DEPARTMENT OF
CIVIL & ENVIORNMENTAL ENGINEERING

Brunel University London

Pro-forma to accompany Assignment/Coursework 2022/23

This pro-forma should be the first page to any set assignment/coursework. A full assignment brief should accompany this pro-forma.

Module Code: CE5617	**Module Title: Advanced Geotechnical Engineering**
Module Leader: Dr Tao Zhao	**Assessors(s): Dr Tao Zhao**
Assignment title: Geotechnical Designs	**Weighting: 30% (section 1); 70% (section 2)**

Main Objectives of the Assessment:
This assignment aims to help the students to understand the fundamental principles of geotechnical designs, such as earthwork, retaining structures, and foundations, when developing a design concept (or taking the idea from the imagination to creating a feasible solution).

Brief Description of the Assessment:

Three types of geotechnical design projects are provided (i.e. shallow foundation, T-shaped retaining wall, embankment stability), and the students (worked in groups) are required to choose one of the projects for this assignment. In the following introduction, only indicative design model and parameters are given, while students in different groups may receive different design parameters. The detailed information will be provided during the lectures.

Learning Outcomes for the Assessment: 1) Demonstrate knowledge and a clear understanding of geotechnical design principles for a range of complex problems; 2) Effectively collect and thoroughly organise information on structural design addressing the issue of sustainability, risk management; 3) Work and organise tasks within a group leading to a set goals, communicate the design in a professional manner and present effectively.	**Assessment and marking criteria:** Section 1: Conceptual design proposal poster (30%) • For the project, propose two design options and decide the favoured one based on at least 2 of the following design priorities: Embodied CO2; Constructability; Future maintenance and whole-life-cycle costs; Sustainability; Safe construction Section 2: Detailed design report (70%) • Project site-wide information • Detailed and accurate calculations for actions and resistances; • Properly use of geotechnical software.

Assessment method by which a student can demonstrate the learning outcomes:
Design reports, including group report, presentation, and individual report.

Format of the assessment/coursework: (Guidelines on the expected format and length of submission):
See the attached guideline.

Distribution date to students:	**31/01/2023**
Submission Deadline:	**Section 1: 27/02/2023; Section 2: 28/04/2023**
Indicative reading list:	The same as the reading list of CE5617
Further information:	• *Misconduct in assessment is taken very seriously by the University. You are expected to abide by Senate Regulation 6 - Student Conduct (Academic and Non-Academic), which can be found here: https://www.brunel.ac.uk/about/administration/governance-and-university-committees/senate-regulations.* • *Advice on understanding what plagiarism and collusion are and how they can be avoided can be found here: https://www.brunel.ac.uk/life/library/SubjectSupport/Plagiarism* • *Senate Regulation 4 –policies on Assessment of Students on Taught Courses*

CE5617 – Geotechnical Designs Assignment

1. Objectives

This assignment aims to help students to understand the fundamental principles of geotechnical designs, such as earthwork, retaining structures, and foundations, when developing a design concept (or taking the idea from the imagination to creating a feasible solution). Other objectives of this design coursework include:

- To develop students' ability to apply the principles of preliminary and detailed design for a civil engineering project;
- To develop students' ability in holistic design of civil engineering projects;
- To balance different design priorities and meet the economic, social and environmental challenges of the changing world.

2. Marking scheme

- The assignment consists of two parts (design of a retaining wall, design of a foundation) of equal importance, i.e. each part contributing towards 1/2 of the final mark.
- Each part will be marked as a percentage score, i.e. as a number ranging from 0 to 100%. The final mark will be calculated as the arithmetic average of the percentage scores obtained in the two parts (total = 100%).
- Calculations should be shown in a way that allows the reader to follow the method that has been used. Diagrams may be hand drawn or using software. Do not report Excel calculations. The solution of the assignment should not exceed 25 pages of written calculations and graphs for each part, so a maximum of 50 pages is expected. There is no requirement on the minimum number of pages.

3. Project information

The background information of two geotechnical projects are provided, and the students are required to **complete the designs** for the two projects. In the following introduction, only indicative design model and parameters are given, while students may receive customized design parameters.

3.1Project 1: earth retaining wall design

The client has proposed to cut a slope to construct a building. The local slope geometry is shown in Figure 1. You are required to design a retaining wall **of appropriate shape** to support the remaining excavated slope. The slope and backfill material is composed by a topsoil sand layer (indicated as SAND in the figure), and a stiff overconsolidated clay layer. All the soils parameters are provided in Table 1. The ground water level (GWL) is 1 m below the excavated ground. A variable surcharge p_k = **P** kPa acts behind the wall on slope that rises at an angle β = 10° to the horizontal.

i) Design the structure according to Eurocode 7 – Design Approach 1 considering **all** the relevant ultimate limit states. You need to consider both short- and long-term conditions. In undrained conditions, adhesion can be taken as 2/3 of the clay undrained strength. Given that there is ground soil in front of the wall, the client requires that you account for the stabilising thrust due to the passive resistance developed by the ground in the design to keep costs down. In doing so you need to comply with EC7 requirements on making allowance for potential excavation works in front of the wall during the lifetime of the wall.

(*The value of **P** is calculated as: **P** = 10 + x, where x is the sum of the last 3 digits in your student ID number (e.g. for student ID 1945103, x = 4, P = 14).*)

- ❖ In the design, you are required to report at least **TWO** different designs, for different shape, dimension, and embedded depth of the retaining structures.

[70%]

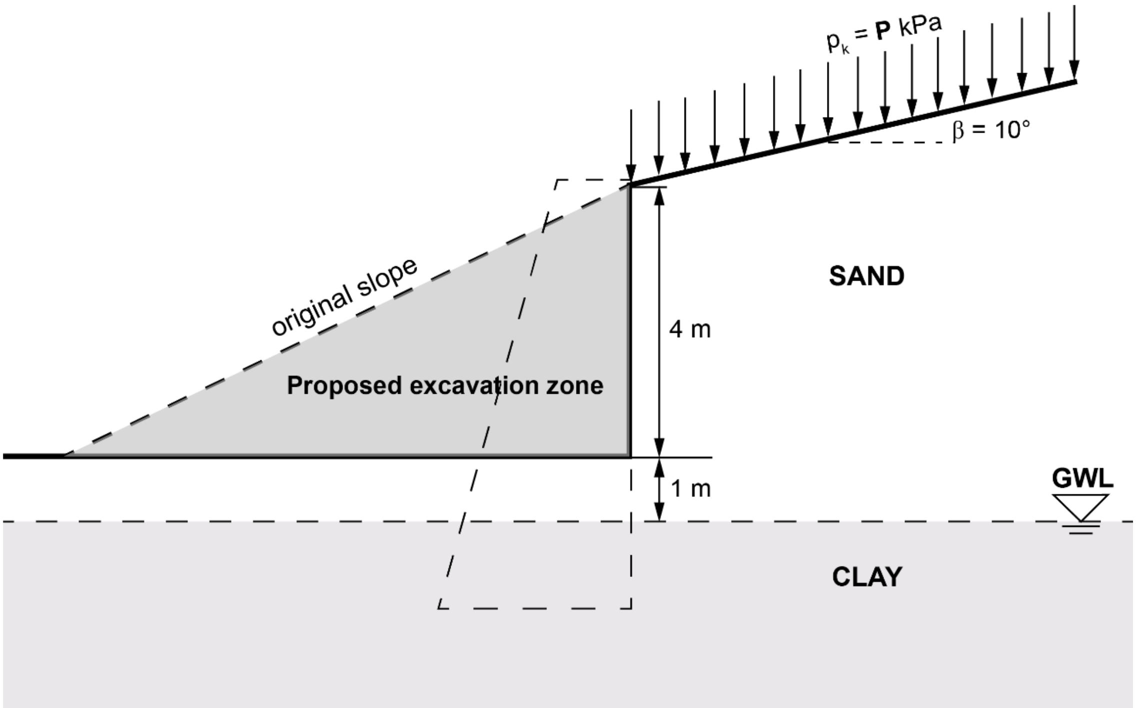

Figure 1. A proposed retaining wall design

Table 1. Soil parameters (ONLY choose one group of soil parameters, based on the last digit of your student ID number, as **A: 0, 1; B: 2, 3; C: 4, 5; D: 6, 7; E: 8, 9**. For example: if the last digit of your student ID number is '0' or '1', you should choose the group A parameters.)

	Group A	Group B	Group C	Group D	Group E
SAND unit weight	20.5kN/m^3	19.5kN/m^3	18.5kN/m^3	18kN/m^3	20.5kN/m^3
SAND ϕ'	35°	34°	32°	33°	31°
CLAY unit weight	20kN/m^3	22kN/m^3	21kN/m^3	18kN/m^3	19kN/m^3
CLAY ϕ'	29°	24°	27°	28°	25°
CLAY c'	13kPa	15kPa	14kPa	12kPa	15kPa
CLAY c_u	80kPa	84kPa	82kPa	79kPa	81kPa

ii) Just after one year after the construction of the wall, you are contacted by the client informing you that due to a revision of the national seismic zonation, the area where the wall is built is now classified as a seismic area. This implies that there is now the additional requirement that the wall is to be able to withstand an earthquake producing horizontal seismic accelerations up to $0.1g$. The client asks you if putting in place dewatering measures to lower the ground water level below the wall base would suffice to guarantee the stability of the wall. If not he would like to know what measures can be put in place to make the wall compliant with the new requirement. Discuss the options available. For full marks, calculations demonstrating that your proposed solution is adequate to guarantee the required performance of the retaining structure are required. To this end, all the relevant ultimate limit states indicated by EC7 Design Approach 1 need to be considered. It is recommended you employ the pseudo-static approach. You can neglect any hydrodynamic effect induced by the earthquake on the water.

[30%]

3.2 Project 2: foundation design

The client has the plan to construct an industrial building. The ground has a 37 m thick deposit composed by a top layer of granular soil, 5 m thick, and a layer of overconsolidated clay (OCR = 3.5) overlying a hard stratum. The ground water level (GWL) is 3 m below ground surface (see Figure 2).

i) You are required to design an **appropriate** foundation to support a permanent vertical load of 2 MN and a variable vertical load of **P** MN. The allowable settlement is 10 cm. Soil parameters are shown in Table 2. In undrained conditions, adhesion can be taken as 2/3 of the clay undrained strength.

1) Check the bearing resistance in accordance with Eurocode 7 Design Approach 1.
2) In addition, determine the immediate and consolidation settlements under the centre of the foundation by dividing the ground in 4 layers.

(*The value of **P** is calculated as: **P** = 1 + x/10, where x is the sum of the last 3 digits in your student ID number (e.g. for student ID 1945103, x = 4, P = 1.4).*)

❖ In the design, you are required to report the designs for **BOTH** shallow and deep foundations, respectively. You need to determine the shape, dimension, and embedded depth of the foundation.

[70%]

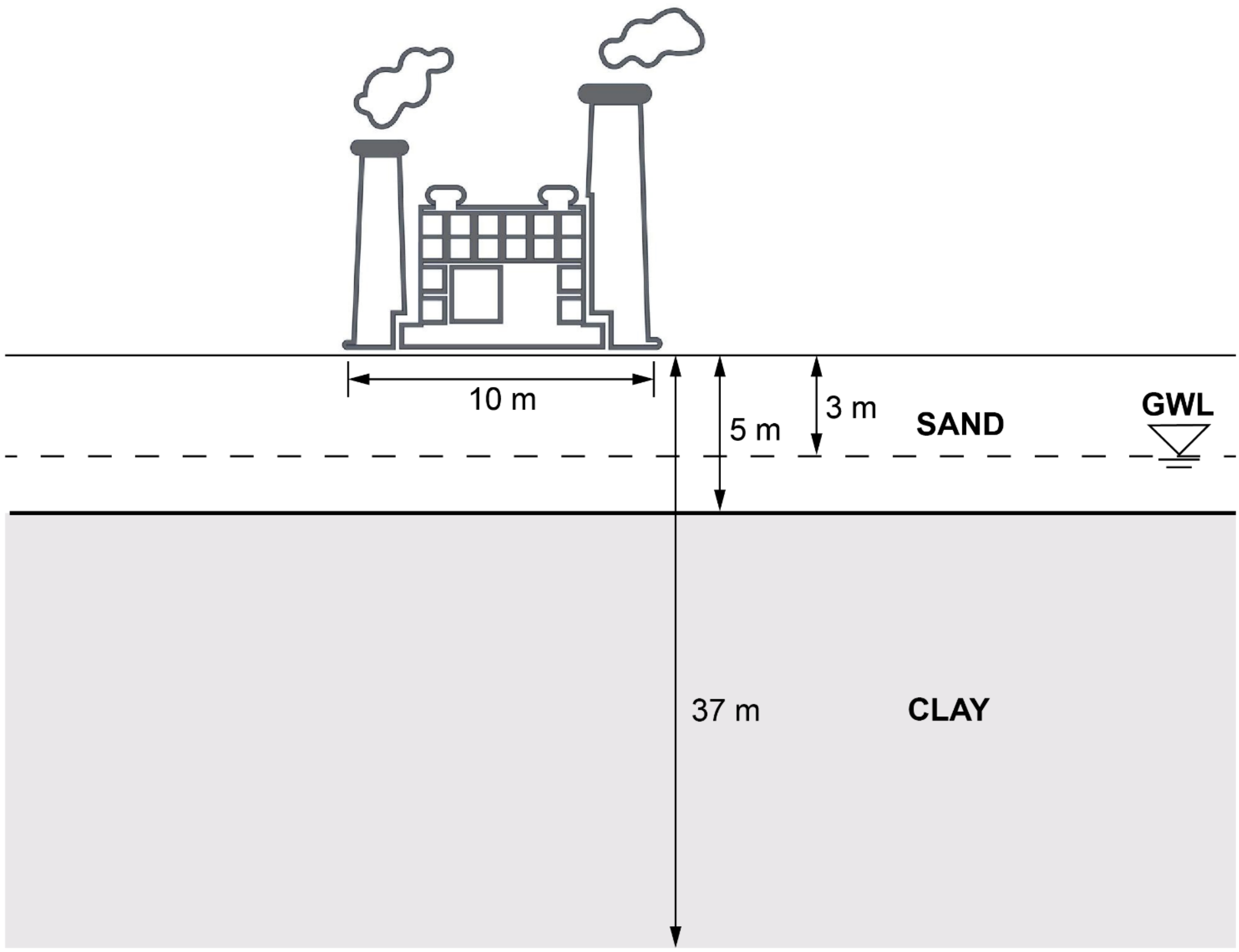

Figure 2. The ground conditions of the site

Table 2. Soil parameters for both shallow and deep foundation designs. (ONLY choose one group of soil parameters, based on the last digit of your student ID number, as **A: 0, 1; B: 2, 3; C: 4, 5; D: 6, 7; E: 8, 9**. For example: if the last digit of your student ID number is '0' or '1', you should choose the Group A parameters.)

	Group A	Group B	Group C	Group D	Group E
SAND unit weight	20.5kN/m3	19.5kN/m3	18.5kN/m3	18kN/m3	20.5kN/m3
SAND friction ϕ'	35°	34°	32°	33°	31°
CLAY unit weight	20kN/m3	22kN/m3	21kN/m3	18kN/m3	19kN/m3
CLAY undrained shear strength at pile base $c_{u;base}$	160 kPa	170 kPa	170 kPa	160 kPa	170 kPa
CLAY average undrained shear strength over the length $c_{u;shaft}$	105 kPa	100 kPa	95 kPa	110 kPa	115 kPa
CLAY initial void ratio e_0	0.9	0.6	0.8	0.65	0.7
CLAY compressibility index C_C	0.10	0.13	0.12	0.11	0.14
CLAY swelling index C_S	0.06	0.07	0.08	0.05	0.05
CLAY undrained Young's modulus E_u	62 MN/m^2	61 MN/m^2	60 MN/m^2	59 MN/m^2	58 MN/m^2

ii) After a few years from construction, a wealth fund has bought the factory and decided to change the production line. Due to several new heavy machineries to be hosted in the factory, there is now the possibility that a significant moment may be applied onto the foundation. The client wants to know what is the maximum moment that the foundation can safely withstand to assess whether the factory can host the proposed new production line. To keep costs down, you want to allow for one or more rows of piles to work in tension (if pile foundation has been used). Calculations are to be carried out according to Eurocode 7 Design Approach 1. **[20%]**

iii) Discuss what problems may arise for piles working in tension and what mitigation measures could be undertaken. **[10%]**

3. Submissions (individually assessed)

You have been appointed as a geotechnical engineer to prepare a concept design and detailed design report. A SINGLE file (PDF format) submission on WISEflow is required in line with the University regulations.

Section 1: Conceptual design – posters [30%]

When conducting the conceptual design in the poster (**20%**), you need to propose two design options and decide the favoured one based on **at least 2** of the following design priorities (clarify which priorities have been addressed on the poster):

1) Embodied CO_2
2) Constructability
3) Future maintenance and whole-life-cycle costs
4) Sustainability
5) Safe construction
6) Potential hazards / challenges

A reflective report (poster) should also be submitted along with the Section 2 submission. (**10%**)

- ✓ reflect on the initial conceptual design proposal
- ✓ explain why the initial design is good or bad; any improvement?

Section 2: Detailed design report [70%]

In the detailed design report, you need to present the following results in your report. Present your results in a report format:

1) Project site-wide information.
2) Detailed calculations of actions (or loads) and resistance. In this part, all actions including permanent and variable loads must be properly discussed.
3) Detailed calculations of major structural elements. You must present the detailed geotechnical designs for major components of the structure, i.e. a foundation, retaining wall, slope.
4) Maximum 50 pages, no minimum page requirement.

4. General expectations

The assessment of your work will also be based on various items including:

- Effective conveyance and communication of the information. As a geotechnical Engineer in design offices you need to present your calculations to other members of the design team and your calculation results will be used by other engineers to continue the work until the stage of construction and completion of the project. The way you present your calculations should flow and must be very clear to everybody not just yourself. You need to use sketches, drawings and diagrams throughout the calculations.

- Accuracy of the calculations is also very important for the same reason as above.
- The software such as AutoCAD, Plaxis or COMSOL can be used to aid your design.
- All calculations can be handwritten or typed in calculation sheets.

5. Academic writing and referencing

It is important to reference your work properly. Why?

- To acknowledge the work of others. This avoids plagiarism!
- To easily allow those reading your work to find the documents you have referred to.
- To demonstrate breadth of knowledge – this will strengthen your work and help you achieve a better mark!

There are a number of support services on the University website to help you with academic practice, take advantage of it: https://libguides.brunel.ac.uk/referencing

Marking criteria for Section I

Item	Weighting (%)	Poor	Moderate	Good	Excellent
Overall structure and presentation	5	Lacks defined structure and appears unfinished. Poorly presented. Apparent weaknesses, e.g. grammar mistake, lack of logic, low resolution figures.	Moderately defined structure, though still appears slightly rushed. Some use of diagrams to explain concepts.	Good overall structure and calculations well laid out overall, with reference to specific clauses used. Care taken in overall presentation and checking evidence. Good use of diagrams to explain concepts. Diagrams / figures have high quality.	Professional standard with all assumptions stated and clauses referenced. Easy to follow and logical structure and clear checking or results made. Excellent use of diagrams to explain concepts. Some diagrams / figures are self-drawn with high quality.
Design proposal	15	The designs for the two projects are incomplete. The background /introductory information is not sufficient for a detailed introduction of the design. The design has apparent mistakes.	The designs are complete, but apparent mistakes exist. The background /introductory information is generally clear. The design plots are fine, but need further improvements.	The proposed designs are complete. The background /introductory information is generally clear and can support the design in a good manner. The plots are good.	The proposed designs are complete. The background /introductory information can perfectly support the designs. The designs are innovative.
Method of construction	5	The method of construction has not been or poorly presented. The related geotechnical knowledge and construction procedures are poorly covered.	The method of construction has been presented briefly. The related geotechnical knowledge and construction procedures are covered briefly.	Good discussion of the fundamental soil mechanics theories behind the identified design example. The analysis is detailed enough to explain the design requirements.	Excellent discussion of the fundamental / advance soil mechanics theories behind the designs. The analysis covers both the existing published data and new explanations.
Design priorities	5	Poor attempt to relate the designs to the design priorities.	Some attempt to explain the design priorities, but not in sufficient detail. Brief suggestions for future development have been provided.	Good summary of the design priorities and clear linkages with the real engineering practice. Good suggestions for future development have been provided.	Good summary of the design priorities and clear linkages with the real engineering practices, particularly with the design projects. Good suggestions for multiple future developments (e.g. beyond the studied subject) have been provided.