# SCHOOL OF CIVIL ENGINEERING AND SURVEYING

# ACADEMIC YEAR 2020/2021

# SOILS AND MATERIALS 3 U23357

## Coursework

## N/A

**Instructions**: N/A

**Provided:** N/A

**Module Coordinator:** MEHDI ROUHOLAMIN

**Author:** MEHDI ROUHOLAMIN

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| School of Civil Engineering and Surveying | Student Registration Number: | |
|---|---|---|
| M23357 Soils and Materials 3 | **Course: BEng/MEng CE, BEng EG(SEGG)** | **Date Set:** 12/10/2020 |
| **Item 1A – Slope Stability Report** | **Lecturer: Dr Mehdi Rouholamin** | **Date Due:** 04/12/2020 |
| | **Ref:** | **Weight:** 60% |

**Objectives:**

- Assess the stability of a cut slope in soft clay in the short and long term.
- Evaluate the impact of pore water pressures on slope stability.
- Identity suitable remedial techniques for unstable slopes

**Task:**

A cut slope in soft clay has been constructed as part of a road alignment. The slope is 1 in 2.466 (or 2.466:1 as a horizontal:vertical ratio) and 10 m high. The unit weight of the soft clay is 18 kN/m$^3$.

(a) At the time of construction the slope was designed based on undrained analysis parameters. An analysis using Taylors Charts yielded a factor of safety of 1.2 for the short term stability of the slope. Backcalculate the undrained shear strength ($c_u$) of the soil assumed for the soft clay at the time.

(b) A walk over survey recently indicated signs of instability. Samples have been collected from the slope and the drained analysis parameters for the soil have been determined as follows:

**Groups 1&4**: φ'= 25 °, c'=2.6kPa, $\gamma_d$=17kN/m$^3$, $\gamma_{sat}$=18kN/m$^3$

**Groups 2&5**: φ'= 24 °, c'=2.5kPa, $\gamma_d$=18kN/m$^3$, $\gamma_{sat}$=19kN/m$^3$

**Groups 3&6**: φ'= 26 °, c'=2.3kPa, $\gamma_d$=18.5kN/m$^3$, $\gamma_{sat}$=19.5kN/m$^3$

Based on the effective stress parameters given, perform a quick initial estimate of the factor of safety of this slope using Bishop and Morgernsterns charts. Assume an average pore water pressure ratio ($r_u$) of 0.28 for the slope.

(c) Piezometers have now been installed to precisely monitor water levels and pore pressures and their fluctuations with the seasons. The maximum water levels occurred during the rainy season. The worst case water table position is given in Table 1 in the form of the mean height above the base of the 6 slices of the slope geometry shown in Figure 1. Using Table 1, estimate the drained factor of safety using the Swedish method of slices, accounting for pore water pressures.

(d) There are plans to build an industrial steel framed building on the top of the slope with the closest footing to be positioned 3m from the top of the slope. The footing will be 0.7m width and the design load will be 90kN per metre run of footing. Calculate the long term factor of safety using Oasys Slope and Bishops variably inclined interface method, modelling the footing load as a surface load (neglecting any footing embedment). You will need to estimate the centre of the slip circle.

(e) Considering the factors of safety calculated in parts (b)-(d), critically evaluate the original design of this slope, its long term stability and the most important issues that it has.

(f) Identify two viable remedial measures that could be taken to enhance the stability of this slope, explain in detail your rationale for choosing these solutions and how they would be implemented. Consider the soil type and the slope geometry carefully and consider some calculations to assess the effectiveness of your solutions in solving this problem

## Learning outcomes:

On successful completion of this Module, students should be able to:

1. Apply standard procedures to assess the stability of slopes using stability charts and software
2. Evaluate the important issues with regards to the remediation and maintenance of slopes
3. Identity suitable remedial techniques for unstable slopes.

## Reading / References:


- Smith, Smith's Elements of Soil Mechanics, 9e, Wiley-Blackwell, (2014). Ebook on library website.
- Abramson , L. W., Lee, T. S., Sharma, S., & Boyce , G. M. (2002). Slope Stability and Stabilization Methods. New York: John Wiley & Sons.
- Perry J., Pedley M. and Brady K (2003). Infrastructure cuttings – condition appraisal and remedial treatment, 2nd edition. CIRIA C591.
- Carder D.R., Watts G.R.A., Campton L. and Motley S. (2007). Drainage of Earthworks Slopes. UPR IE/143/07. Halcrow Group Ltd.
- British Standards Institute. (2004). 1997-1:2004+A1:2013. Eurocode 7: Geotechnical Design - Part 1: general rules. Retrieved from https:\\bsol.bsigroup.com.
- British Standards Institute. (2004). 1997-1:2004+A1:2013. Eurocode 7: Geotechnical Design - Part 2: Ground Investigation and testing. Retrieved from https:\\bsol.bsigroup.com
- BS 6031:2009, Code of practice for earthworks
- Bromhead E. (1998).The Stability of Slopes. Second edition. Taylor and Francis.


## Submission instructions

The two coursework reports for this Module, slope stability report and cofferdam report make up one coursework artefact and correspond to 60% and 40% of the total coursework mark respectively. The marks for each one will be added to give a mark out of 100%. They need to be submitted as one file on Moodle submission box. It is a soft copy Moodle submission, no hard copy is needed. These two coursework marks make up 40% of the overall mark for the Module (making them worth 30% and 20% of the Module respectively) with the exam accounting for the remaining 60%.

Table 1

| **Slice** | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| α° | 45 | 33 | 22 | 9 | -2 | -12 |
| Area of slice, $m^2$ | 9.61 | 20.47 | 23.37 | 24.25 | 12.85 | 5.20 |
| Arc length, m | 6.2 | 4.9 | 4.6 | 5.06 | 3.8 | 4.2 |
| Mean height of WT. above base of slice, m | 0 | 2.82 | 4.41 | 4.05 | 2.625 | 0.375 |

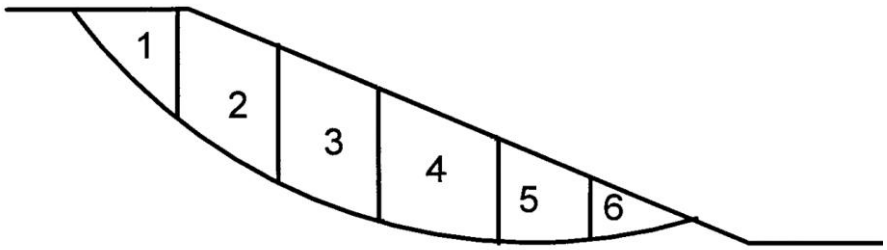


Figure 1

**Grade Criteria**

Please refer to the grade descriptors given in the Student Handbook. The following table shows specific features of work at each grade for this particular task.

| **Grade (%)** | Specific Features |
|---|---|
| **A* (80+)** | Work is structured according to requirements with correct calculations and critical assessment of the design decisions taken for this slope, its long term stability and remedial options, showing originality and creativity and making use of references beyond the material given to provide extra insight. The report is clear and logical and procedures are well explained. The presentation is at a standard suitable for dissemination to a client of an engineering consultancy. |
| **A (70-79)** | Work is structured according to requirements with correct calculations and critical assessment of the design decisions taken for this slope, its long term stability and remedial options. The report is clear and logical and procedures are well explained. Professional presentation. |
| **B (60-69)** | Work approaches A grade but lacks critical thinking or shows some minor errors in structure, explanation of procedures followed or calculations. |
| **C (50-59)** | Work has some incorrect or missing aspects to structure or explanation of procedures and lacks critical thinking but appears to show correct calculation process. |
| **D (40-49)** | Work has significant incorrect or missing aspects to structure or explanation of procedures but appears to follow calculation process correctly. |
| **E (30-39)** | Incomplete and/or incorrect calculations. Inadequate explanation of procedures. |
| **F (0-29)** | No serious attempt to address the requirements of the assignment. |

| School of Civil Engineering and Surveying<br><br>Coursework self-assessment sheet for students | | | Student Registration Number: | |
|---|---|---|---|---|
| | | | Date: | |
| Unit Name | SOILS AND MATERIALS 3 U23357 | | | |
| Artefact Number | Item 1 | Artefact Title | Report | |

**The University of Portsmouth regulations require students to keep electronic copies of all assignments, and submit these at any time upon request.**

**Shaded areas to be completed by student and this sheet submitted with assignment.**

**Student comment: I have read and understood the University's regulations on plagiarism – please type an 'x'**

| Criteria Description | Weighting % | Student Evaluation *(to be completed before submission)* *(enter an 'x' in required boxes)* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Pass | | | | | Fail | |
| | | A* | A | B | C | D | E | F |
| Back calculation using Taylors Method and discussion | 15 | | | | | | | X |
| Bishop & Morgenstern | 15 | | | | | | | X |
| Swedish Method of slices | 15 | | | | | | | X |
| Oasys Slope Analysis with footing load | 20 | | | | | | | X |
| Assessment of long term stability | 10 | | | | | | | X |
| Suggestion of remedial methods for this slope | 25 | | | | | | | X |

| **Overall Grade** *(to be completed before submission)* | Letter Grade (A* - F) | Percentage (100 – 0) |
|---|---|---|
| | | |

**Key**: A*: 80% or above, A: 70% - 79%, B: 60% - 69%, C: 50% - 59%, D: 40% - 49%, E: 30% - 39%, F: 29% or less
**IMPORTANT**: See separate Grade Criteria for characteristics of work in the above grades

**Student Comment**
***(to be completed before submission)***