UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Course guide
250803 - 250803 - Modelling of Flow and Transport in Porous Media

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: DANIEL FERNANDEZ GARCIA

Others: DANIEL FERNANDEZ GARCIA, MAARTEN WILLEM SAALTINK

TEACHING METHODOLOGY

The course consists of 3 hours per week of classroom sessions in the classroom. Class hours are divided into theoretical hours which teachers exposed the basic concepts and materials of the subject; Class hours presenting examples and doing exercises; Hours and modeling workshops where the teacher presents a specific software for the modeling of flow and transport in porous media. Support material is used in the form of detailed teaching plan using the virtual campus ATENEA: content, programming and evaluation activities directed learning 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.

- General process to model natural phenomena.
- Basic formulation of hydrogeological problems.
- Formulation of the flow equation.
- Resolution of the flow equation by means of numerical methods.
- Methodology to model aquifers flow.
- Formulation of the transport equation.
- Numerical resolution of the transport equation and its difficulties.
- Real cases.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Introduction

Description:
Conceptos
Review of the governing equations

Specific objectives:
Introduction to basics
review

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

Flow models

Description:
Description of the finite difference method to solve the flow equation
Presentation of the finite element method to solve the equation of flow in porous media
Solving exercises in class

Specific objectives:
Learned finite differences to solve the flow equation
Learn the finite element method to solve the equation of flow in porous media
Consolidate knowledge through exercises

Full-or-part-time: 38h 24m
Theory classes: 12h
Practical classes: 4h
Self study : 22h 24m

Transport Models

Description:
Solving the transport equation through Eulerian methods based on finite differences and finite elements
Solving the transport equation with Lagrangian methods

Specific objectives:
Learn how to solve the equation Eulerian transport methods based on finite differences and finite elements
Learn how to solve the transport equation with Lagrangian methods

Full-or-part-time: 19h 12m
Theory classes: 8h
Self study : 11h 12m

Inverse problem

Description:
Nonlinear regression. Automatic calibration for solving the flow and transport equation
Description of statistics associated with the automatic calibration

Specific objectives:
Learn automatic calibration
Learn statistics associated with the automatic calibration

Full-or-part-time: 18h
Theory classes: 7h 30m
Self study : 10h 30m

Nonlinear Problems

Description:
Unconfined aquifers, unsaturated zone
Nonlinear problems in the transport equation

Specific objectives:
Learn problem solving nonlinear
Learn solving nonlinear problems

Full-or-part-time: 8h 24m
Theory classes: 3h 30m
Self study : 4h 54m

Workshops modeling

Description:
workshops

Specific objectives:
consolidate knowledge

Full-or-part-time: 12h
Laboratory classes: 5h
Self study : 7h

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review

Full-or-part-time: 7h 11m
Laboratory 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).

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

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 (NF) is the weighted average of homework (PR), exams (EX) and the final course (TR), such that :

PR NF = 0.1 *PR + 0.6 * EX + 0.3 * TR

EXAMINATION RULES.

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

BIBLIOGRAPHY

Basic:
- Zheng, Chunmiao; Bennett, Gordon D. Applied contaminant transport modeling : theory and practice. New York [etc.]: Van Nostrand Reinhold, cop. 1995. ISBN 0442013485.
- Anderson, Mary P; Woessner, William W. Applied groundwater modeling : simulation of flow and advective transport. San Diego: Academic Press, cop. 1992. ISBN 0120594854.
- Harbaugh, A.W.; Banta, E.R.; Hill, M.C.; McDonald, M.G. MODFLOW-2000: the U.S. Geological Survey Modular Ground-Water Model: user guide to modularization concepts and the ground-water flow process [on line]. Reston, VA: U.S. Geological Survey, 2000 [Consultation: 30/07/2021]. Available on: http://mmc.geofisica.unam.mx/cursos/hc/Software/Software/MODFLOW/MODFLOW-2000%20Ref%20Manual%20-%20OFR-00-92.pdf.
- Istok, J. Groundwater modeling by the finite element method. American Geophysical Union, 1989. ISBN 9780875903170.
- Bear, Jacob; Verruijt, A. Modeling groundwater flow and pollution : with computer programs for sample cases. Reprinted with corrections. Dordrecht: D. Reidel Pub. Co, 1994. ISBN 1556080158.
- Pinder, George Francis; Gray, William G. Finite element simulation in surface and subsurface hydrology. San Diego [etc.]: Academic Press, cop. 1977. ISBN 0125569505.