Course guide
250820 - 250820 - Numerical Models in Geotechnical Engineering

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: ALBERTO LEDESMA VILLALBA

Others: ALBERTO LEDESMA VILLALBA, PERE PRAT CATALAN

TEACHING METHODOLOGY

The course consists of 3 hours/week of classes in a small group. Approximately, 2 hours/week correspond to theoretical classes and the rest to practical classes involving examples developed on a computer.

Additional material is also provided on the website ATENEA, including the material used in the class as well.

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 interpret 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. Finite element method.
- Soil constitutive models.
- Special problems and boundary conditions. Effective stress. Excavations. Embankments construction. Natural slopes.
- Rock mechanics problems.
- Structure and use of a Finite Element program.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Introduction. The Finite Element Method.

Description:
Brief presentation of the subject and the numerical methods in the context of Geotechnical Engineering
Reminder of the basics of the Finite Element Method
Examples of application of the finite element method to problems of elasticity in 2 dimensions

Specific objectives:
Presentation about the subject.
Remember the concepts of Finite Element Method in general.
Illustrate the theory of finite element method with simple examples

Full-or-part-time: 14h 23m
Theory classes: 5h
Practical classes: 1h
Self study : 8h 23m

Constitutive equations. Elastic and Elasto-plastic models.

Description:
Concept constitutive law. Elastic model in 2D and 3D. Axisymmetric geometry. Transverse anisotropy. Hyperbolic model.
Description of critical state models
Description of other typical models in Geotechnics. The elastic - perfect plastic Mohr-Coulomb model. Hardening and softening.
Visco-elastic and visco-plastic models.
Examples of application of constitutive equations.

Specific objectives:
Role of constitutive equations in numerical analysis. Description of elastic model and its variants.
Understanding the fundamental features of the critical state models and its ability to simulate the mechanical behavior of the soil.
Understanding other families of constitutive models from the basic models of plasticity.
Illustration theoretical aspects described in the subject

Full-or-part-time: 24h
Theory classes: 8h
Practical classes: 2h
Self study : 14h

Fluid-solid interaction. Formulation of Biot

Description:
General equations of Biot formulation. u-p approach and formulation of the finite element solution.
Application of the u-p formulation to flow and consolidation problems.
Application of the u-p formulation to soil dynamics problems.
Application examples: subsidence of Venice, flow problems in earth dams, San Fernando dam in California.

Specific objectives:
Understand the concept of H-M coupled formulation of the problem and the particular case of the u-p formulation.
Understanding a particular case of application of the u-p formulation.
See the application of the u-p formulation to seismic engineering problems in the context of Geotechnics.
Illustrating the u-p formulation in complex real problems

Full-or-part-time: 26h 24m
Theory classes: 9h
Practical classes: 2h
Self study : 15h 24m

Boundary value problems in Geotechnical Engineering

Description:
Specific aspects of geotechnical problems: initial stresses, effective stresses and dissipation of water pressure.
Specific aspects to be considered in problems of construction and excavation

Specific objectives:
Understanding some specific aspects of Geotechnical Engineering in the field of simulation of real problems by finite elements.
Understand the specific aspects to be considered in geotechnical problems when solving via finite elements

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

Application examples

Description:
Illustration of the concepts explained in various problems

Specific objectives:
Understand the application of numerical methods in real cases of Geotechnical Engineering.

Full-or-part-time: 21h 36m
Practical classes: 9h
Self study : 12h 36m

Assessment

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

GRADING SYSTEM

Final exam of the subject at the end of the semester. Additional examination after at least a week for students who do not pass the initial exam.

EXAMINATION RULES.

Exams consist of several short questions to answer in the sheets provided. Books, class-notes, etc. are not allowed. Typical duration: 2 hours,

BIBLIOGRAPHY

Basic:
- Potts, D.M., Zdravkovic, L. Finite element analysis in geotechnical engineering. London: Thomas Telford, 1999-2001. ISBN 0727727532.
- Zienkiewicz, O.C.; Morgan. K. Finite elements and approximation. Mineola, NY: Dover, 1983. ISBN 9780486453019.

Complementary:
- Profesores asignatura. Material Adicional disponible en Atenea [on line]. [Consultation: 08/03/2021]. Available on: atenea.upc.edu.