

Course PM: AF2610 Tunnel Engineering, 7.5 credits

Date: 2019-10-23

Course main content

The aim of the course is to provide students with: a broad knowledge in all aspects of tunneling i.e. planning, design and construction; and deeper knowledge in four areas of tunneling: (1) excavation with drilling and blasting method, (2) design of support (3) hydrogeology, water related problems and grouting and (4) tunnel cost and time planning and risk management.

Intended learning outcomes

After the course students will be able to:

- Identify main characteristics of different ground behaviour,
- Identify and plan tunnel excavation method from technical, production, and sustainability point of view,
- Design tunnel reinforcement based on empirical, analytical and numerical assessment depending on complexity and acquire a holistic perspective on the design process,
- Analyse water ingress to tunnels and identify possible water related problems for excavation, as well as plan and implement suitable tunnel draining and/or grouting methods,
- Analyse cost and time for ordinary tunnels based on risks and construction management principles.

Course Responsible and teacher

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Students Office

Visit at: School of Architecture and Built Environment, Brinellvägen 23

Students Office: room M107A,

Open at: Monday - Thursday 10.00 – 11.00 and 12.30 -13.30

Eligibility

AF2609, Foundation Engineering or equivalent

Recommended: AF 2602 Rock Mechanics, AF2024 Finite Element Methods

Literature

- Palmström and Stille: Rock Engineering
Bookstore “Kårbokhandel” sells the book. Address: Drottning Kristinas väg 15-19.

Additional recommended literature

- Hoek and Brown: Underground excavation in rock
- C.L. Jimeno, E.L. Jimeno and F.J.A. Carcedo: Drilling and Blasting of Rocks

Examination

- Passed written examination, 4.5 credits, grade scale: A-F, Fx
- Approved- assignments, 3 credits :
 - (Assign. 1) Tunnel drilling and blasting, , grade scale: A-E, Fx
 - (Assign. 2) Tunnel rock support analyzed with FEM, , grade scale: A-E, Fx
 - (Assign. 3) Tunnel cost and time planning, , grade scale: A-E, Fx
 - (Assign. 4) Ground water ingress and grouting, grade scale: A-E , Fx

Final grade:

Assessment of the final grade in the course is based on 1 written examination and 4 assignments. For the final grade the examination is weighted as 50 % and 4 assignments as 50 %. It means that a grade obtained in written examination is worth 4xgrade. For ex. obtained grade A in written examination is calculated as 4A, a B as 4B and so on in the assessment of final grade. A grade obtained in an assignment is calculated as 1xgrade. The total 8 grades are obtained.

If the student passed the exam with at least E, the final grade requirements are:

For A: Minimum 6 A, and no grade worse than C

For B: Minimum 6 B, and no grade worse than C

For C: Minimum 6 C, and no grade worse than E

For D: Minimum 6 D, and no grade worse than E

For E: All partial grades at least E

Note: assignment grades that have been upgraded from Fx to E after resubmission are counted as a normal E in the weighing.

If a student obtains Fx on the exam, E will be obtained as final grade if the student passes a supplementary exam and has at least E in the all assignments.

The assignments are done as group work. At the end of the course each group have to present one chosen assignment.

Examiner

Professor Stefan Larsson

Structure of reports for assignments

The report has to be structured as a scientific paper i.e. with chapter: Introduction, Material and Methods, Results, Discussion and Conclusion.

- **Introduction:** Introduction (description) of the assignments (problem).
- **Material and Methods:** Describe the methods / measurements / materials you have used to solve the problem.
- **Results:** Present your results.
- **Discussion:** Discuss the results. Compare with expected results? Did you reach the goal? Limitation during the work.
- **Conclusion:** ...,put it in the context, relate it to real case, ...etc

For inspiration see more about IMRAD structured of a scientific paper on this webpage
<https://writing.wisc.edu/Handbook/ScienceReport.html>

Table 1: Grade criterion for AF2610 Tunnel Engineering

ILO	E	D	C	B	A
1. Identify main characteristics of different ground behaviour	List some different ground behaviour		E+ describe some different ground behaviour and suggest possible proper rock support.		C+ Discuss use of proper design tool to suggest possible rock support.
	Assessment through written examination.				
2. Identify and plan tunnel excavation method from technical, production and sustainability point of view	Identify different parameters, perform calculation and plan one excavation cycle.		E+ discuss and justify choice of different parameters and plan excavation cycles including a grouting cycle		C+ A broad discussion about eventual problems and assumptions in calculations, related to a real case. Discuss the choices (explosive, borehole dimension etc.) related to cost, time and environmental issues.
	Assessment with assignment 1. Excavation method related to stability and productivity issues and sustainability issues are also assessed through written examination.				
3. Design tunnel reinforcement based on empirical, analytical and numerical assessment depending on complexity and acquire a holistic perspective on design process	Perform stability analysis with a numerical design method on a simple case		E+ discuss and justify the reasons for choice of numerical method (continuous vs. discontinuous, elastic vs. plastic) and the used parameters		C+ A broad discuss about eventual problems, assumptions in calculation related to some real cases.
	Assessment through assignment 2. Empirical and analytical evaluation of support and holistic perspective on design are assessed through written examination.				
4. Analyse water ingress to tunnel. Plan and implement proper tunnel draining and/or grouting method.	Make a simple hydrogeological map of a tunnel. Divide tunnel length in similar rock mass classes. Identify		E+ Make a more detailed geological map and detailed plan for grouting sections. Discuss choice		B+ Analyse possible excavation and stability problems related to possible water issues. Discuss possible

Identify possible water related problems for excavation.	possible fault zones. Calculate water ingress in the tunnels sections and decide need for grouting.		continuous vs. discontinuous model in estimation of water ingress. Discuss influence of faults.		changes in planning of grouting in the construction stage.
Assessment through assignment 3 and written examination.					
5. Analyse cost and time for ordinary tunnels based on risks and construction management principles	Prepare a tender document based on a simple case		E+ Further instruction from the teacher		C+ Further instruction from the teacher
Assessment through assignment 4 and written examination.					