

Geological Engineering I: Rock Mechanics

Code: 101054
ECTS Credits: 6

Degree	Type	Year	Semester
2500254 Geology	OT	3	0
2500254 Geology	OT	4	0

Contact

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Teaching groups languages

You can check it through this [link](#). To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Prerequisites

In order to take this course, it is recommended that students have passed the following subjects: "Structural Geology I" and "Structural Geology II". It is assumed that the students have basic competences on mathematics and physics, acquired during previous courses.

Objectives and Contextualisation

This optative course is part of the "Geotechnics and Geological Resources" mention.

The main aims of this course are to provide a basic overview of the rock mechanics and their practical application to geological and engineering problems. On successfully completing this course, the students will know the basic procedures to collect, describe and interpret the geological information required to predict the strength and stability of rocks under natural or anthropogenic actions (i.e. excavations, fluid injection, reservoir mechanic, etc)

Competences

Geology

- Draw up and interpret geological maps and other means of depicting geological information (columns, correlation frames, geological cross-sections, etc.)
- Identify and characterise minerals and rocks through instrumental techniques, determine their formation environments and know their industrial applications.
- Learn and apply the knowledge acquired, and use it to solve problems.
- Plan the exploration and sustainable development of geological resources.

- Process, interpret and present field data using qualitative and quantitative techniques, and suitable computer programmes.
- Recognise theories, paradigms, concepts and principles in the field of geology and use them in different areas of application, whether scientific or technical.
- Recognise, depict and reconstruct tectonic structures and the processes that generate them and relate types of rocks and structures to geodynamic environments.
- Show an interest in quality and incorporate it into practice.
- Show initiative and adapt to problems and new situations.
- Suitably transmit information, verbally, graphically and in writing, using modern information and communication technologies.
- Work in different environments and localisations, with respect for diversity and multiculturalism.

Learning Outcomes

1. Assess methods for restoring and remediating land.
2. Correctly sample industrial mineral and rock deposits.
3. Draw up geological cross-sections or other types of presentation for geological data in order to characterise hydrocarbon reserves and mineral deposits.
4. Enumerate the industrial applications of minerals and rocks.
5. Identify the environmental problems related to exploitations of hydrocarbons, mineral deposits and industrial rocks.
6. Identify types of deposits with geodynamic environments.
7. Learn and apply the knowledge acquired, and use it to solve problems.
8. Resolve and present paragenetic mineral sequences of deposits.
9. Show an interest in quality and incorporate it into practice.
10. Show initiative and adapt to problems and new situations.
11. Solve problems in reserves, mineral deposits and geological engineering based on field and laboratory observations and the concepts studied.
12. Suitably transmit information, verbally, graphically and in writing, using modern information and communication technologies.
13. Work in different environments and localisations, with respect for diversity and multiculturalism.

Content

Theoretical formation

Preliminary

Introduction. Objectives of the Rock Mechanics. The discontinuous and heterogeneous characteristics of the rock systems.

Block I. Fundamentals of the Rock Mechanics

- Overview of continuum media: stress and deformation.
- Strength and deformability of rocks. Ideal behaviours: elasticity, plasticity and viscosity. Fracture criteria. Onset and propagation of fractures.
- Discontinuities. Geometrical and mechanical properties.
- Experimental techniques at laboratory. Uniaxial compressive and tensile experiments. Triaxial experiments. Influence of the scale and geometry of the rock samples. Influence of fluid pressure, confining pressure, temperature and strain rate. Geophysical techniques.
- Rock behaviour in extreme conditions. Deformation mechanisms at microscale.

Bloc II: Aplicacions a l'Enginyeria de Roques

- Reservoir Geomechanics. Pore pressure at depth. Wellbore stability and failure.

- Geomechanical classifications of rocks (RMR, ESR, Q). Strength of the rock masses. Hoek-Brown criteria.
- Safety factor and fracture probability.
- Surface excavations. Types of slope instabilities. Stability analysis: kinematic and mechanical methods.
- Underground excavations. Stability of tunnels. Numerical approaches. Settlement and subsidence curves.
- In-situ techniques to measure principal deformation and stress directions.
- Stability measurements in ground. Instruments and auscultations of ground problems.

Practical Formation

- Exercises and problems related with the theoretical formation
- Numerical methods applied to slope stability, tunnel deformability and rock mass strength. Introduction to the Rockscience suite of programmes (RocLab, Examine 2D, etc) and Itasca FLAC code. These practical sessions will be done using specialised programmes applied to rock mechanics.
- Description and interpretation of geomechanical properties of a rock borehole core.

Field Practical Formation

The course includes a one-day field trip near to the Barcelona Metropolitan area. The goals of the field trip are (1) visit a rock quarry currently in exploitation and observe the practical application of rock mechanics, (2) practical geomechanical characterisation of rock masses and (3) inspection of rock slope instabilities and stability measures. Acquired data during field trip will be used for the elaboration of a geomechanical study and a technical report based on a hypothetical constructive project.

Methodology

The course is structured in 10 sessions of 4 hours/session. Each session is organised in a lecture part (aprox. 1-2 hours), followed by a second part focused to solve practical problems under the supervision by teachers (aprox. 1-2 hours) and a last part on discussion and resolution of the problems (aprox. 1 hour). During these sessions, the teachers will expose the different thematic units of the course and will explain the guidelines to the students to complement in an autonomous way the proposed problems, exercises and readings.

Apart from the recommended references, the students will have access to the lecture's slides and additional materials through the Virtual Campus of the course. During the course, two readings and/or watching documentaries will be proposed as homework assignments. This work carried by the students will be presented and discussed through oral presentations.

The field trip will consist in (1) the practical application in the terrain of the geomechanical classifications, (2) the identification of different rock slope instabilities and (3) the study of the engineering measures applied to stabilise and recovery the terrains. The field trip will be done near to the Barcelona metropolitan area (Vallcarca and Martorell) and include the visit to an active quarry to investigate the stability measures in temporal rock slopes. For each stop, there will be a general introduction by the teachers followed by acquisition of the most relevant geomechanical data by the students. The data will be further used by the students to elaborate the geotechnical study and report of a hypothetical constructive project in the area. The practical case will be focused on the stability analysis of surface and underground excavations related to the construction of a road and/or tunnel. After the field trip, there will be a practical session to interpret the field data and give the main guidelines to elaborate the practical case report. This report will be done individually or in pairs and will be submitted in the deadline indicated by teachers. The field trip is compulsory to pass the course.

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Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Field practical sessions (PCAM)	7	0.28	4, 1, 7, 5, 10, 9, 2, 3
Lectures (TE)	22	0.88	7, 9, 8, 11
Practical sessions (PAUL)	22	0.88	4, 1, 7, 6, 10, 8, 2, 11
Type: Autonomous			
Complete of the exercises and problems	30	1.2	1, 7, 5, 10, 8, 2, 11, 3, 12
Field and practical case report	30	1.2	1, 7, 5, 10, 9, 8, 12
Study and reading of specialised lectures, Virtual campus utilities, etc	30	1.2	5, 9, 2, 12

Assessment

The evaluation of the course is using continuous assessment and is based on the following activities,

1. Midterm and final exam. They consist in individual written exams of the first and second blocks, respectively. The exams are structured in a theoretical part with short questions and a second part with practical problems. The weighting of these activities is 50% of the final grade.
2. Submission of the field report and the practical case project. The report will include the acquisition of field data, the analysis to solve a series of geomechanical practical cases and the discussion of these results. The quality of writing report (i.e. concise, organisation, clarity, etc), graphical figures, discussion/conclusions and proper use of references and network resources will be used to grade the reports. The weighting of this activity is 25% of the final grade.
3. Submission of the problems and exercises done during the practical sessions and autonomous activities. The weighting of this activity is 15% of the final grade.

4. Oral presentations and discussion of the readings and/or watching documentaries. The weighting of this activity is 10% of the final grade.

There are only reassessment of the midterm/final exams and the reading activities. The students must to present to all the reassessment activities that they failed during the course. The reassessment will be done through a written exam and the maximum weighting of the reassessment exam will be 60% of the final grade.

The directed-learning activities correspond to a substantial part of the activities of the course, and for this reason they are obligatory. The students will be evaluated if the attendance to the course activities is higher than

- 60% for the theoretical sessions
- 60% for the practical sessions
- the field trip (compulsory).

To pass the course, the student must to obtain an average score equal or higher than 5. A student will be considered as "*not assessable*" only if the attendance to assessment activities is lower than 35% of the total weighting of the course.

Single evaluation

The assessment of the course will consist of a theoretical exam (25%), a practical problems exam (35%), submission of the laboratory practical exercises (15%) and a field report (25%). The last two activities are not reevaluable.

- Plagiarism and Misconduct in assessment activities:

- Students who engage in misconduct (plagiarism, copying, personation, etc.) in an assessment activity will receive a grade of "0" for the activity in question.
- Total or partial plagiarism of any of the assessment activities will automatically be awarded a "fail" ("0") for the plagiarised item. Plagiarism is copying from unidentified sources and presenting this as original work (this includes copying phrases or fragments from the internet and adding them without modification to a text which is presented as original). Plagiarism is a serious academic offence. It is essential to respect the intellectual property of others, to identify any source uses, and to take responsibility for the originality and authenticity of all work produced.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exercises and problems of practical sessions	15	3	0.12	1, 7, 6, 10, 8, 11, 3, 12
Field and practical case report	25	0	0	4, 1, 7, 5, 6, 9, 8, 2, 3, 12, 13
Final Exam (Block II)	25	2	0.08	1, 8, 2, 11, 12
Midterm exam (Block I)	25	2	0.08	1, 8, 2, 11, 12
Readings and watchings documentaries (presentation/discussion)	10	2	0.08	4
Reassessment exam	màx. 60	0	0	1, 8, 2, 11, 12

Bibliography

* Main reference textbooks

González de Vallejo, L. I. (2002) Ingeniería Geológica. Person Educación. Madrid. *

Goodman, RE (1989) Introduction to Rock Mechanics. John Wiley & Sons.

Hoek, E. (2000) Practical Rock Engineering. Online version.

<https://www.rocscience.com/assets/resources/learning/hoek/Practical-Rock-Engineering-F>

Hudson, J. A. & Harrison, J.P. (1997) Engineering Rock Mechanics. An introduction to the Principles. Pergamon, Elsevier.*

Harrison, J.P. and Hudson, J. A. (2000) Engineering rock mechanics: Illustrative worked examples. Pergamon, Elsevier. 506 p.

Twiss, R.J. & Moores, EM. (1992) Structural Geology.

Wyllie, D.C. (2004) Rock slope engineering, civil and mining. Spon Press.

Zoback, M. D. (2007) Reservoir Geomechanics. Cambridge University Press. 449 p.

Software

Matlab (Mathworks; campus academic license)

CloudCompare (3D point cloud and mesh processing software, open source)

Stereonet (Allmendinger, R. W; <https://www.rickallmendinger.net/stereonet>, freeware)

Rock Mechanics specific software

Flac/Slope 8.10 (Itasca, freeware)

RocLab, Examine 2D (Rocscience, freeware)

Adonis, Hyrcan (freeware)