Spread footing verification

Input data

Project

Date : 28.10.2015

Settings

(input for current task)

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard

Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : based on structural strength

Spread Footing

Analysis for drained conditions : Standard approach
Analysis of uplift : Standard
Allowable eccentricity : 0,333
Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor for vertical bearing capacity :	SF_v =	1,50	[–]
Safety factor for sliding resistance :	SF_h =	1,50	[–]

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]	γ_{su} [kN/m^3]	δ [°]
1	Soil No. 1		31,50	0,00	17,50	7,50	0,00
2	Soil No. 2		45,00	100,00	22,00	12,00	0,00

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	ν [–]	OCR [–]	K_r [–]
1	Soil No. 1		cohesive	-	0,30	-	-
2	Soil No. 2		cohesive	-	0,20	-	-

Soil parameters

Soil No. 1

Unit weight : γ = 17,50 kN/m^3
Angle of internal friction : φ_{ef} = 31,50 °
Cohesion of soil : c_{ef} = 0,00 kPa
Deformation modulus : E_{def} = 21,00 MPa
Poisson's ratio : ν = 0,30
Coeff. of structural strength : m = 0,30
Saturated unit weight : γ_{sat} = 17,50 kN/m^3

Soil No. 2

Unit weight : γ = 22,00 kN/m^3

Angle of internal friction :	φ_{ef}	=	45,00 °
Cohesion of soil :	c_{ef}	=	100,00 kPa
Deformation modulus :	E_{def}	=	1000,00 MPa
Poisson's ratio :	ν	=	0,20
Coeff. of structural strength :	m	=	0,30
Saturated unit weight :	γ_{sat}	=	22,00 kN/m^3

Foundation

Foundation type: centric spread footing

Depth from original ground surface	h_z	=	2,00 m
Depth of footing bottom	d	=	1,20 m
Foundation thickness	t	=	0,40 m
Incl. of finished grade	s_1	=	0,00 °
Incl. of footing bottom	s_2	=	0,00 °

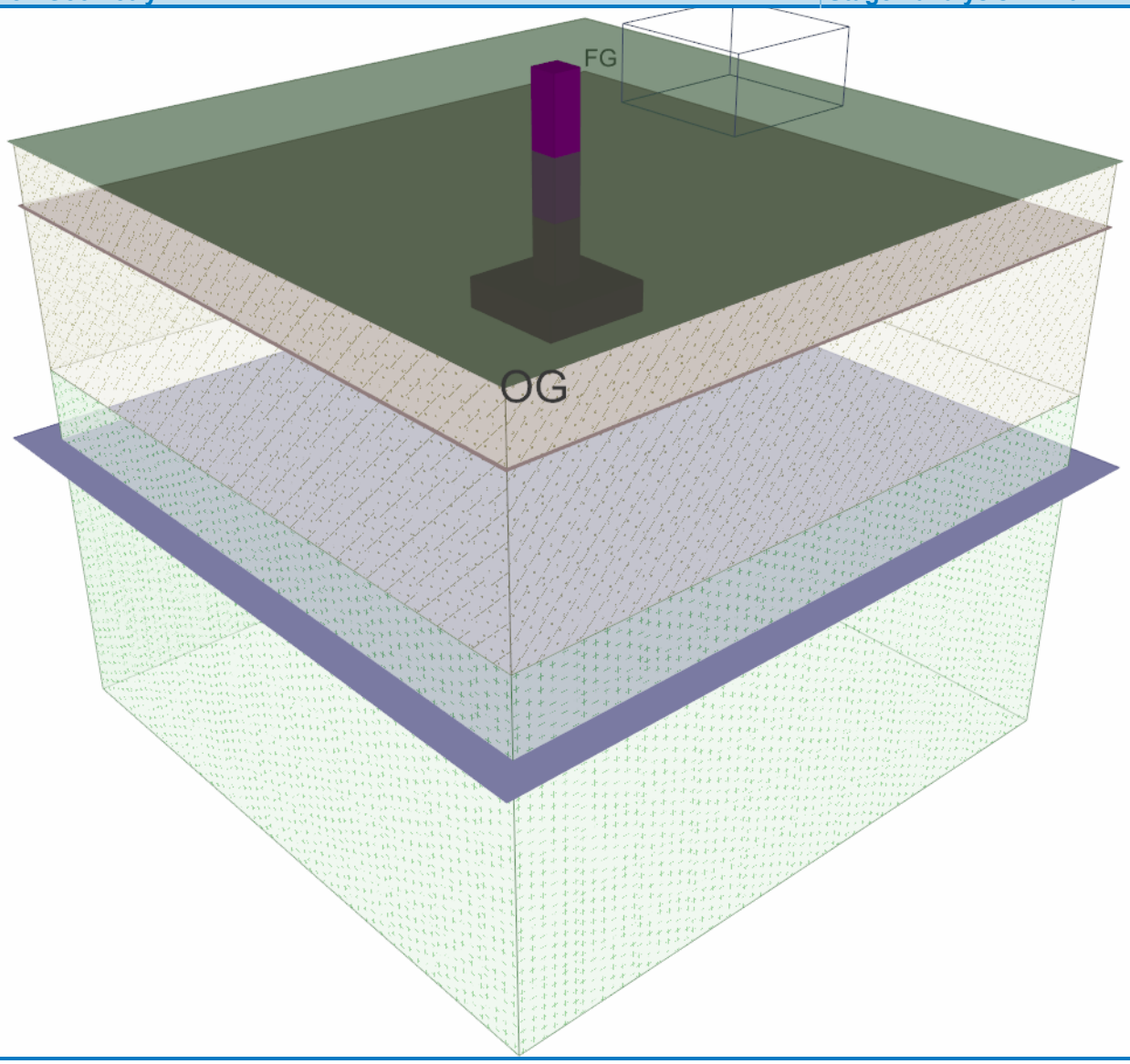
Unit weight of soil above foundation = 20,00 kN/m^3

Geometry of structure

Foundation type: centric spread footing

Spread footing length	x	=	1,50 m
Spread footing width	y	=	1,50 m
Column width in the direction of x	c_x	=	0,40 m
Column width in the direction of y	c_y	=	0,40 m
Spread footing volume		=	0,90 m^3

Name : Geometry | **Stage - analysis : 1 - 0**



Material of structure

Unit weight γ = 23,00 kN/m^3
Analysis of concrete structures carried out according to the standard EN 1992-1-1 (EC2).

Concrete : C 20/25

Cylinder compressive strength	f_{ck}	= 20,00	MPa
Tensile strength	f_{ctm}	= 2,20	MPa
Elasticity modulus	E_{cm}	= 30000,00	MPa

Longitudinal steel : B500

Yield strength	f_{yk}	= 500,00	MPa

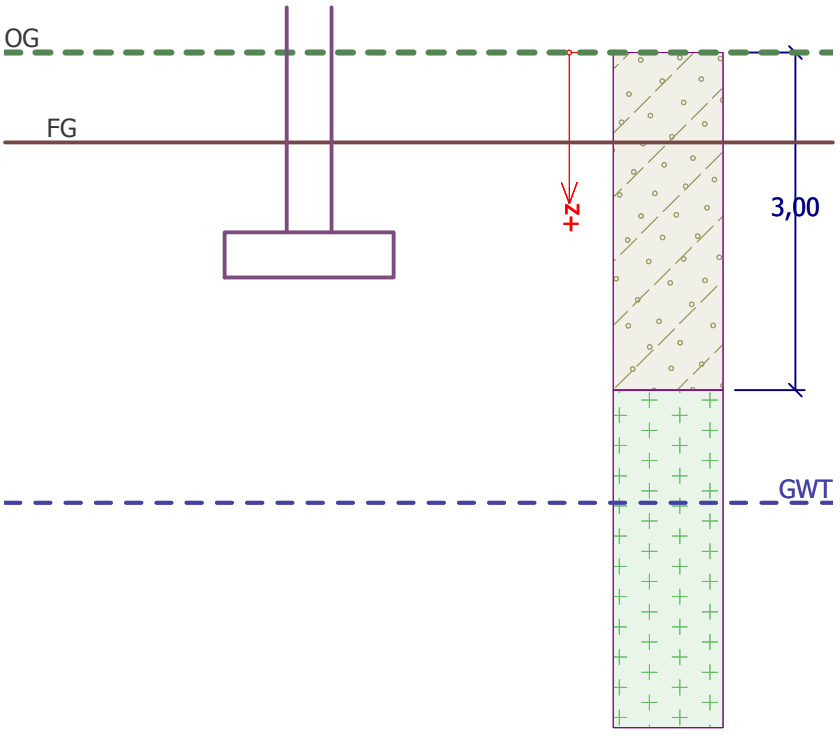
Transverse steel: B500

Yield strength	f_{yk}	= 500,00	MPa

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	3,00	Soil No. 1	
2	-	Soil No. 2	

Name : Profile and assignment | **Stage - analysis : 1 - 0**



Load

No.	Load new	Load change	Name	Type	N [kN]	M_x [kNm]	M_y [kNm]	H_x [kN]	H_y [kN]
1	Yes		Load No. 1	Design	910,00	-2,00	70,00	14,00	5,00
2	Yes		Load No. 2	Design	820,00	0,00	-100,00	0,00	0,00
3	Yes		Load No. 3	Service	700,00	0,00	0,00	100,00	0,00
4	Yes		Load No. 4	Service	700,00	100,00	0,00	0,00	0,00

Surface surcharges in the vicinity of footing

No.	Surcharge new	Surcharge change	Name	x_s [m]	y_s [m]	x [m]	y [m]	q [kPa]	α [°]	h [m]
1	Yes		Surcharge No. 1	3,00	0,00	2,00	2,00	15,00	0,00	0,00

Ground water table

The ground water table is at a depth of 4,00 m from the original terrain.

Global settings

Type of analysis : analysis for drained conditions

Settings of the stage of construction

Design situation : permanent

Verification No. 1

Load case verification

Name	e_x [m]	e_y [m]	σ [kPa]	R_d [kPa]	Utilization [%]	Is satisfied
Load No. 1	-0,07	0,00	470,40	11233,98	6,28	Yes
Load No. 2	0,11	0,00	458,43	11423,46	6,02	Yes

Analysis carried out with automatic selection of the most unfavourable load cases.

Computed weight of spread footing $G = 20,70$ kN
Computed weight of overburden $Z = 33,44$ kN

Vertical bearing capacity check

Shape of contact stress : rectangle
Most severe load case No. 1. (Load No. 1)

Parameters of slip surface below foundation:
Depth of slip surface $z_{sp} = 2,85$ m
Length of slip surface $l_{sp} = 9,39$ m

Design bearing capacity of found.soil $R_d = 11233,98$ kPa
Extreme contact stress $\sigma = 470,40$ kPa

Factor of safety = 23,88 > 1,50
Bearing capacity in the vertical direction is SATISFACTORY

Verification of load eccentricity

Max. eccentricity in direction of base length $e_x = 0,076<0,333$
Max. eccentricity in direction of base width $e_y = 0,000<0,333$
Max. overall eccentricity $e_t = 0,076<0,333$

Eccentricity of load is SATISFACTORY

Horizontal bearing capacity check

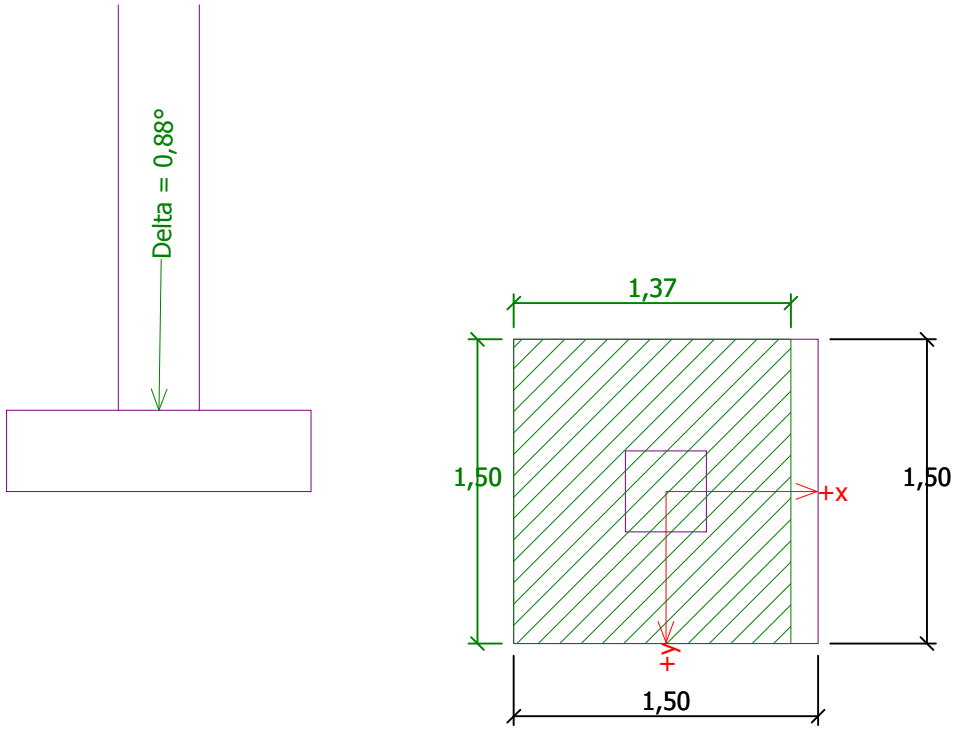
Most severe load case No. 1. (Load No. 1)
Earth resistance: at rest
Design magnitude of earth resistance $S_{pd} = 5,01$ kN

Horizontal bearing capacity $R_{dh} = 595,84$ kN
Extreme horizontal force $H = 14,87$ kN

Factor of safety = 40,08 > 1,50
Bearing capacity in the horizontal direction is SATISFACTORY

Bearing capacity of foundation is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - 1**



Verification No. 2

Load case verification

Name	e_x [m]	e_y [m]	σ [kPa]	R_d [kPa]	Utilization [%]	Is satisfied
Load No. 1	-0,07	0,00	470,40	11233,98	6,28	Yes

Analysis carried out for the load case No. 1. (Load No. 1)

Computed weight of spread footing G = 20,70 kN
Computed weight of overburden Z = 33,44 kN

Vertical bearing capacity check

Shape of contact stress : rectangle

Parameters of slip surface below foundation:
Depth of slip surface z_{sp} = 2,85 m
Length of slip surface l_{sp} = 9,39 m

Design bearing capacity of found.soil R_d = 11233,98 kPa
Extreme contact stress σ = 470,40 kPa

Factor of safety = 23,88 > 1,50
Bearing capacity in the vertical direction is SATISFACTORY

Verification of load eccentricity

Max. eccentricity in direction of base length e_x = 0,045<0,333
Max. eccentricity in direction of base width e_y = 0,000<0,333
Max. overall eccentricity e_t = 0,045<0,333

Eccentricity of load is SATISFACTORY

Horizontal bearing capacity check

Earth resistance: at rest
Design magnitude of earth resistance S_{pd} = 5,01 kN

Horizontal bearing capacity R_{dh} = 595,84 kN
Extreme horizontal force H = 14,87 kN

Factor of safety = 40,08 > 1,50
Bearing capacity in the horizontal direction is SATISFACTORY

Bearing capacity of foundation is SATISFACTORY

Verification No. 1

Settlement and rotation of foundation - input data

Analysis carried out with automatic selection of the most unfavourable load cases.
Analysis carried out with accounting for coefficient κ_1 (influence of foundation depth).
Stress at the footing bottom considered from the finished grade.

Computed weight of spread footing G = 20,70 kN
Computed weight of overburden Z = 33,44 kN

Settlement of mid point of edge x - 1 = 5,5 mm
Settlement of mid point of edge x - 2 = 2,5 mm
Settlement of mid point of edge y - 1 = 4,0 mm
Settlement of mid point of edge y - 2 = 4,0 mm
Settlement of foundation center point = 7,5 mm
Settlement of characteristic point = 5,1 mm

(1-max.compressed edge; 2-min.compressed edge)

Settlement and rotation of foundation - results

Foundation stiffness:
Computed weighted average modulus of deformation E_{def} = 336,54 MPa
Foundation in the longitudinal direction is rigid (k=1,69)
Foundation in the direction of width is rigid (k=1,69)

Verification of load eccentricity

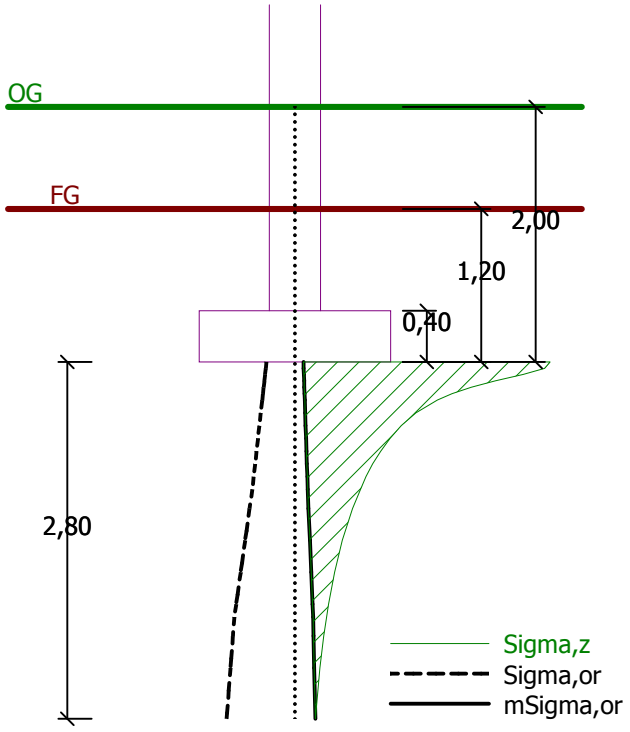
Max. eccentricity in direction of base length e_x = 0,035<0,333
Max. eccentricity in direction of base width e_y = 0,088<0,333
Max. overall eccentricity e_t = 0,088<0,333

Eccentricity of load is SATISFACTORY

Overall settlement and rotation of foundation:
Foundation settlement = 5,1 mm
Depth of influence zone = 2,80 m

Rotation in direction of x = 0,799 (tan*1000); (3,9E-02 °)
Rotation in direction of y = 1,998 (tan*1000); (6,3E-02 °)

Name : Settlement	Stage - analysis : 1 - 1



Dimensioning No. 1

Analysis carried out with automatic selection of the most unfavourable load cases.

Verification of longitudinal reinforcement of foundation in the direction of x

Bar diameter		=	22,0	mm					
Number of bars		=	10						
Reinforcement cover		=	35,0	mm					
Cross-section width		=	1,50	m					
Cross-section depth		=	0,40	m					
Reinforcement ratio	ρ	=	0,72	%	>	0,13	%	=	ρ_{min}
Position of neutral axis	x	=	0,10	m	<	0,22	m	=	x_{max}
Ultimate moment	M_{Rd}	=	516,78	kNm	>	115,81	kNm	=	M_{Ed}

Cross-section is SATISFACTORY.

Verification of longitudinal reinforcement of foundation in the direction of y

Bar diameter		=	22,0	mm					
Number of bars		=	8						
Reinforcement cover		=	35,0	mm					
Cross-section width		=	1,50	m					
Cross-section depth		=	0,40	m					
Reinforcement ratio	ρ	=	0,57	%	>	0,13	%	=	ρ_{min}
Position of neutral axis	x	=	0,08	m	<	0,22	m	=	x_{max}
Ultimate moment	M_{Rd}	=	424,35	kNm	>	103,59	kNm	=	M_{Ed}

Cross-section is SATISFACTORY.

Spread footing for punching shear failure check

Column normal force = 820,00 kN

Maximum resistance at the column perimeter

Force transmitted into found. soil		=	58,31	kN
Force transmitted by shear strength of SRC		=	761,69	kN
Considered column perimeter	u_0	=	1,60	m
Shear resistance at the column perimeter	$v_{Ed,max}$	=	2,05	MPa
Resistance at the column perimeter	$v_{Rd,max}$	=	2,94	MPa

Critical section without shear reinforcement

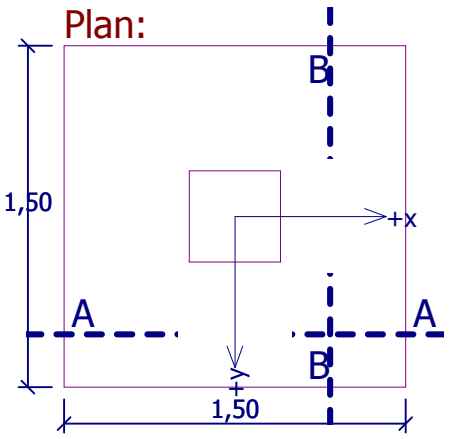
Force transmitted into found. soil		=	293,80	kN
Force transmitted by shear strength of SRC		=	526,20	kN
Distance of section from the column		=	0,27	m
Section perimeter	u	=	3,27	m
Shear stress at section	v_{Ed}	=	0,61	MPa
Shear resistance of section without shear reinforcement	$v_{Rd,c}$	=	1,31	MPa

$v_{Ed} < v_{Rd,c}$ => Reinforcement is not required

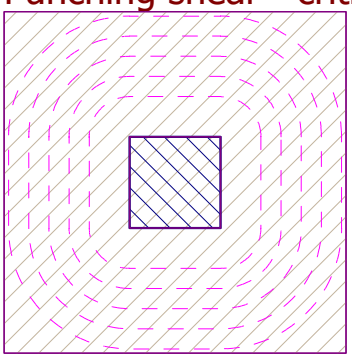
Spread footing for punching shear is SATISFACTORY

Name : Dimensioning | **Stage - analysis : 1 - 1**

Plan:



Punching shear - critical section:

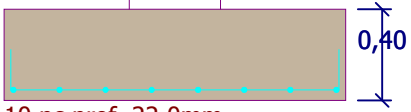


Loading area
transmitted by RC through shear
area: 1,60E-01m²

critical section
length: 1,60m

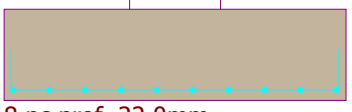
checked sections

Section A-A:



10 pc prof. 22,0mm
length 1430mm, concrete cover 35mm

Section B-B:



8 pc prof. 22,0mm
length 1430mm, concrete cover 35mm