CEE 586 – Rock Mechanics & Behavior

Course Syllabus

Instructor: Professor Roman Y. Makhnenko, PhD (217) 300-4587 (phone)
2221 Newmark Civil Engineering Laboratory romanmax@illinois.edu
Office hours: Tuesday 3:30 - 5 pm (or by appointment)

Class Meetings: Time: TTh 2:00 – 3:20 pm
Rm.: 2310 Newmark Civil Engineering Laboratory

Class Website: http://compass2g.illinois.edu/

Textbooks and Reading:
Required: Jaeger, J.C., Cook, N.G.W, Zimmerman, R.W. (2007). *Fundamentals of Rock Mechanics*, *4th Edition*. Blackwell, U.K., 475 p.

Suggested supplemental text: Goodman, R.E. (1989). *Introduction to Rock Mechanics, 2nd Edition*. John Wiley and Sons, New York, NY, 562 p.

Other: Additional reading from handouts

Course description

Rock mechanics is the theoretical and applied science of the mechanical behavior of rock; it is that branch of mechanics concerned with the response of rock to the force fields of its physical environment. For practical purposes, rock mechanics is mostly concerned with rock masses on the scale that appears in engineering and mining work, and so it might be regarded as the study of the properties and behavior of accessible rock masses due to changes in stresses or other conditions. On one hand, shallow, weathered or fragmented rocks can be treated with the approaches similar to soil mechanics. On the other hand, there is an increasing demand to study the behavior of rocks under conditions that occur deep in the Earth's crust, i.e. at elevated pressures and temperatures. Additionally, accessible rock masses are broken up by joints and faults, and pressurized fluid is frequently present both in open joints and in the pores of the rock itself (after Jaeger et al., 2007).

This course introduces students to the theoretical and practical aspects of rock mechanics. Constitutive behavior of continuum media is reviewed and applied to the behavior of geomaterials. Elastic, inelastic, and failure response of dry rock is discussed. Fluid flow in porous media is described in terms of coupling with rock deformation. Finally, it is shown how rock mechanics principles can be applied to tunneling and deep geological storage.

Class Sessions: Sessions begin at 2:00 pm and end at 3:20 pm. Class notes or slides when used will be posted to the Compass2g website. It is recommended to save on printing (and be sustainable) and try to take written notes (including using electronic devices). You are responsible for what is presented verbally, what is presented on the chalkboard, and what is presented on the slides and the assigned reading materials. After each session, you should review your notes and re-read appropriate assignments.

Participation and Attendance: Participation is an important part of learning and will be strongly encouraged. Three unexcused absences are allowed, after that each case should be reported. Regular attendance of class sessions and active participation in in-class discussions is worth 5% of your grade.

Quizzes: There will be approximately 10 quizzes at the beginning of Tuesday classes that will include theoretical questions and simple problems based on the course material covered during the week prior to a quiz.

Project: There will be a laboratory-based project worth 15% of your grade. The lab report should cover background information, testing methods, experimental results, and discussion of two in-class demonstration tests.

Exams: There will be one 80-minute long mid-term exams during the semester and a 2.5-hour long final exam. Although tentative dates are shown in the schedule below, specific date for the mid-term exam will be announced in class at least two weeks in advance of the exam. In the exams you will be asked both qualitative and quantitative questions; the exams are not a mere repetition of the problems solved in class. You will be asked to apply material you have learned in lecture and readings, as well as during in-class discussions and questions. Example problems will be available on caompass2g at least 2 weeks prior an exam.

Honor Code: All students at the University of Illinois are expected to uphold the highest ethical standards, be honest, and practice academic integrity. Campus policies are explained in the Student Code, Article 1, Part 4 (http://admin.illinois.edu/policy/code/Full_Code_web2012.pdf). Students at Illinois are also expected to produce original work and properly cite any sources used. **Plagarism will not be tolerated.** Section 1-402(d) of the Student Code provides campus policy on plagiarism (http://admin.illinois.edu/policy/code/Full_Code_web2012.pdf). I define cheating as any violation of the Student Code; and I do not tolerate cheating in any form. At a minimum, cheating will result in a 0 on the test, and may result in failing the class and other University penalties. You are encouraged to discuss assignments and study for exams with your classmates and colleagues, but the work that you submit must be your own.

Grade Distribution:

In-class participation	5%
Quizzes	20%
Project	15%
Mid-term exam	25%
Final exam	35%

Grades & Performance:

Superior 90 – 100 A (including +/-)
Proficient 80 – 89.9 B (including +/-)
Satisfactory 70 – 79.9 C (including +/-)
Mediocre 60 – 69.9 D (including +/-)
Unacceptable below 60 F

Course Schedule – Tentative and subject to change

1. Aug. 28: Introduction, outline of main topics
2. Aug. 30: Rock vs Soil, Rock classification
3. Sept. 4: Traction and stress tensor
4. Sept 6: Mohr's circle, stress invariants
5. Sept 11: Displacement and small strain, strain and rotation tensors
6. Sept 13: Deformation of dry rock, laboratory testing
7. Sept 18: Stress-strain diagrams, elastic response of rock
8. Sept 20: Generalized Hooke's law, inelastic deformation of rock
9. Sept 25: Different regimes of rock failure
10. Sept 27: Linear failure criteria
11. Oct 2: Advanced failure criteria
12. Oct 4: Lab project – machine stiffness and dry testing
13. Oct 9: Joints in rock
14. Oct 11: Jointed rock mass behavior
15. Oct 16: Review of dry rock behavior
16. Oct 18: **Midterm**
17. Oct 23: Fluid flow in porous media
18. Oct 25: Theory of poroelasticity
19. Oct 30: Poroelastic regimes
20. Nov 1: Effective stress and constitutive poroelastic relationship
21. Nov 3: Effective media theories
22. Nov 6: Lab project – fluid-saturated testing
23. Nov 8: Creep of rock
24. Nov 13: Inelastic deformation of fluid-saturated rock
25. Nov 15: Failure of fluid-saturated jointed rock
    Nov 17-Nov 25: Thanksgiving break
26. Nov 27: Novel lab methods in rock characterization
27. Nov 29: Tunneling in rock
28. Dec 4: Deep geological storage
29. Dec 6: Oil exploration and recovery
30. Dec 11: Rock mining, **Project report is due**
31. Dec 17-20: **Final**