ARE WE OVERDESIGNING? – A SURVEY OF INTERNATIONAL PRACTICE

A joint initiative by: Corporate Associates Presidential Group (CAPG), Young Members Presidential Group (YMPG, Technical Committee TC205 (Safety and Serviceability), and Technical Committee TC304 (Risk).

1. MOTIVATION

At the XVI Danube European Conference (Skopje Macedonia, June 2018), the question was raised “Are we overdesigning?”. Although the question originated from the Asian Region, it is valid internationally where different countries and users of various testing techniques or design codes tend to follow local practice for geotechnical design.

This survey is intended to assess the consistency of calculation models and design methods for a variety of geotechnical structures and, where possible, to compare the results with full-scale tests and reliability analyses.

2. OUTLINE

The survey is based on two soil profiles, one in clay and the other in sand. Soil test results, typical of those one would find in a geotechnical investigation report, are provided for each soil profile. The soil properties for the clay and sand profiles are given in Annexes A and B respectively. Excel spreadsheets are also provided with numerical data.

Ten specimen problems have been proposed, namely concentrically and eccentrically loaded spread footings, axially and laterally loaded piles, slopes and retaining structures (see Annex C). The idea is to keep the problems easy to analyse and representative of every-day geotechnical structures.

Some problems require the prediction of performance of the geotechnical structure (prediction problems) while others call for the design of the structure as it would be constructed (design problems). The prediction problems are aimed assessing the selection of parameters and calculation models. The design problems are aimed at assessing the provisions made for safety and serviceability in geotechnical structures.

You do not need to analyse all ten problems, although it would be appreciated if you did. Please feel free to submit responses for only problems that are typical of the work you do on a day-to-day basis.
3. **INSTRUCTIONS**

1. Analyse as many or as few problems as you wish. Partial solutions will also be accepted.
2. Summarise the results on the reply sheets provided in Annex C.
3. Please use the analysis methods and design codes that would typically be applied in a design office in your country. **This is not a competition to see who can get the “right” answer.** It is an assessment of the results given by design methods in common use.
4. Please complete the “Details of Respondent” sheet and submit it with your reply sheets. Also fill in your country and occupation in the space provided on each reply sheet.
5. Submit the result as a scanned .pdf document to overdesign@issmge.org.
6. The closing date for submissions is Friday 2\textsuperscript{nd} August 2019. Late submissions will be accepted but may not be included in the initial analysis of results for the Asian Regional Conference in October 2019.

4. **PRESENTATION OF RESULTS**

The initial results of the survey will be presented at the Asian Regional Conference in Taipei, October 2019. A detailed analysis of the results will be presented at the ISSMGE International Conference in Sydney 2021.

5. **QUERIES**

Queries regarding this survey may be addressed to overdesign@issmge.org. The data is what it is and no further data is available.

Thank you in advance for your participation. We look forward to receiving your responses.

Peter Day and Sukumar Pathmanandavel
ISSMGE CAPG
ANNEX A: CLAY PROFILE

A1 SOIL PROFILE
The clay profile is predominantly alluvial in origin and is overconsolidated.
The profile can be described as follows:

0 – 5.5m Very stiff clay
5.5 – 6.5m Medium dense sand parting (intermittent)
6.5 – 12.0m Very stiff clay
12.0m + Highly weathered shale.

The water table is at a depth of approximately 6m below ground level.

A2 SOIL PROPERTIES
The results of laboratory and field tests on the clay are summarised in Figures A1 and A2 respectively.
Figure A1: CLAY PROFILE - Summary of Laboratory Test Results
Figure A2: CLAY PROFILE - Summary of Field Test Results

- **SPT (blows/300mm)**
  - Data from 12 tests
  - SPT 1
  - SPT 2

- **CPT Point (MPa)**
  - Data from 12 tests
  - Mean
  - $+1.0\sigma$
  - $-1.0\sigma$

- **CPT Friction (MPa)**
  - Data from 12 tests
  - Mean
  - $+1.0\sigma$
  - $-1.0\sigma$

- **PMT Modulus (MPa)**
  - Mean
  - $3.8\text{ MPa}$

- **PMT Limit Pressure (MPa)**
  - Mean
  - $190\text{ MPa}$

Note: no information given on hammer efficiency. Assume $N = N_0$. 
ANNEX B: SAND PROFILE

B1 SOIL PROFILE
The sand profile is also primarily of alluvial origin.
The soil profile may be described as follows:

- 0 – 4.0m Silty sand
- 4.0 – 8.0m Clean sand
- 8.0 – 12.5m Clayey sand
- 12.5m + Highly weathered shale.

The water table is at a depth of about 5m below ground level.

B2 SOIL PROPERTIES
The results of field and laboratory tests are given in the following figures:

- Figure B1: Grading analyses
- Figure B2: SPT test results
- Figure B3: Moisture content results
- Figure B4: CPTu results
- Figure B5: Pressuremeter test results
- Figure B6: Dilatometer test results
- Figure B7: Cross-hole seismic results
Sieve Grading Analysis

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>% Passing by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1m</td>
</tr>
<tr>
<td>9.5</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>1.18</td>
<td>99</td>
</tr>
<tr>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>0.425</td>
<td>95</td>
</tr>
<tr>
<td>0.25</td>
<td>78</td>
</tr>
<tr>
<td>0.18</td>
<td>61</td>
</tr>
<tr>
<td>0.125</td>
<td>27</td>
</tr>
<tr>
<td>0.075</td>
<td>8</td>
</tr>
</tbody>
</table>

**Figure B1**: SAND PROFILE – Summary of Grading Analysis
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>SPT1</th>
<th>SPT2</th>
<th>SPT3</th>
<th>SPT4</th>
<th>SPT5</th>
<th>SPT6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.23</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>0.98</td>
<td>23</td>
<td>23</td>
<td>18</td>
<td>13</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>1.60</td>
<td>30</td>
<td>18</td>
<td>25</td>
<td>18</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>2.20</td>
<td>21</td>
<td>18</td>
<td>17</td>
<td>17</td>
<td>19</td>
<td>13</td>
</tr>
<tr>
<td>2.80</td>
<td>23</td>
<td>16</td>
<td>18</td>
<td>16</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>3.75</td>
<td>28</td>
<td>19</td>
<td>19</td>
<td>15</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>4.95</td>
<td>34</td>
<td>21</td>
<td>19</td>
<td>14</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>5.85</td>
<td>17</td>
<td>14</td>
<td>19</td>
<td>16</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>7.40</td>
<td>13</td>
<td>21</td>
<td>10</td>
<td>20</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>8.90</td>
<td>54</td>
<td>63</td>
<td>44</td>
<td>60</td>
<td>64</td>
<td>49</td>
</tr>
<tr>
<td>10.45</td>
<td>76</td>
<td>40</td>
<td>99</td>
<td>70</td>
<td>38</td>
<td>51</td>
</tr>
<tr>
<td>11.95</td>
<td>40</td>
<td>39</td>
<td>46</td>
<td>53</td>
<td>36</td>
<td>53</td>
</tr>
<tr>
<td>13.50</td>
<td>53</td>
<td>57</td>
<td>36</td>
<td>60</td>
<td>49</td>
<td>54</td>
</tr>
</tbody>
</table>

NB: Average SPT system efficiency 53% (46% - 60%).

**Figure B2:** SAND PROFILE - Summary of SPT results
<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>SPT2</th>
<th>SPT3</th>
<th>SPT4</th>
<th>SPT5</th>
<th>SPT6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.23</td>
<td>14.3</td>
<td>11.9</td>
<td>16.8</td>
<td>14.4</td>
<td>15.9</td>
</tr>
<tr>
<td>0.98</td>
<td>13.0</td>
<td>12.1</td>
<td>11.6</td>
<td>13.0</td>
<td>12.4</td>
</tr>
<tr>
<td>1.60</td>
<td>17.2</td>
<td>15.5</td>
<td>11.8</td>
<td>14.0</td>
<td>11.1</td>
</tr>
<tr>
<td>2.20</td>
<td>19.2</td>
<td>18.3</td>
<td>14.1</td>
<td>20.5</td>
<td>20.5</td>
</tr>
<tr>
<td>2.80</td>
<td>21.8</td>
<td>21.5</td>
<td>19.0</td>
<td>17.6</td>
<td>18.9</td>
</tr>
<tr>
<td>3.75</td>
<td>16.3</td>
<td>21.1</td>
<td>20.9</td>
<td>16.6</td>
<td>18.3</td>
</tr>
<tr>
<td>4.95</td>
<td>16.6</td>
<td>19.2</td>
<td>20.7</td>
<td>16.6</td>
<td>18.7</td>
</tr>
<tr>
<td>5.85</td>
<td>27.7</td>
<td>25.4</td>
<td>25.0</td>
<td>19.4</td>
<td>12.2</td>
</tr>
<tr>
<td>7.40</td>
<td>29.2</td>
<td>29.3</td>
<td>33.5</td>
<td>29.7</td>
<td>31.2</td>
</tr>
<tr>
<td>8.90</td>
<td>27.4</td>
<td>23.0</td>
<td>20.9</td>
<td>29.6</td>
<td>29.0</td>
</tr>
<tr>
<td>10.45</td>
<td>27.0</td>
<td>30.9</td>
<td>32.6</td>
<td>26.7</td>
<td>28.6</td>
</tr>
<tr>
<td>11.95</td>
<td>27.5</td>
<td>34.0</td>
<td>36.7</td>
<td>29.3</td>
<td>29.0</td>
</tr>
<tr>
<td>13.50</td>
<td>27.2</td>
<td>21.9</td>
<td>28.5</td>
<td>32.1</td>
<td>30.7</td>
</tr>
<tr>
<td>15.00</td>
<td>22.1</td>
<td>25.8</td>
<td>21.7</td>
<td>25.1</td>
<td>23.4</td>
</tr>
</tbody>
</table>

**Figure B3:** SAND PROFILE - Summary of Moisture Content results
Figure B4: SAND PROFILE - Summary of CPTu results
MENARD PRESSUREMETER TESTS

<table>
<thead>
<tr>
<th>PMT</th>
<th>Depth (m)</th>
<th>Init Mod (MPa)</th>
<th>Reload Mod (MPa)</th>
<th>Limit Press (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMT 1</td>
<td>0.5</td>
<td>6.42</td>
<td>21.90</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>6.27</td>
<td>24.34</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>7.44</td>
<td>33.90</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>7.75</td>
<td>51.43</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
<td>12.60</td>
<td>78.11</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>4.62</td>
<td>61.10</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>10.8</td>
<td>173.88</td>
<td>369.55</td>
<td>4.20</td>
</tr>
<tr>
<td>PMT 2</td>
<td>0.5</td>
<td>7.62</td>
<td>34.34</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>10.56</td>
<td>47.89</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>8.08</td>
<td>57.78</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>3.3</td>
<td>9.49</td>
<td>55.51</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
<td>13.37</td>
<td>84.97</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>6.39</td>
<td>41.97</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>10.8</td>
<td>132.93</td>
<td>253.73</td>
<td>4.40</td>
</tr>
<tr>
<td>PMT 3</td>
<td>1.4</td>
<td>8.56</td>
<td>87.76</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>9.66</td>
<td>59.29</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>8.13</td>
<td>52.08</td>
<td>0.80</td>
</tr>
<tr>
<td>PMT 4</td>
<td>1.4</td>
<td>14.87</td>
<td>29.57</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>12.37</td>
<td>25.45</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>9.86</td>
<td>23.09</td>
<td>0.72</td>
</tr>
</tbody>
</table>

**Figure B5:** SAND PROFILE - Summary of Pressuremeter results
Figure B6: SAND PROFILE - Summary of Dilatometer results
Figure B7: SAND PROFILE – Summary of Cross-hole Seismic test results
ANNEX C: SPECIMEN PROBLEMS

Problem CLAY 1 – Vertically loaded spread footing  (Prediction)
Problem CLAY 2 – Axially loaded pile    (Prediction)
Problem CLAY 3 – Laterally loaded pile    (Prediction)
Problem CLAY 4 – Slope design    (Design)
Problem SAND 1 – Vertically loaded spread footing (Prediction)
Problem SAND 2 – Axially loaded pile    (Prediction)
Problem SAND 3 – Design of spread footing with horizontal load    (Design)
Problem SAND 4 – Slope design    (Design)
Problem SAND 5 – Embedded retaining wall    (Design)
Problem SAND 6 – Temporary soil nailed wall    (Design)
# DETAILS OF RESPONDENT – Reply sheet

<table>
<thead>
<tr>
<th>Name (optional)</th>
<th>..............................................................................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email (optional)</td>
<td>..............................................................................................................</td>
</tr>
</tbody>
</table>

**Occupation**

- □ Student
- □ Academic
- □ Design consultant
- □ Contractor
- □ Other (please specify) .....................................................................

**Experience**

- □ 0 – 10 years
- □ 10 – 20 years
- □ 20 – 30 years
- □ 30+ years

**Country**

..............................................................................................................

**Design methods used in your country**

- □ WLD: Working load design with global factor of safety
- □ LRFD: Load and resistance factor design (e.g. AASHTO codes)
- □ PF LSD: Partial factor limit states design (e.g. Eurocodes)
- □ Other (please specify: )

**Geotechnical design codes used in your country:**

(please specify standard number and year, e.g. EN1997-1:2004)

**Your favourite geotechnical engineering textbooks (3 max.):**
Problem CLAY 1 – Vertically loaded spread footing

STRUCTURE:

- 2.0m wide concrete strip footing founded on clay at 0.75m below ground level
- Concentric line load $P$ excludes weight of footing

PROBLEM:

This problem requires the prediction of the performance of the footing.

1. Predict the applied load that will cause bearing capacity failure of the footing, $P_{ult}$ (kN/m).
2. Predict the applied load $P_{25mm}$ (kN/m) that will cause the footing to settle by 25mm in the long term.
3. Predict the expected performance of the footing based on the test results, not a conservative assessment as may be used in design calculations.
Problem CLAY 1 – Reply sheet

RESPONDENT PROFILE:

Country ......................................................

Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

PREDICTION:

\[ P_{ult} = \underline{\ldots} \text{kN/m} \quad P_{25\text{mm}} = \underline{\ldots} \text{kN/m} \]

DETAILS OF ANALYSIS:

Method of bearing capacity analysis: .................................................................

Type of analysis: □ Total stress (undrained) □ Effective stress (drained) □ Both

Method of settlement analysis: .................................................................

Codes or Standards used (if any): .................................................................

Parameter values (if appropriate):

\[ c_u \quad \text{Undrained shear strength} \quad \underline{\ldots}\text{kPa} \]

\[ c' \quad \text{Drained cohesion} \quad \underline{\ldots}\text{kPa} \]

\[ \phi' \quad \text{Drained friction angle} \quad \underline{\ldots}\text{deg} \]

\[ E' \quad \text{Drained elastic modulus} \quad \underline{\ldots}\text{MPa} \]

Other parameters / empirical factors used: (please specify)

If you used a Skempton-type analysis, what value of \( N_c \) was used? \( \underline{\ldots} \)

References used:

Any comments:

Over-design Survey: 2019
Problem CLAY 2 – Axially loaded pile

STRUCTURE:

- 0.76m diameter, bored, cast in situ pile in clay
- Depth 10.0m below natural ground level.

PROBLEM:

This problem requires the prediction of the performance of the pile.

1. Predict the ultimate load capacity of the pile $P_{ult}$.
2. If the method used separates shaft and base resistance, state $P_{ult}(shaft)$ and $P_{ult}(base)$.
3. Predict the load-settlement curve to failure.
4. Predict the expected performance of the pile based on the test results, not a conservative assessment as may be used in design calculations.
Problem CLAY 2 – Reply sheet

RESPONDENT PROFILE:

Country

Occupation  □ Student  □ Academic  □ Design consultant  □ Contractor  □ Other

Experience  □ 0 – 10 years  □ 10 – 20 years  □ 20 – 30 years  □ 30+ years

PREDICTION:

\[ P_{ult} = \underline{\text{kN}} \]
\[ P_{ult\ (shaft)} = \underline{\text{kN}} \]
\[ P_{ult\ (base)} = \underline{\text{kN}} \]

DETAILS OF ANALYSIS:

Analysis based on:  □ Empirical correlations with test results e.g. SPT, CPT, etc.

(specify tests .................................................................)

□ Soil strength and deformation parameters

(specify parameters ........................................................)

References used:

Any comments:

Over-design Survey:  2019
**Problem CLAY 3 – Laterally loaded pile**

**STRUCTURE:**

- 0.76m diameter, bored, cast in situ pile in clay
- Founding depth 4.6m below natural ground level
- Load applied at 0.8m above ground level
- Pile reinforcement sufficient to prevent bending or shear failure of pile shaft.

**PROBLEM:**

This problem requires the prediction of the performance of the pile.

1. Predict the ultimate load capacity of the pile $H_{ult}$.
2. Predict the long term load-deflection curve to failure.
3. Predict the expected performance of the pile based on the test results, not a conservative assessment as may be used in design calculations.
Problem CLAY 3 – Reply sheet

RESPONDENT PROFILE:

Country ..............................................

Occupation  □ Student □ Academic □ Design consultant □ Contractor □ Other

Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

PREDICTION:  \( H_{ult} = \underline{\quad} \text{kN} \)

 DETAILS OF ANALYSIS:

Analysis based on:  □ Empirical correlations with test results e.g. SPT, CPT, etc.
(specify tests ..........................................................)

□ Soil strength and deformation parameters
(specify parameters ..........................................................)

References used:

Over-design Survey: 2019
Problem CLAY 4 – Slope design

STRUCTURE:

- Permanent cutting for a public road.
- No surcharges.

PROBLEM:

This is a design problem requiring the specification of the slope angle for construction.

1. Specify the angle $\theta$ at which the slope is to be cut.
# Problem CLAY 4 – Reply sheet

**RESPONDENT PROFILE:**

<table>
<thead>
<tr>
<th>Country</th>
<th>....................................................</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation</td>
<td>□ Student □ Academic □ Design consultant □ Contractor □ Other</td>
</tr>
<tr>
<td>Experience</td>
<td>□ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years</td>
</tr>
</tbody>
</table>

**DESIGN:**

\[ \beta = \text{________ degrees} \]

**DETAILS OF ANALYSIS:**

- Design Code used (if any): .................................................................
- Method of slope stability analysis: ...........................................................
- Type of analysis: □ Total stress (undrained) □ Effective stress (drained) □ Both
- Parameter values: z<6m z>6m (* delete as required)
  - \( c_u \) Undrained shear strength ............ ............kPa (average* / characteristic*)
  - \( c' \) Drained cohesion ............ ............kPa (average* / characteristic*)
  - \( \phi' \) Drained friction angle ............ ............deg (average* / characteristic*)
- Other parameters / empirical factors used: (please specify)

**Did your analysis include a tension crack?** □ Yes □ No
**If so, to what depth?** ............... m
**Did you assume this crack could fill with water?** □ Yes □ No

**References used:**

**Any comments:**

*Over-design Survey: 2019*
**Problem SAND 1 – Vertically loaded spread footing**

**STRUCTURE:**

- 2.25m square concrete footing founded on sand at 0.75m below ground level
- Concentric applied load $P$ excludes weight of footing

**PROBLEM:**

This problem requires the prediction of the performance of the footing.

1. Predict the ultimate load capacity of the footing $P_{ult}$.
2. Predict the load $P_{25mm}$ that will cause the footing to settle by 25mm in the long term.
3. Predict the expected performance of the footing based on the test results, not a conservative assessment as may be used in design calculations.
Problem SAND 1 – Reply sheet

RESPONDENT PROFILE:
Country ..................................................
Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other
Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

PREDICTION:
\[ P_{ult} = \quad \text{kN} \quad P_{25mm} = \quad \text{kN} \]

DETAILS OF ANALYSIS:
Method of bearing capacity analysis: .................................................................
Method of settlement analysis: .................................................................
Codes or Standards used (if any): .................................................................
Parameter values (if appropriate):
\[ c' \quad \text{Drained cohesion} \quad \ldots\ldots\ldots\ldots\text{kPa} \]
\[ \phi' \quad \text{Drained friction angle} \quad \ldots\ldots\ldots\ldots\text{deg} \]
\[ E' \quad \text{Drained elastic modulus} \quad \ldots\ldots\ldots\ldots\text{MPa} \]
Other parameters used: (please supply)

Did your method of bearing capacity analysis include depth correction factors? □ Yes □ No

References used:

Any comments:
Problem SAND 2 – Axially loaded pile

STRUCTURE:

- 0.76m diameter, bored, cast in situ pile in sand. Installed under slurry.
- Depth 10.0m below natural ground level.

PROBLEM:

This problem requires the prediction of the performance of the pile.

1. Predict the ultimate load capacity of the pile $P_{ult}$.
2. If the method used separates shaft and base resistance, state $P_{ult\ (shaft)}$ and $P_{ult\ (base)}$.
3. Predict the load-settlement curve to failure.
4. Predict the expected performance of the pile based on the test results, not a conservative assessment as may be used in design calculations.
Problem SAND 2 – Axially loaded pile

RESPONDENT PROFILE:

Country ........................................

Occupation  □ Student  □ Academic  □ Design consultant  □ Contractor  □ Other

Experience  □ 0 – 10 years  □ 10 – 20 years  □ 20 – 30 years  □ 30+ years

Prediction:

\[ P_{\text{ult}} = \quad \text{kN} \]

\[ P_{\text{ult (shaft)}} = \quad \text{kN} \quad P_{\text{ult (base)}} = \quad \text{kN} \]

DETAILS OF ANALYSIS:

Analysis based on:  □ Empirical correlations with test results e.g. SPT, CPT, etc.

(specify tests .................................................................)

□ Soil strength and deformation parameters

(specify parameters ..........................................................)

Did you include end bearing of bored pile below water table?:  □ Yes  □ No

References used:

Over-design Survey:  2019
Problem SAND 3 – Design of spread footing with horizontal load

**STRUCTURE:**

- Foundation is for a water tank stand
- Vertical load $V$ includes dead load $G$ (excluding weight of footing) and weight of water in tank $Q_{\text{water}}$.
- Horizontal load $H$ is due to wind only $Q_{\text{wind}}$. Can act in any horizontal direction.
- Loads are given as characteristic values.

**PROBLEM:**

This is a design problem requiring the specification of the footing size for construction.

1. Determine the size of footing required ($L = B$).

\[
\begin{align*}
H &= Q_{\text{wind}} = 50kN \\
V &= G + Q_{\text{water}} \\
&= 320kN + 100kN \\
&= 420kN
\end{align*}
\]
Problem SAND 3 – Reply sheet

RESPONDENT PROFILE:
Country ..............................................
Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other
Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

DESIGN:

\[ L = B = \underline{\text{_______}} \text{ m} \]

DETAILS OF ANALYSIS:

Design method (Limit states, working load, etc.): ..........................................................

Code or standard used: ..................................................................................................

Method of bearing capacity calculation: ..........................................................................

Parameter values (if appropriate): (* delete as required)

\[ c' \] Drained cohesion* .......kPa (average* / characteristic*)
\[ \phi' \] Drained friction angle* .......deg (average* / characteristic*)
\[ \gamma \] Bulk density of sand* .......kN/m\(^3\) (average* / characteristic*)

Other parameters used: (please supply)

Design situation: □ Tank empty □ Tank full

Factors applied (load factors, combination factors, material factors, resistance factors, FoS, etc.)

.................................................................

.................................................................

Allowance for large eccentricity (if any): .................................................................

For EN1997-1 users:

Design approach used: □ DA1 □ DA2 □ DA2* □ DA3

Critical ultimate limit state: □ GEO □ STR □ EQU

Any comments:

Over-design Survey: 2019
Problem SAND 4 – Slope design

STRUCTURE:

![Diagram of slope design with n.g.l., 6m cutting, and 1m deep toe drain]

- Permanent cutting for a public road.
- No surcharges.

PROBLEM:

This is a design problem requiring the specification of the slope angle for construction.

1. Specify the angle $\beta$ at which the slope is to be cut.
Problem SAND 4 – Reply sheet

RESPONDENT PROFILE:

Country ............................................................
Occupation □ Student □ Academic □ Design consultant □ Contractor □ Other
Experience □ 0 – 10 years □ 10 – 20 years □ 20 – 30 years □ 30+ years

DESIGN:

\[ \beta = \text{_______ degrees} \]

DETAILS OF ANALYSIS:

Design Code used: ............................................................
Method of slope stability analysis: ............................................................
Type of analysis: □ Total stress (undrained) □ Effective stress (drained) □ Both
Parameter values: 
\[ z<4m \quad 4m - 8m \quad z>8m \]
\[ c' \quad \text{Drained cohesion} \quad \text{_______ kPa} \quad \text{(average* / characteristic*)} \]
\[ \phi' \quad \text{Drained friction angle} \quad \text{_______ deg} \quad \text{(average* / characteristic*)} \]
For WLD, specify Factor of Safety used: ......................
Other parameters / empirical factors used: (please specify):

For EN1997-1 users:
Design approach used: □ DA1 □ DA2 □ DA3

References used:

Any comments:

Over-design Survey: 2019
Problem SAND 5 – Propped embedded retaining wall design

STRUCTURE:

- Permanent retaining wall propped at top.
- 6.0m deep excavation.
- 20kPa variable loading (surcharge) due to traffic.

PROBLEM:

This is a design problem requiring the specification of the geometry of the wall, the propping force and the strength of the wall in bending.

1. Specify the required depth of embedment \( d \) (m).
2. Specify the propping force \( P \) (kN/m).
3. Specify the minimum yield moment of wall element \( M_{yield} \) (kNm/m).

Design to be based on the stability of the wall without considering serviceability requirements.
## Problem SAND 5 – Reply sheet

### Respondent Profile:
- **Country**: .............................................
- **Occupation**:  
  - □ Student  
  - □ Academic  
  - □ Design consultant  
  - □ Contractor  
  - □ Other
- **Experience**:  
  - □ 0 – 10 years  
  - □ 10 – 20 years  
  - □ 20 – 30 years  
  - □ 30+ years

### Design:
- \( d = \) __________ metres
- \( P = \) __________ kN/m  (working load* / LSD design value*)
- \( M_{yield} = \) __________ kNm/m  (minimum yield moment)
  (* delete as required)

### Details of Analysis:
- **Design Code used**:  .................................................................
- **Method of analysis**:  .................................................................
- **Parameter values**:  
  - \( z < 4 \text{m} \)  
  - \( 4 \text{m} - 8 \text{m} \)  
  - \( z > 8 \text{m} \)  
  (* delete as required)
  - \( c' \) Drained cohesion  
    - ................. ................. ................. kPa  
    (* average* / characteristic*)
  - \( \phi' \) Drained friction angle  
    - ................. ................. ................. deg  
    (* average* / characteristic*)
- **Other parameters / empirical factors used**: (please specify)

For EN1997-1 users:
- **Design approach used**:  
  - □ DA1  
  - □ DA2  
  - □ DA3

### References used:

### Any comments:

Over-design Survey: 2019
**Problem SAND 6 – Soil nailed retaining wall design**

**STRUCTURE:**

- Temporary soil nailed wall.
- 10kPa variable loading (construction traffic).
- 10° nail inclination.
- 20mm nails: $F_y = 140kN$.
- All nails $L$ m long.

**PROBLEM:**

This is a design problem requiring the specification of the length of the soil nails and their horizontal spacing.

1. Specify the required length of the soil nails ($L$).
2. Specify horizontal spacing ($S_H$).

Design to be based on the stability of the wall without considering serviceability requirements.
Problem SAND 6 – Reply sheet

RESPONDENT PROFILE:

Country  ........................................

Occupation  □ Student  □ Academic  □ Design consultant  □ Contractor  □ Other

Experience  □ 0 – 10 years  □ 10 – 20 years  □ 20 – 30 years  □ 30+ years

DESIGN:

\[ L = \quad \text{________ m} \]

\[ S_H = \quad \text{________ m} \]

DETAILS OF ANALYSIS:

Design Code used:  .................................................................

Method of analysis:  .................................................................

Parameter values:

\[ z < 4\text{m} \quad 4\text{m} - 8\text{m} \quad z > 8\text{m} \]  (* delete as required)

\[ c' \quad \text{Drained cohesion} \quad \text{........} \quad \text{........} \quad \text{........} \text{kPa} \quad (\text{average}^* \quad / \quad \text{characteristic}^*) \]

\[ \phi' \quad \text{Drained friction angle} \quad \text{........} \quad \text{........} \quad \text{........} \text{deg} \quad (\text{average}^* \quad / \quad \text{characteristic}^*) \]

Other parameters / empirical factors used: (please specify)

For EN1997-1 users:

Design approach used:  □ DA1  □ DA2  □ DA3

References used:

Any comments: