# Course guide
# 250804 - 250804 - Soils Mechanics

**Last modified:** 25/01/2024

**Unit in charge:** Barcelona School of Civil Engineering
**Teaching unit:** 751 - DECA - Department of Civil and Environmental Engineering.

**Degree:** MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Compulsory subject).

**Academic year:** 2023 **ECTS Credits:** 5.0 **Languages:** Spanish

## LECTURER

**Coordinating lecturer:** CARLOS MARIA LOPEZ GARELLO

**Others:** CARLOS MARIA LOPEZ GARELLO, ANNA RAMON TARRAGONA, ENRIQUE EDGAR ROMERO MORALES

## TEACHING METHODOLOGY

The course consists of 2.3 hours per week of classroom activity (large size group) and 0.7 hours of laboratory works.

The 1.8 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

0.5 hours are devoted to solving practical problems. The objective of these practical exercises is to consolidate and evaluate the general and specific learning objectives.

The rest of weekly hours (0.7h) are devoted to laboratory practice.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

## LEARNING OBJECTIVES OF THE SUBJECT

To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
To characterize the geological environment and its interaction with civil works.
To interpret laboratory tests and field observations so as to identify the mechanisms responsible for soil response. To propose laboratory testing programmes.
To formulate and implement Finite Element and Finite Differences numerical models with the objective to analyze the processes that govern ground response, to interpret field information and to predict soil response.

* To apply the theoretical concepts of flow and transportation on porous media.
* To characterize soils.
* To apply the theoretical concepts of deformation and flow in soils.
* To characterize rock massifs and their discontinuities.
* To apply the concepts of mechanical stability and flow in cracks.
* To apply the theoretical problems of elastic and electromagnetic wave propagation in soils and rocks.
* To interpret and process wave signals.

- Basic identification of soils. Laboratory practice.
- Water in soils. Laboratory practice.
- Soil as a continuum. Elasticity and plasticity.
- Experimental observation of soil mechanical behaviour.
- Flow-deformation coupling.

Conceptualize soils as porous media governed by concepts Solid and Fluid Mechanics.
Characterize the geological environment and their interaction with civil works.
Interpret laboratory tests and field observations to identify the mechanisms responsible for the response of the land. Plan programs of experimentation in the laboratory.

* Apply the theoretical concepts of flow and transport in porous media.
* Characterize soils.
* Apply the theoretical concepts of deformation and flow of soils.

- Basic identification of soil.
- The water in the soil.
- The soil as a continuum. Elasticity and plasticity.
- Experimental observation of the mechanical behavior of soils.
- Coupling flow-deformation.
- Analysis of soil failure

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours small group | 9,8 | 7.83 |
| Self study | 80,0 | 63.95 |
| Hours large group | 25,5 | 20.38 |
| Hours medium group | 9,8 | 7.83 |

**Total learning time:** 125.1 h

## CONTENTS

### 1. Introduction to Soil Mechanics

**Description:**
Subject of Soil Mechanics. Geotechnical problem characteristics. History of SM. Mineralogy and soil structure.

**Specific objectives:**
Conceptualize soils and rocks as porous media

**Full-or-part-time:** 7h 11m
Theory classes: 3h
Self study : 4h 11m

### 2. Basic properties and soil classification

**Description:**
- Presentation of the theory (particle size and parameters, specific surface, consistency, plasticity, Casagrande ) (1h)
- Observation of consistency changes of Barcelona's red clay (0.5h)
- realization of the rehearsal and límite líquido Plastic límite (0.5h)
- Visual/manual classification of 10 different soils (1h)

**Specific objectives:**
Knowing the unified soil classification system. Distinguish between different types of soil.

**Full-or-part-time:** 7h 11m
Laboratory classes: 3h
Self study : 4h 11m

### 3. Water flow in saturated soil. effective stresses

**Description:**
- Pressure head, Darcy law, permeability (1h)
- Equation of flow. Methods of solution (1h)
- Potential and current functions. Flow nets. (0.5h)
- Examples (0.5h
Total and effective stress. Stress distribution in the field. Filtration forces. Internal erosion. Earth dams. Hydraulic heave, piping and hydraulic uplift.
- Factors that influence permeability, measurement of permeability, permeameter for variable and constant head, estimation of the critical gradient. (0.75 h)

-Initial estimation of permeability and the critical gradient (0.5h)

-Realization of the test with the falling head permeameter. Calculations (0.75 h)

-Realization of the permeameter of constant head test. Calculations (0.5h)

- Experimental determination of critical gradient. (0.5h)

**Specific objectives:**
Solve flow problems saturated media.
Know the differences between total and effective stresses. Evaluate filtration forces. Learn the basis of design of earth dams.
Solve hydraulic heave problems in deep excavations.
Know the factors that determine the permeability of the soils.
Know experimental techniques to permeability measurement.
See a sand liquefaction process.

**Full-or-part-time:** 21h 36m
Theory classes: 6h
Laboratory classes: 3h
Self study : 12h 36m

### 4. Consolidation 1D

**Description:**
- Deformation in confined conditions. Irreversible deformation. Preconsolidation pressure. Primary and secondary consolidation. Parameters (1h)
- Equation of 1D consolidation. Degree of consolidation. Non uniform increase in interstitial pressure (1h)
- Radial and three-dimensional flow. Variable load in time (0.5h) - Examples (0.5h)

**Specific objectives:**
Understand the phenomenon of consolidation and the coupling between the flow of water and soil deformation.
Resolve problems associated with soil 1D consolidation.

**Full-or-part-time:** 7h 11m
Theory classes: 3h
Self study : 4h 11m

**First test**

**Description:**
- 10 theoretical and practical questions (1.5h)
- Break (0.25h)
- 1 Problem (1,25h.)

**Specific objectives:**
Assess the level of knowledge acquired by students by conducting practical execices

**Full-or-part-time:** 7h 11m
Practical classes: 3h
Self study : 4h 11m

**5. Constitutive models. Elasticity**

**Description:**
- Tensors of stresses and strains. Invariants. Typical stress variables (1 h)
- Circle of Mohr (0.5h)
- Stress paths in typical tests (0.5h)
- Slasto-plastic models (1h)

**Specific objectives:**
- Know the stress and strain variables used in Soil Mechanics.
- Ability to work with Mohr's circle.
- Know the basis of the elasto-plastic models.

**Full-or-part-time:** 7h 11m
Theory classes: 3h
Self study : 4h 11m

**6. Deformation and strength of soils**

**Description:**
- Dilatance. Undrained behaviour (0.75h)
- Failure envelope. Undrained strength (0.75h)
- Experimental behaviour of sands (1.75h)
- Experimental behavior of clays. Clays in triaxial test (1.5h)
-Critical state (1.0h)
- Elasto-plastic models. Introduction (0.5h)

**Specific objectives:**
Understanding the phenomenon of dilatancy and generating pore pressures in undrained conditions.
Understanding the process of undrained failure.
Knowing the mechanical behaviour of the sands.
Knowing the behavior of clays in drained and undrained conditions.
Knowing the critical state significance.
Learn the basics of critical state models in clay.

**Full-or-part-time:** 14h 23m
Theory classes: 6h
Self study : 8h 23m

### 7. Unsaturated soils. Compaction.

**Description:**
- Presentation of the theory (1.25 h)
- Calculation of compaction parameters (0.25h)
- Sample preparation and compaction test (0.75h)
- Preparation of equipment and flood under load test (0.75h)

**Specific objectives:**
Understanding the effect of suction in unsaturated soils. Knowing the behavior of compacted soils.
Knowing the phenomenon of the collapse of unsaturated soils.

**Full-or-part-time:** 7h 11m
Laboratory classes: 3h
Self study : 4h 11m

### 8. Analysis in failure. earth pressure.

**Description:**
- Failure analysis. Real cases (0.15h)
- General equations. Methods of analysis (0.35h)
- Method limit equilibrium (0.25h).
- Method of Coulomb (0.25h).
- Method of slices. Bishop (0.25h).
- Earth pressure at rest. Active and passive states (0.35h)
- Coulomb method (0.5h)
- General case. Effect of water (0.15h)
- Rankine. Horizontal surface (0.5h)
- Rankine. Inclined surface (0.25h).

**Specific objectives:**
Knowing how to soil masses fail.
Using methods limit equilibrium.
Knowing the method of Coulomb.
Knowing Rankine theory.

**Full-or-part-time:** 7h 11m
Theory classes: 3h
Self study : 4h 11m

### Second Test

**Description:**
- 10 theoretical and practical questions (1 h)
- Break (0.25h)
- 1 Problem (1 h)

**Specific objectives:**
Solve problems and evaluate the acquired knowledge

**Full-or-part-time:** 7h 11m
Practical classes: 3h
Self study : 4h 11m

## GRADING SYSTEM

The mark of the course is obtained from the ratings of continuous assessment and their corresponding laboratories and/or classroom computers.

Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom): Problems to solve and Atenea's questionnaires.

The teachings of the laboratory grade is the average in such activities (laboratory reports).

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application exercises.

The final mark is set with the following weights:

0.40 [average of two partial tests]
0.25 [average rating of the delivered problems]
0.20 [average rating of individual practices]
0.15 [average rating of Athena questionnaires]

## EXAMINATION RULES.

- Not all material included with the documentation of the course it will be explained in class. Classes will focus on aspects of more importance and difficulty. The rest will have to work on it at home, with the help of notes, additional documentation, and interaction with other students ("forum") or the teacher in after-hours.

* Questions on exams may refer to all the teaching material provided, although not explained in class (not included here "further" teaching material and recommended readings).

* In all the examination (both part of theory as the practical part) will not be allowed make queries to any type of document (books, notes, fixes, etc.), or conversations between students. Also will not be allowed to use mobile, tablets, PCs, etc.

* In the examinations, for the realisation of the problems it will be allowed that each student has a form that must be contained on one side of a DIN A4 sheet. This form must be written by hand (not photocopies) and may not include texts different from mathematical formulas. Any breach of these rules will mean the expulsion of the examination and a global note of 0 in the global of test.

* In case of absence in an examination (without justified cause proven by documents), the note of the examination will be zero.

* If not attending any of the practices or is not delivered the corresponding report by the deadline,(without justified cause...), the note of the set of practices will be zero.

* If a problem or a questionnaire of those proposed for evaluation is not delivered by the deadline , the note for this problem or questionnaire will be zero.

## BIBLIOGRAPHY

**Basic:**
- Lambe, T.W.; Whitman, R.V. Mecánica de suelos. 2a ed. México: Limusa : Noriega, 1995. ISBN 9681818946.
- Wood, D.M. Soil behaviour and critical state soil mechanics. Cambridge: University Press, Cambridge. ISBN 0-521-33782-8.