University of Kentucky
Mining Engineering

MNG 551-Rock Mechanics
Last Semester Taught: Fall 2009

Catalog Data: MNG 551: Rock Mechanics. 4 Credits. Determination of the physical properties of rocks, rock mass classification, stress around mine openings, strain and displacement of the rock mass, rock reinforcement and support, stress interaction and subsidence, strata control. Lecture, three hours; laboratory, three hours per week. Prereq: EM 302, EM 303, GLY 230, and Engineering standing or consent of instructor.

Textbook: Class notes provided by the instructor.

References: SME Handbook; Brady & Brown; Rock Mechanics, S. Peng, Coal Mine Ground Control, 3rd edition; Herget, Stresses in Rock; Bieniawski, Strata Control in Mineral Engineering.

Coordinator: Dr. Konstanty Unrug, Professor of Mining Engineering

Goals: Understanding of physical process influencing strata control and the influence of geological factor; create the base for engineering design of mine structures;

Outcomes: Understanding of characterization methods of rock mass and its response to mining excavations.

Prerequisites by Topic:

1. Mechanics of Deformable Solids
2. Deformable Solids Laboratory
3. Elementary Geology for Engineers

Topics:

1. Introduction.
2. Engineering classification systems of rock mass.
4. Stress, strain and displacement in rock mass.
5. Support in underground mining.
6. Application of strata control for underground mine design.
7. Rock mechanics measurements and instrumentation.
LECTURE OUTLINE

1. INTRODUCTION

1.1. Rock mechanics as a discipline and its subjects of interest.
1.2. Structural elements and features of rock mass. (Cyrul).
1.2.1. Micromechanics of rock, properties of intact rock.
1.2.1.1. Stress and strain relationship for isotropic material.
1.2.1.2. Two dimensional stage of stress.
1.2.1.3. Rock failure and strength theories (Kot’s handouts).
1.2.2. Macromechanics of rock, properties of rock mass.
1.2.3. Stereoplots of fractures. (Hoek slope stability).

2.0. Engineering Classifications systems of rock mass.

3.0. Predominate mining system in coal mining and associated strata control problems.

4.0. Stress, strain and displacement in rock mass.
4.1. In situ stress.
4.2. Mining induced stress.
4.3. Strength properties of rock.
4.4. Time dependence of rock strength.
4.5. Influence of moisture, weathering of rock, and related stability problems.
4.6. Fractures and discontinuities.

5.0. Support in underground mining.
5.1. Mechanism of rock-support interaction.
5.2. Geological factors.
5.3. Rock-bolts.
5.3.1. Mechanical rock-bolts.
5.3.2. Grouted rock bolts.
5.3.3. Split sets, Swellex bolts, trusses, and cable bolts.
5.3.4. Combination of bolts-mesh, and shotcrete.
5.4. Other support systems, timber, steel sets, posts. cribs, their applications and characteristics.

6.0. Application of strata control for underground mine design.
6.1. Stability and design of mine openings and their structural elements (pillars).
6.1.1. Room and pillar mining-development.
6.1.1.1. Mine entries, determination of span and pillar dimensions.
6.1.1.2. Room and pillar-retreat.
6.1.1.3. Stability of floor, control of floor heave.
6.1.1.4. Subsidence over the room and pillar mining.
6.1.2. Longwall, strata control aspects of the operation.
6.1.2.1. Development, advancing and retreat systems.
6.1.2.2. Face support, stability of gate entries.
6.1.2.3. Gate pillars, yielding pillars.
6.1.2.4. Subsidence.

7.0. Rock mechanics measurements and instrumentation.
7.1. Measurements of load.
7.2. Measurements of strain.
7.3. Determination of in situ stresses.
7.4. Measurements of displacements.
7.4.1. Extensometers, string borehole, tape.
Computer usage:

Spread sheet programs
Word processing
ALPS – Longwall gate entries design
ARMPS – Pillar design program

Laboratory Projects:

Lab #1 - Physical properties, stereo plots
Lab #2 - RQD and Ferm Classification
Lab #3 - Lecture on stress calculation, concept of principal stress and strain (Mohr Circle) + assignment
Lab #4 - Quiz based on labs 1-3 + Brazilian test
Lab #5 - Strength test (E,...)
Lab #6 - Triaxial test
Lab #7 - Quiz based on labs 4-6 + lecture on stress analysis of transversely isotropic Material + assignment
Lab #8 - Concept of in situ stress measurement (lecture + assignment)
Lab #9 - Lecture on stability + assignment
Lab #10 - Small project: pillar and subsidence calculation

The student shall be able to:

- Learn about characteristics of various rock materials and understand the link between the origin of each and its properties.

- Understand a concept of scale in mining engineering with related engineering problems encountered in rocks.

- Learn about application of strength theories to rock and their limits.

- Appreciate influence of geologic factors and properties of each.

- Understand the concepts of heterogeneity and anisotropy in reference to rock material.

- Learn the principle of fracture mechanics as it applies to rock.

- Perform geomechanic tests on rock. - Learn design principles for excavations.

- Evaluate stability of excavation in reference to mining methods.

- Design natural and artificial support for mine structures.
ABET category content as estimated by faculty member who prepared this course description:

Engineering Science: 3 credits
Engineering Design: 1 credit

<table>
<thead>
<tr>
<th>MNG 551 Outcome</th>
<th>Program Outcome</th>
<th>Assessment Tool</th>
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<tbody>
<tr>
<td>1. Have understanding of characterization methods of rock</td>
<td>(a, k)</td>
<td>First test, Lab Reports</td>
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<tr>
<td>masse response to mining</td>
<td></td>
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<tr>
<td>2. Have understanding of a concept of scale in mining</td>
<td>(c, e )</td>
<td>First test, Lab Reports</td>
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<td>engineering, with related engineering problems</td>
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<td>encountered in rocks</td>
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<td>3. Have understanding of the application of strength</td>
<td>(a, k)</td>
<td>First test, Lab reports</td>
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<td>theories to rocks and their limits.</td>
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<td>4. Have understanding of a concept of heterogeneity</td>
<td>(a, k )</td>
<td>First test, Lab reports</td>
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<td>and anisotropy in reference to rock material</td>
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<td>5. Learn the principles of fracture mechanics as it</td>
<td>(a, e )</td>
<td>First test, Lab reports</td>
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<td>applies to rock</td>
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<td>6. Perform geomechanic tests on rock.</td>
<td>(b, k )</td>
<td>Lab reports</td>
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<td>7. Learn design principles for excavations</td>
<td>(e, k )</td>
<td>Design report,</td>
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<td>8. Evaluate stability of excavations in reference to mining</td>
<td>(a, e, k )</td>
<td>Design report</td>
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<tr>
<td>methods</td>
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<tr>
<td>9. Design natural and artificial support for mine</td>
<td>(a, e, k )</td>
<td>Design report</td>
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LAB #1: 10 pts.

This lab will involve two different scopes, such as Lab #la and Lab #lb:

LAB #la: Concept of geological discontinuities, its representation in terms of Dip, Direction of Dip, strike, Pole, Plunge, and Trend.

Discussion on geological compass and its use to measure Dip, Direction of Dip and Strike.

Graphical representation of data on geological discontinuities (Stereoplots).

Individual assignment:

1) Plot pole #1, i.e., Dip Direction (1)/Dip (1)
2) Plot pole #2, i.e., Dip Direction (2)/Dip (2)
3) Find intersection of two planes, and determine Plunge and Trend.

LAB #lb: Motivation for rock classification and identification, introduction to the concept of RQD and FERM classification.

Assignment (group of 2 or 3):

RQD(Rock Quality Designation) test for a core run (box).

NOTE:
Prepare two separate reports for Lab and Lab #lb. All assignments are due on the following Monday.

Prepared by: Dr. Konstanty Unrug
Date: September, 2009