1 Level:

- Cracking : permissible
- Exposure : 1 - dry

.

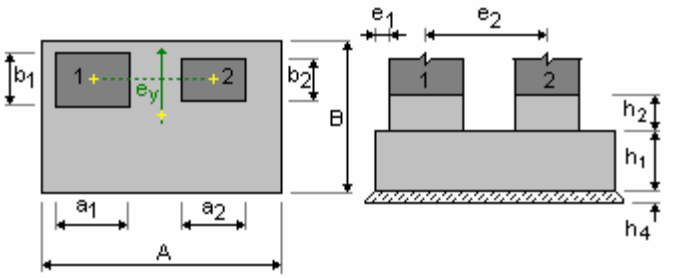
2 Spread footing: Foundation1 Number: 1

2.1 Material properties:

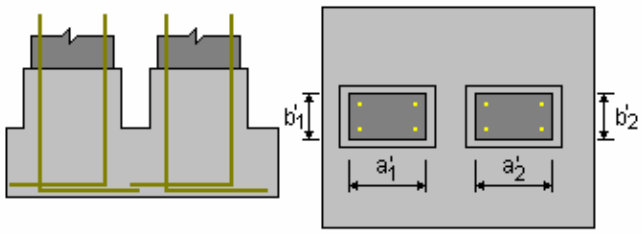
- Concrete : C20/25; Characteristic strength = 20.00 MPa
  Unit weight = 2501.36 (kG/m3)
- Longitudinal reinforcement : type A500HW Characteristic strength = 500.00 MPa
- Transversal reinforcement : type A500HW Characteristic strength = 500.00 MPa

.

2.2 Geometry:



A	= 2.60 (m)	a1	= 0.40 (m)	a2	= 0.40 (m)
B	= 0.70 (m)	b1	= 0.40 (m)	b2	= 0.40 (m)
h1	= 0.60 (m)	e_1	= 0.15 (m)		
h2	= 0.01 (m)	e_2	= 2.00 (m)	e_y	= 0.00 (m)
h4	= 0.05 (m)				



a1'	= 35.0 (cm)	a2'	= 35.0 (cm)
b1'	= 35.0 (cm)	b2'	= 35.0 (cm)

c = 5.0 (cm)

2.3 Calculation options:

- Geotechnic calculations according to : ENV 1997-1:1994
- Concrete calculations according to : ENV 1992-1-1:1991
- Include seismic dispositions
- Shape selection : without limits
- Conditions without drainage

.

Partial factors for soil properties:

	tan(ϕ)	c'	cu	qmax
Case B	1.00	1.00	1.00	1.00

2.4 Loads:

2.4.1 Foundation loads:

Case	Nature	Group	Pier	N (kN)	Fx (kN)	Fy (kN)	Mx (kN*m)	My (kN*m)
LC1-2	dead load	1	1	1.50	0.00	0.00	0.00	0.00
			2	1.20	0.00	0.00	0.00	0.00
LC4	snow	1	1	3.53	0.00	0.00	0.00	0.00
			2	3.41	0.00	0.00	0.00	0.00
LC3	wind	1	1	-7.20	0.00	0.00	0.00	0.00
			2	-0.82	-4.30	0.00	0.00	0.00
LC5	wind	1	1	5.97	0.00	0.00	0.00	0.00
			2	0.70	3.60	0.00	0.00	0.00

2.4.2 Backfill loads:

Case	Nature	Q1 (kN/m2)
DL1	dead load	2.00

2.4.3 Combination list

1/	ULS A : 1.00LC1-2+1.50LC3+1.50LC4
2/	ULS A : 1.00LC1-2+1.50LC3
3/	ULS A : 1.00LC1-2+1.50LC4
4/	ULS A : 1.00LC1-2
5/	ULS A : 0.95LC1-2+1.50LC3+1.50LC4
6/	ULS A : 0.95LC1-2+1.50LC3
7/	ULS A : 0.95LC1-2+1.50LC4
8/	ULS A : 0.95LC1-2
9/	ULS A : 1.00LC1-2+1.50LC5+1.50LC4
10/	ULS A : 1.00LC1-2+1.50LC5
11/	ULS A : 0.95LC1-2+1.50LC5+1.50LC4
12/	ULS A : 0.95LC1-2+1.50LC5
13/	ULS B : 1.35LC1-2+1.50LC3+1.50LC4
14/	ULS B : 1.35LC1-2+1.50LC3
15/	ULS B : 1.35LC1-2+1.50LC4
16/	ULS B : 1.35LC1-2
17/	ULS B : 1.00LC1-2+1.50LC3+1.50LC4
18/	ULS B : 1.00LC1-2+1.50LC3
19/	ULS B : 1.00LC1-2+1.50LC4
20/	ULS B : 1.00LC1-2
21/	ULS B : 1.35LC1-2+1.50LC5+1.50LC4
22/	ULS B : 1.35LC1-2+1.50LC5
23/	ULS B : 1.00LC1-2+1.50LC5+1.50LC4
24/	ULS B : 1.00LC1-2+1.50LC5
25/	ULS C : 1.00LC1-2+1.30LC3+1.30LC4
26/	ULS C : 1.00LC1-2+1.30LC3
27/	ULS C : 1.00LC1-2+1.30LC4
28/	ULS C : 1.00LC1-2
29/	ULS C : 1.00LC1-2+1.30LC5+1.30LC4
30/	ULS C : 1.00LC1-2+1.30LC5
31/	SLS : 1.00LC1-2
32/	SLS : 1.00LC1-2+1.00LC3
33/	SLS : 1.00LC1-2+1.00LC5
34/	SLS : 1.00LC1-2+1.00LC4
35/	SLS : 1.00LC1-2+1.00LC3+1.00LC4
36/	SLS : 1.00LC1-2+1.00LC5+1.00LC4
37/*	ULS : 1.35LC1-2+1.50LC3+0.75LC4
38/*	ULS : 1.35LC1-2+1.50LC3
39/*	ULS : 1.35LC1-2
40/*	ULS : 1.00LC1-2+1.50LC3+0.75LC4
41/*	ULS : 1.00LC1-2+1.50LC3
42/*	ULS : 1.00LC1-2

43/* ULS : 1.35LC1-2+1.50LC5+0.75LC4
44/* ULS : 1.35LC1-2+1.50LC5
45/* ULS : 1.00LC1-2+1.50LC5+0.75LC4
46/* ULS : 1.00LC1-2+1.50LC5
47/* ULS : 1.35LC1-2+0.90LC3+1.50LC4
48/* ULS : 1.35LC1-2+1.50LC4
49/* ULS : 1.00LC1-2+0.90LC3+1.50LC4
50/* ULS : 1.00LC1-2+1.50LC4
51/* ULS : 1.35LC1-2+0.90LC5+1.50LC4
52/* ULS : 1.00LC1-2+0.90LC5+1.50LC4
53/* SLS : 1.00LC1-2+1.00LC3+0.50LC4
54/* SLS : 1.00LC1-2+1.00LC3
55/* SLS : 1.00LC1-2
56/* SLS : 1.00LC1-2+1.00LC5+0.50LC4
57/* SLS : 1.00LC1-2+1.00LC5
58/* SLS : 1.00LC1-2+0.60LC3+1.00LC4
59/* SLS : 1.00LC1-2+1.00LC4
60/* SLS : 1.00LC1-2+0.60LC5+1.00LC4
61/* SLS : 1.00LC1-2+0.20LC3
62/* SLS : 1.00LC1-2+0.20LC5
63/* SLS : 1.00LC1-2+0.20LC4

2.5 Soil:

Soil level:	N_1	= 0.00 (m)		
Column pier level:	N_a	= 0.00 (m)		
Minimum reference level:	N_f	= -0.60 (m)		
Water level:	$N_{max.}$	= -4.40 (m)	$N_{min.}$	= -4.10 (m)

C-Cs

- Soil level: 0.00 (m)
- Unit weight: 1900.00 (kG/m3)
- Unit weight of solid: 2700.00 (kG/m3)
- Internal friction angle: 0.0 (Deg)
- Cohesion: 0.12 (MPa)

2.6 Calculation results:

2.6.1 Required reinforcement

Spread footing:

bottom:

ULS : 1.00LC1-2+1.50LC3
My = 4.13 (kN*m) A_{sx} = 8.10 (cm2/m)

ULS : 1.35LC1-2+0.90LC5+1.50LC4
Mx = 0.31 (kN*m) A_{sy} = 8.10 (cm2/m)

$A_{s\,min}$ = 8.10 (cm2/m)

top:

ULS : 1.35LC1-2+1.50LC5+0.75LC4
My = -4.75 (kN*m) A'_{sx} = 8.10 (cm2/m)

ULS : 1.00LC1-2+1.50LC3
Mx = -0.16 (kN*m) A'_{sy} = 8.10 (cm2/m)

$A_{s\,min}$ = 8.10 (cm2/m)

Column pier: 1

Longitudinal reinforcement A = 4.80 (cm2) $A_{min.}$ = 4.80 (cm2)
A = 2 * (Asx1 + Asy1)
Asx1 = 1.20 (cm2) Asy1 = 1.20 (cm2)

Column pier: 2

Longitudinal reinforcement A = 4.80 (cm2) $A_{min.}$ = 4.80 (cm2)
A = 2 * (Asx2 + Asy2)
Asx2 = 2.40 (cm2) Asy2 = 0.00 (cm2)

2.6.2 Real reference level = -0.61 (m)

2.6.3 Stability analysis

Stress calculations

Soil type under foundation: not layered
Design combination **ULS B : 1.35LC1-2+1.50LC5+1.50LC4**
Load factors: **1.35** * Foundation weight
1.35 * Soil weight
1.00 * Archimedes pressure
1.35 * Backfill (dead)
1.50 * Backfill (live)
Calculation results: On the foundation level
Weight of foundation and soil over it: Gr = 40.70 (kN)
Design load:
Nr = 64.76 (kN) Mx = 0.00 (kN*m) My = -4.03 (kN*m)
Soil profile parameters:
C = 0.00 (MPa)
ϕ = 0.00
γ = 0.00 (kG/m3)
Stress in soil: 0.04 (MPa)
Design soil pressure 0.10 (MPa)
Safety factor: 2.334 > 1.4

Uplift

Uplift in ULS
Design combination **ULS B : 1.00LC1-2+1.50LC3**
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
1.35 * Archimedes pressure
1.00 * Backfill (dead)
0.00 * Backfill (live)
Contact area: s = 0.09
s_{lim} = 0.33

Sliding

Design combination **ULS B : 1.00LC1-2+1.50LC3**
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
1.35 * Archimedes pressure
1.00 * Backfill (dead)
0.00 * Backfill (live)
Weight of foundation and soil over it: Gr = 30.14 (kN)
Design load:

Nr = 20.81 (kN) Mx = 0.00 (kN*m) My = 4.84 (kN*m)
Equivalent foundation dimensions: A_ = 2.60 (m) B_ = 0.70 (m)
Sliding area: 1.82 (m2)
Foundation/soil friction coefficient: tg(ϕ) = 0.00
Cohesion: C = 0.12 (MPa)
Soil pressure considered:
Hx = -6.45 (kN) Hy = 0.00 (kN)
Ppx = 3.27 (kN) Ppy = 0.00 (kN)
Pax = -3.27 (kN) Pay = 0.00 (kN)
Sliding force value F = 6.45 (kN)
Value of force preventing foundation sliding:
- On the foundation level: F(stab) = 8.33 (kN)
Stabilility for sliding: 1.291 > 1.1

Average settlement

Soil type under foundation: not layered
Design combination **SLS : 1.00LC1-2+1.00LC5+1.00LC4**
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
1.00 * Archimedes pressure
1.00 * Backfill (dead)
1.00 * Backfill (live)
Weight of foundation and soil over it: Gr = 30.14 (kN)
Average stress caused by design load: q = 0.03 (MPa)
Thickness of the actively settling soil: z = 1.05 (m)
Stress on the level z:
- Additional: σzd = 0.01 (MPa)
- Caused by soil weight: $\sigma z\gamma$ = 0.03 (MPa)
Settlement:
- Original s' = 0.1 (cm)
- Secondary s'' = 0.0 (cm)
- TOTAL S = 0.1 (cm) < Sadm = 5.1 (cm)
Safety factor: 72.38 > 1

Settlement difference

Design combination **SLS : 1.00LC1-2+1.00LC3+1.00LC4**
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
1.00 * Archimedes pressure
1.00 * Backfill (dead)
1.00 * Backfill (live)
Settlement difference: S = 0.0 (cm) < Sadm = 5.1 (cm)
Safety factor: 103.5 > 1

Shear

Design combination **ULS : 1.35LC1-2+1.50LC5+0.75LC4**
Load factors: **1.35** * Foundation weight
1.35 * Soil weight
1.00 * Archimedes pressure
1.35 * Backfill (dead)
1.00 * Backfill (live)
Design load:
Nr = 59.55 (kN) Mx = 0.00 (kN*m) My = -4.21 (kN*m)

Length of critical circumference: 0.70 (m)
Shear force: 3.28 (kN)
Section effective height h_{eff} = 0.54 (m)
Shear area: A = 0.38 (m2)
Reinforcement ratio: ρ = 0.15 %
Shear stress: 0.01 (MPa)
Admissible shear stress: 0.34 (MPa)
Safety factor: 39.65 > 1

Rotation

About OX axis
Design combination **ULS B : 1.00LC1-2+1.50LC3**
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
1.35 * Archimedes pressure
1.00 * Backfill (dead)
0.00 * Backfill (live)
Weight of foundation and soil over it: Gr = 30.14 (kN)
Design load:
Nr = 20.81 (kN) Mx = 0.00 (kN*m) My = 4.84 (kN*m)
Stability moment: M_{stab} = 10.55 (kN*m)
Rotation moment: M_{renv} = 3.27 (kN*m)
Stability for rotation: 3.231 > 1

About OY axis
Design combination: **ULS B : 1.00LC1-2+1.50LC3**
Load factors: **1.00** * Foundation weight
1.00 * Soil weight
1.35 * Archimedes pressure
1.00 * Backfill (dead)
0.00 * Backfill (live)
Weight of foundation and soil over it: Gr = 30.14 (kN)
Design load:
Nr = 20.81 (kN) Mx = 0.00 (kN*m) My = 4.84 (kN*m)
Stability moment: M_{stab} = 43.16 (kN*m)
Rotation moment: M_{renv} = 20.93 (kN*m)
Stability for rotation: 2.062 > 1