.4.2.4 *Form of Grains*

Percentage of grains having an unacceptable form shall be less than 30%. Grains with unacceptable form are those for which the following equation applies :

$$\frac{L+G}{2E} >= 3$$

where : L = Maximum distance between two parallel surfaces tangent to the grain.
G = The minimum diameter of a circular aperture that the grain can pass.
E = Minimum distance between two parallel surfaces tangent to the grain.

Values L, G and E may be defined approximately and should not necessarily be measured along three perpendicular directions.

41.4.3 Spreading of Earth Fill Courses

Prior to placement of the fill material, unsuitable top soil shall be removed and replaced with suitable material as instructed by the Service. The material shall be meticulously compacted. The whole fill foundation area shall be compacted to a density not less than 90% of the maximum density obtained by the modified compaction test.

The applicable E105-86 Proctor modified compaction test shall be in accordance with :

METHOD A : For soil material containing a percentage retained by sieve No 4 inferior or equal to 7%.
METHOD ID : For soil material containing a percentage retained by sieve No 4 exceeding 7%.

Compaction shall reach to a depth not less than 40 cm and to a width not less than 2.00 m beyond the foot of the fill, or at least to the right-of-way boundary line, wherever relevant width limits exist.

Placement and compaction of the fill shall follow. Layers shall be continuous, parallel to the sub-grade and of such uniform thickness as to ensure the specified degree of compaction throughout using the existing mechanical equipment.

Materials in all layers shall have common properties, or they shall be mixed using appropriate mechanical equipment.

No layer shall be placed unless it has been previously verified that the underlying layer satisfies the requirements. Layer placement shall not be permitted if the underlying layer became malleable due to excessive moisture content.

Fills on ground of low bearing capacity are subject to specific Study and shall be constructed in accordance with the recommendations of that Study. Meticulous care shall be paid not to exceed the ground bearing capacity by providing adequate dimensioning of the thickness of the first fill layers in order to protect the ground from loading due to material transportation vehicles and compaction equipment.

During execution of works, the layer surface shall have the necessary crossfall ensuring water drainage without corrosion or excessive water soaking of the fill.

The Contractor shall take all necessary measures to protect the fill as well as the cut from rain water effects as well as from water originating from other sources (torrents, rivers, groundwater).

In case that in-situ measurements establish that the moisture content of the placed material is not the optimum for compaction, the material shall be watered in a way ensuring uniform dampness, or, if moisture content needs to be reduced, then it shall be dried by ventilation or by mixing with suitable dry material or chemical additives such as quick or hydrated lime as approved by the Service.

41.4.4 Weather Constraints for Earth Fills

No construction of earth fill shall take place whenever ambient temperature falls below 2°C.

41.4.5 Traffic On Earth Fill

No vehicles shall be permitted to use fill layers under construction until their compaction is completed. If this is not feasible, vehicles shall be distributed in a way ensuring that they shall not pass on the same locations and thus create wheel ruts and gutters. This is also applicable to areas where compaction is completed.

41.4.6 Compaction of Earth Fills

(1) Earth fills of Railroads shall be compacted to a density not less than 95% of the maximum density as per the Proctor modified compaction test (E 10586 Method 11D).

(2) Moreover, *"deformation modulus'* Ev2 in the second loading of the bearing plate test (according to DIN 18134 or NE P94 117.1 standards) shall be not less than:

a. 45 MN/m2 for cohesive soils (percentage passing sieve No 200 higher than 35% b.w.)
b. 60 MN/m^2 for granular soils (percentage passing sieve No 200 up to 35% b.w.)

41.4.7 Rock Fill Construction

41.4.7.1 Foundation Surface Preparation

Prior to placement and compaction of the rock material, cleaning, grubbing and removal of unsuitable material or vegetation earth shall take place, if necessary, to the whole depth prescribed as per clause 2.3 of S.T.S. X-1.

Whenever it is necessary to construct a rock fill on unstable or disturbed soils, or on soft clays, measures shall be taken to consolidate or remove these materials. If a rock stratum exists close to the fill foundation level, material on top of the rock may be removed and fill foundation may be effected directly on the rock.

41.4.7.2 Production - Excavation, Loading and Transportation of Rock Material

Prior to excavating rock material, soil materials or unsuitable weathered rock surface shall be removed. Moreover, the quantities of unsuitable earth material appearing in the rock formation shall be removed throughout the duration of the rock excavation.

Excavation shall be effected in a way ensuring that the grading and shape of the produced rock material satisfies the requirements of the present clause (sub-clause 49.4.2). If necessary, after excavation, elements having unsuitable shape or dimensions shall be removed or further crushed.

Loading and transportation of excavation material shall be effected in a way avoiding segregation and alteration of the grain forms.

41.4.7.3 Spreading

Spreading shall be by consecutive layers of uniform thickness parallel to the foundation surface.

Material for every layer shall be unloaded on site on an already compacted part of the same layer close to the construction front. From this location, it shall be pushed to the construction front and it shall be laid beyond that in a way minimizing its eventual segregation. Layer thickness shall conform with the compaction capability of the existing mechanical equipment, to ensure the specified degree of compaction.

Maximum thickness after compaction is 1.00 m for the core while for the transition section thickness shall be reduced from the bottom of the fill upwards by gradual steps.

The following conditions shall need to be adhered to between two consecutive layers :

$$\frac{I_{15\%}}{S_{85\%}} < 5 \quad \text{and} \quad \frac{I_{50\%}}{S_{50\%}} < 25$$

where : Sieve aperture allowing passage of x% b.w. of the material of the underlying layer.
Sieve aperture allowing passage of x% b.w. of the material of the layer above.

41.4.7.4 <u>*Compaction*</u>

(1) The selected method of compaction shall ensure achievement of the required degree of compaction. In this respect, for each part of the till the grading of the material, layer thickness, type of compaction equipment and number of passes shall be properly selected. These variables shall be defined in relation to results obtained from the construction of the Trial Section as shown in sub-clause 49.4.9.

(2) Only towed vibratory rollers or self-propelled vibratory rollers bearing a static linear load (on the drum and supported part of the chassis) more than 250 N/cm shall be used for compaction (higher than category V2 of the French Roadworks Specification).

Moreover, static road-rollers with a rectangular grid of steel bars (grid rollers), with a static load at the drum in excess of 800 N/cm may be used.

(3)
ompaction shall be considered as completed when, between two consecutive passes of the compaction equipment mentioned above, the settlement at the foundation and core shall be no more than 0.7 cm, and no more than 0.3 cm at the transition layer.

Settlement shall be measured using a steel device having dimensions 40x40 cm., made of steel plate at least 15 mm thick having a suitably shaped base. The device type shall be submitted by the Contractor to the Service for inspection and approval and shall be able to maintain its horizontal position while compaction equipment passes nearby. These devices shall be placed at the level control positions as defined in sub-clause 49.4.10 (Tolerances of finished surfaces) and after compaction completion they shall be removed to be used again.

(4) Alternatively to the above method of rock fill compaction control, the Service may opt (at his own discretion) for another method in case that, during construction of the 'Trial Section', it is proved that another reliable

method guarantees conformity of the construction to the above mentioned requirements, taking into consideration all the parameters affecting the supervision of the works.

(5) If, during implementation of this new method, its reliability proves to be questionable as to the supervision, the correlation of the results to the compaction etc., then the Service may ask the Contractor to apply from then on the compaction control method described in the above sub-clause (3).

(6) Apart of what is mentioned above, it is hereby defined as "minimum compaction requirement* not less than twelve passes over each layer of a towed vibratory roller bearing a static linear load (on the drum and supported part of the chassis) more than 250 N/cm (category V2 of the French Roadworks Specification) or of a static road-roller with grid equipment (grid roller) bearing a static load in excess of 800 N/cm.

41.4.8 Compaction of the "Prepared subgrade Layer"

The 'Prepared subgrade Layer" of the Railroads shall be compacted to a density not less than 98% of the maximum density as per the Modified PROCTOR Test (E 105-86 Method 11D).

Moreover, the 'deformation modulus" E2 in the second loading of the bearing plate test (according to DIN 18134 or NF P94 117.1 standards) shall be not less than 80 MN/sq.m,

41.4.9 Trial Section for Rock Fills

The Contractor shall submit in writing to the Service the construction method that he considers as more suitable to each type of material, to better meet the requirements of the present clause. The proposal shall include :

- Specifications of the mechanical equipment.
- Excavation, loading and transportation methods of rock material.
- Spreading method.
- Layer thickness, compaction method and number of trips of the equipment.
- Previous experience concerning the proposed method of construction using similar material.

Unless there is sufficient experience on the proposed method, its approval by the Service shall depend on site testing. This testing shall consist of the construction of a trial section having a volume of not less than 3,000 m3 intending to prove the suitability of the proposed method or to adapt it in a comparable case.

During construction of the trial rock fill, the grading of the recently excavated material shall be evaluated, as well as the grading of the placed material and the grading and density of the compacted material. To evaluate these values, representative samples of at least 4 m3 shall be used. Not less than 10 tests of each type shall be conducted. Moreover, lateral surfaces of sections cut through the fill shall be inspected to define the properties of the compacted material. These sections shall be cut throughout the layer thickness and shall have a surface of not less than 4 m2. Fill surface deformations shall be monitored using topo-survey methods, following each trip of the compaction equipment, as well as the average density of the compacted material.

The Service shall decide on approving, modifying or rejecting the proposed method, following appraisal of the above results.

In case that the values of the material properties show a marked fluctuation, the Service may opt to ask for a reassessment of the working method.

41.4.10 Tolerances of Finished Surfaces of Rock Fill

Finished surfaces of the core and transition section shall be verified using pegs placed along the road axis and at the ends of sections spaced at no more than 20 m, the levels of which shall be measured with 1 cm accuracy.

Deviations between actual and theoretical levels of pegs in accordance with the drawings shall be measured and the extreme algebraic values of these deviations shall be evaluated along stretches no longer than 100 m. Deviations corresponding to points situated above the theoretical shall be considered as positive.

The following requirements have to be met :

- If the sum of the extreme values divided by 2 is positive, it shall have to be less than 1/5 of the last layer thickness.
- If the sum of the extreme values divided by 2 is negative, its absolute value shall have to be less than 1/2 of the last layer thickness.
- The difference of the extreme values divided by 2 shall have to be less than 5 cm for the core surface and less than 3 cm for the transition section surface.

If the first condition is not met, the last layer shalt be excavated and a new one having a correct thickness shall be constructed. If the second condition is not met, a new layer having a correct thickness shall be constructed. If the third condition is not met, a levelling layer shall be added having a minimum thickness of not less than 15 cm if it is placed on the core, and 10 cm if on the transition section. This layer shall consist of well graded granular material, with mechanical properties not inferior to the ones of the rock fill material, and maximum size 10 or 6 cm respectively.

41.4.11 Measurement and Payment of Rock Fill

Rock fills shall be paid in cubic meters (m3) of actually constructed geometrical volume (see also sub-clause 49.7), measured on the cross section drawings.

Extra cost of rock excavation resulting from adopted precautions which aim at ensuring suitable rock material shall be considered to be included in the rate per cu.m for fills.

In case that different unit rates are applicable, the top of the fill shall be considered as included in the earth fill works, unless otherwise defined in the Tender Conditions.

41.5 SOIL CLASSIFICATION FOR RAILROAD WORKS

(1) Soil materials for the construction of the railroad network infrastructure are classified into categories QS_0 until QS_3 , as per TABLE 49-2, in accordance with their geotechnical properties and local hydrogeological and hydrological conditions.

(2) Hydrogeological and hydrological conditions are designated *'good"*, provided that the following conditions are satisfied:

a. If the upper ground layer is not subject to harmful effects of the upper groundwater table. (This groundwater table shall be determined considering unfavorable weather conditions. Ten-year rainfall and seepage at a rate of 2 mm per hour).

For new railroad infrastructure construction, this condition is considered as satisfied if the upper High Ground Water Table (H.G.W.T.) is not less than 1.60 m below the sleeper's foundation level.

b. If there is no harmful water infiltration through to the *"infrastructure"* (transversal, longitudinal or vertical).

c. If rainwater drains properly away from the *"infrastructure"* and if the transverse and longitudinal drainage systems function normally.

(3) If even one of the above conditions is not satisfied, then hydrogeological and hydrological conditions are defined as "bad".

41.6 ACCURACY REQUIREMENTS REGARDING ELEVATIONS AND SURFACE EVENNESS OF THE *'PREPARED SUSGRADE LAYER'*

Accuracy requirements regarding elevations and surface evenness of the "prepared subgrade layer" are dealt with in clause 47 hereof.

41.7 FILL SETTLEMENTS

Dimensions, slopes, lines and elevations of railroad fills shown in the contract drawings shall be the final ones, i.e. the ones obtained after the expected subsidence of the fill material and the settlement of its foundation soil, the latter caused by the fill loads brought onto the ground.

The Contractor shall increase the height and width of the fill either once or by consecutive additions of material, to the degree needed to counterbalance settlements of any kind.
Volume wasted due to subsidences shall not be paid for to the Contractor and the Contractor should take into account in his pricing that in reality the true volume of fills (and borrow material) constructed shall be higher than the one resulting from the contract drawings and documents (geometric volume).

This waste has to be taken into account by the Contractor in the calculation of the true conditions of earthworks balance.

41.8 COVERING SIDESLOPES WITH AGRICULTURAL SOIL

41.8.1 Works to be executed

41.8.1.1

In order for vegetation to grow on the sideslopes of fills and cuts of railroad works, agricultural soil shall be spread in accordance with the design and/or the Service's

instructions in one layer of 0.30 m minimum thickness over sideslopes of fills and of non-earth cuts whose slopes shall be (as per the tender conditions)
h : b 1 : 1. The agricultural soil layer shall be lightly compacted.

41.8.1.2

It is hereby noted that the use of material originating from the removal of asphaltic courses (from nearby road works) is strictly prohibited. Such material shall be collected, dumped in spoil areas and finally covered with soil not less than 0.50 m thick.

In the opposite case, the Service may impose the complete reconstruction of the fill, or additionally impose penalties for defective work affecting the whole project (project stability, planting problems, environmental complications etc.).

41.8.1.3

(1) It is specifically clarified that cover of fill sideslopes with agricultural soil <u>*shall proceed simultaneously to the rising of the fill.*</u>

(2) Furthermore, and with regard to cut sideslopes higher than 5.0m scheduled to be covered with agricultural soil (as per the tender conditions), such cover works shall proceed simultaneously to the cut excavation.

(3) If, during construction of sideslopes (of fills or cuts) without accessible berms, the Contractor executes the respective fill or cut works at heights more than 6.0 m without simultaneous construction of the agricultural soil cover, the Service shall apply provisions regarding defective works both to the fill/cut construction and to the agricultural soil cover of sideslopes.

41.8.1.4

Sideslopes (of fills and/or cuts) shall be covered using agricultural soil (not garden soil) originating either from stacks of eventual top soil excavation products, or removed from any area, without the Service assuming any responsibility related to obtaining any permits from the pertinent Authorities.

41.8.2 <u>Quality of Agricultural Soil</u>

1. Agricultural soil shall be of best quality, since it constitutes the main element for the development of the biological functions of plants.

2. Agricultural soil shall be selected from the most suitable top soil excavation products, collected and stored in regular stacks. Agricultural soil shall be preferably selected from products of sandy-clayey consistency, unless no such soil is available, in which case the Service may accept suitable material of other consistency.

3. Excavation products earmarked for use as agricultural soil shall be free of
foreign matters, such as demolition products, building construction waste, stones, pebbles, dried lime, NaCl, or even plant remains that are hard to rot.

4. In case that agricultural earth excavation products available are considered suitable from the point of view of soil consistency but contain admixtures as above, it becomes obvious that such soil shall be used after the above admixtures are removed by any suitable method (even by screening).

5. Agricultural soil shall result from surface excavation to a depth of not more than 0.70 m and when visually examined shall be found to be of reddish or light reddish color.

6. In order for the agricultural soil to be accepted by the Service, the Contractor shall without fail submit a sample analysis report by a recognized Soil Institute. The relevant expenses shall be borne by the Contractor.

   One sample for each consecutive quantity of 500 m3, or no less than 3 samples per individual source of the topsoil (taken at varying depths within the effective depth of 0.70m) shall be subjected to the abovementioned analysis.

7. Samples shall be taken in the presence of the Service's representative from the areas to be used by the Contractor, in adequate number in accordance with the estimated volume to be used. Samples shall be numbered and their location shall be marked with their characteristic number on the plan of the borrow area. Then the samples shall be dispatched, accompanied by the Service's representative, to the Soil Institute and following the analysis of the samples and provided that they satisfy the present specification, the Service shall grant his approval for the Contractor to deliver the agricultural soil on the site. Whenever samples prove to be unsuitable, the corresponding borrow areas shall be excluded from use.

8. In case that a borrow area presents a certain disparity in its characteristics, the Service may in his own judgement increase the number of necessary samples, while the relevant expenses shall again be borne by the Contractor.

9. It is hereby clarified that the above numbers of samples are the minimum ones and that the Contractor is solely responsible for the suitability of the agricultural earth he is using. In case that unsuitable agricultural soil as per the stipulations hereabove is found on the site area, the Contractor shall remove such unsuitable quantity and replace it with suitable material at his own care, responsibility and expense.

10. With regard to all remaining matters related to the agricultural soil, such as quality, location and method of borrowing, execution method etc., the contents of STS X-1 (Chapter C, clauses 1, 2.4, 2.5 etc.) shall apply.

11. For small quantities of agricultural soil, following the Contractor's request approved by the Service, it is possible to obtain their approval on the site, solely on the basis of macroscopic examination both on site and at the borrow area.

41.8.3 <u>Measurement - Payment of Sideslope Cover with Agricultural Earth.</u>

41.8.3.1

Measurement shall refer to true surface covered in square meters, with minimum agricultural soil thickness of 0.30 m. Measurement shall be conducted on true sideslope surface prior to the execution of the cover, as specified in STS X-1 (fig. 1) and clause 1610 of the 1975 Descriptive Price List for Roadworks

41.8.3.2

Payment shall be effected by application of the corresponding unit rate included in the Contractor's proposal, concerning "sideslope cover with agricultural soil'.

41.8.3.3

The above rates and payments include for the supply of agricultural soil from any location in any borrow area, excavation of the agricultural soil to the depths specified for each location, loading and unloading, delays of transportation equipment, transportation of material from any distance to the site, spreading of agricultural soil to thicknesses specified by the design or by the Service's instructions, light compaction, suitability tests, as well as for any other expense needed to complete the works.

Clause 42: REINFORQED FILLS

42.1 DOMAIN OF VALIDITY

The present article refers to the construction of structures whose function is based on the method and theory of "reinforced fills' and which have the possibility to act as retaining structures or even to bear significant loads. The structures may be in the water.

As such structures, indicative, are quoted retaining walls of various uses etc.

Object of the present is to make available recommendations within the framework of which the design and construction of such structures shall be made and which have been issued based on scientific analysis, experiments and the experience from the construction of numerous similar works abroad

According to this specification are acceptable structures with mainly granular backfill material, reinforcement from steel strips or grids of bars and concrete panels.

For everything related to the design of R.F. structures are covered in a special article of D.I.S. For what is eventually not covered by the present in relation with those covered in the D.I.S. the codes and specifications of other countries are to be applied following the recommendations of the competent services of the Ministry of Infrastructure.

In any case the use of the "reinforced fill' assumes a complete study with drawings and calculations to be approved by the competent authority.

The authority may not approve the use of the reinforced fill if it judges that some functions of the project will be prevented during its service life.

42.2 DEFINITIONS

“Reinforced fir” is a soil with incorporated layers of reinforcement (Fig.42-1), which undertake tensile forces from it and transmits them again back to the soil.

”Reinforced block” is the mass of the soil which contains the reinforcements. It has height equal to the height H1 of the panels and width equal to the length L of the reinforcement of the reinforced fill (Fig. 42-2).

“Backfill material” is the fill which surrounds the reinforcement (Fig. 42-1).

“Fill behind the structure” is the fill behind the reinforced block and up to its top surface (Fig. 42-1).

“Facing panel” is the vertical or inclined wall formatted by precast concrete panels of limited thickness anchored on the reinforcements. The facing panel does not constitute the retaining element but its facing (Fig. 42-1).

“Reinforcement” are the steel strips or bars or bar grids which undertake the internal horizontal forces of the reinforced block (Fig. 42-1).

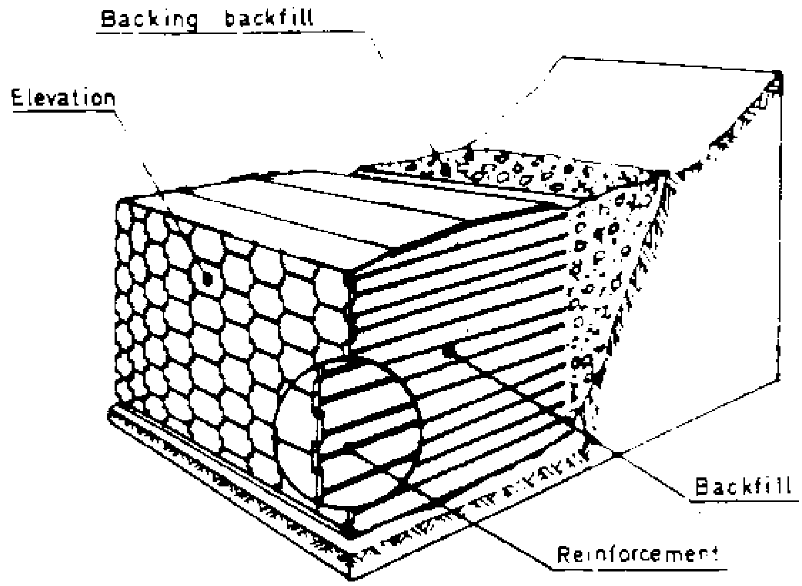


Figure 42 – 1

<u>Geometrical elements</u> : Figure 42-2 shows the various geometrical data of a "reinforced fill' structure. According this figure H1 is the total height of the face which includes the depth of positioning. H is the mechanical height which is used in the calculations and L is the length of the reinforcement.

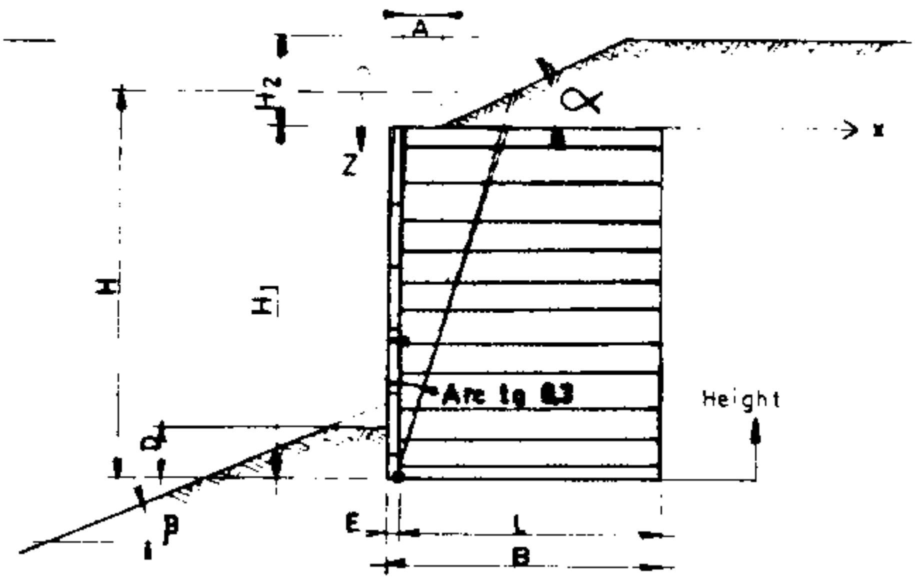


Figure 42 - 2

Height measurement shall be made in a section from the lowest level of the face. As a starting level for the measuring of the depth shall be taken into account the level in which a straight line passing from the lowest extremity of the face as defined in Figure 42-2 intersects with the slope overlying the reinforced block of the wall.

42.3 CLASSES OF STRUCTURES

CLASSIFICATION BASED ON THE ENVIRONMENTAL CONDITIONS

In the present specification and according to the influence of the environment the following four basic classes of structures are distinguished :

CLASS A : Structures out of the water.

These are the structures which are never inundated by the water and are not classified in class D usual structures.

CLASS B : Structures in fresh water.

These are structures which are permanently or periodically, partially or fully inundated by the water. The water content in salts must be limited to the limits valid for drinking water and is characterized by the content in ions (CI -) <= 250 mg/I and (SO4--) <= 250 mg/l.

CLASS C : Structures in salt or brackish water.

These are structures which are permanently or periodically, partially or fully inundated by salt or brackish water or/ and may be directly exposed to marine waves. The brackish water denotes here the water of river estuaries, lagoons and generally the water whose content in salts lies between the content in salts of the fresh water and of sea water.

CLASS D: Particular structures

These are structures within an environment very corrosive for steel and concrete (see also para. 42.8).

42.4 REINFORCEMENT

The material of the reinforcement is determined by the license of the system based on its specifications to be approved by the competent authority and according to which the laboratory testing of the reinforcement shall be effectuated.

42.5 PRECAST CONCRETE ELEMENTS(panels, corner elements, cover slabs and wall top elements)

42.5.1 General

Precast elements (panels, slabs) to be constructed of concrete with characteristic strength fck at least equal to 27 MPa and to be checked according to the concrete technology code (G.G.G. 266/6/9.5.85).

Panels to be cast in horizontal surfaces with the finally visible surface at the bottom. The concrete is to be cast without interruption and be vibrated with a vibrator approved by the competent authority, disposing also a manual head in order to allow for the vibration of the angles of the steel moulds. For their lubrication pure oil for moulds is needed to be used throughout the whole fabrication of the panels and to be of the same type and from the same constructor.

42.5.2 Tolerances

All dimensions 3 mm. Diagonal dimension of the panel 5 mm in 1500 mm.

42.5.3 Handling

The handling of the elements, the stocking and their transport must be such that no fracture due to shearing, bending etc. occurs. The panels must be stocked on supports so that damage of their exceeding equipments (anchors etc.) is avoided.

The supports have to be such that they do not provoke prints or damages on the facing of the panels. On the back of each panel it must be clearly written their type and destination. The erection of the panels is to take place 14 days after the day of their production.

42.6 CONNECTORS

They shall be of hot galvanized steel according to the specifications of the licensed system and having a resistance appropriate to bear the loads. This resistance should not be less than of the resistance at yield of reinforcement and if this cannot be obtained to be at least twice the pull out resistance of reinforcement.

42.7 JOINTS

The materials for joints (foam, geotextile, joint filter etc.) to be as denoted in the drawings and to have resistance appropriate for their use.

42.8 BACKFILL MATERIAL

42.8.1

The materials for the backfill may be either natural materials or originated from a quarry. It is not allowed to include planting materials, decomposed materials, garbage or other harmful material.

42.8.2

The fill must comply with the geotechnical and chemical / electrochemical criteria described below.

42.8.3

Material for the fill to be utilized and are of industrial origin or from the sea or more generally of doubtful behavior, must be notified to the competent authority and controlled in the laboratory. The use of such materials can be done only with the agreement of the competent authority and following a specific study with additional requirements.

42.8.4 Geotechnical criteria

42.8.4.1

The fill material must comply with the grading to be determined according to the specifications for laboratory testing and having a uniformity coefficient greater or equal to 2.

TABLE 42-1 : GRADING OF FILL MATERIAL

Sieve diameter	% Passing
250 mm	100
75 mm	no less than 75
10 mm	no less than 10
0.75 mm	0-15

If the fill material has more than 15% passing the 75 pm sieve it may still be acceptable subject to further tests of fine particle analysis with hydrometer and shear box tests (specifications of Soil Mechanics laboratory testing, E 105-86, no 9 and 16 respectively).

For this purpose the passing percentage of material finer than 15 £m is to be examined and

- if this is more than 20% the material is inappropriate
- if this is less than 10% the material is appropriate
- if it lies between 10% and 20% then the angle of internal friction is determined by means of rapid direct shear tests on consolidated specimens and if this angle is
  - greater or equal to 250 for ribbed steel or 220 for smooth steel the material is appropriate
  - less than 25° for ribbed steel and 220 for smooth steel the material is inappropriate.

42.8.4.2

The fill shall not contain materials which will lose its frictional characteristics, material sensitive to water or unsuitable material such :

- Materials from marsh
- Turf, peat and perishable material
- Material susceptible to spontaneous combustion
- Materials in a frozen condition
- Materials with a moisture content greater than the maximum permitted for such materials as determined by the competent authority.

42.8.4.3

The fill material shall be compatible with the thickness of the layers to be compacted and shall be capable to be adequately compacted, according to the requirements and by using ordinary site engines. The fill should not contain particles greater than 250 mm.

42.8.5 Chemical and electrochemical criteria

42.8.5.1 The activity of Hydrogen ions or "pH"

The pH value of fill measured according to methods in 851377:1975, on water extracted from a soil - water mixture (1 part of dry soil with 1 part of distilled or de-ionised water with a resistivity greater than 200 KΩcm) shall be in the range of 5 to 10.

42.8.5.2 Resistivity

42.8.5.2.1 General

The resistivity of a compacted and saturated sample shall not be less than 1000 0cm for structures of class A and 3000 Ωcm for structures of class B. This test must be carried out following the procedure recommended in paragraph 1.3 of the French Code for "Reinforced Earth" structures (1979). For fill material with a resistivity in the range of 1000 to 5000 Ωcm the content of soluble salts (sulphate and chloride) shall also be measured. In this case the testing must be carried out as described in the following paragraph.

42.8.5.2.2

Content of soluble salts (sulphate and chloride) - additional testing requirements for fill which has a resistivity in the range 1000 and 5000 Ωcm

A representative bulk sample of fill material shall be obtained for the purpose of determination of Soluble salts concentration. The soil/water extract to be use for these s shall be prepared as follows. (this water may be used for the pH measurement).

A thermostatically controlled drying oven capable of maintaining a temperature of 750C to 800C (the normal drying oven can usually be adjusted to cover this range) shall be used to dry the bulk sample at a temperature of not less than 750C and not more than 800C.

The sample shall be deemed to be dry when the differences in successive weighing, carried out at intervals of 4 hours, do not exceed 0.1% of the original weight of the sample. Drying overnight is usually sufficient. Particles larger than 10mm shall be removed by sieving from the dry sample.

Next, approximately 500 gr of the dry sample shall be accurately weighed to the nearest 0.01 gr and placed in 1 It wide mouthed, screw taped plastic bottle. In this 500 mi of distilled water shall be added and the sample shaken. The necessary portions of soil/water extract shall be taken and prepared according to the specific requirements for the following determinations

a. Determination of chlorides (Cl)

The determination of the chlorides is required for the natural fill materials the resistivity of which is within the range of 1000 to 5000 Ωcm.
The concentration of chloride is to be determined in accordance with BS812:1976, Part 4, on a soil/water extract obtained as described before. The average of the values obtained from these soil/water extracts shall be reported to the nearest 10mg/kg (0.001%).

The chloride content shall be not greater than 200mg/kg (0.02%) for structures in class A or 100mg/kg (0.01%) for structures in class B.

b. Determination of sulphates (SO4--)

The determination of sulphate content is required for natural fill materials, the resistivity of which is within the range of 1000 to 5000 Ωcm.

The soil/water extract as described before shall be prepared in accordance with B51377:1975, Test 10, and the concertation of sulphate (SO_4^{--}) shall determine gravimetrically in accordance with BS1377:1975, Test 9, paragraph 3.2.4.3. This test reports the percentage of sulphate as S03-.

The sulphate (SO_4^{--}) content shall not be greater than 1000 mg/kg (0.1%) for structures of class A or 500 mg/kg (0.05%) for structures of class B. For results reported as sulphite (SO_3^{--}) the content shall not be greater than 833mg/kg (0.083%) or 416mg/kg for the respective classes of structures as previously stated. Results reported as (SO_3^{--}) may be converted to (SO_4^{--}) by dividing by the factor 0.833. In the table below are summarized the chemical and electrochemical criteria already described which refer to usual fills.

TABLE 42 - 2
ELECTROCHEMICAL AND CHEMICAL CRITERIA FOR FILLS

Class of the structure	Resistivity	PH	Cl^-	SO_4^{--}
A	> 1000 Ωmm	5 to 10	< 200 ppm	< 1000 ppm
B	> 3000 Ωcm	5 to 10	< 100 ppm	< 500 ppm

42.9 CONSTRUCTION OF "REINFORCED FILL"

42.9.1 Foundation preparation

The foundation for the structure shall be graded level for a width equal to or exceeding the length of reinforcements or as shown on the drawings. Prior to wall construction, the foundation shall be compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced by materials according to the suggestions and requirements of the competent authority. The facing panels shall be founded on a concrete levelling pad at levels shown on the drawings. The finish of the top surface of the levelling pad shall be smooth and flat and must not vary more than 3 mm from the levels shown on the drawings.

42.9.2 Filling and compaction

The fill shall be deposited, spread, levelled and compacted in horizontal layers of thickness appropriate to the compaction equipment used in accordance with the requirements of S.T.S. X1 (Π.Τ.Π. X1), the suggestions of the supervising authority and in addition :

a. The deposition arid compaction shall be carried out so that all layers of reinforcing elements shall be placed at the required levels on top of compacted fill,

b. The deposition, spreading, levelling and compaction of fill shall be carried out generally in a direction parallel to the facing and shall be executed in stages to alternate with the placing and fixing of the reinforcing elements and the facing.

c. Care shall be taken to ensure that the reinforcing elements and facing are not damaged or displaced during deposition, spreading, levelling and compaction of the fill. The programme of filling shall be arranged so that no machines or vehicles run on the reinforcing elements.

d. All vehicles, and all construction equipment weighting more than 1500kg shall be kept at least 1.5 meters away from the facing.

e. The fill within 1.5 meters of the face of the wall shall be compacted using one of the following :
   i. Vibro tamper
   ii. Vibrating plate compactor having a mass not exceeding 1000kg
   iii. Vibrating roller having a mass per meter width of not more than 1300kg and a total mass of not more than 1500kg

42.9.3 <u>Reinforcement</u>

All elements which constitute the reinforcement shall be loaded, unloaded and handled in such manner that :

— No permanent deformations is caused by bending,
— Protective coating is not damaged. (e.g. zinc coating)
— Stored fiat clearly to identify items having different lengths and cross sectional dimensions.
— Connected to the facing panels as backfilling progresses.

42.9.4 <u>Panels</u>

The precast facing panels shall be erected in such a manner to give a good line and appearance within the tolerances described below. Unless otherwise stated in the drawings, the structure is to be erected so that there are no local deviations from line of more than 20 mm in 4.5 meters. The facing shall be vertical with the following tolerances: Walls ±4 m per meter of height, abutments ± 3mm per meter of height. In addition no point of the facing shall be more than 30 mm from its theoretical position.

Clause 43 : CONCRETE ROAD PAVEMENTS

43.1 GENERAL

Unless otherwise stated in this Specification, the stipulations of Clause 6 of the Technical Conditions of Contract (T.C.C.), shall be applicable in general, for all matters pertaining to materials, composition, procedures for preparation, transportation and consolidation, sampling and testing of conformity and obligations.

43.2 MATERIALS

43.2.1 Cement

Cement shall conform to the requirements of "Cement Regulations for Concrete Works". (See paragraph 6.4.2 of Clause 6 of the T.C.C.).

43.2.2 Water

Mixing water and water for curing must satisfy the requirements of Standards. (See paragraph 6.4.4 of Clause 6 of the T.C.C.).

43.2.3 Additives

If additives are used, the stipulations of Concrete Technology Regulation shall be applicable. It is compulsory to use air entraining concrete admixture, according to the special specifications in quantity that ensures air content in the mixture 4.5 11.0%. Air content testing is carried out at least 6 times a day in accordance with the method and paragraphs 6.8.5 and 6.8.9 of Clause 6 of the T.C.C.

43.2.4 Aggregates

Concrete aggregates shall be in accordance with Clause 6 of the T.C.C. and in particular should satisfy the following requirements :

1. The grain-size grading of the aggregate mixture shall be within sub-zone of diagram 1 of Clause 6 of the T.C.C.
2. The loss of the coarser than sand, aggregate particles, during the friction and impact strength test (Los Angeles Test ASTM-C131/AASHTO-T96), should not exceed 30%.
3. Sand equivalent value (ASTM-D 2419/AASHTO-T176) should not be less than 80.
4. Sand fines (ASTM C-33) must not exceed 3.3 neither be less than 2.3. The value fluctuation from the mean value shall not exceed ±0.4.
5. The percentage of friable and soft particles, defined according to method, must not exceed 1% of the weight of the portion of aggregate, as brought to the mixing plant.Silt content must not exceed 0.25% of the weight of the portion of aggregates, as brought to the mixing plant.

6. Sand may be natural sand (from river, mine or sea) or mixture of sands (crushed or natural) that satisfies the relative requirements of this Specification and the requirements of Clause 6 of the T.C.C.
7. For obtaining a skid resistant surface, durable to the long term effects of traffic and for low speeds, the following must be satisfied :
   a. Sand must consist of hard aggregates durable to wear and abrasion. This sand can originate from natural hard gravels, that have been partly crushed, to obtain a high percentage of particles with crushed surfaces, or from crushed hard rock material, or crushed coarse gravel from river beds, originating from hard rock, or can be natural (selected) sand. The percentage of the sand silica grains defined according to ASTM D-3042 Standard, must not be less than 40%. if such sand is not easily available, then the sand durability in wear and abrasion is tested with the friability test, according to the French Standard NF P 18-576. The sand's friability coefficient must not be larger than 15.
   b. Most of the coarser sand particles must have a Polished Stone Value (P.S.V.), defined according to BS 812 Part 3/1975 Standard, larger than 0.45.1
8. In case of difficulties in finding aggregates that satisfy the above requirements or for achieving economy, it is possible to
   a. Construct the concrete slab in two layers (20cm on the bottom and 8 cm on the top) that are poured and consolidated one after the other with a maximum time lap of 20 min. The lower layer is constructed with crushed limestone aggregates and the top layer with aggregates that satisfy the requirements of the previous subparagraphs 43.2.4.8a and 43.2 .4 .8b.
   b. Construct the whole concrete slab with limestone aggregates and have the surface sprayed - embedded with durable to abrasion aggregates, that satisfy the requirements of the previous subparagraphs 43.2.4.8a and 43.2.4.8b.

43.2.5 Concrete curing materials

The special liquids for curing that will be used in this case, are sprayed on the surface of the fresh concrete creating a fine impermeable membrane, which prohibits water evaporization. They must conform to the requirements of Specification ASTM C 309 and must have white or metallic color that causes light reflection.

43.2.6 Joint materials

43.2.6.1 Joint Sealers

Joint sealers must preserve resilience and good bond with the concrete for a long period and under all weather conditions. They must not allow penetration of foreign bodies in the joints and ensure their watertightness.

During hot weather, the sealers must not overflow from the joints, nor stick on the tires. Under low temperatures, they must not lose their resilience and become friable. They must also be resistant to chemical actions from fuel, lubricants and oils from vehicles.

The type of sealing material, that will be used for the joints, must have the prior approval of the Service, which will take into consideration the conditions of the project and the cost of the material. The Contractor shall submit, in due time, test certificates, to the Service, from a recognized laboratory, certifying that, depending on the type of material used, the latter satisfies the requirements of one of the following Regulations:

a. ASTM D 1850 Specification for Concrete Joint Sealer, Cold Application Type.
b. ASTM D 1190 Specification for Concrete Joint Sealer, Hot-Poured Elastic Type.
c. ASTM D 1854 Specification for Jet-Fuel-Resistant Concrete Joint Sealer, Hot-Poured Elastic Type.
d. SS-S-195b Federal Specification Sealing Compound, Two Components Elastomeric, Polymer-Type, Cold Applied, Concrete Paving Joints.
e. SS-S-200d Federal Specification Sealing Compound, Two Components Elastomeric, Polymer-Type, Jet-Fuel-Resistant Cold Applied, Concrete Paving.
f. ASTM D 2628 Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements.
g. ASTM 2835 Specifications for Lubricant for Installation of Preformed Compression Seat in Concrete Pavements.

43.2.6.2 Expansion Joint Fillers

Fillers for expansion joints must be flat rectangular sheets of soft wood, free of knots and other defects, or of other suitable compressible material. Fillers must have the prior approval of the Service, and must satisfy the terms of one of the following Regulations:

a. ASTM D 1751 Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types).
b. ASTM D 1752 Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
c. ASTM D 994 Specifications for Preformed Expansion Joint Filler for Concrete (Bituminous Types).

43.2.7 Steel

43.2.7.1 Tie Bars for Slabs

The tie bars for the slabs are bars of S-220 or S-400 steel of plain round section or ribbed, with or without end hooks.

Dimensioning of the reinforcement, placing and other construction details are given in paragraph 43.4.8.2 of this Specification.

43.2.7.2 Dowels

Dowels are usually bars of S-220 steel, of suitable diameter, that are placed in the joints at specific spacing, for the purpose of load transfer through the joint from one slab to another, and to avoid any vertical displacement of the ends of two adjoining slabs.

Dimensioning of reinforcement, placing and other construction details are given in paragraph 43.4.8.1 of this Specification.

43.3 COMPOSITION OF CONCRETE

The Concrete composition is defined according to the stipulations of paragraph 6.5 of Clause 6 of the T.C.C. so that the resulting concrete satisfies the following requirements:

a.	Characteristic strength (compression)	400 Kg/cm^2
b.	Slump value	max 5 cm
c.	W/C ratio	max 0.50
d.	Minimum cement content	350 Kg/m^3

It is also recommended not to use cement more than 420-450 Kg/m3, as the risks of cracks due to shrinkage are increased.

During the mix design, strips 0.5m wide, 1.50m long and 0.08m thick, are constructed and shaped by a method similar to the one that will be applied in the project.

Afterwards, the surface is brushed with the same method and the same brush that will be used in the project. The shape of the resulting surface is evaluated to see if it is skid resistant, and whether the grooves created have the desired depth, and remain unchanged with time (whether they fill-up with watery cement mortar or not). Furthermore the time period, within which brushing is more successful, is found. Minor modifications are also made to the mix design, during these tests, to facilitate the contractor in the formation of the skid resistant surface. It is noted that in general, the most suitable mixtures are those with increased sand content, more than usual, and with minimum perspiration.

If the method of spraying and embedding hard aggregates into the top surface of the concrete (see above para 51.2.4.9b) is to be used, then similar tests are conducted, to define the correct ratios of the mixture that will facilitate this job.

43.4 CONSTRUCTION METHODS

43.4.1 Placing of side forms

The side forms will be steel forms 4 - 8 mm thick, with a minimum 20 cm wide base. The forms must not be distorted2 under the loads and the vibrations of the placing and consolidating machines. Their placement must be carried out to the true positions and levels, on very well compacted sub-base, with close supports and correct location to each other, in order to ensure a firm frame. The precision of the placement of the forms, measured at any time on a 3 m distance, shall not exceed 3 mm in elevation and 6 mm in length.

The forms, before their placement, must be cleaned and before concreting must be coated with a suitable liquid compound to avoid concrete bonding on the forms. The removal of the forms will take place after the concrete has set and acquired sufficient strength, so there are no risks of damage to the concrete surfaces and edges in contact with the forms. The removal of the forms cannot take place before 10 hours, unless special cements are used, and avoidance of damages is guaranteed.

It is permissible to use, instead of forms, the sides of the neighboring strips of concrete, provided that, this concrete is at least 3 days old, all necessary measures are taken to protect this concrete from being damaged from impact or other actions, and it's surface satisfies the requirements of correct placement of forms (divergence not greater than 3 mm in a 3 m distance).

43.4.2 Preparation of sub-base (C.T.C.S.)

The layer that will support the concrete slab shall be well brushed with a mechanical broom so that all loose and weak parts are removed. The surface is then well sprayed with plenty of water. During concreting there must not be places with accumulated water, but the surface must be wet.

43.4.3 Concrete transportation

Further to the stipulations of paragraph 6.7 of Clause 6 of the T.C.C. the duration of transportation must not exceed 45 min. when the ambient temperature is less than 25°C and 30 min. when the ambient temperature is between 25°C and 35°C. If the ambient temperature is greater than 35°C, concreting is postponed until such time as the temperature is less than 35°C. Concreting may be allowed, provided special measures are taken to cool the concrete and protect it during placement, consolidation and for the following 48 hours after completion of the work.

The means of transportation and their filling and evacuating arrangements, shall be approved by the Service prior to the commencement of the works. The Service, however reserves the right, to withdraw such approval, should it be found that for any reason whatsoever, these means unfavorably affect the production of homogenous concrete.

43.4.4 Concrete placement

Concrete placement must be carried out in such a manner that requires the minimum shifting of materials, with methods and mechanical means that do not allow segregation and facilitate homogenous and complete consolidation. Placement shall be carried out in the whole width of the road, or in strips from a joint or edge of a slab to a joint. The thickness of the concrete placed must be constantly greater than the required slab thickness, depending on the mixture, by 5 - 20 mm approximately. Special attention must be given in cases with high longitudinal and cross-slopes, to take into account the shifting of the concrete towards the side with lower level. The laboratory responsible for the design mix shall define in first approximation the required additional thickness, which will be defined more precisely after placement of the trial section.

Placement may be carried out by special machinery (of the type of moving bucket, endless screw or spreading blade) which must be approved by the Service and tested during the construction of the trial section, to prove that they operate satisfactorily.
Concrete temperature during placement must not exceed 30°C.

43.4.5 Levelling and consolidation

Immediately after placement, concrete is levelled and consolidated by mechanical means, which must be approved by the Service. These mechanical means, during the construction of the trial section must be tested to prove that they level and consolidate the concrete satisfactorily.

The final approval for the use of any levelling and consolidating machinery will be given after the trial section is inspected from the point of view of levelling, strength and the required time for completion of one concrete batch (concrete placed on the road must be levelled and consolidated within 45 minutes for ambient temperatures that do not exceed 25°C and within 30 minutes for ambient temperatures above 25°C). Levelling and consolidation of concrete may be carried out in one of the following ways :

43.4.5.1 Use of special machines on tracks or slip-form

These machines are equipped with rotating blades or endless screw or a special blade that remove the concrete in excess. Consolidation is achieved with vibration or combining vibration and impact and the final levelling is done by a vibrating beam of rectangular section that operates on the whole width of the strip across, or slightly slanted. This beam is supported in combination with the moving mechanism of the machine to minimize the errors in the placement of the forms.

To obtain a surface with special finishing requirements it might be necessary to have the machine pass twice over the section in question, or use two similar machines.

Movement of the levelling/consolidating machines on the side forms or tracks must be done with constant speed.

The vibrating equipment of the machines must be provided with an arrangement that interrupts operation when the machine is not moving to avoid segregation of the concrete. The surfaces of the forms must be thoroughly cleaned before the passing of the machine to avoid having irregularities on the final surface of the concrete.

Consolidation must be uniform across the whole width of the strip under construction, and if necessary will be supplemented at the edges and corners with mass vibrators.

Instead of machines on tracks, plain slip-form pavers for levelling and consolidation may be used. The use of such machines is permitted only after prior approval by the Service. Such approval will be granted provided, manufacturer certificates are submitted, certifying that construction of the work is possible with the given requirements of this specification (concrete class, slab thickness, strip width, concrete density, concrete strength, evenness).

43.4.5.2 Consolidation with Power Compacting Beam

It is possible to use with this method (relatively small) special machines that provide satisfactory levelling and consolidation with vibration of the whole thickness and width of the strip under construction. The use of such machines (Power Compacting Beams) will not be permitted unless certificates of the machine's manufacturer are submitted, (accompanied by relative bibliography) certifying that construction of the work is possible with the given requirements (concrete class, slab thickness, strip width, concrete density, concrete strength, evenness).

43.4.5.3 Consolidation with plain means

In roads of small or medium traffic loads, or in special cases (slabs with highly variable width), it is possible to use simple means of consolidation, following approval by the Service.

Concrete is first levelled with a vibrating bar uniformly across the whole width of the strip under construction, so that the thickness of the concrete after full consolidation is as required by the design. Consolidation then follows with mass vibrators operated by experienced personnel. Moving the vibrators in and out of the mass of the concrete must be carried out in slow motion, perpendicularly and in distances not exceeding 45-50 cm.

Vibration should last long enough until full consolidation of the concrete is achieved (no air bubbles come to the surface) but should not last more than necessary, as it will segregate the concrete materials. Vibration of the edges of the slab shall be carried out with special care, to obtain perfect consolidation with no voids or segregation of the concrete. The vibrator must not come in contact with the reinforcement of the joints for fear of dislocating the bars from their correct position. After consolidation with the mass vibrators, follows the surface consolidation with a hand held vibrating bar for the final formation of the surface. The vibrating bar must be of wood with casing of steel, or similar material, not less than 75 mm wide and more than 220 mm high, having absorbsion not less than 250 W for every meter of bar. The length of the vibrating bar must be greater than the width of the strip under construction by at least 50 cm.

The vibrating bar is moved forward (in the direction of concreting), lifting it with the hands and shifting it in small paces, that must not exceed the width of the vibrating bar. After completion of the vibration in this manner for a length of approximately 1.50 m, the bar is brought back 2 m and without lifting it, is dragged slowly forward with the vibrator in operation and with it's two ends always in contact with the side forms, to form the final concrete surface.

43.4.6 Formation of the skid resistant surface

Once the concrete has obtained a surface in accordance with the requirements of levels, slopes, and super elevation and no irregularities, it is treated with a special brush or other suitable tool, to obtain a skid resistant surface.

This treatment can be carried out with a special wire brush that is dragged slowly over the surface of the concrete , across the axis of the road. For this purpose the person operating the brush must move on a simple wooden bridge that is rolled on the side forms, or use a special machine.

The brush must be at least 450 mm long and consist of two lines of wire tufts at 20 mm distance from each other. The distance between tufts of the same line is 10 mm, and the two lines are placed in such a way, so that the tufts of the first line are aligned with the void between the tufts of the second line. Each tuft consists of approximately 14 wires, of steel used for springs, with a section of 0.355 mm X 1.25 mm and 100 mm long. The wires must be replaced when their length is down to 90 mm.

The grooves that are created on the concrete surface must have a depth of 0.8 2.0 mm.

The Service may permit the use of another suitable tool or brush of another type, for the formation of the final surface of the concrete provided the requirements of this Specification for a skid resistant surface are satisfied.

43.4.7 Curing

After completion of all the operations mentioned above, all necessary measures must be taken to protect the concrete from premature loading or shocks, harmful' external chemical attacks and the effect of unfavorable weather conditions.

In particular, the concrete must be protected from the evaporation of the water in the mix and sudden temperature variations. For this purpose the following method can be used

43.4.7.1 Curing with special liquid compounds

After the brushing of the concrete surface and provided there is no free water on the surface in the form of a fine membrane, a special curing liquid compound is uniformly sprayed with a special device in a quantity not less than 0.27 ltim2.

In case of high temperatures (i.e. > 30°C) or wind or low relative humidity (i.e. < 50%) there is danger of the concrete cracking while it has not yet set, and that is why the curing compound must be sprayed in double quantity from the one specified, immediately after the treatment for skid resistant surface.

The spraying tool must be equipped with a mixing device that will constantly mix the curing liquid compound during the spraying operations. Operations must be carried out very thoroughly and with great care to ensure that the material is sprayed uniformly and there are no spots that are not covered by the curing liquid. This is best achieved with mechanical sprayers that are fixed on a carriage that rolls on the tracks.

The spraying mechanism covers the whole width of the strip under construction, or moves on the carriage across to the axis of the road, and is equipped with a special cover to stop the wind from blowing away the curing liquid.

The sprayer must move with a constant speed to achieve uniform spraying.

The Service may request the use of such a machine, depending on the weather conditions, the importance, the extent and the special requirements of the project. Otherwise, spraying will be carried out with hand-held sprayers in quantity 0.36 lt/m2.

The curing liquid must have a silver color to limit the increase of concrete temperature from radiation.

After removal of the side forms, the exposed surfaces of the concrete must also be sprayed with curing liquid.

For protection from sudden temperature variations (increase of temperature due to sun radiation, or sudden fall of the temperature during the night) and from rain, the concrete laid on each day must be covered with low shades that have reflecting external surface with a light color (metal or white). These shades are rolled on the tracks of the side forms and must cover the concrete from all sides to protect it from the wind. Particular attention must be paid in covering also the sides across the axis of the road to avoid the creation of wind currents. On the other hand, in case of high temperatures, some sides must be left open to allow slight movements of air, and thus avoiding increase of temperature.

In case of relatively high temperatures during the day, but expected considerable drop of temperature during the night, the sections of concrete that have been cast till noon, must be further protected by covering them with a thick layer of saw dust or straw or impermeable curing sheets to reduce the sudden temperature drop, that might create premature cracking of the concrete.

In projects of minor importance, depending on the conditions of the work and the prevailing temperatures, the Service may agree to omit the shades, provided the concrete has been thoroughly sprayed with curing liquid compound.

43.4.7.2 *Curing with impermeable sheets*

It is not permitted to apply the method of curing with impermeable sheets for concrete road pavements.

43.4.7.3 *Curing by covering with soaked hesian cloths*

Similarly, as in paragraph 43.4.7.2 above, it is not permitted to use the method of curing by covering with soaked hesian cloths, for concrete road pavements.

43.4.8 Joints

The pavement joints are distinguished as transverse and longitudinal joint, and shall be constructed according to the detailed design drawings (Construction Drawings).

43.4.8.1 *Transverse Joints*

43.4.8.1.1 Expansion Joints

They will be constructed only before structures and other structures that need to be isolated from the possible effects of the concrete contraction/expansion. Expansion joints must also be provided in the crossings of rigid pavements and wherever the Service or the designer deems necessary. The locations of expansion joints are shown in the construction drawings.

The filler material of the joints shall be according to the requirements of paragraph 43.2.6.2 and must be 18 - 25 mm thick. It must be sufficiently rigid and supported in such a way that it will not be deformed or dislocated during the pouring and consolidation of the concrete. If soft wooden boards are used, these shall be soaked in water for 48 hours. The Construction Drawings shall indicate whether or not the joints will be provided with reinforcing bars (dowels), depending on the location and the loading. When reinforcing bars are provided for the joints, then holes must be opened in the filler material at the specific distances provided for in the construction drawings.

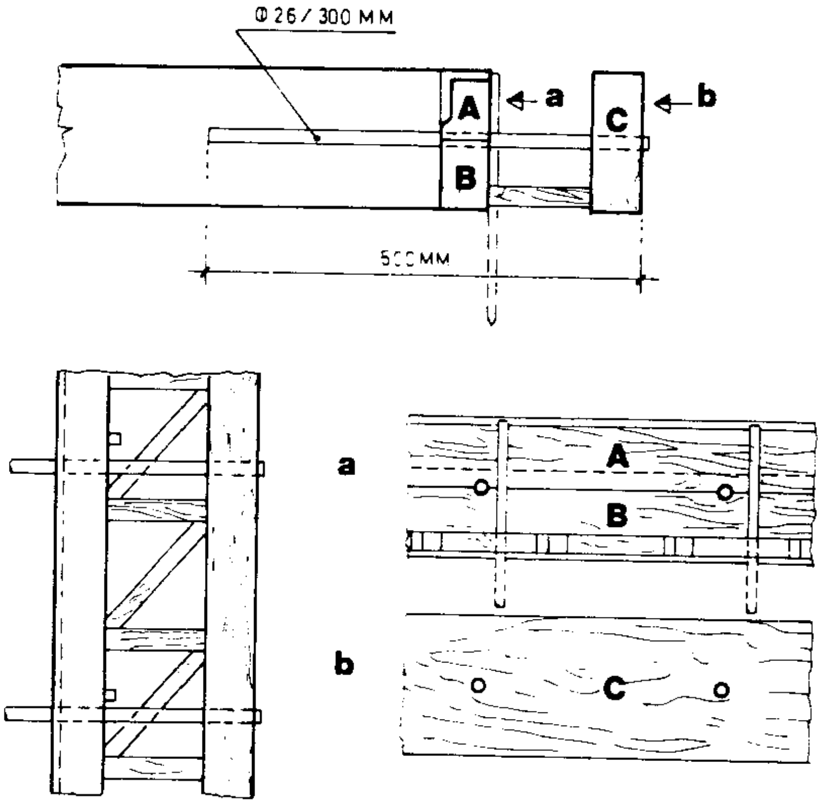
The bars diameter shall be 26 mm and 24 mm for heavy traffic roads or for average or light traffic roads respectively. The length of the bars shall be 500 mm. The distance of the first bar from each end of the slab shall be 7.5 cm, then two bars at 15 cm distance are provided, and afterwards the spacing shall be 30 cm.

The support and fixing of the reinforcing bars shall be done with special arrangements such as that of figure 51-1 that does not permit displacement of the bars prior to and during the pouring and consolidation of the concrete. The placement of the reinforcing bars must be carried out with great care. They must be placed in the center of the thickness of the slab and be parallel to the road surface and the longitudinal axis of the road, with the following tolerances :

a. The distance of the axis of the bars from the surface of the concrete must be equal to half the thickness of the slab i2 cm.

b. The deviation from the parallel to the surface of the pavement and the longitudinal axis of the road must not be greater than 2 mm on 300 mm length in all bars.

A special cylindrical cup, from hard durable carton board or other suitable material, approved by the Service, shall be placed and fixed on one end of the bars, in such a way that it provides , space for expansion inside the cover. For better fixing of the cover this space is filled with cloth or other compressible material. The part of the bar that has the cover is coated with special liquid that prohibits bonding of the bar and the concrete (bond breaker).



It is recommended that the bars are steeped in thick asphalt solution to provide bond breaking with concrete

Fig. 43-1 Indicative arrangement for the formation of construction joint

This coating is provided on more than half of the total bar length, by 3 cm to 5 cm. The suitability of the bond breaking liquid must be tested and proven in a laboratory prior to the start of the work.

At locations of islands for toll booths, when these are near to rigid structures (canopy foundation etc.), expansion joints are provided as indicatively shown in fig. 43-2.

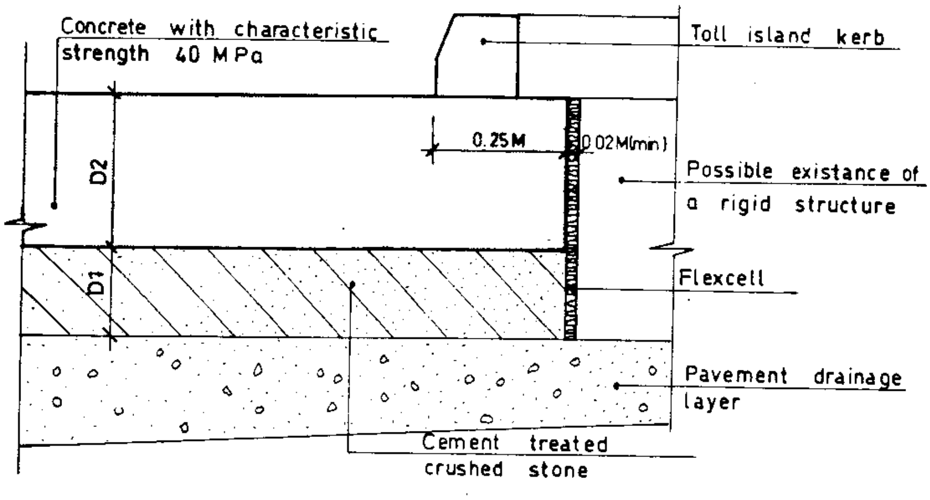


Fig. 43-2 : Expansion Joint

43.4.8.1.2 Contraction joints or dummy joints

These joints constitute an interruption of the continuity of the concrete, and are provided to avoid cracking due to the obstruction of the movement of the slab, generated from the shrinkage and the temperature variations of the concrete.

This interruption of the continuity of the concrete is achieved by cutting the concrete with a joint-cutting machine, after it has set, to a depth equal to 1/4 of the thickness of the slab (See figures 43-3 and 43-6 and table 1-43).

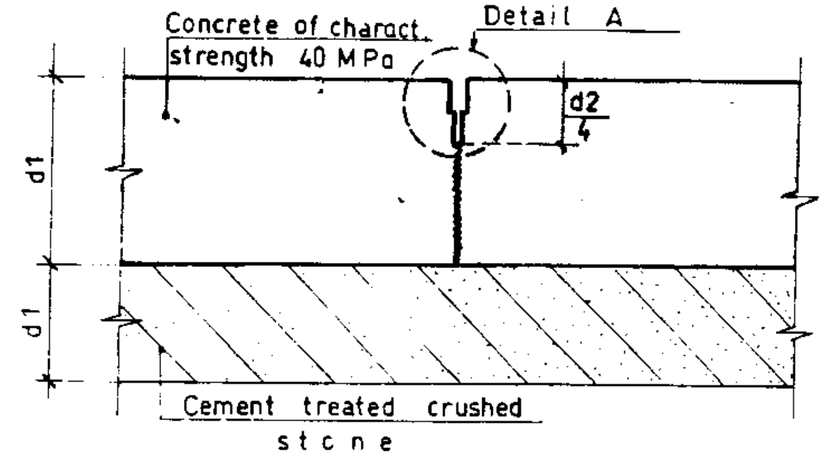
The contraction joints are constructed at spacings of 4.0 m and 5.0 m and have no reinforcing bars (dowels).

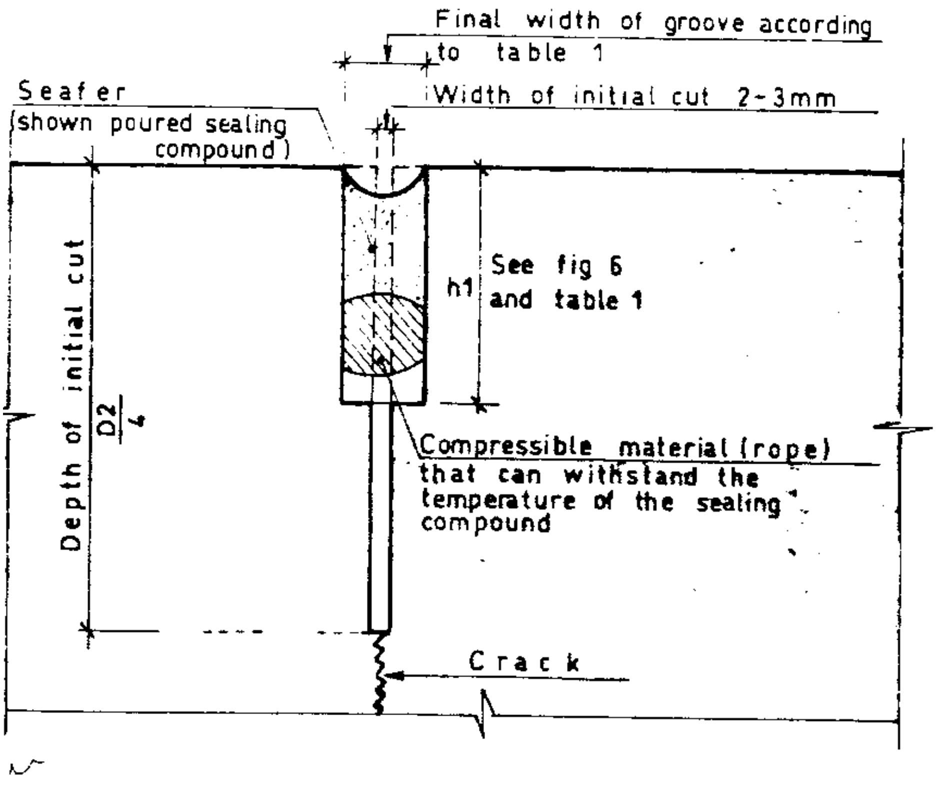
43.4.8.1.3 Construction joints

Construction joints are provided at the end of the section of each day's work and must coincide with the location of a contraction joint or an expansion joint, or are constructed in cases of emergency (i.e. rain), or in cases that for some reason work was interrupted for more than 30 min. It is not permitted to create a construction joint closer than 2.5 m from another joint. In such cases the concrete poured is to be removed up to the previous joint.

Construction joints must be constructed as contraction joints with reinforcing bars (dowels). A special arrangement, such as the one shown in figure 43-1, must support the reinforcement on the side of the slab that is not to be constructed that day, and also allows the removal of the temporary side form.

The dowels shall be 500 mm long and have a diameter of 26 mm. They shall be placed at 300 mm spacing and at least the 2/3 of their total length shall be coated with special asphaltic material as bond breaker, that also protects the steel from corrosion.





43 – 3 Construction Joint - Detail A

43.4.8.2 <u>Longitudinal joints</u>

When the width of the concrete strip is greater than 5 m, then longitudinal joints shall be provided at the center of the strip (Figure 43-4).

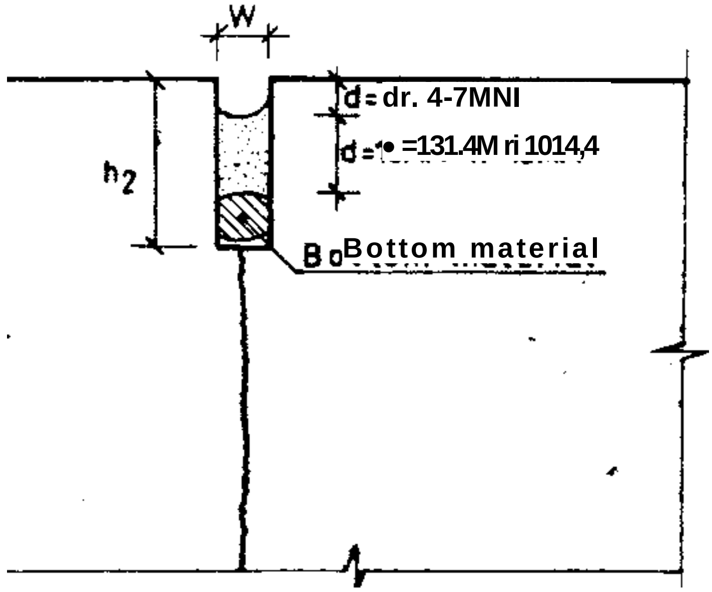


Fig. 43 -4 : Longitudinal joints

In roads with two or more traffic lanes, the longitudinal joints are provided along the longitudinal axis of the road or the separating axes of the lanes. The width of the strip resulting from such arrangement may vary from 3.60 m to 4.60 m, depending on the road section, and it is not permitted to exceed the upper limit. In special cases, when the width of the strips is less than 3.60 m then the transverse joints shall be constructed at distances smaller than 4.0 m so that the ratio of the slabs width to length will range between 1 : 1 and 1 : 1.7. In the case of toll pavements the locations of the longitudinal joints are shown in the Construction Drawings.

In the areas outside the islands the joints must be provided with anchoring bars, consisting of bars with a diameter of 12 mm, a horizontal length of 1.0 m, and placed at 60 cm distances (Fig. 43-5a and Fig. 43-5b).
When the concrete strips are constructed on different days, cutting and filling of the joint may be omitted (after such omission has been approved by the Service), provided that a suitable elastic tape that satisfies the requirements of paragraph 43.2.6, is placed on the side of the hardened concrete, and then followed by the casting of the neighboring strip.
Cutting and filling of the joints shall be carried out according to the stipulations of the following paragraph 43.4.8.4.

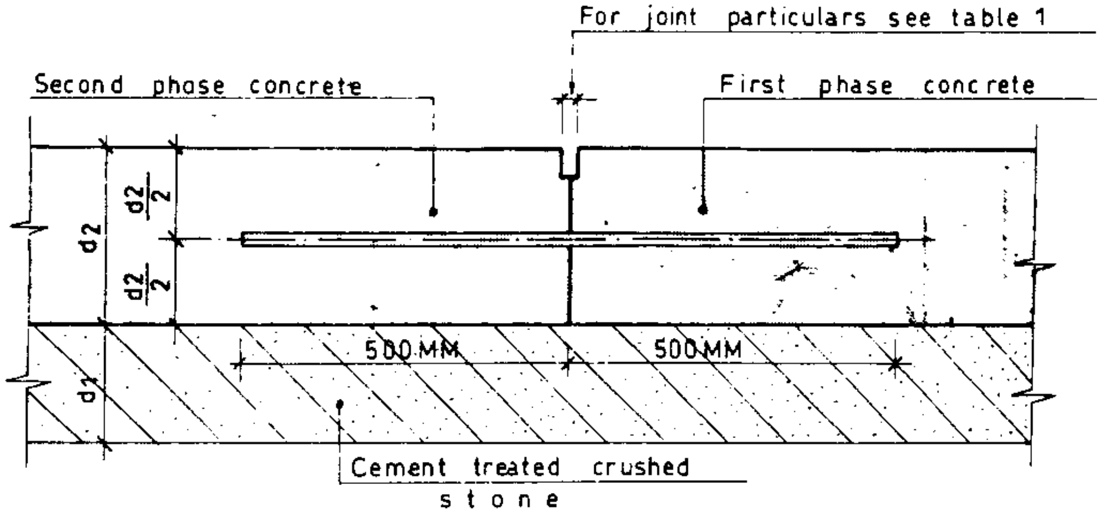


Fig. 43-5a : Longitudinal Joint provided with anchoring bars

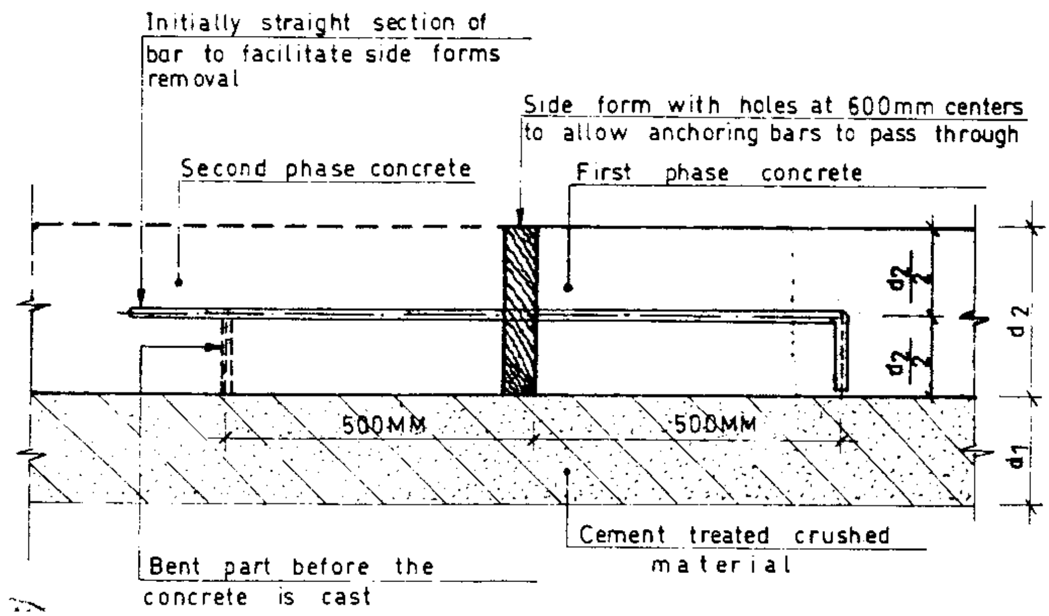


Fig. 43-5b : Recommended method of embedding the anchoring bars in the longitudinal joints

43.4.8.3 Cutting of Joints

Cutting of the concrete with the joint cutting machine must be carried out as soon as possible after the concrete has set3 provided the cutting operations do not detach aggregates from the body of the concrete to a large extent and that the final result is a smooth cut groove with no local damages. Cutting of the joints of the concrete section that was cast until noon is carried out first, and then follows cutting of the joints of the remaining part. Depending on the prevailing weather conditions and the type of cement that was used, it might be necessary to cut the joints of the section that was cast until noon, the same night, and this is why the contractor shall have available all the necessary equipment for suitable lighting, and have the joint-cutting crew available to work night shift.

It is also necessary for the contractor to have twice the number of required joint-cutting machines for the daily use (with the necessary spare parts), and standby personnel experienced in the use of such machines. The supervision has to check on a daily basis for the availability of standby joint-cutting machines. It is noted that delay in cutting the joints at the appropriate time will cause the slab to crack, and the contractor will be required to remove and reconstruct the cracked section between two normal joints.

To facilitate the timely cutting of the joints, it is permitted to carry out the operation in two phases. First a thin groove is cut approximately 3 mm thick, 4 to maximum 24 hours after casting. The depth of the cut must be 1/4 of the total thickness of the slab.

The second phase of joint cutting must be completed within 7 days from casting and includes the widening of the groove to a depth in compliance with TABLE 1-43, so that it has the suitable section for the insertion of the sealing material. The width of this widening shall be in accordance with TABLE 1-43 of this specification.

The sides of the grooves that have irregula7ities are corrected and smoothed.

The joint-cutting operations must be carried out with extreme care and precision, so that joints are in their predefined location with tolerance of ±10 mm.

43.4.8.4 *Sealing of Joints*

(1) Prior to the sealing of the joints the sealing groove must be formed. The latter, depending on the type of joint and the sealing compound must have the dimensions given in TABLE 1-43 of this specification.

The sides of the groove must be vertical with no protruding irregularities or cavities.

When cutting is done with simultaneous watering, removal of the resulting paste must be done thoroughly with a high pressure water jet before it adheres on the sides of the groove. When cutting is carried out dry, removal of the resulting dust and particles may be done either with compressed air or a high pressure water jet.

TABLE 1-43

JOINT ELEMENTS

		Dimens. (mm) depending on the type of mat	
		Poured compounds	

Joint Elements	Type of joint	Cold	Hot	Preformed (compressed
MM. width (w)	Contraction joint	13	13	*
	Expansion joint	30		30
	Longitud. joint	5 - 10	5 - 10	5
Min. thickn (d)	Contraction joint	13	15	*
	Expansion joint	20	25	*
	Longitud. joint	10	13	20 (25**)
Distance of Sealer from the surface (a)	Contraction oint	5± 2	5± 2	5± 2
	Expansion joint	7 ± 2	7 ± 2	7 ± 2
	Longitud. joint	3 to 7	3 to 7	3 to 7

* See subparagraph b of paragraph 43.4.8.4.
** For the case of longitudinal joints between strips cast in different times.

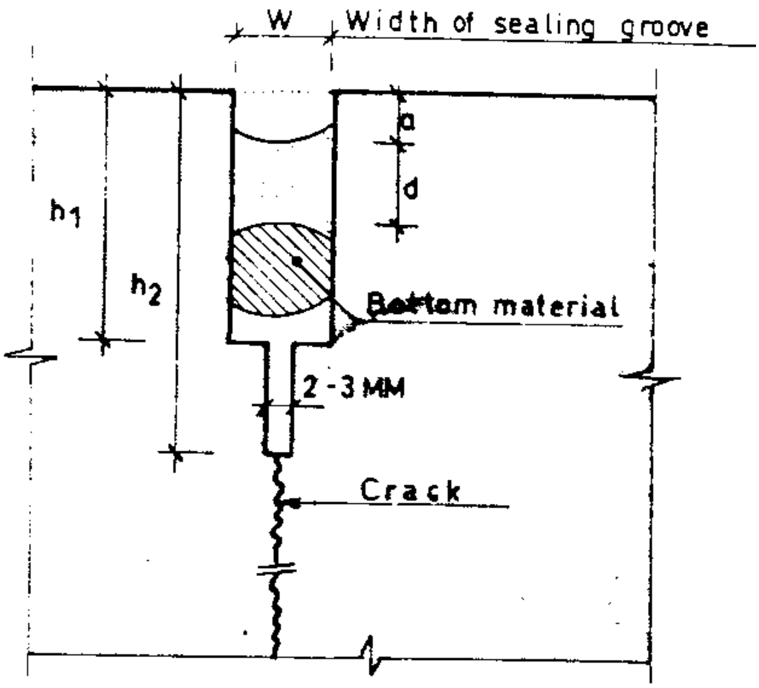


Fig. 43 – 6 : Joint Elements

(2) Any material used as temporary sealer to protect the joint is removed from the groove without damaging the sides and edges of the joint, down to a depth of 25 mm, when preformed sealing materials are used, or down to the necessary depth to satisfy the requirements of TABLE 1-43, when poured materials are used.

(3) Prior to the placement of the sealer the sides of the grooves must be cleaned and dried. For this purpose a steel mechanical brush may be used followed by blowing compressed air, so that all fine dust particles are removed.

(4)

1. In the case of poured sealing materials, a suitable compressible material is placed at the bottom of the groove, before the pour, that stops the sealer and prevents it from adhering on the bottom. This material may be a rope, a plastic pipe or other material compatible with the used sealer, approved by the Service. The depth of placement must be such, that the requirements of TAB 1-43 are satisfied.
2. The compressible material on bottom of the groove is necessary for the good performance of the sealer and must not be omitted. It's placement serves the following purposes :
   - Ensures the precise definition of the depth to be filled by the sealer which is not allowed to run down in the crack.
   - It does not allow the sealer to adhere to the bottom of the groove and thus ensures the sealer adheres to the two opposite sides of the groove.
   - It ensures the correct relation between width and depth of the sealing compound, which is important for the longer life of the compound.
3. The dimensions of the mater!3I on the bottom of the groove must be appropriate so that :

   a. The material is inserted in the groove with relative difficulty thus ensuring it will not be displaced after placement.

   b. The distance of the top of the material from the top surface of the slab is such that the requirements of TABLE 1-51, as far as (d) and (a) are concerned, are satisfied.

(5) Prior to the pouring of the sealer (whether cold or hot), if this is required according to the instructions of the manufacturer, the sides of the groove are coated with a suitable primer accordingly. The sealer is then poured in the groove within the time period provided by the manufacturer.

(6) Joints sealing operations must be interrupted when the ambient temperature drops below 7°C, unless the material manufacturer allows work in lower temperatures.

(7) Hot pouring of sealing compound will be carried out with a machine equipped with a thermostat that controls the temperature of the sealing compound, has double walling and a mixer device.
The temperature of the sealer compound must be within the permissible limits and the duration of heating must not exceed the limits set by the manufacturer. The machine shall be cleaned at the end of each day's work.

(8) The components of the cold applied sealers shall be mixed to the correct amounts according to the instructions of the manufacturer, and for such time period as is necessary to obtain a homogenous mix containing no air bubbles.

Each mixed batch must be poured in the joint within the time period provided by the manufacturer of the compound.

(9) The width of the preformed sealing materials (compressed materials) will be selected in combination with the instructions of the manufacturer and the width of the joints, so that the estimated maximum opening of the joint does not exceed 70% of the initial width of the sealing material. For the estimation of the opening a displacement of 0.4 mm per 1 m length of slab shall be considered. Preformed sealing materials are placed by being compressed in the sealing groove, without turning them or pulling them excessively, and if recommended by the manufacturer, with the help of a lubricant that also works as a glueing liquid. This liquid must be compatible with the concrete and the sealing material. The two sides of the sealer and/or the two sides of the groove are coated with this liquid. Any liquid in excess on the top surface of the sealing material must be removed and cleaned.

43.4.9 Quality Control

Quality control shall be in accordance with the stipulations provided in Clause 6 of the T.C.C. More specifically, for the ,construction of pavements, the tests shown in tables 43-4.9 a,b,c of this specification shall be carried out (further to the tests required by Clause 8 of the T.C.C.).

Cement, cement admixtures (additives), joint fillers and joint sealers, as well as curing materials, shall be tested, on delivery, to ensure they conform to the requirements of the relative paragraphs of this specification.

43.4.10 Trial Section

The first 50 m. section of the road is considered a trial section. The purpose of the trial section is to examine the method of work and the mechanical means of the contractor, during it's construction.

The rate of concreting shall be similar to the one that the contractor intends to use for the construction of the project. The mechanical means, the materials and the main technical staff, must be the same as for the whole project.

During construction, the satisfactory pouring and consolidation of the concrete, with the means used, is tested. It is further checked whether the pavement skid resistant surface is as required, and whether minor changes to the design mix are necessary.

TABLE 43-4.9.a : Main Tests for Aggregates

Test	Frequency of Testing	Requirement	Remarks
Grain size Grading Sand fines	1 per 50m3 or 2 for every strip or 1 per day	Sub-zone ID	When the slump value changes, Irrespective of the quantity of aggregates consumed
Percentage of friable particles	At the start of Works, for each aggregates source	< 1% of each quantity brought to the mixing plant	When macroscopic observations I indicate that the percentage is ' greater
Los Angeles	At the start of Works, for each aggregates	source < 30%	
Sand Equivalent	At the start of Works, for each aggregates source	< 80	
Silt content	At the start of Works, for each aggregates source	< 0.25%	
Apparent weight	At the start of Works, for each aggregates source		
Possibility to react with the cement's alkali	At the start of Works, for each aggregates source	ASTM 0289 ASTM C227 ,	It is required only for certain limestone materials when there is no information of successful use
Resistance to decay (weathering)	At the start of Works, for each aggregates source	HOS 408	

TABLE 43-4.9.b : Main Concrete Tests

Test	Frequency of Testing	Requirement	Remarks
Slump	1 per 25 m3	< 5 cm	
Temperature of fresh concrete	Start, Noon, end of concreting	< 30°C	Every 1 hour when the ambient temperature is > 30°C
Air content	I every hour	4.5% ± 1%	Only if air entraining additive is used
Density	On each test cube taken		
Test cubes	6 or 12 test cubes per day or strip	criteria A or B of Clause 6 of the T.C.0	

TABLE 43-4.9.c : Main Tests of Finished Pavement

Test	Frequency of Testing	Requirement	Remarks
Surface levelling		The surface must not have irregularities with difference greater than 4mm measured in the vertical on a 4m stretch	
Surface roughness	At least 6 on the test section 2 for each strip	Average value >11mm No individual value < 0.65 mm	Measurements in the strips may be reduced if macroscopic observation shows that roughness is no different from the test section

The thickness of the concrete poured before consolidation is tested and adjusted if necessary, so that the slab, after consolidation, has the required thickness.

After the concrete has set, the following tests are carried out

a. Testing of the surface evenness

b. Testing that the side forms can be removed satisfactorily without damages to the concrete.

c. Testing of timely and satisfactory cutting of the joints.

d. Consolidation test.

   10 cores are cut from uniformly distributed locations of the trial section of the road, out of which 6 are taken from areas not more than 30 cm away from the edges of the section constructed, and the others from the areas inside the slab. The cores are examined to test the uniformity of consolidation throughout the whole thickness of the slab. The difference between the theoretical maximum consolidation, calculated from the specific density of the constituent materials, and the mean consolidation value of the 10 cores must not be greater than 7.5%, if an air entraining admixture was used, or 3% if not used.

   The individual cores must not have voids and obvious points of bad consolidation, or show segregation of materials. The density of the cores, cut from the edges of the slab, must not be smaller than the density of the cores of the interior of the slab by more than 2.5%.

e. The surface roughness is tested with the method of sand spreading ASTM E 865183.

   The contractor cannot proceed with the normal construction of the road, unless the tests mentioned above have been conducted, and it has been proven that the construction method adopted and the mechanical means used are satisfactory. These tests must be completed within 10 days. The contractor may deem that the results of the tests are satisfactory arid he may proceed with the main works, if within 10 days after completion of the trial section, the test results have not been communicated to him with any eventual remarks regarding faulty construction.

43.4.11 Delivery to traffic

The pavement shall not be delivered to traffic, before the concrete has acquired the strength with which the slab thickness was calculated, and before all joint filling works are complete and the surface thoroughly cleaned.

It is permitted to use the pavement for the circulation of very light machinery, such as the joint-cutting machine, provided all measures have been taken to avoid any damage to the concrete surface.

Furthermore, after 3 days, it is permitted to load the edges of the slab for the circulation of the machines used for laying and consolidation of the concrete and for finishing the pavement surface, provided the wheels of the machines are of rubber, or that all necessary measures are taken for the best distribution of the loads and the concrete bending strength has exceeded 28 Kg/cm2.

Clause 44 : SEGMENTAL CONSTRUCTION

44.0 GENERAL

The present specification refers to segmental construction from precast concrete units.

44.1 MANUFACTURE

44.1.1

The Contractor shall submit to the Service full details of the method of “Match Casting” he will employ, in particular whether he will use the *long' or the -short bed' method, the full details of the formwork system including positive methods of preventing concrete displacement due to hydrostatic pressures during casting, methods of ensuring accuracy of alignment and accuracy during manufacture of the units and all aspects of quality control.

44.1.2

The tendon ducts must be positioned within the units so as to produce and ensure a smooth transition from unit to unit and rigidly fixed to prevent any movement of the ducts during the placement of concrete. Removable stiffeners of sufficient length to stiffen the full length of the unit being cast and project into the matching unit a minimum of 500mm shall be used in each duct. The Contractor shall submit full details of the stiffeners and the supports required for the ducts. Tendon ducts shall be rigid where straight runs are required and flexible spirally wound where curved runs are required and shall be galvanized and suitably sealed to protect the duct surfaces from contamination during storage of the units.

44.1.3

Each precast concrete box unit must be clearly and indelibly marked with a unique identification mark. These identification marks must be positioned on the top surface of the top flange and on the inside face of the webs.

44.1.4

Tendon duct positions must be clearly and indelibly marked a unique identification number. These identification marks must be positioned on or adjacent to the anchor for the tendon. In the case of tendons anchored on the end face of a unit the identification mark should be placed on the inside face of the web as near to the anchor point as possible. In the case of tendons anchored in internal blisters the identification mark should be placed on the blister.

44.1.5

Grout vents must be clearly tagged or otherwise marked with an identification mark relating to the tendon duct it vents. These identification marks must be clearly visible during grouting operations.

44.1.6

The precast concrete match cast box units shall be manufactured within the following tolerances :

Web thickness	±10mm
Top flange thickness	+ l0mm to 0mm
Bottom flange thickness	+ 10mm to 0mm
External overall dimensions	±5mm
Length of match cast units	± 10mm

Diaphragm dimensions	± 10mm

The above tolerances are not cumulative and there will be no tolerance allowed on planes meeting at the mating surfaces of the units.

44.2 HANDLING AND PLACING

44.2.1

'Match Cast" precast segmental box units shall be removed from their casting stations in such a way as to cause no damage to the unit or the unit cast against it. In particular care must be exercised to avoid damage to the mating surfaces and prevent distortion of the box unit.

44.2.2

Units shall, as appropriate to the method of casting, be transported from their casting station to a suitably prepared storage area where they will be supported on hardwood packs situated immediately under the webs.

No other support position will be permitted. Temporary supports shall be so designed to void any distortion of the box units during storage.

44.2.3

Lifting of units shall be carried out using lifting points cast into the unit for this purpose. The position of these lifting points shall be agreed with the Quality Control firm and shall be approved by the Service. No other method of lifting the units will be permitted. After erection cast in lifting points shall be removed to a minimum depth of 25mm below the concrete surface and the resulting holes completely filled with mortar.

44.3 PREPARATION OF UNIT MATING SURFACE

44.3.1

Contact surfaces are to be prepared by lightly grit blasting to remove laitance and all traces of mould oil, hydraulic oil, grease or any substance that may impair the bond between the adhesive and the concrete surface. The surface must be free from dust and loose particles. Great care must be exercised to avoid excessive etching of the mating surfaces, the degree of grit blasting shall be determined by trials on sample precast concrete panels (samples) 400mm x 400mm x 150mm thick of the same grade of concrete and degree of compaction as the precast units to be jointed. A panel selected by the Service as being representative of the standard of grit blasting required shall be kept and protected from damage at a point near the site of the grit blasting operation to enable a comparison of standards to be judged. A second panel blasted to the same standard will be kept by the Engineer.

44.3.2

Grit blasting of the unit contact surfaces should take place no earlier than 2 days before the unit is installed in the permanent works and must be protected from recontamination.

44.4 ADDITIVE FOR CONCRETE AROUND GALVANISED REINFORCEMENT

44.4.1

Where concrete is to be placed around galvanized reinforcement an approved chromate additive is to be used. The type and proportion to be approved by the Service.

44.5 POST-TENSIONING EQUIPMENT

44.5.1

The dimensions of internal blister anchors, recesses and clearances shall be designed to be compatible with the post-tensioning equipment to be used. No post-tensioning work shall proceed if alternative equipment to that which has been originally specified by the Contractor, without the approval of the Service.

44.5.2

The Contractor shall supply, to the Service for his approval, full details of the method and equipment to be used for the post-tensioning work, prior to the commencement of the works.

44.5.3

The Contractor shall ensure that sufficient jacks are available to enable the post-tensioning to proceed smoothly and without interruption and that suitably designed and constructed handling equipment is used to ensure damage is avoided to tendons, anchors and jacks.

The accuracy of the jacks shall be checked to the satisfaction of the Service each day the jacks are used or whenever the jacks are moved to a new tendon. Each jack must have a current calibration certificate supplied by the manufacturer of the jack. Jacks without such certification will not be permitted for use on these works.

44.6 ERECTION

44.6.1

The Contractor shall take full account, in his design, of the effects and method of erection.

The Contractor shall submit full details of the erection proposals to the Service in sufficient time before the proposed work is to be executed to enable the Service to give his consent to the proposals.

44.6.2

Erection tolerances shall be as follows :

- Maximum differential between outside faces of adjacent segments in the erected position shall not exceed 5mm.
- Transversely the angular (twist) deviation from the theoretical slope difference between two successive segment joints shall not exceed 0.1%.
- Longitudinally the angular deviation from the theoretical slope change between two successive segments shall not exceed 0.3%.

44.6.3

The alignment specified in Clause 21 of the completed structure must be within the required tolerances for vertical and horizontal alignment when measured at the time of substantial completion of the structure.

44.7 PLACING AND STRESSING OF PERMANENT TENDONS

44.7.1

Placing and stressing of the permanent prestressing tendons shall generally be in accordance with the recommendations set out in the F.I.P. Guides for Good Practice, 'Recommendations for segmental construction in prestressed concrete', except where noted in this specification and in accordance with the instructions of the supplier of the post-tensioning system. Where tendons are to be left ungrouted for a long period of time they shall be protected against corrosion to the satisfaction of the Service.

44.7.2

The Contractor shall carry out friction tests to the approval of the Service to confirm the assumed values of friction coefficient and wobble coefficient used in the design.
He shall submit a method statement for carrying out the tests for the approval of the Service. When approval has been given, the Contractor shall advise the Service well in advance of carrying out the tests, and submit records of the tests to the Engineer as soon as practicable after testing. In the event of the measured values differing from the assumed design values, the Contractor shall submit his proposals for any modifications required to prestressing to ensure compliance with the Design Specification.

44.7.3

The Contractor shall provide suitably designed and safe temporary platforms to enable the inspection of every facet of the erection procedure.

44.8 JOINTS BETWEEN *'MA TCH CAST'* UNITS

44.8.1

The joints between the 'match cast' units shall be filled with an adhesive which complies with Clause 53, para 53.3 of this specification.
Sufficient adhesive shall be used to completely fill the joints which shall be smoothed over once made while the adhesive is still workable.

44.8.2

The adhesive shall be applied to unit mating surfaces which shall have been prepared in accordance with pare 52.1.3 of this clause and after a trial "match up' of the units has taken place. Adhesive shall be applied to the mating surfaces of both units at a thickness and method approved by the manufacturer the Quality Control Firm's representative (if such firm exists) and the Engineer.

44.8.3

To determine the correct rate of application of the adhesive trial applications may be required by the Engineer on sample concrete panels prepared to the same standards as the mating surfaces of the units.

44.8.4

No adhesives shall be applied to joint surfaces when the temperature falls to 50C or below. When prolonged periods of temperature of 50C or below can be expected then the Contractor shall provide such heating devices weather shielding etc., to ensure the temperature of the concrete box local to the joint surfaces is maintained at a temperature sufficient to ensure the curing of the adhesive.

44.8.5

Immediately following the application of the adhesive to the joint surfaces the temporary prestress shall be applied. Surplus adhesive, extruded from the joint will be removed before the adhesive has set. It will be removed in such a way as not to stain or smear the exposed concrete faces with adhesive or solvent. Tendon ducts shall be cleared initially by the drawing of a suitable size 'Torpedo' through the duct immediately after the temporary prestressing is applied. The 'Torpedo' shall be drawn through the tendon ducts again approximately half an hour after the initial clearing of the duct.

44.8.6

If for any reason the joint is not closed then the adhesive shall be removed from the joint surfaces using spatulas, steel trowels or similar tools. Adhesive remaining shall be allowed to cure and the surface gloss and irregularities removed using a hand held grinding tool. Should such action be required then the Contractor shall ensure that a perfect fit between the adjoining units will be obtained when the units are subsequently rejoined, and must satisfy the Engineer on his proposals to achieve this before the joint is remade.

44.8.7

Surplus adhesive extruded after the initial removal of surplus shall be carefully chipped off when the adhesive is fully cured. Adhesive which is not readily removable by this method shall be removed using a hand held grinding tool. Care must be exercised not to deface the surface of the unit.

44.9 MIXING AND APPLICATION OF ADHESIVE

44.9.1

The epoxy resin adhesive for use in the joints between the 'match cast" units shall be mixed strictly in accordance with the manufacturer's instructions. The mixing shall take place as near to the site of application as possible and carried out in the containers supplied by the manufacturer.

44.9.2

Resin and hardeners must be taken only from new and undamaged containers and the whole contents used. The contents of damaged or part full containers will be rejected and must be disposed of to an approved tip for dangerous chemicals.

44.9.3

The Contractor shall engage and maintain a team of experienced personnel for themixing arid application of the adhesive. This team shall be supervised by a qualified Engineer experienced in the use of this type of adhesive. The manufacturer's instructions for the safe use of the adhesive must be followed at all times and the Contractor shall ensure that his adhesive application team, other employees, sub-contracotrs or any other personnel under his direction who may handle or otherwise come into contact with the mixed adhesive or its constituent parts are informed of these instructions and any precautions necessary in the use of the adhesive and that an adequate supply of clean water, barrier creams, soaps and protective clothing, etc., are available to those who will come into contact with the uncured adhesive or its constituents.

44.9.4

Waste epoxy materials and empty or part filled containers used for mixing the adhesive or containing the constituent materials must be removed to an approved tip for the disposal of dangerous chemicals. The Contractor shall ensure that all containers, disposable items, etc., contaminated by the adhesive or its constituent materials are removed to such an approved tip and that the Engineer and the Authority permitting the use of the tip are informed in writing of the tip location and the area of the tip in which the materials and contaminated items are deposited.

44.10 ALIGNMENT CONTROL

44.10.1

A limited degree of alignment correction may be achieved during erection of the precast box units using a packing material in the joints between the units. The packing material shall be glass fibre matting thoroughly impregnated with adhesive. in no circumstances will the thickness of the packing be permitted to exceed 4mm and it must be so placed that its thickness varies so that the full contact area between the units is maintained with no gaps, voids or other imperfection in the joint. Use of such packing shall be subject to the approval of the Service having due regard to the tolerances specified in 44.6.2 and 44.6.3 and being based on the monitoring specified in 44.10.4.

44.10.2

The Contractor must design and use special temporary works, launching gantries and/or lifting equipment etc., to satisfactorily achieve the required alignment.

44.10.3

The Contractor must use suitable specialist computer programmes, etc., to predict the deflections and stresses in the structure during erection of the structure and the effect of the proposed erection procedures on the completed structure. Calculations must take full account of time-dependent effects such as creep, shrinkage, loss of prestress, etc. Copies of all results shall be supplied to the Service for approval before work proceeds.

44.10.4

The Contractor shall monitor deflections and stresses actually occurring during construction and submit to the Service with full records of measured and predicted values.

44.11 TEMPORARY PRESTRESS

44.11.1

Temporary prestressing designed by the Contractor shall be applied across a joint immediately the adhesive has been applied to the matching surfaces of the units and the joint closed. The temporary prestressing shall be applied by means of temporary tendons. Temporary ducts cast into the units, etc. must be completely filled with grout and any associated recesses, box-outs etc., must be filled with well compacted concrete of a grade similar to that used for the units.

44.11.2

The values of the compressive stress imposed by the temporary prestressing shall have an average 0.3N/mm2 which locally shall not vary by more than +/-0.15N/mrn2 allowing for coexistent load effects, and which must not exceed the maximum recommended compressive stresses for the adhesive.

44.11.3

The temporary prestress must be applied across the joint with the specified 'open assembly time' for the adhesive and shall be released when the permanent prestress has been applied and satisfactorily anchored.

44.12 PERMANENT PRESTRESSING

44.12.1

Permanent prestress shall be applied through the permanent tendons at the values and in the sequence determined by the design.

44.12.2

The Contractor shall measure and record values of prestressing forces, tendon extensions, jack pressure readings, etc., for each permanent tendon and provide the Service with full documentation of these immediately after the stressing of each permanent tendon.

44.13 GROUTING

All grouting procedures for tendons shall be in accordance with Clause 45, pare 45.2.

Clause 45 : GROUT AND MORTAR

45.1 GROUT FOR PRESTRESSING DUCTS

45.1.1

Materials, testing method, and injection procedures for grouting of prestressing ducts shall be in accordance with DIN 4227 Part 5 except as modified below :

45.1.1.1

Unless otherwise directed or agreed as a result of grouting trials, the grout shall :

a. Consist of ordinary portland cement, water and an approved water reducing agent.
b. Have a water to cement ratio as low as possible consistent with the necessary workability, and under no circumstance shall the (free) water to cement ratio exceed 0.42.
c. Not to be subject to bleeding in excess of 2 per cent after 3 hours or 4 per cent maximum measured at 180C in grass covered cylinder approximately 100mm diameter with a height of grout of approximately 100mm and the water shall be re-absorbed after 24 hours.

45.1.1.2

The grout shall be mixed for a minimum of 2 minutes and until a uniform consistency is obtained.

45.1.1.3

Dry materials shall be measured by weight.

45.2 EPDXY BONDING AGENTS

45.2.1

Epoxy bonding agents shall be used for sealing joints in precast segmental concrete structures.

45.2.2

Methods of application, preparation of surfaces, testing of materials and inspection of procedures shall be in accordance with the requirements of AASHTO pare 4.33.13, 4.33.14 and 4.33.15.

45.2.3

Records shall be kept of each joint made detailing the joint location, date and time of jointing, batch number of resin and hardener, weather conditions continuously recorded (temperature and humidity) and results of tests.

Records shall be submitted to the Supervision in an agreed manner.

45.3 MORTAR FOR BEARINGS

45.3.1

Mortar beneath bearings shall be either a drypack mortar or epoxy mortar of proprietary make.

45.3.2

Compressive strength of mortar shall be not less than 60 Nisq.mm when tested in accordance with BS 1881.

45.3.3

Methods of mixing and use of epoxy mortars shall be in accordance with manufacturer's recommendations.

45.3.4

Bedding material shall not be mixed or placed when the ambient temperature is below 5 degrees Centigrade.

45.3.5

For cementitious mortars the water to cement ratio shall not exceed 0.35.

45.4 EPOXY NOSING FOR EXPANSION JOINTS

45.4.1

In-situ epoxy nosings shall be of a proprietary system with proven qualities of durability and performance.

45.4.2

Nosings should be clearly dimensioned on the deck expansion joint drawings and should be applied only to sound concrete.

45.4.3

Methods of mixing and application of epoxy materials shall be in accordance with manufacturers' recommendations.

Clause 46 : EPOXY PAINT PROTECTIVE COATING OF PIPES

46.1 SCOPE

46.1.1

This technical specification refers to the protective coating with coal tar epoxy paint of all internal surfaces of sewage ducts of asbestos cement pipes or concrete pipes (reinforced or non-reinforced) and their manholes, irrespective of whether they are constructed with ordinary cement or cement type IV (sulphate resistant), according to the requirements of the design.

46.1.2

It is also applicable to any surfaces that need to be protected against corrosive liquids, such as the inside of pumping stations tanks for sewage, etc. and mainly surfaces that need to be inspected.

46.1.3

The following conditions are also applicable to small pipes, accordingly adapted, with regard mainly to the equipment.

46.2 GENERAL

46.2.1

The Contractor shall construct the protective coating, wherever required according to the approved drawings and/or the other terms of tender and in accordance with the conditions of this specification.

46.2.2

The material to be used for the protective coating shall be an epoxy polyamine paint with coal tar mixture (coal tar epoxy), EPOTAR type or SINMAST 8237 type or similar. For the sections of the pipe that are above the ground water table, the application of the epoxy paint shall be made directly onto the concrete surface of the pipe, following a suitable preparation of the latter, in accordance with the specifications of the following paragraph 46.4.1.2.a.(1).

46.2.3

For the sections of the concrete works (pipes or manholes) that are under the ground water table, a waterproofing coat shall be applied onto the external surface of the concrete to protect the epoxy paint coating from water pressure.

46.2.4

When, for any reason whatsoever, it is not possible to construct an external waterproofing coat on concrete works, after approval by the Service, and before the application of the epoxy paint coating, the internal surface of the duct/manhole shall be coated with a material system NEROSIL-TERASOL type or cement-like emulsion TAMOSEAL (SINTOSEAL) type or SINTOPLAST etc. or similar, that have proven and guaranteed adhesion to the epoxy paint. This internal waterproofing coat shall be applied on the surface after it has been suitably prepared with the same method as for pipes above the ground water table.

46.2.5

Basic criterion for the application of the waterproofing surface coating mentioned above, shall be the level of the permanent ground water table in relation to the pipe.

46.2.6

The waterproofing coat shall be applied, in general, when the level of the permanent ground water table is above the top line of the pipe.

For asbestos cement pipes, it is not required to apply the first waterproofing coat (ground water table) of paragraph 46.2.4 above.

46.3 INFORMATION TO BE SUBMITTED

Prior to starting the work, the Contractor shall submit to the Service for control, the following information :

(1) Detailed information regarding the paint he proposes to use as well as brochures of the paint manufacturing factory, including instructions regarding the preparation of the surfaces, the application method of the paint etc. If requested, the Contractor shall submit suitability certificates of the materials he proposes to use with special reference to the conditions of the works.

(2) The same information as above regarding the material for the waterproofing coating.

(3) Quality control program of the factory (or factories) that produce the materials of the paint and waterproofing coating, for the delivery tests etc. of the materials from the factory.

(4) Work execution program, in which the Contractor shall give in full detail all the procedures for the execution and the control of the work.

46.4 MATERIALS AND METHOD OF EXECUTION OF THE WORK

The specification given herebelow for the material and the method of execution of the work constitute the minimum requirements for the subject work, on the basis of which the Contractor shall prepare his tender, shall submit to the Service for approval the information of the previous paragraph 46.3 and shall execute the work.

46.4.1 Protective coating with epoxy paint

46.4.1.1 Material

Polyamin epoxy paint with coal tar mixture (coal tar epoxy), EPOTAR or SINMAST B237 etc. or similar, shall be used. The material shall be in accordance with the specifications of the American Standard ASTM C 541-67. The material shall be applied in three coats of combined thickness 600 pm. The first coat shall be 100 pm thick and the next two 250 pm each.

46.4.1.2 Method of execution of the work

(1) The concrete surface shall first be repaired and free from all defects with special non-shrinking mortar of minimum strength B15, and then shall be cleaned of all loose waste material (excess material, dried mortar, dust etc.) by brushing or washing or rinsing with water and then shall be further cleaned with sand blasting (when high standard protection is required) until the surface crust of concrete

created by the formwork is removed and the concrete relief is exposed. After sand blasting and before painting the concrete surface shall be cleaned from dust. The resulting materials from the sand blasting shall be collected by suitable means and shall then be removed for disposal to locations that will be defined by the Service.

(2) The humidity of the concrete surface which is to be painted shall be measured by the use of an electronic measuring device. No painting shall be carried out when the relative humidity of the surface exceeds the value of 18%. Before use of the paint, the Contractor shall carefully study the manufacturer's instructions regarding the minimum and maximum allowable temperatures of the surface to be painted. In general, no painting shall be carried out when the surface temperature is below 10° C or above 38° C. Also no painting shall be carried out when the relative humidity is greater than 90 %.

(3) During painting operations adequate lighting of the surfaces and continuous ventilation of the space shall be ensured.

(4) The application of the paint shall be carried out with an accepted method (spraying, brush etc.) of the Contractor's choice, unless a specific method is specified or recommended by the paint manufacturer. Each coat shall be left to dry, then rubbed down and cleaned as required, before the next coat is applied. During painting operations the Contractor's tools and painting equipment in general, shall be kept clean and all surfaces shall be clean and dust-free. The Contractor shall take all necessary precautionary measures to protect the freshly painted surfaces from damage from any cause whatsoever.

(5) In those parts of ducts where joint construction with waterproofing tape is foreseen, the application of the epoxy paint shall be carried out after completion of the sealing of the joints with asphaltic based material.

(6) For asbestos cement pipes washing of the surface is considered adequate preparation and the paint shall be applied with high pressure sprayer.

46.4.2 Surface waterproofing

46.4.2.1 Material

Material of the system NEROSIL-TERASOL type or cement-like TAMOSEAL (SINTOSEAL) - emulsion SINTOPLAST type etc. or similar, which shall act in a similar way, shall be used, and shall ensure successful waterproofing of the concrete under external hydrostatic pressure of at least 1.5 atm. These materials create small crystals in the mass of the concrete that block the potential passage of water into the concrete. The material shall be applied in at least two coats and according to the manufacturer's instructions.

46.4.2.2 Method of execution of the work

In this case the general requirements of above subparagraphs (1), (3), (4) and (5) of paragraph 46.4.1.2 shall apply.

46.5 TESTS AND CONTROL

46.5.1 Protective coating of epoxy material

The quality control and testing program of the protective epoxy material coating shall be defined according to the following minimum requirements, and shall be subject to approval by the Service.

(1) Quality testing of the coating material

The resistance of the material to chemical attack shall be tested according to the stipulations of paragraph 80 of the American Standard ASTM C 54167. The number of samples, the procedure of sampling and the method of acceptance of the material shall be defined by the Service with the manufacturer of the material. In any case, at least one test shall be carried out for every 1000 kgr of material.

(2) Test of material adherence

It will be defined by the Service on the basis of the Contractor's proposal and the instructions of the manufacturing firm of the material, which will be submitted to the Service according to the conditions of paragraph 46.3.(4) above.

(3) Control of the thickness of the completed coating

The thickness of the completed coating shall be checked continuously by use of a suitable device for the purpose or a method approved of by the Service. Parts of the coating that have a smaller thickness than the one specified shall not be accepted unless corrected by the Contractor at his own expense.

46.5.2 Surface waterproofing

The quality control and testing program shall be defined by the Service on the basis of the information that will be submitted by the Contractor, according to the conditions of paragraph 46.1(4) above.

46.6 MEASUREMENT AND PAYMENT

Measurement shall be made on the basis of the actual surface in square meters of protective coating that was constructed satisfactorily and in accordance with the requirements of this specification and which was accepted by the Service, separately for the following categories

- Without surface waterproofing
- In combination with surface waterproofing

Payment shall be effected on the basis of the square meters, by category, that was measured according to the conditions set out above, and the respective contractual unit prices of each category for 'epoxy protective coating of ducts and manholes of concrete or asbestos cement". This payment shall constitute full compensation to the Contractor for all the works specified in the previous paragraphs 64.1 through 64.5.

Payment may also be effected on the basis of a composite price that shall cover both above categories (above and below the ground water table) if such is the description in the price list (and there is no distinction) and shall refer to complete price as above for the actual square meters of protective coating and shall constitute full compensation to the Contractor etc. as above.

When the works are executed based on prices including all items of related works and it is stated that the complete construction of the above works of protective coating are included in such respective prices, then no separate payment will be made to the Contractor for the cost of protective coating.

Clause 47 : GENERAL SPECIFICATION FOR THE CONSTRUCTION OF UNDERGROUND WORKS

47.0 INTRODUCTION - PERTAINING REGULATIONS - CONTENTS OF PRESENT SPECIFICATION

47.0.1 Introduction

The present clause 47 of the T.C.C. includes :

(1) The pertaining regulations and specifications.

(2) The GENERAL SPECIFICATION FOR TUNNELS CONSTRUCTED BY UNDERGROUND EXCAVATION (Sub-clauses 47.12 to 47.15)

(3) The GENERAL SPECIFICATION FOR TUNNEL ENDS CONSTRUCTED BY UNDERGROUND EXCAVATION (Sub-clauses 47.12 to 47.15)

(4) The ROCK CLASSIFICATION (Sub- clause 47.16)

47.0.2 Pertaining regulations and specifications

For the design and construction of tunnels, along with the related regulations and specifications applied generally to all open field works, the following regulations and specifications concerning underground works apply as well. Complementary references related to underground works are mentioned:

(1) Regulations and specifications

a. The directives for tunnel waterproofing DS 853 of German Railways.

b. The regulation RVS - 824 for tunnel waterproofing DS 853 of Austrian Railways.

(2) References

For the construction of tunnels and generally underground works, the following references or their newer editions are mentioned:

a. EMPFELUNG FUR DEN TUNNELAUSBAU IN ORTBETON BEI GESCHLOSSENER BAUWEISE 1M LOCKERGESTEIN. Arbeitskreis "Tunnelbau der Deutschen Geselshaft fur Erd und Grundbau e.v., Essen, 1986.

b. RVS 825: TUNNELBAUTEN, Apr. 1982.

c. EMPFEHLUNG ZUR BERECHNUNG VON SCHILDLVORGETR1EBENEN TUNNEL. Arbeitskreis mTunnelbau der Deutschen Geselshaft fur Erd und Grundbau e.v., Essen, 1973.

d. TEXTE PROVISOIRE DES RECOMMANDATIONS RELATIVES A L' EMPLOI DES CINTRES DANS LA CONSTRUCTION DES OUVRAGES SOUTERRAINS. Groupe de Travail "Soutenements et Revetement" d' AFTES, 1978.

e. TRAVAUX SOUTERRAINS, NORME SIA 198; 1975.

f. A series of books under the general title - Research and Application Underground Traffic - Underground Structures. Edition: Design Company STUVA KOLN, ALBA BUCHVERLAG, DUSSELDORF, November 1969.

g. Tunnel Construction Manual 1981, 82, 83 section II 'Waterproofing of Underground Structures" GLUCKAUF GmbH, ESSEn.

47.0.3 General Specification for Tunnels (G.S.T.) constructed by underground excavation

(1) This specification, which includes sub-clauses 47.1 to 47.11, concerns:

a. The proposed construction methods.

b. The materials to be used and the regulations and specifications concerning these materials.

c. The measurements, in-situ investigations and data, the Contractor should undertake.

d. The directives for the construction, measurements etc., according to the pertaining regulations and specifications.

e. The safety rules and regulations which should be applied during construction and the measures the Contractor should take to ensure proper and technically correct construction.

(2) More specifically, the sub-clauses of G.S.T. are the following:

Sub-clause

- 47.1 : Excavation - Construction Methods
- 47.2 : Immediate support
- 47.3 : Investigations and testing during excavation Measurements during excavation and immediate supporting
- 47.4 : Measurements after the permanent lining of the tunnel and its ends
- 47.5 : Removal of excavation material
- 47.6: Ventilation - Lighting during tunnel excavation
- 477: Water control during tunnel excavation
- 47.8 : Safety measures during construction
- 47.9 : Drainage - Waterproofing
- 47.10: Permanent lining
- 47.11: Final Works

47.0.4 General Specification for Tunnel Ends (G.S.T.E.) constructed by underground excavation

(1) This specification, which includes sub-clauses 47.12 to 47.15, concerns:

a. The construction methods of tunnel ends.

b. The construction equipment.

c. The safety measures which should be taken during construction of tunnel ends.

(2) More specifically, the sub-clauses of G.S.T.E. are the following:

Sub-clause

- 47.12 : Location and shape of excavation fronts
- 47.13 : Slopes at the tunnel ends
- 47.14: Final protection of the open field works against rock falling
- 47.15: Water drainage from the tunnel surroundings

47.0.5 Rock Classification (Sub-clause 47.16)

47.1 EXCAVATION METHODS

47.1.1 General

The Contractor is fully responsible for the selection of the method for the tunnel drilling, among blasting excavation or mechanical excavation, full face excavation in one or more phases with pre-drilling, as well as for the selection of the necessary equipment.

The Contractor, on the basis of the geological and geotechnical data derived from investigations he shall perform of from other investigations already performed at the site of the tunnels, the site conditions, his experience from related projects and the current practices, shall submit to the Service for approval a detailed presentation of the selected excavation method or methods and the equipment and means to be used.

In case that the equipment or the excavation methods selected by the Contractor cannot be applied to the whole extent or to some sections of the tunnels, the Contractor is not entitled to additional compensation. Moreover, all expenses incurred by or related in general to changes of the excavation method selected by the Contractor (equipment removal, new equipment arrival, delays, stalling of personnel or machinery etc.) due to encounter of unfavorable conditions (faults, poor ground quality, water level problems etc.) are included in the bidding unit prices.

47.1.2 Blasting Excavations

47.1.2.1 General

The drilling and blasting methods is generally adjustable to several types of rock materials and has several advantages compared to the full face cutting method using mechanical equipment (full facers), such as the option of simultaneous tunnel drilling at two (2) fronts, the required smaller investment capital, the adjustability to several rock materials, the multiple use of drilling equipment (drilling holes, anchorage, drainage systems) etc.
As basic disadvantages of the blasting method for tunnel excavation, compared to the full face cutting method, could be considered the over-excavation and the rock disturbance, leading to increased Contractor's expenses (backfilling of the over-excavated area with concrete, eventual additional support measures etc.).

In order to minimize the above disadvantages and consequences, the Contractor should adjust the blasting technique and methods according to the nature of the rocks encountered, calibrating suitably the relationships among the various influence parameters, such as the location, the dimensions and the levels of the excavation, the applied load, the distances and the size of the drilling holes, the quantity, the type and the application depth of the explosive, the relative firing times etc.

During tunnel excavations it is considered important to fire first the drills of the preliminary excavation (usually in the middle to the section to be blasted) in order to create an auxiliary free surface, and afterwards the drills of the main excavation and the drills at the circumference.

In order to perform the drillings the Contractor should make available the suitable drilling equipment, such as heavy duty percussion hammers, JUMBO, having minimum two booms etc., and suitable air compression equipment, so that the required compressed air flow is available for the maximum efficiency of the drilling equipment.

Blasting is permitted only after the Contactor takes all the precaution measures required by the Safety Regulations for the protection and safety of the personnel and the project. No blasting is permitted at distances less than 25 m from any concrete structures, unless otherwise approved by the Service.

47.1.2.2 *Mixed Blasting - Mechanical Excavation*

The above method aims to attainment of an excavated section having the most regular and smooth shape and to be contained nearest to the theoretical excavation line.
The technique of the above method is based to the mixed use of blasting and mechanical means. The basic excavation is performed by carving the sides using rock cutters with articulated head.

Using the above method, the over-excavation caused by the regular method (drilling - blasting) disappears or is minimized.

The cost of the mechanical equipment required by the above method is compensated, to some extent, by the cost of backfilling the over-excavation with concrete or gunite, and by any other expenses incurred by the over-excavations (support, removal of excavated material etc.).

47.1.2.3 *Controlled Blasting Methods - Minimization of Rock Disturbance - Reduction of Over-excavations*

The Contractor should carry out the blasting in such a manner that rock material disturbance and loose rock is avoided beyond the excavation lines defined in the design, and the remaining rock or rock-mass retains its strength after the blasting and constitutes a strong, safe and self-supporting system, as much as possible.

Furthermore, the Contractor should take all necessary measures so that over-excavations are avoided beyond Line "B", as it is defined in the present volume, and the drawings, because over-excavations, especially large ones, contribute to the weakening of the surrounding rock-mass and create support problems. Moreover, the over-excavations lead to additional works (backfilling of the caves with concrete or gunite, loading and removal of the additional excavated material, use of support systems), on the Contractor's expenses.

In cases that, due to the nature of the rock material, the above mentioned unfavourable situations(over-excavations, rock material disturbances etc.) cannot be avoided when using the regular blasting method, it is required to apply methods of controlled blasting aiming to:

- The reduction of cracks in the rock material by creating a preliminary cutting urface, on which the blasting waves of the explosion are reflected and directed to the desired direction.
- The reduction of over-excavation.
- The most efficient use of the energy of the explosion, to break to small pieces the excavated material.
- The reduction of vibrations.

The following are considered as the most popular current methods of controlled blasting, but other versions are also available:

- Smooth blasting.
- Cushion blasting.
- Line drilling.
- Presplitting.

The smooth blasting method is successfully applied to tunnel drillings, while the other three (3) methods are applied mainly to stepping tunnel fronts or to cut excavations. Controlled blasting excavation methods shall be used to form the tunnel fronts and to drill the first twenty (20) meters of the tunnels, unless otherwise approved by the Service.

The cost of using controlled blasting methods is higher compared to the regular blasting methods, but this difference is fully compensated in most cases by the most favorable results of the controlled blasting.

47.1.3 Excavation dimensions - Safety Tolerances

47.1.3.1 Excavation dimensions

(1) The excavation of the tunnel sections shall be made on the lines and slopes and dimensions shown on the design drawings approved by the Service- for the construction with minimum over-excavation.

For the dimensioning of the tunnel the detailed elements determining the geometry of the characteristic lines of the tunnel section for each type of rock material have been defined as follows:

(2) Minimum Excavation Line 'A" is the line inside which any non-excavated rock-mass section of any kind or dimensions is not allowed to remain.

The theoretical radius defining Line "A" of the tunnel sections in each location should include:

- The radius of utility section, R.
- The statically required thickness of the permanent lining, d_3.
- The statically required thickness of the immediate support, d_1.
- The convergence allowance, d_2.

Checking of Line "A" can be made at any phase during construction, but the convergence thickness (d2) shall be considered differently. if check is made before convergence starts the full thickness d2 shall be considered, while if check is made after convergence is completed Minimum Excavation Line "A" shall be zero. In intermediate phases d2 shall be calculated according to measurements results and according to the Service's directions.

Unless otherwise defined in the special conditions of contract(S.C.C. etc.) the above dimensions are defined by contract in sub-clause 47.16 of the present clause.

(3) Line "B" is the line shown on the design drawings which defines the outer limits considered in the measurement of quantities for the payment of the excavation, and for this reason is named Pay Line.

The distance between Line "B" and Minimum Excavation Line "A" is do, which unless differently defined in the special conditions of the tender (S.C.C. etc.) is defined in sub-clause 47.16 of the present clause. The above provisions for Line "B' are valid even for the case when:

i. The limits of actual excavations are inside or outside Line "B".
ii. The preliminary excavation lines or a construction process, shown on the drawings as ancillary method for obtaining the permanent tunnel excavation, present required excavations beyond Line "B".
iii. The construction method selected by the Contractor and approved by the Service, requires permanent excavations beyond line "B".

In case that, due to the nature of the rock-mass encountered during the excavation, it is necessary to change one or more parameters defining - Line 'A", such as the convergence allowance d2 or the thickness of the immediate support di, the distance dip between Lines "A" and "B" remains the same as initially defined, and the Contractor is not entitled to additional compensation for such changes, while the contract price remains the same.

(4) Finally, Line "C" is the line defining the limit, inside which no parts of the immediate support are permitted.

(5) The Contractor shall take any necessary measures to prevent loosening of the material beyond Line "B" and shall be obliged to remove any quantity of loose rock and to replace it by gunite or concrete of the same class as the permanent lining, without being entitled to additional compensation beyond the contract price.

Following the excavation of unsupported sections, all loose material inside Line "B", which is likely to fall or move, should be immediately removed. All material protruding inside Line "A" shall be removed by the Contractor at his expenses. The removal of these protrusions can be done at any time during construction, but no later than the installation works of the water collecting layer and the impervious membrane, according to the specifications of the present volume. If, during the removal of the protruding material, any damage to the support system is caused, it shall be fully rehabilitated at the Contractor's responsibility and expenses.

The actual excavations shall be checked by measuring cross-sections at locations and distances fixed according to the Service's directions. These cross-sections shall be measured using surveying equipment of electronic measurement devices, by means and methods proposed by the Contractor and approved by the Service.

The measured cross-sections shall be drawn in full detail and shall be compared to the cross-sections appearing on the approved design drawings. The comparison of the actual excavation in each cross-section with Lines "A" and "B" could provide the Supervising Service and the Contractor useful data for the certification and final measurement of the works.

47.1.3.2 Safety Tolerances

During excavation and immediate support works, the Contractor should have in mind that the dimensions of the performed excavations should secure that the tunnel gabarit, formed after the construction of the immediate support and the permanent lining, has the dimensions defined in the approved design drawings. Any deviations from these dimensions should be such, that the distance between the dynamic vehicle outline from the tunnel gabarit in each location should not deviate from the corresponding theoretical distance more than two (2) cm.

47.1.4 Excavation phases

47.1.4.1 General

Based on the evaluation of the available geological data, and the data of the geological investigations performed by the Contractor and their geotechnical evaluation, the Contractor shall select the -method of tunnel excavation. These selections shall be obligatory for him and any change during construction shall not affect the total price.

47.1.4.2 Details of excavation phases

This paragraph describes indicatively, but not exclusively, without any Service's responsibility and without any Contractor's restraints, three basic tunnel cutting methods. Each of these methods concerns a wide area of rock materials and has been successfully tested in similar cases in Albania and abroad.

(1) Full Face Cutting

In this method, the excavation is made by blasting arranged over the whole area of the cross-section, according to one of the methods described above in paragraph 47.1.2.

Usually, full face cutting is applied to solid rock for short tunnels, where ventilation problems during construction do not affect the work schedule.

(2) Partial Tunnel Excavation

Partial tunnel excavation can be generally applied in cases of long tunnels in weak rock materials, if it is considered that it facilitates the plan of the project and the technical excavation of the tunnel.

During partial tunnel excavation, it is recommended:

a. Full excavation of the upper section of the tunnel, so that the immediate support measures of the tunnel roof operate under load longer, and the rock-mass becomes completely unstressed in the permanent lining construction stage.

b. Special attention should be given to joining the immediate support measures of the upper section to the lower section, in order to prevent any failures of the immediate support measures in the sensitive region of their joint.

Technically, this method has the following advantages compared to the others:

a. In the case of blasting excavation, it drastically reduces the use of special equipment (Jumbo drills), because the lower part of the cross-section can be excavated by regular drilling equipment (crawlair, wagon drill)

b. It drastically reduces the tunnel ventilation cost during the second and third stage of excavation works.

(3) Excavation by pre-drilling a pilot tunnel

This method is usually applied to weathered rocks or pseudo-rocks, especially in cases when the results of the geological investigations provided to the Contractor by the Service and those performed by the Contractor before the final design stage, reveal a poor quality rock-mass.

In such cases, it could be decided to excavate the tunnel by pre-drilling a pilot tunnel, having a cross-section to the Contractor's choice, but smaller than 15m2.

This method has the following advantages compared to the others under the above circumstances because:

a. Allows immediate acknowledgement and handling of the conditions of
the rock-mass.

b. Allows the Contractor to evaluate the conditions of the rock-mass in time and to be ready for the second stage of section widening.

During construction works using this method, the length of the pre-drilling pilot tunnel should be determined and the location of the pilot tunnel inside the final cross-section, so that part of the pilot tunnel immediate support measures could be used in the final section. No additional compensation shall be given to the Contractor for damaged support material, unless in special occasions justified approval is given by the Service in advance.

47.1.5 <u>Facing Adverse Conditions</u>

As adverse conditions are defined zones of serious faults, large karstic caves, specially adverse conditions of rock-mass or locations of ventilation shafts or locations and zones of high water inflow in the tunnel etc.

If, during tunnel drilling adverse conditions as described above are found, or such conditions are revealed by the geological investigations performed by the Contractor, each case shall be examined by the Contractor separately, based on the nature, its special characteristics, its extent and difficulty, in order that the most suitable and effective measures be taken the soonest possible to confront the situation. Eventually, it might be necessary that the situation is examined by special geologists, geotechnical engineers etc., called by the Contractor for this purpose.

47.2 IMMEDIATE SUPPORT

47.2.1 <u>Rook material control - Removal of loose rock</u>

During the drilling and the excavation of the tunnel sections, the Contractor shall make every possible effort to remove any loose rock remaining on the surface of the excavated section using any suitable means (levers, mechanical excavators etc.). Thus, the section shall be delivered ready for the installation of the immediate support measures.

47.2.2 <u>Immediate Support Measures</u>

The term "Immediate Support Measures" refers to all those measures that should be taken during or immediately after drilling, which allow excavation of the section according to the provisions of the final design, the specifications and the drawings. Furthermore, immediate support measures prevent possible failure of the rock-mass, or unacceptable deformations, before the construction of the permanent lining is completed. Moreover, immediate support measures protect the structures from danger of damages and insure the personnel from danger of accidents in general.

The immediate support measures suitable for tunnel construction are mentioned below:

(1) Nailings and simple rock bolts.

(2) Shotcrete,

(3) Metal grid or galvanised fence.

(4) Steel frames.

(5) Metal truss frames.

(6) Metal plates, flat or riveted, perforated or solid.

(7) Pre-placed plates or bars or forepoling.

(8) Cast in-situ or precast concrete elements.

(9) Rock pre-reinforcement (stabilizing grouting).

The present specification covers all construction works related to excavation works, necessary for the secure support of the excavations during tunnel drilling and includes the supply of all machinery and equipment, the personnel, the required materials and all additional work required according to the drawings, the specifications and the Service's orders.

47.2.3 Selection of the immediate Support Measures

47.2.3.1 General

The details of the support and stabilization of the tunnel section vary, depending on each rock type drilled. These measures shall be adjusted, according to the requirements of the actual conditions encountered, concerning the locations and the application zone limits, but always after the Service's consent and within the limits determined in the design and the contract documents.

The Contractor shall be always responsible for the installation and successful operation of the rock support and stabilization measures, during the drilling and excavation works and any approval by the Service of the applied methods does not reduce his absolute responsibility.

47.2.3.2 Selection Methods of the Immediate Support Measures

During construction, the Contractor is responsible for the selection of the immediate tunnel support measures stated in the design. The Contractor shall inform the Supervising Service and, after its consent, he shall proceed to take the necessary measures according to the design to resolve each case. The participation of the Contractor's Construction Consultant might be necessary, in the decision stage. It is mentioned that the Service has the right, without any additional compensation to the Contractor, to request the employment of a Construction Consultant by the Contractor, even if the presence of such a Consultant is not provided in the special conditions of the tender (S.C.C. etc.). No delay is excusable in taking a decision on site, because it is necessary problems concerning immediate tunnel support measures to be solved immediately, directly by the qualified personnel present on site. The following elements should be taken into consideration for onsite decisions:

a. The final design for tunnel excavation and immediate support, containing all basic information for the installation of the immediate support measures, such as the number, the location and the type of the anchorage, the shotcrete layer depths, the layout and dimensions of the frames etc.

b. The test and measurement results, for the quantitative assessment of rock-mass quality. The Contractor in co-operation to his Consultant (according to the above) shall evaluate these results and inform the Service.

c. The plan for measurements that should be taken inside the tunnel, as detailed mentioned in sub-clauses 47.3 and 47.4 of the present clause 47, covers all relative issues and it is quite extended to include all the required information.

d. The Contractor's excavation and immediate support crews should consist of experienced personnel, whose observations and comments are of decisive importance for the excavation process and the selection of the excavated section immediate support measures, or for the reinforcement of already supported sections. These observations and comments should be recorded to the Supervising Service and to the Construction Consultant (according to the above) of the Contractor.

47.2.3.3 Immediate Support Measures for each Rock Type

The immediate support measures are related to the classification of each tunnel section, according to the procedure described in the contract documents.

47.2.4 Method, Phases and Application Time of the Immediate Support Measures in Various Rock-Mass Class

The behavior of the rock-mass at and behind the tunnel front requires almost always rapid actions for its stabilization. Besides it is evident that there is a specific installation method of immediate support measures for each section type.

For example, in the case of a good quality rock-mass in order to accelerate the progress of the excavation, it is not necessary to finish first all support works at the front. On the contrary, in the case of a poor quality rock-mass, it is imperative to complete the support of the whole section as quickly as possible, including the invert at the base of the tunnel. That means that the stability conditions of the rock-mass influences the rate of installation of the immediate support measures, as well as the type and form of the measures to be used.

47.2.4.1 *Work Zones*

To resolve the previous interaction between the excavation Method and the selection of the appropriate immediate support measures and the required application time in conjunction to the stability conditions of the rock-mass, three work zones are defined:

a. The front zone, of length L1 (m).
b. The zone of attack, of length L2 (m).

The zone The Contractor shall submit the minimum values for lengths L1, L2, L3, that shall be verified during each tunnel excavation. These minimum values shall be modified on the basis of the rock conditions. It is particularly suggested that length L1 does not exceed five (5) m, and length L2 is equal to one (1) to two (2) times the diameter of the excavated section.

The following paragraphs give indicative rules for the application of the immediate support

47.2.4.2 *Shotcrete - Rock Bolts*

Basic immediate support measures for all types of rock-mass consist of shotcrete and rock bolts of various types, as well as plain bolts.

In region L, (the front zone) the shotcrete shall be applied immediately after excavation, many times during the excavation and anyway at the same time with the removal of the excavation products, in a thin layer having a typical thickness of 3 to 5 cm. The immediate application of the shotcrete aims at reducing the rock-mass deformation and extending the rock-mass self-support time after the excavation.

Concurrently with the construction of the initial layer of shotcrete, a small number of rock bolts is installed in characteristic locations of the tunnel front to ensure the coherence of the section. After the completion of the removal of the excavated material, the immediate support measures in zone 12 should be installed at a time not much later than the installation of the support measures in zone L1, and finally the complete set of support measures is installed according to the design; these measures include a layer of concrete having a thickness defined in the final design, usually reinforced with a steel grid of garvanised wiremesh according to the design. The completion of the support measures also includes the installation of all the rock bolts according the the final design within a minimum time period after the excavation of the section.

47.2.4.3 Shotcrete - Steel Frames

In the case of immediate support measures including the installation of steel frames, a layer of shotcrete, having a typical thickness of 3 to 5 cm is applied immediately after the excavation to prevent the loosening of the rock-mass and then the steel frame is placed and fixed on the first layer of shotcrete either by using special wedges made of concrete or steel in order to avoid any appreciable deformation of the rock-mass. These actions are completed in the region of zone L1. During the fixing of the steel frame, a steel grid is attached on it, in order to facilitate the application of the final layer of shotcrete.

The activities to be performed in the second phase L2, are the completion of the shotcrete to its statically required thickness and the secure fixation at its base, as well as its longitudinal connection to the previous frames.

The same as above are valid in the case of steel trusses which shall be incorporated in the final layer of the shotcrete.

If the excavation of the section is performed in two phases (upper and lower part) it is evident that the previous guidelines are applied for the installation of the support measures for both phases. Special care should be taken for the support of the crest of the tunnel section.

The application of the support measures in the lower part shall depend mainly on the time schedule of the Contractor, i.e. if the excavation of the upper part follows that of the lower part immediately or much later. It should be emphasized that in both cases special care should be taken for the connection of the steel frames of the upper part to those of the lower part.

Different treatment is required in the case of a rock-mass class that requires the construction of a closed invert. In such a case, the excavation, the immediate support measures and the construction of the invert should be completed in the zone L1, in order to activate the static strength of the complete ring of the support measures.

47.2.5 Supplementary Measures Reinforcing the Initial Support

In zone L3 and the rest part of the tunnel are areas, where supplementary measures reinforcing the immediate support could be taken. These measures are:

a. Supplementary layers of shotcrete, to reinforce the immediate support, if this is determined from the re-evaluation of the rock-mass characteristics during the excavation.

b. Reinforcement and compaction of the anchors if this is determined from their stress measurements or the re-evaluation of the rock-mass characteristics.

c. Reinforcement of the foundation of the steel frames during completion of the second phase of the excavations, if a concrete support beam is to be constructed etc. Eventually, addition of support cross bars, installation of additional frames in between or anchorage of the already installed frames if this is required according to the rock-mass behavior.

d. All rehabilitation works of any eventual faults of the immediate support measures are also carried out in this region L3,

47.2.6 Rock Reinforcement or Pre-installation of Immediate Support Elements

In the cases of classes of soft rocks, that have a short self-support time, many times it is required to support the ceiling of the excavation by certain systems advancing in front of the main excavation e.g.

(1) Pre-installation of steel plates

This concerns regions of medium dense rocks, where metal frames are installed. After the installation of the last frame, at the beginning-of the next excavation phase, a trench is carefully dug in the rock-mass around the tunnel section, in which the steel plates are fixed. These are placed over -the top of the frame already installed and they form a shelter protecting the personnel working in the next excavation phases.

(2) Steel Forepoling

This system concerns the use of forepoling (iron tub pipes, or steel beams of various sections), either placed in holes drilled right before the excavation, or penetrating the rock-mass by mechanical means, in a layout forming a cone shaped surface, which offers a safe shelter for the advancement of the tunnel excavation for several steps. Before the "ombrella's" length runs out, another `umbrella" is placed, and so on. Thus, the construction works in the tunnel are carried out under the continuous protection of the "ombrella".

(3) Cast On-site or pre-cast Concrete Elements

The use of these elements depends on the submission by the Contractor of a justified proposal concerning the method to be used for the construction, transportation and installation of these elements. This proposal is subject to the Service's approval.

(4) Rock Pre-reinforcement

This activity is performed based on the evaluation of the geotechnical design, mainly by rock stabilization grouting according to the relative clause 50 of the present T.C.C.

47.2.7 Minimum immediate Support Measures

47.2.7.1 General

The prevention of loosening end erosion of the rock material, and also the fundamental protection of the personnel, requires the minimum immediate support measures mentioned below. This minimum quantity shall be installed even if best quality rock material is encountered. This minimum quantity does not confine the Contractor's obligation to install suitable quantities of support measures according to the design and the requirements of the rock material, but they just indicate their lowest limits. The minimum quantity defined below includes the absolute minimum quantity for any tunnel part section and the average minimum quantity installed at the whole tunnel length.

47.2.7.2 *Absolute Minimum Immediate Support Measures for any Tunnel Part*

a. Shotcrete:

Placed on the ceiling of the excavation, in a 10 m long arch, for pavement width up to 10 m (or relatively longer for wider pavements), symmetrical around the key, having minimum thickness of 0.05 m.
At the other sides, besides the floor, minimum thickness of 0.03 m.

b. Reinforcing grid:

Placed on the ceiling of the excavation, in a 10 m long arch, for pavement width up to 10 m (or relatively longer for wider pavements), symmetrical around the key, metal steel grid having minimum weight of 1.5 kg/m2.

c. Nailings with reinforcing steel St III bars of diameter 0 26 mm:

Placed on the ceiling of the excavation, in a 10 m long arch, for pavement width up to 10 m (or relatively longer for wider pavements), symmetrical around the key, (if at the specific tunnel location are not installed metal frames), at least one nail having minimum length of 2.0 m, every 4 m2 of the excavation perimeter.

47.2.7.3 *Minimum Immediate Support Measures per Tunnel Unit Length. as average values of the Installed Quantity at the whole Tunnel Length.*

(1) For tunnels with pavement width up to 10 m:

a. Shotcrete having a volume of 1 m^3 per one meter of tunnel length.

b. Metal reinforcing grid, having a weight of 15 kg, per one meter of tunnel length.

c. Metal frames, having a weight of 70 kg, per one meter of tunnel length for the parts they are installed.

d. Nails, of St Ill, having a diameter of 0 26 mm, total length 10 m, per one meter of tunnel length.

(2) For tunnels with wider pavements, relatively larger quantities than the ones defined in the above paragraph (1).

47.3 INVESTIGATION AND TESTING DURING EXCAVATION MEASUREMENTS DURING EXCAVATION AND IMMEDIATE SUPPORT

47.3.1 Introduction

The purpose of these specifications is the description of the control and measurements that should be performed during the tunnel construction. These measurements shall provide data for the adjustment of the support system to the actual rock-mass conditions encountered during the excavation. Finally, they shall provide monitoring means during the operation phase of the project.

In order to issue the measurement system specifications, suggestions of international references, international practice and experiences form the construction of other tunnels in Albania were taken into consideration.

47.3.2 General

When flexible support techniques are used, the results of the measurements during construction provide data for the adjustment of the tunnel support to the encountered rock-mass conditions. Since measurements consist inseparable part of current construction methods, the Constructor should be able to suggest his preferred requirements and techniques, provided that they satisfy the minimum requirements defined by the Service.

These activities, which include monitoring program during excavation, construction and operation of the tunnel, are divided into the following main classes:

a. Devices installed during construction, for operational safety and for monitoring the behavior of the excavation and the immediate support.

b. Monitoring the behavior of the materials and the constructual elements used and the quality of the performed works.

c. Devices installed on the permanent lining and the tunnel ends for the examination of the operation of the tunnel support and the monitoring of the tunnel behavior during its operation.

d. Warning devices for remedial action.

The two last activities concern mainly the monitoring of the structure and the behavior of the tunnel after the delivery for operation, and for this reason they are performed at the Owner's request. Of course, there are mutual interests because in current tunnel construction practice. the behavior of the materials and the excavation methods affect the design and construction procedures. Experiences constructors need measurements, and for this reason, basic measurement items have been included in the rest tender documents. Unit prices are necessary, so that the Service can request additional installations or measurements.

47.3.3 Measurements during Excavation and Immediate Support

Monitoring of the excavation, as drilling progresses, is an important element for the construction safety and the design. Its main purpose is to determine the adequacy or not of the support and the progress rate of the excavation and lining. The main means for this purpose include deformation measurements on the walls and inside the surrounding rock, with convergence stations and estensometers.

In order to determine the approximate values of the deformations anticipated in a tunnel, deformations are calculated using `boundary elements" for tunnel parts representative of the ground conditions anticipated. The results are recorded on drawings of equal value deformation curves. These correspond to linear direct material response without any interference from the support. They do not represent the minimum deformation measure, because they are computed using total deformation modulus, including correction factors to account for the existing rock-mass condition, neither they cover permanent deformations or plastic behavior on the yielding "ring" of loose material.

The deformations indicate that full conversion measurement rings of regular precision (mm) are required, and the lowest end of the extensometer (zero point of reference) should be placed at depth of one diameter length from the tunnel wall. The ring layout for monitoring the deformations is indicatively the following:

Full measurement rings are installed at distances of 300 m, or for poor ground materials at shorter distances up to 50 m: They should be installed as soon as possible after the excavation and at least in half diameter in a recess, protected from accidental damage. The heads on the roof and the upper part of the side walls shall be installed on the pre-drilled roof, and the heads on the lower part of the side walls shall be installed on the bench. All diagonal distances should be measured daily for the evaluation of the interaction of the support and the advancement rate schedule.

The evaluation shall be performed according to the Service's directions.

In special sections, after the Service's approval, three (3) triple extensometers shall be installed, one at the key and each on the upper part of the sides towards the wall (in closed sections of inverted arc five (5) extensometers are required).

The bar lengths are 3 m, 6 m and 9 m, unless otherwise determined. The heads should be placed in recesses and protected. It is useful to use extensometers equipped with a measurement system from a distance (telecontroled), because of the inaccessible roof and to extend the operation of the extensometers by sealing them inside the permanent lining. Initially, readings should be taken daily, until the deformation converges to a certain small value. In any case, however, monitoring should continue until the tunnel (or bench) front advances to five (5) times the diameter of the tunnel (approximately 50 m).

For extremely poor rock other methods may be used based on electronic strain gauges, fixed on bolts or metal arches.

Electronic strain gauges should be installed on certain metal frames to measure their stress intensity. These shall be installed in group of five (5) pieces on the same arch at distances of every 300 m.

Measurements of the capacity and the loading of the bolts should be carried out occasionally at various location of the whole tunnel length. These measurements are independent of the scatter sampling tests, which should be carried out at intervals on the older bolts, and which are the Contractor's obligation.

Finally, in order to relate the measurements, a surveying control of the tunnel points should be made. The points should coincide to the convergence points.

47.3.4 Ground Conditions Control during the Excavation

(1) Certain measurements are necessary for the determination of the mechanical ground characteristics and the calculation parameters on the real tunnel axis under the actual construction conditions. Since the final design of the permanent lining shall be performed during the construction stage, a related measurement program should be defined.

It is anticipated that such a program should include the following:

a. Regular sampling and laboratory in-situ testing.
b. Slab loading tests on test side windows.
c. Flat jack tests on the tunnel walls.
d. Tests for the determination of the characteristics: (water pressure etc.) mentioned below.

The permanent lining shall be subject to long-term evolving effects, -which it is better to be defined in advance during construction, than rely on legal procedures, if problems arise after delivery.

(2) The ground conditions specially affecting the behavior of the permanent lining are:

a. The water pressures. Provisions should be taken to measure the water pressure before and during the excavation, so that it is possible to determine the residual water pressure to be taken into account in the calculations.
b. The ground expansion pressure. Provisions should be taken to evaluate the size and the effect of any ground expansion pressure on the combination of the permanent lining and the support.
c. The presence of harmful components or erosion materials in the groundwater or unusual temperature conditions. These elements could affect the quality of concrete or other materials.

It is assumed that the above factors can be easily determined using piezometric borings (from the outside and the inside of the tunnel) and sampling. Testing of the expansion pressures, besides the laboratory tests, could be preferably carried out in an experimental chamber, with rigid lining, equipped by devices, constructed as soon as expansible ground is encountered. In extreme cases, the construction schedule should be delayed, so that measurement results of approximately one semester are available to be considered in the desing of the lining.

47.3.5 Material Quality Control

(1) The purpose of monitoring material behavior concerns two classes:

a. Application of project quality control. This concerns and it belongs to the responsibility of the Owner representative and it is applied by the Contractor at his expense.
b. Ascertainment of the material behavior, so that the relationship between the design and the construction is controlled, if it is considered necessary. The relative program, given by the Service and concerning tests beyond

the mandatory in number and kind for the project quality control, shall be compensated independently.

(2) Design control tests include:

a. Tensioning and relaxing tests of nailings.
b. Strain load tests for nailings and bolts. Adhesion of nailing with resin or grouting.
c. Tests for the determination of the modulus of elasticity of shotcrete, as above.
d. Strength tests and tests for the determination of the modulus of elasticity of concrete, as above.
e. Monitoring of certain metal frames by electronic strain gauges.
f. Excavation monitoring results, as above.

(3) The Owner of the Project requires regular quality control measures, for the confirmation of the observance of the standard specifications for the materials.

The Owner representative could request his own testing and sampling. These measures could include:

a. Tensioning and re-screwing of nails.
b. Pull-out of nails.
c. Sampling (blocks) of shotcrete and concrete from any location during concreting.
d. Sampling cores of shotcrete and concrete from the walls at time intervals
e. Chemical analyses of the above mixtures and their components.
f. Sieving of aggregates and control of admixtures at the delivery locations.
g. Tension, torsion, backling etc. strength of the steel reinforcement and the frames used.

47.4 MEASUREMENTS AFTER THE INSTALLATION OF PERMANENT LINING AT THE TUNNEL AND THE TUNNEL ENDS

The main objective of instrumentation on the permanent lining of the tunnels is to ensure a timely and early warning for any failure or degradation during the useful life span of the tunnel, due to delayed loading, accidental loading, sealing of the drainage holes on the lining etc.

The measurement of pressures behind the lining, offers the added usefulness, in conjunction to the general measures, to assess the interaction with the support pressure.

The requirements of installing instrumentation on the permanent lining and the exact locations of these instrument will be determined by the Service. These consist mainly of internal stress/strain measuring devices and external piezometers.

It is anticipated to incorporate in the tunnel lining vibrating wire strain gauges (of any approved manufacturer) in radial direction (seven, 7), in tangential direction (seven, 7) and fewer in the axial direction (four, 4), i.-e., eighteen (18) devices in each cross-section. At the same location, total stress cells shall be fixed on the outside surface of the lining (GLOETZL type of similar).

Two piezometers shall be installed in horizontal boreholes in each sidewall, at distances of 6 m and 30 m from the tunnel.

The rock slopes at the tunnel ends shall be monitored with extensometers, installed along the face and side sections. Indicatively, triple head devices could be used with the anchor block bolted at 20 m and the remaining heads at depth of 10 m and 5 m.

47.5 REMOVAL OF EXCAVATED MATERIAL

If not specifically mentioned in the special conditions of tendering (S.C.C., Bill of quantities etc.) and subject to the condition of abiding with the Approval of Environmental Terms of the project, the materials excavated from surface of underground excavations shall be transported and dumped or deposited by the Contractor in areas designated by him and approved by the Service. In general, the waste excavated materials and other useless or inadequate materials shall be placed in areas not interfering with any part of the project.

The depositions of such materials shall be levelled and given a smooth surface with uniform and stable slopes and aesthetically pleasing appearance and they shall have inclinations which allow drainage without collection of waters or erosion.

If not specifically mentioned in the special conditions of contract (S.C.C. etc.), the waste materials shall be levelled in layers not exceeding 1.50 m without any extra compaction other than that made by transportation and levelling equipment. The Service reserves the right to enforce other specifications for the levelling, compaction etc.

The Contractor is not entitled to additional compensation for loading, transportation and levelling of the waste and other useless materials, as described above, unless it is mentioned otherwise in the respective clauses of the Bill of Quantities or in other contractual documents.

47.6 VENTILATION - LIGHTING DURING EXCAVATION

The requirements of the present clause are supplementary to the requirements of the Albanian Laws and the International Specifications for the prevention of Accidents.

47.6.1 Tunnel Ventilation during Excavation

47.6.1.1 General

The Contractor shall design, provide, install and operate the ventilation systems during tunnel excavation. In addition, the Contractor shall provide systems for monitoring air quality inside the tunnels. Details of the system proposed by the Contractor shall be submitted to the Service for approval after the acceptance of the Contract and at the latest one (1) month before commencement of the tunnel excavations.

The consistency of the air along the whole length tunnels shall fulfil qualitatively and quantitatively the- conditions required for the safety and health of the personnel. The oxygen ratio in the air should be no less than 20% and the concentration of gas, vapour, dust etc. should not exceed the allowable limits. When the air quality control determines that the natural ventilation of the tunnels is not sufficient, artificial ventilation should be used. Artificial ventilation has the following objectives:

a. To provide the personnel with clean air, replacing the air consumed by themselves, the equipment, vehicles or absorbed by gases and water flowing in the tunnel.

b. To dissolve and remove gases and dust produced during the work, blasting or surging through the ground.

c. To replace the warm air of underground spaces with cooler air.

d. To adjust the air pressure in the working environment.

The ventilation system should be maintained operative even after the end of the tunnel excavation. Fans at intermediate locations shall be attached where necessary along the main ventilation duct to achieve adequate removal of the dirty air inside the tunnel.
The ventilation ducts shall be attached near the top of the tunnel in a location at least 20 cm away from the edge of the equipment moving through the tunnel.

The Contractor shall check the quantity and quality of the clean air supplied at the tunnel front during excavation at a frequency equal to 100 m of tunnel excavation and at least once every 15 days or more frequently depending on the actual conditions. The joints of the ventilation tubes shall be checked regularly for leakage and all faults shall be corrected immediately.

If the quantity of the supplies fresh air is not the required, the whole ventilation system shall be checked (pressure and supplied quantity) in sections. The control points shall not be located at distances less than ten (10) times the diameter of the ventilation pipe from a fan or other irregularity of the air flow.

The personnel is not allowed to return to their posts inside the tunnel after a blasting cycle, before the fumes from the blasting are removed and certainly not before 15 minutes following the blasting.

The supplied air should be free form pollutants, dust, smoke and for this reason the entry of the ventilation system should be away from all sources of pollution.

It is imperative to have available spare fans and electrical generators for the case of faults or interruption of the operation of the ventilation system for any reason (power failure etc.). In case that the operation of the ventilation system is interrupted, the tunnel should be evacuated.

47.6.2 Lighting of Tunnels end Surrounding Areas

47.6.2.1 External Lighting of Tunnels

Tunnel entries and exits, accesses and work sites around the tunnels shall be sufficiently lit at night by electrical sources and where that is not possible by storm lamps or carbide lamps. The minimum required luminosity in the above areas is 32 lux.

47.6.2.2 *Internal Lighting of Tunnels*

The excavation fronts of the tunnel should be amply lit by one or more storm lamps.

The roof along the whole tunnel shall be lit by electrical bulbs during working hours. The bulbs shall be placed at distances such that the following luminosities are achieved:

a. Regions of excavation, removal and transportation of overhanging rock pieces, locations of concrete placement, support placement and generally work sites: 54 lux.

b. Other locations or regions in the tunnel: 22 lux.

Each bulb shall be at least 40 W. The bulbs shall be put in place immediately after the installation of the support measures.

The electrical wiring shall be adequately insulated, protected and properly fixed on the tunnel walls with adequate number of insulators. The bulbs, and especially those located in dangerous areas shall be protected from damage.

The Contractor should have available an adequate number of mobile lamps for the lighting of work sites, supervision and checks by the personnel of the Service.

The mobile lamps should be supplied with very low voltage (36 to 46 V at most) via transformers.

It is imperative to have available spare security lighting inside the tunnels, supplied by separate cables and autonomous generators or other source of independent and secure supply and immediate response, to cover any need for safe evacuation of the tunnel in the case of interruption of the normal power supply of the site.

For the protection against electricity hazards which are increased inside tunnels due to the moisture, lack of space, hard operation of electrical equipment and lighting, the precautions of the 'Regulations for Interior Electrical Installations" regarding 'wet areas" and the relevant specifications of the P.P.C. should be strictly enforced.

47.7 WATER CONTROL DURING DRILLING

47.7.1 General

The term water control during drilling means the set of all equipment and manpower required for the drainage of the water of the rock-mass in the region of the excavation front and the unsupported zone, as well as their temporary diversion outside the tunnel, in a way that does not impede the progress of the excavation and the temporary support of the tunnel. This diversion is usually made through a drainage trench having adequate dimensions for the anticipated quantities of water from the rock-mass.

The Contractor's attention is specially drawn in cases of swelling rocks, that water drainage should be carried out the quickest possible way, to avoid long contact of the rock-mass with the water.

47.7.2 Use of pumping

In the case that the tunnels shall be drilled at fronts, where, due to the longitudinal slope of the road, water is collected, it should be pumped towards the exit of the tunnel and the water receptor. Regarding the remaining fronts, the Contractor should maintain an adequate longitudinal slope of the drainage trench, for the flow of water towards the receptor.

47.7.3 Receptor of Tunnel Drainage

The water from the rock-mass, diverted to the exit of the tunnel, as described above, are usually mixed with machine oil and other waste produced by the tunnel excavation procedures. For this reason, they should be collected in a special sedimentation tank, where solid residuals shall settle first, and then the cleared water shall be allowed to flow towards the natural receptor either through pipes or trenches or directly from the stilling basin through a small channel. The sedimentation tank should be cleaned from the solid settlements at regular time intervals, to ensure its proper operation.

A similar sedimentation tank shall be constructed, as a permanent structure, near the tunnel ends to collect surface runoff from the tunnel pavement regularly (see sub-clause 47.9 of the present clause 47). The Contractor may decide on the relative combination of the temporary and permanent sedimentation tanks described above.

Water control is still part of the Contractor's responsibilities even during the waterproofing, drainage and permanent lining construction works, as described in detail in sub-clauses 47.9 and 47.10 of the present clause 47 of T.C.C.

47.7.4 Water Flow Measurement

Water flow shall be measured by a special VENTOURI flow meter or a similar device, proposed by the Contractor, according to the provisions of clause 51 of the present T.C.C.

47.8 SAFETY MEASURES DURING CONSTRUCTION

The provisions of the present sub-clause are supplementary to the requirements of the Albanian Laws and Regulations, concerning the safety and health of the personnel working in underground construction sites as well as the accredited international regulations for accident prevention.

47.8.1 Personnel Safety Measures - General Measures

47.8.1.1 General Obligations of the Contractor

The Contractor is obliged to care about the following:

a. To set-up and maintain the construction sites, installations, equipment, materials, etc. and organize the work in a way to ensure the safety of the personnel against accidents and health hazards.

b. To regularly supervise all works, construction sites, production processes etc.

c. To forbid the entrance to and use of underground structures, when they are in dangerous condition, until they are fixed.

d. To ensure the best working conditions to the personnel in terms of health and safety.

e. To notify the personnel of the provisions of the laws on their health and safety, as well as the security of the project.

f. To ensure that all newly hired personnel are informed about the general and special dangers regarding their work assignments and the ways to prevent them.

g. To supply the necessary and suitable individual protection means to the personnel, according to the nature of their work.

47.8.1.2 *Emergency Response Team*

The Contractor should organize an emergency response team among his personnel. This team shall be adequately organized, so that a sufficient number of its members is available for action and assistance at all times during the construction works.

This team shall be trained by specialized personnel. Each member of the team shall be able to provide first aid care, to operate the recuperation devices, the fire extinguishing apparatus and shall have knowledge of the local conditions. The team shall be provided with equipment and machinery to have access even to the most remote

47.8.1.3 *Telephone connections*

The tunnel excavation fronts shall have telephone connections to the ends of the tunnel. The telephones shall be hanged on the walls of the tunnel,. near the excavation- front, on heavy duty boxed adequately marked for use in case of emergency. The telephones at the ends of the tunnel shall be equipped with sirens.

47.8.1.4 *Fire Extinguishing Measures*

The Contractor shall take every suitable measure for the prevention and extinguishing of fires in work sites, structures, warehouses, machinery etc. and shall provide all the required equipment for this purpose.

The fire extinguishing equipment shall consist of portable fire extinguishers using gas, dust or other appropriate chemicals as well as autonomous water pumps of adequate capacity and height, equipped with the necessary hoses. The fire extinguishing equipment shall be maintained and be ready for operation at all times.

47.8.1.5 *First Aid Medical Supplies*

As the relative regulation requires, indicatively but not exclusively, at least the following first aid supplies should be available, so that first aid can be provided in the case of an emergency:

a. A stretcher.

b. A wool blanket.

c. A recuperation breathing device.

d. A compressed oxygen container.

e. Bandages, sterilizing materials etc.

f. Pain killing injections.

g. Breathing devices equipped with dust filters.

47.8.2 Activities in case of hazardous gases

47.8.2.1 Control of dust and silicates

In order to minimize dust concentration inside the tunnels, besides the installation of an adequate ventilation system, all drilling should be carried out using water and the piles of the excavated material should be continuously kept wet by sprinkling with low pressure water.

Fine dust concentration and silica oxide (Si02) content shall be monitored by the Contractor during all dust producing activities (inside the tunnel), using a method approved by the Service.

47.8.2.2 Poisonous gases

Internal combustion engines, using gasoline or gas fuels such as propane; boutane, propylene or boutylene are not allowed to operate inside the tunnels. Concerning internal combustion engines, the following measures should be taken:

a. Be maintained at regular time intervals, even more often than prescribed by the manufacturer, in order to ensure the best possible combustion.

b. To interrupt their operation when possible.

c. To fuel them, to the largest feasible extent, with special quality fuels having small contents in harmful substances (sulphate, lead etc.).

d. To use special filters for the absorption of harmful fumes and residues.

The Contractor shall provide and maintain suitable equipment for monitoring of the concentration of air in poisonous gases and oxygen at each tunnel front and any other location inside the tunnel.

Tests measuring the contents of air in carbon monoxide, carbon dioxide, methane, other flammable gases etc. shall be performed before and after each blasting cycle, as well as in the beginning of each work shift, by experienced personnel. These measurements shall be recorded in a log-book available to the Service.

The above instruments measuring gas concentration in air shall be subject to the approval of the Service and they shall be calibrated in an accredited laboratory approved by the Service.

When poisonous gas or other flammable gas concentration exceeds the allowable limits according to the pertaining regulations, all activities should be immediately interrupted and the personnel should evacuate the tunnel. All sources of sparks or flame should be removed from the tunnel or their operation should stop. Furthermore, the operation of all equipment should stop except the ventilation equipment. Re-entry of the personnel in the tunnel and resumption of the work is forbidden until it is approved in writing by the Service, after ensuring that no danger exists for the personnel. Poisonous gas concentration control measures shall be established jointly by the Contractor and the Service. In case of an emergency, the Contractor should consult an expert in tunnel excavation in the presence of gases.

47.8.3 Readiness of Spare Materials and Equipment

The Contractor must provide and maintain in a stand-by state at the construction site spare equipment and sufficient quantities of materials and supplies in order to act effectively and without substantial delay in the case of emergencies or unpredicted conditions and problems during the excavation and construction of the tunnel, in the case of equipment faults etc.

For the timely action, depending on the actual conditions, for the stabilization and support of the tunnel walls and excavation front, the Contractor shall have available on site spare quantities of rock anchors and rock bolts of various types, steel frames, metal truss supports, metal grids, materials for the production of shotcrete etc. Also, the Contributor shall have available the required equipment for the installation of rock bolts (drilling equipment) and the application of shotcrete as well as a reasonable amount of spare parts to repair equipment damages.

The selection of a specific working procedure by the Contractor, e.g. excavation by mechanical means, and the approval of the procedure by the Service does not relieve the Contractor from the responsibility to maintain spare equipment and materials for the continuation of the work using another appropriate method (drilling and blasting), if the method initially selected does not produce satisfactory results or proves to be inadequate.

47.9 DRAINAGE – WATERPROOFING

47.9.1 General

(1) Drainage and waterproofing of the tunnel sections shall be carried out according to the respective specification.

(2) Water-proofing shall aim at the following results:

a. Relief of the permanent tunnel lining from the hydrostatic water load.

b. Reduction of the humidity in the tunnel, a fact that could obstruct normal operation.

c. Prevention of water inflows in the tunnel, a fact that could result to the washing out of fine material and to erosion.

d. Insure controlled diversion of all water inflows through the drainage system.

The tunnel drainage and waterproofing system shall consist of the following parts:

a. Water collection works, i.e. the construction of the drainage holes and the pipes network for the diversion towards the main receptor.

b. Water collection layer consisting of geotextile.

c. Water-proofing layer consisting of a membrane.

d. A network of perforated drainage pipes, connection pipes, junctions, cleaning areas etc. as well as any drainage joints.

The detailed description and the structural requirements of each of the above parts are mentioned in the following paragraphs 47.9.2 to 47.9.6.

47.9.2 Water Collection Works

The water collection works commence after the completion of certain immediate support works (anchorage, frames, initial layer of shotcrete), but before the completion of the shotctete layer.

The Contractor shall construct a fan of drainage holes each having a diameter of 3" and a length of -3 to 6 meters and their number depending on the actual conditions. The ends of these holes shall be connected to flexible drainage tubes, usually plastic, to divert the water into the drainage pipes installed at the base of the tunnel section. These tubes shall be attached to the shotcrete using nails (e.g. of the HILTI type) and they will be incorporated in the shotcrete layer. The fan of drainage holes shall be repeated in places proposed by the Contractor and approved by the Service.

The drainage holes may be partly or fully filled with perforated steel tubes covered with a geotextile similar to the one to be used in the water collection system, especially in areas prone to deformations. These tubes shall be placed in regions of significant water inflows, in order to ensure adequate drainage and protection of the holes from local failures that may plug them. In cases of extreme inflows without deformations which would require pipes of significant strength, special pipes made of aluminium, P.V.C. or other material approved by the Service may be used as filters instead of the above steel pipes.

The construction of the drainage holes shall be performed according to clause 50 of the present T.C.C.

47.9.3 Water Collection Layer

The water collection layer consists of a geotextile according to the provisions of the specification 'Drainage and Water-proofing of Tunnels', according to sub-clause 48.21 of clause 48 of the present T.C.C.

The geotextile is fixed on the smoothened surface of the shotcrete or, generally, the smoothened surface of the immediate tunnel support, is placed radially on the surface of the tunnel crest and sidewalls and it ends at the contact of the sidewalls to the invert of the tunnel. In areas of large water inflows, the Service might require the installation of a double layer of geotextile to ensure improved drainage of the rock-mass and free flow of the water towards the lower part of the tunnel sidewalls, where the perforated drainage pipe is installed.

47.9.4 Drainage pipe

The drainage pipe shall be adequately covered by the ends of the geotextile in order to collect the water flowing through the geotextile and to prevent water percolation towards the permanent lining. The drainage pipe shall have a diameter of 160 mm, it shall be made of P.V.C. or other appropriate material approved by the Service, it shall be perforated on the upper part and it shall be placed on fresh porous concrete.

The drainage pipe is designed to operate at the 2/3 of its nominal capacity, and for this reason it shall be equipped with `cleaning nests" at 100 m intervals and cross connections to the main collector pipe. The cleaning nests shall be twin (one at each side of the tunnel) and the distance of 100 m is considered the maximum allowing an adequate cleaning of the 160 mm drainage pipe using the equipment available at present.

47.9.5 Main Collector Pipe

Drainage water collected in the cleaning nests are diverted to the main collector pipe via cross connections. The main collector pipe consists of a concrete pipe 400 mm in diameter, or even larger, depending on the local conditions according to the design. This pipe is placed in the lower part of the tunnel unless prescribed differently in the approved design. At the cleaning nests locations, the concrete pipe is connected to a pit, to which the cross pipes are also connected.

47.9.6 Waterproofing Membrane

(1) The drainage and waterproofing system is completed after the placement of the waterproofing membrane, which consists of standard-sized sheets according to the order placed by the Contractor to the manufacturer of the material. The membrane fulfils the provisions of the specification regarding its quality and method of installation.

The water-proofing membrane completely precludes the percolation of water into the permanent tunnel lining, by diverting the ground water towards the drainage pipe. It thus creates a water-proof layer along the permanent lining, permitting the safe progress of the permanent lining construction without any interference by water from the rock-mass and generally the operation of the tunnel under completely dry conditions.

(2) The operations sequence for the installation of the membranes is the following:

a. The water-proofing membranes (sheets) are fixed on the special attachments of the geotextile using special self-adhesion devices. The ends of the waterproofing sheets should not coincide with the location of the special attachments to allow the creation of a waterproof seam by glueing.

b. Glueing at the ends of the water-proofing sheets is achieved with automated self-adhesion devices to create a double seam with an intermediate control channel, a method which is considered as the most effective in controlling the quality of the seam.

(3) In the following, the Contractor's attention is drawn on several special issues. Essentially, during the permanent lining construction and after that, serious efforts should be made to avoid damage of the already placed water-proofing membrane. To achieve this, the following measures should be taken:

a. Contact grouting between the concrete of the permanent lining and the water-proofing membrane is achieved by placing special tubes, preferably made of P.V.C., during concreting.

b. If stabilization grouting is required, then this is performed through special tubes penetrating the water-proofing membrane, while their contact with the membrane is water-proofed as prescribed in the relevant specification.

c. At the locations where tunnel control instruments (e.g. piezometers) are installed after the construction of the permanent lining, special care shall be taken to drive pipes, cables etc. through the water-proofing membrane according to the manufacturer's specification.

d. In the case that steel reinforcement should be placed in the permanent lining, it should be attached on special fixtures.

47.10 PERMANENT LINING OF TUNNELS

47.10.1 General

The permanent lining of tunnels should provide a uniform operation section. The outline of the operation section should not deviate from the approved section by more than 20 mm at all locations. The permanent lining should have a smooth surface according to the corresponding articles of D.I.S. (sub-section 1.20) and of T.C.C. (clause 6) with uniform roughness along the whole tunnel length.

The Contractor shall submit for approval the construction method statement of the permanent lining. In all cases, the permanent lining should incorporate all necessary functional elements.

47.10.2 Minimum Thickness of the Permanent Lining

The thickness, in all locations of the roof and side walls should not be less than the statically required (d3) and it shall follow any other minimum thickness constraints included in the tender conditions of the project (S.C.C. etc.)

In any case the minimum thickness d3 mentioned in sub-clause 47.16 of clause 47 of the T.C.C. shall be observed.

47.10.3 Mechanical Installations - Services

(1) The permanent lining shall incorporate in the concrete the following mechanical installations of parts of installations:

a. Interior tunnel lighting (cable tubes)

b. Sidewall cleaning recess

c. Sidewall electromechanical control recesses, fire lighting recesses, telephone recesses.

d. Instrument recesses.

e. Illuminated traffic signs.

(2) If not specially mentioned in the special conditions of tendering (S.C.C. etc.), the services will be placed on or incorporated inside the permanent lining. In the case that the services will not be incorporated in the permanent lining but fixed on it, they will be placed and fixed in such a way, that:

a. They ensure the required free space for traffic and pedestrians.

b. There is no danger by air-dynamic phenomena caused by the traffic in the tunnel.

47.10.4 Concreting of the Permanent Lining

The concrete for_ the permanent lining shall comply with the "requirements of clause 49 of this T.C.C., in conjunction with any additional- conditions required by the special conditions of tendering (S.C.C. etc.).

In particular, concerning the tunnels, the following conditions also apply:

47.10.4.1 Placement - Compaction of Concrete

The placement of concrete shall be performed only at the presence of a representative of the Service, unless otherwise decided by the Service in any particular case. Concrete placed without previous notification of and approval by the Service, might be required, at the Service's absolute judgement, to be removed and replaced with new concrete, at the Contractor's expense.

The placement of concrete shall be performed by concrete pumps or other method approved by the Service. In case that concrete pumps are used, the concrete should have a slump of 100 mm.

Equipment or pumps using compressed air are not permitted for concrete placement. Generally, methods, which do not prevent the segregation of coarse aggregates during concrete placement, are not allowed.

The concrete shall be placed in a manner securing uniform loading of the formwork is ensured. The concrete level difference between the opposite sides of the formwork should not exceed one (1) m. The length of concrete placement shall be such that concreting is completed in one work shift.

The end of the concrete placement pipe shall be marked to indicate its depth inside the fresh concrete at all times. The concrete pouring equipment shall be used only be experienced personnel.

Special care shall be given to avoid damage of the waterproof membrane (placed on the inner surface of the temporary lining) during concrete placement or during compaction with mass vibrators. For this reason, it is preferable to compact the concrete using surface vibrators, fixed on a grid on the framework.

Concreting interruption joints should be avoided as much as possible. In the case that concreting is interrupted due to damage of the concreting equipment or for any other reason, the Contractor shall carefully compact the concrete at these joints at a practically uniform and constant slope while the concrete is still plastic (before it sets). The surface of the joints should be cleaned and roughened, as required for the construction joints, before resuming concreting.

Concreting shall not be permitted when, in the Service's opinion, weather conditions prevent proper placement and setting.

Concrete with excessive slump or segregated or partly set or non-workable
should not be placed. Re-mixing of concrete that has partly set with or without additional cement, aggregates or water shall not be allowed.

All pipes, screws, anchors and other metal structures to be incorporated in the concrete according to the construction drawings or as required, shall be placed before. concreting. The Contractor is responsible for the accurate placement of all materials to be incorporated. Any incorporated object wrongly or inadequately placed shall be replaced at the correct position at the Contractor's expense.

Concrete shall be carefully placed and compacted around incorporated objects. Mechanical vibrators shall not be used for the placement of concrete around incorporated objects.

During concrete placement in the spaces between steel rebars and around incorporated metal objects, care should be given to avoid the segregation of coarse aggregates and ensure at all times the necessary workability of the concrete and the uninhibited flow through the spaces between rebars and incorporated objects.

The concrete should be compacted with appropriate equipment to achieve the maximum possible density, without inclusions of segregated coarse aggregates and air, and it should be in complete contact with the base, the formwork and the surrounding surfaces.
Concrete compaction should be performed with surface vibrators (formwork vibrators) or immersable vibrators (mass vibrators) or a combination of the two.

The immersable vibrators should vibrate at a minimum speed of 6000 revolutions per minute during operation at the specification voltage, air pressure etc., and are immersed in the concrete.

The surface vibrators should be properly fixed on the formwork and they shall operate at 8000 revolutions per minute during the vibration of concrete, or as approved by the Service. These vibrators shall be placed at distances not exceeding 1.20 m.
The location of surface vibrators near the tunnel roof, the position of the concreting nozzle, the operation of the vibrators and the rate of concreting should be combined and coordinated so that the maximum possible filling with concrete of the tunnel roof is achieved.

Eventual remaining gaps behind the permanent lining should be filled with grout, so that complete contact between the permanent lining and the waterproof membrane is achieved.

Freshly concreted surfaces should not be used in any way in the first 12 hours after concreting.

47.10.5 Permanent Lining Metal Formworks

The requirements and the characteristics of the metal formwork used for concreting the permanent lining of the tunnels are described in clause 49 (paragr. 49.1.2.8) of the T.C.C.

The formwork shall be removed when the concrete of the permanent lining has gained a compressive strength of at least 5 MPa and tensile strength 1.4 MPa. As a result, the sequence of concreting and removal of the formworks should be carefully programmed.

Before formwork removal, the strength of the concrete should be checked by testing (at least 3) specimens to failure, taken at various stages of concreting of the specific portion supported by the formwork.

47.10.6 Repairing Concrete Surface

Every dent, abnormality, void, swelling etc., observed on the concrete face of the permanent lining after formworks removal, shall be repaired within 24 hours after the removal of the formwork.

Repairs should be performed by specialized technicians according to the instructions of the Service.

Repairs should be made with fresh concrete or cement mixture or epoxy resin. If the repair results are not considered adequate, the Service may require additional repairs at the Contractor's expense, at any stage of the works before painting the surface, using suitable materials and method.

47.10.7 Tolerances of the Permanent Lining

The allowable deviations of the permanent lining of the tunnels are the following:

(1) Deviation of the thickness of the permanent lining.

The minimum thickness of the permanent lining, measured between the internal face of the lining and the surface of the waterproof membrane (internal face of the temporary lining), shall not be smaller than the specified in the approved construction drawings (thickness d3), or exceed that by more than twelve (12) mm.

(2) Deviation of the tunnel gabarit.

The dimensions of the tunnel gabarit after the construction of the permanent lining shall not be different than the corresponding dimensions of the gabarit specified in the approved construction drawings by more than twenty (20) mm.

47.10.8 Joints. Finishing of the Permanent Lining

The permanent concrete lining shall have construction joints located at the ends of the formwork.

The joint thickness shall be 1 to 2 cm, unless otherwise approved by the Service.

The waterproofing at the joint locations shall have an extra impervious layer 50 cm wide.

The joints shall be filled with foam plastic sheets (sheets of polystyrene foam) 1020 mm thick. The end of the joint towards the interior of the tunnel shall be sealed by a flexible strip (e.g. Aerofill) and with asphalt-based resin.

A small recess shall be formed on each joint, towards the interior of the tunnel, according to the drawings, contributing to an improved aesthetic appearance of the finished surface.

47.10.9 Steel Reinforcement of Permanent Lining

At locations where steel reinforced permanent lining is required according to the design, steel reinforcement shall be placed according to the provisions of the specification included in the present contract documents, concerning structural steel STIII or metal grids STIV.

47.11 FINISHING WORKS

47.11.1 General

The present sub-clause includes all utilities and portions of utilities that are either incorporated in the concrete of the permanent lining or are constructed on the floor (invert) or under the floor of the tunnel.

47.11.2 Utilities on the Floor (Invert) of the Tunnel and under the Floor - Tunnel Floor layout

The tunnel floor (invert) shall be constructed in a manner permitting the construction of the pavement according to the specifications.

The tunnel invert shall also contain the drainage ducts and the pedestrian sidewalks.

47.11.3 Drainage of the tunnel pavement

The useful section of the tunnel shall be delivered equipped with an integrated drainage system for the fluids that may spill out during the operation of the tunnel. These fluids may be due to washing out, waste disposal or even firefighting water. The drainage system shall contain suitable pipes along the tunnel. The pipes installed by the curb for water collection shall have a minimum diameter of 0.20 m.

In the lower part of the tunnel section, under the pavement, a concrete pipe having a minimum diameter of 0.30 m shall be installed; this pipe shall be covered by porous concrete and it shall be perforated in the upper part to collect waters from the tunnel floor. Alternative layout proposals according to the design may be accepted by the Service.

47.12 LOCATION AND LAYOUT OF TUNNEL ENDS

47.12.1 Location of tunnel ends (entry and exit)

The locations of the entry and exit ends of the tunnels are selected on the tunnel longitudinal section so that there is a rock cover (thickness of the rock cover over the tunnel roof) at least equal to the diameter of the tunnel. Minor changes and adjustments are allowed during the construction works, if required by the actual conditions, subject to the Service's approval.

47.12.2 Preliminary Works - Access - Protective Frame

Before commencing the tunnel drilling and the- underground excavations, it is necessary to take precautions and protect the personnel working at the tunnel access fronts from falling stones. In this phase of the works, all surface excavations should be completed and all slope supporting measures necessary for the commencement of the tunnel drilling should be already placed; however, even then, the danger of falling stones cannot be eliminated, especially in cases of high slopes.

Consequently, for the safety of the personnel and the uninterrupted progress of the drilling operations, a protective frame should be placed at each tunnel end, if necessary. The frame shall consist either of steel sections covered by metal sheets and sand/gravel, or it shall be made of other materials (e.g. concrete) and it shall have a length of 4-8 m depending on local conditions. The construction of the protective frame is subject to the Service's approval.

The dimensions and materials of the protective frame shall be such that it is possible to incorporate it in the permanent lining of the tunnels.

The cost of the protective frame shall be paid according to the unit prices of the bidding price list.

47.12.3 Initial Tunnel Chilling Procedures

Before the commencement of underground excavations, all surface excavations and slope protective measures shall be performed according to the conditions mentioned in the above paragraph 47.12.2. Regardless of the total length of the underground drilling to be performed from each tunnel end, drilling to a minimum length of three times the tunnel diameter shall be performed from each end towards the interior of the tunnel, unless otherwise specified in other contract documents. It is, thus, not allowed to perform the drilling of the tunnel exclusively from one end without drilling a minimum length from the other end.

The initial drilling of the tunnels shall be performed with extreme caution. If drilling is performed by blasting, the advancement of the tunnel in at least the initial twenty (20) m, or as approved by the Service, shall be performed using controlled blasting techniques (linear drilling, mild blasting etc.) as described in sub-clause 47.1 of the present clause 47 and using the least possible charges to avoid disturbance and fracturing of the rock-mass.

The blasting advancement length of the initial explosions shall be small and analogous to the type and quality of the excavated rock.

The tunnel support measures (steel frames, anchorage etc.) should be increased and they also should be placed rapidly to avoid loosening of the rock-mass.

Before the commencement of the underground excavations, the Contractor shall submit to the Service for approval the method statement to be used for drilling the initial length of the tunnel.

47.13 ROCK SLOPES NEAR THE TUNNEL ENDS

47.13.1 Strengthening and Protection of Rock Slopes

The rock slopes at the tunnel ends shall be strengthened, protected and stabilized, depending on the- local conditions, using shotcrete, structural or galvanized grids, rock nails, pre-stressed rock bolts etc., as these methods are described in clause 48 of the present T.C.C.

The Contractor shall submit to the Service for approval, the proposed design and drawings of the protection and stabilization measures, as well as the design and drawings for the excavation of rock slopes described in paragraph 47.13.2 of the present clause 47.

The locations, zone limits, types and generally the layout of the measures proposed in the drawings shall be modified according to the instructions or approval of the Service, as and when required, been adapted to the local conditions, as these conditions are revealed during the excavation.

Modification and changes that may be required due to the above, create no right for additional compensation (payment) to the Contractor.

The Contractor is completely responsible for the adequacy and successful operation of the rock stabilization measures, regardless of the approval of such measures given by the Service.

In the case of rock nails and pre-stressed rock bolts, the Contractor shall submit detailed manufacturer specifications for the placement, pre-stressing, testing etc.
For the strengthening of the rock-mass against earthquakes it may be required to install active rock nails (pre-stressed), having a working load at least 20 tons and length exceeding 12 meters.

For the long term protection of the excavated slopes against erosion, it is appropriate to cover them with a layer of shotcrete having a thickness of the order of 10 cm, with or without a reinforcement grid, depending on the existing conditions.

Special care should be given to the strengthening of the rock faces near the tunnel ends, when the cover is not large and the rock-mass is not sound or weathered. In such cases it may be necessary to construct a reinforced concrete slab or a shotcrete slab of sufficient thickness, reinforced with STIV grids and an appropriate number of rock bolts.

The Contractor shall design and construct on the rock slopes appropriate fences to stop or reflect loosened pieces of rock, that may fall from higher levels, and/or construct trenches and possibly walls 'against rock-falls" according to the directives of 0.1.8. (paragraph 1.7.7.3 of sub-clause 1.7).

If such fences are constructed, they may be combined, depending on the local conditions, with steel nets, anchored on the rock slope that will support mainly small loosened pieces of rock. The above fences and steel nets are subject to the Service's approval.

47.13.2 Layout of Rock Slopes and Intermediate Benches - Removal of Loosened Material

The surface excavations near the tunnel ends shall be performed according to the instructions, slope inclinations and dimensions shown in the drawings of the final design as these- will be approved by the Service. During construction, the Service may consider necessary to make modifications to the above drawings depending on the actual conditions; the Contractor -is not entitled to additional compensation (payment) because of such modifications.

The inclinations of rock slopes at the tunnel ends shall be determined from the actual geological and geotechnical conditions, in order to achieve the required margin of safety. The determination of the inclination of rock slopes, the required intermediate benches etc. shall be performed by the Contractor, using a slope stability analysis for each tunnel end, in order to ensure adequate stability and to avoid undesirable consequences. The above design consider the influence of earthquake forces (see appropriate requirement in sub-clause 1.7 of D.I.S.).

The Contractor shall submit to the Service for approval the slope stability analysis and the excavation drawings for the tunnel ends.

Before commencing rock excavations, all standard excavations that do not require the use of blasting should be completed. It is generally not required to clear the rock surface manually before rock excavations, but the surface of the rock should be scraped by a bull-dozer, mechanical shovel etc. to remove the top soil of loose material.

In order to avoid, as much as possible, over-excavation, loosening, disturbance and fracturing of the rock, as well as to achieve smooth and aesthetically pleasing rock surfaces, the final surfaces shall be formed using methods of controlled blasting, such as linear drilling, pre-drilling etc.

Irregular lumps of undisturbed rock shall be allowed only subject to the Service's approval.

In all final excavations faces, loosened overhanging or detached rock pieces, considered dangerous in the Service's opinion, shall be carefully removed manually, by hand-picking, using levers, sticks etc.

Hand-picking and clearing of rock faces, if required by the Service, shall not be additionally compensated.

Excavations performed by the Contractor to give access to the rock slopes are subject to the approval of the Service and should be limited within the approved limits.

Intermediate horizontal benches shall have a width of at least four (4) meters. More details on the analysis and layout of high rock slopes (H > 10.0 m) are given in sub-clause 1.7 of 0.1.5. (paragraph 1.7.7.2).

47.13.3 Drainage of Rock Slopes

The Contractor is obliged to take all measures required for the collection and drainage of surface runoff on the rock slopes of the tunnel ends.

The necessary measures: that should be taken at each tunnel end to achieve proper collection and drainage of surface runoff, obviously depend on the actual conditions at each tunnel end. AS general measures the following are mentioned:

a. Construction of a trench at the top of the slope for the collection of rainfall runoff.

b. Construction of a rainfall runoff collection trench at the inner boundary of the horizontal benches.

c. Lining of the drainage trenches with concrete to prevent water leakage in the underlying rock mass at the tunnel.

d. Covering the horizontal benches of the rock slopes with shotcrete, when considered necessary, to protect them from erosion and protect them from erosion and to prevent water leakage.

e. Diversion of the water collected in the above trenches, away from the slopes, via additional trenches, pipes etc. into the main drainage of the tunnel or to other suitable locations.

f. Planting of the slopes for protection from erosion.

The Contractor shall compile and submit to the Service for approval, drawings of the collection and drainage of surface runoff system on the rock slopes of the tunnel ends.

The cost of the collection and drainage of surface runoff works is paid according to the unit prices of the bidding price list.

47.14 LONG-TERM SAFETY OF SURFACE WORKS AGAINST ROCK-FALLS

The Contractor shall design and construct structures for the protection of the highway in the region of tunnel ends from rock falls and local failures.

These structures shall be retaining walls, or wing-walls, frames or covers etc., or combinations of the above, depending on the particular conditions prevailing in each tunnel end.

These structures can be constructed of plain or reinforced concrete, steel frames, masonry walls, wire-mesh stone-filled containers or other materials. Anyway, the materials to be used in each case, as well as the design of each particular structure not only shall ensure the necessary protection of the highway in the region of the tunnel ends, but they shall also conform to the imposed aesthetic criteria, since these structures are permanent.

The Contractor shall compile and submit for approval an integrated design (drawings, calculations etc.) of the necessary protective measures for the highway in the region of each tunnel end. The Service reserves the right to modify or even require full re-submittal of the design if, according to its opinion, the proposed structures do not provide the required safety and protection of the highway or if they do not comply with the actual conditions or if their appearance is not aesthetically pleasing.

The construction cost of the above structures is paid according to the unit prices of the bidding price list.

47.15 WATER DRAINAGE FROM THE EXTERIOR OF THE TUNNEL

In the region of the tunnel ends, the Contractor shall construct a water collection and drainage system for the following water flows collected in these areas from the exterior of the tunnel:

a. Water draining from the rock-mass on the faces of the tunnel ends, diverted there by collecting pipes.

b. Water and other fluids draining from the highway pavement outside the tunnel, if they drain towards the tunnel.

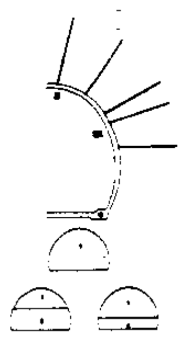
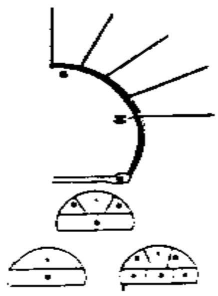
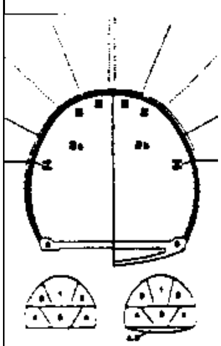
The Contractor is obliged to collect water and fluids in collection and sedimentation tanks, to take appropriate measures for their treatment and eventually to divert them to natural receptors in the vicinity of the tunnel ends, without causing any harm to the environment. Similar solution has been selected for the collection of water from the interior of the tunnel (sub-clause 47.7 of the present clause 47) and it is possible to combine the two systems.

47.16 CLASSIFICATION OF THE ROCK MASS

47.16.1 Generalities

The attached Tables 1 and 2 shall be used for the classification of the rock mass with reference to the excavation and support of the tunnel; this Table includes three (3) classes (I, II, IIIa and IIIb). The classification is based on the rockmass conditions, the pressure and deformation conditions, the support requirements, the excavation method and the necessity of the final lining. Table 2 presents the areas that is presumed (without being certain or restrictively exclusive) to apply each of the rockmass categories. The same Table includes, for the assistance of those interested, similar classifications according to the LAUFFER-PACHER and BIENIAWSKI which, however, are not classification criteria of the present specification.

ROCK MASS CLASSIFICATION - TABLE 1

CLASS	ROCK-MASS CONDITIONS	PRESSURES AND DEFORMATIONS OF THE ROCK-MASS	SUPPORT MEASURES	INDICATIVE DRAWINGS OF EXCAVATION AND SUPPORT
I	Jointed to frlable rock-mass Jointed rock-mass visible separation by bedding and occasional jointing, clayey filling of joints and cleavage of intermediate layers The strength of the rock- mass is larger than the tangential stresses. The stability of the tunnel section is ensured with light support. Little or no influence of groundwater. Dander of rock-falls.	Negligible to low deformation, Negligible to low lateral stresses.	Sporadic bolts or systematic anchors, where required, and wiremesh at the tunnel top; where required, a layer of shotcrete having *a* statically required thickness of 10 cm in the complete section. Sporadic steel support frames.	
II	<u>Fractured to completely fractured. saucezing to highly squeezing rockmass</u> Highly tectonized, faulted and laminated rockmass, with cracks in various directions. Strength of the rockmass is moderate, less than the tangential stresses. Low modulus of deformation. Little to moderate influence of water in the filling of cracks. Very low friction along fractures.	Significant lateral pressures. Moderate to significant deformation. Possibility of local swelling. Plastic material is squeezed towards the tunnel opening.	Systematic anchors and wiremesh in the whole section. Sholcrete having a statically required thickness of 15 cm in the whole section. Steel support frames at the roof and tunnel sides. Immediate support of the section after the excavation. Possible need to coat the excavation face with shotcrete.	
III a, b	<u>Extremely weathered or gisturbed rockmass. Extremely saueezinq</u> Sheared, weathered, washed rockmass, extremely tectonized CD hemorkss material. Significant or very significant inflow of water. Softening or piping of sot due to the water inflow.	The tangential stresses exceed significantly the strength of the rockmass. Plastic material is squeezed inside the tunnel opening, Intense swelling is expected. Significant lateral pressures and possible bottom heave.	Systematic installation of medium of heavy metal frames. Long rock anchors where possible. Shotcreie having a statically required thickness of 20 cm, with single or double wiremesh in the whole section. Connection beams in frames and where required steel lining plates, and where required, immediate lining of the section and protection of the excavation face. Where required (III b) invert concrete beam at the tunnel floor, during the completion of the excavation of the section. Use of forepoling beams or roof protection shields or grouting, for the improvement of the ground before the excavation, as required.	

ROCK MASS CLASSIFICATION - TABLE 2

CLASS	EXCAVATION	FINAL LINING	INDICATIVE TYPES OF GEOLOGICAL FORMATIONS	SIMILAR CLASSIFICATIONS	
				L + P	BIENIAWSKI
I	Excavation using explosives. Excavation of the roof in the first stage and formation of an excavation bench (two-phase excavation) for construction reasons. Excavation progress step: >= 1.5 m	Required for construction reasons, water-proofing of the tunnel and undertaking of future secondary loads. Reinforced lining is not foreseen. Estimated thickness 0.30 m.	- Limestones - - Granites, gneiss - Sandstones, sandstones with thin layers of siltstone - Cohesive conglomerates - Sound ophiofites - Cohesive anglomerates - Dolomites - Charts - Schist charts - Schist sandstones - Gabbro - Dolerites (with small influx of water, regardless of pressure)	I - II	I - II
II	Excavation with blasting or a Rodheader or other machinery. Excavation of the section in at least two (2) phases. Possibly sectional excavation in phases of the half-section of the tunnel as well. Excavation progress step: c 1.50 m	In addition to the above, it is required in order to undertake the primary loads. It is not required to extend the lining at the tunnel bottom. Reinforcement if required by static reasons. Estimated thickness: 0.30 m	- Clay schists - Siltstones - Loose or moderately cohesive conglomerates - Combination of the above types or continuous interbedding of the above - All types of loose ground not requiring closure of the tunnel invert during excavation, according to the data coHected during excavation - Loose or moderately cohesive anglomerates - Ophioliles (with moderate inflow of water regardless of pressure)	Ill & IV	III & IV
Illb	Occasional blasting, but mainly conventional excavation with mechanical equipment or manually. Sectional excavation, in at least three phases for each half-section. Advanced shield where required. Completion of the section along a length of one diameter.	Required for the same reasons as for class II. Mainly reinforced especially in swelling ground. The thickness may reach 0.40 m if statically required.	- Very loose soils - Intensely swelling soils - Zones of intense faulting - Running ground - Gypsum (with large inflow of water regardless of pressure)	V	V
lila	Special cases in which, whie during the first excavation phase the rock- mass was classified as IIlb which requires closure of the invert, the subsequent behaviour of the rock mass allows to avoid the closure of the invert. This fact will become evident during the design of the final lining.			as well as all soil types and conditions not included in these classes	

It is pointed out that for the excavation, support and lining of the tunnel, two 'lines" are contractually defined: Line "A" (Line of Minimum Excavation) and Line "B" (Pay Line). The distance between the two lines, which defines the thickness of the over-excavation that is contractually paid, is defined as equal to 0.25 m for rock classes I and II and equal to 0.15 m for rock class Ill.

The Contractor does not have the Fight to propose or require any modification of this quantity and should consider it and select the appropriate tunnel excavation methods. No additional over-excavation shall be paid, even if it is included in the final design of the Contractor.

It is clarified that various types of geological formations can be included in each rock mass class, if they have the same characteristics and if they require similar excavation and support methods as shown in the Tables.

Subsequent reinforcements of the tunnel support with materials and methods that possibly exceed the approved for each class, in order to either strengthen the temporary supports of as a part of the permanent support and lining of the section, do not establish claims for a change in the rockmass classification in relation to the payment for the excavation and support.

Possible use of materials in addition to those predicted for the support in each class shall be paid if they have been approved by the Service.

It is clarified that the Contractor shall consider that the most adverse conditions are covered by class IIIb which includes may method for excavation and advancement and any means and methods of support, in any number of phases required for the completion of the final section. Classes of more adverse conditions shall not be accepted.
It is repeated that the classification shall be made by combining all factors described above and shown in the attached Tables, and that each factor considered alone does not necessarily establish a classification criterion.

Finally, it is clarified that the previously mentioned three classes (I, II and III a, b) which form the contractual method of classification and payment of the Contractor, DO NOT CORRESPOND and should not be correlated to the classification classes mentioned in the preliminary design of the project and its corresponding drawings. The above data shown in the preliminary design are solely indicative, and can only be consulted for the final design of the project.

47.16.2 Procedure for the selection of the support measures

The rock mass classification in a particular region of the tunnel is initially performed, by the Supervising Service, by a two-person (or more) committee; this committee includes the engineer who supervises the project and one or more employee of the Supervising Service, having University education, in preference a geotechnical engineer, or mining engineer or geologist.

The side of the Contractor is represented by an approved representative having University education.

A special log book shall be maintained on site, in which the classification of the rock mass along the tunnel shall be recorded and justified according to the criteria of paragraph 47.16.1 of the present specification.

The classification shall be performed daily and necessarily for every change in the quality of the rockmass, for which the Contractor shall inform the Service.
According to the previous log book, in regular time intervals, a rockmass classification document shall be drafted in the presence of the Contractor's representative.
This document shall be signed by the members of the Committee participating in the classification, and the representative of the Contractor.
The drafting of this document cannot be performed for tunnel lengths larger than that determining by the Managing Service and in any case not larger than one-hundred (100) meters.

47.16.3 Disputes

In the case that the Contractor disagrees with the opinion of the Committee, he signs the log sheet "with reservation" and submits to the Committee a report which includes his own opinion. This report is attached to the corresponding log sheet and is mentioned in the draft of the rockmass classification document.

A petition may be filed within a period of fifteen (15) days from the day the classification document is signed by the Contractor "with reservation".

In the case of a difference of opinions between the members of the Service Committee, then the justified opinion of each Committee member is recorded in the log book. The document, however, only includes the opinion followed by the majority of the Committee members, or in the case of an equal vote, the opinion which is economically more favourable for the Public (government).

The petition is judged by the Managing Authority, which may form a Consulting Committee, due to the special nature of the issue; the manager of the Managing Authority shall necessarily participate in this Committee. The Committee shall draft a report, with its own opinion for the classification of the rockmass in the sections of the tunnel for which there was a dispute and a petition was filed, based on the existing data and any additional data that may be collected after a site visit or the additional data that may be supplied by the Contractor. The Committee may demand the services of any existing Consultant to the Service in all matters that are considered necessary.

47.16.4 Safety of the project

If the Contractor judges that the support measures foreseen by the corresponding design class, based on the classification of the Committee, can endanger the immediate stability of the tunnel, and not its future stability, should and must take all necessary support measures to alleviate such a danger, regardless of his written reservations.
Failure to take the above measures, due to his dispute with the Service, does not relieve the Contractor from his responsibilities for the immediate safety of the project and the personnel, as these are caused by the existing directives and the other documents of the contract.

47.16.5 Determination of maximum limits of payment

The payment of the Contractor, for certain items, is limited up to a certain line that depends on the position of Lines "A" (line of minimum excavation) and "B" (pay line) for each rockmass class and their distance (d0), the statically required thickness of the final lining (d3) the static thickness of the shotcrete layer (d1) and the foreseen convergence of the rockmass (d2).

All the previous quantities are analyzed in sub-clause 47.1 of the present specification and are determined in the following Table 3 for each rock class.

The data of this Table shall give the contractually paid quantity of tunnel excavation for each rock class (sub-clause 48.1 of the T.C.C. and of the Tender Bill of Quantities).

TABLE 3
DETERMINATION OF MEASURES FOR THE PAYMENT OF EXCAVATIONS

Class	d_o (cm) distance of lines A and	d_1(cm) shotcrete static thickness of	d_2 (cm) convergence	d_3 (cm) static thickness of permanent lining	Excavation thickness paid in excess of the internal surface of permanent lining (cm)
3.1 TUNNELS OF USEFUL DECK WIDTH IN NORMAL[1]SKTION UP TO 10.5 m					
I	*25*	10	5	30	70
II	*25*	15	10	30	80
III a, b	*15*	25	15	35 - 45	90 - 100
3.2 TUNNELS OF _USEFUL DECK WIDTH IN NORMAL SECTION 14.5 m					
I	25	15	10	45	95
II	25	20	15	45	105
III a, b	15	30	20	55 - 65	120 - 130

The following Table 4 determines the quantities (thickness) of shotcrete that are the maximum to be paid to the Contractor, according to sub-clause 48.3. It is clarified that these quantities are the average for each rockmass class and each type of section.

For the final lining, as mentioned in sub-clause 49.1 of clause 49 of the present T.C.C., the volume of concrete is the real volume at the time of concreting but not beyond the line "B" as determined above.

TABLE 4

MAXIMUM PAYABLE QUANTITIES OF SHOTCRETE

Rock mass Class	Type of Section	Maximum thickness of shotcrete (average) (cm)	
		Useful deck width in normal section up to 10.50 m	Useful deck width in normal section 14.50 m
I	Normal	15	20
I	Enlarged	20	25
II	Normal	20	25
II	Enlarged	25	30
III a, b	Normal	30	35

As "normal section" is defined here the section having the standard deck width, in contrast with 'enlarged sections" that are used in parking areas and other special locations

In the case where all support measures for the corresponding rockmass class have been installed to prevent damages and to reduce deformations, then in these locations, and for the smoothening of the surface where the water-proofing membrane shall be installed, it is allowed after the agreement of the Service to construct an extra layer of shotcrete having a thickness of 5 cm which shall be paid extra.

For the remaining support materials (rock anchors, wire mesh, metal frames, etc.), the required and consequently payable quantities of materials, shall be determined according to the design drawings and the provisions of the corresponding clauses of the present T.C.C. and the Bill of Quantities of the Tender.

Clause 48 : EXCAVATION AND SUPPORT OF UNDERGROUND WORKS

48.0 GENERAL - CONTENTS OF THE PRESENT SPECIFICATION

The present specification covers the following tunneling works using underground excavation:

1. Tunnel excavation (sub-clause 48.1)
2. Removal of products of geological rock-falls (sub-clause 48.2)
3. Shotcrete (sub-clause 48.3)
4. Structural grid St IV (sub-clause 48.4)
5. Galvanised wire mesh (sub-clause 48.5)
6. Metal frame supports made of steel normal sections (sub-clause 48.6)
7. Metal truss supports (sub-clause 48.7)
8. Metal forepoling beams (sub-clause 48.8)
9. Metal support sheets (sub-clause 48.9)
10. Padding of the BUFFLEX type for filling gaps (sub-clause 48.10)
11. General specification for anchors [sub-clause 48.11 (applicable in sub-clauses 48.12 to 48.20)]
12. Simple rock anchors using St III, Φ26 rebars (sub-clause 48.12)
13. Permanent rock anchors Φ26, having a bearing capacity of 200 kN, of the "expandable end" type (sub-clause 48.13)
14. Permanent rock anchors Φ26, of the PERFO type, having a bearing capacity of 200 kN (sub-clause 48.14)
15. Permanent rock anchors Φ26, having a bearing capacity of 200 kN, with resin grout (sub-clause 48.15)
16. Permanent rock anchors, having a bearing capacity of 400 kN (sub-clause 48.16)
17. Permanent rock anchors, having a bearing capacity of 100 kN and 200 kN of the SWELLEX and SUPER SWELLEX type or similar (sub-clause 48.17)
18. Permanent rock anchors Φ32, having a bearing capacity of 300 kN of the SELF DRILLING type (sub-clause 48.18)
19. Annular, fully grouted, high capacity rock anchors (sub-clause 48.19)
20. Prestressed anchors having a bearing capacity of 400 kN (sub-clause 48.20)

21. Drainage and waterproofing of tunnels (sub-clause 48.21)

22. PVC plastic tubes (sub-clause 48.22)

In the following paragraphs, each of the above items is specified, analysed in sub-clauses 48.11 to 48.22.

48.1 TUNNEL EXCAVATION

48.1.1 Object

This work includes the disposal of all the facilities, necessary equipment, materials, manpower and the execution of any relative work concerning the tunnel excavation accordingly to the drawings, Technical Specifications as well as the instructions of the Service. This work includes the scouring of the excavated surface, loading and transportation of all the products to a distance up to 700 m. from the tunnel openings. These products can be used as construction materials, or stored in pre-specified areas for future use, or refused in approved places. This work also includes the disposal of all the necessary equipment, materials, manpower and the execution of every work required for maintaining the headings in a good condition, without waterflows during the excavation and until the Final Acceptance of the Project, as well as the removal of every temporary construction after the completion of the excavation.

48.1.2 General

During the works, as these are described in subclause 47.6 of clause 47 of T.C.C, the Contractor must provide the proper lighting and adequate airing to the underground excavations. In addition, the Contractor must drain the excavated areas by pumping the water, where this is necessary, for ensuring satisfactory working conditions. The Service must approve the succession of the works and the security measurements. Nevertheless, the Contractor will be the only exclusively responsible for the security during the works irrespectively of the approval of these measurements from the Service.

The Contractor shall submit the Program of Construction" and the complete design, that will fully justify the selection of excavation methods, the anticipated equipment, which will be used in combination with the geological conditions in the tunnel area, the working cycles for every type of support, the specification of Clause 47 of T.C.C.. In some limited cases where the rock mass quality is very poor, special excavation methods can be used, for example hand excavation or excavation by other means. In all these cases the Contractor will not be eligible for any additional reimbursement.

Methods, technique and processes, used by the Contractor for all tunnel excavations will result to a completed excavation with smooth perimeter, surrounded by undisturbed rock formations and located between the minimum and the maximum lines of ("A" and 13" Lines - See Clause 47, Paragraph 47.1.3.1 of T.C.C.).

The Contractor shall submit to the Service, for approval, all the detailed elements concerning methods, technique and processes that he intends to use. These element must be submitted at least 3 weeks before the commencement of the excavation of each underground part of the project. The same applies to every case for which he will_ propose the modification of the excavation methods

These elements will include drawings and reports, covering all, the parameters referred in the beginning of this paragraph, as well as other relative important elements that can allow the Service to control the methods proposed by the Contractor. Every such proposal, submitted by the Contractor, must satisfy all the demands of the present specification and the rest of the terms of tender document

The Contractor will not be allowed to commence any excavation work, or to modify the excavation methods, before the Service approves all the proposals concerning the methods, technique, and the excavation processes. This approval does not dispense, by any means, the Contractor from his conditional obligations and does not exclude the application of more conservative methods aiming at the confinement of impulsive waves in the surrounding rock mass and the limitation of the subsidence at the ground surface.
If the Service has the opinion that methods, technique and excavation processes, used by the Contractor for every part of the project are not satisfactory, because they do not agree with the Contractor's proposals, which have been already approved from the Service, or because they have resulted to hyper-excavations, (excavations beyond the determined lines of maximum excavation (pay line B)), or because they create exposures of excavated rock with serious anomalies or rock mass relaxation, then the Contractor, irrespective of the previous approval of these methods from the Service, must adopt those modified methods, technique and processes that are necessary for satisfying the demands of the Technical Specifications.

Excavations will be executed according to lines, inclinations and dimensions, shown in the drawings, approved from the Service, aiming at the minimum possible hyper-excavations beyond these lines. The Service can revise the locations and dimensions of the tunnels and tunnel openings shown in the drawings.

The Contractor must take precautionary measurements during the execution of the works in order rock relaxation beyond the limits of the excavation to be avoided. These limits are shown in the drawings and determined from the Service in Appendix A of the present specification.

Lines "A", determined in Clause 47 of T.C.C. (paragraph 47.1.3.1 and sub-clause 47.16) and in Appendix A of the present specification, are lines inside which no rock will be allowed to project. All materials projecting inside "A' line, except of the support measurements shown in the drawings and for which the Service demands to remain in their positions, will be removed from the Contractor as part of the work described in this sub-clause. All materials that project inside 'A' line can be removed at any time during the construction works, but always before the commencement of concreting of the lining.

Lines 'BTM. determined in clause 47 of T.C.C. (paragraph 47.1.3.1 and sub-clause 47.16) and in Appendix A of the present Specification,, are the outer (theoretically) limits of the excavation. Excavation beyond these lines is characterized as hyper-excavation. For hyper-excavations no additional reimbursement will be defrayed.

It is possible, the nature of the excavated rock, to necessitate the change of the distance between "A" line, or the final line Of the excavation, and the final inner surface of the lining. Nevertheless, the Service must determine any of these changes. In this case the position of "B" line will change, such as the relative distance between "A" lines and "B" lines to be the same as it was before the change. If these are the adopted changes, then the Contractor will not be eligible for additional reimbursement, except of this for the additional amount of excavations at the new pay lines. The aforementioned additional excavation, resulted from the enlargement of the cross-section, is executed after the completion of the excavation in its predetermined dimensions. This additional excavation will be paid according to the relative values of the Price-list.

Placing of new, or replacing of existed metal frame supports made of section steel, as well as placing or replacing of other approved steel elements, resulted from the enlargement of the tunnel cross-section, after the agreed shift of 'A' and 13" lines, will be paid according to the effective conditional unit prices concerning the placement of steel frame supports. No additional payment, is anticipated for the removal of the aforementioned steel frame supports from their original places.

Wherever, due to foundation conditions, the use of steel frame supports or other approved elements from channel steel has to be expanded and an additional excavation is necessary, this excavation will be reimbursed according to the corresponding conditional items concerning the tunnel excavation. The installation of supporting measures must agree with the demands of the relative clauses and subclauses of the Specifications of T.C.C.

During the execution of the works, the Contractor must take all the necessary measurements to avoid any relaxation of the rock mass beyond 'B" lines. All drilling and excavation works must be executed carefully in order hyper-excavations, disturbance of the rock mass beyond 13" lines and progressive relaxation of the surrounding rock to be avoided. Any damage of the structures, including relaxation or removal of the steel frame supports, as well as any damage of any other part of the project due to excavation or due to other Contractor's works will be restored immediately by the Contractor, at his expenses, with a way approved from the Service.

In any case, the rock mass at the bottom of the tunnels must be protected from relaxation. Any relaxed or soft rock at the bottom must be removed immediately and replaced with concrete. In areas with groundwater, the relaxed or soft rock will be replaced with a well-graded filter after the Service's approval. The damages on the floor, caused by the circulation of the drilling equipment, machinery and the flow of waters must be restored at the Contractor's expenses. The Contractor is obliged to maintain the floor with sandy gravel or by executing another work.

For rock formations, which are extremely sensitive to water, the Service may demand the execution of drilling without water and proper airing measurements.

The real cross-sections of all underground excavations will be plotted and designed by the Contractor, at his expenses, at locations and distances determined from the Service. The real lines of the excavated cross-section will be plotted and, designed accurately in relation to "A" and 'V lines shown in the drawings of the approved design. The plotting and the drawing must be done with photographic or electronic measuring equipment, devices and methods that have the Service's approval.

In a case, where irrespective of any reason, the dimensions of the tunnel sections are such as the resulted thickness of the concrete is smaller than the corresponding minimum, statically demanded thickness, shown in the drawings, the Contractor must proceed, at his expenses, to the necessary restorations of the cross-section. These restorations include the removal of frames, partly or completely, the removal of shotcrete, etc., for ensuring the requisite concrete thickness. The Contractor will also proceed, at his expenses, to the reinstallation of all precautionary measurements, destroyed during the restoration works of the tunnel cross-section.

The Contractor will be exclusively responsible for the secure support of the underground structures, having as basis the supporting measurements of the approved study and the construction methods, chosen by him.

The Contractor must take the necessary measurements to stop and drain the surficial waterflows at the tunnel openings, when the opening works stop for a period longer than the period of one shift, or for the personnel's holidays, or for any other reason.

48.1.3 Use of Explosives - Protection of Present Works and Passers-by

Only capable and well-trained personnel, employed by the Contractor, will be allowed to execute excavations, by using blasting techniques, under the supervision of experienced technicians and only if the approved and according to the terms in effect security measurements have been taken. These measurements are for the protection of people, structures and State or private property. All blasting works, irrespective of their previous approval from the Service, are controlled, by a portable accelerometer, at the Contractor's expenses, according to the Service's guidelines.

The Contractor should submit, on time, his proposals or the modifications of his proposals, concerning the execution of every blasting work, in order to take the Service's approval. The Service's approval for the technique and the blasting methods does not dispense the Contractor from his responsibility to execute the whole work according to the present specification.

Blasting close to existed or completed concrete structures will be controlled in such a way as the velocity of concrete vibrations not exceeding 100mm/sec. In cases where blasting are executed close to fresh concrete, the limits of the maximum allowed velocity of vibrations are as follows:

- Up to 5 hours after concreting, no limit is applied.
- After 5 hours from concreting and until concrete acquires 25% of its strength in compression (2 days approximately) ppy=25mm/sec.

- Until concrete acquires 50% of its strength in compression(4 days approximately), ppy=50mm/sec.
- Until concrete acquires 80% of its strength, in -compression ppy=70mm/sec.

Blasting methods will being modified after observations, or on the basis of results of vibration measurements, in order the disturbances in the surrounding rock mass and in areas adjacent to the project to be limited, if this is judged as necessary.
Any damages, caused to the project or to any state or private property, by blasting will be restored at the Contractor's expenses.

Even if the tunnel opening is being executed with slower time steps, or in more than one phase, due to use of charges, lighter than those originally anticipated, then the Contractor is obliged to execute the work without any other reimbursement, except of this, concluded from the present Clause.

In the case of necessity, the Contractor must execute the blasting works with a way that results to the minimization of hype-excavations, the regularity of the excavation shape, the non-disturbance of the soil mass (possible disturbance cause instability phenomena), and to the non-breaking of the rock mass. This rock mass forms the base on which the concrete will be placed. Additionally, the execution of blasting must not cause any damages to the existed structures.

If the Service's opinion is that blasting may damage the rock mass, on which the structures will be founded, or disturb existed structures, or create extended hyper-excavations, or influence the stability of soil, then the Service can order the Contractor to change the diameter, or length of borings, modify the firing times of explosive charges, use lighter explosive charge, apply methods of controlled blasting, or even to stop the use of explosives and complete the excavation by line drilling, or by using wedges or other suitable means,. In these cases the Contractor's reimbursement, resulting from the rock mass categories, is not modified.

48.1.4 Controlled Peripheral Blasting

48.1.4.1 General

Methods of controlled peripheral blasting will be executed wherever the Service will approve and demand. The details of these methods and the relative means, which will be used, must have the prior approval of the Service. The Service may demand the execution of a test blasting in order to choose the best process.

48.1.4.2 Final After-cutting, Smooth Blasting, Presplitting

For the final after-cutting and the smooth blasting, the diameter of borings will be between 51 and 89 mm. For the presplitting the diameter of borings will be between 51 and 101 mm. The final chosen diameter must have the approval of the Service.

The divergence of each category of borings, (for the final after-cutting, smooth blasting and the presplitting), from the corresponding approved surface of the-final after-cutting, smooth blasting and the presplitting, will not exceed 15cm, at the level of their bottom.

The distance and the length of borings for the final after-cutting, smooth blasting and the presplitting must be -approved from the Service.

Borings of the final after-cutting, smooth blasting and the presplitting will be charged with cartridges, connected to an instant fuse. The distance and the types of cartridges, filling, plugging and other details concerning the charging and the firing, will be results of a test blasting. All the aforementioned elements must have the approval of the Service. The borings of the smooth blasting will be fired by electric detonators not at the same time with the main blasting, but with a proper delay. In some cases the rock conditions impose some of the holes for the smooth blasting not to be charged.

The borings of the final after-cutting will be fired one after the other, in order shear forces along the periphery of the blasting to be created. Presplitting will be used after the Service's approval in areas, where the tunnel covering is enough and not smaller than 15 m.

48.1.4.3 Line drilling

Line drilling will be used only in areas that will be indicated especially for this reason. Additionally, these areas will have the approval of the Service.

The diameters of the borings will be between 46 to 76 mm. These borings will not be charged, and the distances among them will be short enough in order the rock mass to segregate along a surface of a sound rock, in front of the line of the borings, after the main blasting. Crowbars or wedges may be used.

The Service must approve the diameter and the length of borings, used for the line drilling, as well as the distances among them.

48.1.5 Rock mass Classification

Underground excavations, surrounded from "B" lines, in a tunnel with ordinary or expanded cross-section, are classified into 3 categories (I, II, IIIa, IIIb), according to the criteria and processes mentioned in Appendix A of the present Specification. Each one of these categories anticipates different thickness do (distance between "A" and "13- lines) and different supporting measurements. It is noted, that every individual parameter, used for the rock mass classification, does not constitute an exclusive, determinative criterion. It is also noted, that the category III (a & b), the most adverse of all, includes soil of the poorest quality, which can be found. Consequently the Contractor is not eligible for asking additional reimbursement, due to the quality of rock in excess of the amount anticipated by the present clause.

The later installation of supporting measurements, in addition to those anticipated for the support of every rock mass category, in a specific part of the tunnel does not consist a serious reason to revise the rock mass category in this part.

48.1.6 Excavation for Concrete Spreading

All rock surfaces, which will be covered with concrete, must have been excavated in the dimensions,- anticipated from the drawings, or as the Service will determine. Rock ledges, inside the external lines of structures, shown in the drawings, will not be allowed to exist. Any sharp ledge or any overhanging rock piece, which may cause cracking to concrete, will be removed, according to the Service's instructions.

Special attention will be given to the finishing of the excavation on the tunnel floor, where water will outflow.

In areas, where excavations for rock foundations extend beyond the lines shown in the approved drawings or those determined by the Service (hyper-excavations), the hyper-excavations must be filled with concrete of the same quality with this, which is used in the superstructure. The same process applies to hyper-excavations, executed by the Contractor, in rock, already damaged by blasting or other works. The expenses for such an additional and the materials , will bear the Contractor.

48.1.7 Use - Refusal of Excavation Products

The most appropriate products of the underground excavations can be used for the construction of permanent structures.

In any possible case, materials, appropriate for construction use, must be separated from materials, which are going to be refused. During the excavation, the appropriate products will be chosen in loads and disposed either at determined, definite locations or in temporary dumping areas, from where they will be transported to the determined definite locations, mentioned previously. The disposal in temporary dumping areas, the oblique transportations, the reloading and any other relative work will be executed by the Contractor without additional reimbursement.

All other excavation products, not used in permanent structures, must be refused in areas shown in the drawings, or in areas that the Service will propose and indicate. If the Service approves, then these materials can be used in temporary landfills.

Dumping areas will occupy places that are not parts of the sites, where the works are in progress. The depositions of these materials will form stable and uniform slopes, having an elegant appearance and will be flattened, smoothed, shaped and drained for avoiding their erosion and the accumulation of water. In dumping areas, inappropriate excavation materials, will be spread layer by layer unless the special terms of Tender Document (S.C.C. etc.) specify differently. The thickness of these layers, without any further compaction except of this caused by transportation equipment and spreaders will not exceed 1.5 m.

48.1.8 Site recording of Underground Excavations

The Contractor will keep accurate elements for all the underground excavations. These elements will be complete in order to allow, locations and the limits of every advance to be accurately drawn, in plane and in cross-section. The drawings must be presented in the general recording report.

At the end of every shift, the Contractor will give the Service two (2) copies of the excavation elements recorded during this shift. These elements will be written in forms, having the Service's approval, and will be signed by the representatives of both the Contractor and the Service. At the end of every shift, both representatives will control the elements in the relative forms and certify that these elements are not in conflict with the ones recorded in the previous shift.

Without limiting the generality of all mentioned before, the reports of every shift will include the following data:

a. The kilometric position of the heading at the commencement and at the completion of every advance, as well as the position and the direction of the side or sides of the advance, relative to the tunnel axis or to any other proper reference line, in the case that this advance is executed until the final lines of the excavation.

b. The layout of drillings, which will include the number, locations, sizes and the length of the holes, in the case of excavation by blasting.

c. The type and the quantity of the explosives ,used in every advance, the type, location and the firing succession of the detonators, as well as the time of blasting, in the case of excavation by blasting.

d. The number, length, location and the type of metal frame supports, lattice girders and rock bolts which have been placed after the installation of every rock bolt. The performed tests in rock bolts, the location, length and the indicative number of the placed steel girders and metal grid, as well as all data concerning the used shotcrete.

e. The number and the specialities of the workers, as well as, the number and the categories of the used equipment.

f. The time of commencement and completion of all the working cycles, namely the transportation and installation of the excavators, the installation of the airing system, the scouring, the placement of rock supporting measurements, the collection of the excavation products. The period of waiting, before the commencement of every work and the period for which the work was interrupted due to any reason.

g. Unusual incidents, which will include indicatively and not restrictively, rock falls, unstable or relaxed rock and water or gas inflows.

In addition to the aforementioned elements, the Contractor will plot the cross-sections of the excavations, at fixed intervals, for evaluating the excavation processes and determining geometrically all the rock ledges, inside "AN lines which must be removed. The plotting of the cross-sections will also help to compare the excavation lines, shown in the drawings, with the actual excavation lines after scouring.

During the first stages of the work these cross-sections will be taken perpendicular to the tunnel axis. and at distances that will not exceed 3m., or the length of every advance, or a length approved by the Service.

The works concerning the in situ plotting of the cross-section of the excavation, for every advance, must be executed immediately after scouring, if this is practically possible. Diagrams of cross-sections, in a form acceptable from the Service, will be drawn, by the Contractor, the next day after the in situ plotting. Copies of these diagrams will be submitted to the Service in: a period of two (2) working days following the completion of the in situ plotting.

If the Contractor is unable to keep the aforementioned elements, then this will be a sufficient reason for the Service not to approve any payment or any Certification, which will include sums relative to the tunnel opening, or to proceed to a temporary retrenchment of the Contractor's reimbursement concerning the tunnel opening, until the drafting and the submission of the elements.

48.1.9 Geological

The Contractor must take account that he ought to map all the rock surfaces of the underground excavations, with the exception of those at the bottom of the tunnel. For this purpose, the Contractor will clean all the rock surfaces, exposed since the previous geological mapping, at time intervals determined by the Service and in a way that will satisfy the Service. Additionally, the Contractor will put plates, every 50m., showing the kilometric position of tunnel cross-sections.

The Service may demand from the Contractor to clean all the excavated surfaces and bring the airing and lighting systems into operation on Saturdays, Sundays, in a holiday period, at night times etc., without additional reimbursement, in order the Service's personnel to perform the geological mapping.

The Contractor will help in the geological mapping by providing all the means, and equipment, which may be demanded from the Service, and by securing the access to the excavated rock surfaces.

48.1.10 Accounting – Payment

48.1.10.1 Tunnel Excavation

This item will be accounted per cubic meter of the excavated material along a straight line or a curve inside "B" line, named "Pay Line" for this reason. In the present clause and for accounting reasons, the beginning (and the end) of the tunnel will be considered as the points where the tunnel cross-section is complete, inside the natural (autochthonous) soil and consequently supporting measurements are necessary.

The Contractor is eligible for the reimbursement concerning the cubic meters of rock inside "B" lines, even if the actual excavation , locally or in average, is smaller or bigger than this. The Contractor must have executed the excavation at least until "A" line (Line of Minimum Excavation).

It is emphasized that any additional work (tunnel excavation), which may facilitate the Contractor will not be reimbursed.

Line "B" is determined in sub clause 47.16 of clause 47 of T.C.C. for any soil category [I, II, III (a, b)) and every type of cross-section (regular or enlarged). It is noted that "A" and "B" lines coincide on the tunnel floor. This means that the Contractor will not be reimbursed for any excavation beyond "A" line.

Sub-clause 47.16 of clause 47 of the T.C.C. includes all information concerning the classification of rock at the tunnel site into categories. (criteria, processes, etc.).

The Contractor's reimbursement differs according to the category of every part of the tunnel. It is clarified that every cross-section of the tunnel will be classified into a category as whole. The classification of different parts of the tunnel cross-sections into different categories, is not allowed.

The Contractor's reimbursement for the tunnel excavation includes every work concerning the loading, transportation, and the refusal of all the excavation products in a place locating up to 700m. from the tunnel openings. The aforementioned reimbursement also includes all the security measurements, which the Contractor ought to provide according to the relative clause of S.C.C. and the present Technical Specifications. Repairing works or restoration works or compensations, which will be demanded due to the non-implementation from the Contractor of the anticipated security measurements, or due to any other reason, will burden the Contractor. In the case that the Contractor will not have complied with the obligation to apply security measurements, then he will be charged extra for all the works, that the Service will perform in order to meet this demand.

48.1.10.2 Controlled Peripheral Blasting

The payment of the controlled peripheral blasting, namely smooth blasting, the final after-cutting, the presplitting and the line drilling will be based on the accounting of the actual length of borings (in meters), as this will be approved and ordered by the Service.

If an executed controlled peripheral blasting has not the previous approval of the Service, then this will not be accounted for payment.

48.2 REMOVAL OF PRODUCTS OF GEOLOGICAL ROCK-FALLS

48.2.1 Object

This sub-clause specifies the reimbursement for loading, transporting and refusing the products of landfalls occurred at the tunnel site and caused by geological reasons exclusively. The transportation distance from the tunnel openings must be 700m.

48.2.2 Specification

The previous sub clause 48.1 of the present specification, concerning the tunnel excavation is in effect. The same applies for the combination of S.T.S. X1 and the relative specifications for earthworks in road works (clause 2 of T.C.C), or in railway works (clause 2 of T.C.C).

48.2.3 Accounting - Payment

The drafting of a relevant protocol is necessary for the payment and the accounting of all the aforementioned quantities. Causes and factors, caused the landfall, will be presented in this protocol. The location and the exact dimensions of the landfall will be presented and its volume will be calculated in the protocol. The Accounting and the payment are related to the volume of the geological landfall products. These products are beyond "B" line, determined in clause 47 of T.C.C. (paragraph 47.1.3.1) and in Appendix 'A" of the present specification.

48.3 SHOTCRETE

48.3.1 Object

The present sub clause describes the work that includes the disposal of necessary work-force, materials, proper equipment and the performance of every relevant work needed for producing shotcrete and also spreading it, according to the Supervision's guidelines, on structures, located inside the tunnel and shown in the drawings. (The relevant work concerning the use of shotcrete in field works is covered by clause 42 of T.C.C)

48.3.2 Definitions

Shotcrete is the concrete that is spread on a surface by shooting from a blowpipe. Thus, it forms a concrete layer on the surface in question.

Rebound of shotcrete is the phenomenon, in which part of the shot materials are bounded reflected on the spreading surface and finally not embodied in the concrete layer, formed on the aforementioned surface.

48.3.3 General

The methods and the execution of the shotcrete spreading will agree with the best, up-to-date practice and with all the determined in the present sub-clause 48.3.

Shotcrete will be spread on positions and structures, shown in the drawings. The extent of the shotcrete spreading, the thicknesses of the spread layers and the times of spreading are specified in the present document, or indicated by the Supervision, according to the local conditions.

In general, the decision to use shotcrete will be taken from the Supervision after the removal of the relaxed pieces from rock surfaces that will be revealed after the excavation. Nevertheless, the Contractor may demand to restart the shotcrete spreading in areas and positions, any time after the excavation, according to the Supervision's instructions.

48.3.4 Materials

Shotcrete will consist of cement, Fine and coarse aggregates, water and approved admixtures, as the present document determines.

Cement, water, aggregates and admixtures will cover the demands of paragraph 48.3.5 of the present sub clause.

Fine and coarse aggregates must have gradings inside the limits referred in the following table, unless the Supervision approves something different. All the demands of clause 6 of T.C.C. (Concrete) will also apply to the aggregates of shotcrete.

TABLE
GRADING OF SHOTCRETE AGGREGATES

Sieve size American Standards Square Aperture	Fine Aggregates	Coarse Aggregates	
		No.8 - 3/8"	Size No.4 - 3/4"
2	-	-	100
3/4	-	-	90 - 100
1/2	-	100	-
3/8	100	85 - 100	20 - 55
No. 4	95 - 100	10 - 30	0-10
No.8	80 - 100	0-10	0 - 5
No. 16	50 - 85	0 - 5	-
No. 30	25 - 60	-	-
No. 50	10 - 30	-	-
No. 100	2 - 10	-	-

The quantity of water of the aggregates, at the time of their embodiment in the mixture will be less than 5% of the aggregates' weight after their drying in oven.

The air used in shotcrete will be clean and without oil.

An easily congealed admixture of an approved type, will be embodied in shotcrete

The Contractor can use various admixtures that will have the Service's approval and will satisfy the demands of Specification ASTM C-494.

48.3.5 Composition of Shotcrete

The category of shotcrete, which will be used at every particular position of the works, will be determined by the Service. The demanded proportions of the mixture of cement, aggregates and proper admixtures, for every category will be proposed from the Contractor (mixture design) and the Service will approve them. The proportions will result from the recommendations of ACI 214. Thus, the specified, in the following table, rupture strengths can be achieved.

Shotcrete Class	Grading of Aggregates	Minimum rupture strength(kg/cm2)	
		8 hours	28 days
1	3/4 inches - No.4 (Coarse)	40	285
2	3/8 inches - No.8 (Coarse)	49	285
3	Only Fine Aggregates	40	285

The above strength values correspond to cubic specimens of 20x20x20 cm and in the case of testing specimens with different dimensions, the proper conversions must be made.

The minimum rupture strengths will be estimated from tests on cubic specimens, according to paragraph 48.3.6 of the present sub clause.

Mixtures of shotcrete will not be used in the works unless they have the Service's approval. The proportions of mixtures will be modified, according to the Service's directions, for limiting at the minimum the rebound phenomenon, according paragraph 48.3.12 of the present sub clause.

The minimum-rupture strength of 40 Kg/cm2, after 8 hours, is a basic property of the shotcrete admixtures, which will be used immediately in order the support and the protection of the underground structures to be achieved according to the Service's directions.

The Contractor shall inform the Supervision for the modifications in the mixtures.

48.3.6 Quality Assurance Tests of Shotcrete

For the approval of mixture's composition, the Contractor will prepare no less than 3 testing panels for every mixture. These panels will be used for the conduction of series of tests from the Service. The Service will perform the tests at least 40 days before the commencement of any concreting, or before an admixture will be approved by the Service. The Service will also perform tests, when the use of a new equipment is proposed and whenever the produced shotcrete does not fulfil the present Technical Specifications, according to the Service's opinion.

For performing the usual quality control, the number of necessary panels will be in general 3 per 100m3 of concrete, which is ready for spreading.

Each one of the series of 3 panels is used for the approval of shotcrete's composition and for the usual control test. The 3 panels will come from a shot downwards on a horizontal surface, a shot on an inclined surface and a shot upwards on a horizontal surface too.
For the usual quality control of shotcrete and for the determination of the admixtures' suitability, testing panels will be constructed as the present clause determines and according to the Service's directions.

The Contractor will dispose the necessary installations, equipment, materials, and the necessary help and he will conduct all the work in a manner of constructing representative panels for the shotcrete testing.

Testing panels will be constructed in a wooden or metal square frame, having a side of lm., height of 10cm, side thickness of 2cm and a rigid base. The aforementioned panels must have the Service's approval. The frame will be securely fixed, either on a rock surface, having similar inclination to the one on which the shotcrete will be placed, or on another approved surface. At the same time with the watering of the frame, shotcrete is being spread on the area surrounded by the frame, according to the way, described in the present clause. The same mixture and spreading equipment must be used both in the described process and in the works.

All the panels will have a minimum thickness of 10cm. and will be constructed in the presence of the Supervision. The panels will be left undisturbed at the spreading location, until the final concrete setting.

Testing panels and specimens will be transported by the Contractor to the Laboratory of the worksite, immediately after the final setting, avoiding to cause any damage.

The Supervision will determine the rupture strength of shotcrete by testing either 8 cubes, having side of 8cm, detached from the panels by sawing according to specification ASTM C-192, or 8 cylinders with diameter of 10 cm, detached by coring.

At the receiving of cores, the reinforcement, where exists, must be avoided. The specimens must not be received from positions, which are at a distance, from the panel edges, shorter than 10cm. The specimens will be stored, the edges of the specimens will be covered and the tests will be performed according to the specification ASTM C-192.

The specimens will be ruptured as follows:

- Two (2) specimens, after 8 hours (if the Service demands)
- One (1) specimen after 3 days
- Two (2) specimens after 7 days
- Three (3) specimens after 28 days.

If the Service will demand to control the already spread shotcrete, then two series of specimens, having diameter of 10cm, will be taken from specific positions and ruptured after 28 days, similarly to the specimens of the testing panels. The holes, after the withdrawal of cores, will be hand filled with proper materials having a composition similar to the shotcrete's

The results of tests on cubes will be analyzed statistically, according to specification ACI 214. The demand for adequate strength in compression will be satisfied when:

a. No more than one in five strength tests gives values which are smaller than the value of the specified rupture strength, with the deviation coefficient being 15%, for tests conducted for approving the design of the composition, and 20% for the quality control tests.

b. For every series of 6 successive tests, the frequency, that the mean rupture strength appears to having a value smaller than the one already determined, does not exceed 1%.

If tests, performed by the Service, show that shotcrete does not correspond to the specified demands, then the Contractor will take the proper measurements following the Service's demands. These measurements will be the stoppage of shooting the shotcrete, with the unsatisfactory composition, a series of compositional tests, for proving that the new, proposed composition is acceptable, in-situ receiving of cylindrical specimens, with diameter of 10cm, from the Contractor, for performing tests etc.

If the conclusion from the tests is that the shotcrete quality, in any part, does not ,meet the specified demands, then the Contractor is obliged to take, at his expenses, measurements, decided by the Service. These measurements are as follows:

a. Enforcing the surface, which have been already spread, with new shotcrete, or other materials (e.g. nailing), in quantities determined by the Service.

b. Deposition and reconstruction of shotcrete, if the enforcing is not possible due to 'A" line or due to large deviations.

c. For small deviations, the acceptance of the structure is possible after the imposition of a retrenchment to the Contractor's reimbursement. In this case, the Contractor is obliged to draft, at his expenses, a static design, which can prove the adequacy of the tunnel supporting. The acceptance of the design, from the Service, does not dispense the Contractor from his responsibilities in the case of a future failure.

If the Contractor asks to re-check the shotcrete quality, then he is obliged to dispose, at his expenses, means and personnel for receiving and preparing cylindrical specimens from the spread concrete and also pay for the specimen's control in an official laboratory.

48.3.7 Equipment

The Contractor will inform the Service about the constructors and the types of shotcrete machinery, that he intends to use in combination with all the rest equipment being necessary for the execution of shotcreting. This must be done before the dispatching of the equipment to the Worksite.
All the equipment will have the Service's approval. The use of equipment for dry or wet mixture is possible. All the equipment necessary for preparing, mixing and spreading the shotcrete will be kept clean and in good operational condition, for the whole period of the construction work. The equipment for the preparation and the mixture will correspond to the demands of the present Specification.

The shotcrete spreading machine will have adequate spreading capacity, for achieving minimum delays during tunnel excavation and other construction works in the tunnel. The equipment will be such as the admixtures can be mixed satisfactory and immediately before spreading.

The Contractor will care for supplying the machine with air and water, in adequate quantities, as this is described by the equipment's constructor and according to the Service's instructions. If according to the Service's opinion the operation of the shotcrete spreading machine is unsatisfactory, then the Contractor must proceed to all the necessary repairs or replace the equipment. The Service may order the interruption of the concrete shooting, until the Contractor complies finally with the Service's directions.

In areas, where excavations are in progress, the Contractor will care for providing adequate equipment for the shotcrete spreading on every slope of the excavations, as this is determined in the present document.

48.3.8 Specialty of Handlers

Handlers of the blow-pipes will possess previous experience in spreading shotcrete with coarse aggregates, or work under the supervision of overseers or instructors who have such an experience. Every working group will proceed, after the- Service's demand, to a demonstration of its accepted capabilities in shooting the shotcrete towards vertical and overlaid testing panels, before the commencement of the production work.

Accepted shotcrete will be composed of thick, homogeneous concrete, without large enclosed rebound materials and obvious adhesion points between the layers.

Handlers of the blow-pipes will shoot concrete, having homogeneous cohesion and the maximum possible moisture quantity, before the layer starts separating from the rock surface beneath. The blow-pipe will be kept in such a position as the flowing material will be hitting the surface at a right angle from the minimum possible distance. The distance between the blow-pipe and the surface, under shooting, will be such as the maximum possible compaction and homogeneity of the spread concrete will be achieved. The distance will not be longer than 1.5m. and shorter than 0.5m, unless the relative test will show differently, or the constructor of the equipment specifies differently.

The complete work must be clear of enclosed rebound materials or pockets of aggregates. This document determines that rebound materials will be detached and refused.

48.3.9 Shotcrete under Cold Weather Conditions

If the air temperature is below 0 degrees Celsius (C), then shotcrete will not be spread. in case that the air temperatures are below 00 C, the Contractor will take all the necessary precautionary measurements in order to keep the spread shotcrete in a temperature above 00 C for a minimum period of 5 days, after its spreading.

48.3.10 Preparation of Spreading Surface

The preparation of surfaces, which are going to be spread with shotcrete and have resulted from excavation, will include the removal of loose materials, according to the Service's guidelines. The joints will be cleared from fine materials, up to depth, determined by the Service. The cleaned joints will be filled with shotcrete. Successively, all the surfaces will be washed with clean water. During the period of the shotcrete spreading, all surfaces will be wet, clean and without rebound materials.

After the first setting of the first shotcrete layer on the surfaces, under spreading, these surfaces will be cleaned completely with air and pressurized water, or other means, which have the Service's approval. So, all tracks of dirt, mud, fragments, oil, loose pieces, rebound materials, surficial concrete pourings, and every other noxious material will be detached. The shooting of the next shotcrete layer will follow the aforementioned process of cleaning. The surfaces, will be kept wet until the next spreading of the shotcrete.

Where water outflows from a rock surface, on which shotcrete will be spread, and this flow can be controlled by sealing with shotcrete only, then the water will be taken away from this area by deviating it via collector pipes or other approved piping system or by blocking. This work is necessary for protecting the shotcrete from hydrostatic pressures or corrosive effects die to water seeping.

Anytime -during the preparation of a rock surface, the Service can order the Contractor to spread shotcrete on limited areas of this surface, before he completes the preparation of the surface for the shotcrete spreading.

48.3.11 Mixture and Spreading

48.3.11.1 Mixture

The components of shotcrete will be weighted accurately, before their mixing. In the case of dry mixing, aggregates will be mixed completely, without water, before their deposition on the spreading equipment. In the case of wet mixing, aggregates will be mixed according to the Service's approval.

Cement will be added not earlier than 1 hour before spreading. Mixtures not being spread in 1 hour after adding cement will be rejected.

The quantity of an admixture of quick setting, will be weighted accurately In order its determined analogy to meet the design of the shotcrete composition Admixtures will be added in proper times, before the shotcrete spreading.

48.3.11.2 Spreading

The category of shotcrete will have been determined by the Service. Shotcrete will not be spread, on every surface, without the Service's approval. The time of shotcrete spreading, as this will be determined by the Service, in relation with every cycle of advance of the tunnel excavation, will depend on the conditions of revealed rock. The Contractor will inform the Service, on time, about surfaces, which need immediate spreading with shotcrete. Additionally, the contractor will be ready to execute all the necessary works, having the Service's approval, without delay.

The Service will examine the rock surfaces, immediately after opening or blasting and the removal of loose pieces. The Service may order the Contractor to proceed to the immediate covering of the surfaces with shotcrete. So, the shotcrete spreading can be executed not later than 4 hours, after opening or blasting and earlier than the time of drilling for the next excavation cycle. In areas, where very poor rock conditions are expected, the Service may demand the equipment for the shotcrete production and spreading be available before opening or blasting. This will create conditions that can make possible the shotcrete spreading with the minimum delay.

Any existing reinforcing elements will be covered completely with shotcrete. The minimum covering 15mm from the rock surface and 25mm from the final surface of shotcrete. Special care will be taken, during spreading, in order no voids to remain behind the wires of the reinforcement.

The Contractor will develop processes and works, which will satisfy the Service, for ensuring:

a. Minimum rebound.

b. Avoidance to create nets of rebound materials inside the finished concrete.

The smoothing of the final surface of shotcrete, for the secure placement of water-tight material (geotextiles, membrane) according to the demands ofsub clause 48.21 of present clause 48, referred to water-tightness. The Contractor is obliged to use a layer of fine aggregates (0.6mm) exclusively,for fulfilling the demand of water-tightness.

c. Avoidance to create cavities inside shotcrete.

d. Minimum number of cracks, due to shrinkage of the set concrete.

e. Good adhesion of shotcrete with rock surface or any other surface.

f. Quality of shotcrete with the maximum possible resistance to frost.

The material flow from a blow-pipe will be continuous and uniform, and the material rate of spreading on every surface will be also uniform. Excessive loose materials, sandy nests, wet areas or other imperfections will be removed and restored according to those specified in the present clause.

At the commencement of the shotcrete shooting, in every area, the Contractor, in close collaboration with the Service, will determine processes of shotcrete shooting, as part of the initial spreading process, which will ensure the excellent quality of the produced material with the minimum losses due to rebound. The determination of these processes will include small modifications in mixtures, if this will be demanded, determination of accepted surface formations, layers thickness and determination of quantities, per unit area of the rock surface or per unit length of the tunnel, which will be shot from the blow-pipe, as the Service demands.

The quantities of shotcrete, shot from a blow-pipe will be determined either on the basis of the mean thickness of shotcrete, shown in the drawings, or after the exact measurement of rebound, if this is the demand of the Service. Provided that the processes of shotcrete spreading have been established, next works will be conducted accordingly.

When the Service demands to control the thickness of a shotcrete layer, in every area, this can be done by penetrating the layer with a bar, immediately after the completion of the shotcrete spreading, or by putting nails of known length inside the rock mass, before shooting starts. Alternatively, any other means, approved from the Service, can be used, such as the receipt of sections, or cores on the basis of grid, before and after spreading.

Shotcrete will be spread in different layers and every layer will be structured with different runs of the blow-pipe on the working surface, forming, so, a continuous work. If , for some reason, the flow, from the blow-pipe, is not continuous, then the handler will take the blow--pipe away from the working surface, until the flow becomes continuous again.

The distance between the blow-pipe and the working surface will vary between 0.5m and 1.5m. The blow-pipe will be kept at a right angle to the spreading surface. In case of the shotcrete spreading on the surface having grid, the blowpipe will be kept closer to the surface and at small angle to the perpendicular of the surface. Thus, the embodiment of the grid and the removal of rebound materials become easier.

If the total thickness of shotcrete is more than 8 cm, then the grid will be placed in the middle of the layer and anchored in the previous layer by small anchorage, suitable for the grid stabilization.

In case of the shotcrete shooting towards vertical surfaces, or towards largely inclined surfaces, with the exception of the tunnel's dome, the shooting will start from the lowest point and the shotcrete layer will be structured in horizontal sub-layers, from bottom towards top, until the complete surface will be covered. Where the Service demands, the edges of the spread with concrete areas, on which no additional shotcrete is going to be shot, will be formed as to shape clear regular lines, inclined at 45o to the adjoining surfaces, according to the Service's demands. This formation is executed, after the Service's approval.

Where draining holes have been drilled and instruments have been installed inside the rock mass, on which shotcrete will be spread, the Contractor will take all the necessary precautionary measurements to avoid blocking the holes in question, or damaging the instruments.

If shotcrete will start be shooting close to existed structures, then the Contractor is responsible for not damaging the structures. Additionally, he will protect the surfaces of the structures by covering them before the shooting of concrete starts.

In areas where groundwater outflows from joints or spouts and as a consequence affects the works, the Contractor will install leakage piping and seal the continuous joints before the shotcrete spreading.

The appearance of wet spots in areas where shotcrete has already been spread and set will oblige the Contractor to drill shallow holes, for relieving the water pressures.

In areas, covered by shotcrete with problems of bad compaction, or loss of adhesion, or problems of segregation (dry areas), voiding, sandy pockets, or problems of inadequate strength in compression, the shotcrete will be removed immediately and new shotcrete will be shot to an area of 0.30x0.30m, at least, with the Service's approval.

The maximum thickness of every shotcrete layer, continuously spread, will not exceed 8 cm. If a thicker layer is necessary, then this can be achieved by spreading successive layers. Each one of the layers will have thickness, which will not exceed 8cm. Every layer will be shot only if the previous one has set. The thickness of shotcrete, shown in the drawings, for every type of support, is the mean thickness.

48.3.12 Rebound

Rebound materials will be detached and removed, according to the Service's instructions, before the shooting of shotcrete to anyone of the adjoining surfaces. Rebound materials will be refused in damping areas and covered with excavation products. The covering will have a minimum thickness of 1m., according the requirements. Rebound materials will not be reused.

The Contractor has the obligation to show special concern for the rebound materials not to be accumulated at the joins between the walls and the floors.

The Contractor will make every effort to limit the rebound phenomenon as much as possible. If according to the Service, rebound is excessive, then the Contractor may be asked to change the composition of mixtures, or reassess the way of shooting, or take measurements, which the Service considers necessary for reducing the rebound phenomenon in reasonable limits.

48.3.13 Construction Joints

Construction joints and joints due to the stoppage of works will be shaped according to the Service's demands and approvals. They will have an inclination of 45o to the adjoining shotcrete surfaces with clear regular edge. The inclined part and shotcrete, being anticipated for covering the adjacent surface, will undergo the preparation, determined in paragraph 48.3.10, before the shotcrete spreading on the adjacent surface.

48.3.14 Repairing

Before spreading the next shotcrete layer, the previous layer will be checked for voids, in a way which satisfies the Service.

The Contractor will proceed, at his expenses, to the repair of every area with voids, sandy pockets, joints or detachments. In any other area, where the Service's opinion is that the already shot. concrete is of bad quality, the Contractor will proceed to its removal up to the rock surface, or the surface of the next shotcrete layer beneath. The Contractor's next step is the preparation of the revealed surface and the repetition of concrete shooting in this area, with a way which will satisfy the Service.

48.3.15 Maintenance

When the first dry spots make their appearance on the surface of a shotcrete layer, this surface will be kept wet by watering, at least once every 4 hours or maintained differently but satisfactory for the Service, for a minimum period of 7 days. No maintenance, by using membranes, will be accepted, without the Supervision's approval.

48.3.16 Shotcrete in Areas of Steel Supports

The Contractor will remove all the loose inserts from the steel supports, as to the Service's demand. All the rest inserts, as well as other materials will be stabilized by blocks and wedges (not wooden), or tighten by other means, in a way satisfactory for the Service.

The surface will be prepared as the present clause specifies. The Contractor will show special concern for not jeopardizing the stability of the structure due to washing below its footing ,or due to any other reason, which may arise during the preparation of this surface.

The thicknesses of the layers and the techniques used for the shotcrete shooting, will be approved by the Service. The covering of all the badly fissured areas of the rock mass with adequate quantity of shotcrete, services the need to avoid corrosion and damage, as required by the Service.

48.3.17 Accounting - Payment

(1) The Accounting for the payment of shotcrete will be done on the basis of cubic meters, spread conditionally and measured on the finished surfaces, according to the drawings of the design, the demands of clause 47 of T.C.C. (sub-clause 47.16 etc.) and the Service's directions.

(2) The Accounting of the shotcrete volume, spread conditionally, can be done with one of the following methods:

a. The thickness of concrete will be measured at the points of a grid, approved from the Service. The average thickness will be the conditional thickness, which when multiplied by the area of the evoluted surface will give the conditional volume.

The area will be measured as the area of the theoretical surface found in the middle between "A" and "B" lines, as these are determined in clause 80 of the present T.C.C.

b. Sections will be received, before and after the concrete shooting, with the use of proper electronic recording equipment. The surface and consequently the shotcrete volume, will result from these sections. The points, measured in every section, will be at least 20 and the Service will determine the distance between the sections.

(3) The thicknesses, considered for the calculation of the average shotcrete thickness are:

a. 2/3 d < d, < 4/3 d, if (d) is the thickness of shotcrete layer and d < 3cm

b. 213 d < di < 715 d, if (d) is the thickness of shotcrete layer and d > 3 cm

In cases with thicknesses less than (3/5 d), additional concrete is necessary., while in cases with thicknesses more than (7/5 d), the value of (7/5 d) will be taken.

(4) For the works under consideration, both the limitation for the minimum quantities, mentioned in clause 47 of the present T.C.C. (paragraph 47.2.7) and the following limitation for the maximum quantities, are valid

(5) The average volume of shotcrete per meter of tunnel's length, for which the Contractor is not eligible for reimbursement, must not exceed the quantities referred in sub-clause 47.16 of clause 47 of the T.C.C. These limiting quantities correspond to any of the 3 categories (I, II, III) and to every type of section (regular or enlarged). Additional quantities, which will be spread, without the previous approval from the Service, will not be reimbursed.

(6) It is clarified, that the aforementioned maximum quantities are referred to shotcrete, which will be spread, in one or more layers, for the tunnel support, the smoothing of shotcrete surface, in order the water-tight system to be placed on (sub clause 48.14 of present clause 48 of T.C.C.) and the covering of the water-filtering system.

(7) Lost concrete, or shotcrete used in the testing panels, or in repairs, or shotcrete used for the Contractor's accommodation, or shotcrete used without the Service's approval are not accounted for payment.

Shotcrete, accounted with the way presented in the previous paragraphs paid according to the conditional unit price for this clause.

48.4 STRUCTURAL GRID St IV

48.4.1 Object

The present sub clause concerns structural grid St IV, used in underground excavations, as shotcrete reinforcement and lining reinforcement.

48.4.2 Content

This work will include the supplying , construction, placement and the anchoring of grid. The work of construction will include the evolution and the cutting, while the work of placing will include possible scaffolds or necessary lifting equipment

The reimbursement includes all the expenses (labour and corresponding materials), relative to the fixing, tying, covering, cutting and the damages of netting, used as shotcrete reinforcement. The covering of the reinforcement will fulfil the demands of the rules, in effect, and the design.

48.4.3 Materials

48.4.3.1 Structural Grid

Sub-clause 49.3 of clause 49 of the present T.C.C. arid standard Specification ASTM A-185 °Welded Steel Fabrics For Concrete Reinforcement", or Standards and Specifications of the European Union Countries, or Standards and Specifications of the European Economic Area (E.E.A.), or equivalent standards and specifications of the Service's approval, determine everything that applies to structural grid.

The type, diameter and the distances between the bars of grid, will be just as in the drawings, or according to the Service's directions. Grid will have square mesh with side longer or equal to 100mm. The wires will have a diameter between 3 to 5mm. and the yield limit will exceed 275 MPa.

48.4.3.2 Anchors for Grid Stabilization

Anchors for grid stabilization will not be injected. They must be complete, having length of 0.5m, diameter of 16mm, choking mechanisms, nuts, washers and resting plates with minimum thickness of 5mm. The minimum area of grids must be 150 cm2. Anchors will be made of materials, which will meet Specification ASTM A-615, Grade 60, or any corresponding specification of a European Union country, or a E.E.A. specification. Anchors for grid stabilization must meet all the demands, specified for rock anchors (rock bolts).

48.4.3.3 Placement

Grids will be placed on the excavated surfaces of the tunnel, according to the drawings and the Service's directions or with the Service's approval. Grids will be removed, according to the Service's directions, if this will be demanded, without extra reimbursement for the Contractor and before the shotcrete spreading.

The Contractor will cover the structural grid, with concrete or shotcrete, if this will be demanded, according to the Service's directions. Sub-clause 48.3 of present clause 48 of T.C.C. describes the aforementioned work of covering. Grid will be placed at a distance from the rock mass surface, which is not shorter than 3 cm. For this reason, shotcrete of average thickness 3cm, will be shot directly to the rock mass. Structural grid will be firmed on the aforementioned shotcrete layer.

Structural grid will be firmed very well on the rock. For this reason, anchors for grid stabilization will be placed between rock bolts, which have been already placed for supporting the rock mass. The layout of anchors for grid stabilization will be such as the grid is being fixed at about every 1.0 or 1.5m, or at distances determined by the Service. So, the maximum possible adhesion between grid and rock can be achieved. Grid will also be fixed to already placed rock bolts, by using additional plates, washers and nuts. This will be done, after the filling of anchors with grout.

In all the splicings of the grid, which is used as shotcrete reinforcement, its anticipated covering is 15cm.

48.4.4 Accounting – Payment

The Accounting for the payment of the aforementioned work is based on the kilograms of grid, which was used according to the designs and after the Service's approval. If there is no provision in the special conditions of the tender (S.C.C., etc.) relative to the accounting of grids, then this will be done on the basis of the data presented in the daily reports. This data includes the exact location, type and the dimensions of the used grids

The weight of structural grid will be calculated on the basis of the weight of grid per unit area, as the constructor gives for every type of grid, and the area on which the grid was placed. It must be clarified that the area of coverings, with the exception of those demanded from the Regulations and the design, will be accounted once.

48.5 GALVANISED WIRE MESH

48.5.1 Object

This sub clause is referred to galvanized wire netting, used in the tunnels as shotcrete reinforcement.

48.5.2 Contents

The work will include the supplying, construction, placement and the anchoring of galvanized wire netting. The work of construction will include the evolution and the cutting, while the work of placing will include all the possible scaffolds and the necessary lifting equipment.

The reimbursement includes all the expenses (labour and corresponding materials), relative to the fixing, tying, covering, cutting and the damages etc. of netting, used as shotcrete reinforcement. The covering of reinforcement will fulfil the demands of the rules, in effect, and the design.

48.5.3 Specification

Sub clauses 48.3 and 48.4 of present clause 48, standard specification ASTM A392 "Zinc Coated Steel, Chain - Link Fence Fabric", or relative specifications of the European Union countries, or Specifications of the European Economic Area (E.E.A.), or equivalent specifications of the Service's approval, will apply to galvanized wire netting, used as reinforcement of shotcrete layers.

48.5.4 Accounting – Payment

The Accounting for the payment of the aforementioned work will be done on the basis of the kilograms of wire netting, placed as reinforcement between the shotcrete layers with the approval of the Service.

The weight of wire netting will be calculated on the basis of the weight of wire netting per unit area, given by the constructor, and the area on which wire netting was placed. The areas of coverings, with the exception of those demanded from the regulations and the design, will be accounted once.

48.6 METAL FRAME SUPPORTS MADE OF STEEL NORMAL SECTIONS

48.6.1 Object

The Contractor will supply and place, at the Service's instruction, all the metal frame supports of channel steel, shown in the drawings of the application design, or which are necessary due to local conditions.

Additionally, the Contractor will supply and place all the relative steel elements, which are necessary for the assemblage, connection, choking and wedging of the frames. These steel elements include screws, nuts, wedges, connecting bars and other accessories, approved by the Service.

48.6.2 General

The Contractor will supply and install all the permanent supports made of channel steel. These supports will be composed of steel frames, founding plates, connecting plates, splicing plates, corrugated steel sheeting, connecting beams or bars, and other approved structural elements. The aforementioned elements must be complete including screws, nuts, wedges, connecting links, connecting bars and other equipment necessary for the assemblage, of the permanent supports from channel steel, their placement, the connection between them, and their wedging inside the rock mass.

The drawings show typical supports of channel steel, composed of steel frames. Other permanent supports of channel steel can be used after the Service's approval.

Metal supports, necessary at locations where the tunnel's cross-section is not typical (exits or widenings), will be constructed according to the terms of clauses 47, 48 of T.C.C., the Service's guidelines and the application design, drafted by the Contractor.

The details of permanent steel supports will be under the Service's approval. These details include the dimensions, section's weight, founding flanges, various materials and the distance between the supports installed in the tunnel. Before any use of supports of channel steel commences ,the Contractor is obliged to submit all the relative structural drawings, to the Service for approval.

48.6.3 Materials

All the materials of metal supports, made of channel steel, must be new, without oxidization and will fulfil the demands of Specification ASTM A - 36 (for channel steel), or the corresponding specifications of the European Union Countries, or specifications of the European Economic Area (E.E.A.), or equivalent specifications, having the Service's approval.

Sub clause 48.18 of the present clause specifies all the assembling elements of frames, such as screws, nuts, wedges and connecting rods.

Metal frames will have cross-sections of Π, or I, or other shape, according to the drawings or Service's demand.

Corrugated steel sheeting will be constructed from a material similar to the one of steel frame and will have thickness of 2 mm.

48.6.4 Placement of Supports

The dimensions, sections of metal frame supports as well as the distances between them, will be determined in the final design, finalized according to revealed local conditions and will be under the Service's approval.

Metal supports will be placed according to theoretical lines, inclinations and dimensions (accepted divergence 2.5 cm), shown in the drawings, or following the Service's directions.

Metal supports will be placed firmly and wedged in equal distances along their peripheries, for avoiding their disturbance due to the future Contractor's works. Any damaged frames by the Contractor's work, will be replaced, at the Contractor's expenses, in 24 hours after the Service's notice.

The founding plates of frames (footings) will have been designed properly and have the adequate section in order to secure the frame from settlements 'or horizontal displacements. in special cases, if the Contractor thinks that the use of metal anchoring bars, for stabilizing the founding plates, might be necessary, then these anchoring bars can be used, after the Service's approval and according to the Service's directions.

Supports must be placed in a way, which does not affect the strength, watertightness or the execution of works for the lining construction.

The Contractor will obtain and place temporary links (collar braces) and other necessary metal supports for supporting the frames temporarily. These links and metal supports will be removed after the concreting of the lining. The Contractor is not eligible for reimbursement relative to these temporary metal supports.

The Corrugated steel sheeting will be fixed on the supports, following the advisable way, with screws, connectors or other approved means, which will not be removed, unless the Service gives different relative instructions.

In any case, the dimensions, and the number of founding plates of the corrugated steel sheeting, as well as the dimensions and the number of distribution beams, wedges, and chocks, if not shown in the drawings, must be adequate in order to service the reasons of their placement and the security demands.

The material of footings, insets (corrugated steel sheeting), inserts, wedges and girders can be steel or concrete, according to the Contractor's decision.

Shotcrete can be used, in combination with metal supports, instead of insets. Structural or common grids can be used for the protection from rock-falls outside the metal supports. in general, inserts will be placed on the extrude of supports, or in locations approved from the Service. Use of wooden inserts, chocks and wedges is STRICTLY forbidden.

The Contractor will place, immediately, the necessary supports, according to the opening conditions, in a distance up to 5m, from the heading. Supports will be placed, during the shift, which will follow the rock blasting, or according to the Service's directions
.
It is emphasized, that no special payment will be made for every kind of inserts, chocks, wedges, temporary supports, etc., used for supporting the metal frames during the tunnel opening. Additionally, no reimbursement will be given for the connecting beams and the angular pieces used to support these beams on the frames. This expense is meant to be included in the price offered by the Contractor, for the complete placed frame.

48.6.5 Accounting - Payment

The works of this clause will be accounted and the reimbursement will be calculated on the basis- of the real weight, of the placed frames, in-kilograms, unless the special conditions of tender (S.C.C., Price-list, etc.) specify alternatively. The weight, in kilograms, must be written in the protocol of weighing, which will be drafted and cross-examined by both the- Service's Representative and the Contractor's Representative.

Screws, nuts and all metal connecting plates of the various parts of frames, which are necessary for the right assemblage of a frame, must be brought with the frame, during its weighing.

If the Contractor, for his convenience, will obtain materials with heavier sections than the approved ones from the Service, then these materials may be used only if the Service considers that they satisfy the strength demands. The weight of these materials will be accounted only in the percentage, which the Service considers necessary for the fulfilment of the strength demands.

48.7 METAL TRUSS SUPPORTS

48.7.1 Object

This work includes the supplying and the placement of Lattice Girders (L.Gs), as well as the supplying and the placement of all the other material, which are necessary for the support and the placement of L.Gs.

48.7.2 Content

The need for using light frames becomes peremptory in cases, where the shotcrete shooting, combined with rock bolting, are insufficient for supporting the rock mass. Lattice girders combined with shotcrete, in which they are embodied, create a flexible supporting frame, that the Contractor may place in the tunnels. The aforementioned frames can be placed very quickly and are capable in carrying loads, immediately after the start of the shotcrete setting. The setting of shotcrete can be achieved in a very short period, by using new, very effective substances, which help the whole procedure (setting) to be completed very quickly.

The rapid installation of L.Gs makes them to meet their fundamental function, which is the prevention of rock mass from further relaxation and the creation of the "dome" phenomenon. Consequently, this function, helps the rock mass to carry its own loads.

48.7.3 Materials

L.Gs, used in triangular or rectangular section will be composed of 3 or 4 reinforcing bars respectively, with diameter Φ26. The reinforcing bars will be connected to each other in distances, shown in the drawings, or specified from the Service, by reinforcing rods, with diameter l0mm and the appropriate preparation. The whole assembly consists a truss, as this is shown in the drawings.

L.Gs will be new, without oxidization. The quality and the demands for the reinforcing bars of L.Gs will agree with the demands of Specification ASTM A615, Grade 60, or with the corresponding specifications of the European Union countries, or with the specifications of the European Economic Area (E.E.A.), or with equivalent specifications of the Service's approval.

48.7.4 Placement

The fixing of L.Gs, before the shotcrete shooting, will be secured by using small anchoring bars, similar to the ones referred in subclause 48.4 of present clause 48 concerning the fixing of structural grids, or by applying approved methods shown in the diagrams, or according the Service's instructions.

Shotcrete must be shot in many layers for ensuring the complete embodiment of L.Gs in it. No voids between the reinforcing bars of L.Gs and shotcrete will be allowed to exist. The actual distances between L.Gs, where these are going to be used according to the types of support, shown in the diagrams, will be determined in the Application Design and finalized according to the local rock conditions, being revealed during the excavation. The aforementioned distances will be under the Service's approval.

Anything referred generally in sub clause 48.6 of present clause 48 will apply to the rest of the work (way of placing, damaged L.Gs, their replacement, etc.).

48.7.5 Accounting - Payment

The work of this clause will be accounted and the corresponding reimbursement will be calculated on the basis of the total weight of the placed L.Gs, in kilograms, unless the special condition of Tender (S.C.C., Price - List) specify alternatively. The weight, in kilograms, must be shown in the protocol of weighing, which will be drafted and cross-examined by both the Representatives of the Service and the Contractor. This protocol will also include all the auxiliary metal elements suitable for the installation of L.Gs at the heading. The weights of the connecting bars and the angular pieces, used for supporting these bars on the corresponding placed L.G, will be accounted with L,G.'s weight. It is noted that the connecting bars help L.Gs to be fixed together, during their placement in the tunnel section, according to the design or after the Service's approval.

It is emphasized that no special reimbursement will be paid for every kind of insets, chocks, wedges, temporary supports, etc., which may be used for supporting L.Gs, during the tunnel opening. These expenses are meant to be included in the price offered by the Contractor for a complete, placed L.G.

48.8 METAL FOREPOLING BEAMS

48.8.1 Object

The technique of the fore poling, is used for supporting the heading and the non-excavated area ahead of it. This technique is also used for securing every advancing step of the excavation. It is applied during the opening of tunnels in soils with serious instability problems. Fore poling can be iron tubes or steel bars, placed in holes, which have been opened immediately after the excavation. The method of opening the holes is either by pushing or by mechanical means. The aforementioned metal materials must have adequate moment of inertia for fulfilling the reason of their placement.

48.8.2 Content – Placement

This work includes the supplying of materials, which are either iron tubes, or steel reinforcing bars, their transportation to the site of the project, the workers, technicians and the mechanical equipment needed for the execution of this :particular work. Tubes or iron bars, with various cross-sections, are usually used. These- tubes or bars are placed in holes opened by JUMBO. The layout of the holes forms a conic surface and enough advancing steps are being made under its protection. Before the length of an "umbrella" will be reduced by two advancing steps, the next "umbrella" will start being placed. So, all the tunnel works are being executed under the continuous protection of the “umbrella”. The length of the aforementioned bars must allow the advancing of a large number of steps and in every case their overlapping must be larger than 20%. In the case of extended overlapping all the additional works and materials will burden the Contractor.

48.8.3 Accounting – Payment

The weight of bars, placed and accepted from the Service, will be accounted in kilograms. Unit price includes the cost of a bar, its transportation to the site of the project, the labour of the personnel, the operational cost of the machinery, which will be used for installing a bar, and all the relative works, except of the drilling, which has been executed in a previous phase. Unit price does include the cost of cementing materials, if this work is executed at a later stage. The aforementioned works are reimbursed according to the rest clauses of the offer's price-list.

48.9 METAL SUPPORT SHEETS

48.9.1 Object

This clause includes the supplying, transportation to the site, the placement, and the wedging, of metal plane or folded, punched or unpatched sheeting in the tunnel section, for supporting the tunnel during its opening.

48.9.2 Content

In cases, where the rock mass, at the tunnel site, is very weathered, very structured, composed of cohesionless material and the support of the excavation's slopes by shotcreting cannot be executed on time, steel channel-sheets will be placed in the rock mass, along the outer perimeter of frames by pneumatic hammer or other means. Steel channel-sheets will be placed before the excavation.

48.9.3 Specifications

The quality of the materials and the process of placing the lagging are referred in this clause. Subclauses 48.6 and 48.18 of present clause 48 describe the process of placing the lagging.

48.9.4 Accounting – Payment

The accounting of the works of this clause and the calculation of the Contractor's reimbursement are based on the real weight of lagging,, having been placed -during the tunnel support. The lagging are placed according to the design or after the Service's approval.

The weight of lagging is accounted on the basis of the protocol of weighing, which has been drafted under the cross-examination of both Representatives of the Service and the Contractor, unless the special terms of Tender (S.C.C., Price - list, etc.) specify alternatively.

The price of this clause includes the expenses for the supplying of materials, their transportation to the project site, the disposal of the necessary personnel and the disposal of the proper mechanical equipment, used for the complete and right execution of the work concerning the placement of sheets, according to the technical specifications and the Service's directions.

48.10 PADDINGS OF THE BULLFLEX TYPE FOR FILLING GAPS

48.10.1 Object

In cases of an hyper-excavation at the heading, inserts of BUFFLEX type for filling the voids, can be used instead of some other filling materials.

48.10.2 Contents – Specifications

The work will include the supplying of bags of polyamide or other proper material, which have the Service's approval, proper size and dimensions. The work also includes the transportation and installation of bags at the project site, the labour of the personnel and the operation of machinery for filling the bags with slurry.

The bag will be filled with the quantity of cement-slurry, which is necessary considering if this bag will be used for filling a hyper-excavation or a landfall.

The slurry, which will fill the bag, must have a ratio of weights Water/Cement: N: T= 1:2.5, as to the Service's demands. It will be pressurised in the bag, by a valve, with pressure not exceeding the specified value by the constructor. The maximum volume of the expanded bag, without rupturing it, must be specified by the constructor.

The bag is placed empty and after its fixing, the process of its filling with grout of the aforementioned composition, starts. The necessary amount of the bag's expansion is approved by the Service.

48.10.3 Accounting - Payment

The accounting of the inserts (BUFFLEX type) and the calculation of their cost, are based on the number of bags, used for filling 1 m3 of voids. These bags will have the Service's acceptance and will be filled with cement-slurry.

The unit price includes the cost of bags of polyamide or other proper materials, their placement at the proper position, the labour of the personnel and the operational cost of the machinery, which have been used for installing the bags. The unit price also includes the bags filling with cement-slurry, the cement-slurry and the used materials.

Use of inserts of BUFFLEX type for fixing frames, as well as in the lower half part of the tunnel section will not be justified by any means.

The bag is placed empty, it is fixed in place, subsequently it is filled with cement grout under the previous water-cement proportionality ratio, and it is expanded to a degree required and approved by the Service.

48.11 GENERAL SPECIFICATION FOR ANCHORS (applicable for sub-clauses 48.12 to 48.20)

The present sub-clause specifies the general requirements for all types of anchors that might be used in tunnel construction. The following sub-clauses 48.12 to 48.20 include special specifications for each type of anchor.

48.11.1 Rock Anchors

48.11.1.1 General

The Contractor shall prepare the borings, supply the materials and fully install the anchor system, as prescribed in the design drawings of the in-situ conditions and the commands of the Service.

The available equipment for the drilling of the boreholes for the anchors shall be adequate for drilling in any direction inside the tunnel.

The positions, layout, directions of installation, lengths and working loads of rock anchors shall be according to the drawings and the instructions or approval of the Service.

The layout, density and application area of the rock anchors shown on the drawings is not binding. The Service might demand any modification that it considers necessary in the installation of the rock anchors, regarding those shown on the drawings, if that is required by the rock-mass condition.

The lengths of the rock anchors are shown on the drawings and in the respective clauses of the present volume. However, according to the in-situ conditions of the rock-mass, the lengths or the anchors and their required capacity may be modified according to the commands of the Service.

The direction of the rock anchors should be adapted to the discontinuity systems of the rock-mass in order to: prevent its loosening and the formation and fall of wedges. As a rule, the direction of the anchors should form an angle larger than twenty degrees (200) with the discontinuity planes.

The above adaptation of the direction of the rock anchors may cause a deviation from their theoretical direction shown on the drawings, and thus the anchors may not be perpendicular to the surface of the rock-mass in the tunnel.

Steel beams or metal sheets fixed on excavation surfaces and combined with anchors shall be used for local support according to the instructions or the approval of the Service.

The Contractor shall perform test drillings and installation of test anchors, according to the specification in the present clause and the instructions of the Service, in order to establish the type, size, position, length etc. of the anchors to be used depending on their in-situ conditions compared to the design drawings. The Contractor shall maintain the logs of all test anchors.

48.11.1.2 *Materials*

The rock anchor systems, with the exception of the grouted rock anchors, shall be standard products made by manufacturers specialized in the production of rock anchors and related products.

At least sixty (60) days before the commencement of any excavation, the Contractor shall submit to the Service for approval a report for the various types of rock anchors he plans to use.

This report shall include, indicatively and not exclusively, data on the mechanical properties of the anchors and their materials, their geometrical characteristics, the real area of the cross-section along the coiled part of the anchor, full details about all the gadgets of the anchors (e.g. expandable heads, equipment for their grouting) as well as the certificates of physical and chemical analyses for each batch or moult of the steel from which the anchors to be used are manufactured.

The report shall also include data on the tensile strength, the yield limit and the corresponding yield strain for both parts of the anchor, threaded and non-threaded. These data shall be obtained from real laboratory tests performed in independent laboratories and on anchor material similar to that proposed to be used by the Contractor.

Finally, this report by the Contractor shall include detailed information on the installation of similar anchors with successful operation for at least two years.

In each anchor, the end protruding from the borehole, shall have appropriate threading on which an hexagonal heavy-duty nut shall be attached, a hard steel washer, two or more wedge-type washers, as required, and a steel screw plate, either fiat or of a special shape, with holes or grooves for the grouting.

All metal fittings of the rock anchors, such as steel bars, screw nuts, screws, washers, wedge-type washers, screw plates etc. shall conform to the requirements of the standard specification ASTM A-675, Grade 90 or the corresponding standards of the countries of the European Union or the European Economic Area or other equivalent standards or specifications approved by the Service. They shall also have anti-corrosion protection, regardless of whether or not they shall be grouted along their whole length.

The active rock anchors of the expandable head type, epoxy-resin or grout-type, self-drilling, swellex or super-swellex, spin-lock or other type approved by the Service shall have a working load of one hundred (100) kN, at a factor of safety with respect to the yield limit greater or equal to 1.50 or a factor of safety with respect to the ultimate strength greater of equal to 1.75.

The method and the details of the fixation of the rock anchors, with the exception of those used for the attachment of the structural grid, shall be selected by the Contractor and approved by the Service, according to the requirements of the tests as described below. The strength of the anchor-to-rock adhesion shall be such that it allows the development of the load corresponding to the yield limit of the anchor material.

The anchors for the fixing in place of the structural grid are described in detail in a previous clause of the present specification.

The threading of the rock anchors and the whole surface of the screw nuts and the washers shall be coated, at the manufacturing plant, with approved plastic grease of the type used for the protection of the underwater hull of ships; the grease shall contain anti-corrosion substances as recommended by the manufacturer of the rock anchors. Before the installation of the rock anchors, the grease shall be removed, the threading shall be cleaned and the surface between the screw nut and the washer shall be coated with lubrication grease, of a type approved by the Service, that will provide the necessary lubrication.

Wherever required by the Service, and in order to use the rock anchors as anchoring bars of the concrete lining, the protruding heads of the anchors shall be equipped with appropriate attachments that allow the attachment of a hook as an extension of the steel bar of the anchor, as shown in the drawings. The attachments and the hooks shall have a tensile strength and bearing capacity equal to that of the anchor bars. The cost of the attachments and the hooks shall be included in the contract price of the item for various metal structures.

No extra payment shall be made for all fixings accompanying the rock anchors, since their cost is included in the cost of a linear meter of anchor.

48.11.1.3 <u>Installation of Rock anchors</u>

48.11.1.3.1 <u>General</u>

The rock anchors shall be supplied in lengths and sizes and shall be installed in grids and layout according to the drawings and the instructions and approval of the Service.

The Contractor shall always have available on site at least twenty (20) pieces for the extension of rock anchors, each about 0.50 meters long, complete with fittings, so that the extension of an anchor is possible if the fixation conditions require that. Extension pieces for the small anchors •used for the fixation of the metal grid are not required.

The Contractor shall handle and place all rock -anchors and their fittings appropriately, according to the manufacturer's specification, bearing in mind the condition of the in-situ rock-mass and using the best approved procedures. Copies of the manufacturer's handling procedures shall be given to the Service in duplicate for the advice of the site personnel.

The rock face shall be sufficiently flat so that the bearing plate can transfer the load on it. The diameter of the borehole drilled in the rock for the installation of the rock anchor shall be the required for the most appropriate fixing for the type of rock anchor used.

The boreholes shall be drilled to a depth of twenty (20) cm beyond the theoretical end of the anchor for boreholes inclined downwards, and no more than ten (10) cm for boreholes inclined upwards. Subsequently, the boreholes shall be washed of the drilling products (mud and rock pieces) using air and water under pressure. In the case of boreholes in swelling rocks or with discontinuities filled with clay material, only compressed air shall be used for cleaning the boreholes.

48.11.1.3.2 <u>Installation of anchors</u>

In the case of active rock anchors, the fixation mechanism shall be placed according to the manufacturer's guidelines. If proper fixing cannot be achieved, the Service may require an increase in the length of the borehole and the use of a longer rock anchor or the use of extension pieces.

The preparation for the filling of boreholes with grout shall be made during the installation of the rock anchors. This preparation shall include the removal of the grease of manufacturing lubricant from the anchor bar, the application of a lubricant in the threading, according to the specification mentioned in the previous paragraph, the centering of the anchor in the hole, the installation of the grouting and aeration tubes as required, the sealing of the hole under the bearing plate with rapid setting cement grout under the bearing plate and the tensioning of the anchor, as required, in order to achieve proper seating of the bearing plate on the grout and the rock.

The consistency of the previous cement grout shall be such that the setting time is about ten (10) minutes.

The rock anchor installation procedure shall be such that the protruding threading at the end of the anchor is not damaged. Unless shown differently in the drawings, that threading shall extend at least five (5) cm beyond the screw nut, in order to leave sufficient length for the installation of the device for test tensioning or of structural grid or of wire mesh with an additional plate and screw-nut, or of other devices as required.

Between the bearing plate and the washer made of hard steel, wedge type washers shall be placed and attached in a way to ensure the- seating of the screw nut perpendicular to the anchor. Subsequently, the threading of the anchor, having already been cleaned of the manufacturing grease, is coated with the approved lubricant as well on the contact surface of the washer and the screw nut.

The screw nut should move freely on the anchor and it shall be tightened until the required torsional moment is reached, as that is determined from the results of the tests performed as described below and approved by the Service. The screw nuts should move during tightening, when the torsional moment is measured.

The tensioning of the anchors could be made by a pneumatic or mechanical wrench, applying a torsional momentum, selectable in advance, or by a hydraulic jack. The Contractor shall provide onsite auxiliary tensioning devices of rock anchors.

After installation, the anchors shall be tested by a wrench, to determine any substantial decrease of their load. If such a reduction is shown during the test, the Contractor shall take rehabilitation measures, according to the instructions of the Service, which shall have the possibility to instruct any of the following or all of them:

a. To increase the tension of the anchors.

b. To decrease the distance between the anchors to be installed in the future.

c. To install additional anchors so that the distance between the existing anchors.

d. To perform additional test anchorages.

After the tensioning of the anchor is completed, the load shall not decrease for the grouting of the hole or for any other reason. After the initial installation, the Contractor shall measure and record the torsional moment, and he shall re-tension, as required, any rock anchors have not been grouted.

48.11.1.3.3 Grouting of the Anchors

Unless otherwise instructed by the Service, active anchors, after screwing and tensioning, shall be cemented along the whole length. The plastic grouting and ventilation pipes shall be fixed on the anchor bar, and they shall be inserted in the hole together. For passive anchors, grouting fills the whole from start.

Before grouting, the load on each anchor shall be measured, using a mechanical or pneumatic wrench or a hydraulic jack and the measurement shall be recorded. If the measurement shows that the anchor is tensioned to a load less than required, the anchor shall be re-tensioned, as required, by screwing the screw nut.

The anchor holes on the rock surface, shall be sealed, according to the manufacturer's instructions. The sealing shall be tested before grouting and, when required, it shall be repaired. The grouting shall be made under sufficient pressure, so that the hole is totally filled, using a grouting pump of minimum capacity seven hundred (700) KPa.

Grouting of an anchor is considered completed, when permanent return of the grout through the ventilation pipe or the central hole of a hollow anchor, is observed. If, during anchor grouting, flow of the grout is observed from points around the anchor or neighboring locations in the rock-mass, these leakage points shall be blocked, to prevent further leakage of the grout.

The grout shall be a water-cement mixture, of four (4) to ten (10) approximate weight ratio, or as suggested by the anchor manufacturer. The grout shall be mixed at least for three (3) minutes in a high speed mixer, before pressed in the hole.

The grouting of the anchors shall be carried out within seven (7) days after their tensioning or before the excavation advances more than thirty (30) m from the anchor location, whichever occurs first, unless otherwise specified in the drawings or other instructions are given or the Service approves differently.

Special care shall be taken for the protection of the anchor heads from corrosion. The anchor heads, not covered by shotcrete, or not incorporated in concrete, shall be protected by shotcrete or asphalt materials.

48.11.1.4 *Tests*

48.11.1.4.1 General

Rock anchor tests shall be carried out by the Contractor on site, as follows:

a. Preliminary Pull-out Tests

   The tests shall be carried out before the commencement of the tunnel excavation works, in order to point out the suitability of the rock anchors and their fixations, that the Contractor proposes to use in the project, and also to determine the torsional momentum - load ratio for the anchors, so that the required torsional momentum for anchor tensioning.

b. Regular Quality Control Tests and Re-tensioning

   These tests shall be carried out on a continuous and regular basis, along with the progress of the excavation and the tunnel drilling, on all areas where anchors have been installed. Whenever considered necessary, based on these test results, the anchors shall be re-tensioned.

c. Special Tests

   These tests shall carried out according to the instructions and orders of the Service.

The Contractor shall record all test results, in a way acceptable by the Service, and he shall submit to the Service copies of these tests not later than the end of the next work shift after the execution of tests.

48.11.1.4.2 Test Details

The Contractor shall supply, without any additional compensation by the Service, two (2) series of approved pull-out equipment for the execution of the tests. Each equipment series shall include a hole measurement device, a suitable hydraulic jack and measuring device, accurately calibrated, accessories for the adjustment of the jack at the end of the anchor, hydraulic pump, equipped by pressuremeter, extensometer for measuring the anchor strain and deformation, and all additional fittings necessary for proper execution of the tests including lubricants.

The Contractor shall also supply, without additional compensation by the Service, mechanical wrenches, suitable for the measurement of the torsional moment on the anchors. These wrenches shall be of suitable size to apply the yield load on all anchors used in the project, and they shall have the option of selecting in advance the applied torsional momentum, and a sound indication that the selected momentum has been reached. These wrenches shall be subject to the Service's approval. Finally, the Contractor shall supply, without additional compensation by the Service, a wrench calibration device, approved by the Service.

The Contractor shall carry out several test programs, defined below and according to the instructions and orders of the Service:

a. Preliminary Pull-out Tests

At least thirty (30) days before the commencement of the excavations, the Contractor shall bring to the construction site five (5) samples of each rock anchor type, he plans to use in the project, in suitable lengths, according to the anchor lengths provided in the contract, including all accessories and fixing elements. The anchors shall be installed and tested on site at locations approved by the Service and in the Service's presence, in order to prove that the fixings are capable of developing the rock yield strength, as well as to determine the torsional moment -load ratio of the anchors.
The determination test results of the torsional moment - load ratio of the anchors shall be used by the Service for the definition of the torsional moment applied to each anchor type. Unless otherwise instructed by the Service, as applicable torsional moment for anchor installation shall be considered the moment, which, when applied on the anchor, develops a tensile load equal to the operational load, as this is defined in paragraph 1.2 of the present clause 48.

If the preliminary pull-out tests show that, according to the Service's opinion, the anchor samples and/or their fixings, tested, are not satisfactory, the Contractor is obliged to supply samples of alternative anchors and/or fixings, and he shall perform additional tests, as required, according to the Service's judgement, in order to prove the suitability of the anchors and their fixations, he plans to use.

The Contractor shall not deviate from the use of materials and the applied torsional moments, approved by the Service, for each anchor type and their fixation, unless such a deviation is approved in writing by the Service.

b. Regular Quality Control Tests and Re-tensioning

The Contractor shall develop and apply a load control schedule of the anchors, installed at all tunnel areas, in order to locate anchors affected by excavation works carried out after the anchor installation or by other reasons, before their grouting. Anchors having developed a load less than the required shall be re-tensioned, according to the Service's instructions, in order to develop the required operational load. The corresponding program shall be carried out on a regular and continuous basis, during the excavation works until their completion.

During the works, the Contractor shall perform at least one (1) pull-out per one hundred (100) installed anchors. These anchors shall not be grouted, and they shall be installed on the sides of the tunnel section, according to the Service's instructions.

The tests shall consist of measurement of the actual torsional moment required to turn the screw nut. When the moment is measured, the screw nut shall be in movement, but the turn of the screw nut should not exceed five (5°) degrees approximately.

48.11.2 Pre-stressed rock anchors

48.11.2.1 Objective

The Contractor shall supply pre-stressed anchors, equipped with all their fittings, drill holes for the anchor installation, insert or adjust the anchor heads, tension, re-tension and maintain the prestressed anchors at locations shown on the design drawings and according to the Service's instructions and directions, depending on the local conditions. The locations, layout, directions and depths of the prestressed anchors for the support of the rock-mass, shall be defined according to the approval or instructions of the Service. As for the rest, the Contractor shall comply to the requirements for the rock-mass support and
protection measures, as they are described in previous clauses of the present specification.

The Contractor shall submit to the Service, for approval, in time and the latest forty five (45) days before the commencement of the works and anyway before placing the order for the anchors, full details for the type and the materials of the anchors he plans to use, along with manufacturer's certificates, data concerning the anti-corrosion protection, instructions for the installation method, description of the tensioning and grouting equipment, instructions for the grouting method, proposals for the anchorage tests and relative equipment etc.

Before the installation of the prestressed anchors, the Contractor shall perform tensioning tests to investigate the behavior of the anchor types he plans to use, and the determination of the maximum allowable operational loading for the different rock-mass qualities and types.

The number of test anchors shall correspond to two percent (2%) of the total number of anchors to be installed but not _less than three (3) anchors. These anchors shall not be reused in permanent works. Full record of the test shall be maintained, i.e., data on the drilling, tensioning, re-tensioning and grouting. The test load shall be one-and-a-half (1.5) times the working load unless otherwise required by the Service. During the test, the following shall be measured: the axial translation of the anchor head, the translation of the bearing plate and the tension load.

48.11.2.2 Materials

The prestressed rock anchorage shall be made of anchors consisting of deformed (ribbed) steel bars or appropriate groups of bars or cables or wire cables equipped with all necessary fittings (e.g. base plates for the anchor heads made of reinforced concrete or steel, including steel beams, metal sheets and other steel fittings).

The prestressed anchors shall be effectively protected, along their whole length, from oxidation, corrosion, electrolysis, or any other deleterious factors with a double plastic coating system or other method. The protection measures as well as their fittings shall be approved by the Service.

The materials, diameter of bars or cables, working loads and the prescribed load sequence for each type of prestressed anchorage to be used, shall be according to the requirements of the applicable standards and the instructions or approval of the Service. The use only of tested types of prestressed anchors shall be allowed.

Depending on the condition of the rock-mass and the design requirements, the final working load for each type of prestressed anchor shall be in the range of four hundred (400) kN to six hundred (600) kN, as determined by the Service, and a factor of safety with respect to the yield limit greater or equal to one and sixty six per cent (1.66).

The wire cables shall be continuous, without joints or attachments, free of oil, dirt, oxides and without mechanical damage. They shall be supplied in circular bundles at least 1.50 meters in diameter, appropriately packaged in the factory for their protection against corrosion and damage.

The anchor heads shall consist of a steel plate that allows the tensioning of each bar, cable or wire separately, or all together, and the grouting for the filling of the borehole. The static strength of the anchor head shall not be less than the sum of the strengths of the bars, cables of wires. The fixation end of the anchor shall be made of plain carbon steel or other approved material. It will include an attachment for the separation of the bonded zone from the tensioned part. The slippage load of the bonded zone shall be greater or equal to the breaking strength of the tendon.

The tensioning equipment shall apply the tension load on the tendon in a guaranteed way, without problems, it shall allow the unloading and reloading and it shall guarantee the measurement of the loads and deformations during the tension tests.
The grout tube shall be made of PVC or other adequate material approved by the Service, it shall be perforated in regular spacing with holes covered with a rubber sleeve as prescribed by the manufacturer of the prestressed anchors and according to the guidelines of the -Service.

48.11.2.3 Drilling of holes for prestressed anchors

The minimum diameter of the holes for the prestressed anchors shall be according to the manufacturer's specification and shall be subject to the approval of the Service. The drilling of holes shall be performed according to the locations, inclinations and depths shown in the drawings or according to the requirements due to the in-situ conditions after the approval of the Service.

The drilling of holes shall be made with a rotary drill, with or without coring, or with a rotary-percussion drill, according to the orders of the Service. The Service might require, without extra cost, the drilling of holes with sampling (coring) for a total length of holes not exceeding ten percent (10%) of the total length of the prestressed anchor holes to be drilled in the project; samples shall be maintained occasionally for research purposes.

Drilling of the anchor holes shall comply to the requirements of clause 50 of the T.C.C. The prestressed anchorage holes shall be drilled fifty (50) cm longer than the required length of the anchors.

For all prestressed anchor holes, a record of all drilling data considered necessary by the Service shall be maintained (rate and drilling speed, color of returning water, behavior of drilling rods, existence of cavities or soft layers etc.).

48.11.2.4 Installation and grouting of anchors

Immediately after drilling, the boreholes shall be washed by flushing clear water and compressed air until the returning water is clean and then no water is left inside the boreholes. If the anchors are not going to be installed and grouted immediately, the holes shall be sealed in a waterproof way and shall be re-flushed and cleaned immediately before the installation of the anchors and their grouting.

Before the installation of the anchors, the borehole shall be subject to a water injection test along its whole length, by installing a waterproof packer at a depth of two (2) meters from the top of the hole and applying a pressure of one hundred (100) kPa at the manometer for a time period of five (5) minutes. If the loss of water during the test exceeds three (3) lt/sec, regardless of the depth of the hole, a pressure grouting with cement mortar shall be performed in stages according to the instructions of the Service and the provisions of the corresponding clause of the present specification. After the grout has set, the hole shall be re-drilled, a new water injection test shall be performed etc. The anchors shall be installed in the hole only if the borehole is guaranteed to be waterproof.

The anchors shall be centered along the axis of the hole with special fittings supplied necessarily by the manufacturer of the prestressed anchors and, subsequently, the anchor shall be grouted several days before tensioning.

The part of the borehole in the region of the anchor fixing shall be filled with injected cement grout. The grout mixture shall contain the absolute minimum water/cement ratio and shall contain appropriate additives, for the improvement of its workability, as approved by the Service. In addition to that, the mixture shall be designed in a way that the excess water shall not exceed one percent (1%).

The quantity of the cement grout shall be sufficient to fill the annular space around the required anchor length; at the same time appropriate measures shall be taken for the removal of air from the grouted borehole.

A complete record of the installation data shall be maintained for each rock anchor (type of grout mixture, grout pressure, volume of injected grout, corresponding length of grouted fixation etc.).

Tensioning of the anchors shall be performed in the prescribed loads after the grout in the fixation zone has achieved sufficient strength determined during the anchor tests with appropriate equipment and methods approved by the Service.

After tensioning or re-tensioning of the anchors, a second stage grouting shall be performed, which aims at the protection of the prestressed anchor form corrosion. Second stage grouting shall be performed according to the manufacturer's instructions and the approval of the Service. Other methods and procedures for the protection from corrosion may be used provided that they are approved by the Service.

48.11.2.5 *Tensioning and control of Prestressed Anchors*

Tensioning and control of prestressed anchors shall be made according to the Standard DIN 4125 or equivalent standards of European Union countries and/or the European Economic Area or standards approved by the Service. Tensioning shall be performed as soon as possible according to the requirements of subparagraph 48.11.2.4 of the present clause.

Prestressed anchors, which exhibit deformations higher or lower than the prescribed limits during tensioning shall be rejected and they shall be replaced by new prestressed anchors in their vicinity. The Contractor is not entitled to any compensation for rejected prestressed anchors.

48.11.3 Anchor Rods - Plain Bars

Anchor rods shall be installed at the locations shown on the design drawings and according to the instructions of the Service, depending on the requirements caused by the in-situ conditions.

The anchor rods shall be rebars St ill that shall comply to the requirements for rebars of clause 49 of the T.C.C., and they shall be threaded and they shall have a screw nut and a bearing plate at their head, analogous to those of the expendable head anchors. The boreholes for the installation of anchor rods shall have an appropriate diameter for the fixation of the rod. Drilling of the holes may be performed using common percussion or rotary-percussion drilling equipment (hammer or compressed air hammer).

After drilling, the holes shall be washed and cleaned using compressed air, until no water or other loose material is left inside them. The holes shall be sealed with a waterproof plug if the fixation of the rods is not performed immediately. Immediately before the installation of the anchor rods and their grouting the holes shall be re-washed and cleaned. During installation, the hole shall be partly filled with high viscosity sand-cement mortar, at a proportion of one (1) part cement to three (3) parts sand and a water/cement ratio less than 0.9 by volume_ (0.6 by weight). The filling of the boreholes shall- be made starting from the bottom of the hole.

The anchor rod shall be pushed in place, while vibrated with a vibrator and, immediately afterwards, any gap between the rod and the walls of the hole shall be filled with cement grout. The whole procedure of filling the hole with grout shall be approved by the Service. Anchor rods which are loose after the set of the grout shall be replaced at the Contractor's expense. If, in certain boreholes, seepage or flow of water is observed, grouting shall be performed form the bottom of the hole upwards, using a tremie pipe in order to prevent grout segregation before the installation of the anchor rod in the borehole.

After the setting of the grout, the anchors shall be tensioned via the screw nut with a wrench so that the minimum applied force is fifty (50) kN

48.12 SIMPLE ROCK ANCHORS USING ST III. Φ26 REBARS

48.12.1 Objective

This clause refers to simple rock anchors using St III, 26 mm diameter rebars and cement grout along the whole length of the rod. These anchors are used for the support of tunnels.

48.12.2 Contents

The work shall include the supply of the necessary mechanical equipment and work force, the cost of drilling the holes, at any height from the work level and at any inclination, cleaning of the hole, installation of an appropriate cement grout or other material and the cost and installation of the anchor rod. It shall also include the cost of all other materials and their installation, that are necessary for the completion of the work (bearing plate, screw nuts etc.).

48.12.3 Specifications

This work shall be performed according to sub-clause 48.11 of the present clause 48, the design drawings and the "General Specification for the Construction of Underground Works (clause 47 of T.C.C.).

The steel for these anchors shall comply with the relevant requirements of clause 49 of T.C.C.

Injection of cement grout shall be performed with an appropriate pump approved by the Service, via a flexible elastic tube having appropriate diameter whose end shall be placed at the bottom of the borehole. Upon commencement of grout injection, the flexible tube shall be pulled out from the bottom of the hole progressively. When a sufficient -quality of grout shall have been injected in the bole to ensure that the gap between the anchor rod and the rock-mass shall be completely filled, the-injection will be stopped, the flexible tube will be pulled out completely and the anchor rod shall be installed in the hole and it shall be fixed in place with the wedges or other approved methods. If required, the hole shall also be sealed with appropriate materials (rapid setting mortar, cloth etc.) to prevent the flow of the grout outside the hole.

Since the anchor rods are usually installed upwards with a steep inclination, the cement grout used for their fixation should be rapidly setting in order to prevent its outflow and to make sure that the installation of the anchor rods, as described above, is possible without a significant loss of grout from the borehole. For this reason, the Contractor shall submit to the Service for approval before the commencement of the excavations a description of the equipment that he plans to use, the prescription of the cement grout and data regarding the additives for rapid setting.

Before the commencement of the excavations, the Contractor shall perform anchor installation tests on site under conditions similar to those anticipated during the excavation, to prove the adequacy of his equipment and verify that the cement grout to be used complies to the requirements of the present paragraph.

48.12.4 Accounting - Payment

The accounting of quantities for the payment of simple rock anchors shall be made by the length of the borings predicted in the design and approved by the Service as acceptable and necessary for the project.

The above price shall be used for the payment of every material and labour that is necessary for the completion of the anchors, such as boring of the hole, rod, bearing plate, screw nut, anti-corrosion protection of the rod, grouting etc. The compensation per unit length of the anchorage also includes the cost for the test holes and lest anchors and their installation, the tests using a wrench and for the re-tensioning of the anchorages as required.

48.13 PERMANENT ROCK ANCHORS Φ26 HAVING A BEARING CAPACITY OF 200 kN OF THE EXPANDABLE - END TYPE

48.13.1 Objective

This clause refers to the permanent rock anchorages for the support of tunnels 0 , using steel rock anchors of the expandable end type, a stem having a diameter of twenty six (26) mm and a bearing capacity of the tendon equal to 200 kN

48.13.2 Contents

The work shall include the supply of all necessary mechanical equipment and work force, all the materials and fittings, the cost of drilling the borehole, cleaning and washing the hole, the installation of the anchor which shall be adequately processed to prevent oxidation, the injection of grout when required, the initial and subsequent screwing, the control measurement and tests. It shall also include the cost of all other materials and their installation, that are necessary for the completion of the work (bearing plate, screw nuts etc.). The Service maintains the right to demand the use of cement grout in all or few of the anchors.

48.13.3 Materials

The steel anchors of the expandable end type, shall have a diameter of twenty six (26) mm, threading at one end and an expandable head made of heat-processed steel at the other end. They shall consist of an hexagonal screw nut, a steel wedge forming one piece with the anchor, a steel plate for the bearing of the anchor head, a screw nut and an inclination accessory where required. The bearing plates shall have a surface not less than two hundred and twenty five (225) cm2 per anchor and a thickness not less than seven and a half (7.5) mm. These plates may be made of steel or deformed steel sections of a U shape, beams or angles, according to the requirements of the paragraph 48.11.1.2 of the sub-clause 48.11 of the present specification. The bearing plates may bear one or more than one anchors.

48.13.4 Installation

The boreholes for the installation of the expandable head rock anchors shall have a diameter of one and 5/8 inches (V 5/8) and the borehole shall reach exactly the prescribed depth. The expandable tip anchor shall be installed at the appropriate depth and then the bearing plate and the screw nut shall be attached. The screw nut shall be tightened until the required tension of the stem is achieved, i.e. a stress equal to two thirds (213) of the yield limit. If the bearing plate of the screw nut is attached on the anchor at an angle, then a special accessory shall be used between the plate and the screw nut in order to reduce the tension acting on the screw when the screw nut has the tendency to pull perpendicular to the bearing plate. In all cases, at least four (4) cm of threading shall protrude from the screw nut after installation.

48.13.5 Specification

The work for permanent anchors of the expandable tip type shall be performed according to the sub-clause 48.11 of the present clause 48.

The steel of the anchors shall comply to the ASTM A-675 Grade 90.

48.13.6 Accounting - Payment

The accounting for the payment of permanent rock anchors of the expandable tip type shall be made according to the length of the anchors approved by the Service as acceptable from the technical point of view and as necessary for the project. The payment for anchors shall be made with a different price if cement grout was used during the installation of the anchor according to the command of the Service.

Using the previous prices, the Contractor shall be paid for every material and labour that is necessary for the completion of the anchor such as borehole drilling, rod, bearing plate, screw nut, expandable end, anti-corrosion protection of the rod, grouting etc. The price per unit length of the anchorage shall also include the cost of the test holes, the test anchors and their installation, the tests using the wrench and the re-tensioning of the anchorages, as required.

48.14 PERMANENT ROCK ANCHORS Φ26. OF THE PERFO TYPE. HAVING A BEARING CAPACITY OF 200 kN

48.14.1 Objective

This clause refers to the permanent rock anchorages for the support of tunnels using rock anchors of the perfo type, with a stem diameter of twenty six (26) mm and anti-corrosion protection.

48.14.2 Contents

The work shall include the supply of all necessary mechanical equipment and work force, all the materials and fittings, the cost of drilling the borehole, cleaning and washing the hole, the installation of the anchor which shall be adequately processed to prevent oxidation, the injection of grout, the initial and subsequent screwing, the control measurement and tests, as well as any other work necessary for the technical completion of the anchorage. It shall also include the cost of all other materials necessary for the completion of the work (bearing plate, screw nuts, head etc.).

48.14.3 Materials

The PERFO type anchors consist of a perforated pipe having minimum nominal thickness of one (1) mm, cut lengthwise into two pieces. The PERFO pipes are filled with grouting and a ribbed steel bar is placed inside them. The steel bar shall have a diameter of twenty six (26) mm, a conical shape at one end , fifty (5) mm long, and a threading at the other end. The anchors shall be equipped by a wedge, screw nuts and bearing plates, and they shall conform to the requirements of the specification ASTM A-675, Grade 90 or the corresponding specifications of the European Union countries and the European Economic Area or other equivalent specifications approved by the Service.

The size and length of the anchors shall be proposed by the Contractor and approved by the Service.

The grouting filling the PERFO pipe shall consist of a mixture of cement, water and washed sand having a maximum grain size two and a half (2.5) mm. The cement/sand ratio shall be one (1) to one (1).

48.14.4 Installation

This work shall be performed according to sub-clause 48.11 of the present clause 48, the design drawings and the "General Specification for the Construction of Underground Works" (clause 47 of T.C.C.). Specifically:

The PERFO type anchors shall be placed in boreholes of sizes and depths proposed by the Contractor and approved by the Service. _The bolts shall be installed, according to the manufacturer's instructions and the _Service's approval, by the use of special tools.

The two halves of the pipe shall be fastened by wire, not thicker than half (0.5) mm and they shall be filled with grouting. The filled pipe shall be inserted in the hole and the reinforcing bar shall be inserted in the hole manually or by handgun.

Unless otherwise instructed by the manufacturer and subject to the Service's approval, the following relationship between the diameters shall be followed: Bar diameter twenty six (26) mm, internal pipe diameter thirty two (32) mm and hole diameter thirty four (34) mm to thirty eight (38) mm.

48.14.5 Accounting – Payment

The accounting for the payment of permanent rock anchors of the PERFO type shall be made according to the length of the anchors approved by the Service as acceptable from the technical point of view and as necessary for the project, with the same unit price for all meters, regardless of the total length.

Using the previous prices, the Contractor shall be paid for every material and labour that is necessary for the completion of the anchor such as borehole drilling, rod, bearing plate, screw nut, anti-corrosion protection of the rod, grouting etc. The price per unit length of the anchorage shall also include the cost of the test holes, the test anchors and their installation, the tests using the wrench and the re-tensioning of the anchorages, as required.

48.15 PERMANENT ROCK ANCHORS Φ26 HAVING A BEARING CAPACITY OF 200 kN WITH RESIN GROUTING

48.15.1 Objective

This clause refers to the permanent rock anchorages for the support of tunnels with resin grouting and anti-corrosion protection.

48.15.2 Contents

The work shall include the supply of all necessary mechanical equipment and work force, all the materials and fittings, the cost of drilling the borehole, cleaning and washing the hole, the installation of the anchor which shall be adequately processed to prevent oxidation, the injection of grout when required, the initial and subsequent screwing, the control measurement and tests, as well as any other work necessary for the technical completion of the anchorage. It shall also include the cost of all other materials necessary for the completion of the work (bearing plate, screw nuts, head etc.).

48.15.3 Materials

These anchors shall by of type and construction approved by the Service.

The steel bars of the anchors shall have a diameter of twenty six (26) mm, a threading at one end, and they shall be equipped by a wedge, screw nuts and bearing plates.

The epoxy resin shall consist of two components, packed for transportation in separate containers or in cylindrical caption with double wall pipes. The type and the quality of the epoxy resin to be used shall be subject to the Service's approval. The Contractor shall submit to the Service for approval all necessary data including manufacturer's certificatet, proving that the materials are suitable to develop enough adhesion between the anchor and the rock-mass.

The hardening speed of the resin shall be such that the anchor steel bar should not fall from a vertical or an upwards steeply inclined hole, due to its own weight. The resin anchors should be able to sustain a tensional load equal to the yielding strength of the anchor within fifteen (15) minutes after the installation of the anchor in the hole.
The size and length of the anchors shall be proposed by the Contractor and approved by the Service.

48.15.4 Installation

This work shall be performed according to sub-clause 48.1 of the present clause 48, the design drawings and the "General Specification for the Construction of Underground Works" (clause 47 of T.C.C.). Specifically:

The rock anchors filled with resin shall be installed by qualified workers of the Contractor under experienced supervision. To obtain maximum adhesion strength of the anchor, the hole filled with resin and rock-mass, the difference in the diameters of the drilling and the anchor should be the minimum possible. The steel bar shall be inserted and rotated by mechanical means in the hole, in which sufficient number of resin capsules shall be placed, so that the plastic bags of the capsules are destroyed and torn apart completely and proper mixing of the two components is made, which, pushed by the steel bar, shall completely fill the hole and create full contact between the rod and the rock-mass.

For the anchors that are going to be tensioned, a high-speed hardening resin capsule shall be placed at the deepest point of the hole for the fixation of the rod. The rest part of the hole shall be filled with capsules containing slow-speed hardening resin grout, so that the tensioning of the anchor is possible.

The detailed procedure for the installation of rock anchors filled with resin shall be determined according to the manufacturer's instructions, the results of tests and according to the Service's instructions.

48.15.5 Accounting – Payment

The accounting for the payment of permanent rock anchors with resin grout shall be made according to the length of the anchors approved by the Service as acceptable from the technical point of view and as necessary for the project.

Using the previous prices, the Contractor shall be paid for every material and labour that is necessary for the completion of the anchor such as borehole drilling, rod, bearing plate, screw nut, anti-corrosion protection of the rod, epoxy resin etc. The price per unit length of the anchorage shall also include the cost of the test holes, the test anchors and their installation, the tests using the wrench and the re-tensioning of the anchorages, as required.

48.16 PERMANENT ROCK ANCHORS._ HAVING A BEARING CAPACITY OF 400 κN

This clause refers to the permanent rock anchorages for the support of tunnels from hard prestressing steel di 28, having a bearing capacity of 400 kN. The anchor rods shall have suitable treatment for anti-corrosion protection, they shall have ribs and they shall conform to the requirements of specification ASTM A615, Grade 60 or the corresponding specifications of the European Union countries and the European Economic Area or other equivalent specifications approved by the Service. The anchorage shall be fixed along its whole length.

For the rest, that is objective, contents, specifications, accounting, payment, sub-clauses 48.11 and 48.13 of the present clause are applied.

48.17 PERMANENT ROCK ANCHORS. HAVING A BEARING CAPACITY OF 100 kN AND 200 kN OF SWELLEX AND SUPER SWELLEX TYPE OR SIMILAR

48.17.1 Objective

This clause refers to the permanent rock anchorages performed in the tunnel by rock anchors of the SWELLEX and SUPER SWELLEX type of Atlas-Copco or similar, for the support of the tunnel, having a bearing capacity of 100 kN and 200 kN, respectively.

48.17.2 Contents

The work shall include the supply of the SWELLEX or SUPER SWELLEX type anchor (a steel pipe, which deforms by application of high pressure inside it, after it is installed in the hole), the necessary mechanical equipment for its installation (high pressure pump), the work force for the installation, the cost of drilling the boreholes at any height from the working level and in any inclination, cleaning the hole, the installation of the rod - pipe and all relevant and necessary material for the installation.

48.17.3 Specifications

The deformed anchor - steel pipe or the SWELLEX or SUPER SWELLEX type are reinforced by short rings, sealed by welding. The length of the short rings shall be forty one (41) mm and the thickness of the pipe shall be two (2) mm for the SWELLEX and three (3) mm for the SUPER SWELLEX, or as specified by the manufacturer and approved by the Service. Similarly, the diameter and depth of the hole shall be defined by the manufacturer.

48.17.4 Installation

After the installation of the anchor - pipe in the hole, at its lower end a high expansion pressure is applied. It is recommended that this pressure, for hard rockmass, is about thirty (30) MPa, while for soft and brittle rockmass is lower, according to the manufacturer's instructions and the approval of the Service.

Besides the above, the work shall be performed according to sub-clause 48.11 of the present clause 48, the design drawings and the 'General Specification for the Construction of Underground Works" (clause 48 of T.C.C.).

48.17.5 Accounting – Payment

The accounting for the payment of the SWELLEX or SUPER SWELLEX type anchors shall be made according to the actual length of the installed anchors, provided in the design and approved by the Service as acceptable from the technical point of view and necessary for the project.

The unit price includes all material and labour, and the suitable equipment, necessary for the complete installation of one (1) m of SWELLEX anchor, such as drilling of the hole, the steel pipe, the high pressure pump, the water inflow, the work of the personnel and the use of the necessary machinery and any other auxiliary accessory for the installation. The price per unit length of the anchorage shall also include the cost of the test holes, the test anchors and their installation, the tests using the wrench and the re-tensioning of the anchorages, as required.

48.18 PERMANENT ROCK ANCHORS Φ32. HAVING A BEARING CAPACITY OF 300 kN of the SELF-DRILLING type

48.18.1 Objective

This clause refers to the permanent rock anchorages for the support of tunnels, form steel rock anchors of the SELF-DRILLING type.

48.18.2 Contents

The work shall include the supply of all necessary mechanical equipment and work force, all the materials and fittings, the cost of drilling the borehole, and the simultaneous installation of the anchor which shall be adequately processed to prevent oxidation, the injection of grout when required, the initial and subsequent screwing, the controls, measurements and tests etc., as well as any other work necessary for the technical completion of the anchorage. It shall also include the cost of all other materials necessary for the completion of the work (bearing plate, screw nuts, head etc.). The Service reserves the right to request the use of grouting in all or some of the anchors.

48.18.3 Specifications

The hollow rock anchor of the SELF-DRILLING type consists of a stem, having external diameter of thirty two (32) mm, longer than five (5) m and having a bearing capacity 300 kN, made from special steel having yield limit 270 kN and ultimate strength 330 kN, weight 45 N/m without the auxiliary fittings, threaded along its whole length.

The desired anchorage length is achieved by jointing the commercially available pieces by joints. At the lower end a cutting piece is jointed, while at the head a special bearing plate of dimensions 150 x 150 x 8 mm. This anchor is suitable for any kind of ground (earth, sandy gravel, running, semi-rock, rock).

Besides the above, the work shall be performed according to sub-clause 48.11 of the present clause 48, the design drawings and the 'General Specification for the Construction of Underground Works" (clause 47 of T.C.C.).

48.18.4 Accounting – Payment

The accounting for the payment of the permanent rock anchors of the SELF-DRILL ING type shall be made according to the length of the anchors, fully installed, approved by the

Service as acceptable from the technical point of view and necessary for the project regardless of the anchorage length and in any case longer than five (5) m.

The unit price includes all material and labour, and the suitable equipment, necessary for the completion of the bolting, such as rod, incorporated special cutting end, plate, bolt, anti-corrosion protection of the rod, drilling of the hole, grouting etc., as well as any work, relevant to the installation, personnel and machinery used (e.g. drilling, grouting etc.). The price per unit length of the anchorage shall also include the cost of the test holes, the test anchors and their installation, the tests using the wrench and the re-tensioning of the anchorages, as required.

48.19 ANNULAR. FULLY GROUTED. HIGH CAPACITY ROCK ANCHORS

This clause refers to the high capacity, grouted, annular rock anchors of the "SPIN - LOCK' type of the WILLIAMS, USA company or equivalent, used for the support of tunnels. The anchors shall have an operation load of one hundred and eighty (180) kN, and a safety factor against yield limit greater of equal to one and a half (1.5) or a safety factor against ultimate strength one and seventy five percent (1.75). The steel bearing plates shall have minimum dimensions of 25 x 25 x 2.5 cm. The anchor rods shall have been suitably treated for anti-corrosion protection. The anchorage shall be fixed along its whole length.

For the rest, that is objective, contents, specifications, accounting, payment, sub-clauses 48.11 and 48.13 of the present clause are applied.

48.20 PRESTRESSED ANCHORS HAVING A BEARING CAPACITY OF 400 kN

48.20.1 Objective

This clause refers to the prestressed rock anchorages performed in underground works, form steel of bearing capacity 400 kN

48.20.2 Contents

The work shall include the supply of all necessary mechanical equipment and work force, all the materials and fittings, the cost of drilling the boreholes, their washing and cleaning, the installation of steel, the tensioning, the control and re-tensioning, the grouting (resin or cement grout) along the whole length of the anchorage, the recording of all data concerning the anchorage in general and any other work necessary for the technical completion of the prestressed anchorages.

48.20.3 Specifications

This work shall be carried out according to the specified in sub-clause 48.11 of the present clause.

48.20.4 Accounting – Payment

The accounting for the payment of the prestressed anchorages shall be made according to the length of the anchors constructed and approved by the Service. as acceptable from the technical point of view and necessary for the project .

The payment shall be made for the length of the anchorage, based on the corresponding clauses of the unit price list, separately for anchorage depth from twelve (12) m to twenty (20) m and for anchorage depth greater than twenty (20) m.

The unit price includes all cost for the supply and transportation to the construction site of the prestressed rock anchorages, including the anti-corrosion protection, drilling of the holes, installation, filling by injection of grouting of the part of the hole at the fixation point and at the whole length of the anchorage before and after the tensioning (material and labour), according to the manufacturer's instructions for the tensioning, control and re-tensioning, as required. The contractual unit price also includes the cost for all auxiliary works, such as, washing of the drilled holes, performance of water injection tests, re-drilling of holes, measurements of load and deformations during tensioning, controls and re-tensioning, building and removing the construction scaffolds and all other measures and relevant works that are necessary for the completion of the construction works, according to the present specification and the instructions of the Service. Finally, the price per unit length of the anchorage shall also include the cost of the test holes, the test anchors and their installation, the tests the re-tensioning of the anchorages, as required.

No additional compensation is provided, beyond the contractual unit price, for drilling installation holes for prestressed anchorages by rotary drill, under the condition that the total length of these holes, drilled by a rotary drill with coring, shall not exceed ten percent (10 %) of the total length of the prestressed rock anchorages installed in the project.

Holes drilled by rotary drill with coring, exceeding the aforementioned limit, shall be paid by fifty percent (50 %) of the contractual unit price of the item of sub-clause 50.3 of clause 50 of the T.C.C., regardless of the actual depth of the hole.

48.21 DRAINAGE AND WATER-PROOFING OF TUNNELS

48.21.1 General

During the construction of tunnels, there are requirements for their waterproofing from the waters of the rock mass. The satisfaction of this basic insulation requirement allows the calculation of the permanent tunnel lining without the influence of loads due to hydrostatic pressures caused by the collection of water, a fact which eventually means significant savings during the construction of the permanent tunnel lining.

The degree of water-proofing and the extend of the water-proofing works are determined according to the minimum allowable quantity of water that may be accepted by the owner of the tunnel; for this reason the water-proofing requirements vary from case to case.

48.21.1.1 Factors which influence the water-proofing activities

The determination of the water-proofing requirements is influence, among others, by the following factors:

- Geological conditions
- Anticipated rockmass loads
- Chemical properties of water and rockmass
- Construction method of the project
- Water-proofing requirements in relation to the use of the tunnel (highway tunnel, railway tunnel, METRO tunnel)
- Anticipated deformations, settlements and relative movements of the water-proofed sections of the tunnel
- Effects of the hydrostatic pressure due to the water-proofing activities

48.21.2 Water-proofing requirements of the present project

During the construction of the present project, the complete water-proofing of the useful tunnel section is required, since this serves better the traffic through the tunnel and the safety at its structures against the presence of water (erosion of concrete structures, danger of short-circuits in electrical installations etc.).

The permanent lining of the tunnel, which is made of in-situ poured concrete, is calculated free of hydrostatic pressures and as a result it requires the complete water-proofing of the outer surface of the final lining.

48.21.3 Water collection layer - Water proofing layer - Materials

48.21.3.1 General

Complete water-proofing of structures is achieved by using geotextiles as a water collection layer and insulating membranes made of high density polymers, usually of Poly-Vinyl Chloride or Polyethylene, a methodology which developed in the last years in Europe and the USA (Washington Metro and parts of the New York City Metro).

The construction methodology that developed specifically for tunnels with complete automation for the fixation and welding of membranes, with practical and effective control of the achieved insulation and, finally, with accurate solution of all mechanical details, represent today the most technologically advanced insulation technique, with regard to:

a. The materials

b. The application methodology

c. The safety and accuracy of construction

48.21.3.2 *Requirements for the construction of the water-proofing*

The water-proofing membrane must be installed properly and easily, especially in the region of the internal crest of the tunnel and in rough areas created during the tunnel excavation and preserved after concreting; it should also be possible to repair and test the water-proofing membrane. Its construction method must also correspond to the current safety requirements of the project.

The fixation of the water-proofing membrane may be made on the layers of shotcrete of the temporary tunnel lining.

More generally, the layout of the water-proofing activities foreseen in the present specification is as follows:

a. A bare rock mass surface exists initially.

b. The shotcrete of the temporary lining has been placed on this surface.

c. The network of the plastic water collection pipes is installed inside the shotcrete layer, in regions of high water inflow.

d. The water collection layer, usually a geotextile, is installed on the internal face of the shotcrete, to protect the water-proofing membrane from damages that may be caused by the rockmass and the temporary lining; this layer drains the rock mass and the temporary lining; it drains the rockmass by guiding its water towards the main collection pipes along the length of the tunnel.

e. The fixation measures (washers) of the water-proofing membrane on the geotextile are placed next.

f. The water-proofing membrane is placed by thermal welding.

g. Finally, the permanent tunnel lining is constructed.

48.21.3.3 *Requirements for the construction of the water collection layer*

This layer shall be placed outside, and before the installation of the waterproofing layer, towards the rockmass, and aims to:

a. Protect the water-proofing membrane, to be installed subsequently, from damage that may be caused by the roughness of the rockmass of the elements of the temporary support. For the same reason, the Contractor must considered that the water collection layer shall be placed after smoothing the internal face of the temporary support by removing protruding pieces of shotcrete, flattening of sharp edges, covering rock anchor heads with shotcrete and cutting off all protruding metal objects.

b. To ensure quick drainage of the waters of the rockmass towards the drainage pipes, to eliminate the possibility of development of hydrostatic pressures. This role of the water collection layer is the most important and thus, the method, the system and the type of material shall be selected in a way to fulfil in the best possible way the permanent drainage function of the water collection layer.

Usually, a geotextile of the commercially available types is selected having the desirable features shown in Table 1.
It is specifically pointed out that the basic characteristic of the water collection layer is its permeability and especially under compression (pressure of concrete, water etc.) and under variable temperature conditions.

The Contractor shall submit the following before supplying the materials of the water collection layer:

a. Table of material characteristics according to the previously mentioned.

b. Samples of the material for the water collection layer.

c. Quality control certificates from an accredited laboratory, Albanian or international.

48.21.3.4 Water-proofing membrane

The water-proofing membrane, which ensures the complete water insulation of the useful tunnel section, is usually made of Poly-Vinyl-Chloride (PVC) (DIN 16938) and is commercially available in sheets of standard sizes. The connection of the plastic sheets is performed by thermal welding and their fixation on the geotextile is performed via special nails equipped with circular disks (washers) made of the same plastic material.

Details on the method of fixation and welding of the membrane are given in the following paragraphs of the present specification.

The desirable properties of the water-proofing membrane are given in Table 2.

It is pointed out that the water-proofing membrane shall be fire-resistant and in particular shall:

a. Be non-flammable.

b. When they are burnt, they should not develop smoke and the released substances and possibly toxic fumes shall be acceptable under the construction conditions of the project.

c. They should not liquefy in high temperatures.

During the construction, the following conditions must be observed:

a. No works using open flame shall be performed in areas of exposed insulation materials.

b. Adequate fire extinguishing facilities shall be available.

c. The length of the tunnel sections in which insulation works are performed and where insulation materials are exposed to the danger of fire, shall be minimized.

Several escape routes from the exposed sections shall be available.

Before the delivery on site of the water-insulation materials, the Contractor shall submit to -the Service for approval the following:

a. Table of the membrane characteristics according to the previously mentioned.

b. Samples of the membrane and special items to be used (fixation, connection, etc.).

c. Quality control certificates from an approved laboratory.

48.21.4 <u>Water control - Construction method - Work sequence</u>

48.21.4.1 Regions of high water influx - Water Collection

In regions of high influx, which the Contractor shall identify during the progress of the excavation works, and after a relevant command of the Service, a system of drainage holes shall be installed according to sub-clause 50.1 of clause 50 of the S.C.C. and clause 47 of the S.C.C. The quantities of the water drained by the drainage holes shall be collected in a special network of plastic tubes of appropriate diameter, and shall be lead into the perforated drainage pipe of any other place selected by the Service, without inhibiting the water-proofing of the useful tunnel section. The installation of the plastic tubes shall be concurrent with the shotcreting so that the tubes are incorporated in the layer of the shotcrete.

48.21.4.2 Construction of the water collection layer and the water-proofing layer

48.21.4.2.1 Requirements of the surface of the shotcrete

The quality of the surface of the shotcrete shall significantly influence the proper function of the whole water-proofing system since the system is installed on this surface. As a supplement to those mentioned in the section regarding the shotcrete, the following issues are noted:

It is required that the shotcrete layer not only ensures the stability of the rockmass but also covers all sharpnesses, protrusions and troughs and the fixations or the rock anchors that are used, in a way that fulfils the following requirements:

a. Sufficient strength and stability.

b. A final layer of shotcrete made by using fine grained aggregates having a maximum diameter of six (6) mm.

c. Ratio of length to height in local protrusions at least 5:1 in the case of elastic membranes up to three (3) mm thick, while for harder or thicker membranes, the required ratio shall be at least equal to 10:1.

d. Radius of curvature at least twenty (20) cm.

The Contractor is advised to organize the construction of the shotcrete layer according to the following:

a. To construct an initial layer of shotcrete to a thickness required for the stability of the temporary support.

b. After the rockmass is stabilized and any deformations have stopped, a second layer of shotcrete should be constructed with aggregate sizes between 0 and 6 mm.

In this way the optimum co-operation of the geotextile with the underlying layer of shotcrete is ensured.

The acceptance of the surfacing of the shotcrete layer and the check for the minimum dimensions of the tunnel section shall be performed by the Supervision in sections, before the commencement of the works for the installation of the water-proofing materials. The Contractor is required to improve at his own cost, the surface of the shotcrete in all locations indicated by the Service as not acceptable.

48.21.4.2.2 Fixation of the Geotextile

For technical reasons, the water-proofing of the tunnel crest is constructed in a radial direction towards the tunnel axis and ends with its connection to the drainage pipe at the base of the section.

It is evident that the geotextile must be secured on the tunnel walls. The number of the fixation points must be limited as much as possible, in a way that the insulation sheet lies on the tunnel walls, stress-free if possible, during the loading caused by the internal concreting. No uncovered area of shotcrete shall remain between the sheets of the geotextile.

In addition to that, the rough surface of the rock mass resulting from the blasting, requires the fixation in deeper locations, in order to ensure the existence of sufficient material and to eliminate the possibility of voids.

After extensive testing, it has been proven that the most effective fixation system is the following:

The geotextile (width 2 - 4 m) is fixed on the surface of the shotcrete via layers or disks (washers) made of synthetic material, which are installed on the shotcrete with steel nails. The water insulation membrane is fixed on these washers by thermal welding.

The fixation washers must have a recess four (4) mm deep, for the placement of the head of the nail and diameter or width at least eighty (80) mm.

Under the synthetic washers and the head of the nail, a metallic washer having a minimum diameter of twenty (20) mm and a minimum thickness of one (1) mm shall be placed, to avoid any stamping during the hammering of the nails.

In general, in the case of uniform excavations in rock, it is sufficient to have three fixation points per square meter on the average. In cases of extensive surface roughness of the rock mass, especially in the region of the tunnel crest, it is necessary to use a larger number of fixation points.

The number of fixation points shall be at least equal to:

a. One (1) piece per m2 in the region of the floor.

b. Two (2) pieces per m2 on the tunnel walls.

c. Three (3) pieces per m2 in the region of the tunnel crest.

48.21.4.2.3 Welding of water-proofing membranes

The membrane sheets shall necessarily overlap in order to weld them in a perfectly water-tight way.

The minimum width of overlapping depends on the construction method used by the Contractor and it shall be approved by the Service after the Contractor submits the necessary data.

The quality of the welded seams is the resultant of the correct welding temperature and the adequate mechanical pressure exerted at the point of local melting of the membrane material at the welding location. A double seam shall be necessary both for the safety of the water-tightness and to allow the check of the water-tightness.

At the present time, automatic welding machines are used which operate via a contact with a metal heating element. These automatic machines are equipped with a special support system which moves via a separate micro-motor. As a result, the welding can be performed independently of the existence of a membrane support base.

The speed of the machine is adjusted according to the required temperature using an electronic continuous adjustment; thus, the operator only directs the machine and maintains a sufficient overlap or interrupts the operation in the case of a fault. The welding seam performed by the above machine can start at either end of the membrane and, in general, it continues to the other end in one run.

The heating element has a recess, about ten (10) mm wide at the center, in order to create a predetermined geometrical interruption of the continuous seam at this location. In this way, a trench is formed along the whole length of the seam which becomes double.

According to DIN 18195, the whole thickness of the double seam must be thirty (30) mm if an automatic machine is used, or forty (40) mm if a hot air unit is used.

The trench between the two seams is used for the subsequent check of the water-tightness and mechanical strength of the seam using compressed air which is pressurized inside the trench at a pressure of two hundred (200) kPa for ten (10) minutes. Before the check, it must be certain that the seams have cooled sufficiently. In practice, all seams are checked towards the end of each work shift.

48.21.4.2.4 Scaffolding

The execution of the water-proofing as described above is performed using a temporary mobile scaffolding.

The layout of the scaffolding should not prevent other activities performed inside the tunnel. The appropriate design of the -scaffolding frame is of utmost importance for the achievement of an adequate work progress.

The safety in the work place, of course, requires continuous and adequate lighting.

48.21.4.3 Special construction applications - Connection details 81.21.4.3.1 Construction joints

48.21.4.3.1 Construction joints

The construction joints of the internal concrete lining are a weak spot for the water-proofing. Usually, the largest shear stresses develop on the membranes at these locations. Besides, there are dangers during the application of the steel form for the concreting. For this reason, there is a necessity for extra protection of the water-proofing membrane in the location of the construction joints; this is achieved by welding an additional protective layer made of the same material, having a thickness of 50 cm, which is placed on the main seam along the tunnel periphery and is welded using a manually operated machine.

48.21.4.3.2 Waterproofing of the tunnel ends

The connection of the insulation structures inside the tunnel with those of the tunnel ends (entry and exit) occurs in an area sensitive to settlements which requires special treatment. As a rule, the structures at the tunnel ends are constructed after the completion of the internal concrete lining and, as a result, in the meantime the insulation must be protected with auxiliary measures.

After the completion of the tunnel entry structure, the auxiliary fixing is removed and the joint is sealed. The entry is constructed with surface techniques (surface excavation) and is water-proofed by incorporating a water-light membrane between the two protective geotextiles. If the membrane is to be coated with mortar, then it is recommended to construct a protective concrete cover having a thickness of at least five (5) cm.

The final fixation of the water-proofing membrane on the periphery of the entrance is performed mechanically with an adequate blade or by welding on
special profiles incorporated in the concrete during the pouring phase.

48.21.4.3.3 Crossing (of pipes etc.) through the membrane

Crossings of various elements (pipes etc.) are basically achieved via gasket structures (combination of fixed and floating). The protective layer (geotextile) should not pass through the gaskets. The insulation membrane is pressed between two NEOPRENE layers, 5 mm thick.

The dimensions of the gaskets, depending on the actions (water under pressure or not) should be constructed according to the specifications of the manufacturer of the membrane.

48.21.5 General site conditions

It is well known that difficult conditions and unforeseen effects may significantly influence the construction of the tunnel. As a consequence, the water-proofing activities are significantly dependent on the existence of specialised knowledge for the overcoming of possible adverse conditions by all parties involved in the project.

It is preferable that the water-proofing activities commence after the tunnel has been completely excavated. In the case that this is not possible, there are significant difficulties for the materials transport, increased safety measures are required, and the activities should be interrupted during blasting.

The water-proofing front should be at least 200 m away from the excavation front to avoid any disturbance and facilitate the smooth progress of all activities.

The ventilation duct at the roof of the tunnel may prove to be a severe obstacle. For this reason, it is recommended that a flexible alternative pipe exists on the mobile scaffolding; this pipe can be connected to the main ventilation duct so that the welding of the seams of the membrane can be performed without interruptions.

48.21.6 Quality control

48.21.6.1 Material requirements

It is allowed to use only adequate water-proofing materials. These should be permanently stable against the water of the rockmass and they should not lose their protective capability due to anticipated movements of tunnel sections caused by thermal changes and settlements.

48.21.6.2 Compatible properties of materials

All water-proofing materials shall be mutually compatible as well as compatible with all adjacent construction materials, principle and auxiliary, and they should behave uniformly against external agents and they should have a proportional resistance in durability compared to the useful life of the project. No adverse interaction among the materials of the same structure is allowed.

48.21.6.3 Tests - Control of materials

All insulation materials to be used should be initially checked in an approved government materials testing laboratory, or in an approved private materials testing laboratory, Albanian or international to verify their compliance with the minimum mechanical properties according to the attached Tables 1 and 2. These tests should be performed according to Chapters 36 and 37 of DIN 18200.

TABLE 1

CHARACTERISTICS OF THE WATER COLLECTION LAYER (GEOTEXTILE)

Properties	Unit	Characteristics
Invariance	-	Indefinitely
Non-solubility in any kind of groundwater	-	Absolutely
Non-harmful in potable water	-	Neutral
Inflammability	-	Difficult
Permeability perpendicular to the surface of the layer	lt/cm^2/sec	>= 60
Coefficient of permeability perpendicular to the surface a. Under normal pressure 0.02 bar b. Under normal pressure 1.00 bar c. Under normal pressure 2.00 bar	cm/sec	>= 5 x 10^{-1} >= 1 x 10^{-1} >= 0.5 x 10^{-1}
Coefficient of permeability parallel to the surface of the layer a. Under normal pressure 0.02 bar b. Under normal pressure 1.00 bar c. Under normal pressure 2.00 bar	cm/sec . .	>= 10 x 10^{-1} >= 1 x 10^{-1} >= 0.9 x 10^{-1}
Weight per unit surface when placed as a sub-base of shotcrete	gr/m^2	>= 500
Acceptable difference from the nominal weight per unit surface	%	< 10
Minimum thickness		> 3 mm
Acceptable difference from the nominal thickness	%	< 10
Longitudinal tension force, perpendicular and diagonal in a strip 50 mm wide	N/50 mm	650
Elongated, cracking, longitudinal, perpendicular, diagonal	%	60

TABLE 2

CHARACTERISTICS OF THE WATER-PROOFING MEMBRANE

Properties	Unit	Characteristics
Thickness	mm	12.00
Rupture strength (longitudinal)	N/mm^2	>= 11.00
Rupture strength (transverse)	N/mm^2	>= 10.00
Elongation at rupture (longitudinal)	%	>= 300.00
Elongation at rupture (transverse)	%	>= 300.00
Residual strength at rupture (longitudinal)	N/mm	>= 50.00
Residual strength at rupture (transverse)	N/mm	>= 50.00
Hardness	SHORE/A	75
Compressive stress at 20 % compression	N/mm^2	>= 25.00
Plastic residual compressive strain after 20% compression	%	<= 5
Tensile strength after the first rupture (mean of longitudinal and transverse)	N/mm^2	>= 4
Compressive strength in scratching	N/mm^2	>= 12
Quality at durability and after maintenance at 80^0 C		
a. Generally development of bubbles		none
b. Change of dimensions, longitudinal and transverse	%	<= 3
c. Change of rupture elongation longitudinal & transverse	%	<= 10
d. Change of rupture elongation longitudinal & transverse	%	<= 10
e. Non-cracking longitudinal and transverse at temperature	^{0}C	-20
Behavior after maintenance in aquatic solutions		
a. Change in rupture strength, longitudinal and transverse	%	<=10
b. Change in rupture elongation, longitudinal & transverse	%	<= 10
c. Non-cracking longitudinal and transverse at low temperature (method of 2 mm needle)	^{0}C	-30

d. Non-cracking longitudinal and transverse at low temperature	^0C	-20
Shrinkage behavior	%	<= -2
Invariance	-	Indefinitely
Resistance to puncture	-	No puncture for a fall of height 750 mm
Water absorption	%	<= 1
Resistance to fracture under water pressure	-	10at/hr
Welding test for a length of 30 mm and width 10 mm	N	>= 90
Behavior of joints of seams (welding)	-	no escape of air up to pressure of 0.5 bars
Shear strength for a welding with asphalt material along 50 mm	N	>= 100
Behavior during a fire	-	hardly inflammable
Resistance to acids and alkalis	%	-
Compression strength for penetration in a test width 10mm	N	>= 700
Non-harmful in potable water	-	Neutral

48.21.6.4 Acceptance of site constructed seams, of the water-proofing membrane

All seams of the loosely placed water-proofing membranes shall be submitted to a (continuous) water-proofing test according to DS 835, Chapter 9.3.

The pressure of the compressed air test should not exceed 2.5 bar. In addition, the duration of the test shall be at least 10 minutes and at most 30 minutes.

In certain cases, the lengths of the seams tested may be reduced.

The tests of the seams of the loose water-proofing membrane should be performed in the presence of a representative of the Contractor and a representative of the Supervising Service.

- A test document shall be maintained which shall include at least the following:
- Project
- Location
- Contractor
- Subcontractor for the water-proofing if there is one
- Tests, results, comments
- General condition of the water-proofing
- Temperature during installation
- Signature of the Service
- Signature of the Contractor
- Signature of the water-proofing sub-contractor

48.21.7 Execution and acceptance of the water-proofing

It is recommended that the execution of the water-proofing in tunnels is performed by capable and experienced personnel which have performed successfully similar projects.

It is possible that the water-proofing activities are performed by a team of the Contractor which has been trained by technicians of the manufacturer supplying the materials for at least two months, provided that it is considered adequate by the Supervising Service.

The acceptance of the water collection layer (geotextile) and of the water-proofing membrane, which together form the water-insulation system, is made by drafting a special acceptance document which approves that the water-insulation system fulfils the requirements of the water-proofing technique mentioned in the present specifications.

48.21.8 Accounting - Payment

The work of this clause shall be accounted for and paid according to the square meters of completed water-proofed tunnel surface according to the specifications which was approved as acceptable and necessary by the Supervision.

It is clarified that the unit price refers to fully completed work (materials, labour, delays,_ damages etc.) and it is indicatively noted that the following are also included in the unit price:

1. Miscellaneous materials and support labour
2. Scaffolding and work levels
3. Special equipment and trained personnel
4. Check of the seams (equipment, personnel, reporting)
5. Crossing of pipes (special materials, labour)
6. Water-proofing in special locations such as recesses, parking, entrances
7. Delays to other activities

Using the price of the first clause of the bill of quantities which refers to this work, the square meter of tunnel surface, on which a water collection layer (geotextile or analogous material) is installed, shall be paid; using the price of the second article, the square meter of tunnel surface, on which a complete insulation membrane is installed (PVC sheet), shall be paid.

Regarding the method to account for the work, the following are clarified:

1. The quantity used for overlapping of the sheets and for the protective strips placed on the construction joints is included in the square meter of tunnel surface and is not accounted for separately.

2. The waste of loss of material, as well as the use of a larger quantity due to over-excavation, is not accounted for separately.

3. The surfaces of the tunnel which shall be covered with double layers of geotextile, according to the instruction of the Service, shall be accounted for twice.

48.22 PLASTIC PVC TUBES

48.22.1 Objectives

This sub-clause refers to the set of labour and materials which, according to the technical design, are required for the construction of the water collection systems and/or the drainage of grained water from the tunnel or the installation of drainage pipes in retaining walls, and other structures inside and outside the tunnel etc.

48.22.2 Contents

The work shall include all the required materials in the diameters determined in the design, the labour, the equipment and every other expense (miscellaneous materials, special connection pieces, waste, delays, etc.) for the complete construction. It is pointed out that in the perforated pipes (a) 160 mm) the unit price also includes the labour to perforate the pipe or to order and supply pre-perforated pipes. The perforations shall be placed according to the design and the instructions of the Supervision.

48.22.3 Specifications

The strength of the pipes shall be at least 6 bar and they shall necessarily withstand the loads during the pouring of -concrete or shotcrete on them. If the construction method used by the Contractor requires_ pipes of higher strength, the Contractor is obliged to have them supplied without extra payment.

48.22.4 Accounting - Payment

The accounting for the payment of pipes is made per linear meter of completely installed pipe and according to its diameter. The price includes all materials for the connection, support, etc. wastes, losses and perforations. The length corresponding to regions of manholes and recesses is subtracted.

Clause 49 FINAL LINING OF UNDERGROUND WORKS

49.0 GENERALITIES - CONTENTS OF THE PRESENT SPECIFICATION

The present specification covers the following activities of projects constructed by underground excavation:

1. Final concrete lining (sub-clause 49.1)
2. Shotcrete or poured concrete B15 to fill geological collapses (sub-clause 49.2)
3. Steel reinforcement in general (sub-clause 49.3)
4. Steel reinforcement St I (sub-clause 49.4)
5. Steel reinforcement St III (sub-clause 49.5)

49.1 FINAL CONCRETE LINING

49.1.1 Objective

The present clause refers to the supply of all activities, materials and equipment required for the construction of the final tunnel lining (dome and foundation) at a normal or enlarged section, at the entry structures near the tunnel ends, in normal straight line sections or in section at a curve both in plan or longitudinally.

The final tunnel lining shall be made of concrete of quality at least B25, reinforced or not reinforced depending of the design; this lining shall be applied along the whole tunnel length and, in addition to a structural element, it shall also be the internal finishing of the tunnel.

Tunnels constructed in the major area of urban centres as well as tunnels of projects having intense traffic in non-urban areas shall have concrete in the final lining of minimum quality B35 for durability reasons.

The determination of the quality of the concrete in the final lining (B25 or B35) in non-urban areas shall be made in the design or the Special Conditions of the Tendering (S.C.C. etc.).

49.1.2 Contents – Specifications

49.1.2.1 Generalities

The construction of the final lining shall include the supply, transportation and storage on-site, of the required materials and additives and the provision of all required work-force and mechanical equipment which are necessary for the production, mixing, transportation, pouring and maintenance of the concrete inside the tunnel.

It also includes the special formwork (sliding formwork) which is required for the construction of the tunnel crest and the other part of the tunnel (invert, etc.) as well as the external formwork in the structures at the ends of the tunnel.

It also includes low pressure grouting for the filling of the voids between the final lining and the water-proofing membrane, the supply and the installation of plastic tubes for the low pressure grouting, the finishing of the joints, the construction of a recess at the location of joints or in between joints, the material and the labour to fill the joints, the finishing of the surface of the concrete, as well as any other construction cost such as sampling, laboratory tests on aggregates and mixed concrete, studies of concrete consistency, concrete additives, accounting, surveying etc.

The unit price for the payment of the aforementioned activities and materials includes the labour and materials (special pieces of formwork) for the construction of recesses, for the lining of the tunnel at the enlarged sections (parking areas) as well as for the wooden or metal formwork used for the construction of the tunnel invert.

The final surface of the concrete of the permanent lining shall be smooth, flawless and any deficiencies shall be corrected at the Contractor's expense according to the instructions of the Service.

Care should be given to put in place, before pouring the concrete of the final lining, all pieces which according to the design should be incorporated in the concrete; these fixtures shall be properly attached using an approved method to ensure that they shall not be displaced during concreting; this is the case for instruments, cable channels, reinforcement etc.

In general, the provision of clause 6 of the T.C.C. are in effect for the materials used and the activities for pouring, compacting, maintaining, as well as for the sampling, verification testes and quality control for the construction of the final lining of the tunnel. The specifications for the materials, the work methods etc., for the contact grouting are mentioned in clause 50 of the T.C.C.

If not specified otherwise in the Special Conditions of the Tendering (S.C.C. etc.), the minimum statically required thickness of the final lining is mentioned in sub-clause 47.16 of clause 47 of the T.C.C.

49.1.2.2 *<u>Preparation for Concrete Pouring at the Tunnel Floor</u>*

Rock surfaces which form the tunnel floor and on which concrete shall be poured, shall be clean, free of oil, still of moving water, dirt and loose semi-dislocated rock pieces.

Geological faults, cracks or discontinuities of the rockmass shall be cleaned to a depth satisfactory to the Service before pouring concrete. Immediately before the pouring of concrete, all surfaces shall be carefully cleaned by injecting high velocity water-air, by sweeping, by wet sand-blasting or by other means satisfactory to the Service.

All surfaces shall be wetted before pouring of the concrete. All the practically horizontal surfaces shall be covered immediately before the pouring of the concrete, with a two (2) cm thick layer of mortar consisting of one (1) part cement and two (2) parts of fine aggregate by weight and a water-cement ratio similar to that of the surrounding concrete but not exceeding one half (0.5). This layer shall be pasted carefully by using brushes to penetrate all cracks of the rockmass and thus ensure complete contact between the concrete and the rockmass. Segregations of fine grained concrete shall not be allowed to pile up in cavities of the rockmass.

Connecting mortar shall not be laid down in areas larger than those which can be covered with fresh concrete during the current batch of concreting or the immediately next or that which can be covered before the mortar starts to set. Connecting mortar which has started to set before the pouring of the concrete shall be removed. The quality of the mortar which shall be laid down at any time, or the surface which it will cover, shall be according to the instructions of the Service. The equipment and the methods of trafficking and pouring shall be in accordance with the design and the type approved by the Service.

If open drains are used for the collection and the removal of the seeping water, they shall be covered with low-slump concrete which shall be allowed to set before pouring. No extra payment shall be made for the above activities.

All the installations of vertical pipes, branching pipes, drains and other utilities required to have the tunnel floor free of flowing or standing water shall be installed by the Contractor at his own expense and shall be firmly fixed in place to avoid any loosening or movement during the pouring of the concrete.

If concrete is poured on soil materials, all soil surfaces on which concrete shall be poured shall be clean, wet, free of standing or flowing water, ice, sleaze or mud. The pouring surface shall be carefully wetted according to the instructions and the approval of the Service, if it absorbs water.

The tunnel floor, except that of rock, shall be cleaned of all water, mud, fill materials and materials which were loosened during the excavation of the tunnel. The soil foundation materials shall be carefully compacted before pouring the concrete in a way satisfying the Service.

49.1.2.3 *Layers of Concrete*

A layer of concrete is defined as the thickness of the concrete which is poured between two (2) consecutive and adjacent horizontal construction joints. The allowed pouring thickness of one (1) layer shall generally be equal to two (2) meters for bulk concrete unless shown differently in the drawings or instructed otherwise by the Service.

The minimum time period between pouring of two consecutive layers shall be seventy two (72) hours for bulk concrete and according to the instructions of the Service for all other types of concrete.

The pouring of a concrete layer shall be made at a rate (velocity) such that concrete setting has not started at an intermediate pouring surface before pouring the concrete to cover it.
The surface of a layer shall be the minimum required for the compaction of the concrete in this last layer and at the same time, to create a rough surface for the connection with

the next layer as determined by the Service. All final surfaces which are not poured in a formwork and which shall not be covered by concrete or earth fill shall be slightly elevated above the final level, and the excess concrete shall be removed with a flat stick or will be subjected to the required final processing as shown in the drawings or as determined by the Service.

As time between adjacent pourings of concrete is defined the time between the end of a pouring and the beginning of the next. The minimum time between adjacent pourings for the structures shall be as shown in the following unless determined and approved otherwise:

Structure	Time
Tunnel lining	12 hours
Other locations	72 hours

The minimum time span between the pouring of the concrete in columns and that of beams and slabs resting on the columns shall be five (5) hours. Drawings showing the pouring sequence shall be drafted by the Contractor and shall be approved by the Service.

49.1.2.4 <u>Construction joints - Thermal expansion joints</u>

The construction joints shall be practically horizontal unless shown differently in the drawings or determined otherwise by the Service. Their layout shall be achieved by using formwork where required or other means which ensure their appropriate connection with the next pouring of concrete, provided that keys are not required, unless shown differently in the drawings. All construction joints which end up in visible concrete surfaces, shall be rectilinear horizontal or vertical.

The positions of the construction joints in the concrete shall be those shown in the drawings or approved by the Service.

All joints in the surface of the concrete tunnel lining and other underground structures resulting from the use or non-use of formwork shall be treated as construction joints unless instructed otherwise by the Service. The long joints in the upper part of the concrete-lined tunnel floor shall also be treated as construction joints.

Thermal expansion joints should be constructed in the positions shown in the drawing details or as instructed by the Service. No metal piece placed inside the concrete shall continue through a thermal expansion joint unless shown differently in the drawings or instructed by the Service.

The thermal expansion joints may have a smooth and flat surface or a see-saw surface to ensure the contact of the adjacent structures. The facing surfaces forming the joint shall be completely separated.

The Contractor shall commence the pouring of the second face of a joint only after the first face has fully set. When shown in the drawings or required by the Service, a simple joint filler sheet or other approved material shall be placed on the face of the first layer before commencing the pouring of the second.

The surfaces of the thermal expansion joints resulting from the use of a formwork, shall be carefully cleaned of concrete lumps or other foreign materials by scratching, etching or other effective methods. The surfaces shall be subjected to the treatment described in the immediate following paragraph.

The disruption of the surficial concrete in the construction joints during the initial stages of the hardening should be avoided. Any necessary traffic on fresh concrete shall be performed on wooden planks constructed in a way which does not cause any harm to the concrete.

49.1.2.5 Treatment of Construction .Joints

The construction joints shall be clean and moist but not wet when covered with fresh concrete. The cleaning shall consist of the removal of excess concrete, lose or defective concrete, covers of sand, sealing or insulation material and other foreign materials.

The horizontal construction joints having open and accessible surfaces, shall be prepared to accept the next layer by wet sand-blasting or cutting via an air-water jet as specified below.

If the surface of a layer is full of reinforcement steel and thus not accessible or, if for any other reason the Service considers unwanted to disturb the surface of a layer before the complete setting, the cutting of the surface via an air-water jet shall not be allowed; it shall be required to use wet sand-blasting or the mild blowing by a light brushy hammer. It shall not be allowed to use materials to retard the setting of surfaces.

The cutting of a construction joint via an air-water jet shall be performed after the initial setting but before the complete hardening of the concrete. The surface shall be cut by a high-pressure air-water jet (at a pressure exceeding forty (40) MPa) to remove the excess concrete and to reveal clean, sound aggregates. After the cutting, the surface shall be washed until the water comes out completely transparent.

In the case of processing the construction joints by wet sand-blasting, the work shall be performed immediately before pouring the next concrete layer. The equipment of wet sand-blasting shall operate at a pressure of seven hundred (700) kPa. The sand shall be dense, hard, non-friable and sufficiently dry. The work shall continue until all the inadequate concrete or the concrete which overflowed has been removed; the same with overlays, spots, trimmings and other foreign materials. After the processing, the surface of the concrete shall be carefully washed to remove all loose materials.

The same processing as above shall be performed when the construction joints have been covered with stationary water for a time period exceeding ten (10) days or if they have been covered with foreign substances which cannot be removed by normal cleaning.

If the construction joints are not covered with concrete within twenty (20) days from their construction, the Contractor shall roughen all surfaces by using small air-hammers before commencing the pouring of the next concrete layer.

The thickness of the concrete to be removed from the construction joints shall be indicated by the Service.

The use of formwork to shape the construction joints shall not be allowed unless approved by the Service. When this is necessary, the surfaces or the joints shall be grooved.

The vertical construction joints shall be cleaned by using methods approved by the Service.

49.1.2.6 Concrete Casting in Tunnel Linings

The concrete used for tunnel lining shall be cast by pumping or other method approved by the Service.

The equipment used for concrete casting and the method employed for ail activities shall allow the casting of the concrete in the desired location without segregation of the coarse-grained aggregates. Casting equipment operating with compressed air should not be used. The Contractor shall ensure that all pipes, screws, anchors and other materials to be incorporated in the concrete lining as shown in the drawings, have been installed before casting the concrete. The Contractor shall be responsible for the accurate positioning of all incorporable materials. Any incorporable object which has been installed inadequately or erroneously shall be replaced in its proper position at the Contractor's expense.

During casting of the concrete between the steel reinforcement and the incorporable metallic objects, care should be taken to avoid the segregation of coarse-grained aggregates. At the bottom of beams, slabs or other sections, where the dense reinforcement adjacent to the formwork prevents proper casting, a sand-cement mortar having the same proportions of sand and cement as the concrete to be used shall be cast initially to cover the reinforcement steel.

Mechanical vibrators shall not be used for the compaction of the concrete around mobile incorporable objects unless approved by the Service. In this case, the concrete shall be compacted by tamping.

The concrete shall be cast in a way to ensure the symmetrical loading of the supports of the formwork for the roof of the tunnel. The transverse areas of concreting shall have a length such that the roof and the tunnel walls are cast in a single operation. After the beginning of the concreting of each layer, and after the concrete has completely covered the roof and the walls of the tunnel in the region where the concreting has started, and until the roof and the walls are cast in the remaining section to be concreted, the nozzle of the concrete supply pipe shall be completely embedded inside the concrete to ensure a complete filling of the tunnel section.

The nozzle of the concrete supply pipe shall be marked to indicate the depth of embedment in the concrete at any time. Special care shall be taken to push the concrete inside all anomalies of the surface of the rockmass and for the complete filling of the roof of the tunnel. The operation of the casting equipment shalt be made only by experienced technicians.

The "cold'. joints in the lining of all underground activities shall be avoided as much as possible. In the case of equipment malfunction of if for any reason the casting of the concrete is interrupted, the Contractor shall completely compact the concrete at these joints, with a uniform and constant slope as long as the concrete is still plastic.
The concrete at the surface of such joints shall be cleaned and wetted, as required for the construction joints, before resuming the concrete casting.

The work and the sequence of the concreting at the various sections shall be approved by the Service, and should avoid to create an initial stressing of the reinforcement.

The Contractor shall draft detailed drawings of the concreting, which shall show the dimensions of the layers, the positions and layout of all incorporable objects including the reinforcement bars. The drawings shall comply with the most acceptable standards and methods and shall be submitted to the Service for checking and approval sufficient time before the casting of the concrete.

The Contractor shall inform the Service for the time of concrete casting. The approval of the Service is required before the commencement of the concreting. Concrete casting shall not be permitted if, according to the opinion of the Service, the conditions do not permit adequate concreting.

The concreting shall be performed only in the presence of an authorized representative of the Service, unless in each specific case, it is considered that this is not necessary. Concrete which was cast without the notification and approval of the Service may be required to be removed and replaced by new at the Contractor's expense.

49.1.2.7 Compaction of the Concrete

The concrete must be compacted by internal vibrators unless the Service gives a written approval of other methods. The concrete shall be compacted at the maximum possible density, in order to be free of inclusions of coarse-grained aggregates and air and to be in complete contact with the sub-base at the surfaces of all formwork and incorporable objects.

The type and make of the vibrators, proposed by the Contractor to be used shall be subject to the approval of the Service. They should be capable to vibrate the concrete at a frequency of at least 3600 revolutions per minute under load. The Contractor shall provide all the required equipment for the adequate operation of the vibrators according to the Specifications of the manufacturer. He should also provide at least one (1) spare working vibrator on-site.

Vibrators shall never be used for the horizontal movement of the concrete.

Formwork vibrators or surface vibrators shall not be used unless specifically approved by the Service. The intensity of the vibration shall be sufficient for adequate compaction. The duration of the vibration shall be limited to the absolutely necessary. Excessive vibration of the concrete shall not be allowed.

The compaction of the concrete used in the lining of tunnels shall be made with mass vibrators (sinking vibrators) or with vibrators attached on the formwork. The formwork vibrators shall be firmly attached on the formwork and shall operate at a speed of at least eight thousand (8000) revolutions per minute during the vibration of the concrete, or as approved by the Service.

The formwork vibrators shall be placed in successive positions spaced at intervals not exceeding one hundred and twenty (120) cm, immediately behind the moving sloping surface of the concrete on the side walls and the curved parts of the arch. The position of the vibrators on the tunnel roof, their operation, the supply of the concrete, the position of the supply nozzle and the movement of the supply pipe shall be coordinated in a way to achieve the maximum filling of the roof with concrete and to avoid the slump and flow of concrete from the filled roof, due to the inappropriate position and adjustment of the vibrator.

The concrete along the longitudinal construction joint at the bottom of the tunnel shall be compacted up to the face of the excavation surface.

49.1.2.8 Tunnel Metallic Formwork

49.1.2.8.1 Objective

The construction of the tunnel lining at the walls and the roof of the tunnel shall be made with the use of a metallic steel-plated formwork.

The formwork shall be strong and have a sufficient form and construction to withstand the pressures exerted during the casting and vibration of the concrete; it shall also be fixed in the proper location without movement and it shall have the exact shape of the tunnel as required in the design drawings. The formwork shall also not permit the flow of the mortar from the concrete.

The formwork shall be equipped with a transportation train having wheels and moving on rails; the rails shall be appropriately placed on the floor of the tunnels. The formwork may consist of similar sections or elements which shall form a length of at least six (6) meters.

The formwork shall have a series of openings at each side, which shall permit the concreting, the access for the vibration and the inspection of the cast concrete behind the formwork. These openings shall have dimensions of 0.45 m x 0.90 m, with the long dimension parallel to the tunnel axis; their doors shall be opened from balconies for a convenient and safe access and inspection.

The horizontal axis of the openings at the lower row shall be located about one meter and eighty centimeters (1.80 m) above the longitudinal construction joint at the tunnel floor. The centers of the openings of each subsequent row shall be spaced at one meter and eighty centimeters (1.80 m) from the horizontal axis of the previous lower row.

The openings shall be staggered and spaced by two-and-a-half (2.50) m approximately, center-to-center (in the vertical direction); two series of openings shall be constructed near the top of the formwork. The formwork shall be constructed in a way permitting the satisfactory compaction of the concrete at the floor of the tunnel along the longitudinal joint in its whole length.

Before the construction of the formwork and its transportation on-site, the Contractor shall submit detailed construction drawings and a static design for approval by the Service according to the provisions of clause 7 of the T.C.C. The concrete foundation blocks, the curbs etc. that may be required for the support of the formwork are also subject to the approval of the Service.

During the design and construction of the metallic formwork, the Contractor should consider that the tunnels also have curved sections, in order to provide the required additions and modifications (e.g. provision of metal wedges attached on the formwork) to form the curvatures. The Contractor should also consider the existence of recesses for the electromechanical equipment, enlargement etc. in order to provide the required additions and modifications on the formwork or to combine it with other formworks.

Regarding the formworks for the construction of the final internal lining of the other concrete structures, the provisions of clause 7 in conjunction with clause 6 of the T.C.C. shall apply.

49.1.2.8.2 Clearing - Oiling of the Formwork

Before the metal formwork is used for the casting of concrete, its surface should be carefully cleaned to be free of mortar or other foreign substances.

Before the casting of concrete, the surface of the formwork shall be coated with a special oil, which shall consist of refined motor-oil of special type, with one of more substances adequate for the desired objective.

49.1.2.8.3 Removal gf the Formwork - Deficiencies of the Concrete

To facilitate the achievement of sufficient progress but also to achieve the quick repair of any defects at the surface of the concrete, the formwork shall be removed immediately after the concrete has gained sufficient strength to avoid cracking, fracturing, swelling etc. The development of the minimum required strength to remove the formwork shall be checked by testing at least three (3) samples for each tunnel section.

In the case of low temperatures, the Service may command that the formwork remains in place for a longer time period in order that the concrete gains the required strength.

Immediately after the removal of the formwork and if possible within twenty four (24) hours, the repairs and the treatment of the surface of the concrete which are considered necessary by the Service shall be performed concurrently with the maintenance of the concrete. The repairs shall be performed by specialized technicians, using a cement and sand mortar in a proportion of one (1) to (2) up to one (1) to two and a half (2.5) and according to the instructions of the Service.

The Contractor shall inform the Service before commencing any repair work. Materials, procedures and operations for the repair of the concrete, as well as activities for the finishing of the final surfaces, shall be made according to the commands and the instructions of the Service. Regarding the rest about the repair and treatment of the concrete surfaces, the provisions of clause 6 (sub-clause 6.15) and clause 18 of the T.C.C. shall apply.

49.1.2.9 Tolerances of the Final Tunnel Lining

49.1.2.9.1 Alignment and slope

The axis of the tunnel is determined as the geometrical locus of the intersections of the horizontal and vertical axes of the tunnel sections as shown in the drawings.

The deviation of the tunnel axis and the tunnel lining from the determined alignment or slope shown in the drawings shall not exceed one (1) cm.

49.1.2.9.2 Deviation from the Internal Dimensions of the Tunnel

The difference between the minimum and maximum ,diameter of the tunnel lining at any section shall not exceed five (5) cm.

49.1.2.9.3 Deviation of the Thickness of the Tunnel Lining

The thickness of the tunnel lining, measured between the internal face of the tunnel lining and the Line "A' shall not be less than that determined in the relevant clause of the specifications.

49.1.2.10 Tolerances _of the Entry Structures of the Tunnel

49.1.2.10.1

The deviation of the constructed linear perimeter from the pre-determined location shall not exceed:

At six (6) m:	one and three tenths (1.3) cm
At twelve (12) or more m :	two (2) cm

49.1.2.10.2

The deviation from verticality or from the predetermined slope or form the curves of all the surfaces of walls, piers, etc. shall not exceed:

At three (3) m:	one and three tenths (1.3) cm
At six (6) m:.	one and nine tenths (1.9) cm
At twelve (12) or more m:	three and two tenths (3.2) cm

In filled areas the above tolerances shall be doubled.

49.1.2.10.3

The deviation of the dimensions of the cross-section of columns, beams and of the thickness of slabs and walls shall not exceed:

Minus: five (5) mm
Plus: ten (10) mm

49.1.2.11 Tolerances in the Position of Steel Reinforcement and Incorporable Metallic Objects

49.1.2.11.1 Tolerances for the Steel Reinforcement

(1) The length of overlapping shall not be less than the prescribed by more than twenty-five (25) mm.
(2) The deviation of the protective cover of the reinforcement in places where its width is five (5) cm, shall not exceed six (6) mm and where its width is seven and a half (7.5) cm or more it shall not exceed thirteen (13) mm.

49.1.2.11.2 Deviation of the Reinforcement from its Prescribed Location

The deviation from the distance indicated in the drawings shall not exceed twenty-five (25) mm.

49.1.2.11.3 Tolerances in the Placement of incorporable Metallic Objects

The deviation from the distance indicated in the drawings shall not exceed five (5) mm.

49.1.2.11.4 Tolerances in the Placement 9f Footing Slabs

(1) The deviation from the horizontal level shall not exceed three (3) mm.
(2) The maximum level difference along a diagonal shall not exceed three mm.
(3)

49.1.3 Accounting - Payment

The final lining of the tunnel (normal section, recesses, enlargements, side walls, entry structures near the tunnel ends etc.) shall be paid by the cubic meter of concrete of class B25 or B35 (depending on the specified and constructed class), completely constructed final tunnel lining according to the provisions in the present clause, in clause 47 and in clause 6 of the T.C.C.

In excess of the quantity which is statically required, the quantity which covers the space between Lines AN and V and which has not been paid as shotcrete is also accounted for and paid. Quantities for the filling of over-excavations are neither accounted nor paid.

It is clarified that in the case of over-excavations beyond Line "B" and if the layer of the shotcrete has been partly or completely displaced outside Line "B", during the accounting of the concrete of the final lining, the contractually payable quantity of the shotcrete is subtracted as if it had been placed completely inside of Line "B". In the comparison with Line "B", the average of each category (class) should be used and not each section separately.

49.2 SHOTCRETE AND CAST-IN-SITU CONCRETE B15 FOR THE FILLING OF GEOLOGICAL FALLS

49.2.1 Objective

This clause refers to the supply of all required materials, equipment and manpower for the filling with shotcrete or cast-in-situ concrete of class B15, the cavities of geological falls, according to the design and the instructions of the Service, for which the Contractor is not responsible.

49.2.2 Contents

The activities described in the present clause include the supply, transportation and storage on-site of the necessary materials for the production of concrete of class B15, shotcrete or cast-in-situ, and the supply of all the man-power and mechanical equipment for the production, mixing, transportation, casting, vibration and maintenance of the concrete inside the tunnel and its placement in the locations where required.

The activity also includes the construction of a make-shift formwork that may be required to facilitate the filling of the fall, as well as the low pressure grouting to fill the void between the rock-mass and the concrete placed to fill the fall, in case of cast-in-situ concrete. The filling of the fall may be made either before or after the placement of the shotcrete which is required for the support of the tunnel (sub-clause 48.3 of clause 48 of the T.C.C.). If the filling is performed after the support, the Contractor is required to form the final surface, at his own expense, in a way that satisfies the requirements of the specifications for the installation of the water-proofing system.

If approved by the Service, it is permitted to fill a fall, either partly or completely, concurrently with the final lining, after the construction of the support required by the design. The payment of the Contractor for the concrete required to fill the fall shall be made using the present clause and not using the unit price of the final lining.
The unit price used for the payment of the aforementioned activities and materials includes all other expenses required for the completion of the construction, such as sampling, laboratory testing of aggregates and concrete, surveying etc.

49.2.3 Specifications

The activities of this clause shall be performed according to the Specifications of sub-clause 48.2 (removal of the products of geological fails) of the T.C.C.

49.3 STEEL REINFORCEMENT IN GENERAL

(refers to sub-clauses 49.4 and 49.5)

49.3.1 Objectives

The activity included in this clause consists of the supply of all equipment, manpower, materials and mechanical plants, and the performance of all actions related to the placement of steel reinforcement in the concrete for permanent structures. The Contractor shall provide, cut, bend and install all reinforcement bars and structural grid shown in the drawings or indicated by the Service and shall draft all the drawings of the steel reinforcement mentioned in the present clause.

49.3.2 Materials

All the steel reinforcement shall be new, clean, straight and free of rust. Unless instructed otherwise, all the reinforcement shall be grooved bars complying to the requirements of DIN 488 for grooved bars of quality 42/50 RU or 41/50 RK or for structural grids of quality 50/55 GK or 50/55 PK or 50/55 RK. The metal reinforcement bars shall comply to the above standards or the equivalent standards of the European Union countries and of the European Economic Area (E.E.A.) or the equivalent standards and specifications approved by the Service.

The steel reinforcement shall be stored on special bases or they shall be protected from its contact with the ground in some other way.

49.3.3 Checks

The Contractor shall provide to the Service two (2) stamped copies of all check reports performed in the laboratories of the manufacturer or in another approved laboratory, according to the present Technical Conditions of the Contract. The stamped copies of the reports shall be submitted to the Service before the delivery of the material on site.

49.3.4 Performance of the Work,

The performance of the work shall be of high quality and shall be according to the latest and best standard methods.

49.3.4.1 Cutting and Bending

The reinforcement bars may be bent at the factory or on-site. Cutting and bending shall be performed according to an approved standard and using approved methods. Bending of the steel by heating shall not be permitted unless specifically approved by the Service.

49.3.4.2 Installation

Before the installation of the reinforcement, the surfaces of the bars as well as the surfaces of any metal bar supports shall be cleaned of the thick foliated rust, of loose rust, dirt, greasy substances and other foreign materials, which, according to the opinion of the Service are unacceptable. Thick foliated rust which can be removed by a strong rubbing using sand-paper or a similar treatment is considered unacceptable.

After their placement, the reinforcement bars shall be maintained clean until they are completely buried in the concrete.

The reinforcement bars shall be placed, as shown in the drawings or according to the instructions of the Service. Unless specified otherwise, the measurements during the placement of the re-bars shall be made with respect to the axis of the bars. Unless specifically approved by the Service, the net distance between two parallel bars shall not be less than one and a half (1.5) times the diameter of the bar and in any case not less than 25 mm.

After its placement, the reinforcement shall be checked for compliance with the design requirements with respect to the diameter, shape, length, welding, position and quantity.

The reinforcement bars shall be installed exactly as shown in the drawings or approved by the Service and shall be held in their positions, so that they are not displaced during the casting and compaction of the concrete. Special care shall be taken to avoid the disturbance of the reinforcement already placed in the concrete. Wire, special bases, metal hooks, metal spacers, reinforcement bars either anchored or not anchored in the ground or other satisfactory supports made of steel or concrete, approved by the Service, may be used by the Contractor to support the reinforcement bars. Such supports shall have a sufficient strength to keep the reinforcement in its place for the whole duration of the concreting operations.

The supports shall be used in such a way that they do not facilitate the discoloration or the erosion of the concrete. They shall also be placed in a way so that they do not protrude from the concrete. When necessary, to avoid ugly stains on the exposed surfaces, the supports of the reinforcement shall be constructed of concrete or stainless steel.

The minimum clear distances between the edge of the main reinforcement and the surface of the concrete or other surfaces shall comply with the drawings or with the directions of the Service. The concrete cover of stirrups, hooks, spacer bars, and similar secondary reinforcement may be decreased by the diameter of these bars if approved by the Service.

49.3.4.3 Connections

All connections of the reinforcement shall be constructed as shown in the drawings or according to the instructions of the Service or as shown in the specifications supplied by the Service. Connection of the bars by overlapping may be applied if the overlapping sections of the bars are placed in contact and are securely fastened by wire in a way approved by the Service. Alternatively, the bars may be placed away of each other in a way that the whole surface of each bar is incorporated inside the concrete.

The contact welding of bars, instead of their connection by overlapping shall be permitted if approved by the Service and according to the provisions of the latest issue of AC1 Code 318. The welding shall be performed according to the AWS standards. The weldings shall be performed by specialized technicians, submitted to the standard tests as described in the "Operations Qualifications" of the AWS. Electrodes of the low-hydrogen content type (AWS E-7015-16) shall be used for the welding of the reinforcement.

All weldings shall use the whole strength of the smaller bar (they shall increase the strength of the smaller bar). In the welding, the bars shall have sufficient overlapping to transfer the stress to the bars via the connection. Adjacent reinforcement grids shall be connected by an overlap not less than fifteen (15) cm with the ends of the overlapping securely fastened to each other by wire or fixed by standard connectors.

49.3.5 Protection of the Reinforcement for Future Use

Exposed reinforcement, which shall be incorporated in the concrete in the future, shall be protected against oxidation by a thick coat of cloth soaked in asphaltic material as determined by the Service. The thus protected reinforcement shall be carefully cleaned before being incorporated in the concrete.

49.3.6 Drafting of Detailed drawings of Re-bars

The Contractor shall draft all the construction drawings of the reinforcement. These drawings shall include all the drawings for the placement of the bars, drawings for the bending of bars, reinforcement tables and other reinforcement drawings which are required to facilitate the construction and the placement of all reinforcement bars.

The reinforcement construction drawings shall be drafted based on the application design which the Contractor shall perform and the Service shall approve. These drawings shall be finalized, adjusted to the actual conditions, during the progress of the work and shall be submitted for approval at least thirty (30) calendar days before the placement of the reinforcement steel, unless approved otherwise by the Service.

49.3.7 Accounting - Payment

The accounting for the payment of the supply and placement of steel reinforcement bars shall be based on the number of kilograms of steel reinforcement bars actually placed in the concrete according to the drawings and the reinforcement tables, as approved by the Service or as ordered and approved by the Service.

The weight of the reinforcement, including the lengths of the overlapping shown in the detailed drawings shall be computed based on their length and the unit weight shown in the weight catalogues for the bar used. Where the bars are welded, the accounting and payment for the overlapping of the bars shall be made as if the bars were connected by overlapping.

No payment for steel reinforcement shall be made for damages, losses or overlapping made exclusively to facilitate the Contractor. No special payment shall be made for supports, spacers, connectors, wire or other connection accessories, whose cost shall be included in the contractual offered price for steel reinforcement.

49.4 STEEL REINFORCEMENT ST I

This clause refers to steel bars of quality St I, which are incorporated in concrete structures as reinforcement.

The contents, the specification, the accounting and the payment of this Clause are mentioned in the previous sub-clause 49.3. Where in the drawings a reinforcement quality St I is mentioned, the bars shall have a plain circular cross-section.

49.5 STEEL REINFORCEMENT ST III

This clause refers to steel bars of quality St III, which are incorporated in concrete structures as reinforcement.

The contents, the specification, the accounting and the payment of this Clause are mentioned in the sub-clause 49.3 of the present clause.

Clause 50 : DRAINAGE - GROUTING - BOREHOLES IN UNDERGROUND WORKS

50.0 GENERALITIES - CONTENTS OF THE PRESENT SPECIFICATION

The present specification covers the following activities of projects constructed by underground excavation:

1. Generalities on drainage - grouting - boreholes [Sub-clause 50.1 (Applicable in sub-clauses 50.2 to 50.8)]
2. Drilling of drainage holes (Sub-clause 50.2)
3. Grouting boreholes with stages (Sub-clause 50.3)
4. Investigation boreholes, horizontal, vertical or inclined, with sampling, inside or outside the tunnel (Sub-clause 50.4)
5. Supply and installation of buried metal pipes and connectors (Sub-clause 50.5)
6. Connection with grouting boreholes (Sub-clause 50.6)
7. Supply and transportation on-site of grouting materials (Sub-clause 50.7)
8. Production and pouring of grout in dry weight (Sub-clause 50.8)

50.1 GENERALITIES ON DRAINAGE - GROUTING BOREHOLES

50.1.1 Generalities

The activities described in the present sub-clause 50.1 consist of the complete supply of the work-force, materials, equipment and plants required for the performance of all activities related to the borehole drilling and grouting required for the project and includes the drilling of investigation boreholes and control boreholes, the drilling of drainage holes, the drilling of holes for the installation of instruments, the drilling, cleaning and performance of injection tests, the drilling of holes for contact grouting and stabilization, the production of mixes for grouting, the supply, processing, transportation, storage, mixing and injection of grout materials, the refilling and sealing of completed grouting boreholes, the collection and disposal of the drilling products, excess waters and waste grout, the cleaning of the site after the completion of the works, the construction of drains and all other activities related to the drilling, grouting and drainage.

In relation to the contact grouting, it is clarified that the compensation of the Contractor is referred to the unit price of the final lining, and the present section is applicable only with reference to the Specification.

The extent, methods, types, programme and the details of the drilling activities, grouting and drainage of the works that may be required are indicatively shown in the drawings and shall be adjusted according to the actual conditions during the construction of the project.

The Service shall determine the drilling and grouting methods, the locations, number, distances, directions and depths of the drainage and grouting boreholes, as well as the applied pressure and the grout mixes that will be used in the grouting activities, depending on the nature of the conditions revealed during excavation, the results of water injection tests, and the results and conditions of the grouting boreholes already completed.

The Contractor shall conform, during the execution of the drilling and grouting activities, with the general principles, the method and the order of the activities, as described below, according to the requirements of the present specification, the drawings and the instructions of the Service.

The activities to be performed include, however not restrictively, the following:

50.1.1.1 Cement Grouting

(1) The drilling and execution of contact grouting under low pressure, behind the final concrete lining of the tunnel, between the concrete lining and the water-proofing membrane.

(2) The drilling and execution of peripheral stabilization grouting under high pressure and/or water-proofing of the surrounding rock-mass or ahead of the tunnel excavation front.

(3) The drilling and execution of grouting in other locations determined by the Service.

50.1.1.2 Installation of Instruments

(1) Boreholes with sampling (investigation or control) to determine the condition of the rock-mass behind the excavation front or in other locations and for the control of the effectiveness of grouting activities.

(2) Drilling of holes in various locations of the project for the installation of instruments.

50.1.1.3 Drainage

Drilling of drainage boreholes as shown in the drawings or as the Service shall determine.

The Contractor shall perform all the drilling and grouting activities according to the specifications, the design and in a manner which complies with the rules of engineering.

The drilling and grouting activities required for rock anchors, prestressed rock anchors and the installation of anchor rods are covered by the Clause 48 of the T.C.C.

50.1.2 Drilling of Boreholes

50.1.2.1 <u>Generalities</u>

The position, size, depth, direction and the spacing of the grouting and drainage boreholes, the investigation and control boreholes and the boreholes for the installation of instruments shall be in accordance with the drawings and the directions of the Service.

immediately after the interruption or the completion of the drilling, the hole shall be protected by a cap, a cover or other adequate protection of its top, until the performance of the work inside the hole shall be re-opened at the Contractor's expense. Ali boreholes shall be cleaned by washing using water or compressed air and shall be clearly marked during the performance or the work and after its completion, according to the instructions of the Service.

In the case of borehole drilling in loose soils, metal casing shall be used to retain the walls of the borehole. No payment shall be made for borehole casing that may be required for grouting boreholes, investigation boreholes, control boreholes and boreholes for the installation of instruments, and is left in place to facilitate the Contractor or due to his actions, since the related cost is included in the corresponding contract prices for borehole drilling.

If the casing is abandoned inside the borehole at the request of the Service due to project requirements, the Contractor shall be compensated for the actual weight of the casing in kilograms.

50.1.2.2 <u>Drilling of Investigation Boreholes (Sampling Boreholes)</u>

50.1.2.2.1 <u>Objective</u>

This item refers to the execution by the Contractor of sampling boreholes at the request of the Service; these boreholes may be required to investigate the condition of the rock-mass which surrounds the tunnel of in other locations, or to evaluate the effectiveness of grouting operations performed either from the ground surface or inside the tunnel.

50.1.2.2.2 <u>Method Statement of the Work</u>

All sampling boreholes shall be performed using standard drilling equipment, appropriate for the type of the material to be drilled and the specified minimum core recovery. Borings in rock materials shall be performed using only double or triple core samplers or double wall split spoon samplers with diamond bit of an accredited manufacturer, adequate to achieve the required core recovery for the condition of the rock-mass (with inset diamonds, diamond powder, step-bit etc.).

The Contractor may select the initial and intermediate diameters of each borehole, depending on the available equipment provided that the diameter of the borehole in the loose topsoil shall not be less than one hundred and one (101) mm and the diameter at the bottom of the borehole shall not be less than seventy six (76) mm.

The boreholes shall be cased, where required, to achieve adequate drilling and sampling.

The Contractor may use cement grout to help him stabilize the borehole walls, only after the written approval of the Service and at his own responsibility. All activities, like drilling through the grouted section, down time, washing etc. made for the stabilization of the borehole walls according to the above, shall not be paid to the Contractor. Grouting of a borehole which is going to be used subsequently for an injection test shall not be permitted.

The Contractor must provide all the required water for borehole drilling. The recirculation of drilling water shall be acceptable only if at the location of each borehole, there exists a sedimentation tank of adequate capacity which shall be approved by the Service. Only clean water shall be used for the drilling of boreholes.

All boreholes shall be drilled in a technically sound way by capable and experienced personnel and special care shall be made to recover cores in the best possible condition, from all boreholes in formations which permit an adequate degree of core recovery.

The drilling stem shall be retrieved to recover the cores at the frequency which permits the maximum core recovery. The intermediate steps of the boreholes shall be limited to one meter and a half (1.50) m, unless determined otherwise by the Service.

The drilling stem shall be retrieved immediately if the progress of the boring indicates that the corer has been encased or that the core is being split in pieces, regardless of the length of the individual drilling step.

If the core recovery for a drilling step of at least one meter is less than eighty per cent (80 %), the length of the next drilling step shall be reduced to fifty percent (50 %) unless directed otherwise by the Service.

The core recovery in rock shall not be less than ninety five percent (95 %), and in loose topsoil materials it shall not be less than sixty percent (60 %). If the core recovery is less than the above limits, the Service can, at its sole discretion, accept or reject the borehole. During the boring, if required, the Service may request the dry sample recovery (i.e. without water circulation) without extra payment to the Contractor. The dry sample shall be considered as a core, regarding the minimum core recovery.

The Contractor shall pay for all investigation boreholes using pressure grouting, in the cases that a relevant order has been given by the Service.

50.1.2.2.3 Securing the Position of a Borehole

Immediately after the removal of the drilling rig from the location of the borehole, the Contractor shall mark the position using a concrete block. A rod having a diameter of at least twenty five (25) mm and a height at least one-and-half (1.5) meter, as well as a metal plate shall be attached in the concrete block; the number of the borehole shall be engraved on the metal plate.

50.1.2.2.4 Casing and Storage of Samples

Immediately after they are removed from the sampler, the cores shall be placed in appropriate wooden boxes of a type approved by the Service. The boxes shall not be longer than one hundred and seven (107) cm and shall not have more than five (5) parallel series for the placement of the cores. They shall have a cover made of dry plywood and a padlock. On each box, on both the outside and the inside surface of the cover, the number of the borehole, the number of the specific box and the total number of boxes of the borehole, and the sampling depths shall be clearly marked. On the front side of the box, the number of the borehole and the included sample depths shall be written. The cores shall be placed in the boxes according to the sequence of their recovery using wooden separators and they shall have marked on them the depth at the beginning and at the end of the advancement of the sampler. The sampling direction shall be marked with an arrow. The spacing where no sample was taken shall be marked with a sign indicating "no sample". The internal side of the cover and the front of the boxes shall be painted white.

Each box shall contain cores of only one borehole.

For record-keeping reasons, the Contractor shall take pictures of the sample boxes, immediately after the end of the drilling according to the instructions of the Service. The pictures shall be taken under appropriate conditions of lighting, using a good quality, fine grained, high contrast color film. The Contractor shall give to the Service, within two weeks from the completion of each borehole, the negatives with two sets of photos having a size of (9 x 12) cm or the closest standard size, on good quality paper, ordered in a sequence inside a photo-album. The cost of the pictures is included in the contractual unit price for investigation borehole drilling.

Any loss of cores or confusion regarding the coring sequence may require the repetition of the borehole at the Contractor's expense.

After the end of the investigation activities and within a time period determined by the Service, all the sample boxes shall be transported to a storage indicated by the Service at the Contractor's expense. During the delivery of the boxes an appropriate dispatch-receive document shall be signed.

It is evident that during the execution of the investigation activities, the Contractor is obliged to stow the boxes containing the sample cores, in a space of his choice, adequately protected and covered with a plastic cover.

50.1.2.2.5 Borehole Logs

For each borehole, the Contractor shall maintain detailed daily logs of the approval of the Service, which will contain in detail, the number and location of the borehole, the inclination and its direction, the drilling date, the type and diameter of the cover/sampler used, the length of the borehole casing, the achieved work progress, the possible difficulties and delays, the percentage core recovery, the Rock Quality Designation (ROD), the advancement rate of the cutting bit (m/hr), the description of the penetrated layers and their special characteristics (clay seams, open cracks, soft or fractured rock), notes concerning the water conditions (percentage of returning water, positions of abnormalities in water loss, changes in the color of the returning water, colors of the water in artesian zones, changes in water elevation etc.), details on water injection test. the water level in the borehole in the beginning and at the end of the work shift.

The Contractor is obliged to submit, adequately signed, the above detailed daily log to the Service in five (5) copies and within twenty four (24) hours. After the end of the borehole, the Contractor shall submit to the Service the geological section of the borehole.

The fact that the Service may be present and maintain its own records of the drilling does not waive the obligation of the Contractor to maintain the above data accurately.

50.1.2.2.6 Tolerances

For boreholes of up to fifty (50) m deep, the maximum allowable total deviation from the verticality or from the theoretical axis of the borehole shall be two percent (2 %) of the corresponding depth of the borehole. The deviation shall be measured with a special instrument approved by the Service, which the Contractor shall obtain at his expense. Measurements of the deviation shall be taken by the Contractor at his expense, at the command of the Service, at intervals of depth not exceeding twenty (2) m for each borehole.

The results of the measurements shall be compiled by the Contractor in a special report which shall be an annex of the detailed daily boring log. Two (2) copies of the report shall be submitted to the Service, with two (2) copies of the films showing the deviation measurements.

50.1.2.2.7 Presentation of the Results

After the end of the investigation activities, the Contractor is obliged to submit a Technical Report which shall describe the activities performed, shall present the results of the investigations and shall evaluate them. The report shall be accompanied by the geological sections of the boreholes. These sections shall include the position (co-ordinates) and the elevation of the top of the borehole, the type of the drilling rig, the date of the beginning and of the end of the drilling operations, the technical characteristics of the borehole (casings, diameters, samplers etc.), the retrieved samples (their types), the lithological section, the sample recovery, the Rock Quality Designation (RQD), the rate of drilling in relation to the pressure applied on the drilling rods, the results of the water injection tests, their graphical changes, the representation of the piezometers and the positions of installation of the perforated tubes, elements of micro-tectonics (discontinuities) and the statistical processing of the measurements of the discontinuities, as well as any other useful information required by the Service.

The report shall be submitted in six (6) copies. One copy of the set of the drawings of the report on drawing paper as well as the negatives of the pictures shall also be submitted. No extra payment is foreseen for the drafting of the above Technical Report and the relevant cost is included in the contractual price for the drilling of investigation boreholes.

50.1.2.3 Drilling of Boreholes for Grouting and Drainage

50.1.2.3.1 Objective

This item refers to the drilling by the Contractor of grouting and drainage boreholes in the rock-mass surrounding the tunnel or in other positions according to the instructions of the Service.

Grouting and drainage boreholes shall be drilled in the positions indicated in the drawings. Grouting and drainage boreholes may be drilled through the surface of the concrete if, according to the opinion of the Service, it is necessary to drill supplementary boreholes to ensure sufficient water-insulation or drainage according to the instructions of the Service, depending on the actual conditions revealed during the progress of the work.

It may be required to drill grouting and drainage boreholes at any angle. It is pointed out that if boreholes are drilled for contact/filling grouting in locations where a water-proofing membrane is installed, the Contractor is obliged and is responsible to take all required measures to avoid any damage to the waterproofing system.

50.1.2.3.2 Drilling of Grouting Bore:4s

The Service shall determine the grouting boreholes to be drilled using rotary drilling equipment with a diamond bit without coring and those to be drilled with percussion drills. The use of "ROD DOPE grease or other lubrication agent for the rods of a rotary borehole shall not be permitted.

The minimum diameter of a grouting borehole shall be one-and-a-half (1 1/2) inch.

The grouting boreholes drilled through the surface of rock and of concrete shall be drilled through pipes installed on the rock or on the concrete, as shown in the drawings or as described in paragraph 50.1.3 of the present sub-clause. It is clarified, however, that contact/filling grouting behind the final lining shall be performed through pipes placed inside the lining by the Contractor during concreting. These holes shall be placed according to a programme approved by the Service and no extra payment shall be approved for any omission of this requirement.

After drilling and grouting the boreholes in a certain region, it may be considered necessary to perform supplementary grouting. Drilling for the second stage grouting shall be performed through the holes of the first stage grouting.

Boreholes for stabilization grouting shall be drilled in any direction shown in the drawings or required by the Service. The Contractor is not authorized for any compensation due to a possible modification of these directions or for drilling holes in any direction required by the Service.

The drilling of grouting boreholes in a distance less than twelve (12) m from holes being grouted shall not be permitted.

If the Service does not give different directions, the initial grouting sleeves and the initial grouting holes in each sleeve inside the tunnel shall be placed in large distances and shall be opened and grouted before the drilling and grouting of the intermediate holes.
In certain locations, it may be required to perform supplementary grouting boreholes in addition to those already drilled and grouted. No compensation shall be given for the drilling of the above boreholes or for the transportation of equipment in other sites and its return to a region already grouted.

Where required, according to the in-situ conditions or the directions of the Service, the drilling and grouting shall be performed in consecutive stages. These activities shall include the drilling of a borehole up to a certain depth, grouting of the hole at this depth, cleaning of the hole by washing or by another appropriate means before the grout in the hole sets and requires re-drilling, making sure that the grout surrounding the hole sets, drilling of the hole to an additional depth, second stage grouting and then drilling in the same way and grouting of the hole in different depths until the full length of the hole has been drilled and grouted, according to the instructions of the Service.
Re-drilling due to the omission of the Contractor to clean the hole before the grout sets, shall not be paid.

If the grout is allowed to set inside the hole according to the command of the Service, the required re-drilling shall be paid at a rate of fifty percent (50 %) of the contractual unit price per linear meter of drilling grouting boreholes in stages of depth in ten (10) meter increments, regardless of the depth.

No additional compensation shall be paid to the Contractor in excess of the contractual unit prices, for drilling grouting boreholes in stages, due to the requirement to interrupt the drilling to perform grouting, to clean the holes before the resumption of the drilling or for the required transportation of the equipment due to the requirements of this sequential grouting operation in small or larger depths.

With the progress of the works, the appearance of water seepage or the condition of the surrounding rock-mass may indicate that certain parts of the already lined with concrete formations, require further water-proofing, which may require the drilling of boreholes through the concrete, inside the underlying or surrounding rock. Connection pipes to the grout supply conduit shall be installed according to the instructions of the Service.

Before the drilling required for the grouting of formations surrounding the tunnel ends, and the locations where the tunnel follows protrusions-cavities of the rock-mass, the Contractor shall complete the installation of the structural concrete and the concrete lining as well as the activities for the placement of mortar or grout.

After the completion of the drilling of each borehole, this shall be protected from plugging by placing a temporary cover or other appropriate protection, until it is grouted. Boreholes which become plugged before they are grouted shall be re-drilled at the Contractor's expense.

50.1.2.3.3 Drilling of Drainage Boreholes

At least seven (7) days after the completion of the peripheral stabilization grouting of the tunnel and according to the instructions of the Service, the Contractor shall drill drainage boreholes, through pipes incorporated in the concrete lining, to a depth of four (4) meters or more, according to the drawings and as required by the in-situ conditions or the instructions of the Service.

The drainage boreholes shall be drilled using rotary or percussion-rotary equipment and according to the instructions of the Service. The minimum diameter of the drainage boreholes shall be three (3) inches. All drainage boreholes to be drilled by the Contractor, after having reached the required depth, shall be washed for ten (10) minutes or more until the returning water becomes clear.

The drainage boreholes shall be drilled in locations determined by the Service, either vertically upwards or downwards or inclined and at the depths indicated in the drawings or according to the commands of the Service.

No drainage boreholes shall be drilled until all adjacent grouting boreholes in a minimum radius of twenty (20) meters have been drilled and grouted to their final depth, unless directed otherwise by the Service.

In the case that the drainage boreholes are filled with grout or become plugged by another method becoming useless, due to lack of care by the Contractor, the Contractor shall re-drill these boreholes at his own expense in order to ensure adequate drainage.

if, after the completion of the grouting in a given area, and after the drainage boreholes are drilled, it is considered necessary to drill and grout supplementary boreholes, it may be required that the Contractor has to re-drill drainage boreholes previously opened to ensure adequate drainage. This re-drilling shall be paid at a unit price equal to fifty percent (50 %) of the contractual unit price for the linear meter of drilling drainage boreholes to depths between zero (0) and twenty-five (25) meters, regardless of their actual depth.

The Service may require the installation of perforated PVC tubes in the drainage boreholes in regions where there is danger of the walls collapsing or the hole becoming plugged due to the alteration and weathering of the rock-mass. For drainage holes having a diameter of three (3) inches, PVC tubes having an external diameter of two (2) inches shall be used. The PVC tube shall have six (6) longitudinal slots per linear meter, having a width of one (1) mm and a length of fifteen (15) cm, arranged in equal distances along the periphery.

50.1.2.4 Drilling of Control Boreholes

During the drilling of grouting boreholes, it shall be required to drill control boreholes having a minimum diameter of three (3) inches, with concurrent coring, according to the instructions of the Service.

The control boreholes shall be drilled in stages with concurrent execution of water injection tests in any direction and at any depth. After the completion of the drilling of the control boreholes they shall be grouted under pressure.

The control boreholes shall be considered as grouting boreholes with respect to the drilling, washing, injection tests and grouting and the requirements of paragraphs 50.1.2.2, 50.1.2.3, 50.1.4 and 50.1.5 of the present sub-clause shall apply.

50.1.2.5 Drilling of Boreholes for the installation of Instruments

As described in clause 51 of the T.C.C., the Contractor shall perform all the borehole drilling required to install level observation wells, extensometers, convergence anchors and other instruments. The minimum diameter of each hole shall be as described in clause 51 of the T.C.C.

The Service shall determine the locations of the boreholes to be drilled with rotary drilling equipment and those to be drilled with rotary-percussion drills. Coring may be required in the boreholes to be drilled with rotary drills, according to the commands of the Service.

Before the installation of the measurement equipment, the boreholes shall be washed and water injection tests shall be performed as determined by the Service.

The divergence of the boreholes for the installation of instruments, as well as of all control boreholes having a length exceeding fifty (5) meters, shall be checked by the Contractor, at no cost to the Service, according to the requirements of paragraph 50.1.2.2.6 of the present sub-clause. If the results of this check, at any point, give divergence from the verticality of from the theoretical axis of the borehole higher than two percent (2 %) for depths up to fifty (50) meters and higher than five percent (5 %) of the drilled length at this point for larger depths, then it is up to the absolute judgement of the Service to require that the Contractor drills a new borehole at no cost to the Service.

50.1.3 Metal Tubing and Accessories for the Grouting and Drainage Boreholes

50.1.3.1 Objective

The Contractor shall supply, produce and install all the metal pipes, the connectors and the grout injection hoses, which are required for the grouting and drainage programme of the tunnel, as shown in the drawings or according to the instructions of the Service.

50.1.3.2 Materials

The accessories for the connection of the pipes and the grout injection hoses, shall be supplied, cut, screwed and bent as required by the drawings or according to the instructions of the Service and shall be constructed and placed in the concrete by the Contractor.

The tubing shall be standard black steel-pipes complying to the ASTM A-120 specification, or the corresponding Specifications of the European Union countries and the European Steel Organization or with specifications approved by the Service.

The pipe connection accessories shall be made of soft iron and shall comply with the ASTM A-338 Specification or the corresponding specifications of the European Union countries and the European Steel Organization or with specifications approved by the Service. The grout supplying hoses of the tunnel plug shall comply with the Standards and Specifications as described in the drawings or as approved by the Service.

Anyway, the tubing and the tubing accessories may comply with the corresponding standards holding and approved in the manufacturing country, instead of the aforementioned standards and specifications as approved by the Supervision.

The sizes of the pipes and accessories as well as the grout supply hoses, shall be as shown in the drawings or as determined by the Service.

50.1.3.3 *Execution of the Work*

The metal pipes, either perforated or not, shall be incorporated in the concrete lining of the tunnel for the drainage holes, for the ventilation during the injection of grout, for the filling of over-excavations, if it is possible to create air pockets, for the injection of mortar or grout in the case of stabilization grouting behind the concrete lining of the tunnel and inside the rock-mass surrounding the tunnel, for the contact grouting, as shown in the drawings or according to the commands of the Service.

The grouting pipes installed in the concrete shall end at the surface of the rock-mass and shall start at the internal surface of the concrete, unless shown differently in the drawings or instructed differently by the Service. The dimensions of the grouting pipe for each hole shall be as shown in the drawings or as determined by the Service.

In order to facilitate the removal after grouting, a standard connector and a cap (supply nozzle), covered by an appropriate material shall be connected to the grouting pipe and shall be extended beyond the external surface of the concrete, as shown in the drawings. The holes created when the covered supply nozzles are removed shall be filled immediately and completely by a dry mortar.

The drainage pipes shall be installed and covered with a cap as shown in the drawings or as determined by the Service.

The grouting pipes shall be anchored in the rock or the concrete and the gaps around the pipes shall be carefully sealed by a cloth, grout or other appropriate material, to prevent the entry of concrete or other materials before grouting. All the required clothing or other materials for the sealing shall be provided by the Contractor.

All the pipes and the accessories shall be put together and installed carefully, they shall be secured in their position and they shall be protected from damage during concreting. Care must be taken to avoid plugging or other damage to the pipes before the grouting; any pipe that shall become plugged or damaged for any reason, shall be cleaned or replaced at the Contractor's expense.

50.1.4 Washing and Injection Tests in Investigation Boreholes. Control Borehole, Grouting Boreholes and Boreholes for the Installation of Instruments

50.1.4.1 Investigation Boreholes

The Contractor shall be required to execute water injection tests during drilling using the Lougeon method with a single sealing packer without an extra payment beyond the corresponding contractual prices. Tests using a double packer may be required by the Service after the end of the drilling. All the injection tests shall be executed in the presence and under the supervision of the Service. Injection tests shall be performed along the whole length of the borehole in five (5) meter increments or as determined by the Service.

When an injection test is to be performed, the drilling shall be interrupted and the test shall be performed in the lower five-meter-long portion of the borehole, using a sealing packer that shall be fixed on the walls of the borehole at a distance of five (5) meters from the bottom or according to the commands of the Service.

Before the commencement of the injection test, the hole shall be washed with clean water under pressure and/or air under pressure, until the returning water is clean or for at least fifteen (15) minutes. Subsequently, the hole shall be left for a maximum period of thirty (30) minutes, while the level of the groundwater is measured by the Contractor under the supervision of the Service. In the following, the sealing packer shall be placed in the desired position and the Contractor shall verify that the inflow is prevented when the packer is set under pressure. The maximum water pressure in each test should not exceed the weight of the overburden rock-mass and as determined by the Service. The specific gravity of the rock-mass shall be considered equal to twenty-seven (27) kN/m^3.

During the injection test, the pressure shall be applied in increasing and then decreasing steps as determined by the Service (e.g. 0.25, 0.5, 1.0, 0.5, 0.25 MPa). Five pressure steps shall be applied in each test and the maximum required pressure at the top of the highest drilling stem, shall be one-and-a half (1.5) MPa. In each step of applied water pressure, the Contractor shall maintain the required pressure constant for a total duration of ten (10) minutes at least. In each step of applied water pressure, if it is not possible to maintain a constant required pressure, the sealing packer shall be placed fifty (50) cm or even one (1) meter lower, according to the commands of the Service, until the pressure can be stabilized.

If, during the execution of the test, it becomes evident that the location of the packer is not satisfactory to achieve sealing, the packer shall be repositioned one (1) meter lower or higher than its original position after the approval of the Service. If this attempt to achieve sealing has no effect, then the packer shall be retrieved, inspected and repositioned and a new attempt to achieve sealing shall be made.

Where injection tests using double packers are performed, the water pressure application sequence shall be identical to that prescribed for the single packer tests. The distance between the packers shall be five (5) meters or as determined by the Service.

The equipment for the injection tests should have a capacity of at least one hundred and fifty (150) It/min at a pressure of one-and-a-half (1.5) MPa unless required otherwise by the Service. There should be a capability of continuous adjustment of pressure and discharge. Only centrifugal pumps shall be allowed for the discharge of water. The use of pumps of other types shall be subject to the approval of the Service. Unless prescribed otherwise, the sealing packers shall be of the expendable type with elastic rings. The expansion of the packers shall be performed from the top of the borehole using mechanical means, unless sealing packers with water or air are used. The length of the packer shall be at least four (4) times the diameter of the hole. The internal diameter of the packer shall not be less than nineteen (19) mm.

The apparatus for the injection tests and the drilling rods shall be calibrated by the Contractor as required by the Service and shall not be used before the approval of the Service. The calibration shall be checked at regular intervals, after the command of the Service. The water pressure shall be measured with BOURDON type manometers whose accuracy shall be regularly checked. The apparatus for the measurement of the discharge shall have an accuracy of ten percent (10 %) for discharges larger than one half (0.5) lt/min.
The Contractor shall be obliged to maintain records with all the data of the injection tests and submit them to the Service, in a number of copies determined by the Service, within twenty four (24) hours from the end of the test. The form of the records shall contain the following information (not restrictively):

a. The borehole number.

b. The depth of the section where the test was performed.

c. Date and time of the test.

d. Water level before and after the test.

e. Height of the BOURDON gauge above ground level.

f. Loss of pressure between the gauge and the test section.

g. Loss of water in It/min at each pressure step.

h. Packer types.

i. Special remarks, such as leakage, pressure changes etc.

50.1.4.2 Grouting and Control Boreholes

The grouting boreholes shall be washed with clean water under pressure, under the supervision of the Service, before grouting.

Intersected weak zones, discontinuities or faults, which may be filled with clay or other materials and are washed away by the water, shall be cleaned with water and air under pressure, to remove as much such material as possible and until the returning water is clear. These materials shall be removed from one or more boreholes by supplying water under pressure in an adjacent borehole. AD boreholes which are sufficiently water-tight to allow the development of the maximum required pressure shall be washed at this pressure and the washing shall be continued if an increase in the absorption of water is observed. Boreholes with small water-tightness which may develop low or no pressure shall be washed for five (5) minutes of for as long is required to remove the materials filling the discontinuities; this fact shall become evident by the loss of murky water through surficial discontinuities or through neighboring grouting boreholes.

50.1.5 Grouting

50.1.5.1 Objective

The objective of this activity shall include the following:

a. Supply, storage and use of cement, sand and other admixtures as required for the grout to be injected in the grouting boreholes.

b. Washing under pressure, performance of injection test, mixing and pouring of mortar or grout by injection in the grouting boreholes. Removal of excess waters and wasted grout, cleaning of adjacent positions during the activities and execution of all remaining activities related to the grouting according to the directions of the Service.

50.1.5.2 Generalities

After the completion of the concrete lining of the tunnel and the passage of sufficient time to allow the application of the grouting pressures, an injection of mortar or grout shall be performed using the grouting method (contact grouting at low pressures) to fill all gaps.
The grouting activities described in the present sub-clause 50.1 and in the drawings (dimensions, distances, depths, directions, of boreholes etc.) shall be only considered as a general indication of the required activities. The grouting quantities really necessary, shall be determined by the actual conditions to be encountered during the progress of the work. The mixtures, pressures, rate of pumping and the sequence of injection of the boreholes shall be determined in-situ according to the directions of the Service. The pressures shall be the maximum possible which shall not cause significant deformations of the rock-mass and the concrete.

All grouting operations shall be performed under the supervision of the Service. The Contractor shall be completely responsible for the control and maintenance of the grouting pressures determined by the Service and the damages which may occur by their exceeding.

50.1.5.3 Equipment

All the drilling and grouting equipment shall be of a type, capacity and mechanical condition adequate for the performance of the work, as determined by the Service.
The power of the equipment and its set-up shall satisfy all holding requirements, specifications and code, regarding the safety and the general conditions. The use of internal combustion engines for the operation of the drilling and grouting equipment shall not be allowed. The Contractor shall provide sufficient covered spaces to store the cement at the grout pumping stations.

The grout mixing and injection equipment shall be of a type acceptable by the Service and shall be capable to effectively mix and stir the grout, inject it in the boreholes or through the grout supply connectors with continuous and uninterrupted flow at any pressure determined by the Service.

The mixer shall be mechanically operated, and equipped with a cubic meter counter accurate up to readings of a tenth of the cubic meter for the control of mixing water used in the grout. In addition to the mixer, tanks for mechanical stirring shall be available.
All grouts shall be injected with a piston double acting pump, or other pumping equipment as approved. The grouting equipment shall be maintained in a way acceptable by the Service and it shall be capable for continuous and effective operation during the grouting operations.

Unless directed otherwise, the minimum capacity of the grouting plant shall be three hundred (300) lt/min for the injection of grout in continuous uninterrupted operation at a pressure up to one (1) MPa.

The setup of the grouting equipment shall include a supply pipe and a return pipe connected to the grout pump at the grouting borehole. It shall be possible to achieve continuous circulation and accurate control of the pressures and the grout flow in the grouting boreholes.

The mixing equipment shall never be more than fifty (50) meters away from the location of the grouted borehole.

50.1.5.4 Grouting Materials

50.1.5.4.1 Consistencies and Mixtures

The grout shall consist of cement, water and bentonite, sand or additives, depending on the further Investigations and the local conditions, as determined by the Service.

The grout mixes shall be determined by the Service and they shall vary to match the characteristics of each borehole, according the local conditions.

In general, pure cement grout, with or without bentonite shall be used for the stabilization grouting, while grout containing sand at the appropriate proportion to be easily pumpable, shall be used for the low pressure contact grouting.

50.1.5.4.2 Sampling and Control Tests

If not determined otherwise, the Contractor shall perform all necessary procedures and undertake the cost of all sampling and testing of materials in an approved laboratory. The Contractor shall submit to the Service, stamped copies of all laboratory reports.

If not determined otherwise, sampling and testing shall be performed according to the requirements of the corresponding clauses of the Technical Specification or their modifications mentioned below for each material. Sampling shall be supervised by the Service.

50.1.5.4.3 Water

The water used for grouting shall be fresh, clean and shall not contain deleterious waste materials, oils, acids, alkalis and excessive quantities of salts, silt, organic materials and other waste.

The water should not contain materials which diminish the effectiveness of the grouting operations or the behavior of the grout.

50.1.5.4.4 Cement

The cement to be used in the grout should comply with the requirements of clause 17 of the T.C.C.

The use of bulk cement shall be allowed if the Contractor provides acceptable methods of embarkation-disembarkation, transport, storage and weighting; otherwise, only concrete in paper bags shall be used.

Sufficient quantity of cement should by stored on site to ensure that grouting operations shall not be delayed due to lack of materials.

If the cement contains chunks of foreign substances in unacceptable quantities, the Contractor shall sieve the material before it is used, using a standard sieve (e.g. the ASTM No 100), at no cost to the Service.

50.1.5.4.5 Bentonite

The bentonite to be used in the grout shall be purchased from Albanian sources and shall be accompanied by certificates of tests performed in an approved laboratory. These certificates shall mention the type, the moisture content, and the liquid limit of the bentonite, and shall be submitted to the Service for approval

50.1.5.4.6 Sand

The fine aggregates shall comply with the requirements of clause 6 of the present T.C.C. with the following modifications:

1. The sand shall not contain flat of elongated grains having a maximum size larger than five times that of the minimum, in excess of a certain limit. This limit (proportion) shall aim to avoid plugging of the grout supply pipes during pumping at the minimum allowed pressure and when the grout contains the minimum water-cement ratio.

2. The sand shall have a fineness coefficient determined by the Service.

3. The sand shall be well graded from the finer to the coarser fraction; its grain size distribution shall comply with the ASTM C-136 Specification or the corresponding of the European Union countries or the European Steel Organization, or another complying with the requirements of the Service and approved by the Service.

50.1.5.5 Performance of Grouting Operations

50.1.5.5.1 Generalities

All grouting operations shall be performed in the presence of the Service and shall comply with the general procedures described below. Details of the grouting operations not mentioned in the present document shall comply with the directions of the Service.

The applied grout pressures shall vary according to the conditions in each borehole and the pressures to be used shall be according to the specifications in the present document or the instructions of the Service. The maximum pressure shall not exceed three (3) MPa. The mixture proportions shall be according to the approval of the Service, following a proposal made by the Contractor.

50.1.5.5.2 Low Pressure Contact Grouting

Contact grouting shall be performed in a way to ensure that all gaps/voids behind the concrete lining or between the concrete lining and the support fixtures shall be filled with grout.

Pouring of mortar and grout shall be performed in low pressures not exceeding three hundred (300) kPa for each section, unless determined otherwise by the Service. Washing or tests under pressure shall not be required before grouting.

The concrete lining shall be poured at least thirty (30) days before the commencement of the grouting unless approved otherwise by the Service.

For the contact grouting, a cement mortar mixture shall be used; the quantity of the sand to be used in the mixture shall be according the commands of the Service.

The most thick grout mixture for the contact grouting shall have proportions of water-cement-sand of 1:1:1 (by weight).

The grouting of a borehole shall not be considered complete until all voids are filled as much as possible according to the opinion of the Service. For this reason, the adjacent boreholes which have not been grouted yet shall remain open for the observation of the path of the grout from the injection point.

Grouting in over-excavation voids which cannot be filled with concrete shall be performed by installing aeration tubes inside the concrete lining to vent air and water. Unless instructed differently by the Service, after the end of the grouting in any borehole, the pressure shall be maintained with an appropriate method until the grout starts to set.
If, according to the opinion of the Service, any contact grouting hole is used also for stabilization grouting, the hole shall be cleaned of grout in its whole depth before the complete setting of the grout.

50.1.5.5.3 Stabilization Grouting

Stabilization grouting shall be performed in the rock-mass surrounding the tunnel. The application of different pressures shall be required for grouting the various sections of the grouting boreholes.

When instructed by the Service to perform such grouting of a hole, grouting shall be performed by adjusting a sealing packer at the end of the grout supply pipe, by placing the grout supply pipe inside the borehole up to the beginning of the upper part of the lower section to be grouted under a different pressure, by grouting at the required pressure leaving the sealing packer in its place, until the back-pressure dissipates, by drawing the grout supply pipe up to the top of the next higher section to be grouted at a different pressure, and thus performing sequentially the grouting of the borehole in sections of predetermined grouting pressures, until the borehole is completely grouted.

The Contractor shall supply the grout supply pipes and the sealing packers. The packers shall consist of air-expandable tubes of mechanically expandable rubber rings, leather rings of rings made of other appropriate material connected at the end of the grout supply pipe.

The packers shalt be designed in a way permitting their expansion in order to seal the boreholes at the prescribed positions, and when expanded, to be able to withstand without a leak for a period of five (5) minutes, water pressures equal to the maximum grout pressure to be used.

The required quantity of grouted boreholes using a sealing packer, shall depend on the actual conditions revealed during the drilling of the grouting boreholes. Immediately before commencing the grouting of a specific borehole, the hole shall be carefully cleaned under pressure and a water injection test shall be performed according to the provisions of paragraph 50.1.4.2.

In general, if the water injection test indicates a water-tight borehole, grouting shall commence with a lean mix of one (1) part cement to three (3) parts of water by weight. If there exists an open fracture the water/cement ratio shall be decreased gradually while the grouting pump operates continuously at a constant speed as much as possible. The water/cement ratio shall be further decreased, if required, until the required pressure is achieved.

If the pressure tends to rise too high, as determined by the Service, the water cement ratio shall be increased according to the command of the Service.

If required, in order to achieve an early stopping, water under pressure shall be periodically used. If, due to the magnitude and the interconnection of the fractures, the desired results cannot be achieved even with the most dense pumpable mixture containing sand, the grouting operation in this borehole may be interrupted at the command of the Service. In this case the borehole shall be cleaned, the grout shall be allowed to set and subsequently an additional drilling and grouting shall be performed in this borehole or in the adjacent region, according to the instructions, until the required pressure can be achieved.

If, during the grouting of any borehole, flow of grout is observed through the adjacent boreholes or the grouting connections in an appreciable quantity to impede seriously the grouting operations, or if significant loss of grout occurs, these connections may be temporarily sealed (capped).

The grout pressure leaking from any adjacent borehole, shall be measured by placing a packer at this hole and the pressure of the leaking grout shall be maintained lower than the allowable pressure at the prescribed stage for this borehole.

Where this sealing (capping) is not necessary, the non-grouted boreholes shall be left uncapped to facilitate the venting of air and water as the grout injected in the other boreholes.

Before the grout sets, the grout pump shall be connected to the adjacent capped boreholes and to the other boreholes where grout leakage was observed, and these boreholes shall be grouted at their required pressures.

If, during grouting of any borehole, flow of grout is observed at any section of the structure, this leak shall be stopped or painted over by the Contractor at the command of the Service.

The grouting of a borehole shall be continued until the borehole or the grouting connection accepts grout at a rate less than two (2) lt/min for a time period of more than ten (10) min. The full grouting pressure shall be maintained constant during grouting as much as possible.

In any case, the Service may require the reduction of the pumping pressure or the interruption of the pumping as a protection against a deformation of a rock or the concrete or during the plugging of grout leakage.

After the end of the grouting of boreholes or connections the pressures shall be maintained using valves or other appropriate valve systems, until the grout sets sufficiently to hold itself in the holes or the connections which were grouted.

50.1.5.5.4 Protection of Drainage Boreholes

The grouting plan of the Contractor shall be such that it ensures the safety of the drainage boreholes against plugging.

If approved by the Service, the Contractor shall maintain a flow of water through the drainage boreholes which may be affected by the grouting as an indicator.

If a grout leakage occurs in the drainage boreholes, the Contractor shall remove all the grout from the influenced drainage boreholes by washing, in a way acceptable to the Service and no extra payment shall be made for this work.

50.1.5.6 Cleaning and Restoration

After the completion of the grouting, the Contractor shall remove all the supply connections from the pipes incorporated in the concrete lining up to a depth of at least five (5) cm measured from the surface of the concrete.

All holes and cavities created in this way shall be restored as specified by the Service. The restoration shall be made in a clear and technical way to ensure a smooth surface such as that of the areas of the lining not influenced by the cavities.

During the grouting operations the Contractor shall take all required protective measures to prevent the washing water, the drilling trimmings and the grout from deforming or harming the structures.

The Contractor shall be required to supply adequate pumps which may be necessary to remove waste water and grout from the work-site, and he shall install these equipment in a way that minimizes the disruption of other operations.

The Contractor shall maintain all his plants and equipment appropriately tidy.

After the completion of the operations, the Contractor shall clean all waste materials produced from his activities which are aesthetically unacceptable or are obstructing, according to the opinion of the Service, the effective functioning of the works. No extra payment shall be made for activities required for cleaning or restoration.

50.1.5.7 Records

The Contractor shall maintain records, at no extra cost to the Service, for all drillings of grouting and drainage borehole and for all grouting operations in forms approved by the Service.

These records shall contain a section and a log of the grouting and drainage boreholes, the results of washings under pressure and of injection tests, the time of any change in the grouting activities, the pumping rate, the applied pressures during grouting, the changes in the water-cement ratio and the corresponding quantities of comment and other materials, as well as other related data which are considered necessary by the Service. The Contractor shall provide all required assistance and co-operation in relation to the above.

50.2 DRUM FO DRAINAGE BOREHOLES

50.2.1 Objective

This sub-clause refers to the drilling by the Contractor, at the approval of the Service, drainage boreholes having a minimum diameter of three (3) inches, in a horizontal direction, vertical of inclined at any angle; these boreholes shall be drilled using a rotary or rotary-percussion drill according to the instructions of the Service.

All drainage boreholes drilled by the Contractor, shall be washed for ten (10) minutes or more, until the returning water is clear, after reaching their final penetration depth.

50.2.2 Contents

The activities of this sub-clause include the supply and removal from the site of the required equipment, the supply and transportation on site of the required materials as well as the technically sound performance of the drilling of the drainage boreholes.

50.2.3 Specifications

The specifications for drilling, grouting and drainage in general of the present (sub-clause 50.1) are in effect.

50.2.4 Accounting and Payment

The accounting of the activities and the payment of the Contractor shall be made on the basis of the actual linear meters of drainage boreholes drilled.

a. For depths between 0 and 10 m.
b. For depths exceeding 10 m.

50.3 GROUTING BOREHOLES IN STAGES

50.3.1 Objective

This sub-clause concerns the drilling, by the Contractor, of grouting boreholes in the horizontal or vertical direction, or inclined at any angle, having a minimum diameter of one-and-a-half inch (1 ½”); these boreholes shall be drilled by a rotary or rotary-percussion drill, according to the instructions of the Service.

50.3.2 Contents

The activities in this sub-clause include the transfer on-site and the removal from the site of all required mechanical equipment, the supply of the required materials as well as the technically sound execution of the activities of drilling grouting boreholes having a diameter of at least one-and-a-half inch (1 1/2 "), washing and performance of water injection tests.

50.3.3 Specifications

The specifications concerning drilling, grouting and drainage in general, of the present clause (sub-clause 50.1) are applicable.

50.3.4 Accounting - Payment

The accounting of the activities and the payment of the Contractor shall be made based on the actual linear meters of grouting borehole drilled.

50.4 INVESTIGATION BOREHOLES. HORIZONTAL. VERTICAL OR INCLINED WITH SAMPLING. INSIDE OR OUTSIDE OF THE TUNNEL

50.4.1 Objective

The objective of the present sub-clause refers to the execution, with the approval of the Service, of coring boreholes which may be required to determine the condition of the rock-mass surrounding the tunnel or in other locations or to determine the effectiveness of the grouting operations.

50.4.2 Contents

The activity described in the present sub-clause, includes the transfer on-site and the removal from the site of all required equipment, the transfer on site of all consumable materials required to drill the boreholes and the core sampling, all activities required to maintain classify and store the core samples as well as all required actions for the technically sound execution of the activities of the present sub-clause.

50.4.3 Specifications

The specifications concerning the drilling, grouting and drainage in general of the present clause (sub-clause 50.1) are applicable.

50.4.4 Accounting and Payment

The accounting of the activities and the payment of the Contractor shall be based on the actual linear meters of investigation boreholes drilled during the execution of the activities of the present sub-clause.

50.5 SUPPLY AND INSTALLATION OF INCORPORATABLE METAL PIPES AND CONNECTORS

50.5.1 Objective

The Contractor shall supply, construct and install all metal pipes, connection pieces and grout supply nozzles, required for the grouting and drainage programme of the tunnel, according to the instructions of the Service. The present sub-clause concerns only the incorporable materials, according to the design or the commands of the Service.

50.5.2 Contents

This sub-clause refers to the supply, construction, transportation, welding, installation and generally of any action required for the complete and technically sound execution of the activities described in this sub-clause.

50.5.3 Specifications

The specifications concerning drilling, grouting and drainage in general of the present clause (sub-clause 50.1) are in effect.

50.5.4 Accounting and Payment

The accounting of the activities and the payment of the Contractor is based on the actual weight in kilograms of pipes, connection pieces, and supply nozzles, which were actually installed during the execution of the activities of the present sub-clause.

50.6 CONNECTION IN GROUTING BOREHOLES

50.6.1 Objective

The Contractor shall perform the required connections of the grout supply pipe to the various points of the grouting boreholes during the stages for the execution of each grouting.

50.6.2 Contents

This sub-clause concerns all required actions and materials for the complete and technically sound execution of the activities of the present sub-clause.

50.6.3 Specifications

The specifications concerning drilling, grouting and drainage in general of the present clause (sub-clause 50.1) are in effect.

50.6.4 Accounting – Payment

The accounting of the activities and the payment of the Contractor shall be based on the actual number of connections of the grouting boreholes to the grout supply pipe, during the execution of the activities of the present sub-clause. The present sub-clause does not refer to contact grouting, since the relevant cost is included in the contractual price of the cubic meter of the final lining.

50.7 SUPPLY AND TRANSPORTATION IN-SITU OF GROUTING MATERIALS

50.7.1 Objective

The Contractor shall supply, transport, store in a safe are and distribute the quantities of cement, bentonite, clay, sand and lime which shall be sufficient for the requirements of the grouting activities according to the specifications and the commands of the Service.

50.7.2 Contents

This sub-clause concerns the supply, transportation, storage and distribution at the grout production stations of the previously mentioned grouting materials.

50.7.3 Specifications

The specifications concerning drilling, grouting and drainage in general of the present clause (sub-clause 50.1) are in effect.

50.7.4 Accounting – Payment

The accounting of the activities and the payment of the Contractor shall be based on the actual weight in kilograms of the incoming materials, according to the commands of the Service. The present sub-clause does not refer to contact grouting, since the relevant cost is included in the contractual price of the cubic meter of the final lining.

50.8 PRODUCTION AND INJECTION OF GROUT IN DRY WEIGHT

50.8.1 Objective

The Contractor produce the grout for the cement grouting in appropriate installations using appropriate equipment, mixers etc., according to the commands of the Service. Subsequently, he shall wash the grouting boreholes under pressure, h shall perform water injection tests, he shall mix and he shall inject the mortar or grout in the drilled boreholes using cement grouting methods.

Subsequently, he shall remove the excess water and the wasted grout, he shall clean the corresponding locations during the activities and he shall perform all other activities related to the grouting according to the instructions of the Service.

50.8.2 Contents

This sub-clause concerns the supply on-site, operation and removal of all required equipment to perform the grouting, the production operations, the distribution and injection of the grouts and finally all required activities for the complete and technically sound execution of the work, according to the specifications and the commands of the Service.

50.8.3 Specifications

All the specifications concerning drilling, grouting and drainage in general of the present clause (sub-clause 50.1) are in effect.

50.8.4 Accounting – Payment

The accounting of the activities and the payment of the Contractor for the operations of the present sub-clause shall be based on the measured weight in kilograms of the dry materials. The present sub-clause does not refer to contact grouting, since the relevant cost is included in the contractual price of the cubic meter of the final lining.

Clause 51: INSTRUMENTS AND MEASUREMENTS IN UNDERGROUND WORKS

51.0 GENERAL - CONTENTS OF THIS SPECIFICATION

This specification covers the following operations for works that are constructed underground :

1. Pins for measurement of five points convergence per section (Sub-clause 51.1)
2. Three bars Extensometers (Sub-clause 51.2)
3. Piezometers within borings (Sub-clause 51.3)
4. Surface piezometers (Sub-clause 51.4)
5. Rock pressure measurement instruments (Sub-clause 51.5)
6. Deformation measurement instruments (Strain Gauges) (Sub-clause 51.6)
7. System of water discharge measurement at the tunnel exits (Sub-clause 51.7)
8. Cells for the measurement of anchor load (Sub-clause 51.8)

51.1 PINS FOR MEASUREMENT OF FIVE POINTS CONVERGENCE PER SECTION

51.1.1 Object

This clause refers to the installation of five pins for the measurement of convergence of the tunnel section. That is, in locations of the tunnel, proposed by the Contractor, and approved or defined by the Service, five pins are installed in a ring section of the tunnel (suitably fixed deep in the rock), of which one is on the roof, two at the top of the sides of the section and two at the bottom of the sides of the section.

The relative diagonal distances between these pins will be measured to define their convergence. Pins for the convergence measurement, shall also be installed in locations of the final lining (five (5) points per ring section), to monitor its behavior.

51.1.2 Specification

The type, shape and method of fixing the pins, the method of measuring and the measuring instrument shall be of an approved system and the Contractor shall propose the system to the Service for approval from the start.

In any case, the system shall ensure that it is possible to remove the measuring attachments, so that movement and operations in the tunnel are not hindered, and the pins shall be in a protected position (recess, or cover etc.), so that there is no risk of them being damaged by the other operations and the movement of equipment.
The system of convergence measurement that will be attached to the pins, must be such so there is no error of measurement greater that two tenths (0.2) mm. The measuring instrument must use materials that are not essentially affected by temperature and must

ensure measurement precision of at least one tenth (0.1) mm. The accuracy of the instrument shall be proven on site before the commencement of the regular work, in a trial position of fixed ends and correction coefficients, for temperature and other factors, shall be provided.

The measurements shall be carried out by the Contractor, to collect the necessary information regarding the behavior of the rock mass and the implemented system of support, so that conclusions may be drawn about the suitability of the applied method and the necessity of possible corrections in the direct support and the final lining.

The Service shall be informed in time, before the measurements are carried out, and copies of the measurement reports shall be submitted to the Service the same day. Additional measurements will be carried out when and where the Service specifies.

51.1.3 Contents

This Sub-clause includes the supply of materials, tools and measuring instruments, the installation of the pins and the carrying out of the measurements, for as long as the development of displacements continues, until they reach infinitely constant values. The works of this sub-clause also include the evaluation and presentation of the measurement results, according to that mentioned in the D.I.S. (subchapter 1.23) and/or the special conditions of the tender (S.C.C. etc.)

51.1.4 Measurement- Payment

For payment, the ring sections, where measurement pins of five points have been installed, shall be measured, separately for the ring section of support and of final lining. Each one of these ring sections is measured as one piece.

Payment shall be effected after completion of the measurements of each section of the Contractor's program, and the presentation of the results according to the C.I.S. (subchapter 1.23) and the other special terms of the tender (S.C.C. etc.).

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.2 THREE BARS EXTENSOMETERS

51.2.1 Object

The purpose of these extensometers is the measurement of the relative displacement of a point of the excavation surface or of the internal surface of the tunnel lining with reference to specific points of the rock mass at the same radius of the tunnel. These measurements are combined with the convergence measurements of the previous Sub-clause 51.1, having the same aim.

51.2.2 Specification

The type, shape and method of placement of the instruments, the method of measurement and the measuring instrument shall be of an approved system and the Contractor shall propose the system to the Service for approval from the start.

In any case, the system shall ensure measuring at any time, without hindering the other operations of the tunnel, and it is stated here that it is important to be able to use these instruments for measurement even after completion of the final lining.
The heads of the instruments must be in a protected location (recess) and shall be equipped with suitable covers so that there is no risk of them being damaged from the other operations and movement of equipment. The measuring system must be such so that the measurements cannot be affected by subjective judgment, and it is stated here that it is important to be able to achieve remote measuring.

The appurtenances of the extensometers and the measuring instrument shall operate mechanically or electrically or electronically or hydraulically and the system must take into account temperature and other changes.

Three bars of different length, shall be placed in suitably drilled holes, and their internal end shall be fixed. The remaining length of each bar shall be placed in a pipe sleeve so that it can deform freely. The whole depth of the drilled hole shall be filled with grout and the tops of the bars shall be connected to the measuring system. The measuring system shall have precision of at least five hundredths (0.05) mm.

The placement of the expansometers shall be carried out in distances not greater that ten (10) m from the excavation front and measurements shall start immediately after their installation. They will be carried out daily, until they balance infinitely to a constant value, with the minimum difference between two measurements not greater than two tenths (0.2) mm in a months period.

The measurements shall be carried out by the Contractor, in order to collect the necessary information regarding the behavior of the rock mass and the implemented system of support and lining, so that conclusions may be drawn for the need of possible corrections to the support and the final lining.

The Service shall be informed in time before these measurements are carried out, and copies of the measurement reports will be submitted to the Service the same day. Additional measurements will be carried out when and where the Service specifies.

51.2.3 Contents

This sub-clause includes the supply of materials, tools and measurement and reading instruments, the drilling of the holes, the placement, fixing and checking of three bars, testing the system and carrying out the measurements, for as long as is necessary, and at least as long as the development of deformations continues, until they reach infinitely to constant values.

This sub-clause also includes the evaluation and presentation of the results of measurements, in accordance with the D.I.S (subchapter 1.23) and/or the special terms of the tender (S.C.C. etc.).

51.2.4 Measurement – Payment

The number of positions of installation of expansometers with three bars of different length each, shall be measured for payment, and specifically the number of expansometers with bar length 3m, 5m, 9m and the number of expansometers with bar length 5m, 10m, 20m shall be measured separately.

Payment shall be effected by 60% when the installation of the instruments is completed, the necessary checks are made and the two first measurements are carried out. The remaining 40% shall be paid after completion of all measurements of the Contractor's program and the presentation of the results.

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.3 PIEZOMETERS WITHIN BORINGS

51.3.1 Object

The purpose of these piezometers is the measurement of the pressure of underground water in the area of the tunnel. These piezometers are placed in horizontal or inclined holes, and each hole contains two piezometric elements, one at a distance of thirty (30) m and the other at six (6) m from the sides of the tunnel.

The type, method of operation and installation, the instrument and method of measuring the pressure of the underground water will be in accordance with an approved method of an approved manufacturing firm. The Contractor shall submit from the start the proposed system to the Service for approval, along with the specification of the method of installation and operation.

51.3.2 Specification

The piezometric elements shall be installed in the same hole or in separate holes, if the Contractor prefers, without additional compensation. The piezometric elements shall be encased in a porous shell and shall be placed in the hole within a filter.

The piezometric elements and the surrounding filter shall be isolated by filling the hole with waterproof material (cement, clay, bentonite etc.). The piezometric elements shall operate pneumatically or hydraulically or electrically and the measuring instruments shall correspond to the system of piezometric elements, but must be of the type that can be removed, unless they are permanently protected at the head of the hole.

During the installation of the instruments, operation checks, and ventilation shall be carried out, and in general everything provided for in the specification of the manufacturer.

The placement of these instruments shall be carried out at least four (4) months before the construction of the final lining and care shall be taken so they are not damaged during the construction operations. The measurements shall last at least for four (4) months, with a frequency of one (1) measurement every ten(10) days for each instrument, according to the instructions of the Service.

51.3.3 Contents

This sub-clause includes the opening of the holes, the supply and installation of the piezometric elements, the auxiliary equipment, the pipes, cables etc., the supply assembly and check of the measuring instrument, the filling of the hole with a filter at the location of the piezometers, and with isolating mortar, the adaptation and formation of the head, in combination with the lining and the insulation of the section, the supply of the appropriate plugs, the carrying out of the measurements, for at least four (4) months and the presentation of the results all in accordance with the D.I.S. (Subchapter 1.23) and/or the special terms of the tender (S.C.C. etc.).

51.3.4 Measurement – Payment

The number of piezometric elements, depending on the depth of installation (6m or 30m) from the sides of the tunnel, shall be measured for payment. Payment shall be effected by 80% for the installation and check of the instruments and the remaining shall be paid after completion of the measurements and presentation of the results.

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.4 SURFACE PIEZOMETERS

51.4.1 Object

These piezometers are placed on the outer surface of the tunnel section so that they measure the pressure of the water outside the water insulating membrane.

51.4.2 Specification

These piezometers shall consist of a galvanized pipe painted with two (2) coats, which will have at one end a netting protection and on the other an isolating valve and a permanent hydraulic manometer.

The region of the manometer readings shall be defined by monitoring the behavior of the water and the drainage system.

These pipes shall be placed in such a way so that they are embedded in the final lining, they maintain the impermeability of the membrane at the points of contact and they have their free end in the region of the drainage layer, behind the insulation layer.

The Contractor shall submit a proposal to the Service, along with a real sample of the system of piezometers.

51.4.3

This sub-clause includes the materials (pipes, painting, netting, valve, manometer, etc.). the installation and the carrying out of the measurements, for as long as is necessary and the presentation of the results, according to the D.I.S. (Subchapter 1.23. paragraph 1.23.4.4) and/or the special terms of the tender (S.C.C. etc.).

51.4.4 Measurement - Payment

51.4.4.1

The number of points where such piezometers are installed will be measured for payment. Payment shall be effected by 60% for the complete installation of the instruments, the measurement checks and the execution of the first two measurements. The remaining 40% shall be paid after the completion of the measurements and the presentation of the results.

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.4.4.2

For works that are tendered with the “CONCESSION AGREEMENT” system and are included in the “MAIN CONCESSION PROJECT”, the cost of the measurements for the whole period of operation and further for the period of mandatory maintenance, are included in the responsibilities borne by the Contractor.

51.5 ROCK PRESSURE MEASUREMENT INSTRUMENTS

51.5.1 Object

Instruments for measuring the rock pressure shall be installed on the outer surface of the final lining. These instruments shall be embedded in the final lining of the tunnel and shall measure the rock pressure after the completion of the tunnel construction.

51.5.2 Specification

These instruments shall be electrically or electronically or hydraulically operated and the measurement shall be carried out by an apparatus that shall be connected with each instrument through pipes or cables by suitably protected terminals. The measuring apparatus shall be removed and carried to each section to be measured.

The pipes or conductors of each measuring point shall have such length and shall be placed in such a way in the lining so as to be easily accessible for the execution of the measurement at a man's height. The precision of the measurements shall be at least one (1) kPa and correction coefficients shall be given for every kind of effect (temperature etc.).

After the installation of the instruments, tests and calibration shall be carried out according to the manufacturer's specifications.

The Contractor shall propose to the Service for approval the system of instruments and apparatus, which shall be of the standard range of production of an approved manufacturing firm.

51.5.3 Contents

This sub-clause includes the supply of instruments and apparatus and all auxiliary materials, the installation and testing of the instruments and the carrying out of the measurements for three (3) months, with a frequency of one (1) measurement per day, from the construction of the permanent lining and the presentation of the results, according to the D.I.S. (subchapter 1.23) and/or the special terms of the tender (S.C.C. etc.).

Also included are the suitable formation of the water insulating membrane at the location of the instruments, and the protection of the instruments and apparatus.

51.5.4 Measurement - Payment

51.5.4.1

The number of instruments installed, irrespective of the number and location of instruments placed in the same section, shall be measured for payment. Which means, that if in one section there are seven (7) instruments for measuring the rock pressure, seven (7) pieces shall be measured for that section.

Payment shall be effected by 60% after placement, testing and execution of two (2) measurements and the remaining 40% shall be paid after completion of the measurements and the presentation of the results.

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.5.4.2

For works that are tendered with a "CONCESSION AGREEMENT' and are included in the "MAIN CONCESSION PROJECT" (M.C.P.), the cost of the measurements for the whole period of operation and further for the period of mandatory maintenance, are included in the responsibilities borne by the Contractor.

51.6 DEFORMATION MEASUREMENT INSTRUMENTS (STRAIN GAUGES)

51.6.1 Object

The purpose of these instruments is the measurement of the special deformations in various locations (in frames or inside the permanent lining) and various directions (radial, tangential, longitudinal).

51.6.2 Specification

The type of the tools, the elements and instruments, that will be used, shall be proposed by the Contractor from the start for approval by the Service. The proposed type shall be of standard production of an approved manufacturing firm.

These instruments shall be mechanically or electrically or electronically operated and shall secure reading precision of at least one (1) mm and the measurements must be carried out in such a way so as not to hinder the operation of the tunnel, without being affected by the subjectivity of the operator.

These instruments shall be placed in such a way so that they remain protected from the other construction operations of the tunnel, and those placed in the permanent lining must be accessible at a man's height (connecting cables or pipes) and have long term life.

51.6.3 Contents

This sub-clause includes the supply and placement of the materials, instruments and apparatus, the reading instruments, testing and calibration, the carrying out of the measurements for at least three (3) months and the presentation of the results, in accordance with the D.I.S. (Sub-clause 1.23) and/or the special terms of the tender (S.C.C. etc.).

51.6.4 Measurement – Payment

51.6.4.1

The number of individual instruments, that will be installed, irrespective of the number and location of similar pieces contained in the same section, shall be measured for payment. Which means, that if In one section there are seven (7) instruments of radial, seven (7) instruments of tangential and four (4) instruments of longitudinal orientation, a total of eighteen (18) pieces of instruments shall be measured.

Payment shall be effected by 60% after the installation, the tests and the execution of two measurements, and the remaining 40% shall be paid after the completion of the measurements and the presentation of the results.

It is clarified that no additional compensation shall be paid to the Contractor for any effects or delays in the realization of the other construction works of the tunnel, due to the installation and operation of these instruments.

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.6.4.2

For works that are tendered with a "CONCESSION AGREEMENT" and are included in the "MAIN CONCESSION PROJECT" (M.C.P.), the cost of the measurements for the whole period of operation and further for the period of mandatory maintenance, are included in the responsibilities borne by the Contractor.

51.7 SYSTEM OF WATER DISCHARGE MEASUREMENT AT THE TUNNEL EXITS

51.7.1 Object

A special construction shall be provided at the portals of the tunnel for measuring the quantity of waters that will outflow during the construction of the tunnel.

51.7.2 Specification –Contents

The Contractor shall propose for approval by the Service, the formation of the aforementioned structure and the instrument for measuring the water discharge, of satisfactory accuracy, that will be acceptable to the Service. The accuracy shall be not less than two tenths (0.2) of lt/sec.

The work of this sub-clause includes the supply and installation of all instruments, the materials and actions necessary, the maintenance and operation, during the whole period of construction of the work, including the necessary actions, if needed, for the operation of the instruments, the execution of measurements at least three (3) times a week, and the presentation of the results, along with the necessary remarks regarding the phase of construction (drilling, removal of the excavation materials etc.). Measurements shall be carried out for the duration of the construction period of the works (excavation, lining, etc.).

51.7.3 Measurement – Payment

Each complete arrangement for the measurement of the water discharge along with all the related works as one unity, shall be measured for payment. Payment is effected by 80% of the cost immediately after the installation and the remaining 20% shall be paid after completion of the final lining and the presentation of the results.

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

51.8 CELLS FOR THE MEASUREMENT OF ANCHOR LOAD

51.8.1 Object

This sub-clause regards the installation of cells for the measurement of the load of the anchors in the tunnel. I.e., in locations in the tunnel, that will be proposed by the Contractor and approved or defined by the Service, special cells shall be placed on the heads of anchors to monitor the load that is undertaken by the anchors.

51.8.2 Specification

The type, shape, and method of placing the instruments, the method of measuring and the measuring instrument, shall be of an approved system, that the Contractor will propose to the Service for approval, from the start.

In any case the system must allow for measurements to be carried out at any time, without hindering the other construction operations of the tunnel. The heads of the instruments must be located in a protected position (recess), or must be provided with suitable cover so there is no risk of them being damaged from the other works and the movement of equipment.

The measuring system shall be such as to exclude subjective judgment of the measurements. The appurtenances of the cells and the measuring instruments shall be mechanically or electrically or electronically or hydraulically operated and the system must also take into account temperature effects and other variations.

The cells must be very sensitive, with a sensitivity of the order of two thousandths (2‰). The capacity must be up to four hundred (400) kN. The cells must be easy to install and able to be moved and used in other locations.

These measurements shall be carried out by the Contractor to collect the necessary information regarding the behavior of the anchor and of the implemented system of support and lining, to draw conclusions for the suitability of the implemented method and the possible necessary corrections to the support.

The Service shall be informed in time, before the measurements are carried out, and copies of the measurement reports shall be submitted to the Service the same day. Additional measurements will be carried out when and where the Service specifies.

51.8.3 Contents

The works provided include the supply of materials, tools, and measuring instruments, the installation of the cells and the carrying out of the measurements, for as long as the increase of the loads continues, until they reach infinite to constant values. Also included is the evaluation and presentation of the results of the measurements.

51.8.4 Measurement – Payment

The number of cells installed for the first time, shall be measured for payment. Payment shall be made after the completion of the measurements of the Contractor's program, and the presentation of the results, in accordance with the D.I.S. (subchapter 1.23) and/or the special terms of the tender (S.C.C. etc.).

It is clarified that revision of prices shall be calculated for the time of execution of the measurements and not the time of their completion and payment.

In the case where the same cells are used in another location, the Contractor shall be compensated with fifty percent (50%) of the unit price of this sub-clause.

Clause 52 : ELECTROMECHANICAL INSTALLATIONS FOR TUNNELS

52.1 GENERAL

52.1.1 Scope

Electromechanical installations for tunnels refer to :

a. Tunnel ventilation (sub-clause 52.2)
b. Tunnel lighting (sub-clause 52.3)
c. Tunnel power supply (sub-clause 52.4)
d. Fire announcement - Firefighting in tunnels (sub-clause 52.5)
e. Communications traffic control in tunnels (sub-clause 52.6)

52.1.2 Specifications General Requirement

Miscellaneous materials, equipment, instruments, apparatuses used for the project or incorporated therein, shall be in compliance with :

a. *"European Standards"* approved by the European Electrotechnical Standards Committee (CENELEC)

b. In addition to the foregoing and for those items for which European Standards do not exist, the "Common Technical Specifications" published in the European Communities Official Gazette.

c. Notwithstanding the above, HOS (SLOT) Standards should be satisfied where available.

Items not covered by the above specifications shall comply with relevant approvals issued or to be issued in accordance with the procedure of the European Technical Approvals (refer also to clause 1 of the TCC).

Wherever in this Clause, hereinafter, reference is made to a particular specification, such specification shall be entirely applicable, except for those parts or stipulations which are in contradiction to the provisions of the abovementioned standards a through c. In such case the stipulations of those standards shall be applied.

52.2 VENTILLATION

52.2.1 Jet fan ventilators

52.2.1.1

The fan shall consist of a housing (shell) made of steel sheet and an axial impeller equipped with airfoil type blades. Blades shall have the possibility of regulation, with a tolerance not exceeding 1^0.

52.2.1.2

The impeller shaft shall be made of cast aluminum alloy.

52.2.1.3

All parts shall be x-ray tested , in order to ensure lack of voids, pores, pinholes and air bubbles in dangerous areas , such as blades initial parts.

52.2.1.4

The whole structure shall be statically and dynamically balanced in accordance with ISO 2372, for machinery class II, so that the maximal vibration velocity does not exceed 4.5mm/sr.m.s.

52.2.1.5

Electric motor shall be induction type, squirrel cage, in compliance with IEC-34.1, insulation class F, suitable for operation in 400 C ambient temperature. The electric motor ball bearings shall have a guaranteed life of not less than 20.000 hrs in accordance with ISO 281, their lubrication being possible without the need for disassembling the fan housing.

52.2.1.6

Prior to assembly, all metal parts shall be hot dip galvanized.

52.2.1.7

Each ventilator shall be accompanied by two noise attenuators (silencers) each having a length 1.5 times the impeller diameter, with suitable adaptation basis. The noise absorption material shall be damp proof and corrosion resistant. The frame shall be made from galvanized steel, while the structure shall be fire resistant in compliance with BS 476, Part 7.

52.2.2 CO Measurement System

52.2.2.1 Sampling Outlets

a. Sampling outlets shall have a diameter of 10 cm approximately and shall be equipped with a special filter for airborne particles, filtration grading P2 to DIN 3184, so as to avoid dust and smoke suction.

b. The outlets shall have a suction capacity of 6 lt/min.

52.2.2.2 Automatic Sampling Pipework

a. Sampling pipework DN 4 shall be made of semihard polyethylene, type PE 6 x 4 x 2.

b. The longest distance between sampling outlet and CO measurement device shall not exceed 75m.

52.2.2.3 Automatic Sampling System

a. The system shall consist of a series of solenoid valves, automatically operated, connected to the ends of the sampling pipework.

b. Solenoid valves are successively controlled on the basis of a program, the air sample being sucked vide a pump, 6 It/min capacity, and subsequently lead into the analysis chamber, vide a second air pump.

52.2.2.4 CO-Content Measurement Apparatus

a. The CO-content measurement apparatus shall be fully electronic and shall have incorporated a fully automated system of 20 sampling points.

b. The CO measurement shall be effected through an electrochemical head where CO shall be electrochemically combusted.

c. The apparatus shall be placed in a metal housing protection rating IP54 to IEC 144. Its characteristics shall be :

- supply voltage: 220V/50Hz
- power: 70W
- measurement range: 0-300 ppm
- maximal deviation: +1- 2%

d. The apparatus shall be controlled through a microprocessor (CPU). For the purpose of calibrating measurement accuracy, the apparatus shall dispose a grading gas canister, pressure regulator and suitable fittings (union type joints etc.).

e. Measured CO-content shall be digitally displayed, alongwith the number of the channel being monitored. In the meantime, a 4-20 mA outlet (constant for ohmic load 500 Ω) and a RS-232 outlet shall be available.

f. Further to the above, following indications shall also, be made available :

- Operation
- Fault
- Notification for the need to change detection head
- 4Nos preset levels

g. In case of power disruption, the apparatus shall maintain in its memory the operation program for 72 hours alongwith the preset limit levels.

h. The sampling of points controlled by the apparatus is effected in a rotational sequence, with 30sec interim waiting time between two consecutive points.

52.2.2.5 *CO-content Limits Monitoring System*

a. Apart from the LED indicating lamps -through which the excess (or not) of the preset threshold levels is notified- the apparatus shall dispose for each channel 4Nos free voltage contacts, each of them changing status in case of a specific level being exceeded. Threshold levels, may be changeable and may be related to following commands :

- For 50ppm CO-content 33.5% of the ventilators shall be put in operation.

- For 100ppm CO-content 66.67% of the ventilators shall be put in operation.
- For 150ppm CO-content, 100% of the ventilators shall be put in operation.
- For 250ppm CO-content an alarm signal shall be released alongwith the command to "close" the tunnel.

b. Sampling inlets shall be placed at a height of 1.5m, above ground level.

c. In order to avoid incidental activation of the alarm and excessive tear and wear to the fan motors due to repeated continuous starts and stops, the system shall be equipped with a delay apparatus:

- From 0-3min for activation of the alarm and ventilators starting.
- From 0-30min for retaining the fans in operation subsequent to reduction of the CO-content.

52.2.3 <u>Visibility Measurement System</u>

52.2.3.1

The visibility measurement system (clarity reduction) due to smoke presence, shall share with the CO-content measurement system same sampling points and same pipework.

52.2.3.2

Main parts of the system are be the photometer and the control unit.

52.2.3.3

The photometer main parts are

a. Optical parts (light source, optical elements, reflectors, photocell amplifier)

b. Electronic parts (voltage stabilizer, rotating reflector mechanism, photocell signal transducer amplifier).

c. Sampling chamber, 25-30 lt/min capacity at a pressure of +/- 300 mm WG, with 20/22 mm piping connections, suitable for ambient temperature up to 40° C and humidity up to 65%.

d. Measurements comparison apparatus (Turbidity Standard) made of opaline accompanied by factory adjusted filters, capable of measuring up to values of $K=15X10^{-3}$ rn^{-1}.

52.2.4 <u>Anemometers</u>

52.2.4.1

Anemometer shall be suitable for tunnel installation and shall consist of a plastic tube with incorporated wind indicator and an apparatus for signal transmission.

52.2.4.2

It shall be suitable for wind speeds up to 20 m/sec and temperature range between -30 and +80° C. All metal parts of the measurement tube shall be stainless steel. Impeller shall be made of aluminum.

52.2.4.3

The apparatus shall be suitable for operating voltage 220V/50Hz and shall be accompanied by a digital display and a recorder unit. Measurement accuracy shall be 0.1%.

52.3 TUNNELS LIGHTING

52.3.1 Tunnel-type Lighting Fixtures

52.3.1.1 General

a. The fixtures to be used shall be suitable for tunnel installation, of excellent quality and aesthetics.

b. Lighting fixtures provided for, shall be complete, wired and tested in their fabrication premises, and shall include lamps, lamp sockets, required starters and power-factor correction apparatus, connecting terminals with incoming and outgoing lines, fixing and suspension facilities and all other part necessary for their regular and safe operation.

c. All lighting fixtures metal parts shall be corrosion treated, by a special highly-adhesive humid-resistant varnish layer. Lighting fixtures white reflection surfaces shall have a reflection factor not less than 80%.

d. All metal lighting fixtures shall be earthed. All internal wiring shall be suitable for high temperatures. Consecutive lighting fixtures wiring shall be internal. High pressure sodium and incandescent luminairs shall have porcelain lamp sockets, whereas sockets for fluorescent lamps shall be security type, placement requiring lamp rotation.

e. Control switches shall be placed in a special suitably formed compartment, for the release of heat caused by the lamps.

52.3.1.2 Lighting Fixtures

a. HP-Sodium Luminaires

(1) Wall or ceiling mounted luminaires shall be provided suitable for tunnel lighting

(2) Luminaires shall have a shell made of pressure-cast aluminum alloy or hot- compressed aluminum sheet not less than 2mm thick, with smooth surfaces and corrosion treatment in accordance with following specifications [pars 52.3.1.4(2) and (3)]

(3) Reflector equipped luminaires shall be provided for the creation of asymmetric lighting distribution. Reflector shall be made of chemically pure aluminum (99,9% purity) anodized or polished. Reflector position shall be adjustable.

(4) Luminaire front surface shall be covered by tempered dirt proof glass, free of dust- attracting qualities, not less than 5mm thick, fixed on a frame vide a high-grade silicone elastomeric joint.

(5) The frame shall be rotating on two special construction pivots and shall be fixed on the cover through rapid fastening devices. Housing and cover construction shall secure a degree of protection not less than 1P65 in compliance with IEC144.

(6) Luminaire shall include electrical unit, ie special space within the shell, separate to the lamp space, protected from heat transmitted by the lamp, including all luminaire electric apparatus such as reduction solenoid, starter, capacitor, lamp socket, radio signal interference protection apparatus. The stipulations for the HP sodium luminaires referring to the electrical unit and electrical apparatus shall also be applicable for this case. All luminaire internal wiring shall be made with conductors sized 2.5mm2.

(7) Each luminaire shall be equipped with junction terminal suitable for the connection of 2Nos 4-wire cables, sized not less than 4mm2, 2Nos clams for cables fastening a cable inlet and one outlet with glands not less than Pg 21.

(8) Depending on type, luminaires shall be suitable for the installation of one or two tubular type high-pressure sodium lamps, 150, 250 or 400W capacity. Lamps shall comply with the stipulations of pare 52.3.1.4(e)

(9) Luminaires shall be ceiling mounted. For such purpose it shall be accompanied by 2Nos corrosion-resistant metal railings to be installed on wire-racks underside. Luminaire shall be fastened to such railing by means of 4Nos suitable screws.

(10) With respect to luminaires phototechnical characteristics, required tests and questionnaire (schedule) the stipulations of specification 04)4 through to 00-6 shall generally apply except that these luminaires shall not be of the cut-off type [refer to pare 52.3.1.4(e)].

b. <u>LP-Sodium Luminaires</u>

Provision shall be made for LP-Sodium luminaires similar to the ones stipulated above, but with suitable socket to receive the lamp. Depending on type and use single or dual lamp type luminaires shall be provided, 55, 90, 135 or 180W, alternatively SOX-E 26,36,66,91 or 131W capacity, in accordance with specifications OΦ-8 and 0OΦ-9 [refer to para 52.3.1.4(e)].

c. <u>Fluorescent Luminaires</u>

(1) The provisions of the previous paragraphs shall generally apply, with respect to shell and glass cover fixation method, wiring and access to lamps and ignition apparatuses.

(2) Reflector shall be made of white color polished or anodized aluminum, with symmetrical or asymmetric light distribution depending on type and use. Fixed (non-adjustable) reflectors shall be provided.

(3) The stipulations of para 52.3.1.3(c) are applicable with respect to lamps and ignition apparatus. Single or twin lamp luminaires shall be provided, with fluorescent lamps 36 or 58W capacity.

52.3.1.3 *Lamps*

a. High Pressure Sodium Lamps (Na-HP)

(1) Provision shall be made for pear-shape or tubular corrected-spectrum lamps, with E40 base, operating voltage 220V/50Hz and life span not less than 6000 hrs.

(2) The reduction solenoid shall be suitable for the relevant lamp, for 220V/50Hz supply, its losses not exceeding 10% of its nominal capacity. Its construction shall comply with VDE 0712 Standards.

(3) The capacitor shall be suitable for use in conjunction with the reduction solenoid in such a manner so as to ensure power factor not less than 0.85. Capacitors shall be made for 85° C ambient temperature, shall have a discharge resistance and shall comply with VDE 0560 Standards.

(4) The ignition device shall be electronic type without moving parts, free of sparks starter. It shall be suitable for ambient temperatures ranging between -15 to 70° C. The ignition shall preferable be of self-disrupted operation.

The lamps luminous flux, after 100 hrs of operation shall be not less than the following values :

LAMP CAPACITY	LUMINOUS FLUX	
	NORMAL	**HIGH PERFORM**
400 W	47,000 lm	55,000 lm
250 W	26,500 lm	31,500 lm
150 W	14,500 lm	16,000 lm
70 W	5,900 lm,	6,800 lm

b. Low Pressure Sodium Lamps (Na-LP)

(1) Provision shall be made for tubular form lamps with oval burner, B22 base, operating voltage 220V/50Hz. Life span shall be not less than 6000 hrs. For reduction solenoid, capacitor and ignition the stipulations of previous paragraph 52.3.1.3(a)(2)(3) and (4) are applicable.

(2) The lamps luminous flux , after 100hrs of operation shall be not less than the following values:

LAMP CAPACITY	LUMINOUS FLUX
180 W	33,000 lm
135 W	22,500 lm
900 W	13,500 lm

c. <u>Fluorescent Lamps</u>

(1) For fluorescent lamps provision is generally made for 36W and 58W capacities, total length respectively 1200 and 1500 mm. They shall be suitable for connection vide reduction solenoids and ignition devices to a 220V/50Hz network. Their average life span shall be not less than 7500 hrs, with average operating conditions 3 hrs per start.

(2) Provision shall be made for brightness-type quick starting starters, with a long life span, equipped with contact proof cover, with no power consumption when the lamp is on.

(3) Reduction solenoids shall be high quality, long lifespan, low noise level, made of material ensuring heat diffusion and temperature limitation within the limits specified by IEC/CEE.

(4) Lamp sockets shall effectively hold the lamp by means of spring type contacts. They shall be contact-proof, protect the lamp against poor contact extinction, and ensure in the meantime easy lamp installation and removal.

(5) Fluorescent lamps connection devices shall ensure high power factor (not less than 0,90) and feeder line disturbance-protection. Lamps of the same luminaire shall be connected in a lead-lag configuration, whereas isolated lamps shall be connected in self-induction configuration.

(6) All fluorescent lamps shall be provided in hot white color (4100o K, 83 lm/W) with luminous flux subsequent to 100 hrs of operation, not less than following values :

LAMP CAPACITY	LUMINOUS FLUX
36 W	3,000 lm
58 W	4,700 lm

52.3.1.4 Tunnel Luminaires Construction

a. Metal Parts

(1) Luminaires aluminum sections shall be made of special low-copper (less than 0.05%) aluminum alloy, for ensuring high corrosion resistance.

(2) Where chromium plating, or hot dip galvanizing surface treatment is provided, for luminaire parts, components etc, such treatment shall be made effectively, using high purity grade material (over 98%) so that not less than 60-70 pm-thick plating is achieved. Plating adhesion on the base metal shall be tested by sharp blade scraping, whereupon scales removal but no peeling should be observed.

(3) Except for those parts made of copper, bronze or stainless steel, enameled or surface plated, all other luminaire metal parts and components shall be coated with two high-adhesion undercoat layers, followed by two layers of high temperature (oven) treated oil paint. In particular, with respect to metal parts, contributing, in any manner whatsoever, to the lamps light reflection and in general to the -formation of luminaires light- distribution, highly reflective (glossy) white colour coating shall be provided, specially composed to avoid ageing disintegration (paling etc) caused either by solar UV-radiation-generated heat, or by the light of the lamps themselves.

(4) Fastening of cover on the shell shall be effected by means of spring-locks made of excellent quality stainless steel, with sufficient compression force to avoid future loosening of the cover or compression joint tightness deterioration. Such locks shall be easily operable, without the need of tools, and -when opened- shall hold the cover in suspended position for access to the luminaire inner parts.

b. Luminaires waterproofing

(1) Where the luminaires construction makes provision for tight joints (e.g. at the joint between cover and shell), such joints shall be made from special high grade material such as neoprene, ethylpropylene or heat resistant silicate rubber. The joint material shall, furthermore, be resistant to atmospheric ozone, weathering and mechanical fatigue and shall be integrally formed in one single seamless piece, in a manner excluding its ultimate deterioration, breakdown or rupture. In case other non-elastic materials are used for tight jointing (e.g. felt) jointing shall be made sufficiently tight so as to exclude passage to insects, dust etc.

c. In addition luminaires shall be provided with ceiling fixing device, special tight foam plastic, allowing passage only to the power supply wire, excluding the ingress of dust, insects etc into the luminaire.Other technical characteristics

(1) Built-in reducing solenoids and power factor correction capacitors shall be installed within the luminaire, preferably in a separate easily accessible compartment, specially designed for effective release of generated heat.

(2) Special inner reflective surfaces shall be made of aluminum, 99,9% minimum purity, electrolitically oxidized and polished so as to ensure high reflectivity. As reflective surfaces can be used either individual mirrors or, alternatively the luminaire shell inner surfaces, duly processed as mentioned above.

(3) Lamp sockets shall be heavy duty made of porcelain or other material with tracking index not less than 700, their contacts ensuring perfect supply to the lamps even in case of luminaire vibration. Lamps shall be fastened onto the socket vide a security device so as to exclude ultimate relaxation or loosening.

(4) A powerful porcelains or bake lite made connection terminal shall be provided for power distribution, within the luminaire. Connecting conductors to lamps and ignition/ operation apparatuses shall be of high mechanical and thermal strength, insulated with asbestos or silicone coating. Adjacent to the above terminal a special earthing connection terminal shall be provided made of brass or stainless steel.

(5) Luminaires shall be equipped with suitable non-removable fittings (screws, nuts etc.), to adjust their position and tighten them onto the metal railing on which they are fastened.

d. Lamps and ignition apparatus

(1) Luminaire lamps, ignition apparatus and power factor improvement capacitors shall be closed type, corrosion proof construction, suitable for installation even into low protection grading luminaires (IP44 to IEC144 or lower), resistant to usual vibration, highly resistant to severe ambient conditions, vandal-proof, noiseless operation, safely cooperating in a guaranteed manner, both between them and with the luminaire on which they are installed.

(2) In general, mechanical and electrical characters of such equipment shall ensure :

- ignition and operation in the right voltage and current as required in each case by the manufacturers.

- Least possible power loss.

- Excellent release of generated heat ensuring effective operation and long life to apparatuses and materials.

- High power factor for the total complex of apparatuses and their materials, by the use of suitable capacitors. Power factor value achieved shall be not less than 0.85.

e. Luminaires and lamps specifications

Ceiling mounted type luminaires and respective lamps shall meet specification requirements as follows :

Item	Luminaire	Specification
1	HP-Sodium 150W	0.0.-4
2	HP-Sodium 250W	0.0.-5
3	HP-Sodium 400W	0.0.-6
4	HP-Sodium 90W	0.0.-7
5	HP-Sodium 135W	0.0.-8
6	HP-Sodium 180W	0.0.-9
7	HP-Sodium 1x135W+1x9OW	0.0.-10

It-is clarified that pear or tubular type lamps can be used in connection with bracket-mounted HP-Sodium luminaires.

52.3.1.5 *Luminaires Installation*

Luminaires installation shall be made in a manner avoiding damage or soiling to covers, light reflecting and dispersing surfaces.

52.3.1.6 *Phototechnical Control*

The maximal, average and minimal value of light intensity shall be measured so as to verify results in accordance with the design desired values.

52.3.2 Tunnel Safety Lighting

52.3.2.1 *General*

a. Safety lighting installation aims to ensuring the required minimal lighting level and signing of escape routes, in case of ordinary power supply failure.

b. The installation comprises each and every appurtance, instrument or fitting alongwith installation, labour and materials, as specified in this clause, and all other element not stipulated in the specification and drawings, necessary for the regular and safe operation of the installation.

c. System general characteristics.

(1) Escape routes safety luminaires shall be permanently connected to the power distribution network and shall remain continuously "on".

(2) Safety lighting operating voltage shall be 220V/50Hz

(3) Escape routes signing luminaires shall bear orientation symbols and text as stipulated by the regulations.

(4) Tunnel safety luminaires shall have fluorescent lamps of identical type to the regular (night) lighting luminaires and shall be supplied from the uninterrupted power supply (UPS) units.

(5) Required illumination level shall be 10 lux, as stipulated in the standards in force.

52.3.2.2 Safety Luminaires

a. The luminaires provided for, shall be delivered complete, wired and tested at the manufacturing premises and shall include lamps, lamp sockets, eventual required ignition and power factor correction apparatus, connecting terminals with incoming and outgoing lines, fixing and suspension devices and each and every fitting necessary for their safe and regular operation.

b. Escape routes luminaires shall have a built-in adaptor/charger device, 3hrs independent operation nickel cadmium batteries and 8W fluorescent lamp.

c. All luminaires metal parts shall be corrosion proof treated, with special damp proof high adhesion varnish coating. Luminaires reflection white surfaces shall have a reflection coefficient not less than 80%.

d. All metal luminaires shall be duly earthed. Inner wiring provided shall be suitable for high temperatures. Inner wiring shall be provided for successive luminaires. Luminaires shall be equipped with safety type lamp sockets, requiring lamp rotation for its due positioning.

52.3.2.3 Escape routes luminaire signing

a. Provision shall be made for signs and direction descriptions on the escape routes luminaire covers in a manner ensuring legibility of the text from 10m distance and maximal viewing angle 450 approximately, such legibility being unaffected from natural or artificial lighting reflections.

b. Symbols and texts shall be provided in white color on top of self-adhesive green film background, extending to the full surface of the luminaires cover (DIN 4818), made of material unaffected through long-time use.

52.4 POWER SUPPLY

52.4.1 Medium Voltage Lines

52.4.1.1

Medium Voltage lines (20kV) connecting the PPC supply points to the medium voltage switchgears and the latter to the primary circuits of power transformers shall be constructed using 3Nos single phase copper cables with very strong thermoplastic insulation rated 20kV of the type N2YSH, section 1 x 95 mm^2.

52.4.1.2

For each of these power lines a fourth cable N2YSY shall be positioned in parallel and shall remain with terminal boxes, but unconnected, so that in case of failure to be able to replace the damaged cable within a short period of time.

52.4.2 MV Cables Terminal Boxes

52.4.2.1

The MV cables connection referred to in the previous paragraph to the MV switch gears, the PPC control panels and the transformers shall be effected by using plastic cables prefabricated cone terminal boxes, indicative type JOSLYM, or similar.

52.4.2.2

The terminal box connection points shall be carefully tighten so as to avoid ultimate loosenings caused by dynamic loading of the contact points.

52.4.3 General Medium Voltage Switchboards (GS-MV) 20kV

52.4.3.1

The general technical characteristics of the Medium Voltage switchboard shall be the following :

a.	Maximal Operating Voltage	24 kV
b.	Operating Voltage	20 kV
c.	Nominal (rated) current	>400 A
d.	Nominal cut-off power	>250 MVA
e.	Earthing Test Voltage (1')	> SO kV
f.	Impact Test Voltage (SW)	>125 kV
g.	Automation Voltage	110V AC

52.4.3.2

The General MV Switchboard in each substation shall be formed in one integral unit and shall consist of four fields (cells as required) interconnected through 20kV bars, sized 40x5mm (200mm^2 cross-section, 400A nominal current rating).

52.4.3.3

The unit shall be fabricated by a reputable, well known manufacturer. At selecting the switchboard to be used, due consideration should be given to the overall dimensions of available space.

52.4.3.4

The fields of the MV general switchboard shall have a suitably formed metal housing made of DCP steel sheet 2mm thick with necessary reinforcements, effectively covering all their elements, when fully erected and with all wirings duly connected. They will furthermore be equipped with lifting hooks for transportation purposes.

52.4.3.5

Subsequent to its fabrication the switchboard metal housing shall be subjected to phosphate treatment and coating with not less than three "oven treated" coats, ie a primer coat followed by two further overcoats of the final paint and finish, to be defined by the Supervision.

52.4.3.6

Except for their underside (base) MV Switchboards shall be closed from all sides and shall be accessible from the front, through independent doors, one provided for each individual field.

52.4.3.7

Switch gear operations for each field shall be effected from the switchboard front outer side. The general MV switchboards fields shall offer P30 protection.

52.4.3.8

No access shall be possible to the inner space of each field unless if prior insurance is secured (through mechanical bolting systems) that the field is OFF VOLTAGE AND EARTHED. An earthing bar, sized 30x5mm shall be installed all along the MV general switchboard length.

52.4.3.9

MV general switchboards shall include :

a. One (1) MV arrival field, from the PPC control panel and

b. The required number of fields for transformers supply

52.4.3.10

The 20kV MV arrival field in each MV general switchboard of a substation shall comprise:

a. Current balances 400A nominal rating, made from electrolytic copper,40 x 5 mm section, 20/24kV operating voltage and long duration short circuit current, rated value 10kA for a 1" duration and 20kA peak, to be installed on moulded resin insulators.

b. A three phase main cut-off switch, operable under load, nominal current capacity 400A, with following technical characteristics :

i.	Operating voltage	20/24 kV
ii.	Earth resistance and between phases (1')	50 kV
iii.	Short circuited cut-off capacity	>12.5 kA-1'
iv.	Short circuited connection capacity	>31.5 kA
v.	Earthing impact voltage capacity and between phases	125 kV
vi.	Operation	Depended, manual

c. 3Nos single phase terminal boxes, complete, with all necessary fittings, suitable for 20kV cables termination.

d. 1No earthing cut-off switch for cables earthing with following technical characteristics :

i.	Short duration nominal capacity	9.65 kA-1sec
ii.	Short circuited nominal switching capacity	18.4 kA(peak)

The switch shall be independently operable, manual.

e. A cable voltage control device, with voltage distribution capacitors per phase, for the indication with miniature indicator lamps of the voltage existence at the cable terminal boxes.

f. 3Nos surge arresters for the transfer to earth of dangerous high voltages, suitable for switchboard installation, operating voltage 20/24 kV, 50 Hz, nominal surge current capacity 10 kA, to VDE 0675/Teil 1 or IEC 99.1

52.4.3.11

The bars, their connections and supports should resist without deflection, for a duration of 3sec, short circuit consequences up to the board's maximal rated value.

52.4.3.12

All bar connections shall be coated with epoxy resin or other suitable material. When the main cut-off switch is in the off position, the balances compartment should be safely separated from the rest of the field through bakelite diaphragms.

52.4.3.13

In order to open the arrival field door, the main cut-off switch should be in the "OPEN" position (i.e. the MV circuit be disrupted), the earthing switch being simultaneously in the "CLOSED?' position.

52.4.3.14

The earthing switch shall not be able to "CLOSETM, when the main cut-off switch is in the "CLOSED" position. It should not be possible for the field door to open, in case both the main cut-off and the earthing switches are in the "OPEN" position.

52.4.3.15

Each transformers supply field shall contain :

a. Bars, 400A nominal rating, as stipulated for the MV arrival field (20kV)

b. A three phase main cut-off switch, operable under load, nominal current capacity 400A, with following technical characteristics :

i.	Operating voltage	20/24 kV
ii.	Earth resistance and between phases (V)	50 kV
iii.	Short circuited cut-off capacity	>12.5 kA-1"
iv.	Short circuited connection capacity	>31.5 kA
v.	Earthing impact voltage capacity and between phases	125 kV
vi.	Operation	Depended, manual

c. 3Nos MV 20kV fuses, to the required current rating.

d. 3Nos single phase cable terminal boxes, complete with all necessary fittings, suitable for 20kV single phase cables termination.

e. Voltage control device on the cable side, as stipulated for the 20kV arrival field.

f. One earthing switch for the cable side earthing as defined in the 20kV arrival field.

52.4.3.16

When the main cut-off switch is in the off position, the balances compartment should be safely separated from the field remainder through bakelite diaphragms.

52.4.3.17

It shall not be possible for the field door to open except when the earthing switch is in the "CLOSED" position. In order to enable operating the main switch, the field door should be closed and the earthing switch should be in the "OPEN' position.

52.4.3.18

It shall not be possible for the earthing switch to "CLOSE" in case the main cutoff switch is in the "CLOSED" position. The earthing switch shall be freely operable when the field door is open.

52.4.3.19

Each switch shall be provided with automatic cut- off device in case of failure of even one MV fuse, with working solenoid for remote cut-off as soon as voltage is applied (220V approximately) and with auxiliary contacts (2S + 2o).

52.4.3.20

The switchboard shall be delivered completely installed and shall contain all materials and appurtenances necessary for the installation, such as bases, insulators, conductors, insulating tape, bolts etc. The switchboard shall be accompanied by ail auxiliary operation and maintenance apparatuses provided for by the manufacturer. As there is provision of NAF Sill firefighting system on the MV switchboard, the board manufacturer should take such system into due consideration to avoid problems relating to the passage of pipes, nozzles detectors etc.

52.4.3.21

The entire complex, the switchboard partial elements and its metal construction shall comply with German DIN Standards, the PPC Standards and the respective standards of the switchboard instruments country of origin. Above shall be confirmed in a manufacturers certificate, to be duly issued.

52.4.3.22

Following tests shall be effected in each substation MV General Switchboard :

a. Electric resistance tests at 1.2x industrial voltage frequency for a duration of 50 μS.

b. Electric resistance tests at industrial voltage frequency for a l min duration (50kV and 60kV for 1min).

c. Short duration current resistance test of the MV switchboard main circuit (current impact value I = 40kA for a 1 sec duration).

d. All above tests shall be effected in the PPC material testing laboratory (KAM)* as referred to in detail in the Tests Chapter.

52.4.3.23

The MV General Switchboard installation shall be effected in an individual space, within the substation complex. The base on which the MV general switchboard shall be erected, shall be made of NP 100mm channel steel section levelled.

52.4.3.24

MV supply cables (20kV) at the MV General Switchboard arrival fields, as well as those departing from the fields to the transformers primary coils, shall be connected with suitable section terminal boxes, as defined in sub-clause 52.4.2 above.

52.4.3.25

Prior to placing MV General Switchboards under voltage, the lever-operated interlinks should be checked between the MV main cut-off switch, the earthing switch and the field door.

52.4.4 <u>Power Transformers</u>

52.4.4.1

These shall be suitable for the transformation of 3-phase power, 20kV polar voltage, 50Hz frequency into 3-phase current with outgoing neutral, 400V polar voltage, 50Hz frequency. Delta-star connection shall be provided with outgoing neutral (DYn11), to the required power capacity. The transformer should be suitable for indoors installation and shall be manufactured in accordance with DIN 43511.

52.4.4.2

When the transformer is out of voltage, the transformation ratio shall be capable of 44-5% minimal adjustment, at 2.5% steps, by means of external operation. For 6% approx. short circuit voltage, transformer off-load (magnetic) and copper (full-load) losses shall be as defined in DIN 42511.

52.4.4.3

The transformers coolant liquid shall be special transformer type inflammable silicone oil. Provision shall be made for air tight oil reservoir The transformer shall be equipped with thermometer, thermostat, drain cock and relief valve, as well as with earthing terminal.

52.4.4.4

Each transformer shall be protected by one dual float BUCHHOLZ type solenoid, the first float issuing an acoustic signal (alarm), the second one placing automatically the transformer "off-voltage".

52.4.4.5

Each transformer shall be accompanied by an alarm horn and the official manufacturer technical leaflet, or alternatively by a relevant Manufacturer's Certificate confirming above electrical and other characteristics along with the effected test results
.

52.4.5 Low Voltage General switchboard (LV-GS),

52.4.5.1

This board shall be metal construction of the "cabinet" type, suitable for floor installation, front accessible through suitable doors. The switchboard complex shall be separated into individual cells (fields).

52.4.5.2

LV-GS shall comprise :

a. Transformer side arrival fields

b. Load side departure fields, supplied by each transformer

c. Interconnection fields

52.4.5.3

The transformer side arrival field shall contain an automatic cut-off switch of the required current rating. An electrical safety link shall be provided so that it shall not be made possible for the above switches to "CLOSE" once the respective load switch on the MV switchboard is not closed.

52.4.5.4

The interconnection switches (bus-couplers) shall also be automatic.

52.4.5.5

All departures shall be equipped with load switches and fuses.

52.4.5.6

Automatic power switches characteristics shall be as follows:

a. Nominal insulation voltage shall comply with VDE0110, 500V EP, I Gr D - 750V EP, I Gp C and over 630A 750V EP, 1 Gr D -1000V EP, I Gr .

b. Manual operation shall be provided by means of an operating lever.

c. A minimal of 20000 manual mechanical operations shall be guaranteed.

d. Power switches shall be equipped with thermal overload protection according to IEC 157-1/IEC 292-1, with adjustment possibility.

e. They shall have magnetic short circuit protection, the total cut-off time varying, depending on rating, between 20 and 30 msec.

f. Provision shall be made for the use of no-voltage solenoids or delayed activation operation with selection between 60 through to 30 msec.

g. Switches nominal voltage shall be 660V, EP.

h. Protection class shall be IP 40.

i. Nominal cut-off rating (500V AC, cow = 0,3) 50 kA

j. Number of poles : 3

52.4.5.7

Load cut-off switches shall be of the rotating PACCO type for currents not exceeding 100A, whereas for larger capacities shall be of the disconnect type. Fuses shall be either screwed or disconnect type.

52.4.5.8

The balances interconnection switch shall be an automatic power cut-off switch, of the required current capacity, complying with the requirements of previous Para 52.4.5.6, except that it shall have four poles, and shall not be equipped with no-voltage solenoid.

The device shall dispose key-controlled mechanical linking as well as electrical interlink so as to ensure that the departures of the two transformers cannot be parallelized, i.e. it shall not be possible for the balances interlink switch to close as long as either automatic cut-off switch at the arrival- from-transformer side is not open and vice versa.

52.4.5.9

The switch board shall be placed on a base made of steel channel U-section, NP10.

52.4.5.10

In view of the provision of an automatic fire fighting system with NAF-Sill to be installed within the switchboard, i.e. the positioning within the switchboard of piping, sprinkler nozzles and fire detectors with their electrical lines, the switchboard manufacturer should pay due consideration to the firefighting system, resolving eventual planning and design problems, crossing provisions etc.

52.4.5.11

The switchboard shall be of the closed metal cabinet type made of DCP steel sheet, 2mm thick with angle iron frame, section 40 x 50 x 4 mm and U-shape channels section 40 x 30 x 40 x 4 mm.

52.4.5.12

The switchboard shall be coated with one coat of rust proof paint and subsequently it will be electrostatically coated with color to be decided by the supervision.

52.4.5.13

Switchboard construction shall be such so as to allow easy access to all cut-off, operation, safety indication and other apparatus installed therein. Such apparatuses shall be placed in regular positions, allowing easy removal, repair and replacement without altering the adjacent devices status.

52.4.5.14

In the switchboard inner space provision shall be made for supporting the departing cables on special perforated galvanized steel cable trays.

52.4.5.15

Power distribution to the various departing electrical lights shall be made by means of copper bus bars supported on suitable insulators.

52.4.5.16

Four bus bars shall be provided in total, one for each of the three phases and one for the neutral. They shall be placed with the cross section larger side laid vertical and shall be epoxy resin or otherwise suitably insulated subsequent to their erection and the completion of all electrical connections. They shall be coated with the colors used for phases and neutral identification in all switchboards. Bus bars shall be designed for a 2000A nominal current rating and long term short circuit current 25kA rating for 1" and maximal asymmetric peak 45kA at 0.4kV.

52.4.5.17

On the complex lower side a copper bar shall be placed, 60x1Omm cross section and shall be conductively connected to the metal structure in all its fixings. It shall be furthermore connected to the earthing network and to all earthing conductors of the departing lines (earthing bar).

52.4.5.18

The earthing bar shall be perforated at regular intervals allowing frequent connections, and shall be painted in yellow color.

52.4.5.19

Inner switchboard connection from the automatic incoming line switchboard outlet side on each board up to the balances shall be effected with copper bus bars identical to the ones described above, of suitable cross sections and colors. Beyond the balances such connection shall be made by means of insulated single phase conductors (or through bars for larger sections), of suitable colors (uniformly used for identification of phases and neutral) having a section not less than the respective section of the line served.

52.4.5.20

Balance connections shall be effected by means of stainless steel cross bolts, size 1/2"x40mm using an ordinary washer on the bolt head side and an ordinary and prover type washer on the nut side.

52.4.5.21

For such connections cylindrical conductors shall be provided with suitably sized tin-plated copper round-shape terminal (COSS).

52.4.5.22

For a bar to bar connection 2Nos stainless steel bolts, size 1/2"x40mm shall be used, diagonally placed on the joint.

52.4.5.23

Great effort shall be made in general for ensuring impeccable connection both from the technical and aesthetic aspects, i.e. applying short and straight (as far as practicable) bars and wire routes, effective and tight jointing, avoidance of unjustified crossings etc.

52.4.5.24

For avoiding operation by unauthorized individuals, dust ingress etc., the fields front metal surface shall close with a door. On the door shall be located only the voltage indicator lamps. When opening the door the front metal surface of the field shall be exposed, on which the operating levers of the main cut-off switches and the front plates of the measuring instruments shall appear. Fuses shall be located behind metal or clear plastic access covers.

52.4.5.25

When effecting the switchboards inner wiring, it is necessary to maintain a uniform phase identification system.

52.4.5.26

Accordingly each specific phase shall always be marked with the same color, appearing always in the same position with relation to the others (e.g. R to the left, S in the middle and T on the right) with respect to fuses and indicator lamps.

52.4.5.27

Indicator lamps and measuring instruments conductors shall follow routes as short as practicable along the panel walls, away from lines of strong currents, suitably fastened in single layers.

52.4.5.28

Such conductors shall be single wire NYA or NYAF 1.5 mm2 section for the indicator lamps, 2.5 mm2 section for the voltmeter, its voltage circuits etc. and 4 mm2 section for ammeters and the current circuits of the measuring apparatuses.

52.4.5.29

Voltage circuitry conductors of the measuring apparatuses as well as indicator lamps shall be secured with miniature type circuit brakers, placed in an easily accessible position, at the board inner side.

52.4.5.30

On the front metal surface of each field (behind the door) and under the cut-off switches and the circuit brakers plastic engraved indicator plates shall be positioned, perfectly adapted of impeccable appearance, stating the apparatuses designation.

52.4.5.31

Similar sign plates shall be positioned on the inner surfaces, adjacent to the circuit brakers, cut-off switches etc.

52.4.5.32

Departing cables from the switchboard to the power supply distribution panels shall be marked with suitably numbered rubber rings, so that the cable designation is identifiable by the number.

52.4.5.33

The switchboard shall be delivered complete with all its appurtenances, accompanied by any other additional safety device or auxiliary apparatus or instrument, necessary for its regular and safe operation (even if such equipment, instrument or apparatus is not specifically referred to in the descriptions). It shall furthermore be accompanied by eventually required interdependence link-wires.

52.4.5.34

For transport purposes the switchboard shall be provided with lifting hooks, its protection being class IP40.

52.4.5.35

It should be noted that the Contractor should pay particular attention so that -in cooperation with the supervision- each switchboard is designed and constructed to pleasant aesthetic appearance.

52.4.5.36

The LV general switchboard shall undergo following tests :

a. Short duration current resistance of the LV switchboard main circuit (current impact value I=60kA at 1sec duration)

b. Insulation tests : 2.000V voltage applied between :

    i. Phases
    ii. Phases and earthing
    iii. Phases and neutral

52.4.5.37

Measurement instrumentation They shall comply in general to the VDE 0410 Specifications.

52.4.5.38

Switchboards measurement instrumentations sizes shall comply with DIN 43700 and DIN 43718, measurement ranges to DIN 43701, measurement resistance to DIN 43703.

52.4.5.39

Test voltage for instrumentation resistance shall be 2000V (50Hz) and shall correspond for the measurement instrumentation to 660V operating voltage.

52.4.5.40

Measurement instrumentation positioning shall be vertical, their accuracy class being defined for such positioning. The class of accuracy shall refer to 200 C temperature in accordance with VDE 0410 Specifications.

52.4.5.41

Instrumentation housing and cover shall be tight against water and dust spray. Each instrument shall have a zero position adjustment device, so that the pointer accurately indicates zero position, when out of current or voltage.

52.4.5.42

Instrumentation fixing on the switchboards shall comply to DIN 43835.

52.4.5.43

Measurement step shall be in accordance to DIN 43802 Specifications, electrical terminals and connection layout as per DIN 43807.

52.4.5.44 *<u>Ammeters</u>*

a. Ammeters technical characteristics shall be as follows:

   i. They shall be of the rotating iron type, AC, suitable for 15-100 Hz frequencies.
   ii. Dimensions shall be 96 x 96 mm
   iii. Accuracy class shall be : 1.5%

b. Where in the switchboard diagrams one single ammeter is indicated, a suitable changeover switch shall be provided to enable current measurement on all three phases.

52.4.5.45 *<u>Voltmeters</u>*

a. Voltmeters technical characteristics shall be as follows :

   i. They shall be of the rotating iron type, 50Hz, AC, (range 15-100 Hz)

   ii. Dimensions shall be 96 x 96 mm

   iii. Accuracy class shall be : 1.5%

52.4.5.46 *<u>Power factor measurement devices</u>*

a. The device shall indicate current and voltage deviation per phase and shall consist of a rotating solenoid instrument accompanied by an electronic system.

b. Separate solenoids shall be provided for voltage and current.

c. The device technical characteristics shall be :

   i. Input voltage : 380V
   ii. Current : 5A for direct connection or through current transformer
   iii. Frequency : 50Hz

iv. Current solenoid capacity : 1VA approx
v. Voltage solenoid capacity : 3-10VA approximately
vi. Overload capacity : 20% continuous as per VDE 0410/3.69 para 24
vii. The instrument shall have four uniformly charged conductors
viii. Operating temperature : -10° C to 50° C
ix. Dimensions shall be : 96 x 96 mm
x. Accuracy class : 1,5%
xi. Temperature error shall not exceed 1% for each 10° C

52.4.5.47 *<u>Current transformers</u>*

a. Current transformers shall be used for measuring alternating currents mainly over 5A and shall comply with DIN 42600 and VDE 0414/12.70 Specifications.

b. The current transformers technical characteristics shall be as follows:

i. Secondary solenoid nominal rating shall be 5A
ii. Dry, indoor type insulation shall be provided according to VDE
iii. Nominal frequency shall be 50Hz
iv. Operating voltage shall reach up to 600V

v. Test Voltage shall be 3kV
vi. M5 overcurrent factor (-15% total error at 5x I_N) (Note I_N = nominal current rating)
vii. Short circuit resistance/thermal current : I_{th} = 60 I_N
viii. Dynamic current : I_{dyn} = 150 I_N
ix. Continuous overload : 20%
x. Impact overload : 60 I_N (for 1 sec)

52.4.5.48 *Earth Fault Relay (EFR)*

a. At the entry of the LV-GS from each transformer provision shall be made for the installation of an EFR. In the case of earth-fault, a signal shall be sent to the central monitoring and control system.

b. Each relay shall be suitable for 3-phase, 380V, 50Hz low voltage network, with grounded neutral.

52.4.5.49

All instrumentation to be installed on the boards shall be made by a well-known and reputable electric material manufacturer, such as Siemens, AEG, ASEA, BBC, MG or other approved by the supervision.

52.4.6 Power Factor Correction Capacitors Battery Fields

52.4.6.1

Provision shall be made for batteries of power factor correction capacitors, one for each switchboard section, supplied from one transformer in order to ultimately achieve coscp = 0.95.

52.4.6.2

Each capacitors battery shall be suitable for 380V operating voltage, control voltage 220V/50Hz, total idling power as required.

52.4.6.3

Each capacitors battery shall be separated in sections, enabling a minimal of 6 steps of idling power to be achieved.

52.4.6.4

Idling power steps shall be as follows :

a. One idling power step designated to balance the transformer magnetic current.

b. Five further equal idling power steps for the remaining installation.

52.4.6.5

Any combination of capacitors may be used for the achievement of above sub-clause steps, with suitable steps design and scheduling, to be inserted into or withdrawn from the circuitry, depending on case.

52.4.6.6

Each capacitor shall be three phase, with 3-terminals delta type wiring, incorporating thermal protection which shall automatically switch him off, when its shell temperature exceeds 600 C.

52.4.6.7

Each capacitor shall have separate protection with knife type circuit breakers (NH type) and individual remotely controlled contactor, installed on the capacitor, in a hermetically closed configuration. Provision shall also be made for capacitor discharge resistances, when it is switched off circuit, as well as operation indicator lamps.

52.4.6.8

Each battery shall be equipped with automatic measurement an idling power adjustment device with three measurement systems, for asymmetric loading and shall dispose a graded button for adjustment of the desirable cosφ value.

52.4.6.9

Each complex shall be equipped with ventilation louvres, as required, for its due cooling in a manner ensuring (for ambient temperature in the installation space up to 40° C) regular cooling and released heat draw-off, without temperature increase beyond the safe operating limit, both with respect to the devices as well as to personnel.

52.4.6.10

Each battery shall be accompanied by all fixing, assembly, connection and other materials, along with electrical connection and wiring (terminal connection boxes, connecting wires etc.) and shall represent an integrated closed cabinet-type complex.

52.4.7 Standby Diesel-Generator Unit (DG set)

52.4.7.1 General

The standby diesel generator set should be capable of providing in continuous operation the required electrical power, at a power factor (cow) not exceeding 0.80, and under following conditions :

a. Output current : 3-phase, (polar) voltage 400V, phase voltage 230V, 50Hz, with neutral

b. Fuel : Transportation type "Diesel" fuel as available in the Albanian market

c. Installation space ambient temperature (consequently combustion air temperature to diesel motor) :
Winter -2° C
Summer +45° C (minimum)

d. installation altitude : 100m above sea level

e. Full load takeover time (260 kVA) : 10 sec

52.4.7.2

The DG set should be capable to withstand under full load a 10% overload, for a 1-hour duration every 12 hrs of operation, in accordance with DIN 6270.

52.4.7.3 Extent of the Scope of Work

Within the scope of this work, apart from the supply and installation of the main DG set and its auxiliaries, as defined herebelow, is included also the supply and installation of each and every additional appurtenance, etc. required, the construction of required base, connections to the fuel network, and to the exhaust gazes duct etc., as well as any other work required for the delivery of the DG set in normal operating condition under full load.

52.4.7.4 DG set components

The emergency stand-by DG set shall comprise the following :

a. The diesel engine

b. The alternator

c. The flexible coupling connecting the above and their common base

d. The automation control of the DG set and load changeover system

52.4.7.5 *Diesel Engine*

The diesel engine speed shall be 1500 rpm, with sufficient power to move the alternator effectively under full load in the conditions stipulated in sub-clause 52.4.7.1 above.

52.4.7.6

The diesel engine shall be closed circuit water cooled, equipped with a complete fan-radiator remote cooling water system.

52.4.7.7

The diesel engine shall preferably have removable cylinder jackets and shall contain the following :

a. Speed regulating system : By means of an accurate hydraulically operating speed adjuster, with manual adjustment of desirable rpm speed.

b. Lubrication system : Forced lubrication shall be provided with gear pump directly coupled and moved by the engine. Provision shall be made for oil filter and lubricating oil pressure indicator. Furthermore, lubricating oil radiator shall be provided, cooled by means of cooling water.

c. Fuel system : Fuel supply shall be made by means of a pump sending the fuel to the injection pump. Provision shall be made for twin fuel filter, of alternating operation, controlled by an easy changeover lever. At engine stop a solenoid valve shall automatically interrupt fuel supply. Provision shall be made for daily consumption fuel tank, complete with all necessary fittings, as well as electrically operated level switches for the automatic control of the fuel make-up pump (separately compensated)

d. Electrical Starting System : The diesel engine automatic start shall be achieved by means of batteries and electric starter. The batteries shall have sufficient capacity to withstand effectively not less than a minimal of 10 successive starts. Battery charging and their maintenance in continuous charged condition shall be effected by means of an automatic battery charging device, AC supplied from the power distribution network.

Electric starter, batteries, battery charger and associated electrical wiring are considered as part of the integrated DG set package.

e. Cooling System : The diesel engine cooling shall be effected by means of a cooling water closed circuit, the water being cooled in turn, at a remote electric fan radiator. The latter shall be moved by an electric motor, supplied with power from the DG set. The radiator shall be designed for suction air temperature 40° C. If required, provision shall be made for preheating cooling water with electric resistances and a thermostat, supplied with power from the building distribution network. As installation of the radiator shall be made at an accessible space, all its moving parts shall be equipped with suitably designed protective hoods.

Cooling water circulation pump shall be incorporated on the diesel engine, but should it prove insufficient to Cope with friction losses on the piping network between engine and remote radiator, then an additional electrically operated booster pump shall be provided, for such purpose, supplied from DG set control panel. The Contractor's particular attention is drawn to the fact that the DG set cooling system and associated equipment are not separately compensated, but are included in the offered DG set price along with all relevant connections.

Within the DG set price are, furthermore, included all departures of power supply lines to the radiator fan and eventually required booster pump of cooling water from the DG set control panel, alongwith their complete electrical installation.

f. Combustion Air System: Provision shall be made for an air filter system at the suction inlet of the engine combustion air.

g. Gases exhaust system : Provision shall be made for a high efficiency noise attenuation device (silencer) at the gases exhaust so that the noise from combustion gases reliesed into the atmosphere not to exceed 50 db (A), measured at 10m distance from the exhaust outlet. A flexible joint shall be provided (flexible fire resistant steel pipe), at the silencer connection point to the diesel engine. The whole of the gases exhaust system shall be fire proof insulated. The exhaust pipe size shall be defined by the DG-set manufacturer.

h. Diesel engine indicator instruments : Provision shall be made for following indicator instruments :

- 1No cooling water thermometer
- 1No cooling water pressure gauge
- 1No lubrication oil thermometer
- 1No lubrication oil pressure gauge
- 1No super charger air pressure gauge (if applicable)
- 1No engine speedometer (rpm)
- 1No engine hours run counter
- 1No fuel level indicator, in the fuel tank

i. Engine operation monitoring instrumentation : The following engine operation monitoring instruments shall be provided (as a minimum), incorporated within the diesel engine, fully wired or pipe connected to the control panel :

- 1No lubrication oil pressure monitor
- 1No cooling water temperature monitor
- 1No overspeeding adjuster
- 1No fuel line solenoid valve

52.4.7.8

The diesel engine shall be duly equipped with a flywheel ensuring rotation uniformity, in a manner so as to avoid substantial fluctuations to the voltage produced by the generator.

52.4.7.9 Alternator (generator)

The generator shall be 3-phase synchronous, self-adjusted, self-excited, brushless type. The exciter shall be on the generator shaft. Both generator and exciter shall be brushless, without any moving contacts, subject to tear and wear. Maintenance shall mainly be limited to bearing lubrication and cleaning from eventual fouling.

52.4.7.10

Provision shall be made for a safe lubrication system to the generator bearings. The generator construction shall allow its safe surcharging, particularly in the case of starting large electric motors, up to 2 times its nominal load, for a duration up to 20 sec.

52.4.7.11

Generator protection class IP23S (or higher) to DIN 40050. Provision shall be made for generator protection against disturbances, in accordance with class "N" of VDE 0875. The generator shall be protected by means of overcurrent (thermal) and short-circuit (electromagnetic) elements, provided on the generator board. It shall, furthermore, be protected against reverse power (alternator operation as motor) by means of a suitable reverse power relay.

52.4.7.12

The generator voltage regulator shall be static, electronic type, specially designed for DG-set, automatically releasing the current necessary for adjustment under any loading condition. Voltage static stabilization shall be within +2% limits, for loads varying between 0 and 100%. Dynamic stabilization efficiency shall be better than 15%, and shall act within less than 700msec.

52.4.7.13

Diesel engine speed fluctuations up to 5% shall not affect voltage stabilization. Provision shall, furthermore, be made for the possibility of desirable voltage manual adjustment up to +5%, by means of potentiometer.

52.4.7.14

The alternator shall deliver at its poles the required power, at cosφ) = 0.8 for 450 C ambient temperature at 500m altitude, above sea level.

52.4.7.15

Outlet voltage at the generator poles shall be 400/231 V, 50Hz at 1500 rpm, with star type connection and outgoing neutral. Minimal generator efficiency shall be 90%, at 100% load and cosφ = 0.8.

52.4.7.16

The alternator shall, generally, comply with VDE 0530 specifications and shall be suitable for use on a DG-set.

52.4.7.17

Following indication instruments shall be provided for the generator :

a. 1No voltmeter
b. 1No 7-step voltmeter selector switch
c. 3Nos ammeters with respective current transformers
d. 1No frequency meter
e. 1No power factor meter (cos(p)
f. 1No DC voltmeter, for the starting battery
g. 1No DC ammeter, also for the battery

52.4.7.18 *Flexible coupler - Common base*

Diesel engine and alternator shall be closely coupled with a suitable flexing coupling and shall be installed on a common metal base. The base shall be accompanied by suitable highly effective antivibration springs, excluding the risk of vibration being transmitted to the building.

52.4.7.19 *Automation. Control and Load Changeover System*

The DG-set shall be equipped with an Electronic Voltage Monitoring System, with the following functions :

a. Automatic DG-set start, subsequent to a power failure or PPC network inadequacy or transformer(s) failure and automatic load takeover, with the time-delay required for the PPC network.

b. DG-set operation monitoring.

c. Automatic DG-set cut-off in case of fault (lubricating oil low pressure, coolant water overheating, diesel engine overspeeding, alternator overload, voltage deviation, fuel shortage).

d. In case of starting failure, automatic repetitive restart procedure, for a duration of 8 sec approximately, up to a total of three consecutive times, with intermediate 8 sec pauses.

e. Locking of the starting automation, subsequent to 3Nos unsuccessful start trials.

f. Automatic load changeover to the PPC supply, subsequent to restoration of the PPC network, DG-set load-free operation for a duration between 0 and 5 min (tinier adjustable) and ultimate stoppage of the set and automatic return to stand-by status.

52.4.7.20

Load changeover between the PPC and the DG-set shall be effected via a 4-pole power changeover switch, with one outlet to the emergency general switchboard and two inlets one designated for PPC power supply, the other for DG-set supply. The changeover switch shall be installed at the DG-set automation panel.

52.4.7.21

Provision shall be made in the automation system for an Electronic Voltage Monitoring System (with adjustable upper and lower limits for desired voltage). Such system shall monitor all three transformer outgoing phases, from which the Emergency General Panel is supplied. In case of PPC power supply interruption all voltage inappropriateness (value beyond allowable limits) or failure in one or more phases, or transformer fault then, the network voltage monitor shall release an order for starting the DG-set and subsequently for load takeover by the generator, via the changeover switch, as soon as the generator voltage reaches its normal value. On the other hand, as soon as the voltage monitor detects PPC network voltage reinstatement it shall release an order for load changeover to the PPC supply and DG- set stop subsequent to load-free operation for a duration adjustable between 0 and 5 min.

52.4.7.22

The automation, control and changeover system shall be equipped with following apparatuses :

a. Signing equipment :

i. Indicator lamps for :

- DG-SET, OPERATION
- LOAD SUPPLY FOR PPC NET
- LOAD SUPPLY FROM DG-SET
- STARTING FAULT
- LUBRICANT LOW PRESSURE FAULT
- COOLING WATER HIGH TEMPERATURE FAULT
- GENERATOR SURCHARGE FAULT
- DG-SET OVERSPEEDING FAULT
- FUEL SHORTAGE FAULT - VOLTAGE DEVIATION FAULT
- POWER REVERSION

ii. Audio alarm (horn) with alarm reset button for all above faults, starting fault inclusive.

b. Operation equipment :

i. One single 4-position key operated selector switch OFF-AUTOMATIC-MANUAL-TEST enabling manual repetition of the whole procedure and starting of the 0G-set with or without load changeover.

ii. Button for manual INSTANT STOP of the DG-set.

iii. Indicator lamps operation control button.

iv. Audio alarm reset button.

v. DG-set manual start button.

52.4.7.23 OG-set tests and controls

Tests and controls shall be effected :

a. At manufacturer's premises, particularly :

i. At generator manufacturer's plant where following tests shall be recorded on the generator testing protocol :

— Tracing of the load-free operation characteristic curve
— Tracing of short-circuit operation characteristic curve
— Tracing of full load operation characteristic curve
— Resistance test on AC coils, rotor, exciter rotor, exciter field, exciter auxiliary coil
— Surcharge test
— Speed test
— Stator high voltage test

ii. Particular care shall be paid so that the base is not in contact with the floor and other building elements, leaving a gap not less than 10cm to be filled with suitable elastomeric material or with fine aggregate so as to avoid vibration transmission to the building.

iii. Connecting cables between DG-set and control panel shall be placed in a cable duct to be constructed within the space floor. Such cable duct shall be sized and detailed according to the DG-set suppliers instructions.

b. The DG-set installation on its base frame shall be effected by means of untivibration sleepers, the number of which shall be defined by the manufacturer.

c. Fixing of the DG-set on its base frame shall be effected by means of anchor bolts provided by the manufacturer and twin nuts.

d. Anchor bolts shall be cast into the engine foundation concrete during its construction, except if the foundation is cast prior to the DG-set supply, in which case the bolts exact position shall be defined on a drawing with full dimensional details.

e. In case of delayed supply of the 0G-set, or the foundation drawing, construction of the foundation may proceed. In such case DG-set anchoring shall be effected, subsequent to the DG-set supply, using expanding metal plugs and suitable special bolts (rawlbolts) in the right positions.
f. DG-set silencer and exhaust piping installation shall be effected in accordance with the drawings. At its downstream end, the piping shall have a mobile cap, to avoid stormwater ingress.
g. Provision shall be made for lifting hooks, within the DG-set installation hall, above the diesel engine and the generator, for suspension of lifting devices.
h. The construction of air inlet (through filter) and outlet (exhaust fan) into and from the DG-set space shall be effected by the Contractor, as indicated on the drawings, enabling effective withdrawal of the DG-set generated heat, from the space.
i. Cooling air sanction shall be effected through wall-mounted louvers from which the air shall be pumped into the space by means of axial fans.
j. Electrical installations of the DG-set operation and control panel shall include:

    i. DG-set control and automatic start fields installation.

    ii. Connections of the above boards to the emergency general switchboard by means of suitable cables and wires.

    iii. DG-set auxiliary circuits plugged connections to the control panel.

    iv. Installation and connection of the battery charging system.

k. The special base for the installation of the DG-set batteries should also be constructed and connected to the 0G-set.
l. Construction and installation of the fuel day-tank along with all fuel supply and return pipework and valving, necessary for the DG-set operation.
m. It should be noted that the cooling water pipelines sizes, connecting the DG-set to the remote radiator as well as the size of the exhaust pipe indicated on the drawings, should be checked, and if necessary revised subsequent to Contractor's verification, in consultation with the DG-set manufacturer.

52.4.7.24 *Installation materials. spareparts. Tools*

The DG-set shall also be accompanied by the following :

a. Installation materials : The diesel engine shall be accompanied by pieces of flexible hoses, for its connection to the fuel and exhaust networks.

b. Spareparts : A series of spareparts shall be delivered, sufficient for operation of not less than 1000 hrs (according to manufacturer's written statement). Spareparts list and manufacturer's statement shall be submitted together with the offer.

c. Tools : A series of tools necessary for 0G-set repair and maintenance shall also be delivered, such as spanners, torque-lever, extractors and expanders required etc.

52.4.7.25 *Instructions and drawings*

DG-set shall also be accompanied (in 3-copies) by following documents in English language :

a. Automation operating instructions

b. Automation and DG-set wiring, connection and operation drawings.

c. Diesel engine and alternator operating instructions manuals.

d. DG-set parts manual indicating each part code number.

e. DG-set maintenance and repairs instructions.

52.4.8 DG-sets Synchronization and Control Board (DG-SCB).

52.4.8.1

In view of the fact that the above DG-sets are designated for standby use and synchronized (parallel) operation, the Contractor shall also (if required) provide the DG-sets Synchronization and Control Board.

52.4.8.2

The DG-SCB shall be metal construction, cabinet type as described above in this chapter.

52.4.8.3

The Board shall comprise :

a. For each DG-set one field containing :

   i. Automatic electrically activated generator protection cut-out switch, of the required capacity, with adjustable overcharge, short-circuit and lack-of-voltage protection.

   ii. Four-pole, two-position, electrically activated changeover switch.

b. A measurements and DG-set synchronization field equipped with all necessary instruments for synchronizing and loading of the second DG-set while the first is in operation. These shall include manual start and stop buttons, voltage and frequency adjustment levers for each DG-set, synchroscope and electrical operation buttons both for the automatic switch as well as the four-pole synchronization changeover, DG-sets connection and loading. The field shall, furthermore be equipped with voltage measuring instrumentation (1No voltmeter with 7-positions selector switch), current instrumentation (3Nos ammeters and the necessary current transformers), frequency measurement apparatus (1No sychnometer), power factor measurement apparatus (1No cow-meter) effective power measurement device (kW power meter) and, finally, the necessary number of LED indicator lamps for the operating status and faults of each DG-set.

c. One output field from this panel to the Emergency General Switchboard containing :

   i. Manually operated automatic switch with overcharge and shortcircuit protection,

   ii. 3Nos ammeters and necessary current transformers

   iii. 1No voltmeter with 7-position selector switch

   iv. 1No effective power meter (kW)

52.4.9 Uninterrupted Power Supply System.

52.4.9.1 General

a. The Uninterrupted Power Supply System (hereinafter referred to as UPS) is designated for the continuous power supply of vital building installations, with constant controlled 3-phase voltage. The UPS power rating shall be as required under 0.8 power factor.

b. Under normal operation the UPS consumers shall be supplied from the PPC network through the UPS, ie the UPS rectifiers shall be fed, who shall supply -in turn- a series of batteries (to maintain continuous readiness) and the respective DC/AC Inverter (hereinafter referred to as the INVERTER).

c. The INVERTER shall ensure continuous supply to the consumers. In case of PPC network fault or inadequacy, the consumers shall be supplied for a defined period of time uninterruptedly from the charged and ready battery series, through the INVERTER and subsequently the PPC network shall have to be substituted by an auxiliary source of energy (Standby DG-Set). The battery series shall be capable of supplying 100% of the UPS load for a minimum of 30 minutes.

d. In case of UPS fault, the UPS consumers shall be directly and uninterruptedly supplied from the PPC network, through an Electronic Changeover Switch (hereinafter referred to as ECS). Apart from the ECS, there will be possibility of direct changeover of the consumers from the PPC network, by means of a manually operated switch.

e. The UPS provided for in the specification, shall be delivered fully installed, ready for operation and shall fully comply with following specifications.

52.4.9.2 UPS Construction Specifications: The UPS should satisfy following requirements :

a. The general requirements of Albanian regulations currently in force, and in particular :

   i. The Indoors Electrical Installations Code

   ii. The PPC Installation Codes

   iii. The GT Installation Codes

b. The German VDE Codes and Standards in general, or alternatively those of the UPS country of origin, if more stringent, and in particular :

   i. VDE 0875 (protection against disturbances)

   ii. VDE 0100/5.73 referring to strong currents fields and protective measures, particularly :

      1. pare 46 (protective measures)
      2. pare 10 (neutralization)
      3. pars 30N (distribution fields)
      4. pare 41 (wires and cables)
      5. para 43 (electrical spaces)

6. para 44 (isolated electrical spaces)
7. para 53 (auxiliary power supply sources)
8. para 55 (work sites)

iii. VDE 0105/8.64 (strong current systems operation etc.)

iv. VDE 051018.70, battery related specifications in general, and particularly

1. para 4C (mandatory signs)
2. para 6 (ventilation)
3. pars 7 (installation)
4. para 8 (battery spaces)

v. VDE 0132/5.65 (fire fighting)

vi. VDE 013417.71 (first aid)

vii. VDE 160 (electronic circuitry)

viii. VDE 0530 (electrical machinery)

ix. VDE 0557 (rectifiers)

x. VDE 0558 Part 2, 8.77 (current converters)

c. German DIN and VDE Standards in general.

d. International IEC Standards in general.

e. It is clarified that wherever DIN, VDE, Albanian etc. Standards are referred to in the text, these represent a qualitative reference to the minimally acceptable standard. It is self-understood that any regulations pertaining to the equipment country of origin are acceptable, provided that they are similar to or more severe than those referred to in the text (usually DIN, VDE, IEC).

52.4.9.3 *Uninterrupted Power Supply System (UPS).*

The UPS shall include following main parts :

a. Rectifier with adjustable thyristors.

b. A series of batteries for the inverter supply in case of PPC network failure or inadequacy.

c. A static type DC/AC inverter.

d. AC consumers field (hereinafter referred to as CF)

e. DC field (hereinafter referred to as DCF)

f. Electronic changeover switch (ECS) corresponding to the UPS outlet power

52.4.9.4 *Panels construction*

Various materials shall be positioned and assembled on boards, sized in accordance to DIN 41488 Specifications. Panels color shall be RAL U705 or RAL 7032 or similar. In order to avoid possibility of corrosion, individual fittings shall be coated or painted, in case not made from precious metals.

Boards related wiring shall be placed into conduits or cable racks, all branchings being effected by means of connection terminals.

52.4.9.5 *Electrical fittings*

Electrical or electronic fittings shall be provided for the 100% or rated nominal load and for the upper and lower limits of DC and AC voltages and power factor, and shall comply with VDE Specifications (transformers and reduction solenoids test voltage shall comply with VDE 0550, part 1 and VDE 0532 Specifications). For all power transformers and reduction solenoids minimal insulation class "E" is specified (VDE 0532, para 39, table 8).

52.4.9.6

Various adjustments shall be effected only by means of monocrystallic silicate transistors. Long lifespan fittings shall be exclusively provided. Fittings connection and assembly shall be effected in a manner prolonging their lifespan. In case of market availability of standardized fittings (fuses, fuse-sockets, measurement apparatuses etc.) only such standard fittings shall be allowed to be used.

In case of market availability of high performance industrial type fittings, such fittings shall necessarily be used, without exception, lower quality material being rejected. High performance, electrolytic capacitors shall exclusively be used, to DIN 41240 Specifications.

52.4.9.7 *Protection against Interferences*

The whole of the UPS shall be "grade N" protected against interferences, according to VDE 087517.71.

52.4.9.8 *Operating Conditions*

Only continuous operation rectifiers and DCIAC inverters shall be provided. In case of inverter fault, it should be isolated from both the AC and DC current, excluding the automatic "return" of a faulty inverter. In the case of inverter fault the respective rectifier shall continue maintaining the battery series.

52.4.9.9 *Efficiency*

Efficiency shall refer to the rectifier or inverter or UPS nominal load. The total UPS efficiency for the nominal load should -without failure- be not less than 85%.

For the nominal load, inverter efficiency shall be not less than 90% and the respective rectifier efficiency, not less than 95%.

52.4.9.10 *Protection Measures*

An MS bolt shall be made available at an accessible position, adjacent to the earthing bar, for the connection of earthing conductors to the earthing point, in compliance with DIN 40011 Specification. Earthing bolt shall have perfect and continuous conductivity with the metal frame. Fittings in contact should be earthed by means of connection to the earthing bolt through special conductors. The metal frame individual fittings should have between them high conductivity, i.e. being welded or tightly bolted for ensuring perfect contact. Operation apparatuses within the switchboards inner space, coming in contact with persons, should not be located in the vicinity of current bearing parts. In case this is not possible, protective hoods should be provided.

52.4.9.11 *Noise level*

The level of noise produced by the various UPS complex fields, measured to DIN, at a one meter distance and at the middle of the field height, should not exceed 65 dBA.

52.4.9.12 *Construction label*

The construction label should include following information :

- Manufacturer
- Type
- Manufacturing serial number
- Input voltage
- Nominal output voltage and nominal frequency

The label construction should comply with VDE 0557 Specification.

52.4.9.13 *Technical Manuals*

In conjunction with similar requirements of other chapters of this TCC, the following manuals should be delivered to the Employer, during the UPS complex handover.

a. Startup and Operating Instructions Manual (in three copies)

b. Maintenance, repairs and fault detection manual

c. Fittings full schedules and drawings, with reference to all individual fittings, characterized by :

    i. serial number or manufacturer code number of each particular fitting, referred also into the respective drawings
    ii. Name (designation) of each particular fitting
    iii. Electrical and mechanical data with their characteristic manufacturing tolerances

d. A schedule of proposed usual spareparts, for one two, and five year consumption.

e. A schedule of usual as well as special tools required for maintenance needs.

f. Detailed connection diagrams. In these drawings all elements necessary for fault detection should be indicated as well as the locations of various fittings, markings and connections characteristics. In case circuits consist of more than one groups it is necessary to deliver also summary diagrams of the group connections.

g. Detailed wiring diagrams.

UPS Parts Specifications

52.4.9.14 Rectifier

a. General

In normal operation the rectifier is responsible for the inverter supply, maintaining in the meantime the respective battery series in readiness, with a 2,23V voltage per element. Rectifiers should be designed in such a manner so that the battery series does not supply the consumers, under 100% load, the latter being supplied only from the rectifier.

b. Rectifier Supply Possibility

During 20 minutes, subsequent to the PPC network failure, the rectifier should be in position to supply the consumers through the inverter. It should furthermore be capable of recharging the battery series within six hours, up to 90% of their nominal capacity.

c. Rectifier Characteristic Curve

The rectifier shall be charging the battery series, according to 1U characteristic curve to DIN 41733, ie charging the batteries with constant current until they reach a voltage of 2,35V per element, with time related charge (0-12hrs). Subsequent to charging the battery series shall automatically be fed with 2,23V per element.

d. Quick Charging

Subsequent to inverter disconnection, the rectifier shall also be capable of manually charging the battery series with 2,7V per element, according to the "W" characteristic curve (DIN 41733). To this effect a selector switch shall be provided with AUTO and MANUAL OPERATION positions.
Manual operation shall be enabled only when inverter is OFF.

e. Rectifier supply

The UPS rectifier shall be supplied from 380/220V, 3-phase network. The rectifier should be capable of trouble-free, normal operation during network voltage fluctuations between +10% and -15%, maintaining the specified operating voltage tolerances for network variations +/-10%. The rectifier supply data (kVA, cos(p) should be specified in detail in the offer.

f. Efficiency

The rectifier efficiency measured under normal operated conditions (in maintenance charge and nominal current) should be not less than 95%. Efficiency under 50% of the nominal current should also be stated.

g. Adjustment accuracy

The rectifier output voltage should be adjustable within +1- 1% for supplying network loads between 0-100%, +1- 10% and frequency variations within +1- 10%.

Rectifier should be equipped with a current limitation system, adjustable to within 70-100% of the nominal load. The rectifier construction and operation should be simple containing a minimal number of fittings (automatic switches etc.).

h. Fusing and safety measures

3-phase fusing should be provided on the rectifier supply side and 2-phase fusing of the live conductors on the DC (output) side.

On the network side the rectifier should be secured by means of fuses or protective circuit braker, against overcurrent and short circuit.

No damage should be caused on any of the rectifier fittings, in case of failure on one of the rectifier supply phases. In such case the rectifier should immediately be placed out of operation by means of a protection system provided. In case the rectifier is taken "OFF" there should be an indication "protective device off".

i. Cutout Variation

The degree of the output current variation (AC component) with the battery series connected on its output and under nominal load, shall be 5% (or better) of the nominal DC current rating.

j. Power Factor

Under nominal load, power factor shall be not less than $\cos\varphi = 0.8$.

k. Protection against Interference

On the network side, grade "N" protection against interference shall be provided, in accordance with the VDE 0875 Specification.

l. Ambient Temperature

Rectifier shall be capable to operate normally in ambient temperatures varying between -50 C up to +40° C.

m. Noise level

Noise level, measured at a one meter distance and by the rectifier mid-height shall not exceed 66 dB(A).

n. Cooling

Rectifier shalt be self-cooled.

o. <u>Measurement Apparatuses</u>

Rectifier shall be equipped with following measurement apparatuses :

i. Ammeter (rotating coil type) DC, class 1.5, size 96 x 96 mm.

ii. Voltmeter (rotating coil type) DC, class 1.5, size 96 x 96 mm.

The zero position of the measurement apparatuses shall be adjustable.

p. <u>Switches</u>

Provision shall be made for following switches :

i. ON-OFF operation switch

ii. Selector switch with following positions :
- "AUTO"
- "2.7V/element charge" (manual operation)

Above sub-clause (i) switch shall normally be in the "ON" position. When in the "OFF" position the rectifier shall be disconnected from the network. Rectifier is put in operation when the network voltage is restored.

Above sub-clause (ii) switch shall normally be in the "AUTO" position.

q. <u>Indications</u>

Provision shall be made for the following rectifier indications :

i. "on" indication
red optical indication when rectifier isunder voltage

ii. "protective device off indication
Yellow optical indication and audio signal as well as placing the rectifier out of operation.

This indication announces activation of the protective device and supply network phases fault. This indication shall be put-off only subsequent to fault restoration.

iii. "battery discharge indication
Yellow audio visual indication activated in case of supply network power failure, always when rectifier is manually or automatically taken doff", the inverter being in operation.

iv. "voltage variation" indication
A yellow optical and audio signal should be provided in case the rectifier output voltage varies beyond the permissible limits for a duration longer than 0,5sec. In the case of voltage excess beyond the provided limits (e.g. 110 elements x 2,45V = 270V) the rectifier shall be isolated and locked.

It shall be possible for all above indications to be repeated on a remote indications board.

r. Remark

The bidders shall additionally stipulate in their offer, with respect to the rectifier, following information :

i. Output power in kV for coscp = 0.8
ii. Power losses in kW
iii. Input current
iv. Output current
v. Dimensions
vi. Weight

52.4.9.15 Batteries

a. General

The series shall consist from lead batteries suitable for quick discharge. The batteries nominal voltage shall correspond to the inverter offered voltage and shall have adequate capacity so as to be capable to supply the consumers during twenty minutes for 100% of the load. The batteries shall be used for parallel operation in accordance with VDE 0510 para 3/2.2 Specification.

The supplied battery series shall consist of Gro E type elements.

The DC voltage fluctuation shall allow AC not larger than 1 x 15 (5-hr battery series discharge current). The series conservative charges shall be effective with 2,23 V/element, regular charging with 2,35 V/element and quick charging up to 2,7 V/element. During discharge voltage shall be 1,81,7 V/element.

All necessary fittings required for regular operation and maintenance, as well as a portable voltmeter, a densometer, a thermometer, an electrolyte filling canister and a funnel and two fifty liters distilled water cans, shall be delivered together with the battery series.

b. Installation

The batteries shall be installed in such a manner so as :

i. To prevent short circuit risk and to avail all necessary safety measures
ii. To enable easy batteries control and maintenance
iii. To comply with VDE 0510/8.70 Specifications

c. Maintenance

Provision shall be made for :

i. Monthly electrolyte density test and its eventual correction
ii. Semestrial cleaning of the elements plugs and greasing of poles and terminals
iii. Semestrial general test by the supplier for monitoring the batteries general condition

iv. Quick charging to be effected at regular intervals, as provided for by the batteries manufacturer
v. Acid replenishment to be effected depending on batteries condition, at time intervals between 4-6 years of operation. For such purpose the batteries series shall be disconnected and clean.

d. Batteries board

Provision shall be made for a wall mounted DC board to accompany the battery series. The board shall be equipped with knife type circuit breakers and automatic power switch with a no-voltage solenoid.

52.4.9.16 DC/AC inverter

a. Inverter technical characteristics

i. The inverter output power shall be equal to the nominal load under (induction) cow = 0.8.

ii. Tolerances

The UPS shall be designed in such a manner so as to cater for and cover the computers starting currents.

iii. 3 x 380 V1220V. 50Hz_ voltage stabilization

Output voltage deviation under symmetric load shall not exceed +1- 1%.

A maximal of +1- 2% output voltage deviation, shall be allowed only under following conditions :

- Network voltage variation (static and dynamic) between -10% and +10%
- Output power variation between 10% and 100%
- DC voltage variation between maximal and minimal tolerance limits
- Space temperature variation between +50 C and 350 C
- 35% asymmetric loading
- Under 50% asymmetric loading static deviation up to 3% shall be allowed

A maximal 10% output voltage dynamic deviation shall be allowed, under following conditions :

- Network failure and supply takeover by the battery series
- Network restoration subsequent to a failure
- Instant load change of at least 30% of the nominal (rated) value
- Consumers automatic changeover, directly to the network
- Manual changeover from the network to the inverter and vice versa

Maximal balance time, subsequent to a 10% (maximal) output voltage deviation, shall not exceed 180 msec. Phases angular deviation, at polar and phase output voltage, should be within +1- 4o limits.

Remark

Within the permissible limits of voltage variations, the output voltage shall not be dependent to the consumers power factor.

iv. Frequency Stabilization

Nominal frequency shall be 50Hz. Inverter frequency stabilization during its operation, when the network power has been disrupted, should be not less than +1-0.5. Under the conditions referred to in sub-clause (a)iii stabilization tolerance (static and dynamic), shall not exceed +/- 1%.

v. Voltage deflection

Harmonics content shall not exceed a maximal of 5%.

vi. Asymmetric loads

Regular operation should be ensured also for up to 50% asymmetric loads, in which case the output voltage deviation should not exceed 3%.

vii. Voltage form

Voltage should have the form of a sinus curve.

viii. Supply tolerances

The inverter should operate regularly under DC supply current variations between -15% and +20%.

ix. Protection against Interferences

Great "N" protection against interferences shall be provided to the inverter, in accordance with VDE 0875 Specifications.

x. Ambient temperature

The inverter shall perform regularly and shall maintain permissible tolerances in its technical characteristics, in ambient temperature between -5° C up to +400 C.

xi. Cooling

The inverter cooling shall be effected by self-ventilation, by means of built-in fans.

xii. Noise level

The inverter noise level measured at one meter distance, at its mid-height shall not receive 65 dB(A)

xiii. Efficiency

Under full-load conditions, efficiency shall exceed 90%. Manufacturer shall also state the efficiency value under 50% load condition.

xiv. Short circuit protection

The inverter output shall be secured against short-circuit by the provision of a system disrupting its operation under conditions which might damage the inverter.

xv. Selector switch

The inverter shall be provided with a selector switch with following positions:

1. "on"
2. "off"
3. "test"

When placed at the "test" position the inverter shall be supplied on its input side, but it shall be disconnected on its output side.

b. Instrumentation

The inverter shall be provided with following instrumentation :

i. Output voltmeter, class 1.5, range 0-250V with adjustable zero position, 96x96mm and selector switch for R-O, 5-0 and T-O measurements.
ii. Ammeters class 1.5, with adjustable zero position, 96 x 96 mm.
iii. Sychnometer 49-51Hz, 96 x 96 mm.

c. Indications

The inverter shall be provided with following indications :

i. Red optical indication "on" meaning that the inverter is fed from its output (both input and output sides are "on").

ii. "Test" indication meaning that it is fed from its input side, the output operating under "no-load" condition.

iii. Yellow audio-visual "fault" indication.

   In case the inverter is disconnected on both input and output sides. Automatic reconnection (placement in operation) should be excluded by suitable locking.

iv. "Voltage deviations" indication.

All optical indications shall be directed into one single "fault" group indication. All indications shall be directed to one spare parallel connection set by means of out-of-voltage closed contacts.

52.4.9.17 *<u>Inverter Disconnection Electronic System (IDS)</u>*

The inverter shall be connected to the consumption busbar, by means of an electronic disconnection system. Such system (IDS) shall consist of adjustable thyristors and shall disrupt the inverter connection to the consumers in case of an inverter internal fault or in case of unacceptable variation of the supply DC voltage, beyond the specified limits. Disruption shall be effected automatically, without delay, so that the unacceptable voltage and/or variation is not transferred to the consumption bars. Such case shall be signaled by means of a yellow optical indication.

52.4.9.18 *<u>Electronic Changeover Switch (ECS)</u>*

a. The electronic changeover switch (ECS) shall be "static' type ensuring uninterrupted supply to the consumers, directly from the network in case of :

   i. inverter inner fault (voltage, frequency, monitors excitement fault etc)
   ii. inverter supply voltage variation
   iii. inverter inner temperature monitor excitement or at the hot air extraction circuit above the inverter, and
   iv. inverter maintenance

b. The ECS shall have as coupling elements per phase 2Nos anti-parallel thyristores which shall be bridged by means of an automatic switch subsequent to their changeover to the network.

   Provision shall be made for an inverter electronic monitoring device.

   Furthermore, an inverter and network electronic voltage and frequency synchronization apparatus shall be provided.

c. In case of voltage or frequency deviation or network fault a system shall be made available disabling changeover.

   Provision shall also be made for a system of electronic adjusters, continuously synchronizing the inverter and network voltage and frequency.

d. <u>ECS Power Capacity</u>

   The ECS power capacity shall correspond to the inverter full load power.

e. <u>Operating Voltage</u>

   The ECS operating voltage shall be 3-phase, 380/220V, with +/- 10% tolerances.

f. <u>Operating Frequency</u>

   The ECS operating frequency shall be 50Hz, with +1- 1% tolerance. In case of frequency deviation beyond +1- 1% the ECS shall be locked and the frequency shall be defined thereafter by the inverter.

g. Protection Against Interferences

Grade "N" protection shall be provided against interferences, to VIE 0875 Specifications.

h. Ambient Temperature

ECS shall be suitable for operation in ambient conditions varying between 50 C and +400 C.

i. Indications

The following optical (yellow) indications shall be provided :

1. Protection
2. Network "on"
3. Network "off"
4. Fault (phase synchronization)

j. Switches

The ECS shall be provided with a suitable switch for changeover to the network, in case of eventual fault.

k. Apart of the above a selector switch shall also be provided with following positions :

1. Inverter operation
2. Network operation
3. Test

l. Monitors with Remote Indication Contact

1. Protection
2. Network operation
3. Fault

m. Monitoring - Adjustment

The ECS design shall be such, so that in case of automatic changeover from the inverter to the network (inverter fault, voltage unsuitability etc) inverter monitoring shall be established and once the voltage anomaly or fault is restored, supply shall be automatically restored vide the inverter (automatic changeover from network to inverter), otherwise above changeover from the network shall not be possible.

n. Manual changeover possibility shall also be available from the network to the inverter, with delay (adjustable to within 10sec approximately) so as to allow automatic voltage synchronization of network and inverter.

52.4.9.19 Remote Indication Panel

The UPS operation status shall be indicated on a remote indication panel, bearing a mimic diagram with indicator lamps. On the mimic diagram shall appear the Rectifier input, the Inverter input, the Inverter output with local indication as well as the ECS input and output.

a. Indications

The Rectifier/Inverter/Battery series shall be signaled with indicator lamps as to:
- Operation
- test
- fault

b. The following indications shall be available as general signals for the totality of the complex

- inverter operation
- network operation
- emergency network operation
- battery series discharge, time-graded indication with five indicator lamps successively ignited at 6min approximate intervals when the battery discharge is initiated

c. Audio Signaling

Each and every UPS fault shall be marked by an audio signal by means of an alarm located on the indicator panel. Discontinuation of the alarm shall be effected by means of a reset button located on the panel front. Alarm stop shall be effected with delay *by* means of a timer (adjustable up to 60sec approximately).

52.4.9.20 Monitors

The UPS shall be provided with following monitors :

- Network voltage monitor (phases fault)
- DC voltage monitor (overvoltage, under voltage)
- All fuses and circuit breakers monitor on respective circuitry
- Inverter input monitor (overvoltage, under voltage)
- Inverter output monitor (overvoltage, under voltage). In case of monitors activation immediate faulting system disconnection shall be effected.
- Operating temperature monitor

52.4.9.21 UPS Maintenance and Repair

a. General

Easy access should be available to all the complex particular components for maintenance purposes.

As far as practicable, maintenance should be effected without the use of special instruments and tools.

b. Measuring Instruments and Tools

Along with the complex shall be delivered one full set of measuring instruments and tools for the UPS maintenance and repair. Necessary instruments shall be namely referred in the Contractor's offer.

c. Spareparts

The manufacturer shall include in his offer necessary spareparts, which should be separately listed and should represent (in value) not less than 1% of the total offer price.

52.4.9.22 *UPS Performance Tests*

a. General : Tests and controls shall generally be effected in accordance with IEC 146, chapter 140 International Specifications and shall be the following :

b. Compulsory tests to be effected at the UPS manufacturers plant, in the presence of employers representatives (if requested).

c. Other tests and controls at manufacturers plant (apart from the abovementioned compulsory ones) or alternatively at a relevant Testing Institution.

d. Subsequent to the UPS installation completion, local tests and controls.

e. All tests and controls expenses shall be borne by the Contractor (various representatives travelling, accommodation etc. expenses excluded)

52.4.9.23 *Manufacturers Plant Tests and Control*

At Manufacturers plant tests and control shall be effected on the various UPS components, such as :

- rectifier
- inverter
- switches
- miscellaneous units

a. Rectifier tests

The rectifier shall be tested to international specifications IEC 146, chapter 490-492. Such tests shall include :

- insulation test partial load tests
- auxiliary and protection systems test
- monitoring and adjustment systems test

b. DC/AC inverters test

The inverters shall be tested in accordance with international specifications IEC 146-2, chapter 5. The tests shall include respective controls as mentioned above for the rectifiers, in sub-clause (a).

c. UPS switches test

The UPS switches test shall be effected in accordance with international specifications IEC 146 and IEC 146-2 and shall refer to the following :

1. Insulation test (to IEC 146, chapter 492.1)
2. Auxiliary systems test (to IEC 146-2, chapter 5.4)
3. Protective devices test (to IEC 146, chapter 492.9)
4. Monitoring and remote indicator systems test

5. Measurement instrumentation test
6. Loads partial changeover

d. <u>Monitoring and indication systems test</u>

Individual tests shall include :

1. Insulation test (to IEC 146, chapter 492.1)
2. Connections test
3. Indication systems test

52.4.9.24 *<u>Additional tests at manufacturers plant or at competent Testing Institution</u>*

Should in the judgement of the supervision, special tests be required for verification of the UPS quality, either at manufacturers plant or at a Special Technical Institution, then (at its discretion) the following tests and controls shall be effected (in part or in full) :

— synchronization test
— efficiency test
— asymmetric loads test
— asymmetric phases test
— earthing test
— batteries test
— recharge time test
— AC test - DC voltage fluctuation
— ventilation test
— surcharging test
— short-circuit test
— shortcircuit fuses test
— restarting test
— output overvoltage test
— output voltage periodic formulation test
— frequency formulation test interference protection test
— harmonics test noise level test

52.4.9.25 *<u>In situ tests and controls</u>*

Following installation completion of the whole Uninterrupted Power Supply System, general UPS tests shall be carried out, i.e. :

a. wiring and connections general control

b. partial loads control in order to verify wiring appropriateness and performance

52.4.9.26 *<u>Following shall be tested during operation :</u>*

a. Output voltage, frequency, and measurement instrumentation performance

b. Operating switches performance, putting in operation the UPS various components

c. Monitors and protective devices performance

d. Remote indication and remote control systems performance

52.4.9.27 *Auxiliary systems test. such as ventilation, fans. pumps. etc.*

a. Protective device control for limitation of earthing voltage, i.e. testing earthing connections etc. both visually and with necessary instrumentation so as to verify compliance with protection regulations.

b. Loads test with partial loading at first, followed by full load testing (if applicable)

c. Battery series tests by means of loads in order to verify the batteries operation duration. Should the installation loads be insufficient, additional loads shall be added in order to make it possible for the battery discharge curve to be traced and compared to the one issued by the manufacturer. Under nominal load, discharged time should be computed using the characteristic curves.

   The batteries test shall be effected when they are fully charged, or alternatively, under different conditions, following agreement. The actual battery output power and voltage shall be recorded. As the new battery series during first test may not have developed its full capacity, such test may have to be repeated if expected results are not achieved during the first test.

d. Network interruption test, during which the battery series shall be fully loaded and the supply switch shall be placed "off. During the test voltage and frequency (with connected or disconnected network) shall be recorded on oscillogram and shall be duly evaluated. The frequency variation speed change shall be computed from the frequency difference and the duration up to full restoration (of the permanent frequency form).

e. Network return test can be effected by switching the open switch back into the "on' position. The rectifier should be perfectly reconnected and voltage and frequency variations should be observed. Control shall be effected with the battery fully charged or partly discharged. Subsequent to the battery test as referred in sub-clause (c) above, the network return test should be repeated.

f. Consumers direct connection to network (UPS bypass) test, by means of power switches and electronic changeover switches. The output voltage behavior shall be observed during such test, under load.

52.4.9.28 *UPS general performance test*

52.4.10 UPS Parallelization and Control Panel (UPS-PCP).

52.4.10.1

The above described UPS systems are designated for standby and parallel operation. As a consequence the contractor shall supply and install the UPS parallelization and control panel (UPS-PCP).

52.4.10.2

The UPS-PCP shall be metal construction, cabinet type as specified in this chapter.

52.4.10.3

This panel shall include :

a. One field for each UPS, containing :

   i. One each load switch, nominal current rating as required for the UPS supply from the Emergency General Switchboard.

   ii. One each automatic switch on the UPS output with adjustable surcharge, short circuit and no-voltage protection.

   Depending on the usual UPS construction, above power switch and automatic switch may (either or both) be located on the drawer containing the UPS components (transformer, rectifier, inverter etc.)

b. A UPS measurements and parallelization field equipped with all necessary instrumentation for parallelization and loading of the second UPS, while the first is in operation. Such field would contain manual start and stop buttons, voltage and frequency adjustment levers for each UPS, synchroscope and electrical operation buttons of each automatic switch for parallelization, connection and loading of the UPS units.

   The field shall, furthermore, be equipped with voltage instrumentation (1No voltmeter with 7-position selector switch), current (3Nos ammeters and the necessary current transformers), frequency (1No sychnometer), power factor instrumentation (1No cos- counter) and effective power meter (1No kW counter) accompanied by the necessary (LED type) indicator lamps for operation and fault status of each UPS.

c. One outgoing field to the UPS/1 General Switchboard containing :

   i. An electronic changeover switch TI(ECS), current rating as required, sufficient for all UPS units in parallel operation.
   ii. A manual switch, for manual changeover from the UPS supply to direct power supply from the EGS, in conjunction with the necessary switches.
   iii. The output line to the UPS consumptions panel.

52.4.11 <u>UPC Consumption Panels</u>

52.4.11.1

The complexes shall supply the UPS consumers through UPS panels.

52.4.11.2

Such panels shall be cabinet type, similar to those specified above.

52.4.12 <u>Transformers Protection Panel</u>

52.4.12.1

Provision shall be made for a special panel, the TRANSFORMERS PROTECTION PANEL, for the activation of the power transformer protection apparatuses. To this panel shall be connected :

a. Each transformer's thermal protection device contacts (2Nos)

b. The audio alarm accompanying each transformer

52.4.12.2

Connection shall furthermore be provided for both the MV and LV transformer power switches holding coils.

52.4.12.3

The panel connection shall allow an audio alarm signal in case of activation of the transformer thermometer-thermostat first contact or alternatively the isolation of transformer primary and secondary in case of activation of the thermometer-thermostat second contact.

52.4.12.4

Provision shall, finally, be made for suitable indication signaling the transformer whose protective devices (alarm or isolation) are satisfactorily performing.

52.5 FIRE ANNOUNCEMENT - FIRE FIGHTING

52.5.1

There is no provision, within the tunnel, for a fire detection system with fire detectors of the type used in buildings.

52.5.2

The ascertainment of a fire breaking within the tunnel is based on the parallel performance monitoring of the systems provided for installation therein :

52.5.2.1

The passing vehicles detective loops induction circuitry, as specified hereinafter in the Communications and Traffic Control Installations.

52.5.2.2

The magnetic contacts detecting an eventual door of a certain Emergency Distribution Panel (EDP) or a certain fire cabinet being left open.

52.5.2.3

The magnetic contacts detecting whether a certain "escape door" has been left open at any connecting corridor between the (eventual) 2Nos tunnel tubes.

52.5.2.4

The fire announcement buttons, installed within the tunnel. 52.5.2.5 The emergency telephones installed, also, within the tunnel.

52.5.3

The signals from the operation of the above devices are transferred to the Main Fire Announcement Panel (MFAP) and from there to the Main and (eventually) Repeater Panel of the Central Control and Monitoring System.

52.5.4

The Main Fire Announcement Panel (MFAP) shall ensure the determination of alarm signals from above devices, both with respect to the performance as well as to the sensor position. It shall furthermore ensure triggering an audio and visual alarm at the Control Center.

52.5.5

The system design shall be of modern electronic technology, based on digitally operating microprocessors, and using apparatuses (sensors etc.) connected with the Main Fire Detection Panel by means of a limited number of two-wire loops.

52.5.6

Each loop shall consist of two conductors, 1.0mm2 section (armored wire) connected with the panel on both ends. During operation, time is divided into equal intervals (number of intervals equal to the number of apparatuses capable of being connected on the loop, i.e. 99+99=198). During each interval the panel communicates continuously and successively with all connected sensing devices, receiving a response from each one. The response shall identify the device type, its connection status (regular - unconnected - short-circuited) and its operation status (off - on). For fire sensors, in particular, analogue signal shall be provided, so that their sensitivity is adjustable from the main panel.

52.5.7

For further identification of each device exact location, the devices shall be suitably equipped with a coding arrangement, i.e. a code number through which the device accurate location shall be identified on the loop and in the building.

52.5.8

Finally, the Fire Detection System shall be capable of including a panel or panels of audio sensor operation indications (repeaters), repeating the indications and commands of the Main Fire Detection Panel etc.

52.5.9

The system shall include following components :

a. The Main Fire Detection Panel

b. Fire detection electrical lines network, consisting of :

    i. The main panel communication loops to the peripheral devices (fire detectors or conventional devices) used also for command transmission to the alarm devices automatic fire fighting devices etc.
    ii. Conventional supply lines to Fire Security related apparatuses, with power capacity (or form of electric energy required) exceeding the Fire Detection Panel supply capabilities.

c. Peripheral detection devices such as magnetic contacts, or manually operated fire alarm buttons.

d. Alarm audio or visual signaling devices.

e. Eventual conventional devices for tracking incidents related with the Fire Detection and Automatic or Manual Firefighting Systems (e.g. firefighting water flow valves, foam firefighting devices control valves, fire dampers etc.).

52.5.10 Main Fire Detection Panel

The main fire detection panel shall be wall mounted in a metal box and shall contain :

a. The Central Processing Unit (CPU)
b. The Loop Circuits
c. Operation and control keyboard
d. Visual display unit (monitor)
e. Power supply unit

52.5.11 Central Processing Unit (CPU).

52.5.11.1

It shall contain a microprocessor (with real time clock) programmable according to the installation requirements in order to successively communicate directly or through adaptor devices, with all peripheral devices connected on the communication loops, and controlling their connection status (i.e. their regular connection or their disconnection or the line disruption or short-circuiting) along with their operational status (on, off).

52.5.11.2

In case of a detection of a fire detector excitement, the CPU shall, depending on the procedure selected and programmed vide its software, release an alarm signal or an operation command to other fire protection devices, e.g. visual indicators etc.

52.5.11.3

The visual alarm commands shall be transmitted through same status data transmission loops (detectors excitement etc.) through which the necessary power (usually 24V DC) shall also be transferred for the alarm devices activation.

52.5.11.4

Energy required for the audio and/or visual alarm devices shall be supplied from the CPU, through particular supply lines. Eventually required power under different voltage or in power capacity larger than the Main Panel capacity, can be supplied from separate sources and power lines.

52.5.11.5

CPU shall dispose sufficient memory capacity for the storage of its operating programs, depending on detected conditions as well as storage of selected (each time) parameters and actions, with safety against data loss even in case of regular and backup supply disruption.

52.5.11.6 *<u>Loop circuits</u>*

CPU shall be suitably equipped with the necessary microprocessor for the control of necessary number of loops (6Nos in our case). The loop circuit communicates with all connected devices supplying them with the energy necessary for their operation. Energy required for alarm signaling visual and audio devices is supplied from the CPU by means of separate supply lines.

52.5.11.7

Each loop circuit receives analogue information from all devices connected (sensors etc.) processes them and identifies their connection (regular, disrupted, disconnected or short-circuited) and operational (on, off) status.

52.5.11.8

In full development each loop shall be capable of connecting up to 99Nos addressable sensors and further 99Nos adapter (interphase) equipped devices. Such capacity refers to decimal classification programming devices (units 0 through to 9, tens 0 through to 9). A different classification shall be acceptable (e.g. 12x12) on condition that all system requirements are substantially covered with 30% spare capacity.

52.5.12 <u>Monitor and Operation/Control Keyboard</u>

The device shall dispose all necessary equipment enabling the operator to command and control the CPU programming along with retrieval of necessary information and indications. As a minimum it shall contain :

a. 80 characters liquid crystal display
b. 5Nos LED visual indications for

   i. regular supply operation
   ii. backup supply operation
   iii. alarm
   iv. fault
   v. audio signal silencer

c. Keyboard with no less than 25 keys, enabling data, parameters, status question and commands input possibility for all system functions etc.

   Finally, provision shall be made for the possibility of disabling unauthorized persons operation, by the use of passwords in two steps "data retrieval and programming.

   The keyboard shall contain not less than two additional ports: one of a printer and one CRT-1 (monitor).

52.5.13 <u>Supply Unit</u>

A panel and peripheral devices supply unit shall be built in into the CPU, containing :

a. Main 220V, 50Hz power supply from the CP network, the emergency DG-set and through the UPS, if provided.
b. The backup supply containing sufficient capacity batteries for eight hours system operation without the main supply, and battery charger fed from the main supply.

c. Safety supply with dry cell battery incorporated if required, for safe keeping of programmes and parameters stored, in case of prolongated (over 8 hrs) failure of both regular and emergency supplies.
d. Various voltages production devices, required for the system operation.
e. Apparatuses equipped with switches, fuses, circuit breakers, thermistors, and any other device required for the overcharging and short-circuiting protection of all outputs.

52.5.14 <u>Main Panel indicative type</u>

British made NOTIFIER, Series ID 1000, with special improvements defined above.

52.5.15 <u>Fire Detection System Peripheral Devices</u>

The system peripheral devices are grouped as follows :

a. Status detection devices comprising :

i. Magnetic contacts
ii. Manual alarm buttons
iii. Conventional status detection devices, related to the breaking or the fighting of fire (e.g. network connected water flow switches)

b. Command receiving and alarm apparatus or automatic firefighting activation devices, comprising :

i. visual and/or audio alarm signals transmission device, and
ii. other apparatuses activation devices

52.5.16 <u>Detection Devices</u>

52.5.16.1

All detection devices shall be addressable, of the type whose location can be identified in the building. Programming shall be effected by means of a built in (decimal or other) device with 2Nos rotary switches (10 position for decimal). For easy installation, maintenance and control, each detector shall be mounted on a separate base, on which it shall be fastened by rotation (screw or bayonet type).

52.5.16.2

Detection devices shall have an LED lamp blinking during each contact with the CPU, continuously on during excitement. Provision shall be made for the connection of a visual repeater.

52.5.16.3

When addressed by the CPU, each detection device shall report its type, its connection status (normally connected, disconnected, short-circuited, line disrupted) and its excitement status (off, on).

52.5.17 Fire Alarm Buttons {manual)

52.5.17.1

These devices constitute a special case of detection devices, detecting digital (Yes-No) and not analogue situations.

52.5.17.2

As for the rest, such devices shall contain a programming apparatus and LED indicator lamp as described in sub-clause 52.5.16.1, operating as defined in sub-clause 52.5.16.2

52.5.17.3

Manual fire alarm buttons shall be equipped with manual reset device (once put manually in operation by means of a key or otherwise).

52.5.18 Conventional status detection apparatuses

52.5.18.1

Such apparatuses shall be connected on the detection loops through suitable interphases, by which both the device programming on the Fire Detection System communication loops, and the transfer of information relevant to the status of amplified parameter (eg flow switch activation) shall be enabled.

52.5.18.2

The conventional device to be used for the Fire Detection System shall be connected through a monitor module, disposing programming facility and LED indicator lamp, similar to the ones described in subclauses 13.6 and 13.7 above. It shall also comprise a facility for device-status (off, on) identification with a neutral normally open (cold) contact.

52.5.19 Command Receiving and Activation Devices

52.5.19.1

Such devices (Control Modules) are designated to receive alarm signaling or automatic firefighting operation or fire dampers operation commands from the communication loop and have them transferred to the respective conventional devices for further action.

52.5.19.2

The command to the conventional devices shall be issued by means of a single pole, two direction relay contact (NO or NC type) capacity 30V DC-1A or 120V AC-0.3A/cos(p 0.35. The small power required for the relay coil operation shall be provided for the communication loop, whereas the power required for the operation of the alarm or firefighting signaling devices shall be supplied through 24V DC individual lines from the Main Fire Board.

52.5.19.3

The control modules shall be equipped with a programming device (coded within the communication loop and the LED indicator lamp) as described in subclauses 52.5.16.1 and 52.5.16.2 above.

52.5.19.4

Eventually required additional apparatuses or equipment for the alarm signal or automatic firefighting devices operation shall be supplied and delivered together with such devices.

52.5.19.5

Fire detection installation devices, connected to the control modules are :

a. Alarms or bells. These shall be low consumption, suitable for 24V DC operating voltage. They shall produce strong sound, over 100 dB at 1m distance. They shall be of the multiple sound type, capable of releasing up to 10 different kinds of audio signals (continuous or intermittent) with in-situ selection.

b. Visual alarm lamp. It shall be low consumption (5 joule *per* ignition), suitable for 24V DC operating voltage, flushing at a frequency of 1Hz approximately. Cover lense color shall be red.

c. STOP Luminous Sign. It shall consist of rectangular box 25cm long, 10cm high with red color plastic cover bearing the STOP indication. It shall be wall mounted, suitable for 24V DC operation, with one lamp 12W maximal capacity.

52.5.20 Fire Announcement System Tests and Controls

The Contractor should effect following tests and controls :

52.5.20.1 Installation off-voltage tests and controls

a. Installation construction quality control in accordance with the specifications and drawings and verification as to the application of required cables and. wires marking and signing of remaining installation components.

b. Earth resistance test between conductors as well as between conductors and earth. Insulation resistance should be not less than 500 kΩ

c. Electric circuitry resistance test.

52.5.20.2 Tests and controls under voltage

a. Measurement of the -OFF" status current in each circuit.

b. Maximal installation absorbed current measurement.

c. Alarm activation from any EDP, fire station and "escape door. Verification of visual and audio alarm means performance on the MFAP and on the repeater panel.

52.5.21 Emergency Distribution Panels (EDP)

52.5.21.1

Each EDP shall include :

a. Ceiling mounted air tight fluorescent type luminaire with 36W lamp.
b. Wall mounted, schuko-type power socket, 16A/250V
c. Emergency telephone
d. Instructions boards
e. Portable powder-type fire extinguisher, 9kg capacity
f. Foam production system
g. Flexible hose and sprinkler nozzle for foam injection
h. 2.5" valve for F.B. connection
i. Alarm contacts on the EDP drum and door
j. A luminous sign shall be located above each EDP

52.5.21.2

The instructions board shall be glazed and framed size A4 or A3.

52.5.21.3

The dry powder portable fire extinguisher shall be constructed with deep extrusion process, with a welding seam in the middle and special deep extrusion steel body, tested at 25bar pressure. It shall include a brass discharge head cover, painted gray, a compressed steel gas (CO_2) bottle, cadmium plated handle, high-strength plastic impact switch button and polypropylene safety pin.

52.5.21.4

The fire extinguisher shall be equipped with a high pressure flexible hose made of woven fibre reinforced neoprene, a switchable plastic fire extinguisher gun and a nozzle. It shall be protected externally with rustproof coating followed by red color epoxy paint. It shall be 9kg capacity, delivered complete with wall-mounting support, ready for suitable for grade A, B or C fire to the Fire Regulations.

52.5.21.5

The foam production system shall include :

a. A 1’’ valve

b. 1’’ flexible hose, 50m long, with 8mm dia nozzle, ensuring a flow of 801t/min, 14m foam trajectory under fiber pressure at the flexible hose coupling.

c. A “light water” reservoir with foam forming liquid condensates, 25lt capacity.

d. A mixer for automatic mix of liquid condensate and water from the firefighting network.

e. Flexible hose shall be coiled on a suitable drum. The system shall be designed so that "foam" is injected by the flexible hose.

52.5.21.6

The 2.5" valve shall be angular type, equipped with cover and retention chain, including also a flow control nozzle, with handle positions : full flow - flow isolation - fog.

52.5.22 Fire stations

52.5.22.1

Each fire station shall include :

a. Roof mounted, air tight fluorescent luminaire with 36W lamp
b. Wall mounted, waterproof, schuko type, power socket 16A/250V
c. Emergency telephone
d. A luminous sign shall be installed above each fire station
e. Dry powder, portable fire extinguisher, 9kg
f. Door-mounted alarm contact

52.5.22.2

The powder portable fire extinguisher shall be as specified in sub-clause 52.5.21.3

52.5.22.3

Each fire station shall have a double-leaf door as specified in sub-clause 52.5.21.8

52.5.23 Firefighting Piping Networks

52.5.23.1

The firefighting pipe network shall be made of ductile iron to ISO 2531 (Ductile Iron Pipes, fittings and accessories for pressure pipelines) 16atm nominal pressure rating.

52.5.23.2

All exposed pipework shall be supported on permanent structural elements. Wire-assisted suspension is strictly prohibited.

52.5.23.3

Walls or floors crossing points as well as connection points to the installations and equipment, cannot be considered as pipeline support points.

52.5.23.4

Each support size shall ensure bearing capacity 1.5 times the pipe weight and the weight of water contained therein.

52.5.23.5

Vertical pipework branchings shall not be used as suspension supports for adjacent horizontal pipework.

52.5.23.6

All pipe supports and anchors shall be fabricated from stainless steel, or otherwise they shall receive, prior to installation, two coats of enriched red leadoxide primer.

52.5.23.7

In highly humid, outdoors or indoors conditions, all suspensions and supports shall, subsequent to fabrication, be hot-dip-galvanized and in case the galvanized surface is damaged during installation, the whole surface shall be thoroughly wire-brushed and shall receive two coats of approved enriched red leadoxide primer.

52.5.23.8

Subsequent to pipework installation, its testing and satisfactory commissioning, all suspension rod and assembly nuts shall be thoroughly tightened in order to avoid any ultimate nut movement.

52.5.23.9

Pipeworks shall be flange-connected, using PN16 rated flanges.

52.5.23.10

All network piping isolating valves shall be of same manufacturer and shall be provided with adequate size hand wheel for easy operation, without the need for levers assistance and without causing any damage to the disc, the seat or the spindle. In closed position, isolating equipment shall be perfectly watertight, for operating pressure not less than 10 bar and 120° C water temperature.

52.5.23.11

Fire valves shall be installed at locations indicated on the drawings, for various branches isolation. They shall be threaded brass sluice valves for diameters not exceeding 2" and cast iron flanged gate valves for sizes above 2". All fire-valves shall be equipped with position indication and their type shall be approved by the Fire Brigade.

Valves shall ensure perfectly tight isolation for a 10 bar minimal pressure differential between their two sides.

52.5.23.12

The manifold shall be fabricated from seamless steel tube. The steel pipe ends shall be flanged and shall be connected to the pipe by galvanized bolts, and suitable tightness joint. Holes shall be opened, on the manifold body, for the purpose of welding network departures. Subsequent to fabrication the manifold shall be carefully hot-dip-galvanized internally and externally. Manifold construction shall be suitable for operation in not less than 10bar pressure and shall comply with the drawings. A suitably sized spare outlet shall be provided on the manifold, for pressure gauge connection.

52.5.23.13

Metal ant vibration connections and supports shall be provided, made of stainless steel to DIN 17440 with stainless steel wire mesh external protection, threaded type for sizes up to 75mm dia, flanged for sizes larger than 75mm.

52.5.23.14

Pressure gauges shall be graded in bars with such upper range limit so that the measured actual pressure falls within 1/4 to 3/4 of the instrument's full range. Provision shall be made for brass pressure gauges, 100mm dia dial, with 1/4" connection nipple, indication accuracy 2% approximately.

52.5.23.15

For allowing relevant movement, a spool made of flexible corrugated steel pipe shall be provided, equipped with protective shield. Its connection to the networks shall be flanged.

52.5.23.16

Twin supply includes 2Nos 2.5" dia type B firehose connections to DIN 14303, closed with caps equipped with suspension chains. Above the twin supply, a board shall be displayed with the indication "FIRE BRIGADE CONNECTION".

52.5.23.17

For frost protection reasons, firefighting network shall be installed at a suitable depth. Frost penetration depth is 0.80m.

52.5.23.18

Pipe networks or individual parts thereof shall be subjected for 24hrs to 10bar hydrostatic pressure testing. Should a pressure drop in excess of 5% be observed during above period, the test shall be repeated, subsequent to identification and reinstatement of probable leaking points. This test shall be effected prior to any pipe insulation work or pipe cover with architectural building work or backfill. For the avoidance of damages, any eventually sensitive instruments installed on the network shall have to be removed, prior to this test.

52.5.24 Fire pumps Complex

52.5.24.1

The fire pumps complex shall include :

a. Two electrically driven booster pumps

b. One electrically driven jockey pump

c. Suitable capacity and operating pressure, closed type expansion tank, i.e. pressure air-vessel equipped with separation membrane.

d. Fire pumps automatic operation instrumentation.

e. Isolating valves and interconnecting pipe system suction and discharge manifolds check-valves, pressure gauges etc.

f. Pipe operation, power supply, protection and automatic control panel.

52.5.24.2

All above shall be factory erected, in a single complex on a common metal base, with suitable dimensions ensuring easy access for inspection, repair and replacement disconnection. The complex should be ready for operation, requiring only power and pipework connections on the suction and discharge sides.

52.5.24.3

The complex shall be electrically connected to the building emergency power supply network, so that in case of PPC power failure to be fed from the building standby DG-setin case of power disruption such DG-set shall, automatically, start and get loaded.

52.5.24.4 <u>*Booster Pumps*</u>

a. Two electrically driven pumps shall be provided and installed for the purpose of supplying the firefighting water system (fire stations and sprinklers). Such pumps shall be connected also to the standby DG-set so that they are capable to operate in case of PPC supply disruption.

b. Although one pump shall be standby, it shall also be connected to the automation system, suitably adjusted to start the 2nd pump automatically, when the duty pump is -for any reason whatsoever- not sufficient to cover the water demand. In such case, the standby pump shall always start second and it shall be the first one to stop.

c. Single or multistage low speed (up to 1500rpm) shall be provided. In case of single stage pumps, they can be of either of the end suction or of the split case type.

d. Pumps shall be suitably selected so that in case of shut-off operation (zero flow) they shall not present in their discharge pressure increase more than 40% of their nominal manometric head, whereas when operating at 150% of their nominal flow capacity, they shall maintain a minimal of 65% of their nominal manometric head.

e. Pumps shall be manufactured by a specialized factory, their efficiencies having been determined by laboratory tests and stated on manufacturers pamphlets.

f. Pumps shall be centrifugal type, single or multi stage directly coupled to waterproof electric motors by means of a flexible coupling. Each complex shall be integrally fixed and delivered on a single metal base.

g. Pumps shall be noiseless, appropriate for handling potable water, of usual temperature, suitably designed and constructed in a manner excluding impeller or volund corrosion due to cavitation.

h. The pump body shall be "multipart" i.e. it shall consist from identical ring sections, respective to their stages (except for the end ones) adjustable through tightening (with guide holes and tightening through-bolts). The pumps volund (body) and each stage guide fins, shall be made of fine grain castiron.

i. The pumps impeller shall be made of stainless steel and shall rotate on bearings fastened on the end stages. Ball bearings of minimal 50,000 hrs lifespan shall be provided.

j. Impeller disks shall be made of special bronze and shall be carefully processed.

k. Pumps shall be equipped with mechanical glands, easily accessible for inspection and replacement disassembly, made of material appropriate for potable water. Pumps shall also be equipped with hydraulic pressure balance apparatus at the discharge gland. Pump impeller along with the shaft shall be statically and dynamically balanced and shall not present critical rotation speeds in the rpm-range up to the normal operation speed.

l. Water proof, asynchronous 3-phase, 380V, 50Hz, squirrel cage rotor electric motors shall be provided. In particular, the motor and jockey pump shall unfailingly have a speed of 1450rpm. Their power rating shall be at least 20% in excess of the power absorbed at the pumps impeller when operating under above specified conditions, and -in any case- sufficient for pumps movement under head exceeding nominal pressure by 25%.

m. Pumps shall be equipped with venting taps required as well as drain plugs. They shall be flange connected to the pipeworks and shall be delivered with suitable spare flanges.

n. Each pump shall be accompanied by the following :

(1) 2Nos spare stage impellers and ball assemblies

(2) 2Nos full sets of spare flange joints

52.5.24.5 *Jockey puma*

a. A pump designated for pressure maintenance in the firefighting water network and for coping with eventual leakages (the so called jockey pump) shall be provided and connected in parallel with the booster pumps.

b. The stipulations of above subclauses 52.5.24.4(c) through to (d) is also valid for this pump, with exception that it will be multi stage.

52.5.24.6

For the purpose of avoiding frequent jockey pump starts and stops, a membrane type pressure vessel shall be supplied and connected on the discharge pipe. The vessel shall be spherical in shape, its shell made of steel sheet, 10 atm minimal operating pressure, with a high strength separation membrane made of NW elastomer. The vessel shall be delivered filled with nytrogene at a pressure of 6.0 atm.

52.5.24.7 *Complex electric panel*

a. This panel shall contain all pump motors switching and protection equipment as well as the complex automatic operation instrumentation. The panel protection rating shall be IP55. It shall be installed on the same base together with the fire pumps complex.

b. The panel shall include :

(1) Main automatic switch or switch and fuses and indicator lamps for all three phases.

(2) On each pump supply line cut-off switch and fuses (or alternatively air-type automatic switch), automatic starter switch (star-delta) with thermal and shortcircuit protection, start and stop buttons for the pumps manual operation, wiring and connection suitable for the complex being connected to a low level switch. It shall furthermore contain on-off indicator lamps.

(3) Selector switches for automatic or manual pumps operation.

(4) All automation instrumentation described hereunder.

c. The pressurizing complex shall be delivered fully wired, ie it shall contain all wiring from the electric panel up to the pumps and automation instrumentation, installed in flexible steel pipes, fixed on the equipment by means of waterproof glands.

52.5.24.8 *<u>Automation instrumentation</u>*

a. Provision shall be made both for automatic operation and the protection of pumps. All such instrumentation shall operate with 24V low voltage, through a transformer built-in into the complex electric panel. The automation instrumentation line shall be separate, equipped with a cut-off switch and circuit breaker.

b. Following goals shall be achieved through automation instrumentation :

(1) Automatic start and stop of the jockey pump, on the base of network pressure, through pressure switch.

(2) Automatic start of one out of two booster pumps, in case of further head drop. Should the duty pump fail to start for any reason whatsoever, then the standby pump shall be started. Starting of the main firefighting pump shall automatically result into stopping the jockey pump. For the start of these pumps respective pressure switches shall be provided. Pumps stop shall either be effected manually, or automatically through a flow switch installed at the pumps suction side, when flow to the network is reduced to zero and after a certain time delay.

A selector switch shall be provided to manage booster pumps priority (duty-standby). Each pump shall be delivered with an hours-run counter.

52.5.24.9 *<u>Isolating valves etc.</u>*

Pumps suction and discharge manifolds shall be provided, pumps isolating ball valves, hydrostop type flanged castiron checkvalves, full section (when in open position), with ball made of stainless steel, AISI 304, valve as above for pressure vessel isolation, flow switches, interconnection piping etc.

52.5.24.10

Firefighting water pressurizing system shall be delivered complete and self-dependent, so that subsequent to its installation to be capable to operate, requiring only electrical and piping connections to the firefighting water networks.

52.6 COMMUNICATIONS AND TRAFFIC CONTROL

52.6.1 General

The scope of this chapter comprises following installations :

a. Emergency telephone units
b. Loud speakers installation
c. Closed circuit tv installation (CCTV)
d. Radio frequencies transmission installation
e. Vehicles traffic detection installation
f. Vehicles height control system
g. Variable message signs
h. Central monitoring and control system

52.6.2 Emergency Telephone Units

52.6.2.1

Emergency telephone units shall be provided heavy duty, suitable for wall mounted installation.

52.6.2.2

All units shall be equipped with speaker and headphone sets protected against vandalism by means of metal wiremesh.

52.6.2.3

Apparatuses metal parts shall have suitable corrosion proof protection and paint, and furthermore IP65 protection to IEC144.

52.6.2.4

The apparatuses external shell shall be made of GRP (glassfiber reinforced polyester), easily removable for adjustment and maintenance purposes.

52.6.2.5

The emergency communications switchboard shall be electronic type of expandable architectural structure (plug-in, modular).

52.6.2.6

The switchboard operation keyboard shall be suitable for desktop position with a calling device display on a liquid crystal screen.

52.6.2.7

The whole emergency telephones installation equipment shall originate from same manufacturer, who must dispose proven record and background in similar applications.

52.6.3 Speakers Installation

52.6.3.1 Speakers Installation Amplifying Center

a. The central speaker installation amplifying complex shall include pre-amplifier units, final amplifiers and auxiliary devices, placed in metal cabinet type containers.

b. Each drawer shall be suitable for floor mounting installation and shall include metal frames for positioning the pre-amplifiers, the final amplifiers, the relays, electric fans, the cabinet general switch and the cabinet amplifying units power indication instrumentation (VU-meters).

c. The cabinet amplifying units as well as the cabinets between them shall be suitably wired so that on one hand the required technical characteristics are achieved and on the other hand in case of a single unit failure the remainder of the amplifying apparatus to remain operational.

d. The central amplifying unit construction shall be high quality and appearance of modern IC technology, with low frequencies filtration in the preamplifiers microphonic input, final amplifiers output protection, in compliance with 1EC regulations and standards.

e. Cabinets and metal frames shall be made from steel sheet, which subsequent to fabrication shall be hot deep galvanized and coated with 2 coats oil paint

52.6.3.2 Funnel type loud speakers

a. Each funnel type speaker (horn) shall be provided in refolted cone type suitable for wall or ceiling mounting.

The funnel shall be made from aluminum alloy and shall be resistant to continuous outdoors environment, the sound reproduction unit being tightly screwed on the funnel.

b. The loud speaker capacity shall be at least 106 dB at one meter distance from the funnel, with 1W acoustic power. The sound reproduction unit shall be suitable for a 100V speakers network with the required adaptation transformer built-in.

52.6.3.3 Microphone

a. Dynamic type microphone shall be provided with heart-shape polar diagram, of strong construction and aesthetic appearance.

b. Microphone shall be accompanied by a chromium plated flexible spiral arm with the necessary appurtenances for its base mounted installation.

c. Microphone connection cable shall be two-pole with 2Nos multi-wire tin plated copper conductors, 22 AWG section (0.33 mm2 approx.) with polyethylene insulation and vinyl coat, nominal capacity between conductors 18pF/ft, equipped with single-woven interference protection screen made of tin plated copper (equivalent type BEL-DEN 8422).

d. The central unit microphone shall be installed on the central speakers installation operating console and shall be suitable for either desk top mounting or for incorporation into the operating consol.

e. The console shall be connected to the central amplifying equipment and shall include speaker circuits selection buttons with indicator lamps incorporated, separately for each circuitry and in groups for each speaker circuit group, the characteristic announcement tone, (gong) button the general address button and operation indicator lamp with safety lock.

52.6.4 <u>Closed Circuit Television System (CCTV)</u>

52.6.4.1 <u>Camera</u>

a. Provision shall be made for a black and white recording camera with following basic

Lamp	vidicon 2/3"
Supply voltage	220V, +/-50Hz, 10VA
Operating system (CCIR)	625 lines
Sound to noise ratio	> 43 dB
Operation temperature	-30° C to +50° C
Approximate dimensions (WxHXD) :	90x75x220 mm
Object sensitivity	4 lux (F/1,6 lens)
Larger area	20 lux

b. Each camera shall be suitable for outdoors installation, with a cast aluminum cover and shall be accompanied by the fittings required for wall mounted or roof suspension.

c. Each camera shall have the possibility of remote control of its power supply, its object lens focusing and its aiming direction.

d. Objective lenses shall be made from a well reputed specialized manufacturer of TV optical systems.

52.6.4.2 <u>Monitoring Screen</u>

a. Each monitor shall be professional type suitable for black and white transmission in a 625 lines CCIR system, diagonal length 12" with following basic characteristics :

supply voltage	220V
image brightness	100 cd/m2
frequency width	7,5 MHz (-3 dB)
video input	1V at 75 CI
insulation	class INDE 0804
protection	IP20/DIN 40050

b. Desk top mounted or furniture fitted type monitors shall be provided, with the necessary terminals and buttons for :

— network connection
— light adjustment
— contrast adjustment

c. If required, a suitable built-in video signal amplifier (coaxial cable equalizer) shall be provided, for video signal loss compensation on the coaxial cable.

52.6.4.3 Rotational Changeover Unit

a. Each rotational changeover unit shall have 4Nos video inputs originating from 4 different video cameras and 2Nos video outputs : one to the monitor where camera originating images shall be successively alternated, the other remaining as spare.

b. The rotational changeover unit basic technical characteristics shall be :

—	supply voltage	220V, 50Hz
—	video inputs/outputs	1V at 75
—	alternation intervals	adjustable between 1 through to 30 sec
—	monitoring with	10 inputs alarm signal

52.6.4.4 Selector Switch

a. The selector switch shall be suitable for 5Nos video inputs and 1No video output, with the following technical characteristics :

—	selection buttons number	5
—	inputs/outputs characteristics	75 Ω

b. The switch shall be suitable for installation on a centralized operation board, or alternatively for desktop installation in which case it shall have a white plastic cover and a non-slip base.

52.6.4.5 Cameras Remote Control Panel

The cameras remote control panel shall include a camera supply on/off button with indicator lamp as well as objective lens and aiming mechanism handling buttons.

52.6.4.6 Power Supply Unit

a. The power supply unit is designated to provide the necessary voltages and terminals for the cable connections to the camera.

b. The unit shall be provided with following inputs and outputs :

— camera supply with coaxial cable
— camera and objective lens supply with cable
— aiming mechanism supply with remote control 24V or 48V AC cable
— electric power supply to the camera
— power supply unit self-supply with 220V, 50Hz

c. The supply unit shall be suitable for exposed or fitted installation at a point in proximity to the camera (3m maximal distance). Unit Water-proof ng class : IP 65 to DIN 40050

52.6.5 Radio Frequencies Transmission In4tAljation

52.6.5.1 General

a. Police and Fire Brigade services are usually equipped with mobile radio systems (manually held or installed in vehicles). For those services such communication is vital, particularly in the case of an accident or fire breaking.

b. In order to enable the use of mobile radio communication within and beyond the tunnel, a system of radio transmission relay shall be provided and installed.

c. In addition, the use of such system is recommended for maintenance personnel internal communication or communication of maintenance personnel with the main control room operator.A more flexible communication system is achieved by using portable units, as opposed to wired communication systems.

d. Such a system shall include :

(1) A radiating (transmitting) cable suspended from the tunnel roof, used as antenna.

(2) Control Center Electronic Equipment comprising the necessary apparatuses as well as reception/transmission channels.

(3) Suitable respective antenna, outside the tunnel.

e. Reception/transmission channels shall be provided for the following Services :

(1) One Police channel

(2) One Fire Brigade channel

(3) One Maintenance Crew channel

(4) A spare channel

f. Channel frequencies shall be defined by the Employer.

52.6.5.2 Reception and Transmission Devices

a. Reception and transmission devices shall have a transmitter and receiver incorporated within the same housing. They shall be new, modern technology and design suitable for outdoors installation.

b. All devices shall have an easily removable cover for effecting necessary transmitted power, transmitted/received frequencies and other adjustments without requiring device disassembly.

52.6.5.3 Maintenance Crew Radio Communication Base Unit

a. The base unit shall have a transmitter and receiver incorporated within the same housing. It shall be new, modern technology and design suitable for desktop installation.

b. An alphanumeric display screen (LED or LCD type) shall be provided on the device front for reception or transmission channel indication and VED indicator lamps for verification of device receiving or transmitting signal and whether a certain channel is free or occupied. Provision shall furthermore be made for a transmitted and received signal power measurement device, enabling also power measurement of the antenna stationary waves.

c. At a suitable location on the device front, shall also be located the device operation switches. These are sound regulation switch, on- off switch, transmission and reception channels selection switches and interferences squelch switch.

d. The base unit technical characteristics shall be

— maximal output power:	30W
— Transmission/reception band width:	5MHz
— Modulation:	FM
— Communication mode:	simplex
— AC network supply:	220V +1- 10%, 50 Hz
— Operating voltage:	13,8V
— Channels number:	2
— Frequencies selection:	crystal pairs
— Transmission/reception frequencies width:	shall be defined upon applying to competent Ministries

52.6.5.4 Maintenance Crew Communication Portable Radio Unit

a. Each portable unit shall be pocket type, made of aluminum alloy, impact proof, brand new, modern technology and design with built-in transmitter receiver, microphone and speaker.

b. On its upper part the device shall have operation switches for sound level adjustment, channel selection and interferences squelch. It shall also have suitable sockets for antenna and external microphone/headphone connection. Within the same space an apparatus indicating the batteries condition and a transmission reception power selector switch shall be provided.

c. The units shall be supplied from built-in, small size, rechargeable nickel-cadmium batteries, providing the possibility of continuous operation for a minimum of 8 hours.

d. On the device side, shall be placed at a suitable location the push-to-talk switch while on the front the microphone-speaker device shall be built-in. Device design shall allow its complete operation with suitable single handed movements.

e. Each device shall be accompanied with a rubber antenna, a suitable battery charger unit, leather case with straps, batteries and the crystals required.

f. The portable units technical characteristics shall be :

— output power (with selection)	2,5 & 5W

—	operating band width	5 MHz
—	modulation	FM
—	communication mode	simplex
—	number of channels	2
—	frequency selection	crystal pairs

g. It is clarified that the 2 channels operation frequencies shall be defined subsequent to Employer's application to the competent Authorities.

52.6.6 Vehicles Traffic Detection Installation

52.6.6.1 Inductive Loop Detectors

a. System operation shall be based on the measurement of self-induction reduction of a wire loop, when a vehicle (partly built with magnetic materials) passes from the loop's effective control zone.

b. The sensor shall be self-tuned, shall supply the inductive loop with suitable frequency current, and shall automatically adapt itself to any long term loop characteristics modification caused by environmental or other changes.

52.6.6.2 Traffic Detection Installation Main Equipment

a. System shall ensure counting the number of passing vehicles, measurement of their speed, computation of average stream speed, distance between two consecutive vehicles as well as traffic density measurement.

b. All above data shall yield following due processing of the outgoing pulses forwarded by the sensors to the CPU. Provision shall be made for the storage of such data in files, their printing on a suitable printer as well as their visual display on a monitor screen.

c. The full installation equipment, ie sensors, subunits, CPU, operation keyboard, monitor, printer and necessary interphases shall be of digital technology, originating from one single manufacturer with proven experience and record in similar applications.

52.6.7 Vehicles Height Control System

52.6.7.1

The vehicles height control system shall consist of photocell height-excess control switches, necessary automation and wiring.

52.6.7.2

The height excess control photocell switches shall be installed on a gantry type metal structure, one for each traffic lane. From the one side a luminous beam shall be transmitted, ending on a light sensor on the other side. Each beam disruption shall result into activation of the height-excess alarm signal, the STOP (X) luminous sign on the lane where the excess has been observed and on the respective Main Control input.

52.6.8 Variable Indication and Speed Limit Signs (VIS-LS)

52.6.8.1

The signs for Variable Indication and Speed Limit (VIS-LS) shall be of the latest technology, their operation based on fiber optic light transmission. The light source shall be a low voltage halogen lamp. Light beam shall pass a -single direction- semi permeable mirror through which it shall be directed to the optical fibres bandle, ending at the lighting points. Each sign shall consist of a lighting points series, covering its full area with a density not less than 4 LP/cm2.

52.6.8.2

The VIS signs frame shall be made of standard size aluminum profile and shall incorporate the lighting points sub frame and the protective glazing front made of special antiglare Plexiglas. The whole construction shall form an integrated complex with IP65 protection to IEC 144.

52.6.8.3

The VIS-LS signs programming and control equipment shall be digital technology, suitable for direct connection to the Main Control. It shall contain keyboard, LCD monitor and microprocessor.

52.6.8.4

The whole of the VIS-LS signs installation equipment shall originate from one single manufacturer with proven record in similar applications.

52.6.9 Central Installations Monitoring (CIM) and Direct Digital Control (DDC)

52.6.9.1

In order to enable tunnel installations monitoring and intervention on installations controlled from one single central point (Installations Control Room), provision shall be made for a Central Installations Monitoring (CIM) and Direct Digital Control (DDC) electronic system.

52.6.9.2

For such purpose, the System central equipment shall be installed in a space allowing the stay of building operation, maintenance and/or security personnel during 24 hours. It shall include the CPU keyboard, color monitor, printer, power supply unit etc. Central equipment shall be connected to the DG-set and the UPS.

52.6.9.3

The system shall be installed and delivered in full satisfactory operation. The Central Panel installation, as well as that of its peripheral units and relevant wiring shall be effected under a single equipment manufacturer's direct supervision and control.

System operation commissioning and startup shall be effected by one of the representative's specialized engineers. Following system description is indicative (but not by way of limitation), equivalents or better systems being acceptable, as those manufactured by ADT, JOHNSON, ITT, BARBER-COLMAN, KDS and (USA) HONEYWELL, STAFFA (Switzerland) etc.

52.6.9.4 *General Description*

a. The Central Control and Monitoring System, described hereunder, should consist of solid state material, built on Direct Digital computer technology, in order to ensure system reliability, long life and low-cost maintenance. All units incorporated shall be plug-in sections.

b. The installation shall include all basic and peripheral instrumentation, equipment, apparatuses required, for the construction of an integrated operating system, in accordance with current specification requirements.

c. The installation main processor and peripheral units capacities shall be sufficient to cope with all functions described hereunder, with a minimal of 30% spare capacity, for possible system extension.

52.6.9.5 *System Data Transfer*

All information and data transferred between :

a. the Main Computer and its auxiliary devices, and

b. the Peripheral Control Units

shall be transferred through a pair of conductors. An armored cable shall be used. There will be available a second pair of conductors, as spare.

52.6.9.6

For the achievement of high efficiency, it is necessary that each information contains substantial data, sufficient for its assessment and fault detection. The case of malfunction (failure of the addressed point to duly respond to the command) should be immediately announced to the operating keyboard, by a "wake-up" alarm-type audio signal within the Control Centre space (such signal stopping when the operator presses a specific reset button, confirming fault acknowledgement) being simultaneously recorded on the printer.

52.6.9.7 *System Lines Construction*

a. This system communication loops lines, as well as the peripheral equipment (digital or analogue sensors) connecting lines to local panels shall be made of armored cables, type LiYCY, conductors 1.Omm2 section, using the _number of pairs indicated on the drawings. For the execution of commands, all lines connecting local panels to the machinery and equipment controlled, shall be constructed using NYM cables.

b. LiYCY Cable Links : For fines to be constructed using LiYCY cables, following stipulations governing NYM cable lines shall also apply, with the additional requirement that joints should ensure metal shield continuity and that the shield should be earthed at both line terminals.

Specifications for apparatuses

52.6.9.8 System Composition

The integrated system shall be composed from following apparatuses :

a. The Main Computer and its auxiliary devices, to be installed within the Control Centre Space, from where all operations shall be monitored and all building electrical and mechanical installations shall be commanded.

b. The PPC and building DG-set power supply arrangement to be installed in the vicinity of above Main Computer, ensuring the System's uninterrupted power supply (UPS)

c. The necessary Digital Control Peripheral Units to be distributed in various locations within the building, so as to cover all system requirements, providing also the abovementioned spare capacity.

d. Situations-detecting or parameter-measuring etc. sensors e.g. thermostats, pressure switches, thermometers, etc. Furthermore, command-executing devices e.g. contactors, alarm horns etc. and finally, interface material between sensors or command-executing devices and data gathering subpanels as well as between the latter and the Main Computer.

52.6.9.9 Main computer

The Main Computer shall comprise following components :

a. Central Processing Unit(CPU) with 16- or 32-bit architecture, type 80486 DX or similar (EISA), operating frequency not less than 40MHz, with a minimal of 8 Mbytes expandable RAM, incorporating :

i. Hard Disc Unit, not less than 250Mb capacity
ii. Floppy Disc Drive, 5.25", 1.2Mb capacity, capable of also handling 360kb floppies.

b. Keyboard

c. High-resolution, 14" Color monitor with efficiency in graphics projection.

d. 132-characters/line printer,120 cpm speed

e. Necessary connecting wires with suitable sockets and plugs, for above equipment interconnection

f. Complete software collection necessary for the effective operation of the system described above.

g. Complete software collection for graphics generation.

52.6.9.10

The use of software described in sub-clause 52.6.9.9(f) above, shall provide following possibilities :

a. Digital Monitoring and Control Peripheral Units programming (refer also hereunder)

b. Operator's communication with the system for information retrieval concerning the status of each of the tunnel electrical and mechanical installations appearing on the screen, and parts thereof.

c. Allows the operator, through suitable keying, to :

— Command the start or stop of a specific unit,

— To list on the screen all points, in general, being under "alarm' condition, or alternatively, shortlists of selected points, at predetermined intervals etc.

d. Transfer to the whole of the tunnel electro-mechanical equipment and functions of round-the-clock start/stop commands, in a predetermined time sequence, according to a stored programme, with discrimination between working and non-working days, holidays, winter, summer and mid-season operation etc. yearly programmable on Computer real-time basis with manual revision possibility by the operator.

e. The use of graphics software collection, shall provide the possibility of color graphics generation, with reference to diagrams, building or other installation plans etc. aiming to display the actual status of the air-conditioning or other electrical and mechanical installations.

In all above cases it shall be possible to display, all sensors and automation instrumentation, in their physical position with simultaneous presentation of actual (instant) parameter values and equipment status. Such display shall be continuously updated with new values and conditions.

Graphics generating software shall use a great variety of colors and lines for easy definition of the various image sectors, aiming also in emphasizing a certain specific incident, therein.

f. Finally the use of printer shall enable the following printout possibilities :

i. All detected points general condition
ii. The condition of a specific group of points
iii. A listing of all points in "alarm" situation
iv. Points status change and alarms, automatic printout
v. Selected points status or parameter values printout, at desired intervals etc.

g. form, selection being preferably effected by a mouse, allowing system Operator's communication with the system shall be organized in "Menus" programming simplicity and very easy data-input and information-retrieval.

h. Software and data loading and storage shall not be allowed by the use of magnetic tape, but through the floppy and hard disc mechanisms, ensuring data acquisition and transfer in the greatest possible speed and accuracy.

i. In order to prevent unauthorized use, the system shall dispose access security levels as well as safety against indefinite time power supply disruption. Finally the system shall, once a day, reset and synchronize the clocks of all Control Units to the Main Computer clock.

j. The Contractor shall be responsible to deliver the software fully installed, tested and stored in the Computer's memory, to introduce all operating parameters and the necessary graphics for all monitored equipment and functions, using his own personnel, so as to deliver a fully installed and operating integrated system.

k. Contractor's obligations, furthermore include the initial tracing and introduction into the computer software of operating diagrams relevant to the totality of equipments and installations controlled, as, for example each and every air-conditioning unit covered, hydraulic system e.g. pump set etc. Such diagrams shall appear on the monitor in colors and shall include equipment symbols as defined on the design drawings and the relevant code numbers. Such diagrams shall appear on the screen either automatically (without operator's action) at each alarm signal, relevant to any of the equipment or apparatuses contained in the diagram, or alternatively, following operator's request through the keyboard.

52.6.9.11 *Digital Testing & Monitoring Peripheral Units*

a. The digital testing & monitoring peripheral units shall be installed at locations defined on the design drawings.

b. Such units consist of testing and processing sections as well as input/output control sections.

c. These units enable system communication with the sensors and the installation testing instrumentation. Such communication allows data gathering such as temperatures, currents measurement, equipment status, alarms announcements etc. from the various system controlled points. Through same units commands are transferred to the end control units, for the change in point status, revision of settings (SET POINTS) etc.

d. Finally with the assistance of same units the full testing of air-conditioning units automation systems shall be directly controlled without the need for using any other control units. This last feature shall allow the use of common sensors both for the air-conditioning units tests and for data transfer to the Main Computer system.

e. Peripherals operation shall be based on 16- or 32-bit local microprocessors suitably designed so that the input/output and the operation commands processes are separated from the monitoring and control process.

f. Each unit shall dispose memory of suitable capacity, divided into :

(1) Non-programmable memory (ROM) containing the system organization and its functional parameters

(2) Programmable memory (RAM), placed at the operator's disposal

(3) Memory for the Operating System software storage, and

(4) Memory for the Energy Saving software storage (EMS)

g. The Control Unit shall individually operate as an independent one, providing all software necessary for effecting the full test series on monitored equipment and functions for automatic start/stop programme, energy saving programme. It shall dispose a complete local supply unit for supporting all connected devices.

h. Operating system shall be permanently stored in PROM and shall operate independently to the Main Computer, a fact allowing uninterrupted operation of plant units in case of Main Computer breakdown or fault. All parameters and algorithms shall be contained in random access memory (RAM) for direct access, revision and adjustment.

i. Control Unit programming shall be effected with the aid of Main Computer system.

j. Control Unit software shall include a complete operating system, basic testing algorithm program series, and a series of Owner/operator application programs covering usual tests and related calculations.

52.6.9.12 Main Computer and Peripheral Control Units Joint Performance

a. The complete Monitoring and Control System shall include one Main Computer and a number of Digital Control Peripheral Units.

b. The operating system controls communication between the Main Computer and the Control Units. It provides to a variety of sensor types and motors visual monitoring, alarm announcement testing application program series and communication, containing also diagnostic routines.

c. Each Control Unit has a memory fault test routine. As soon as memory fault is diagnosed, the CPU either rectifies the fault or stops, in order to avoid erratic operation. All stops are reported to the Main Computer as alarms, appear on the monitor and are simultaneously printed on a fault printout report.

d. Subsequent to a power failure incident and once the system regular supply is restored, automatic units successive starts are effected, without the operator's intervention, on the basis of real-time software and with the main programme requirements.

e. Furthermore, defective operation of any isolated Control Unit, does not effect the operation and performance of the remaining Control Units.

52.6.9.13 *Command Sensing Devices*

The Contractor shall supply and install all necessary materials (sensors, wiring etc.) in order to achieve required commands indications, signing etc.

52.6.9.14

The Central Monitoring and Control System for each installation shall correspond to the following minimal requirements :

a. Lighting Installation

Depending on external luminosity, tunnel lighting shall be automatically adjusted in a suitable number of steps (not less than 6). The number of steps may vary for different tunnel zones (threshold zone, transition zone, inner zone, exit zone) for both the day and night lighting operation.

Lighting levels shall be monitored and tested using external and internal video photometers connected to the operational control computer. Reflectivities may also be checked by the video photometers.

b. Power supply Installation

Each system has its own fault announcement panel erected in the respective equipment spaces, e.g. 0G-sets, UPS system, Transformers. From each of the transformers, UPS and DG-set spaces fault signing is transferred as an alarm to the main control system. In addition, certain points of the installation are monitored and parameter-measured through the main control system. Such points are the following:

— On/Off position of MV power switches and of the main automatic circuit breakers of the LV fields
— Transformers oil temperature control
— Current, Voltage and Power measurement in each transformer
— On/Off position of the standby DG-sets
— Batteries voltage and DG-sets output voltage measurement
— UPS system On/Off position
— Current, Voltage and frequency measurement at the UPS output

c. Ventilation Installation

i. Fans performance
ii. Automation

(1) For 50ppm CO content, 33.33% of the fans shall be activated
(2) For 100ppm CO content, 66.66% of the fans shall be activated
(3) For 150ppm CO content, 100% of the fans shall be activated
(4) For 250ppm CO content, the tunnel shall be closed

Fans operation shall be determined by CO and clarity reduction sensors in conjunction with wind speed and direction measuring devices

d. Traffic Detection Installation

- In case of a vehicle breakdown, audio alarm activation and alarm signal release of the VSI-SL installation.
- Automatic revision of the speed limit signals depending on the average vehicles stream speed

e. Vehicles Height Control System

In case of sensor being crossed by a vehicle with height larger than permissible, automatic ignition of the (X) prohibitory sign on the respective lane, audio alarm (horn) and message on the respective signboard, at the tunnel entrance where the excess was detected.

f. Fire Announcement - Firefighting

All functions and features described in sub-clause 52.5 herein, shall be included.

Clause 53 : PAVEMENT PERFORMANCE SPECIFICATION

53.1 GENERAL

53.1.1

The present specification refers to the pavements to be constructed within the framework of projects being tendered through a *"CONCESSION CONTRACT"* and belong to that project section for which the Contractor has the responsibility of construction, exploitation, operation and maintenance during the period that the *"Concession Contract"* is in force. (These works are called *"Main Concession Project') (M.C.P.).*

53.1.2

The present specification DOES NOT apply for the portion of LOCAL ROADS of a "Concession Contract" which are transverse and service roads and other works (beyond the M.C.P.) being constructed by the contractor, though their maintenance is being done by the Project Owner.

53.1.3

Finally, the present specification DOES NOT apply for works being constructed under other tendering systems, except the one of the "Concession contract".

53.1.4

The basic thinking on which the preparation of the present performance specification has been based is that the Contractor of the "Concession Contract" has interest in constructing a high quality pavement, and then, during the operation and exploitation period to maintain it in very good condition, given that this fact will have a positive influence in the increase (or decrease) in the number of the road users and consequently in increasing his revenues.

The Project Owner (P.O.) imposes, through the present specification, minimum acceptable limits for the pavement technical characteristics during the exploitation period, and controls their application. Furthermore the P.O. imposes a minimum acceptable pavement condition, to be met during the transfer of the maintenance responsibility to the P. O., after the guarantee period is expired (which extends beyond the exploitation period).

53.1.5

The project contractor is responsible for the structural design of the pavements being constructed according to the present performance specification. However, the contractor is obliged to submit for approval by the Service the pertinent calculations which shall be based on recognized methods (supported by appropriate bibliography) and also based on the mechanical properties of materials corresponding to those that will be used (asphalt, aggregates, cement, etc.), taking into consideration the climatological and environmental conditions of the area, in combination with the appropriate design data (traffic volumes, geotechnical characteristics, life-span and planned pavement quality etc.).

It is noted that the maximum allowable vehicle axle load in Albania is equal to 13 tons.

53.2 MAINTENANCE WORKS

53.2.1

Both the design and construction shall ensure that no severe maintenance works of "structural nature" will need to be done in the first 10 years to an extent greater than 1% of the total pavement surface. Maintenance works of "operational-functional nature" (ensuring the required "surface conditions") may be carried out after the first 5 years of the road operation.

53.2.2

The planning and execution of maintenance works of "structural nature- shall be done so that during the first 7 years after their execution there should be no need to do new severe maintenance works of "structural nature" to an extent greater than 1% of the total pavement surface.

The requirements of para. 53.2.1 above are applicable for the maintenance works of "operational nature" after performing any maintenance of "structural nature".

53.2.3

In every case of maintenance works, suitable programming shall be made in order to minimize disturbance to traffic by selecting the most appropriate time for intervention (season, night hours, etc.) as well as to minimize the required total duration for the works.

53.3 CRITERIA FOR INTERVENTION TO PERFORM MAINTENANCE WORKS

During the entire period of operation the pavement shall conform to the following requirements for "surface characteristics".

53.3.1 Evenness

The rolling surface along the road centerline shall not present any vertical depressions more than 5 mm, measured by a 3-meter rule. Further, the "irregularity index" measured by the equipment recording irregularities made by TESTLAB of the Central Laboratory of Public Works (C.L.P.W.) (Bump Integrator), in any section and on any route parallel to the centerline, is not allowed to exceed 1,400 mm per kilometer.

53.3.2 Rutting

The depth of any rut measured transversely to the centerline with a 3-meter rule shall not exceed 20 mm.

53.3.3 Texture depth

The average texture depth, measured by the sand patch test according to BS 598: Part 3/1985, shall not be less than 0.6 mm.

Measurements shall be carried out for every traffic lane at points lying 30 to 70 cm from the lane edges.

53.3.4 Skid Number

The Skid Number, measured by the CLPW equipment made by K.J.Law, shall not be less than 35 (S.N. >= 35).

53.4 MEASURING PAVEMENT CHARACTERISTICS

53.4.1

The Contractor shall dispose suitable equipment to be used for regular pavement surveys in order to verify compliance to the requirements of "surface characteristics'. He also must establish appropriate warning thresholds and timely interfere to restore the required values, so that the above values will never be violated during the exploitation period, as well as during the maintenance guarantee period after the expiration of the exploitation period.

53.4.2

The Contractor may perform measurements of the characteristics using equipment other than those mentioned in previous para 100.3, provided that he will suitably correlate the measurements of these equipment with the corresponding ones of the CLPW, and this correlation is approved by the Service.

53.4.3

The Service reserves the right to be present during the measurements of the pavement characteristics, to verify compliance with the required values.

The measurements of each control, accompanied by the necessary calculations, reports, intervention programs and pertinent drawings (location plans of the control etc.) shall be saved in a suitable file, accessible to the Service.

The Service may request to be given a complete copy of the performed controls including all their attachments (calculations, drawings, reports, intervention programs, etc.).

53.4.4

The frequency of performing pavement controls shall be included in the "Inspection and maintenance manual", according to the requirements of clause 22 of the TCC, and shall be such to completely satisfy the Service requirements.

53.5 STRUCTURAL ADEQUACY OF THE PAVEMENT

53.5.1

In addition to the pavement "surface characteristics" (para. 53.3) the Contractor shall carry out periodic checks to monitor the 'structural adequacy" of the pavement and the pertinent wear due to advancing pavement layer and subgrade deformation or/and the fatigue of all layers made of materials processed by hydraulic mortars or asphalt (including all types of asphalt mixes).

53.5.2

Thus, all cracking and crazing in the traffic lanes, deformations, any repairs done, any other cracks, bleeding etc. shall be observed by appropriate controls and instruments and the possibility of evaluating the conditions of the wearing course and the fatigue of the underlying foundation layers shall be ensured.

In areas where relative problems appear, measurements of deformation (vertical or/and horizontal) shall be made by appropriate instruments for a more precise diagnosis.

53.5.3

Based on the above data the Contractor shall timely proceed with the required repair and strengthening interventions.

53.5.4

During the preparation of the "Inspection and maintenance manual', both the appropriate "warning thresholds" and "intervention thresholds" shall be determined, which shall completely satisfy the Service.

53.6 SPECIAL REQUIREMENTS AT TOLL STATIONS (T.S.)

53.6.1

The pavement type (flexible, semi rigid, rigid) is an issue left to the Contractor's option. However, in the areas influenced by the toll stations, the construction of a concrete (rigid) pavement is exceptionally imposed.

53.6.2

The areas influenced by the toll stations (T.S.), that shall be provided with a concrete pavement, are defined as follows :

(1) Front T.S. (Stations on the main roadwork)

a. Minimum influence length ahead1 of T.S. 100 m
b. Minimum influence length after1 the T.S. 25 m

(2) Roadside T.S. (Stations on interchange ramps)

a. Minimum influence length ahead2 of T.S. 50 m
b. Minimum influence length after2 the T.S. 25 m

53.6.3

The requirements to construct a concrete pavement refer to the traffic lanes. Other types of pavements (flexible, semi rigid) may as well be applied for Emergency Lanes and/or shoulders.

53.7 REQUIREMENTS FOR THE GUARANTEE PERIOD AFTER THE EXPLOITATION PERIOD

53.7.1

On the expiration of the exploitation period, the Contractor is obliged to have completed all the required maintenance works in order to ensure that the requirements for the "surface characteristics" and the "structural adequacy" during the guarantee period [which is extended by two (2) years after the end of the exploitation period] are met, according to this specification and the "inspection and maintenance manual". The relative characteristics during the guarantee period shall not be inferior to those of the exploitation period.

53.7.2

The Contractor bears all the expenses for the controls and the execution of the works afore mentioned, during the guarantee period.