# GGY 3051 Blended Class – Assignment 1: Due: 5 June, 2023 17:00 hrs

- Rocks
- Factors Affecting Strength of Rocks in Engineering Practice
- Strike, dip and geological structures
- Industrial & Construction materials
- Introduction to water resources
- Geology in surface excavations

**1.**

Rocks are involved in many civil engineering projects and rock is characterized in terms of Intact Rock and Rock Mass:

i. With respect to the major classes of rocks, explain how rocks originate and provide five examples of rocks from each class.

- The three major classes of rocks are:
  **Igneous rocks** – formed by crystallization of molten magma. Bodies of rock formed by the injection of magma into an existing sequence of rocks. [1 Marks]
  **Sedimentary rocks** – formed by consolidation of sediments [1 Marks]
  **Metamorphic rocks** – formed by transformation of pre-existing rocks under high pressure and temperature [1 Marks]

- Five igneous rocks [5 Mark]:

| | | |
|---|---|---|
| **Granite** | **Basalt** | **Gabbro** |
| **Diabase** | **Diorite** | **Dolerite** |

- Five sedimentary rocks [5 Marks]:

| | | |
|---|---|---|
| **Sandstones** | **Mudstone** | **Chert** |
| **Shale** | **Limestone** | **Conglomerate** |

- Five common metamorphic rocks [5 Marks]:

| | | |
|---|---|---|
| **Gneiss** | **Slate** | **Marble** |
| **Schist** | **Quartzite** | **Amphibolite** |

ii. Mention three types of deformation that an intact rock may undergo and briefly explain what happens in each type of deformation.

- ELASTIC
  - ✓ When load is removed, deformation instantly and completely disappears.
  - ✓ Relationship between stress and strain is more or less linear [1 Marks]
- ELASTIC – PLASTIC
  - Strain resulting from stress starts off as linear relationship with recoverable deformations and then once the yield strength is reached the deformation ceases to be linear and deformation is then permanent. [1 Marks]
- PLASTIC – ELASTIC-PLASTIC

  Deformation starts of non-lineally with an irreversible initial stage, then progresses linearly until it reached the final yield point and becomes permanent and non-uniform.

  [1 Mark]

iii. Explain the difference between elastic strain and plastic strain [1 Marks].

**Elastic Strain:**

- Elastic strain is uniform and when the applied load is removed, deformation instantly and completely disappears.
- Relationship between stress and strain is more or less linear.

**Plastic Strain:**

- Plastic strain is non-uniform and is permanent.

**iv.** Explain the characteristics that influence Rock Mass Strength. **[8 Marks]**

Rock mass strength is influenced by:

- **Intact rock strength**
  - ✓ The greater the intact rock strength [compressive, shear, tensile] the greater its contribution is to the overall strength of the rock mass.
- **Presence and nature of discontinuities**
  - ✓ **Orientation**
    - ➢ The geometrical arrangement of discontinuities relative to directions of imposed stresses and engineering process will determine the bearing capacity of the rock mass. For example:
      - Discontinuities that daylight on slopes render the slopes more prone to failure compared to discontinuities that are dipping into the slope.
      - Discontinuities that re intersecting towards the slope tend to form unstable rock wedges.
    - ➢ **Spacing of discontinuities -** affects overall rock mass strength and/or quality:

➢ The more closely spaced the discontinuities are the weaker the rock mass. Whereas the more widely spaced the discontinuities are the more the strength of the rock mass is influenced by intact rock

properties and the less the effects of the other factors like weathering, discontinuity surface characteristics.

- ✓ **Surface characteristics**
- ➢ Discontinuity surface characteristics include: Roughness / waviness
- ➢ Roughness:
- ➢ results in variations in orientation / attitude along given discontinuity.
- ➢ provides friction btwn two adjacent blocks.
- ➢ Shear strength of discontinuities – expressed in terms of c & □. Roughness has important influence on discontinuity strength, which varies depending on scale of roughness relative to discontinuity plane.
- ✓ **Physical props of material filing the discontinuity space**
- ➢ Filling material can be weaker or stronger than host rock and can increase or reduce the friction along a discontinuity.
- ✓ **Weathering of rock mass -** Weathered state of rock has significant influence on engineering properties of rock mass:
- ➢ Physical weathering results in the increase in the dimensions and frequency of discontinuities in rock mass.
- ➢ Chemical weathering of rock mass is enhanced by the movement of groundwater through networks of discontinuities.
- ➢ Control of water movement through discontinuities may result in localised & often deeply penetrating zones of weathering.

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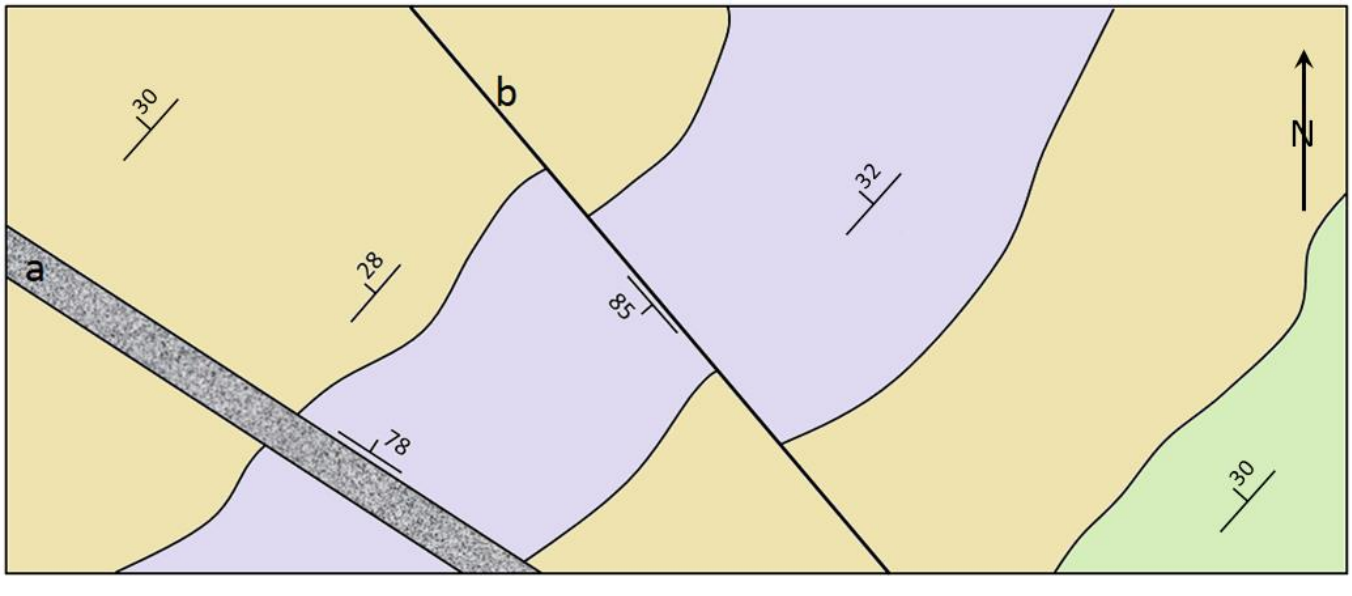
**2.**

Given the figure below:



Describe in words the general attitude (strike and dip) of these beds.

i. Which of these beds is the oldest? **2 Mark] The bend in the eastern end of the map [or shaded green] is the oldest**

ii. What is "a" and what is its attitude?

iii. **[2 Marks] a dike trending NW-SE [or striking SE] with a dip of 78º NE**

iv. What is "b" and what kind of stresses are likely to have produced this feature?

**[2 Marks] A fault, produced by tectonic shear stresses.**

v. What kind of tectonic plate boundary is associated with features like "b"? **[2 Mark]**

Transform boundary.

vi. Explain the difference between True Thickness and apparent thickness with respect to geological formations or strata **[2 Marks].**

- True thickness of a bed is measured perpendicular to the geological boundaries.
- Vertical thickness of an inclined bed is an apparent thickness and this is greater than true thickness.

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**3.**

i. Describe the components of the hydrologic cycle **[20 Marks].**

**Evaporation / transpiration** – transformation of water into vapour from a combination of surface water bodies and plants.

- It's a combined net effect of two processes: - Evaporation & transpiration.
  - ✓ Evaporation – process of returning moisture (on any surface, especially surfaces of ponds, streams, rivers, lakes, & oceans) to atmosphere through water vapour.
  - ✓ Transpiration – process by which plants return moisture to atmosphere.

**Condensation** – saturation/cooling of air masses/vapour to liquid as dew point is reached.

Cooling of water vapour until it becomes liquid:

- As dew-point is reached, water vapour forms tiny visible water droplets.
- When droplets form in sky, and other atmospheric conditions are present, clouds will form.
- As droplets collide, they merge and form larger droplets resulting in precipitation.

**Precipitation** – falling of moisture on Earth's surface from atmosphere as rain, snow, or hail.

- It varies in amount, intensity, and form by season and geographic location.
- Its is recorded as amount of rainfall [in mm] for determination of average rainfalls for a location & for classifying rain-storms.

**Runoff** – movement of water from precipitation across earth's surface towards streams, lakes, oceans

**Infiltration** – Entry of water into the soil.

- Entry of water into soil
- Sustains groundwater availability
- Its rate is usually influenced by physical characteristics of soil, soil cover, water content of the soil, soil temperature & rainfall intensity

**Percolation** – downward movement of water through soil and rock (below root zone) to groundwater store (aquifer).

- Water moves from space to space along fractures in rock, through sand and gravel, or through channels in the geological formations such as cavernous limestone.

ii. Using some component(s) of the hydrologic cycle, describe a situation/condition that would lead to flooding of an area **[10 Marks].**

- High rainfall duration & intensity
- Low infiltration
- Low runoff
- Low percolation
- Pre-saturated soil

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**4.**

During an in-situ test to determine deformation characteristics of a foundation ground, a rock mass with a circular cross-sectional area, with a diameter of 1.5 m. was subjected to a load of 30kN. If the mass experienced a change of 15 cm in its original length of 3m and 7.5 cm in its diameter, calculate:

i. Longitudinal and diametral strains **[5 Marks]**

Assume compressional loading:

- L= 3 m
- D = 1.5 m
- ΔL= 0.15 m
- ΔD= 0.075 m

Longitudinal strain = 0.05

Diametral strain = 0.05

ii. Poisson's ratio **[5 Marks]**

$$\nu = \frac{\text{diametric strain}}{\text{longitudinal strain}}$$

= > 1

iii. Modulus of elasticity **[5 Marks]**

$$E = \text{Stress} / \text{Axial Strain} = \sigma/\varepsilon$$

- Stress = Force/ Area
- Force = 30 kN
- Area = 1.767 m2
- Stress = 16.97 kN/m2
- E = **339.49 kN/m2**

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**5.**

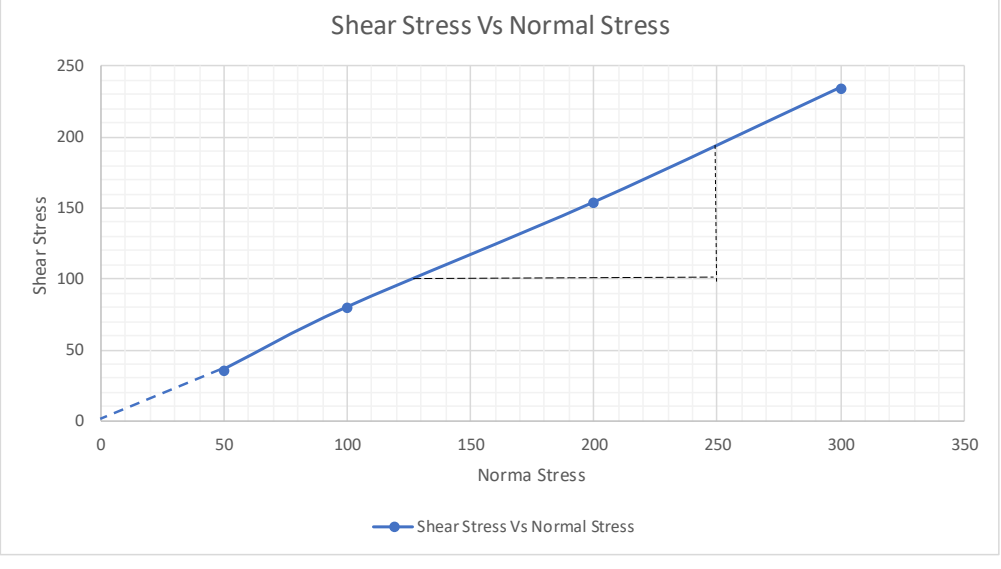
The table below shows laboratory shear box test results on a specimen of a sand soil compacted to in-situ density:

| Normal Stress ($kNm^2$) | 50 | 100 | 200 | 300 |
|---|---|---|---|---|
| Shear Stress ($kNm^2$) | 36 | 80 | 154 | 235 |

i) Determine the shear strength parameters. **[15 Marks]**

The required strength parameters are cohesion c and internal angle of friction Φ:

- Plot the shear stress vs normal stress
- Inverse tan of the gradient is the **angle of internal friction**
- Y- intercept of the graph is the **cohesion**
- Shear strength parameters: $\Phi = 36.9^o$
- $C = 0kNm^2$




190

100

130 250

Shear strength parameters:

**Tan Φ = (90/120)**

**$\Phi = 36.9^o$**

**$C = 0kNm^2$**

ii) Would failure occur on a slope within a mass of this sand at a point where shear stress is **$122kNm^2$** and normal stress of **$246kNm^2$** ? Give reason(s) for your answer. **[10 Marks]**

Ratio of Normal Stress: Shear stress = 246/122 = > 2.02.

Therefore, failure would not occur because the ratio of normal stress [favouring stability] to shear stress [promoting failure] is significantly >1. i.e normal stress is comfortably greater than shear stress.