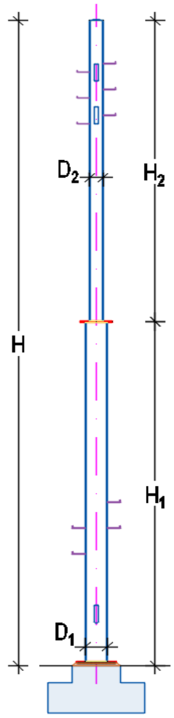
Autoriteti Rrugor Shqiptar

PROJEKTI I SISTEMIT TE MONITORIMIT DHE KONTROLLIT TE TRAFIKUT RRUGOR

Raport Teknik Strukturor

Pole H=15 m Static calculation

General View



Main Data

Pole dimentions

H=	15.0	(m)
$A_{ref,x}$ =	6.86	(m^2)

Section 1			Section 2		
H_1=	8.0	(m)	H_2=	7.0	(m)
D_1=	0.457	(m)	D_2=	0.273	(m)
$t_{w,1}$=	0.016	(m)	$t_{w,2}$=	0.010	(m)
A_1=	2.217E-02	(m^2)	A_2=	8.262E-03	(m^2)
I_1=	5.396E-04	(m^4)	I_2=	7.154E-05	(m^4)
$W_{el,1}$=	2.361E-03	(m^3)	$W_{el,2}$=	5.241E-04	(m^3)
w_1=	174.0	(kg/m)	w_2=	64.9	(kg/m)

Steel class

Fe 360

f_u= 360 (N/mm^2, MPa)

f_y= 235 (N/mm^2, MPa)

General data of wind pressure:

ρ	=	1.25	(kg/m^3)	- Air density
v = 15.0 ×10-6 m2/s		1.5E-05	(m^2/s)	- kinematic viscosity of the air
$v_{b,0}$	=	30.00	(m/s)	- The fundamental value of the wind velocity
$c_s \cdot c_d$	=	1.00	(-)	- The structural factor $c_s \cdot c_d$
z_0	=	0.05	(m)	- The roughness length
z_{min}	=	2.00	(m)	- Minimum height
z	=	15.00	(m)	- Maximum height
c_{dir}	=	1.00	(-)	- The directional factor
c_{season}	=	1.00	(-)	- The season factor
$v_b=c_{dir}c_{season}v_{b,0}$	=	30.00	(m/s)	- Basic wind velocity in m/s
$q_b=0.5\rho v_b^2$	=	562.50	(Pa)	- Basic velocity pressure
k_1	=	1.00	(-)	- The turbulence factor
c_0	=	1.00	(-)	- The orography factor
roughness category II				- Type of terrain
$z_{0,II}$	=	0.05		- For terrain category II, Table 4.1
k_r	=	0.19		- terrain factor
k_I	=	1.00		- turbulenc faktor, recomanded value
$C_{r(z)}$	=	1.0837		- roughness factor
$v_{m(z)}$	=	32.51	(m/s)	- mean wind velocity at a height z
$I_v(z)$	=	0.1753		- turbulence intensity at height z
$q_p(z)=0.5[1+7I_v(z)]\rho v_m(z)^2$	=	1.471	(kN/m^2)	- peak pressure
$v_b(ze) = [2 \cdot q_p(ze) / \rho]^{0.5}$	=	48.5	(m/s)	- Wind velocity corresponding to peak velocity pressure

Calculation of wind forces on the structure

$F_w = c_s \cdot c_d \cdot c_{f,x} \cdot q_p(z_e) \cdot A_{ref}$ *(EC1-1-4 5.3)*

Reynolds number	$R_e = b \cdot v(z_e) / v$	=	**1.48E+06**	
Effective slenderness	λ_{15} = min(l / b, 70)	=	**32.82276**	
End effect factor	ψ_λ	=	**0.843**	
Equivalent surface roughness	**k**	=	**0.200**	(mm)
Force coefficient without free-end flow	$c_{f,0}$	=	**0.802**	
Force coefficient	$c_{f,x}$	=	**0.676**	
Total wind force	F_w	=	**6.82**	(kN)
	q_w	=	**0.45**	(kN/m)

Horizontal force in basement section

M_{Ed}	=	**51.17**	(kNm)	M_{Ed}	=	11.14	(kNm)
V_{ed}	=	**6.82**	(kN)	V_{ed}	=	3.18	(kN)
N_{ed}	=	**18.46**	(kN)				

Steel section calculation

Section 1			**Section 2**			
D1=	0.457	m	D2=	0.273	m	
tw,1=	0.016	m	tw,2=	0.010	m	
d=	0.425	m	d=	0.253	m	
A_v=	0.014	m^2	A_v=	0.005		shear area *A* v EN1993-1-1 §6.2.6(3)
section class:	1		section class:	1		
γ_{M0}	1.1		γ_{M0}	1.1		Partial safety factor
V_{pl} =	0.00311	m^3	V_{pl} =	0.000692	m^3	EN1993-1-1 §6.2.6 (2)
$V_{pl,Rd}$ =	1740.62	kN	$V_{pl,Rd}$ =	648.78	kN	
$M_{pl,Rd}$ =	665.063	kNm	$M_{pl,Rd}$ =	147.84	kNm	EN1993-1-1 §6.2.5(2)

$M_{Ed} < M_{pl,Rd}$ $M_{Ed} < M_{pl,Rd}$

$V_{Ed} < V_{pl,Rd}$ $V_{Ed} < V_{pl,Rd}$

σ_1= 21.67 Mpa σ_2 = 21.26 Mpa (elastic control)

For pure bending, σ < 0.6 · fy , or σ < 0.6 · 235 MPa; σ < 141 MPa max

Reinforcemend Concrete foundation

Dimentions

B=	**2.0**	(m)	(B')	a=	0.84	(m) plate dimentions
L=	**2.0**	(m)	(L')	b=	0.84	(m) plate dimentions
H=	**0.7**	(m)	(H)		Concrete Class C30/37	

General data foundation:

(Trail Pit 1, Layer 2)

Density	**ɤ**	=	**19.21**	(kN/m^3)
Internal friction angle	**ø**	=	**16.0**	(degree)
Cohesion	**c'**	=	**22.0**	(kPa)
Concrete to soil friction coeff.	**f**	=	**0.4**	

Loads

G =	18.46	(kN)	Pole weight
H =	15	(m)	Height
D=	0.457	(m)	Diameter of stack

Foundation controll, Overturning and sliding

Self weight of foundation

W= 88.46 (kN)

Horizontal resistance force

W_h= 35.39 (kN) (rezisting horizontal force)

Stability against Sliding

Wh>H safety factor **5.19**

Over turning (of the shortest side)

M_{Resist} = 88.46 kNm

$M_{Overturning}$= 4.78 kNm

Mresist>Moverturning safety factor **18.52**

Required soil bearing capacity = **0.022** MPa

Ultimate Bearing Capacity of Soil Foundation

$$q_u = 1.3cN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$$

B'=	2.0	(m)	foundation dimention
c=	22.02	(kN/m2)	cohesion
γ =	19.21	(kN/m3)	soil density
ϕ^0=	16.0	(degree)	Internal friction angle of the soil
Df=	1.0	(m)	foundation depth
F=	3		Safety factor
N_c=	13.86		see table 12.1 Bearing Capacity factors of Terzaghi
N_q=	5.0		see table 12.1 Bearing Capacity factors of Terzaghi
N_γ=	3.0		see table 12.1 Bearing Capacity factors of Terzaghi

q_u= 538.91 kN/m2 0.539 MPa

Q_a = 0.17964 MPa Allowable soil bearing capacity, Safety factor = 8.1

Reinforcement Concrete calculation

Section calculation dimentions

b=	200.0	cm	width
h=	70.0	cm	height
a=	5	cm	concrete cover
d=	65.0	cm	

Bending moment M=	7.44	kNm
Shear force V =	25.7	kNm

Calculated the required area of tension reinforcement from bending As= 33.5 mm2 0.0026%

Refer to EN 1992-1, (9.1N), the area of longitudinal tension reinforcemend should not be taken as less than 1467.2 mm2

0.12%

accept: d= 12mm 10 piece at 15cm with As= 1539.4 mm2

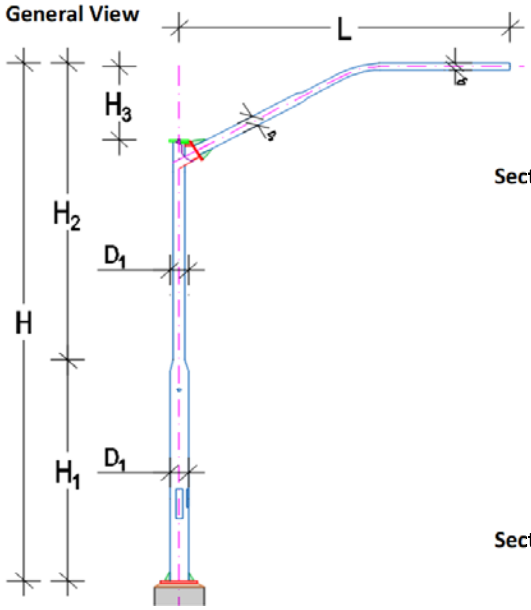
No calculated shear reinforcement is nesesary

$V_{Rd,max}$= 4474.82 kN EC 1992-1 eq. (6.10) Concrete compresion struts

$V_{Rd,c}$= 402.93 kN EC 1992-1 eq. (6.2.a), (6.2.b),

Pole H=7 m Static calculation

General View



Main Data

Pole dimentions

H=	7.0	(m)
$A_{ref,x}$ =	1.53	(m^2)

Section 1

H_1=	3.0	(m)
D_1=	0.219	(m)
$t_{w,1}$=	0.005	(m)
A_1=	3.363E-03	(m^2)
I_1=	1.928E-05	(m^4)
$W_{el,1}$=	1.760E-04	(m^3)
W_T=	3.520E-04	(m^3)
weight	26.4	(kg/m)

Section 2

H_2=	4.0	(m)
D_2=	0.141	(m)
$t_{w,2}$=	0.005	(m)
A_2=	2.141E-03	(m^2)
I_2=	4.979E-06	(m^4)
$W_{el,1}$=	7.047E-05	(m^3)
W_T=	1.409E-04	(m^3)
weight	16.8	(kg/m)

Section 3

L=	4.0	(m)
D_3=	0.141	(m)
$t_{w,3}$=	0.005	(m)
A_3=	2.141E-03	(m^2)
weight	16.8	(kg/m)

Steel class **Fe 360**

f_u=	360	(N/mm^2, MPa)
f_y=	235	(N/mm^2, MPa)

General data of wind pressure:

ρ	=	1.25	(kg/m^3)	- Air density
v = 15.0 ×10-6 m2/s		1.5E-05	(m^2/s)	- kinematic viscosity of the air
$v_{b,0}$	=	30.00	(m/s)	- The fundamental value of the wind velocity
$c_s \cdot c_d$	=	1.00	(-)	- The structural factor $c_s \cdot c_d$
z_0	=	0.05	(m)	- The roughness length
z_{min}	=	2.00	(m)	- Minimum height
z	=	7.00	(m)	- Maximum height
c_{dir}	=	1.00	(-)	- The directional factor
c_{season}	=	1.00	(-)	- The season factor
$v_b=c_{dir}c_{season}v_{b,0}$	=	30.00	(m/s)	- Basic wind velocity in m/s
$q_b=0.5\rho v_b^2$	=	562.50	(Pa)	- Basic velocity pressure
k_1	=	1.00	(-)	- The turbulence factor
c_0	=	1.00	(-)	- The orography factor
roughness category II				- Type of terrain
$z_{0,II}$	=	0.05		- For terrain category II, Table 4.1
k_r	=	0.19		- terrain factor
k_I	=	1.00		- turbulenc faktor, recomanded value
$C_{r(z)}$	=	0.9389		- roughness factor
$v_{m(z)}$	=	28.17	(m/s)	- mean wind velocity at a height z
$I_v(z)$	=	0.2024		- turbulence intensity at height z
$q_p(z)=0.5[1+7I_v(z)]\rho v_m(z)^2$	=	1.198	(kN/m^2)	- peak pressure
$v_b(ze) = [2 \cdot q_p(ze) / \rho]^{0.5}$	=	43.8	(m/s)	- Wind velocity corresponding to peak velocity pressure

Calculation of wind forces on the structure

$F_w = c_s \cdot c_d \cdot c_{f,x} \cdot q_p(z_e) \cdot A_{ref}$ *(EC1-1-4 5.3)*

Reynolds number	$R_e = b \cdot v(z_e) / v$	=	**6.40E+05**	
Effective slenderness	λ_{15} = min(l / b, 70)	=	**31.94888**	
End effect factor	ψ_λ	=	**0.843**	
Equivalent surface roughness	**k**	=	**0.200**	(mm)
Force coefficient without free-end flow	$c_{f,0}$	=	**0.802**	
Force coefficient	$c_{f,x}$	=	**0.676**	
Total wind force	F_w	=	**1.24**	(kN)
	q_w	=	**0.18**	(kN/m)

Horizontal force in basement section

M_{Ed}	=	**4.35**	(kNm)	M_{Ed}	=	1.42	(kNm)
V_{ed}	=	**1.95**	(kN)	V_{ed}	=	1.42	(kN)
T_{Ed}	=	**1.42**	(kNm)	T_{Ed}	=	**1.42**	(kNm)
N_{ed}	=	**2.14**	(kN)				

Steel section calculation

	Section 1			**Section 2**		
D1=	0.219	m	D2=	0.141	m	
tw,1=	0.005	m	tw,2=	0.005	m	
d=	0.209	m	d=	0.131	m	
A_v=	0.002	m^2	A_v=	0.001		shear area *A* v EN1993-1-1 §6.2.6(3)
section class:	1		section class:	1		
γ_{M0}	1.1		γ_{M0}	1.1		Partial safety factor
V_{pl} =	0.0002	m^3	V_{pl} =	9.29301E-05	m^3	EN1993-1-1 §6.2.6 (2)
$V_{pl,Rd}$ =	264.08	kN	$V_{pl,Rd}$ =	168.12	kN	
$M_{pl,Rd}$ =	48.973	kNm	$M_{pl,Rd}$ =	19.85	kNm	EN1993-1-1 §6.2.5(2)
T_{Rd} =	43.416	kNm	T_{Rd} =	17.38	kNm	EN1993-1-1 §6.2.7
4.342E+01						

$M_{Ed}<M_{pl,Rd}$	$M_{Ed}<M_{pl,Rd}$
$V_{Ed}<V_{pl,Rd}$	$V_{Ed}<V_{pl,Rd}$
$T_{Ed}<T_{Rd}$	$T_{Ed}<T_{Rd}$

Reinforcemend Concrete foundation

Dimentions

B=	**1.6**	(m)	(B')	a=	0.45	(m) plate dimentions
L=	**1.6**	(m)	(L')	b=	0.45	(m) plate dimentions
H=	**0.7**	(m)	(H)	Concrete Class C30/37		

General data foundation: (Trail Pit 1, Layer 2)

Density	**ɣ**	=	**19.21**	(kN/m^3)
Internal friction angle	**ø**	=	**16.0**	(degree)
Cohesion	**c'**	=	**22.0**	(kPa)
Concrete to soil friction coeff.	**f**	=	**0.4**	

Loads

G =	2.14	(kN)	Pole weight
H =	7	(m)	Height
D=	0.2191	(m)	Diameter of stack

Foundation controll, Overturning and sliding

Self weight of foundation + pole selfweight

W= 46.94 (kN)

Horizontal resistance force

W_h= 18.77 (kN) (rezisting horizontal force)

Stability against Sliding

Wh>H safety factor **9.62**

Over turning (of the shortest side)

M_{Resist} = 37.55 kNm

$M_{Overturning}$= 1.37 kNm

Mresist>Moverturning safety factor **27.47**

Required soil bearing capacity = **0.018** MPa

Ultimate Bearing Capacity of Soil Foundation

$$q_u = 1.3cN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$$

B'=	1.6	(m)	foundation dimention
c=	22.02	(kN/m2)	cohesion
γ =	19.21	(kN/m3)	soil density
ϕ^0=	16.0	(degree)	Internal friction angle of the soil
Df=	1.0	(m)	foundation depth
F=	3		Safety factor
N_c=	13.86		see table 12.1 Bearing Capacity factors of Terzaghi
N_q=	5.0		see table 12.1 Bearing Capacity factors of Terzaghi
N_γ=	3.0		see table 12.1 Bearing Capacity factors of Terzaghi

q_u= 529.69 kN/m2 0.530 MPa

Q_a = 0.17656 MPa Allowable soil bearing capacity, Safety factor = 9.6

Reinforcement Concrete calculation

Section calculation dimentions

b=	160.0	cm	width
h=	70.0	cm	height
a=	5	cm	concrete cover
d=	65.0	cm	

Bending moment M=	4.85	kNm
Shear force V =	16.9	kNm

Calculated the required area of tension reinforcement from bending As= 17.7 mm2 0.0017%

Refer to EN 1992-1, (9.1N), the area of longitudinal tension reinforcemend should not be taken as less than 1387.1 mm2 0.12%

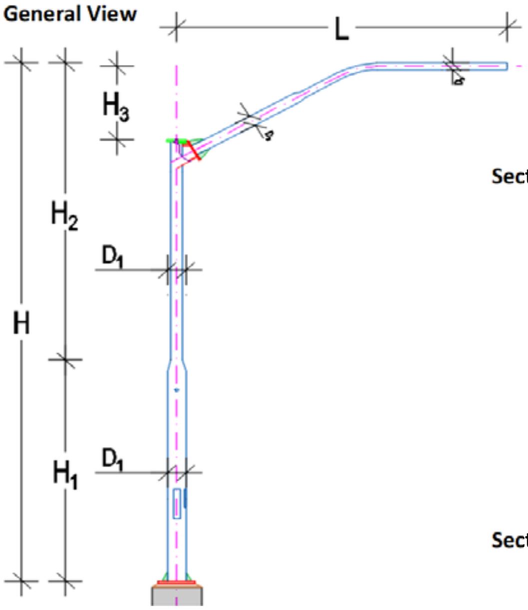
accept: d= 12mm 10 piece at 15cm with As= 1539.4 mm2

No calculated shear reinforcement is nesesary

$V_{Rd,max}$=	**4212.45**	**kN**	EC 1992-1 eq. (6.10)	Concrete compresion struts
$V_{Rd,c}$=	**353.09**	**kN**	EC 1992-1 eq. (6.2.a), (6.2.b),	

Pole H=7 m arm 6 m Static calculation

General View



Main Data

Pole dimentions

H=	7.0	(m)
$A_{ref,x}$ =	1.53	(m^2)

Section 1

H_1=	3.0	(m)
D_1=	0.219	(m)
$t_{w,1}$=	0.005	(m)
A_1=	3.363E-03	(m^2)
I_1=	1.928E-05	(m^4)
$W_{el,1}$=	1.760E-04	(m^3)
W_T=	3.520E-04	(m^3)
weight	26.4	(kg/m)

Section 2

H_2=	4.0	(m)
D_2=	0.141	(m)
$t_{w,2}$=	0.005	(m)
A_2=	2.141E-03	(m^2)
I_2=	4.979E-06	(m^4)
$W_{el,1}$=	7.047E-05	(m^3)
W_T=	1.409E-04	(m^3)
weight	16.8	(kg/m)

Section 3

L=	6.0	(m)
D_3=	0.141	(m)
$t_{w,3}$=	0.005	(m)
A_3=	2.141E-03	(m^2)
weight	16.8	(kg/m)

Steel class **Fe 360**

f_u= 360 (N/mm^2, MPa)

f_y= 235 (N/mm^2, MPa)

General data of wind pressure:

ρ	=	1.25	(kg/m^3)	- Air density
v = 15.0 ×10-6 m2/s		1.5E-05	(m^2/s)	- kinematic viscosity of the air
$v_{b,0}$	=	30.00	(m/s)	- The fundamental value of the wind velocity
$c_s \cdot c_d$	=	1.00	(-)	- The structural factor $c_s \cdot c_d$
z_0	=	0.05	(m)	- The roughness length
z_{min}	=	2.00	(m)	- Minimum height
z	=	7.00	(m)	- Maximum height
c_{dir}	=	1.00	(-)	- The directional factor
c_{season}	=	1.00	(-)	- The season factor
$v_b=c_{dir}c_{season}v_{b,0}$	=	30.00	(m/s)	- Basic wind velocity in m/s
$q_b=0.5\rho v_b^2$	=	562.50	(Pa)	- Basic velocity pressure
k_1	=	1.00	(-)	- The turbulence factor
c_0	=	1.00	(-)	- The orography factor
roughness category II				- Type of terrain
$z_{0,II}$	=	0.05		- For terrain category II, Table 4.1
k_r	=	0.19		- terrain factor
k_I	=	1.00		- turbulenc faktor, recomanded value
$c_{r(z)}$	=	0.9389		- roughness factor
$v_{m(z)}$	=	28.17	(m/s)	- mean wind velocity at a height z
$I_v(z)$	=	0.2024		- turbulence intensity at height z
$q_p(z)=0.5[1+7I_v(z)]\rho v_m(z)^2$	=	1.198	(kN/m^2)	- peak pressure
$v_b(ze) = [2 \cdot q_p(ze) / \rho]^{0.5}$	=	43.8	(m/s)	- Wind velocity corresponding to peak velocity pressure

Calculation of wind forces on the structure

$F_w = c_s \cdot c_d \cdot c_{f,x} \cdot q_p(z_e) \cdot A_{ref}$ *(EC1-1-4 5.3)*

Reynolds number	$R_e = b \cdot v(z_e) / v$	=	**6.40E+05**	
Effective slenderness	**λ_{15} = min(l / b, 70)**	=	**31.94888**	
End effect factor	ψ_λ	=	**0.843**	
Equivalent surface roughness	**k**	=	**0.200**	(mm)
Force coefficient without free-end flow	$c_{f,0}$	=	**0.802**	
Force coefficient	$c_{f,x}$	=	**0.676**	
Total wind force	F_w	=	**1.24**	(kN)
	q_w	=	**0.18**	(kN/m)

Horizontal force in basement section

M_{Ed}	=	**4.35**	(kNm)	M_{Ed}	=	1.42	(kNm)
V_{ed}	=	**2.31**	(kN)	V_{ed}	=	1.77	(kN)
T_{Ed}	=	**3.19**	(kNm)	T_{Ed}	=	**3.19**	(kNm)
N_{ed}	=	**2.47**	(kN)				

Steel section calculation

Section 1			**Section 2**			
D1=	0.219	m	D2=	0.141	m	
tw,1=	0.005	m	tw,2=	0.005	m	
d=	0.209	m	d=	0.131	m	
A_v=	0.002	m^2	A_v=	0.001		shear area EN1993-1-1 §6.2.6(3)
section class:	1		section class:	1		
γ_{M0}	1.1		γ_{M0}	1.1		Partial safety factor
V_{pl} =	0.0002	m^3	V_{pl} =	9.29E-05	m^3	EN1993-1-1 §6.2.6 (2)
$V_{pl,Rd}$ =	264.08	kN	$V_{pl,Rd}$ =	168.12	kN	
$M_{pl,Rd}$ =	48.973	kNm	$M_{pl,Rd}$ =	19.85	kNm	EN1993-1-1 §6.2.5(2)
T_{Rd} =	43.416	kNm	T_{Rd} =	17.38	kNm	EN1993-1-1 §6.2.7
4.342E+01						
	$M_{Ed}<M_{pl,Rd}$		$M_{Ed}<M_{pl,Rd}$			
	$V_{Ed}<V_{pl,Rd}$		$V_{Ed}<V_{pl,Rd}$			
	$T_{Ed}<T_{Rd}$		$T_{Ed}<T_{Rd}$			

Reinforcemend Concrete foundation

Dimentions

B=	2.0	(m)	(B')	a=	0.45	(m) plate dimentions
L=	2.0	(m)	(L')	b=	0.45	(m) plate dimentions
H=	0.7	(m)	(H)	Concrete Class C30/37		

General data foundation:

(Trail Pit 1, Layer 2)

Density	ɣ	=	19.21	(kN/m^3)
Internal friction angle	ø	=	16.0	(degree)
Cohesion	c'	=	22.0	(kPa)
Concrete to soil friction coeff.	f	=	0.4	

Loads

G =	2.47	(kN)	Pole weight
H =	7	(m)	Height
D=	0.2191	(m)	Diameter of stack

Foundation controll, Overturning and sliding

Self weight of foundation + pole selfweight

W= 72.47 (kN)

Horizontal resistance force

W_h= 28.99 (kN) (rezisting horizontal force)

Stability against Sliding

Wh>H safety factor **12.56**

Over turning (of the shortest side)

M_{Resist} = 72.47 kNm

$M_{Overturning}$= 1.62 kNm

Mresist>Moverturning safety factor **44.87**

Required soil bearing capacity = **0.018** MPa

Ultimate Bearing Capacity of Soil Foundation

$$q_u = 1.3cN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$$

B'=	2.0	(m)	foundation dimention
c=	22.02	(kN/m2)	cohesion
γ =	19.21	(kN/m3)	soil density
ϕ^0=	16.0	(degree)	Internal friction angle of the soil
Df=	1.0	(m)	foundation depth
F=	3		Safety factor

N_c=	13.86	see table 12.1 Bearing Capacity factors of Terzaghi
N_q=	5.0	see table 12.1 Bearing Capacity factors of Terzaghi
N_γ=	3.0	see table 12.1 Bearing Capacity factors of Terzaghi

q_u= 538.91 kN/m2 0.539 MPa

Q_a = 0.17964 MPa Allowable soil bearing capacity, Safety factor = 9.9

Reinforcement Concrete calculation

Section calculation dimentions

b=	200.0	cm	width
h=	70.0	cm	height
a=	5	cm	concrete cover
d=	65.0	cm	

Bending moment M=	10.88	kNm
Shear force V =	28.1	kNm

Calculated the required area of tension reinforcement from bending As= 17.7 mm2 0.0014%

Refer to EN 1992-1, (9.1N), the area of longitudinal tension reinforcemend should not be taken as less than 1734 mm2 0.12%

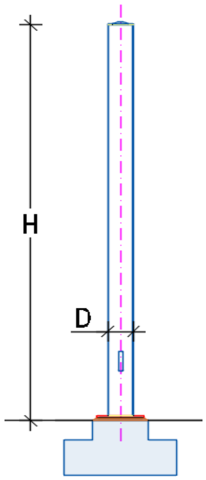
accept: d= 14 mm 12 piece at 20cm with As= 1847.3 mm2

No calculated shear reinforcement is nesesary

$V_{Rd,max}$=	**5265.23**	**kN**	EC 1992-1 eq. (6.10)	Concrete compresion struts
$V_{Rd,c}$=	**441.15**	**kN**	EC 1992-1 eq. (6.2.a), (6.2.b),	

Pole H=4 m Static calculation

General View



Main Data

Pole dimentions

H=	4.0	(m)
$A_{ref,x}$ =	0.46	(m^2)

Section

D=	0.1	(m)
t_w=	0.004	(m)
A=	1.386E-03	(m^2)
I=	2.111E-06	(m^4)
W_{el}=	3.693E-05	(m^3)
w=	10.9	(kg/m)

Steel class

Fe 360

f_u=	360	(N/mm^2, MPa)
f_y=	235	(N/mm^2, MPa)

General data of wind pressure:

ρ	=	1.25	(kg/m^3)	- Air density
ν = 15.0 ×10-6 m2/s		1.5E-05	(m^2/s)	- kinematic viscosity of the air
$v_{b,0}$	=	30.00	(m/s)	- The fundamental value of the wind velocity
$c_s \cdot c_d$	=	1.00	(-)	- The structural factor $c_s \cdot c_d$
z_0	=	0.05	(m)	- The roughness length
z_{min}	=	2.00	(m)	- Minimum height
z	=	4.00	(m)	- Maximum height
c_{dir}	=	1.00	(-)	- The directional factor
c_{season}	=	1.00	(-)	- The season factor
$v_b=c_{dir}c_{season}v_{b,0}$	=	30.00	(m/s)	- Basic wind velocity in m/s
$q_b=0.5\rho v_b^2$	=	562.50	(Pa)	- Basic velocity pressure
k_1	=	1.00	(-)	- The turbulence factor
c_0	=	1.00	(-)	- The orography factor
roughness category II				- Type of terrain
$z_{0,II}$	=	0.05		- For terrain category II, Table 4.1
k_r	=	0.19		- terrain factor
k_I	=	1.00		- turbulenc faktor, recomanded value
$C_{r(z)}$	=	0.8326		- roughness factor
$v_{m(z)}$	=	24.98	(m/s)	- mean wind velocity at a height z
$I_v(z)$	=	0.2282		- turbulence intensity at height z
$q_p(z)=0.5[1+7I_v(z)]\rho v_m(z)^2$	=	1.013	(kN/m^2)	- peak pressure
$v_b(ze) = [2 \cdot q_p(ze) / \rho]^{0.5}$	=	40.3	(m/s)	- Wind velocity corresponding to peak velocity pressure

Calculation of wind forces on the structure

$F_w = c_s \cdot c_d \cdot c_{f,x} \cdot q_p(z_e) \cdot A_{ref}$ *(EC1-1-4 5.3)*

Reynolds number	$R_e = b \cdot v(z_e) / v$	=	**3.07E+05**	
Effective slenderness	λ_{15} = min(l / b, 70)	=	**35.00**	
End effect factor	ψ_λ	=	**0.843**	
Equivalent surface roughness	**k**	=	**0.200**	(mm)
Force coefficient without free-end flow	$c_{f,0}$	=	**0.802**	
Force coefficient	$c_{f,x}$	=	**0.676**	
Total wind force	F_w	=	**0.31**	(kN)
	q_w	=	**0.08**	(kN/m)

Horizontal force in basement section

M_{Ed}	=	**0.63**	(kNm)
V_{ed}	=	**0.31**	(kN)
N_{ed}	=	**0.44**	(kN)

Steel section calculation

Section 1

D=	0.114	m	
tw=	0.004	m	
d=	0.106	m	
A_v=	0.001	m^2	shear area *A* v EN1993-1-1 §6.2.6(3)
section class:	1		
γ_{M0}	1.1		Partial safety factor
V_{pl} =	4.87E-05	m^3	EN1993-1-1 §6.2.6 (2)
$V_{pl,Rd}$ =	108.84	kN	
$M_{pl,Rd}$ =	10.401	kNm	EN1993-1-1 §6.2.5(2)

$M_{Ed}<M_{pl,Rd}$

$V_{Ed}<V_{pl,Rd}$

σ_1= 16.95 Mpa (elastic control)

For pure bending, σ < 0.6 · fy , or σ < 0.6 · 235 MPa; σ < 141 MPa max

Reinforcemend Concrete foundation

Dimentions

B=	0.7	(m)	(B')	a=	0.35	(m) plate dimentions
L=	0.7	(m)	(L')	b=	0.35	(m) plate dimentions
H=	0.7	(m)	(H)	Concrete Class C30/37		

General data foundation: (Trail Pit 1, Layer 2)

Density	ɤ	=	19.21	(kN/m^3)
Internal friction angle	ø	=	16.0	(degree)
Cohesion	c'	=	22.0	(kPa)
Concrete to soil friction coeff.	f	=	0.4	

Loads

G =	0.44	(kN)	Pole weight
H =	4	(m)	Height
D=	0.1143	(m)	Diameter of stack

Foundation controll, Overturning and sliding

Self weight of foundation + pole selfweight

W= 9.01 (kN)

Horizontal resistance force

W_h= 3.60 (kN) (rezisting horizontal force)

Stability against Sliding

Wh>H safety factor **11.51**

Over turning (of the shortest side)

M_{Resist} = 3.15 kNm

$M_{Overturning}$= 0.22 kNm

Mresist>Moverturning safety factor **14.39**

Required soil bearing capacity = **0.018** MPa

Ultimate Bearing Capacity of Soil Foundation

$$q_u = 1.3cN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$$

B'=	0.7	(m)	foundation dimention
c=	22.02	(kN/m2)	cohesion
γ =	19.21	(kN/m3)	soil density
ϕ^0=	16.0	(degree)	Internal friction angle of the soil
Df=	1.0	(m)	foundation depth
F=	3		Safety factor
N_c=	13.86		see table 12.1 Bearing Capacity factors of Terzaghi
N_q=	5.0		see table 12.1 Bearing Capacity factors of Terzaghi
N_γ=	3.0		see table 12.1 Bearing Capacity factors of Terzaghi
q_u=	508.943	kN/m2	0.509 MPa

Q_a = 0.16965 MPa Allowable soil bearing capacity, Safety factor = 9.2

Reinforcement Concrete calculation

Section calculation dimentions

b=	70.0	cm	width
h=	70.0	cm	height
a=	5	cm	concrete cover
d=	65.0	cm	

Bending moment M=	0.20	kNm
Shear force V =	2.3	kNm

Calculated the required area of tension reinforcement from bending As= 3.5 mm2 0.0008%

Refer to EN 1992-1, (9.1N), the area of longitudinal tension reinforcemend should not be taken as less than 685.3 mm2

0.14%

accept: d= 12 mm 8 piece at 20cm with As= 904.8 mm2

No calculated shear reinforcement is nesesary

$V_{Rd,max}$=	**2162.4**	**kN**	EC 1992-1 eq. (6.10) Concrete compresion struts
$V_{Rd,c}$=	**169.23**	**kN**	EC 1992-1 eq. (6.2.a), (6.2.b),