

## Designing the geometry of a spread footing

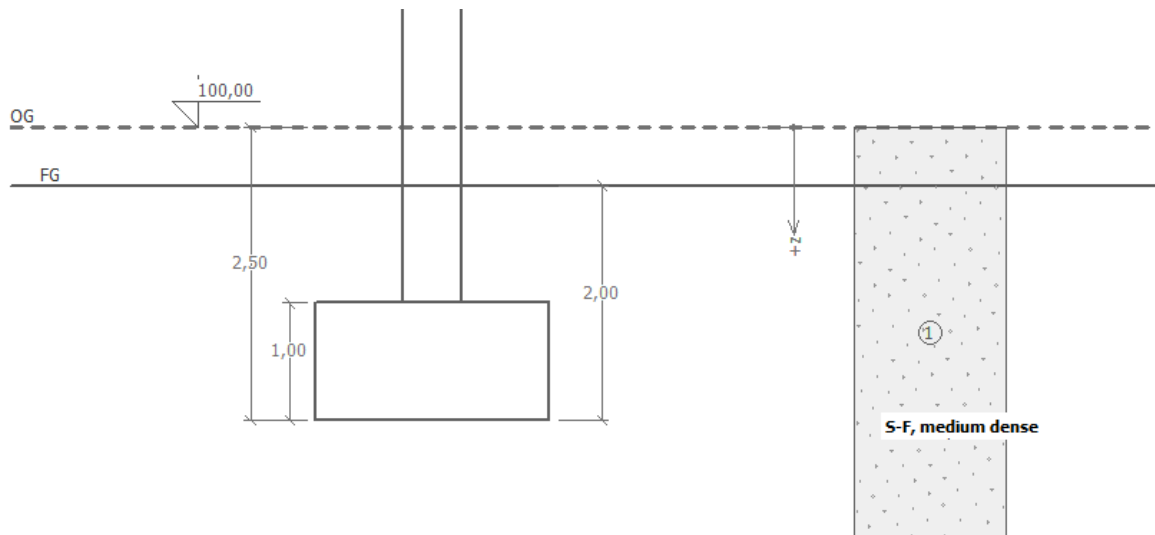
Program: Spread footing

File: Demo\_manual\_09.gpa

In this engineering manual, we are going to show you how to design spread footing easily and effectively.

### Assignment

Using the EN 1997-1 (EC 7-1, DA1) standard, design the dimensions of a concentric spread footing. Forces from the columns act on the top of the foundation. The input forces are:  $N, H_x, H_y, M_x, M_y$ . The terrain behind the structure is horizontal; the foundation soil consists of S-F – Sand with trace of fines, medium dense soil. The footing bottom is located at a depth of 2,5 m below the terrain.



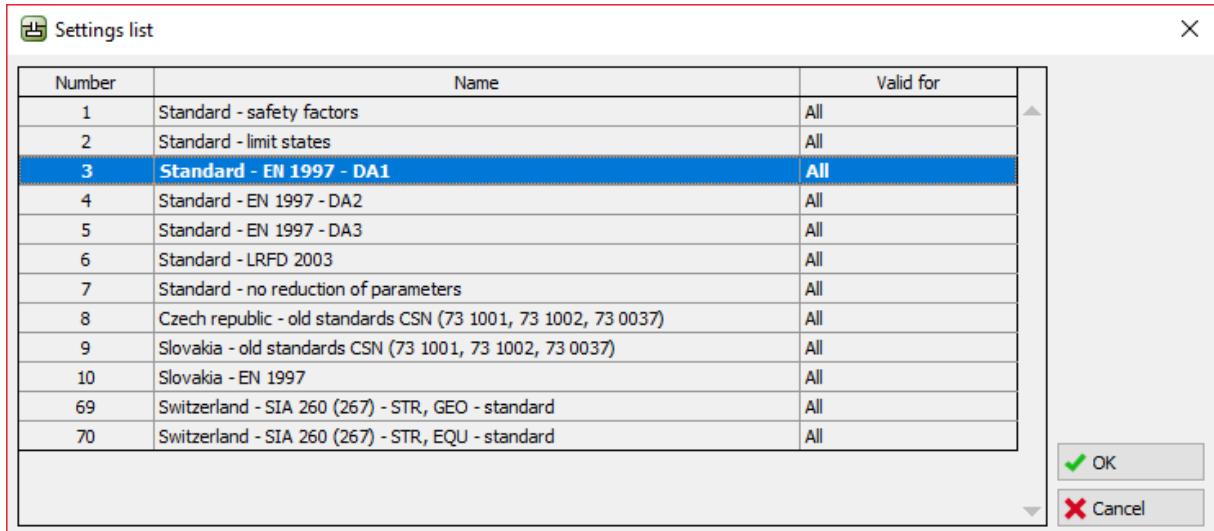
*Scheme of the assignment – analysis of the bearing capacity of a spread footing*

### Solution

To solve this problem, we will use the GEO5 Spread footing program. In the following text, we will explain each step in solving this example. Firstly, we will input all data and then design the spread footing itself in the frame “Geometry”.

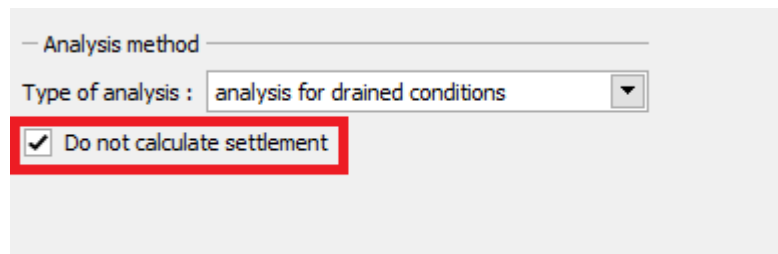
## Basic input

Firstly, go to the frame “Settings”. Click on “Select settings” and then choose No. 3 – “Standard – EN 1997 – DA1”.



Frame “Settings list”

Also, select an analysis method in the bottom right corner – in this case select “Analysis for drained conditions”. **We will not analyze the settlement** (that will be a part of the next engineering manual no. 10).



Frame “Settings”

*Note: Usually, spread footings are analyzed for drained conditions using the effective parameters of the soil ( $\varphi_{ef}, c_{ef}$ ). An analysis for undrained conditions is performed for cohesive soils and short-term performance using the total parameters of the soil ( $\varphi_u, c_u$ ). According to EN 1997 the total friction considered is always  $\varphi_u = 0$ .*

In the next step we will enter the soil parameters and assign them to the profile. First go to the frame “Soils” and click on “Add”. Add one new soil with the following parameters. Then assign it to the profile in the frame “Assign”.

Table with the parameters of soils

Soil, rock (classification)	Unit weight $\gamma$ [kN/m <sup>3</sup> ]	Angle of internal friction $\varphi_{ef}$ [°]	Cohesion of soil $c_{ef}$ [kPa]	Saturated unit weight $\gamma_{sat}$ [kN/m <sup>3</sup> ]
S-F – Sand with trace of fines, medium dense soil	17,5	29,5	0,0	18

**Add new soils**
✕

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**Identification**

Name :

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**Basic data** ?

Unit weight :  $\gamma =$   [kN/m<sup>3</sup>]

Angle of internal friction :  $\varphi_{ef} =$   [°]

Cohesion of soil :  $c_{ef} =$   [kPa]

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**Uplift pressure** ?


Calc. mode of uplift :

Saturated unit weight :  $\gamma_{sat} =$   [kN/m<sup>3</sup>]

**Draw**

Color

Pattern category

Pattern  
  
Sand

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**Classification**

Frame “Soils” – adding a new soil

In the next step, open the frame “Foundation”. Choose “Centric spread footing” as the type of the foundation and fill in all the dimensions such as the depth from the orig. ground surface (2.5m), the depth of the footing bottom (2.0m), the thickness of the foundation (1.0m) and the inclination of the finished grade as shown in the figure below. Also, input the unit weight of the overburden (20kN/m<sup>3</sup>), which is the backfill of the spread footing after construction.

### Frame “Foundation”

*Note: The depth of the footing bottom depends on many different factors such as the natural and climatic factors, hydrogeology of the construction site and geological conditions. In the Czech Republic the depth of the footing bottom is recommended to be at least 0,8 meters below the surface due to freezing. For clays the depth should be greater, such as 1,6 meters. When analyzing the bearing capacity of a foundation, the depth of the foundation is considered as the minimal vertical distance between the footing bottom and the finished grade.*

In the frame “Load”, enter the forces and the moments acting on the upper part of the foundation:  $N, H_x, H_y, M_x, M_y$ . We obtained these values from a structural analysis program and we can import them to our analysis using the “Import” button (you can find more information about importing table data on our website: <http://www.finesoftware.eu/help/geo5/en/table-data-import-01/>). The file to import (import\_load\_spread\_footing.txt) is a part of the GEO5 installation and it is located in the “FINE” folder in public documents.

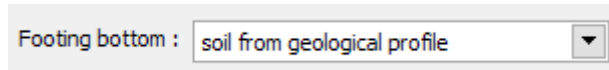
No.	Load		Load name	N [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	H <sub>x</sub> [kN]	H <sub>y</sub> [kN]	Design
	new	change							
1	Yes		Load	2500,00	150,00	200,00	100,00	75,00	✓
2	Yes		Load	1755,00	92,00	114,00	57,00	43,00	✓
3	Yes		Load	2170,00	110,00	165,00	85,00	60,00	✓
4	Yes		Load	1523,00	77,00	116,00	59,00	42,00	✓
5	Yes		Load	1850,00	105,00	120,00	65,00	30,00	✓
6	Yes		Load	1295,00	74,00	86,00	32,00	13,00	✓
7	Yes		Load	1920,00	135,00	160,00	95,00	70,00	✓
8	Yes		Load	1637,00	96,00	108,00	64,00	23,00	✓

### Frame “Load” - import

*Note: To design the dimensions of the spread footing, generally the design load is the deciding load. However, in this case we are using the analysis settings EN 1997-1 - DA1, and you must enter the value of the service load too, because the analysis requires two design combinations.*

We skip the frame “Geometry” now, because the automatic design of dimensions will be performed in this frame. For this reason, we must define all the other parameters first.

We leave the standard “soil from geological profile” option on in the frame “Footing bottom”.

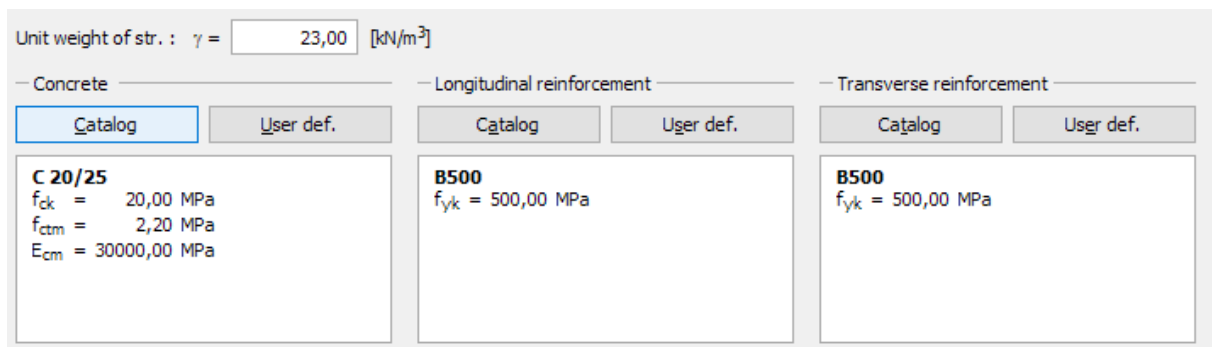


### Frame “Footing bottom”

We are not going to enter a sand gravel bed in the frame “SG bed”, because we are considering a permeable cohesionless soil at the footing bottom.

*Note: Sand gravel beds are not used as often anymore because there have been many cases in areas with cohesive soil when the footing bottom became significantly drenched due to the influence of groundwater. This is due to the fact that without draining, the sand gravel bed itself functions as a drain.*

In the frame “Material”, input the material characteristics of the foundation.

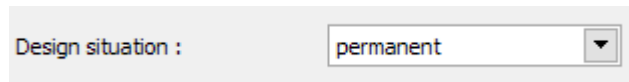


### Frame “Material”

Skip the frame “Surcharge”, as there is no surcharge near the foundation.

*Note: Surcharge around the foundation influences the analysis of the settlement and the rotation of the foundation but not the bearing capacity. In the case of a vertical bearing capacity, it always acts favorably and no theoretical knowledge leads us to analyze this influence.*

Then open the frame “Stage settings” and select “permanent” as the design situation.

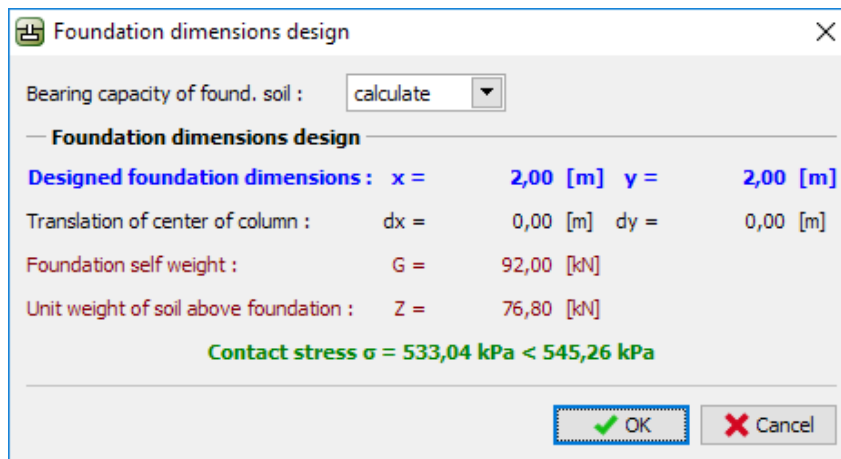


Frame “Stage settings”

## Design of the spread footing dimensions

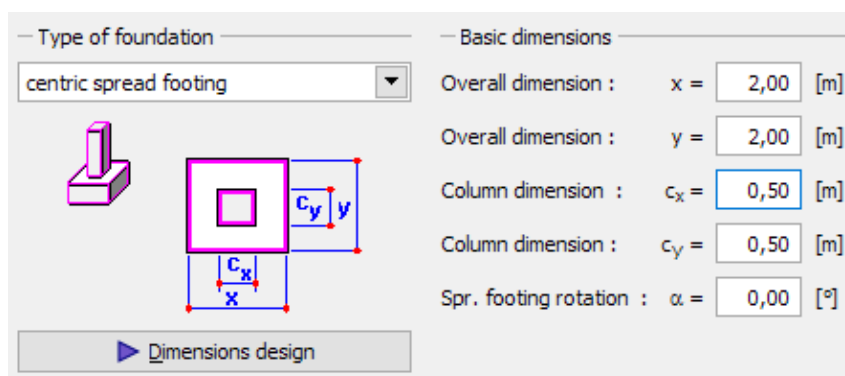
Now, open the frame “Geometry” and apply the function “Dimensions design” with which the program determines the minimum required dimensions of the foundation. These dimensions can be edited later.

In the dialog window it is possible to input the bearing capacity of the foundation soil  $R_d$  or select “Calculate”. We will select “Calculate” for now. The program automatically analyzes the foundation weight and the weight of soil below the foundation and determines the minimum dimensions of the foundation.



Dialog window “Foundation dimensions design”

We accept the design using the “OK” button and all the dimensions are transferred to the input fields in the bottom left part of the frame. We will define both column dimensions as 0,5 m.



Frame “Geometry”

Note: The design of centric and eccentric spread footing is always performed in a way that the dimensions of the foundation are as small as possible and still maintain an adequate vertical bearing capacity. The option “Input” designs the dimensions of a spread footing based on the entered bearing capacity of the foundation soil.

Note: In the case of a nondemanding construction (constructions in simple foundations) we can input the tabulated bearing capacity  $R_d$ . In other more complicated cases, the bearing capacity  $R_d$  is always calculated.

We will verify the design in the frame “Bearing cap.” In this verification, we will not consider Earth resistance.

**Verification of spread footing bearing capacity**

**Vertical bearing capacity check**  
 Shape of contact stress : rectangle  
 Most severe load case No. 2. (Load)

Design bearing capacity of found.soil  $R_d = 545,22$  kPa  
 Extreme contact stress  $\sigma = 532,59$  kPa  
 Bearing capacity in the vertical direction is **SATISFACTORY**

**Verification of load eccentricity**  
 Max. eccentricity in direction of base length  $e_x = 0,019 < 0,333$   
 Max. eccentricity in direction of base width  $e_y = 0,049 < 0,333$   
 Max. overall eccentricity  $e_t = 0,052 < 0,333$   
 Eccentricity of load is **SATISFACTORY**

**Horizontal bearing capacity check**  
 Most severe load case No. 7. (Load)

Horizontal bearing capacity  $R_{dh} = 1180,77$  kN  
 Extreme horizontal force  $H = 118,00$  kN  
 Bearing capacity in the horizontal direction is **SATISFACTORY**  
 Bearing capacity of foundation is **SATISFACTORY**

**Analysis:**

Find max. values automatically

Vertical bearing capacity:  Horizontal bearing capacity:

Shape of contact stress:  Earth resistance:

**Verification**

**VERT. BEARING CAPACITY: SATISFACTORY (97,7%)**  
**HOR. BEARING CAPACITY: SATISFACTORY (10,0%)**

### Frame “Bearing capacity”

- Vertical bearing capacity: 97,7 %       $R_d = 545.22 > \sigma = 532.59$  [kPa] **SATISFACTORY**

## Dimensioning the reinforcement of the spread footing

After the verification of the bearing capacity we will design a reinforcement of the spread footing in the frame “Dimensioning”. We consider the same reinforcement in both directions (X, Y). We design 18 bars with a diameter of 14 mm. The concrete reinforcement cover is 60 mm. We will check this designed reinforcement for the worst load combination (“Find max. values automatically”).

**Plan:** 2,00 x 2,00 m

**Punching shear - critical section:** Loading area transferred by RC through shear area: 2,50E-01m<sup>2</sup>; critical section length: 2,00m

**Section A-A:** 18 prof. 14,0 mm length 1880mm, concrete cover 60mm

**Section B-B:** 18 prof. 14,0 mm length 1880mm, concrete cover 60mm

**Verification:**  
**LONG. IN DIRECTION X: SATISFACTORY (87,5%)**  
**LONG. IN DIRECTION Y: SATISFACTORY (87,5%)**  
**PUNCHING SHEAR: SATISFACTORY (58,0%)**

**Dimensioning:**  
 Find max. values automatically  
 Longitudinal reinforcement in direction X  
 Number of bars: 18,00 [pcs]  
 Reinforcement cover: 60,0 [mm]  
 Bar diameter: 14,0 [mm]  
 $A_{req} = 2425,8 \text{ mm}^2 < A_{imp} = 2770,9 \text{ mm}^2$   
 Shear reinforcement of critical cross section  
 Number of bars: [ ] [pcs] Angle of slope: [ ] [°]  
 Bar diameter: [ ] [mm]

Frame “Dimensioning”

## Conclusion:

The design of the spread footing (2,0 x 2,0 m) is satisfactory.