

250423 - TUNMECROQU - Tunnels and Rock Mechanics

Coordinating unit: 250 - ETSECPB - Barcelona School of Civil Engineering  
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering  
Academic year: 2015  
Degree: MASTER'S DEGREE IN CIVIL ENGINEERING (PROFESSIONAL TRACK) (Syllabus 2012). (Teaching unit Optional)  
MASTER'S DEGREE IN CIVIL ENGINEERING (RESEARCH TRACK) (Syllabus 2009). (Teaching unit Optional)  
ECTS credits: 5  
Teaching languages: Spanish

Teaching staff

Coordinator: EDUARDO ALONSO PEREZ DE AGREDA  
Others: EDUARDO ALONSO PEREZ DE AGREDA, IGNACIO CAROL VILARASAU, NURIA MERCE PINYOL PUIGMARTI

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.

Teaching methodology

The course consists of 3 in-class hours in which theory and problem solving will be taught and case stories will be presented.

Students will apply the knowledge acquired by means of a report, which will consist in elaborating a preliminary draft of a tunnel in a real life environment. Typically the report should include the following aspects:

- Topographic and geological description of the site
- Structural description of the rock massif. Section of the tunnel and geomechanical classification. Estimate of the global strength parameters
- Analysis of the rock-bearing interaction. Determination of the characteristic curves. Linear and non-linear failure envelopes. Bearing curves
- Definition of bearing from the interaction analysis and the geomechanical classifications
- Analysis of the structural stability of the excavation
- Definition of the building procedure

Support materials, such as a detailed teaching plan, can be found in the virtual campus ATENEA: table of contents, activities scheduled and references.

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.

Ability to build geotechnical works, in special underground excavations in soils and rocks.

By the end of the course the students will be able: 1. To determine the properties of a rock from laboratory results geomechanically and hydrologically. 2. To characterize a rock massif through field data. 3. To solve problems regarding underground excavations identifying the materials to be crossed, proposing test campaigns and the most adequate machinery and analyzing the ground response.

Contents of the course:

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Theory classes: 19h 30m</th>
<th>15.60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<tr>
<td>Laboratory classes:</td>
<td>9h 45m</td>
<td>7.80%</td>
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<tr>
<td>Guided activities:</td>
<td>6h</td>
<td>4.80%</td>
</tr>
<tr>
<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
</tr>
</tbody>
</table>
### Content

<table>
<thead>
<tr>
<th><strong>Introduction</strong></th>
<th><strong>Learning time:</strong> 4h 48m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study : 2h 48m</td>
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</tbody>
</table>

- Excavations and tunnels. History of tunnelling
- Dyke foundations. Example: The failure of Malpasse.
- Stability of rock slopes. Example: The failure of Vaiont

<table>
<thead>
<tr>
<th><strong>Introduction to fracture mechanics</strong></th>
<th><strong>Learning time:</strong> 9h 36m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study : 5h 36m</td>
</tr>
</tbody>
</table>

- 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

<table>
<thead>
<tr>
<th><strong>Rock matrix, joints and rock mass</strong></th>
<th><strong>Learning time:</strong> 7h 11m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practical classes: 3h</td>
</tr>
<tr>
<td></td>
<td>Self study : 4h 11m</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th><strong>In situ stresses</strong></th>
<th><strong>Learning time:</strong> 9h 36m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study : 5h 36m</td>
</tr>
</tbody>
</table>

- Significance. Stress states in an excavation site.
# Circular tunnel in elastoplastic soil. Characteristic curves

**Learning time:** 9h 36m

- Theory classes: 4h
- Self study: 5h 36m

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

## Interaction tunnel support

**Learning time:** 4h 48m

- Theory classes: 2h
- Self study: 2h 48m

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

## Water and rock mass

**Learning time:** 7h 11m

- Theory classes: 3h
- Self study: 4h 11m

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

## Construction of tunnels in rock

**Learning time:** 7h 11m

- Theory classes: 3h
- Self study: 4h 11m

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

## Tunnel face stability

**Learning time:** 3h 35m

- Practical classes: 1h 30m
- Self study: 2h 05m

**Description:**
- Application of plastic collapse theorems. 2D and 3D solutions for circular tunnels
The course will be evaluated taking the mean of the two tests taken during the course and the final report.

There will be two tests: one at mid-term (E1) and another one by the end of the term (E2). Both tests will evaluate the knowledge of the students with regards to what has been taught by the time of the test is scheduled.

The result of the tests will be the maximum score of the second test plus the weighted mean of both tests (the first test will weight 40% and the second test will weight 60%).

Final test result = max. (0.4 * Result of E1 + 0.6 * Result of E2 ; ResultE2)

The report will be evaluated independently and will be 20% of the final score.

The final score of the course will be calculated as follows:

Final score = 0.8 * Final test result + 0.2 * Report score

The final score will be calculated from partial scores above 4 over 10.

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### Qualification system

**Construction of tunnels in soil**

- **Learning time:** 9h 36m
  - Theory classes: 4h
  - Self study: 5h 36m

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

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### Movements induced by tunneling

- **Learning time:** 9h 36m
  - Theory classes: 4h
  - Self study: 5h 36m

**Description:**

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### Test

- **Learning time:** 10h 48m
  - Laboratory classes: 4h 30m
  - Self study: 6h 18m

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Regulations for carrying out activities

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

Bibliography

Basic:


Complementary: