Course guide
250819 - 250819 - Soil Behaviour and Advanced Modelling

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). (Optional subject).

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

LECTURER

Coordinating lecturer: JEAN VAUNAT

Others: JEAN VAUNAT

TEACHING METHODOLOGY

The course consists of 3 hours per week of classroom activity.

During the course, 20 hours are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

15 hours are devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

Support material is provided using the virtual campus ATENEA: detailed teaching plan, content, learning advance plan, evaluation activities 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 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 analyze, discriminate and integrate geological and geotechnical information in studies and projects.
To analyze, from the perspective of an expert, cases of failure in Geotechnical Engineering. To report the evidences, identify the mechanisms responsible for the failure and verify using back- analysis models.Eventually provide solutions to risk reduction. (Specific competence of the specialization in Geotechnical Engineering).
To use, in a discriminate manner, commercial software for numerical calculations in order to design and eventually monitor geotechnical structures. (Specific competence of the specialization in Geotechnical Engineering).

* To apply advanced concepts in continuum media and material mechanics to soils and rocks.
* To use advanced behaviour laws to model the stress-deformation response of soils and rocks.
* To differentiate the response of laboratory reconstituted soils from that of natural soils.
* To correctly interprete the response of the latter.
* To use laws of behaviour that include the effect of environmental variables.
* To use in a discriminated manner calculation software to model geotechnical engineering problems.

- Introduction. Fabric and structure of natural soils.
- Laboratory soil testing. Controlling variables.
- Theory of plasticity. Hardening and softening. Shear failure criterion.
- Behavior of remoulded soil. Critical State theory. Consequences in engineering practice.
- Behavior of natural soils. Effect of structure. Elastoplastic modeling.
- Irreversible deformations within the limit envelope. Cyclic strain accumulation. Nested plasticity.
- Inclusion of environmental variables.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Introduction

Description:
Presentation of the course, teaching methodology, type of evaluation, self-presentation by students. Introduction about the content of the course: brief description of the typical responses of soils considered - clays and silts reconstituted in the laboratory, clays and natural silts, clay rocks, sands, cemented sands, sandstones - definition of the concept of micro-structure. Presentation the literature.

Specific objectives:
Recognize the difference between the behavior of natural and reconstituted soils. Acquire the concept of soil micro--structure. Be aware of the logistic aspects of the course (learning advance schedule, evaluation activities, ...).

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

Laboratory tests and modeling frameworks

Description:
Define the concept of deformation, stress and effective stress.
Brief presentation of the theories of elasticity, plasticity and visco-plasticity. Formulation of the one-dimensional theory of perfect and hardening plasticity. One-dimensional Illustration of the concepts of loss of existence and uniqueness in material response.
Presentation of conventional and unconventional tests available in the laboratory to study the response of soils
Implementation of a driver for the integration of an elastic model under triaxial conditions. Simulation of synthetic tests.

Specific objectives:
Handle the variables controlling the mechanical behavior of soil.
Know available frameworks to model the behavior of soils. Handle more particularly the framework of elastoplasticity.
Choosing the most appropriate laboratory tests to study the response of soils under given conditions. Interpret the experimental response.
Acquire concepts to develop a driver for the integration of mechanical laws under mixed stress-strain control. Formulate a elastic model. Apply it to common stress paths in Geotechnics.

Full-or-part-time: 14h 23m
Theory classes: 4h
Practical classes: 2h
Self study : 8h 23m

Mechanical behavior of soils

Description:
Presentation of Mohr-Coulomb shear failure criterion. Formulation of an elastoplastic model based on this criterion. Description of solutions to the problem of the shape of the failure criterion in the deviatoric plane. Discussion on the dilatant aspect of the model. Brief presentation of applications of this type of model in Geotechnics.
Development of an elastoplastic model based on shear strength criterion
Remoulded soil behavior and modeling the phenomenon of dilatancy / contractancia
Development of a model critical condition
Behavior of natural soils and modeling of the phenomenon of destructuración
Behavior within the limit envelope and modeling of the progressive appearance of plastic deformations
Development of an elastoplastic model with softening by degradation

Full-or-part-time: 55h 12m
Theory classes: 10h
Practical classes: 13h
Self study : 32h 12m

Soil behavior under environmental actions

Description:
Modelling unsaturated soil behavior
Modeling of the thermal load response
Introduction to modeling the response of soils under chemical changes
Introduction to the modeling of microstructural changes

Full-or-part-time: 26h 24m
Theory classes: 11h
Self study : 15h 24m

Final evaluation

Full-or-part-time: 4h 48m
Laboratory classes: 2h
Self study : 2h 48m

GRADING SYSTEM

Course mark is computed from the ratings obtained during continuous evaluation activities and evaluation tests.

Continuous evaluation consists in several additive and training activities carried out during the year in and out of the classroom. They are realized individually or in group.

Evaluation tests consist of questions on concepts associated with knowledge/understanding learning objectives, completed by several application exercises.

EXAMINATION RULES.

Any continuous evaluation activity not presented in the scheduled period will be granted with a null mark.

BIBLIOGRAPHY

Basic:
- Mitchell, J.K.; Soga, K. Fundamentals of soil behavior. 3rd ed. Hoboken: John Wiley & Sons, 2005. ISBN 0471463027.
- Leroueil, S. & Hight, D.. Behaviour and properties of natural soils and soft rocks. Lisse: Swets & Zeitlinger, 2002. ISBN 90 5809 537 1.
- Potts, David M; Zdravkovic, Lidija. Finite element analysis in geotechnical engineering. London: Thomas Telford, 1999-2001. ISBN 0727727532.