

Tunnels and Rock Mechanics (250423)

General Information

School	ETSECCPB
Departments	Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE) Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012) MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012) MÀSTER UNIVERSITARI EN ENGINYERIA DEL TERRENY (pla 2015) PARS: ENGINYER/A DE CAMINS, CANALS I PORTS (pla 2022)
Course	2024/25

Main teaching language at each group

- Group 10ES1 Spanish (Q1)

Faculty

Responsible Faculty: Alessandra Di Mariano Simoncini, Nuria Merce Pinyol Puigmartí
Faculty: Ignacio Carol Vilarasau, Alessandra Di Mariano Simoncini, Nuria Merce Pinyol Puigmartí, Anna Ramon Tarragona

Objectives of Education

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.

Competencies

Especific

Escola de Camins

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

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.

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.

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.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	25.5 h	56.67 %
	Medium group	9.75 h	21.67 %
	Laboratory classes	9.75 h	21.67 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Introduction

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

Rock matrix, joints and rock mass

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

In situ stresses

- Significance. Stress states in an excavation site.
- "In situ" stress measurements. "In situ" stress release. Stress restitution. Hydraulic failure. Changes in stress in inclusions.

Water and rock mass

- Permeability of fracture. Flow in fracture networks. Effective stress law. Hydro coupling.
- Characteristic curves of tunnels in the presence of water flow. Implications.

Circular tunnel in elastoplastic soil. Characteristic curves

- Plain deformation. Mohr-Coulomb elastoplastic model. Hoek-Brown elastoplastic model.
- Spherical cavity. Mohr-Coulomb elastoplastic model. Hoek-Brown elastoplastic model.

Interaction tunnel support

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

Construction of tunnels in rock

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

Tunnel face stability

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

Construction of tunnels in soil

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

Movements induced by tunneling

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

Induced damage and movements mitigation

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.

Examples and case studies

Examples and case studies

Laboratory + Evaluation

Laboratory + Evaluation

Activities

Field visit

A field visit is promoted to show to the students the application of the concepts and methodologies studied in the course to engineering practice.

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.

Grading Rules

() The evaluation calendar and grading rules will be approved before the start of the course.*

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 course.

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.

Test 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

Office Hours

During lecture breaks, at the end of the class, or during office hours previously agreed with the instructors.

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](#). Oxford: Elsevier, 1997. 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): Kluwer 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](#). Madrid etc.]: Prentice Hall, 2002. ISBN 8420531049.
- Goodman, Richard E. [Introduction to rock mechanics](#). 2nd ed. New York [etc.]: John Wiley and Sons, 1989. ISBN 0471812005.
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- Jumikis, A.R. [Rock mechanics](#). 2nd ed. Rockport, MA: Trans-Tech, 1983.
- Hoek, E. [Practical rock engineering](#). [s.l.]: [s.n.], 2000.
- 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 9780632057597.