Course guides
250423 - TUNMECROQU - Tunnels and Rock Mechanics

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.
Degree: MASTER'S DEGREE IN CIVIL ENGINEERING (PROFESSIONAL TRACK) (Syllabus 2012). (Optional subject).

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

LECTURER

Coordinating lecturer: NURIA MERCE PINYOL PUIGMARTI
Others: IGNACIO CAROL VILARASAU, ALESSANDRA DI MARIANO SIMONCINI, NURIA MERCE PINYOL PUIGMARTI, ANNA RAMON TARRAGONA

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
8200. The ability to apply knowledge of soil and rock mechanics to the study, design, construction and operation of foundations, cuts, fills, tunnels and other constructions over or through land, whatever its nature and state, and whatever the purpose of the work.

Transversal:
8559. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
8560. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
8561. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

TEACHING METHODOLOGY

The course consists of 3 class hours devoted to theory and exercises, and some case studies will also be presented.
LEARNING OBJECTIVES OF THE SUBJECT

Specialization subject in which knowledge on specific competences is intensified.

Knowledge and skills at specialization level that permit the development and application of techniques and methodologies at advanced level.

Contents of specialization at master level related to research or innovation in the field of engineering.

Acquiring the necessary knowledge for the interpretation of the behavior of rocks and the ability to design geotechnical constructions, especially underground excavations, both in soil and rocks.

The contents of the course will provide the student with knowledge and skills related to:
- Characterization of the mechanical and hydrological behavior of rock masses.
- Characterization of the behavior of the rock matrix.
- Characterization of the behavior of the discontinuities based on the theories of fracture mechanics.
- Characterization, interpretation, and estimation of the stress-strain behavior around an excavation taking into account the elastic and plastic behavior of the terrain using analytical, empirical, and numerical solutions.
- Interpretation and prediction of the mechanical behavior of different types of tunnel supports (shotcrete, bolts, steel ribs and concrete rings) and their interaction with the ground.
- Understanding, interpretation and prediction of the movements induced by underground excavations.
- Knowledge of the different procedures of excavation of tunnels.
- Knowledge of specific real cases.

STUDY LOAD

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

Total learning time: 125.1 h

CONTENTS

Introduction

Description:
- General introduction
- Introduction to the Rock Mechanics part

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

**Description:**
- Introduction. Mechanisms and modes.
- Linear fracture mechanics (Griffith theory, stress intensity factor, toughness)
- Nonlinear fracture mechanics. Scale effect. Onset and propagation of fractures
- Example/Practice: Scale effect on the behaviour of the earth-dam

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

### Rock matrix, joints and rock mass

**Description:**
- Rock matrix. Tests. Mohr-Coulomb & Hoek-Brown criteria
- Discontinuities. General aspects. Patton & Barton Choubey failure criteria

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

### Insitu stresses

**Description:**
- Significance. Stress states in an excavation site.

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

### Water and rock mass

**Description:**
- Characteristic curves of tunnels in the presence of water flow. Implications.

**Full-or-part-time:** 6h  
Theory classes: 2h 30m  
Self study: 3h 30m

### Circular tunnel in elastoplastic soil. Characteristic curves

**Description:**
- Plain deformation. Mohr-Coulomb elastoplastic model. Hoek-Brown elastoplastic model.

**Full-or-part-time:** 9h 36m  
Theory classes: 4h  
Self study: 5h 36m
## Interaction tunnel support

**Description:**
Bearing curves. Bolts. Circular linings and ribs. 3D phenomena in the face.

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

## Construction of tunnels in rock

**Description:**
Traditional methods. New Austrian Method. Stability of portals. TBMs and TSMs

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

## Tunnel face stability

**Description:**
Application of plastic collapse theorems. 2D and 3D solutions for circular tunnels

**Full-or-part-time:** 3h 35m  
Practical classes: 1h 30m  
Self study: 2h 05m

## Construction of tunnels in soil

**Description:**  
- Traditional Belgian and German methods. Example/Practice: Subway construction in Barcelona  
- Shields. Example/Practice: HST line

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

## Movements induced by tunneling

**Description:**  

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

**Full-or-part-time:** 9h 36m  
Laboratory classes: 4h  
Self study : 5h 36m

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**GRADING SYSTEM**

The final course grade will be calculated on the basis of the geometric average of two exams taken during the course: the first one at about half of the semester (E1), and a second one at the end of it (E2).

Exam E1 will cover the first part of the course (Rock Mechanics) and exam E2 will cover the second part (Underground Excavations):

Final grade = √(GradeE1 * GradeE2)

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**EXAMINATION RULES.**

Failure to perform the second test will result in a mark of zero.

It is not possible to advice with notes during the exams.

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**BIBLIOGRAPHY**

**Basic:**

**Complementary:**