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

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).

Last modified: 07/10/2020

Academic year: 2020  ECTS Credits: 5.0  Languages: Spanish, English

LECTURER
Coordinating lecturer: DANIEL FERNANDEZ GARCIA
Others: DANIEL FERNANDEZ GARCIA, MAARTEN WILLEM SAALTINK

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
13308. To conceive soils and rocks as porous media governed by Solid and Fluid Mechanics.
13309. To characterize the geological environment and its interaction with civil works.
13310. To interpret laboratory tests and field observations so as to identify the mechanisms responsible for soil response. To propose laboratory testing programmes.
13311. 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.

General:
13300. To apply advanced knowledge in sciences and technology to the professional or research practice.
13305. To conceive Geo-engineering as a multi-disciplinary field that includes relevant aspects from geology, sismology, hydrogeology, geotechnical and earthquake engineering, geomechanics, physics of porous media, geophysics, geomatics, natural hazard, energy and climate interactions.
13306. To promote innovation for the development of methodology, analyses and solutions in Geo-engineering.
13307. To tackle and solve advanced mathematical problems in engineering from the drafting of the problem to the development of formulation and further implementation in computer programs. Particularly, to formulate, code and apply analytical and numerical advanced computational tools to project calculations in order to plan and manage them as well as to interpret results in the context of Geo-engineering and Mining engineering.

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.
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

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours large group</td>
<td>19,5</td>
<td>15.59</td>
</tr>
<tr>
<td>Self study</td>
<td>80,0</td>
<td>63.95</td>
</tr>
<tr>
<td>Hours medium group</td>
<td>9,8</td>
<td>7.83</td>
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<tr>
<td>Hours small group</td>
<td>9,8</td>
<td>7.83</td>
</tr>
<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.80</td>
</tr>
</tbody>
</table>

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: 33h 36m
- Theory classes: 10h
- Practical classes: 4h
- Self study: 19h 36m

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: 16h 48m
- Theory classes: 7h
- Self study: 9h 48m

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: 10h 48m
- Theory classes: 4h 30m
- Self study: 6h 18m
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

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: