Designing the geometry of a spread footing
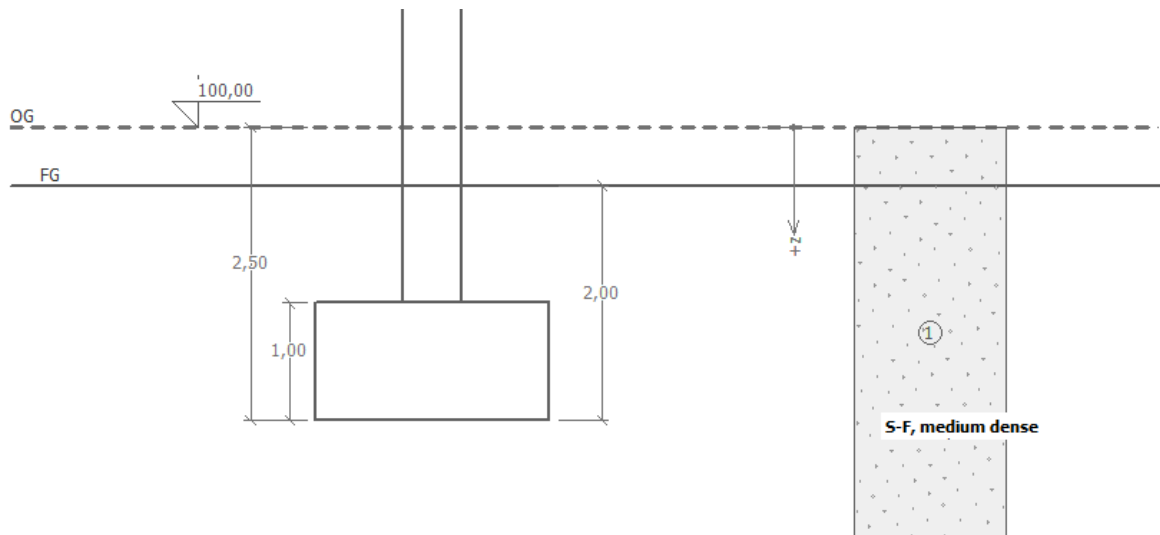
Program: Spread footing

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.
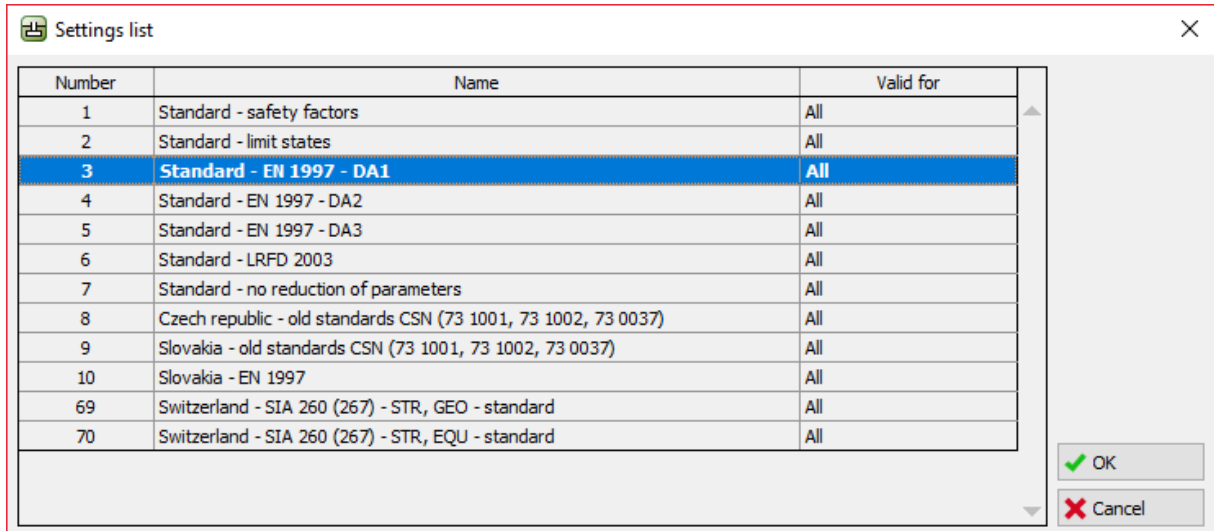

Scheme of the assignment – analysis of the bearing capacity of a spread footing

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 "Geometry" frame.

Basic input

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

Number	Name	Valid for
1	Standard - safety factors	All
2	Standard - limit states	All
3	**Standard - EN 1997 - DA1**	**All**
4	Standard - EN 1997 - DA2	All
5	Standard - EN 1997 - DA3	All
6	Standard - LRFD 2003	All
7	Standard - no reduction of parameters	All
8	Czech republic - old standards CSN (73 1001, 73 1002, 73 0037)	All
9	Slovakia - old standards CSN (73 1001, 73 1002, 73 0037)	All
10	Slovakia - EN 1997	All
69	Switzerland - SIA 260 (267) - STR, GEO - standard	All
70	Switzerland - SIA 260 (267) - STR, EQU - standard	All

"Settings list" Frame

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).
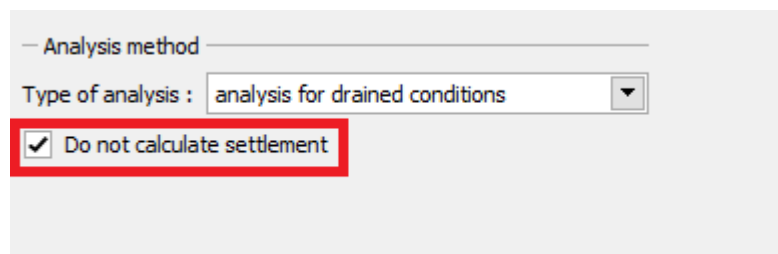
"Settings" Frame

Note: Usually, spread footings are analyzed for drained conditions using the effective parameters of the soil (φ_{ef}, c_{ef}). An analysis for undrained conditions is performed for cohesive soils and short-term performance using the total parameters of the soil (φ_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 "Soils" frame and click on "Add". Add one new soil with the following parameters. Then assign it to the profile in the "Assign" frame.

Table with the parameters of soils

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

"Soils" Frame – adding a new soil

In the next step, open the "Foundation" frame. 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/m³), which is the backfill of the spread footing after construction.

"Foundation" Frame

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 "Load" frame, 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 new	edit	Name	N [kN]	M_x [kNm]	M_y [kNm]	H_x [kN]	H_y [kN]	Type
1	Yes		Load	2500,00	150,00	200,00	100,00	75,00	Design
2	Yes		Load	1755,00	92,00	114,00	57,00	43,00	Service
3	Yes		Load	2170,00	110,00	165,00	85,00	60,00	Design
4	Yes		Load	1523,00	77,00	116,00	59,00	42,00	Service
5	Yes		Load	1850,00	105,00	120,00	65,00	30,00	Design
6	Yes		Load	1295,00	74,00	86,00	32,00	13,00	Service
7	Yes		Load	1920,00	135,00	160,00	95,00	70,00	Design
8	Yes		Load	1637,00	96,00	108,00	64,00	23,00	Service

"Load" Frame - 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 "Geometry" frame for now because the automatic design of the 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 "Footing bottom" frame.

"Footing bottom" Frame

We are not going to enter a sand-gravel bed in the "SG bed" frame, 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 "Material" frame, input the material characteristics of the foundation.

"Material" Frame

Skip the "Surcharge" frame, 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 vertical bearing capacity, it always acts favorably and no theoretical knowledge leads us to analyze this influence.

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

Design situation :   permanent   ▼
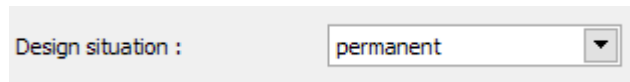
*"Stage settings" Frame*

Design of the spread footing dimensions

Now, open the "Geometry" frame 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 Rd 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.
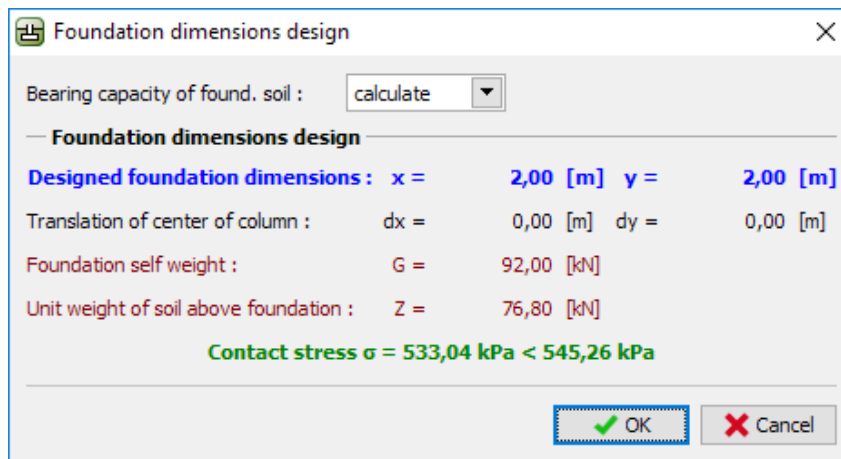
"Foundation dimensions design" Dialog window

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.

"Geometry" Frame

![GEO5 logo]
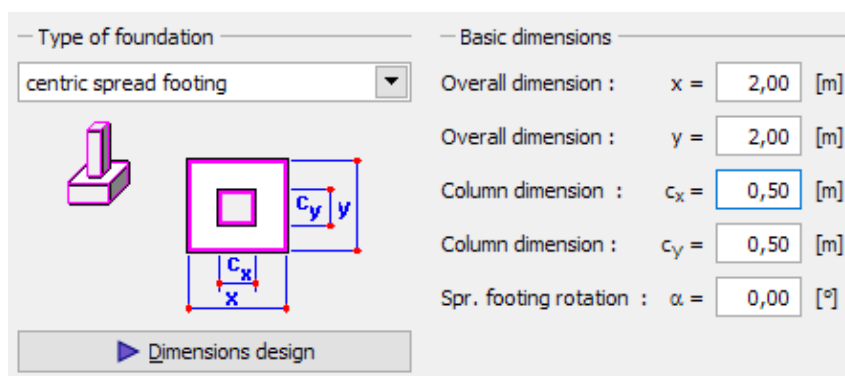
Note: The design of centric and eccentric spread footing is always performed in a way that the dimensions of the foundation are as small as possible and still maintain an adequate vertical bearing capacity. The "Input" option designs the dimensions of a spread footing based on the entered bearing capacity of the foundation soil.

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

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

"Bearing capacity" Frame

− 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 "Dimensioning" frame. 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").

"Dimensioning" Frame

Conclusion:

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