COURSE OUTLINE

1. GENERAL

SCHOOL	SCHOOL OF ENGINEERING		
ACADEMIC UNIT	DEPARTMENT OF MINERAL RESOURCES ENGINEERING		
LEVEL OF STUDIES	*Undergraduate*		
COURSE CODE	MRE911	**SEMESTER**	9th
COURSE TITLE	Advanced Geomechanics – Tunnelling		

INDEPENDENT TEACHING ACTIVITIES	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	2	5
Laboratory or Tutorials	2	
Overall	4	

COURSE TYPE	General knowledge specialization
PREREQUISITE COURSES:	Mechanics - Structures (MRE204) Geotechnical and Soil Mechanics (MRE401) Rock Mechanics - Engineering Geology (MRE701) Retaining and Support of Surface & Underground Excavations (MRE811)
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	NO
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES

Learning outcomes

The course aims to the understanding of the basic principles of Advanced Geomechanics and Tunnelling, the consolidation of knowledge regarding the behavior of soil and rock mass in Tunnelling and Advanced Geomechanics and the ability of computing problems in Advanced Geomechanics and Advanced applications using finite element analysis methods and techniques.

Upon successful completion of the course the student will be able to:

- Understands the required background knowledge on designing of underground projects with advanced geomechanical methods.
- Determines actions and loading cases on underground projects.
- Calculates parts and sections of underground works.

In addition, he/she will advance his specialized knowledge in the following advanced subjects:

- Understanding the specific requirements and methodologies of preliminary tunnel design.
- Application of preliminary design methodologies for the assessment of the critical stress conditions and the plastification zones brought about by the opening of tunnels.
- Identification of immediate support measures with simplified methods.
- Interaction of elastoplastic response curves of the surrounding rock mass with the measures/works of immediate support.
- Tunneling in urban areas - ways to reduce the impact on neighboring buildings safety and settlements.
- Use of numerical methods for the analysis-design of tunnels in two and three dimensions.

General Competences

The course contributes to the acquisition of the following skills:

- Applying knowledge in practice,
- Researching, Analyzing & Synthesizing Data & Information using necessary technologies,
- Adapting to new situations,
- Decision-making,
- Working independently,
- Working in an international environment,
- Working in groups (Teamworking),
- Promoting Free, Creative & Inductive thinking.

3. SYLLABUS

General: Strength of cohesive soils and rocks. Failure theories Griffith, Mohr-Coulomb, Tresca, Drucker-Prager. Exercises. Expansion of rocks, Discontinuities/joints of rocks. Geotechnical Structures Analysis: Coulomb Theory of Earth Pressures (Active, At-rest, Passive) - Retaining Walls, Load-bearing capacity of surface foundations, Stability of slopes, Support of basements and tunnels, Load-bearing capacity of piles. Construction of tunnels: Geotechnical-geostatic model of heterogeneous geological formations, Numerical methods of analysis of stresses-deformations around underground openings, Method of construction of underground works & tunnels with the method of gradual excavation, Methods of construction of tunnels by TBM method, Design with the convergence-relaxation method, TBM machine operating model, Roadheader operating model, Settlements over shallow tunnels, Underground excavation failures.

Theory: Introduction. Methods of construction of underground works. Open trench method (Cut and Cover). Closed excavation method. Underground works in rock formations. Stress field analysis-Plastic stress field - The NATM method. Determination of actions/loading by the method of strength index. Underground works in rock mass formations. Design of support measures with empirical methods (Terzaghi, Lauffer, Barton, Bieniawski, GSI, etc.). Underground works in soil formations. Determination of actions/loading by considering earth domes. Determination of vertical loads (Terzaghi, Kommerell, Bierbaumer). Determination of horizontal loads.

Tutorial exercises: Analysis and dimensioning of typical sections of underground works. Construction configuration.

In more details and specifically:

- ✓ Types of tunnels, construction description, construction methods in soil and rock formations.
- ✓ Assessment of prevailing geological and geotechnical conditions. Required on-site measurements and in-situ tests as well as laboratory tests to determine the simulation parameters of the natural and construction materials, as well as the topology of the problem in question.
- ✓ Determination of initial stress field/regime. Expected kinematic and stress field brought about by the excavation, plastification zones and pathology.
- ✓ Tunnel stability. Typical forms of instability. Surrounding rock mass response curves as a function of excavation progress steps and width. Linear-elastic and Elastoplastic-approach.
- ✓ Elastoplastic response curves of surrounding rock mass depending on the excavation step and width and the pre-reinforcement (e.g. fore polling) and immediate support measures.
- ✓ Description of immediate support and pre-reinforcement measures. Differentiation in terms of ease of installation, the required time of partial and full activation and the financial burden.
- ✓ Preliminary identification of direct support measures according to established geotechnical classification systems (Application of the Bieniawski method).
- ✓ Preliminary identification of direct support measures according to established geotechnical classification systems (Application of the Barton-Q method).
- ✓ Dependence of the selection of direct support measures and the sequence of their implementation on the construction methodology.
- ✓ Example of preliminary tunnel design. Determination of strength and deformability parameters, application of geotechnical classification systems, adequacy control using load-relaxation curves.
- ✓ Application of numerical methods in tunnel design. Reference to simplistic numerical analysis approaches.
- ✓ Use of the finite element method to simulate the construction of tunnels as a multistage problem with variable limits and dimensions and the possibility of activating and deactivating direct support measures.
- ✓ Possibility to change the stiffness of the construction materials during various stages. Interaction of soil environment with the elements of immediate support and final support system.
- ✓ Simulation, analysis, framework for solving and load cases / load combinations, dimensioning. Typical examples of tunnel excavations.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY	In the classroom and in the laboratory (Face-to-face). Webinars. Tutorials. Laboratory demonstrations. Possibility of distance lectures if required via Zoom Cloud Meeting.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY	Presentation of lectures using PC (presentations, experimental videos, etc.). Support of learning process through the electronic platform eLearning and electronic communication with students (Online announcements and comments, forum, email etc.). Self-assessment questionnaires in the eLearning environment of the course and asynchronous training platform - eclass. Assistance in completing assignments through result files for each individual student.
TEACHING METHODS	

Activity	***Semester Workload***
Lectures	26
Laboratory exercises and processing of results with computational procedures	26
Individual assignments on laboratory exercises & theory (Coursework) and application exercises	30
Independent Home Study	48
Overall Course Set (26 hours of workload per credit unit)	***130***

STUDENT PERFORMANCE EVALUATION	Written final theory exam that includes: • Theoretical judgment questions in course subjects (short answer questions and multiple choice questions). • Problem solving-exercises. • Solving of laboratory exercises. Delivery of assignments and oral examination that includes: • Laboratory work (processing of results of laboratory exercises). • Solving of application exercises. • Examining the understanding of basic concepts.

5. SUGGESTED BIBLIOGRAPHY

- Sachpazis, C., "Geotechnical Engineering Lecture-Notes for Tunnels - Dams", 2019.
- Sachpazis, C., (2020) "Geotechnical Engineering of Dams". Academic Book, 455 Pages, Code in Eudoxus: 77120847. ISBN Code: 978-618-83547-0-8. Ch. Tsapraili Publications © 2019.
- Sofianos, A., 2015. Support of underground projects. [digital book] Athens: Association of Greek Academic Libraries. Available at: http://hdl.handle.net/11419/3457
- Brady, BHG, Brown, ET (2006). Rock Mechanics for Underground Mining. 3rd Ed, Springer.
- Hoek E and Brown ET (1980). Underground Excavations in Rock, The Institution of Mining and Metallurgy, London.
- Hoek Evert, «Rock Slope engineering», Chapman and Hall, 1997.
- Hoek Evert, "Underground excavations in rock", Chapman and Hall, 1997.
- Hoek E, Kaiser PK, & Bawden WF (1995). Support of underground excavations in hard rock, Balkema.
- Maidl B., Thewes M., Maidl U. Handbook of Tunnel Engineering: Volume I: Structures and Methods, First Edition 2013, Print, ISBN: 9783433030486, WILEY - VCH Verlag GmbH.
- BARRY BRADDY, «Rock Mechanics: for underground mining», Kluwer, 1999.
- ICE (2004). Tunnel lining design guide. Thomas Telford Publishing
- Ch. Maragos, "Technical Infrastructure Works: Constructions on the rock surface, underground constructions, dams", MARAGOS Publications, Thessaloniki, 2007.
- I. Tsoutrelis, "Underground Works", NTUA Publications, 1987.
- Panet, M., (1995). Tunnel calculation by convergence-configuration method. Department Edition of the Amicale Association of Engineers Ancients Elèves, Paris: Press de the National School of Ponts and Chaussées.

Related scientific journals:

- Electronic Journal of Geotechnical Engineering
- Rock Mechanics and Geotechnical Engineering
- Journal of Geotechnical and Geoenvironmental Engineering Geotechnique
- Tunneling and Underground Space Technology
- Geotechnical and Geological Engineering Canadian Geotechnical Engineering
- International Journal for Numerical and Analytical Methods in Geomechanics Canadian Geotechnical Journal
- Computers & Geotechnics
- Acta Geotechnical
- Soils and Foundations
- Geotechnical and Geological Engineering
- Rock Mechanics and Rock Mechanics