ADVANCED STRUCTURAL GEOLOGY GEO005

COURSE DESCRIPTION

This course covers the assessment of rock strength and the mechanical criteria used to predict and analyze rock failure. Rock is an inherently flawed material, from the scale of individual mineral grains to the large-scale boundaries between tectonic plates. These flaws impact greatly on failure characteristics and associated deformation. In order to understand how brittle failure occurs, it is necessary to describe the mechanical laws that enable us to quantify deformation occurring in rock under the influence of applied stresses.

It therefore introduces the concept of the tensor quantity stress and its consequences for rock deformation. This approach requires an examination of elasticity theory, which commonly provides a good approximation to the mechanical behavior of rock in the crust. A thorough overview of continuum mechanics applied to rock deformation will segue into the concepts and mathematical theory of linear elastic fracture mechanics (LEFM), which is used to address how cracks in rocks enable brittle failure. LEFM theory can be used to quantify the stress, strain, and displacement fields around cracks subject to external loads, and subsequent failure characteristics.

COURSE GOAL

To enhance the participants' knowledge, skills and abilities necessary for understanding and intuition of the mechanics of deformation in the Earth, highlighting the importance and usefulness of quantitative analyses of rock failure using the concepts of fracture mechanics.

COURSE OBJECTIVES

By the end of this course, participant will be able to:

- Define geomechanics and rock fracture mechanics.
- Understand the importance of geomechanics and rock fracture studies.
- Identify the types of fractures in the Earth and their importance.
- Be familiar with the terminologies for natural fracture systems.
- Understand and apply the methodologies for geomechanical analyses.
- Understand the deformation criteria.
- Measure the stress in the Earth.
- Understand the fundamentals of elasticity
- Explain rock mechanics.
- Understand the failure in a continuum.
- Understand griffith criteria for failure.
- Determine stress tensors.

- Understand elasticity theory
- Explain stress functions.
- Identify displacement fields around cracks.
- Identify stress fields around cracks.
- Understand the propagation of fractures.

WHO SHOULD ATTEND

All persons associated in any way with the oil industry, specially Mud Loggers, well site geologists, pressure engineers, Mud engineers and Drilling engineers.

COURSE DURATION

5 Working Days

COURSE OUTLINES

1. **Introduction.**
    - Definition of geomechanics and rock fracture mechanics.
    - Importance of geomechanics and rock fracture studies.
    - Rock rheology.
    - Types of fractures in the Earth and their importance.
    - Terminologies for natural fracture systems.
    - Fractures from a mechanical perspective.
    - Methodologies for geomechanical analyses.
2. **Deformation criteria.**
    - Physical quantities and units.
    - What is a continuum?
    - Coordinate systems and reference frames.
    - Force and pressure.
    - Tractions on a surface.
3. **Stress.**
    - Introduction to stress.
    - Mohr circles.
    - Stress measurements in the Earth.
    - Introduction to displacements and strain.

4. **Elasticity fundamentals.**
    - Definition of elastic behavior.
    - Relationship between stress and strain.
    - Elastic constants.
    - Evidence of elastic response in the Earth.
5. **Rock mechanics.**
    - Theoretical strength of rocks.
    - Determination of elastic moduli.
    - Laboratory measurements of rock strength.
    - Uniaxial and triaxial tests.
    - Stress-strain relationships.
    - Testing machine behaviors.
    - Comparison of laboratory experiments to behavior in the Earth.
6. **Failure in a continuum.**
    - Continuum criteria for strength.
    - Mathematical criteria for brittle failure. Physical criteria for brittle failure.
    - Tensile/shear strength and related fractures.
    - Coefficient of friction.
    - Coulomb stress.
    - Mohr-Coulomb failure criterion.
    - Amonton's and Byerlee's Laws.
    - Crustal strength profiles.
    - Ductile failure and viscosity.
    - Lithospheric strength profiles.
    - Crustal failure.
7. **Griffith criteria for failure.**
    - Griffith-Inglis criteria for elliptical cracks in tension and compression.
    - Derivation of crack solutions.
    - Griffith energy criterion.
    - Application to geological engineering.

8. Stress tensors.

- Mathematical overview.
- Definition of a tensor.
- Stress tensor components.
- Tensor notation.
- Relationship between traction vectors and stress tensors.
- Determination of principal stresses.

9. Elasticity theory in two dimensions.

- Physical quantities and notations.
- Plane strain.
- Plane stress.
- Hooke's law.
- Stress equilibrium.
- Strain compatibility.
- Governing equations and boundary conditions.
- Airy stress function.
- Antiplane strain.
- Applications to bodies with holes.
- Geological and engineering applications.

10. Stress functions.

- Complex representation of plane elastostatic problem.
- Westergaard functions.
- Stress function for uniformly loaded crack.

11. Displacement fields around cracks.

- Definition of displacement.
- Displacement field due to crack motion.
- Applications to planar intrusions and faults.
- Boundary element method and numerical models of displacement fields.

12. Stress fields around cracks.

- Components of stress derived from the stress function.
- Stress trajectories.
- Mean normal stress.

- Maximum shear stress. Near-tip stress fields.
- Applications to geology and geological engineering.

13. Propagation of fractures.
    - Driving mechanisms for fractures.
    - Stress intensity factor criterion for propagation.
    - Energy release rate criterion.
    - Process zones.
    - Inelastic aspects of crack growth.
    - Fracture propagation paths.