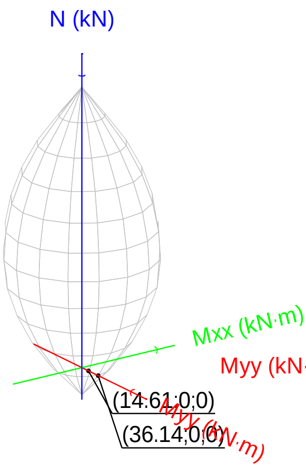
Ultimate limit state under normal stresses (EN 1992-1-1:2004/AC 2008, Articles 5.2, 5.8.3.1, 5.8.8 and 6.1)

The worst case forces to be withstood from the analysis are produced at 'Pile #1', in the combination of loadcase "[4] 1.35·SW+1.35·DL+1.5·Qa (M Min., N Min.)".

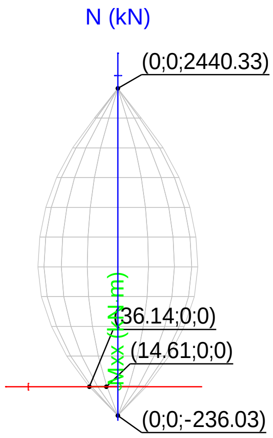
The following criteria must be satisfied:

$$\eta_l = \sqrt{\frac{N_{Ed}^2 + M_{Ed,x}^2 + M_{Ed,y}^2}{N_{Rd}^2 + M_{Rd,x}^2 + M_{Rd,y}^2}} \leq 1$$

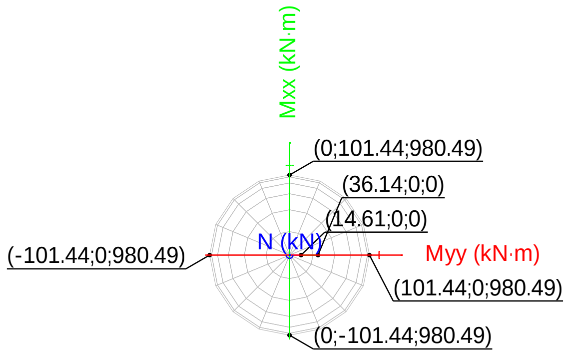
h : *0.404* ✓



Capacity volume



View N, M



View Mx, My

Resistance check of the section (h_1)

N_{Ed},M_{Ed} are the first order design forces, including, the minimum eccentricity in accordance with 6.1(4):

N_{Ed}: Design normal force. — N_{Ed} : *0.00* kN

M_{Ed}: First order design moment. — $M_{Ed,x}$: *0.00* kN·m

$M_{Ed,y}$: *14.61* kN·m

N_{Rd},M_{Rd} are the forces that cause the section to fail with the same eccentricities as the worst-case design forces.

N_{Rd}: Ultimate axial resistance. — N_{Rd} : *0.00* kN

M_{Rd}: Bending resistance. — $M_{Rd,x}$: *0.00* kN·m

$M_{Rd,y}$: *36.14* kN·m

Resistance capacity calculation

The calculation of the ultimate resistance capacity of the sections is carried out using the following general hypothesis (Article 6.1):

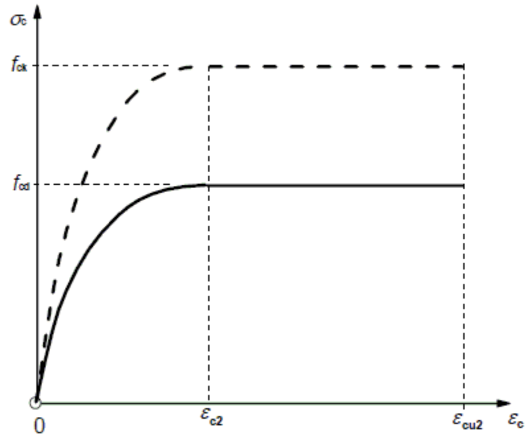
(a) Failure is characterised by the value of the deformation in specific fibres of the section, defined by the domains of failure deformation.

(b) Concrete deformations follow a planar law.

(c) The deformation ε_s of the passive reinforcement remain the same as the concrete surrounding them.

(d) The stresses in the concrete in compression are derived from the design stress/strain relationship given in 3.1.7(1).

The concrete stress-deformation calculation diagram is of the parabola-rectangle type. The tensile resistance of the concrete is not considered.



e_{cu2}: Ultimate strain according to Table 3.1. e_{cu2} : *0.0035*

e_{c2}: Strain at reaching the maximum strength according to Table 3.1. e_{c2} : *0.0020*

f_{cd}: Design value of the concrete compression force in the direction of the longitudinal member axis. f_{cd} : *18.00* MPa

$$f_{cd} = \alpha_{cc} \cdot f_{ck} / \gamma_c$$

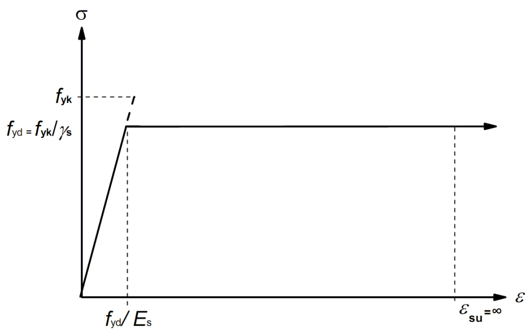
Where:

a_{cc}: Coefficient taking account of long term effects on the compressive strength and of unfavourable effects resulting from the way the load is applied. a_{cc} : *1.00*

f_{ck}: Concrete compressive strength. f_{ck} : *18.00* MPa

g_c: Partial safety factor for concrete. g_c : *1.0*

(e) The stresses in the reinforcing steel are derived from the design curve in: Article 3.2, Figure 3.8



e_{su}: Ultimate strain according to Article 3.2.7(2.b). e_{su} : *0.0100*

f_{yd}: Design yield strength of reinforcement. f_{yd} : *347.83* MPa

$$f_{yd} = f_{yk} / \gamma_s$$

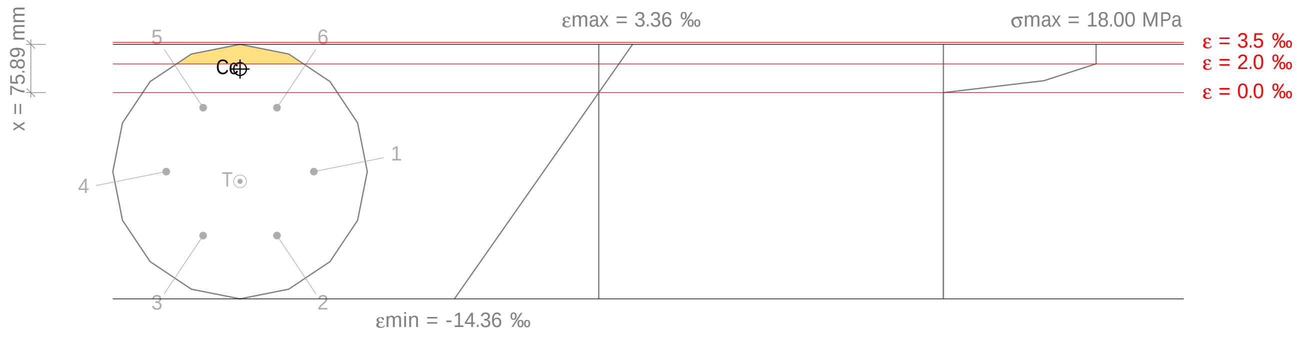
Where:

f_{yk}: Steel yield strength. f_{yk} : *400.00* MPa

g_s: Partial safety factor for reinforcing steel. g_s : *1.15*

(e) The general force equilibrium and moment equations are applied to the resulting stress forces of the section.

Ultimate force balance of the section, calculated with the same eccentricities as the worst-case design forces:



Bar	Designation	X Coord. (mm)	Y Coord. (mm)	s_s (MPa)	e
1	Ø12	0.00	-116.00	-347.83	-0.005499
2	Ø12	-100.46	-58.00	-347.83	-0.009950
3	Ø12	-100.46	58.00	-347.83	-0.009950
4	Ø12	0.00	116.00	-347.83	-0.005499
5	Ø12	100.46	58.00	-209.57	-0.001048
6	Ø12	100.46	-58.00	-209.57	-0.001048

	Resultant (kN)	e.x (mm)	e.y (mm)
Cc	204.76	161.17	0.00
Cs	0.00	0.00	0.00
T	204.76	-15.34	0.00

$$N_{Rd} = C_c + C_s - T$$ N_{Rd} : 0.00 kN

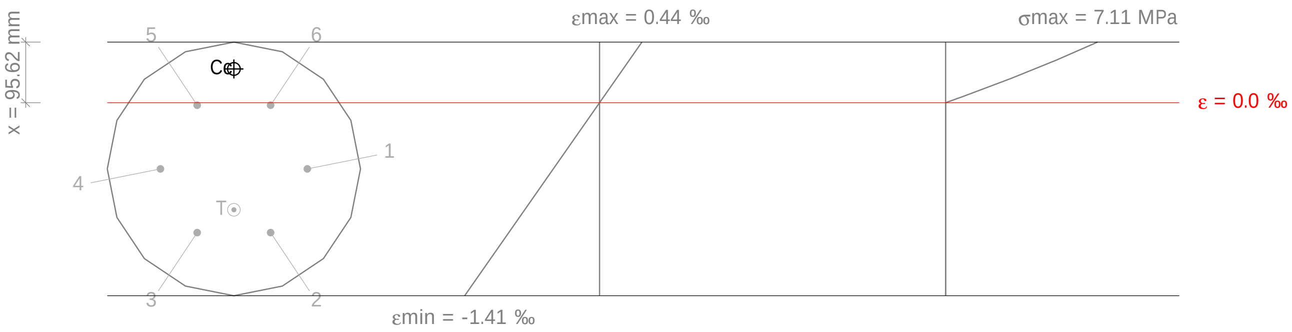
$$M_{Rd,x} = C_c \cdot e_{cc,y} + C_s \cdot e_{cs,y} - T \cdot e_{T,y}$$ $M_{Rd,x}$: 0.00 kN·m

$$M_{Rd,y} = C_c \cdot e_{cc,x} + C_s \cdot e_{cs,x} - T \cdot e_{T,x}$$ $M_{Rd,y}$: 36.14 kN·m

Where:

- C_c: Resultant of concrete compressive forces. — C_c : 204.76 kN
- C_s: Resultant of steel compressive forces. — C_s : 0.00 kN
- T: Resultant of steel tensile forces. — T : 204.76 kN
- e_{cc}: Eccentricity of the concrete compressive forces in the direction of the X and Y axes. — $e_{cc,x}$: 161.17 mm; $e_{cc,y}$: 0.00 mm
- e_{cs}: Eccentricity of the steel compressive forces in the direction of the X and Y axes. — e_{cs} : 0.00 mm
- e_T: Eccentricity of the steel tensile forces in the direction of the X and Y axes. — $e_{T,x}$: -15.34 mm; $e_{T,y}$: 0.00 mm
- e_{cmax}: Deformation of the most compressed concrete fibre. — e_{cmax} : 0.0034
- e_{smax}: Deformation of the steel bar with greatest tension. — e_{smax} : 0.0100
- s_{cmax}: Stress of the most compressed concrete fibre. — s_{cmax} : 18.00 MPa
- s_{smax}: Stress of the steel bar with greatest tension. — s_{smax} : 347.83 MPa

Worst-case force balance of the section:



Bar	Designation	X Coord. (mm)	Y Coord. (mm)	s_s (MPa)	e
1	Ø12	0.00	-116.00	-96.94	-0.000485
2	Ø12	-100.46	-58.00	-190.23	-0.000951
3	Ø12	-100.46	58.00	-190.23	-0.000951
4	Ø12	0.00	116.00	-96.94	-0.000485
5	Ø12	100.46	58.00	-3.64	-0.000018
6	Ø12	100.46	-58.00	-3.64	-0.000018

	Resultant (kN)	e.x (mm)	e.y (mm)
Cc	65.78	157.64	0.00
Cs	0.00	0.00	0.00
T	65.78	-64.46	0.00

$$N_{Ed} = C_c + C_s - T$$

$$M_{Ed,x} = C_c \cdot e_{cc,y} + C_s \cdot e_{cs,y} + T \cdot e_{T,y}$$

$$M_{Ed,y} = C_c \cdot e_{cc,x} + C_s \cdot e_{cs,x} + T \cdot e_{T,x}$$

N_{Ed} : *0.00* kN

$M_{Ed,x}$: *0.00* kN·m

$M_{Ed,y}$: *14.61* kN·m

Where:

C_c: Resultant of concrete compressive forces. — C_c : *65.78* kN

C_s: Resultant of steel compressive forces. — C_s : *0.00* kN

T: Resultant of steel tensile forces. — T : *65.78* kN

e_{cc}: Eccentricity of the concrete compressive forces in the direction of the X and Y axes. — $e_{cc,x}$: *157.64* mm; $e_{cc,y}$: *0.00* mm

e_{cs}: Eccentricity of the steel compressive forces in the direction of the X and Y axes. — e_{cs} : *0.00* mm

e_T: Eccentricity of the steel tensile forces in the direction of the X and Y axes. — $e_{T,x}$: *-64.46* mm; $e_{T,y}$: *0.00* mm

e_{cmax}: Deformation of the most compressed concrete fibre. — e_{cmax} : *0.0004*

e_{smax}: Deformation of the steel bar with greatest tension. — e_{smax} : *0.0010*

s_{cmax}: Stress of the most compressed concrete fibre. — s_{cmax} : *7.11* MPa

s_{smax}: Stress of the steel bar with greatest tension. — s_{smax} : *190.23* MPa