OCW 2020
FUNDAMENTALS OF GEOTECHNICAL ENGINEERING

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1. INTRODUCTION.

Geotechnical engineering is the study of the behaviour of soils under the influence of loading forces and soil-water interactions. This knowledge is applied to the design of foundations for structures, sub-grades for roadways, retaining walls, embankment for water storage and flood control, and containment systems for hazardous materials. As such, the geotechnical engineer is involved in field and laboratory investigations to determine the engineering properties of site soils and other geomaterials and their subsequent use in the analytical study of the problem at hand.

In this course, the fundamentals of geotechnical engineering are introduced, including the basic concepts and applications of soil mechanics and rock mechanics. So that, at the end of the course, the student will have achieved the necessary skills to apply to more specific practical disciplines such as Transportation Infrastructure, Construction Engineering, Building, etc.

2. PREREQUISITES.

This course is intended for undergraduates and first year graduate students. It is a convenient that students are comfortable with mathematical calculations, physics and basics of Geology.

3. LEARNING OUTCOMES.

On successfully completing this course, students will be able to:

LO1. Understand the importance and variability of geomaterials and their impact on civil engineering design.

LO2. Characterise and classify soils, rocks and rock masses from a geotechnical engineering perspective.

LO3. Calculate initial and loading induced stresses and associated displacements below or near shallow foundations, and interpret the results.

LO4. Determine critical failure states for different types of soils, intact rocks and rocks masses.

LO5. Calculate bearing capacity of shallow foundations under different load conditions and interpret the results.

4. COURSE DESCRIPTION.

This course is explained along eight lessons. The first one is an introduction to geotechnical engineering. Lessons 2 and 3 are devoted to identify and classify soil, rocks and rock masses. Finally, lessons 4 to 8 focus on the mechanical behaviour of soils, rocks and rock masses: stresses, settlement analysis and bearing capacity. Special care is taking to mention, explain and work with international standards when necessary. In each lesson, a theoretical presentation will provide the knowledge about the main concepts, while the list of exercises (with answers) will serve to apply the theoretical concepts to real engineering situations.

Two professors, Jesús Mª Hernández and Mª Helena Fernandes, having more than 25 years' experience in this area, constitute the teaching staff.

5. CONTENTS.

1. Introduction. Purpose of Geotechnical Engineering.

   Definitions. Site exploration and characterization: buildings, underground works, tunnels, retaining walls, slope stability. Historical failures.

2. Basic characteristics of soils and rocks.

   Components of soils. Mass and volume relationships. Basic properties and other specific characteristics. Rock mass: definitions. Physical properties of intact rocks: unit weight, porosity, durability and permeability. International standards.

3. Soil and rock classification.

   Soil particles: sizes and shapes. Particle size distribution analysis. Properties of clays. Atterberg limits. Plasticity chart. Unified Soil Classification System (USCS). Rock and rock mass classifications: weathering grade, RQD, RMR. International standards.

4. Stresses.

   Geostatic stresses. Effective stresses. Mohr's circles. Stress distribution due to applied surface loads. Flow of water in soil: permeability. Stress distribution between the phases of a soil.

5. Settlement analysis.

   Definitions. Allowable settlements. Immediate settlement. Consolidation settlement. International standards.

6. Shear strength of soils.

   Definitions. Mohr-Coulomb failure criterion. Direct shear test. Triaxial compression tests. Unconfined compression test. Values of shear strength parameters. International standards.

7. Bearing capacity.

   Definitions. Calculations. International standards.

8. Mechanical behaviour of rock masses.

   Definitions. Mechanical properties of the intact rock: laboratory and in situ tests. Failure criteria for intact rocks: Mohr-Coulomb, Hoek & Brown. Discontinuities. Failure criteria for rock masses. Deformability. Bearing capacity. International standards.

6. METHODOLOGY.

For each lesson, first, the student should carry out a comprehensive reading of the study material. In some lessons, there is additional information, such as specific videos and standards, so that the student can use them for a better comprehension of the concepts. Then, the student should try to solve the set of exercises. The answers to the questions proposed in the exercises are included at the end of each exercise, so that the student can check whether the exercise has been successfully completed. In addition, several exercises are completely solved.

Finally, the student should fulfil the self-evaluation, which encompasses theoretical questions and exercises, and verify with the resolutions included, whether the self-learning has been successful.

7. LECTURE MATERIALS, READINGS AND OTHER RESOURCES.

In this course, the following materials are provided:

- Lecture materials. For each lesson, a presentation of the basic theoretical concepts is included. In these documents, links to additional information and comprehensive videos are also added.
- Standards and specifications. This course is devoted to geotechnical engineering, which is an area strongly regulated by all the countries. Along the course, it is very common to follow the requirements provided by international

regulations, such as Eurocodes (in Europe), the Technical Building Code (in Spain) and ASTM Standards (in USA). Therefore, some links to those regulations are included. In the case of ASTM Standards, the link to the books containing standards related to soils and rocks is provided.

- Comprehensive videos. For each lesson, additional videos for a better understanding of the lecture materials are included. It will be interesting that students watch those videos.
- Assignments. Also for each lesson, a set of exercises is included. Some of them are completely solved in an additional document, so these exercises could also be used as self-evaluation exercises. Anyway, every exercise is given with the final answers.

8. COURSE TIMELINE.

This course is expected to be finished in 12 weeks, 7 hours/week. In table 1, the hours necessary to complete successfully each lesson are presented. In addition, a timeline of activities is included in table 2.

Lesson	Theory/quiz	Exercises
1. Introduction. Purpose of Geotechnical Engineering.	**3**	**0**
2. Basic characteristics of soils and rocks.	**4**	**8**
3. Soil and rock classification.	**6**	**12**
4. Stresses.	**4**	**7**
5. Settlement analysis.	**6**	**10**
6. Shear strength of soils.	**6**	**2**
7. Bearing capacity.	**4**	**8**
8. Mechanical behaviour of rock masses.	**4**	**0**

Table 1. Recommended hours for each lesson.

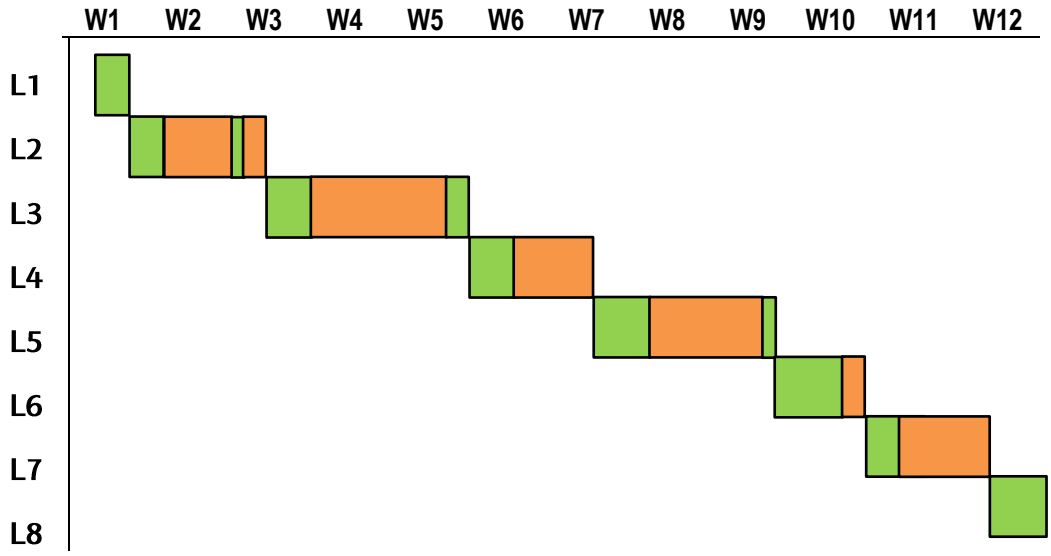

Table 2. Timeline of activities (green = theory, quiz; orange = exercises).