Spread footing verification

Input data

Project
Task: Preliminary design of shallow foundation
Part: Strip footing
Customer: CTU
Author: Bc. Yosufi Mohammad Fayez
Date: 20.12.2019

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Stage - analysis: 1 - 0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graphical representation of spread footing verification.
Settings
Standard - safety factors
Materials and standards
Concrete structures: EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1: standard

Settlement
Analysis method: Analysis using oedometric modulus
Restraint of influence zone: by percentage of Sigma, Or
Coeff. of restraint of influence zone: 10.0 [%]

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Pattern</th>
<th>$\phi_{ef}$</th>
<th>$c_{ef}$</th>
<th>$\gamma$</th>
<th>$\gamma_{su}$</th>
<th>$\delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Well graded gravel (GW), medium dense</td>
<td></td>
<td>38,50</td>
<td>0,00</td>
<td>21,00</td>
<td>11,00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Poorly graded sand (SP), medium dense</td>
<td></td>
<td>33,50</td>
<td>0,00</td>
<td>18,50</td>
<td>8,50</td>
<td></td>
</tr>
</tbody>
</table>

For non-commercial purposes only

---

[GEOS - Spread Footing (educational license) | version 5.2019.77.0 | hardware key 4433 / 4 | CVUT v Praze Fakulta Stavebni | Copyright © 2019 Fine spol. s r.o. All Rights Reserved | www.finesoftware.eu]
All soils are considered as cohesionless for at rest pressure analysis.

**Soil parameters**

**Well graded gravel (GW), medium dense**
- Unit weight: \( \gamma = 21.00 \text{ kN/m}^3 \)
- Angle of internal friction: \( \varphi_{ef} = 38.50^\circ \)
- Cohesion of soil: \( c_{ef} = 0.00 \text{ kPa} \)
- Oedometric modulus: \( E_{oed} = 355.50 \text{ MPa} \)
- Saturated unit weight: \( \gamma_{sat} = 21.00 \text{ kN/m}^3 \)

**Poorly graded sand (SP), medium dense**
- Unit weight: \( \gamma = 18.50 \text{ kN/m}^3 \)
- Angle of internal friction: \( \varphi_{ef} = 33.50^\circ \)
- Cohesion of soil: \( c_{ef} = 0.00 \text{ kPa} \)
- Oedometric modulus: \( E_{oed} = 32.00 \text{ MPa} \)
- Saturated unit weight: \( \gamma_{sat} = 18.50 \text{ kN/m}^3 \)

**Foundation**

**Foundation type: Strip footing**
- Depth from original ground surface \( h_z = 4.40 \text{ m} \)
- Depth of footing bottom \( d = 0.00 \text{ m} \)
- Foundation thickness \( t = 0.80 \text{ m} \)
- Incl. of finished grade \( s_1 = 0.00^\circ \)
- Incl. of footing bottom \( s_2 = 0.00^\circ \)
- Unit weight of soil above foundation = 20.00 \( \text{kN/m}^3 \)

---

For non-commercial purposes only
Overall strip footing length = 1,00 m
Strip footing width (x) = 1,20 m
Column width in the direction of x = 0,30 m
Volume of strip footing = 0,96 m³/m

Inserted loading is considered per unit length of continuous footing span.

---

**Stage - analysis : 1 - 0**

---

**Material of structure**

Unit weight $\gamma = 23,00$ kN/m³
Analysis of concrete structures carried out according to the standard EN 1992-1-1 (EC2).

**Concrete : C 30/37**

- Cylinder compressive strength $f_{ck} = 30,00$ MPa
- Tensile strength $f_{ctm} = 2,90$ MPa
- Elasticity modulus $E_{cm} = 33000,00$ 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**

**Position information**
Terrain elevation = 4,40 m

**Geological profile and assigned soils**

<table>
<thead>
<tr>
<th>No.</th>
<th>Thickness of layer t [m]</th>
<th>Depth z [m]</th>
<th>Altitude [m]</th>
<th>Assigned soil</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4,40</td>
<td>0,00 .. 4,40</td>
<td>4,40 .. 0,00</td>
<td>Poorly graded sand (SP), medium dense</td>
<td></td>
</tr>
</tbody>
</table>
Preliminary design of shallow foundation
Strip footing

<table>
<thead>
<tr>
<th>No.</th>
<th>Thickness of layer [m]</th>
<th>Depth [m]</th>
<th>Altitude [m]</th>
<th>Assigned soil</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-</td>
<td>4.40 .. ∞</td>
<td>0.00 .. -</td>
<td>Well graded gravel (GW), medium dense</td>
<td></td>
</tr>
</tbody>
</table>

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

For non-commercial purposes only
Load

<table>
<thead>
<tr>
<th>No.</th>
<th>Load new</th>
<th>Name</th>
<th>Type</th>
<th>N [kN/m]</th>
<th>M_y [kNm/m]</th>
<th>H_x [kN/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>Load No. 1</td>
<td>Design</td>
<td>300.00</td>
<td>10.00</td>
<td>5.00</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>Load No. 1 - service</td>
<td>Service</td>
<td>214.29</td>
<td>7.14</td>
<td>3.57</td>
</tr>
</tbody>
</table>

Ground water table

The ground water table is at a depth of 12.00 m from the original terrain.

Name : GWT + subsoil

Stage - analysis : 1 - 0

Global settings

Type of analysis : analysis for drained conditions

Settings of the stage of construction

Design situation : permanent

Verification No. 1

Load case verification

<table>
<thead>
<tr>
<th>Name</th>
<th>e_x [m]</th>
<th>e_y [m]</th>
<th>σ [kPa]</th>
<th>R_d [kPa]</th>
<th>Utilization [%]</th>
<th>Is satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load No. 1</td>
<td>-0.02</td>
<td>0.00</td>
<td>277.00</td>
<td>462.25</td>
<td>89.89</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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

Computed self weight of strip foundation \( G = 22.08 \) kN/m
Computed weight of overburden \( Z = 0.00 \) kN/m

Vertical bearing capacity check

Shape of contact stress : rectangle
Most unfavorable load case No. 1. (Load No. 1)
Parameters of slip surface below foundation:
- Depth of slip surface \( z_{sp} = 1,90 \) m
- Length of slip surface \( l_{sp} = 6,26 \) m

Design bearing capacity of found.soil \( R_d = 462,25 \) kPa

Extreme contact stress \( \sigma = 277,00 \) kPa

Factor of safety = 1,67 > 1,50

**Bearing capacity in the vertical direction is SATISFACTORY**

**Verification of load eccentricity**
- Max. eccentricity in direction of base length \( e_x = 0,016 < 0,333 \)
- Max. eccentricity in direction of base width \( e_y = 0,000 < 0,333 \)
- Max. overall eccentricity \( e_t = 0,016 < 0,333 \)

**Eccentricity of load is SATISFACTORY**

**Horizontal bearing capacity check**

Most unfavorable load case No. 1. (Load No. 1)
- Earth resistance: at rest
- Design magnitude of earth resistance \( S_{pd} = 0,00 \) kN
- Horizontal bearing capacity \( R_{dh} = 256,19 \) kN
- Extreme horizontal force \( H = 5,00 \) kN

Factor of safety = 51,24 > 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 $k_1$ (influence of foundation depth).
Stress at the footing bottom considered from the finished grade.

Computed self weight of strip foundation $G = 22.08$ kN/m
Computed weight of overburden $Z = 0.00$ kN/m
Settlement of mid point of longitudinal edge $= 0.4$ mm
Settlement of mid point of transverse edge 1 $= 0.4$ mm
Settlement of mid point of transverse edge 2 $= 0.3$ mm
(1-max.compressed edge; 2-min.compressed edge)

Settlement and rotation of foundation - results

Foundation stiffness:
Computed weighted average modulus of deformation $E_{def} = 319.95$ MPa
Foundation in the longitudinal direction is rigid ($k=30.56$)
Foundation in the direction of width is rigid ($k=52.81$)

Verification of load eccentricity
Max. eccentricity in direction of base length $e_x = 0.015<0.333$
Max. eccentricity in direction of base width $e_y = 0.000<0.333$
Max. overall eccentricity $e_l = 0.015<0.333$

Eccentricity of load is SATISFACTORY

Overall settlement and rotation of foundation:
Foundation settlement $= 0.4$ mm

For non-commercial purposes only
Depth of influence zone = 2,66 m
Rotation in direction of width = 0,025 (tan*1000); (1,5E-03 °)

<table>
<thead>
<tr>
<th>Name : Settlement</th>
<th>Stage - analysis : 1 - 1</th>
</tr>
</thead>
</table>

**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**
6 prof. 25,0 mm, cover 50,0 mm
Cross-section width = 1,00 m
Cross-section depth = 0,80 m
Reinforcement ratio $\rho = 0,40 \% > 0,15 \% = \rho_{\text{min}}$
Position of neutral axis $x = 0,08 \text{ m} < 0,45 \text{ m} = x_{\text{max}}$
Ultimate moment $M_{\text{Rd}} = 903,40 \text{ kNm} > 27,08 \text{ kNm} = M_{\text{Ed}}$

**Cross-section is SATISFACTORY.**

**Spread footing for punching shear failure check**

**Shear reinforcement of critical cross section**
2 prof. 10,0 mm
Angle of slope = 45,00 °
Column normal force = 300,00 kN

**Maximum resistance at the column perimeter**
Force transferred into found. soil $= 75,00 \text{ kN}$
Force transferred by shear strength of foundation $= 225,00 \text{ kN}$
Considered column perimeter $u_0 = 2,00 \text{ m}$
Shear resistance at the column perimeter $v_{\text{Ed,max}} = 0,17 \text{ MPa}$
Resistance at the column perimeter \[ v_{Rd,max} = 4.22 \text{ MPa} \]

**Critical section with shear reinforcement**

- Force transferred into found. soil = 259.38 kN
- Force transferred by shear strength of foundation = 40.62 kN
- Distance of section from the column = 0.37 m
- Section perimeter = 2.00 m
- Shear stress at section \[ v_{Ed} = 0.03 \text{ MPa} \]
- Reinforced section shear resistance \[ v_{Rd,cs} = 1.63 \text{ MPa} \]

\[ v_{Ed} < v_{Rd,cs} \Rightarrow \text{SECTION IS SATISFACTORY} \]

**Spread footing for punching shear is SATISFACTORY**