

1 Spread footing: Foundation37 identical elements: 1

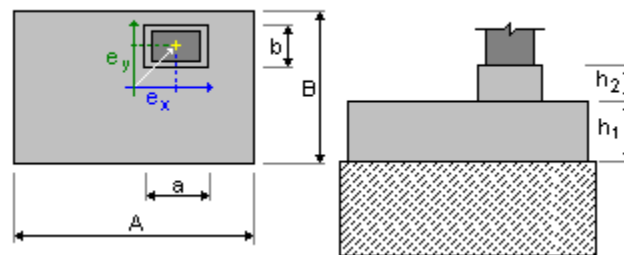
Number of

1.1 Basic data

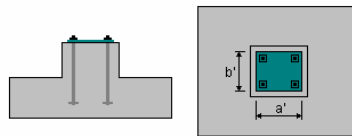
1.1.1 Assumptions

- Geotechnic calculations according to : DTU 13.12
- Concrete calculations according to : BAEL 91 mod. 99
- Foundation with lean concrete
- Shape selection : without limits

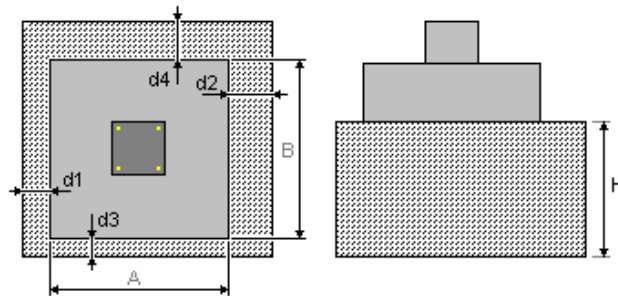
1.1.2 Geometry:



A	= 2.30 (m)	a	= 0.66 (m)
B	= 1.40 (m)	b	= 0.59 (m)
h1	= 0.50 (m)	e_x	= 0.00 (m)
h2	= 0.50 (m)	e_y	= 0.00 (m)



a'	= 36.0 (cm)
b'	= 33.0 (cm)
c1	= 5.0 (cm)
c2	= 3.0 (cm)



H	= 0.10 (m)
d1	= 0.10 (m)
d2	= 0.10 (m)
d3	= 0.10 (m)

$$d4 = 0.10 \text{ (m)}$$

1.1.3 Materials

- Concrete : BETON25; Characteristic strength = 25.00
MPa
Unit weight = 2501.36 (kG/m3)
- Lean concrete : BETON20; Characteristic strength = 20.00
MPa
Unit weight = 2501.36 (kG/m3)
- Longitudinal reinforcement : type HA 400 Characteristic strength = 400.00 MPa
- Transversal reinforcement : type HA 400 Characteristic strength = 400.00 MPa
- Additional reinforcement: : type HA 400 Characteristic strength = 400.00 MPa

1.1.4 Loads:

Foundation loads:

Case	Nature	Group	N (kN)	Fx (kN)	Fy (kN)	Mx (kN*m)	My (kN*m)
DL1	dead load(Structural)	37	10.49	1.99	-0.00	0.00	3.58
1	dead load(Structural)	37	4.16	1.71	-0.00	0.00	2.91
11	dead load(Structural)	37	0.37	0.15	-0.00	0.00	0.26
111	dead load(Structural)	37	8.49	1.90	-0.00	0.00	3.44
1111	dead load(Structural)	37	0.27	-0.01	-0.00	0.00	-0.00
11111	dead load(Structural)	37	0.00	0.00	0.00	0.00	0.00
111111	live load(Category A)	37	9.78	4.03	-0.00	0.00	6.85
1111111	live load(Category A)	37	0.00	-0.00	0.00	-0.00	-0.00
2	live load(Category A)	37	0.98	0.40	-0.00	0.00	0.69
WIND1	wind	37	-10.77	1.95	0.15	-0.21	-1.43
WIND2	wind	37	-10.77	1.95	-0.15	0.21	-1.43
WIND3	wind	37	-4.34	-15.29	-0.00	0.00	-22.53
WIND4	wind	37	-5.81	1.73	0.00	-0.00	6.55
WIND5	wind	37	8.12	-9.78	-0.00	0.00	-12.90
WIND6	wind	37	7.62	6.78	0.00	-0.00	14.85

Backfill loads:

Case	Nature	Q1 (kN/m2)
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1.1.5 Combination list

1/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111
2/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111
3/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.501111111+1.501111111+1.502
4/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.50111111
5/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.501111111
6/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.50111111+1.501111111
7/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.502
8/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.50111111+1.502
9/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.50111111+1.502
10/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.50111111+1.501111111+1.502
11/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.50111111
12/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.501111111
13/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.50111111+1.501111111
14/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.502
15/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.50111111+1.502
16/	ULS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.50111111+1.502
17/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.80WIND1
18/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.80WIND2
19/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.80WIND3
20/	ULS : 1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.80WIND4

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577/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND1
578/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND2
579/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND3
580/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND4
581/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND5
582/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND6
583/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND1
584/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND2
585/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND3
586/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND4
587/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND5
588/* SLS : 1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+0.771111111+0.772+1.00WIND6

1.2 Geotechnical design

1.2.1 Assumptions

Foundation design for:

- Capacity
- Sliding
- Rotation
- Uplift

1.2.2 Soil:

Stresses in soil: $\sigma_{ULS} = 0.07 \text{ (MPa)}$ $\sigma_{SLS} = 0.05 \text{ (MPa)}$

Soil level: $N_1 = 0.00 \text{ (m)}$
Column pier level: $N_a = 0.00 \text{ (m)}$
Minimum reference level: $N_f = -1.20 \text{ (m)}$

Argiles et limons fermes

- Soil level: 0.00 (m)
- Unit weight: 2039.43 (kG/m³)
- Unit weight of solid: 2692.05 (kG/m³)
- Internal friction angle: 30.0 (Deg)
- Cohesion: 0.02 (MPa)

1.2.3 Limit states

Lean concrete stability analysis

Stress calculations

Attention - the selected soil database does not correspond to the geotechnical code. The calculations have been performed based on the default soil types.

Soil type under foundation: not layered

Design combination **ULS :**

1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.501111111+1.501111111+1.502+1.20WIND6

Load factors: **1.35 * Foundation weight**

1.35 * Soil weight

Calculation results: On the foundation level

Weight of foundation and soil over it: Gr = 111.22 (kN)

Design load:

Nr = 168.60 (kN) Mx = -0.00 (kN*m) My = 65.43 (kN*m)

Equivalent foundation dimensions:

B' = 1

$$L' = 1$$

Foundation depth: $D_{min} = 1.10 \text{ (m)}$

Allowable stress calculation method: Stress pressiometric (DTU 13.12, 3.22)

$q_u = 0.15 \text{ (MPa)}$

Design soil pressure:

$q_{lim} = q_u / \gamma_f = 0.07 \text{ (MPa)}$

$\gamma_f = 2.00$

Stress in soil: $q_{ref} = 0.06 \text{ (MPa)}$

Safety factor: $q_{lim} / q_{ref} = 1.214 > 1$

Uplift

Uplift in ULS

Design combination

ULS :

1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+1.80WIND3

Load factors:

1.00 * Foundation weight

1.00 * Soil weight

Weight of foundation and soil over it: $Gr = 82.39 \text{ (kN)}$

Design load:

$N_r = 98.34 \text{ (kN)}$

$M_x = -0.00 \text{ (kN*m)}$

$M_y = -54.31 \text{ (kN*m)}$

Contact area

$s = 83.74 \text{ (%)}$

$s_{lim} = 10.00 \text{ (%)}$

Uplift in SLS

Design combination:

SLS :

1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+0.771111111+0.772+1.00WIND6

Load factors:

1.00 * Foundation weight

1.00 * Soil weight

Weight of foundation and soil over it: $Gr = 82.39 \text{ (kN)}$

Design load:

$N_r = 114.54 \text{ (kN)}$

$M_x = -0.00 \text{ (kN*m)}$

$M_y = 39.69 \text{ (kN*m)}$

Contact area

$s = 100.00 \text{ (%)}$

$s_{lim} = 100.00 \text{ (%)}$

Sliding

Design combination

ULS :

1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+1.80WIND3

Load factors:

1.00 * Foundation weight

1.00 * Soil weight

Weight of foundation and soil over it: $Gr = 82.39 \text{ (kN)}$

Design load:

$N_r = 98.34 \text{ (kN)}$

$M_x = -0.00 \text{ (kN*m)}$

$M_y = -52.13 \text{ (kN*m)}$

Equivalent foundation dimensions: $A_{\perp} = 2.30 \text{ (m)}$ $B_{\perp} = 1.40 \text{ (m)}$

Sliding area:

$2.60 \text{ (m}^2\text{)}$

Cohesion:

$C = 0.02 \text{ (MPa)}$

Foundation/soil friction coefficient: $f = 0.58$

Sliding force value

$F = 21.77 \text{ (kN)}$

Value of force preventing foundation sliding:

- On the foundation level: $F(stab) = 101.25 \text{ (kN)}$

Stability for sliding: 4.651 > 1

Rotation

About OX axis

Design combination **ULS :**
1.00DL1+1.001+1.0011+1.00111+1.001111+1.0011111+1.00111111+1.80WIND1
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
Weight of foundation and soil over it: Gr = 82.39 (kN)
Design load:
Nr = 86.78 (kN) Mx = -0.66 (kN*m) My = 16.86 (kN*m)
Stability moment: Mstab = 81.90 (kN*m)
Rotation moment: Mrenv = 0.68 (kN*m)
Stability for rotation: 119.8 > 1

About OY axis

Design combination: **ULS :**
1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.00111111+1.002+1.80WIND6
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
Weight of foundation and soil over it: Gr = 82.39 (kN)
Design load:
Nr = 138.96 (kN) Mx = 0.00 (kN*m) My = 72.43 (kN*m)
Stability moment: Mstab = 193.20 (kN*m)
Rotation moment: Mrenv = 74.87 (kN*m)
Stability for rotation: 2.581 > 1

Foundation stability analysis

Stress calculations

Design combination **ULS :**
1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.50111111+1.502+1.20WIND6
Load factors: **1.35** * Foundation weight
1.35 * Soil weight
Weight of foundation and soil over it: Gr = 97.98 (kN)
Design load:
Nr = 155.36 (kN) Mx = 0.00 (kN*m) My = 65.43 (kN*m)
Stress in soil: 0.10 (MPa)
Safety factor: 131.4 > 1

1.3 RC design

1.3.1 Assumptions

- Cracking : limited
- Exposure : mild
- Include element sensitivity condition for fragile failure : yes

1.3.2 Analysis of punching and shear

Shear

Design combination	ULS :	
1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.00111111+1.002+1.80WIND6		
Load factors:	1.00 * Foundation weight 1.00 * Soil weight	
Design load:		
Nr = 129.15 (kN)	Mx = 0.00 (kN*m)	My = 72.43 (kN*m)
Length of critical circumference:	1.40 (m)	
Shear force:	36.93 (kN)	
Section effective height	heff = 0.44 (m)	
Shear area:	A = 0.62 (m ²)	
Shear stress:	0.06 (MPa)	
Admissible shear stress:	1.17 (MPa)	
Safety factor:	19.46 > 1	

1.3.3 Required reinforcement

Spread footing:

bottom:

ULS :		
1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.00111111+1.002+1.80WIND6		
My = 36.60 (kN*m)	Asx = 4.84 (cm ² /m)	

ULS :		
1.35DL1+1.351+1.3511+1.35111+1.351111+1.3511111+1.50111111+1.501111111+1.502+1.20WIND5		
Mx = 5.22 (kN*m)	Asy = 4.84 (cm ² /m)	

$$A_{s \min} = 4.40 \text{ (cm}^2\text{/m)}$$

top:

$$A'_{sx} = 0.00 \text{ (cm}^2\text{/m)}$$

$$A'_{sy} = 0.00 \text{ (cm}^2\text{/m)}$$

$$A_{s \min} = 0.00 \text{ (cm}^2\text{/m)}$$

$$\text{Maximum code-specified spacing} \quad e_{\max} = 0.25 \text{ (m)}$$

Column pier:

Longitudinal reinforcement	A	= 10.00 (cm ²)	A _{min.}	= 10.00 (cm ²)
	A	= 2 * (Asx + Asy)		
	Asx	= 4.63 (cm ²)	Asy	= 0.37 (cm ²)

Splice reinforcement (foundation to lean concrete): A = 2.91 (cm²)

1.3.4 Provided reinforcement

2.3.1 Spread footing:

Bottom:

Along X axis:

9 HA 400 10 $l = 2.20 \text{ (m)}$ $e = 1 \cdot -0.59 + 8 \cdot 0.15$
 Along Y axis:
 15 HA 400 10 $l = 1.30 \text{ (m)}$ $e = 1 \cdot -1.05 + 14 \cdot 0.15$
Top:

2.3.2 Pier Longitudinal reinforcement

Along Y axis:
 12 HA 400 12 $l = 1.08 \text{ (m)}$ $e = 1 \cdot -0.25 + 5 \cdot 0.10$

Transversal reinforcement

6 HA 400 10 $l = 2.46 \text{ (m)}$ $e = 1 \cdot 0.18 + 3 \cdot 0.20 + 2 \cdot 0.09$

Splice reinforcement

12 HA 400 12 $l = 0.68 \text{ (m)}$ $e_x = 0.65$ $e_y = 1 \cdot -0.66 + 1 \cdot 0.66 + 1 \cdot 0.65$

2 Material survey:

- Concrete volume $= 1.80 \text{ (m}^3\text{)}$
- Lean concrete volume $= 0.40 \text{ (m}^3\text{)}$
- Formwork $= 4.95 \text{ (m}^2\text{)}$
- Steel HA 400
 - Total weight $= 52.06 \text{ (kG)}$
 - Density $= 28.85 \text{ (kG/m}^3\text{)}$
 - Average diameter $= 10.6 \text{ (mm)}$
 - Survey according to diameters:

Diameter	Length (m)	Weight (kG)
10	54.03	33.33
12	21.09	18.73