# GGY 3051 – Assignment 1: Due: 25nd May, 2023 17:00 hrs

- Plate Tectonics
- Minerals
- Rocks
- Factors Affecting Strength of Rocks in Engineering Practice
- Geological Structures
- Industrial & Construction materials
- Site Investigations

# 1.

a)

i. What are the five decisive properties that define a mineral? **[3 Marks]**

- ✓ Made of an element or a chemical compound
- ✓ Definitive chemical composition
- ✓ Orderly, regular repeating internal atomic arrangement and crystalline structure
- ✓ Made of inorganic solids
- ✓ Formed by geologic processes.

ii. Mention three main classes of rocks and the criteria used to categorize rocks into these three classes?

- The three major classes of rocks are:
  - i. **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]
  - ii. **Sedimentary rocks** – formed by consolidation of sediments [1 Marks]
  - iii. **Metamorphic rocks** – formed by transformation of pre-existing rocks under high pressure and temperature [1 Marks]
- Criteria used to categorise rocks into these three classes is **origin / genesis / formation** [i.e. Igneous rocks are formed by igneous processes; sedimentary rocks are formed by sedimentary processes; metamorphic rocks are formed by metamorphic processes [1 Mark]

iii. List two examples of rock types in each of the three main classes of rocks mentioned in (ii)

- Some of the common igneous rocks are as follows [1 Mark]:

  **Granite** **Basalt**

  **Diabase** **Diorite etc**
- Some of the common sedimentary rocks are as follows [1 Marks]:

**Sandstones** **Mudstone** **Chert**

**Shale** **Limestone**

- Some of the common metamorphic rocks are as follows [1 Marks]:

**Gneiss** **Quartzite**

**Schist** **Marble**

**Slate** **Amphibolite**

iv. Comment on the structure and texture of the rocks in each of the rock classes in (ii)

- The texture of **igneous rocks** depends on the composition of the magma and the conditions surrounding the magma's cooling.
- The textures are different in intrusive, vein, and extrusive rocks.
- Intrusive rocks are characterized by:
  - ✓ A holocrystalline texture, in which all the rock material is crystallized.
  - ✓ also depends on the shape of the crystals of the component minerals. [2 Marks]

- In sedimentary rocks, there is a more pronounced **relationship** between **rock structure, texture** and rock genesis compared to igneous rocks.
- Clastic rocks consist of detrital (clastic) grains of various sizes and shapes.
- The grains, which can be **angular, subrounded**, or **rounded**, sometimes lie freely without attachment.
- The structure of clastic rocks, depends on the mutual arrangement of the grains and **can be random**, **laminar**, or **fluidal.** With a random structure, the particles do not have an ordered arrangement. [2 Marks]

- The structures and textures of **metamorphic rocks** are influenced by the chemistry of parent or source rocks and the metamorphic path that the rocks are subjected to.
- Thus the structures and textures of metamorphic rocks arise during the recrystallization in the solid state of primary sedimentary and magmatic rocks.
- The recrystallization occurs under the action of lithostatic pressure, and temperature, which leads to an ordered arrangement of the mineral Grains? [2 Marks]

b)

Rocks that originate from solidification of molten magma occur either as extrusive or intrusive bodies. Briefly explain:

i. The main mode of occurrence of extrusive rocks and intrusive rocks

- Volcanic [or Extrusive] igneous rocks are formed when **volcanic lava erupts and is cooled on the surface of the earth**. Typical examples are andesite, basalt, obsidian, pumice, and rhyolite [ 1 Mark].
- Plutonic [or Intrusive] igneous rocks are formed when lava flow crystallises **inside the earth.** Typical examples are diorite, gabbro, and granite [1 Marks].

ii. How and why textures of these two groups or rocks differ

- The texture of igneous rocks depends on the composition of the magma and the conditions surrounding the magma's cooling. [2 Marks]

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# 2.

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

i. 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]

ii. Explain the difference between elastic strain and plastic strain [2 Marks].

- In elastic strain is uniform, when load is removed, deformation instantly and completely disappears. Relationship between stress and strain is more or less linear.
- Plastic strain is non-uniform and is permanent.

iii. Distinguish between Intact Rock Strength and Rock Mass Strength [2 Mark]

- Intact Rock Strength is a fundamental and quantitative engineering property defined as **amount of applied stress at rock failure/rupture**.
- The applied stress may be:
  - Compressive → for compressive Strength
  - Tensile → for Tensile Strength
  - Shear → for Shear Strength
- Rock Mass Strength and deformability applies to a mass of rock and is **primarily controlled by a combination of intact rock props and discontinuities [**i.e. their occurrence, nature and characteristics**]** and extent of weathering.

iv. List some of the factors that influence whether a rock will deform in elastic or plastic manner or break when placed under stress. [3 Marks]

- Temperature and pressure at which deformation occurs
- Rate at which deformation occurs
- Presence of fluid in the rock
- Composition of rock
- Confining pressure

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# 3.

a) Mention three types of direct stresses caused by tectonic forces/ processes and the type of plate boundaries likely to cause each type of stress **[3 Marks]**

1. **Tensional stress - Divergent** – plate boundaries (move away from each other)
2. **Compressional stress - Convergent** – plate boundaries (move towards each other
3. **Shear stress - Transform** – plate boundaries (grind horizontally against one another (strike-slip motion)

b) What type of stress creates folds? Compressional stress **[1 Mark]**

**i.** Describe the geological structures anticline and syncline and how they are formed **[1 Marks]**

An **anticline** is a type of fold that is an arch-like shape/ onvex upward and has its oldest beds at its core, whereas a syncline is the inverse of an anticline.

ii. Mention three geometrical features of a fold **[1 Marks]**

i. Fold **hinge** line

ii. Fold **limbs**

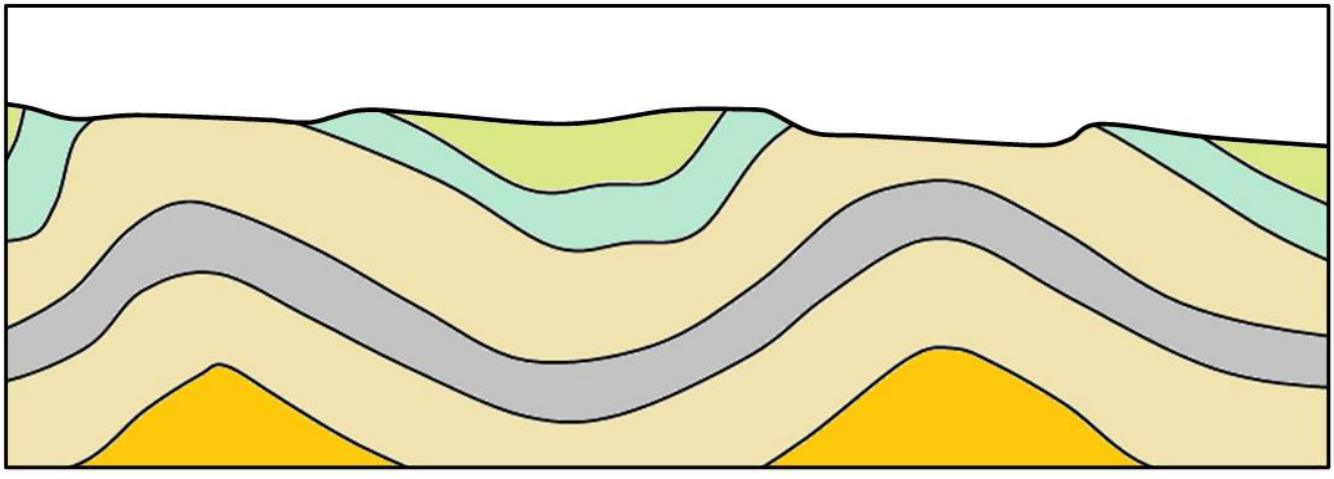
iii. Fold **axial plane** or **axis**

iii. Mention two main types of folds and give two examples of each **[2 Marks]**

i. **Symmetrical folds** – examples are **open fold** and **isoclinal fold**

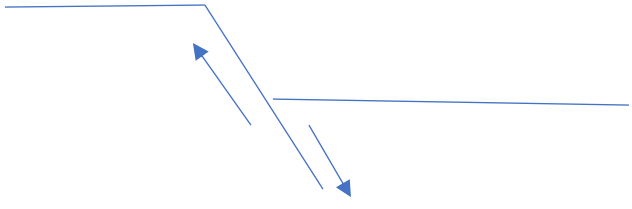
ii. **Asymmetrical folds** – examples are **overturned fold** and **recumbent fold**

**iv.** Label the types of folds in the diagram below, and important geometrical features of the folds **[3 Marks].**

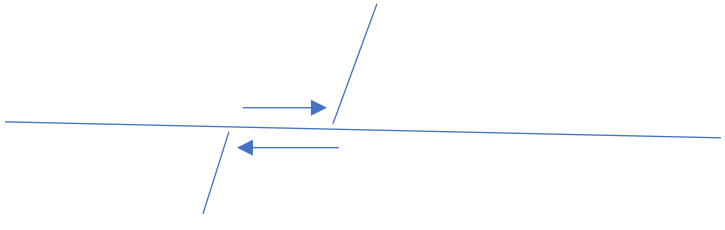


c) Give geological descriptions of the three types of fault movements and or provide simple sketches to illustrate your explanation if you need to.

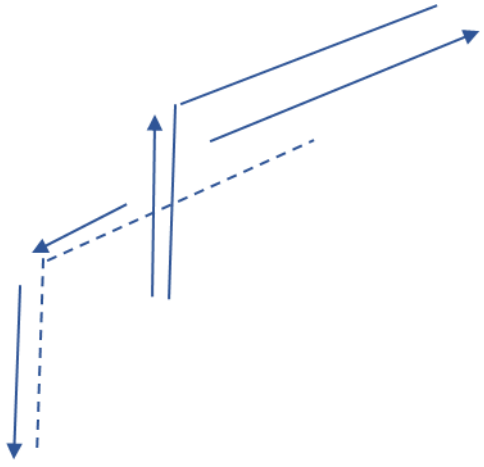
i. In a **dip-slip fault**, movement is parallel to the dip of the fault surface. [1 Mark]



ii. A **strike-slip fault** indicates horizontal motion parallel to the strike of the fault surface. [1 Mark]



iii. An **oblique-slip fault** has both strike-slip and dip-slip components [1 Mark]



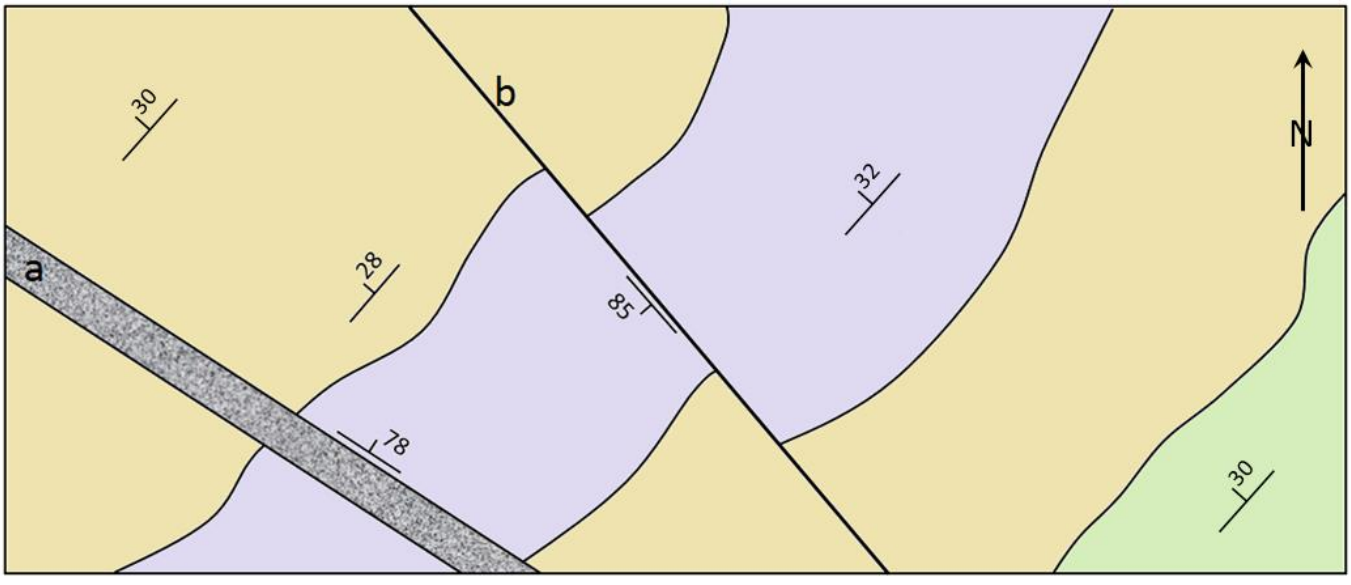
d) What is the difference between a normal fault and a reverse fault, and under what circumstances would you expect these faults to form? In each case state the kinds of stress involved and what happens to the earth's crust.

- ✓ **Normal Fault** – are generally steeply inclined, along which **hanging-wall block has moved relatively downward.**
- ✓ **Reverse Fault-** are generally steeply inclined, along **which hanging-wall block has moved relatively upward. [1 Marks]**
- ✓ Normal Fault **-** is formed under **tensional stresses**
- ✓ Reverse Faulting is formed under **compressional stresses [1 Marks]**
- ✓ Normal Fault **- crust lengthens.**
- ✓ Reverse Faulting **crust shortens. [1 Marks]**

e) What type of fault would you expect to see near to a transform plate boundary? **[1 Mark]**

- A strike slip fault

f) The diagram below is a plan view (map) of the geology of a region. The coloured areas represent sedimentary beds.




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

i. Which of these beds is the oldest? **[1 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? **[1 Marks]** **a dike trending NW-SE [or striking SE] with a dip of 78º NE**

iii. What is "b" and what is its attitude? **[1 Marks]** **A fault trending NE-SE [or Striking SE] with dip of 85º SW**

**iv.** Which of these terms applies to "b": "left lateral" or "right lateral"? **[1] Mark] Right lateral**

v. Explain the difference between True Dip and Apparent Dip

- True dip is the maximum acute [0-90º ] angle measured between the horizontal (regardless of slope of the ground surface) and the strata. **[1 Marks]**

- If the slope of geological boundary is measured in any direction between strike direction and direction of maximum dip, the angle of dip in that particular direction is known as an apparent dip. Its value will lie between 0° and value of maximum or true dip. **[1 Marks]**

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## 4.

i. Mention seven aspects of discontinuities that are significant with respect to stability of Rock Masses in engineering terms. **[7 Marks]**

1. **Orientation**
2. **Spacing**.
3. **Continuity**
4. **Surface characteristics**
5. **Chemical weathering** of rock mass

6. **Thickness & nature of filling** material (if present)
7. **Physical Properties of adjacent rock**
8. **Presence of water**

ii. Briefly explain each one of the aspects in (i) above with respect to Rock Mass Strength and civil engineering processes. **[7 Marks]**

1. **Orientation** [or geometry] – orientation relative to the direction of engineering process or works can determine the stability of the rock mass in handling the stresses.
2. **Spacing** – the more closely spaced the discontinuities are the weaker the strength of the intact rock and rock mass.
3. **Continuity** – the more continuous the discontinuity the weaker the rock mass.
4. **Surface characteristics** (roughness/waviness – has important influence on shear strength of discontinuities as it provides friction between two adjacent rocks; weathering / alteration; physical properties of material filling up the space) - Physical weathering results in changes in size and number of discontinuities in rock mass.
5. **Chemical weathering** of rock mass is enhanced by movement of groundwater through network of discontinuities
6. **Thickness & nature of filling** material (if present)
7. **Physical Properties of adjacent rock**
8. **Presence of water**

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## 5.

i. Mention four physical characteristics/properties to be considered for a good aggregate for engineering use. **[4 Marks]**

1. Toughness & resistance to abrasion
2. Durability and soundness.
3. Particle shape & surface texture.
4. Cleanliness & deleterious

ii. Briefly state why each one of the four characteristics in (i) is important?

1. Toughness & resistance to abrasion – Aggregates must be hard & tough enough to resist crushing, degradation & disintegration from activities, e.g. manufacturing, stockpiling, placing & compaction. [2 Marks]
2. Durability and soundness. Aggregates must be resistant to breakdown & disintegration from weathering (wetting/drying), or else, they might break apart prematurely & cause pavement distress. [2 Marks]

3. Particle shape & surface texture – are important for proper compaction, load resistance & workability. Generally, angular-shaped particles with a rough surface texture are best. [2 Marks]
4. Cleanliness & deleterious materials – Aggregates must be clean…. vegetation matter, soft particles, clay lumps, & excess dust might prevent binder-aggregate bonding & affect performance by quick degradation. [2 Marks]

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# 6.

Site Investigations are carried out in stages, with each stage building up enough information to allow execution of the next:

i. **What is** a Site Investigation?

SI is a Process by which: **Geologic, Geotechnical & Other relevant surface & sub-surface data/information which affect construction and/or performance of an engineering or building project – are acquired to inform the detailed design of the project/structure** [5 Marks]

ii. Mention **two objectives** of a site investigation, the various stages involved in Site Investigation and outline the key activities involved at each stage

Objectives [any two]: [4 Marks]

- ✓ **To assess suitability of a site & its environs** for proposed project
- ✓ **To provide data for effects of proposed project on its environment** → distress to neighbouring structures resulting from loss of ground &/or lowering of GW Table (which would lead to legal action).
- ✓ To **explore & locate sources of construction materials**.
- ✓ To **observe & record any conditions that may have led to failure of existing or former structures**
- ✓ Where alternatives exist, **to advise on suitability of alternative sites**

Stages involved in SI: [10 Marks]

The stages and scope of SI may vary depending on the nature, scale and site specifics for a particular project but the general stages, in full, are:

1. **Project conception stage**

   Activities;

- ✓ **Using secondary data to investigate**: History and previous use of site; any defects /failures of existing or former buildings attributable to foundation conditions; any special features – possibility of earthquakes, flooding, seasonal swelling & shrinkage of ground.

2. **Preliminary investigation**

Activities;

- ✓ **Carrying out limited exploration using relatively simple & inexpensive techniques to:** Establish basic knowledge, and define the main factors that would influence feasibility, cost & safety of project.

3. **Main investigation stage**

Activities;

- ✓ **Getting detailed & appropriate parameters for foundation design**: Geotech. props of ground mass through extensive lab & in situ testing – permeability, shear strength. etc. Distribution of alluvium; ground conditions within zone affected by foundation pressures – geophysical surveys, etc. groundwater levels in various strata

4. **Construction investigation stage**

Activities:

- ✓ Monitoring, recording and assessing for discrepancies from results of the Main Investigation and those encountered during construction.

5. **Post construction investigation stage**

Activities;

- ✓ **Monitor behaviour of completed engineering work computed on basis of data acquired in earlier stages & comparing with predicted performance**; If behaviour of structure is not same as anticipated, need for further investigations. If there are anomalies, their cause must be established & remedial measures undertaken before severe damage/failure can occur.
- ✓ **Reveals discrepancies between forecast and actual conditions**.
- ✓ **Observes anomalies of project behaviour**
- ✓ **Establishes causes of these anomalies** in order to undertake appropriate remedial measures before severe damage / failure occurs.