Course guide
250423 - TUNMECROQU - Tunnels and Rock Mechanics

Last modified: 03/10/2023

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).
MASTER'S DEGREE IN GEOTECHNICAL ENGINEERING (Syllabus 2015). (Optional subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ALESSANDRA DI MARIANO SIMONCINI, 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.

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

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

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:
- General introduction
- Introduction to the Rock Mechanics part
- Fundamentals and applications. Mechanical approach and empirical approach. Geomechanical classifications.

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

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.
- "In situ" stress measurements. "In situ" stress release. Stress restitution. Hydraulic failure. Changes in stress in inclusions.

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

Water and rock mass

Description:
- Permeability of fracture. Flow in fracture networks. Effective stress law. Hydro coupling.
- 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.
- Spherical cavity. Mohr-Coulomb elastoplastic model. Hoek-Brown elastoplastic model.

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

Interaction tunnel support

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

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

Construction of tunnels in rock

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

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

Tunnel face stability

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

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

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: 4h 48m
Theory classes: 2h
Self study : 2h 48m

Movements induced by tunneling

Description:
- Superficial settlements. Empirical methods. Ground loss.
- Sliding near a tunnel. Theoretical and semiempirical methods. Effect of movement on structures. Burland & Boscardin-Cording methods.

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

Induced damage and movements mitigation

Description:
Damage criteria of Burland and Boscardin & Cording.
Examples of mitigation measures.

Specific objectives:
Learn how to roughly assess the damage that the excavation of a tunnel can cause to the structures close to its alignment.
Familiarize with damage mitigation measures that can be applied to limit the consequences of damage as much as possible.

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

Examples and case studies

Description:
Examples and case studies

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

Laboratory + Evaluation

Description:
Laboratory + Evaluation

Full-or-part-time: 16h 48m
Laboratory classes: 7h
Self study : 9h 48m

GRADING SYSTEM

The final course grade will be calculated on the basis of the geometric average of two parts: rock mechanics (MarkRM) and tunneling (MarkT). These marks will be obtained from the marks of the exams and other activities (visit to the laboratory and home work) proposed during the cours.

There will be two exams during the course. The first one will cover the first part of the course (Rock Mechanics) and the second one will cover the second part (Underground Excavations):

The final grade will be calculated as the weighted arithmetic mean of the grades relative to each part.

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

BIBLIOGRAPHY

Basic:
- Atkinson, Barry Kean. Fracture mechanics of rock. London: Academic Press, 1987. ISBN 0120662655.
- López Jimeno, C. (ed.). Manual de túneles y obras subterráneas. Maddrid: E.T.S.I. Minas - Universidad Politécnica de Madrid, 2011. ISBN 9788496140370.
- Maidl, Bernard [et al.]. Mechanised shield tunnelling. Berlin: Ernst & Sohn, 2012. ISBN 9783433029954.
- Hudson, J.A.; Harrison, J.P.. Engineering rock mechanics : an introduction to the principles [on line]. Oxford: Elsevier, 1997 [Consultation: 08/11/2023]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780080438641/engineering-rock-mechanics. ISBN 9780080419121.

Complementary:
- Bieniawski, Z.T. Design methodology in rock engineering: theory, education and practice. Rotterdam: A.A. Balkema, 1992. ISBN 9054101261.
- Broek, David. The Practical use of fracture mechanics. Dordrecht (Netherlands): Kluiwer Academic Publishers, 1989. ISBN 0792302230.
- Broek, David. Elementary engineering fracture mechanics. 4th ed. The Hague [etc.]: Martinus Nijhoff, 1986. ISBN 9024725801.
- Chernyshev, Sergei N.; Dearman, W.R. Rock fractures. Londres [etc]: Butterworth-Heinemann, 1991. ISBN 0750610174.
- González de Vallejo, Luís I .. [et al.]. Ingeniería geológica [on line]. Madrid etc.]: Prentice Hall, 2002 [Consultation: 30/04/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1237. ISBN 8420531049.
- Goodman, Richard E. Introduction to rock mechanics. 2nd ed. New York [etc.]: John Wiley and Sons, 1989. ISBN 0471812005.
- Goodman, R.E.. Engineering geology : rock in engineering construction. New York: J. Wiley, 1993. ISBN 0471544248.
- Jumikis, A.R. Rock mechanics. 2nd ed. Rockport, MA: Trans-Tech, 1983.
- Hoek, E. Practical rock engineering [on line]. [s.l.]: [s.n.], 2000 [Consultation: 29/04/2020]. Available on: https://www.rocscience.com/assets/resources/learning/hoek/Practical-Rock-Engineering-Full-Text.pdf.
- Hoek, E.; Brown, E.T. Underground excavations in rock. London: Institution of Mining and Metallurgy, 1990. ISBN 0419160302.
- Jaeger, J.C.; Cook, N.G.W.; Zimmerman, R.W. Fundamentals of rock mechanics. 4th ed. Malden: Blackwell, 2007. ISBN

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