



Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(ISO 9001:2015 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka



Department of Civil Engineering

Earth Resources and Engineering Laboratory (21CVL46)

B.E - IV Semester Laboratory Manual 2022-23

Name: _____

USN: _____

Batch: _____ Section: _____



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Course Code 21CVL46

Teaching Hours/Week (L:T:P: S) 0: 0:2:0

Credits 01

CIE Marks 50

SEE Marks 50

Exam Hours 03

Course objectives:

- To provide decision support on the nature of the basic raw materials used in construction.
- To provide decision support on Litho logical characters and subsurface conditions.
- To describe various geological maps and interpretation of geological data for mining and subsurface investigations.
- To understand the subsurface using geospatial data.

EXPERIMENTS

1 Evaluation of minerals based on physical properties for basic raw material for construction, industrial application.

2. Investigation of rock based on physical, textural, and mineralogical properties for construction

3 Tests on aggregates (crushing, impact analysis, shape- elongation water absorption, flakiness as per IS Code 2386), Decorative purpose, foundation, monumental works

4 Tests on bricks (load tests and water absorption tests); Size analysis of sands (sieving and presentation and calculation in Microsoft Excel)

5 Geologic maps studies

Cross-section studies of Geological maps for suitability evaluation and subsurface investigation of geological conditions for Dams, tunnels water harvesting, aqua duct, bridges under conditions of Horizontal strata, inclined strata, Folded and Faulted beds, Unconformity, Intrusion relevant–; Construction/ generation of Geological maps based on borehole data.

6 Geospatial data analysis

- Interpretation of toposheets–
- Visual interpretation of FCCs (Geomorphology and Land use/land cover mapping) and TCCs,
- Software application (QGIS)
- Demonstration Experiments (For CIE)

7 Geophysical explorations –

Electrical resistivity methods for subsurface investigation – and its Interpretation, lateral and vertical sounding

Course outcomes (Course Skill Set): At the end of the course the student will be able to:

- Comprehend the relations between minerals and rocks based on their physical properties
- Assess the suitability of materials used in building construction
- Differentiate geological investigations necessary for the construction of dams, bridges, and tunnels
- Describe the groundwater investigation using resistivity methods
- Understand the applications of Geospatial technology in Civil Engineering.

Suggested Learning Resources:

- <https://mg-nitk.vlabs.ac.in/mining-geology/List%20of%20experiments.html>
- https://www.youtube.com/watch?v=D_uYjqZ1nYw
- <https://www.youtube.com/watch?v=NHolzMgaqwE>

Instructions to the Students

1. Students should come with thorough preparation for the experiment to be conducted.
2. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
3. All the calculations should be made in the observation book. Problem calculations for one set of readings have to be shown in the practical record.
4. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
5. Practical record should be neatly maintained.
6. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
7. Theory regarding each experiment should be written in the practical record before procedure in your own words.



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DEPARTMENT OF CIVILENGINEERING

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| | <ul style="list-style-type: none">• Visual interpretation of FCCs (Geomorphology and Land use/land cover mapping) and TCCs,• Software application (QGIS)• Demonstration Experiments | |
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Experiment - 1

EVALUATION OF MINERALS

AIM: To identify the mineral based on its physical properties.

INTRODUCTION

Mineral is a naturally occurring inorganic substance having definite chemical composition and with definite internal structure. The branch of geology which deals with the various aspects of minerals such as their individual properties, their mode of formation and mode of occurrence is called as mineralogy. The most common minerals are quartz, feldspar etc. The important index properties of minerals are,

1. Habit/Form/Structure
2. Color
3. Streak
4. Luster
5. Hardness
6. Cleavage
7. Fracture
8. Diaphaneity
9. Specific Gravity
10. Special properties like magnetism

1. **Habit/form/structure:** It is the internal atomic arrangement of the mineral which is manifested outwardly by development of geometrical shapes or crystals characters. Few structural forms observed in minerals are

| Form | Description | Example |
|---------------|---|-----------------------------|
| Lamellar form | Mineral appears as thin separable layers | Different varieties of Mica |
| Tabular form | Mineral appears as slabs of uniform thickness | Feldspars, Gypsum |
| Fibrous form | Mineral appears to be made up | Asbestos |

| | | |
|--------------------|--|---------------------|
| | of fine threads | |
| Pisolitic form | Mineral appears to be made up of small spherical grains | Bauxite |
| Oolitic form | Similar to Pisolitic form but grains are of still smaller size | Limestone |
| Rhombic form | Rhombic shape | Calcite |
| Bladed form | Mineral appears as cluster or as independent rectangular grains | Kyanite |
| Granular form | Mineral appears to be made up of innumerable equidimensional grains of coarse or medium or fine size | Chromite, Magnetite |
| Columnar form | Mineral appears as long slender prism | Topaz |
| Prismatic form | As elongated | Apatite, quartz |
| Spongy form | Porous | Pyrolusite |
| Crystal form | Polyhedral, Geometrical shapes | Garnets, Galena |
| Massive form | No definite shape for mineral | Jasper, Graphite |
| Concretionary Form | Porous and appears due to accretion of small irregularly shaped masses | Laterite |
| Nodular form | Irregularly shaped compact bodies with curved surfaces | Flint |

2. **Colour:** It is a light dependent property. Colour is not considered as a diagnostic property of mineral. The colour of the mineral may also change due to the exposure to atmosphere.

3. **Streak:** It is the colour of mineral in the powdered form. It is one of the important diagnostic property of mineral especially those with a metallic lustre. It is found by rubbing the specimen on a piece of unglazed tile, or streak plate.

4. **Lustre:** The lustre of a mineral is the way its surface shines when held up to the light. Lustre is a property distinct from colour.

| Lustre | Description | Example |
|-----------------------|---|-------------------------------|
| Metallic Lustre | It is the type of shining that appears on the surface of a metal | Galena, Gold, Pyrite |
| Sub metallic Lustre | If the amount of shining is less when compared to metallic luster | Hematite, Chromite, Magnetite |
| Vitreous Lustre | Shining like a glass sheet | Quartz, Feldspar |
| Sub Vitreous Lustre | Less shining when compared to vitreous lustre | Pyroxenes |
| Pearly Lustre | Shining like a pearl | Talc, Muscovite mica |
| Silky Lustre | Shining like silk | Asbestos |
| Resinous Lustre | Shining like a resin | Opal, Agate |
| Greasy Lustre | Shining like grease | Graphite |
| Adamantine Lustre | Shining like a diamond | Garnet, Diamond |
| Earthy or Dull Lustre | No Shining | Bauxite, Magnesite |

5. **Cleavage:** The definite direction or plane along which a mineral tends to break easily is called cleavage of that mineral. It occurs as innumerable parallel planes along which the mineral is equally weak. Such parallel planes of weakness are referred to as a set.

| Cleavage | Example |
|-------------------------|----------------------------------|
| One set of cleavage | Mica, Chlorite, Talc |
| Two sets of cleavages | Feldspars, Pyroxenes, Amphiboles |
| Three sets of cleavages | Calcite, Dolomite, Galena |
| Four sets of cleavages | Fluorite |
| Six sets of cleavages | Sphalerite |
| No cleavage | Quartz, Olivine, Garnet |

6. **Fracture:** The appearance of the broken surface of a mineral in a direction other than that of cleavage. Common types of fracture are

| Fracture | Description | Example |
|-----------------|--|----------------|
| Even | When the broken surface is smooth and flat | Chert |
| Uneven | When the mineral breaks with an irregular surface | Fluorite |
| Conchoidal | The broken surface of the mineral shows concavities | Quartz |
| Splintery | When the mineral breaks with the rough woody fracture | Kyanite |
| Hackly | The broken surface is highly irregular with numerous sharp, fine projections | Copper |
| Earthy | The surface is smooth, soft and porous | Chalk |

7. **Hardness:** Hardness is the resistance offered by the mineral to abrasion or scratching. It is determined with the help of Moh's scale of hardness which consists of ten reference minerals arranged in increasing order of hardness and numbered accordingly.

| Hardness | Example | Hardness | Example |
|----------|---------|----------|---------|
| Talc | 1 | Feldspar | 6 |
| Gypsum | 2 | Quartz | 7 |
| Calcite | 3 | Topaz | 8 |
| Fluorite | 4 | Corundum | 9 |
| Apatite | 5 | Diamond | 10 |

8. **Specific Gravity/ Density:** Specific gravity or Density of minerals depends on their chemical composition and atomic structure.

| Density | Specific Gravity | Example |
|----------------|--------------------------------------|--------------------------------|
| Low density | Specific gravity less than 2.5 | Gypsum (2.3), Graphite (2-2.3) |
| Medium density | Specific gravity between 2.5 and 3.5 | Quartz (2.7), Feldspar(2.5) |
| High density | Specific gravity greater than 3.5 | Chromite (4.5- 4.8) |

9. **Diaphaneity:** The property possessed by some minerals to transmit light is known as Transparency/ Diaphaneity.

| Diaphaneity | Description | Example |
|--------------------|--|----------------------------|
| Transparent | When the outlines of an object seen clearly though the mineral | Rock crystal |
| Translucent | A mineral which can transmit light only at edges | Calcite, Fluorite, Quartz, |
| Opaque | When no light is transmitted through the mineral | Hematite, Magnetite, etc |

Experiment - 2

INVESTIGATION OF ROCK

AIM: To identify the rock based on its physical properties

INTRODUCTION

Mineral is a naturally occurring inorganic substance having definite chemical composition and with definite internal structure. The branch of geology which deals with the various aspects of minerals such as their individual properties, their mode of formation and mode of occurrence is called as mineralogy. A rock is defined as an aggregate of minerals and the study on rock is called Petrology. Based on their origin, geologically rocks are classified into igneous rocks, Sedimentary rocks and metamorphic rocks.

Igneous rocks:

They are derived from solidification of molten material 'magma' or 'lava'. They subjected to different rate of crystallization. Thus, they exhibit different crystalline textures and structures. They are often connected with the interior of the earth's crust. They are massive in form and free from fossil remains of ancient animals and plants. Ex: Granite from Magma, Basalt from Lava. These rocks are the fore most rocks to be formed on the earth's crust. So they are known as 'primary Rocks'. These rocks are characterized by vesicular structure, amygdaloidal structure and Aphanitic structure if they are volcanic. If they are Hypabyssal or plutonic, they are dense, compact and exhibit interlocking texture.

Sedimentary rocks:

These rocks are formed by the weathered, transported and deposited on the oceanic floor in the form of layers. They are also known as 'Layered Rocks'. They are formed under water, they possess evidences of sedimentation viz, stratification, ripple marks, current bedding, graded bedding, mud/sun cracks, rain prints. Fossils etc., Example conglomerate, sand stone, limestone etc.

Metamorphic rocks:

These are derived from the pre-existing rocks due to intense temperature, pressure or both. These phenomena known as thermal metamorphism, dynamic metamorphism and dynamothermal metamorphism respectively. The rocks subjected to metamorphism, lose their original features and new structures are introduced. Example igneous rock Granite is metamorphosed to form Gneiss, sedimentary rock Limestone is metamorphosed to form Marble.

Some of the index properties of rocks are

1. Grain Size
2. Texture / Structure
3. Mineral Composition
4. Cementing Materials
5. Specific Gravity

1. **Colour** : The colour of rocks depends upon their constituent minerals or cementing material.

2. **Texture**: It is the mutual arrangement of component mineral grains size, shape. The texture will be different for igneous, metamorphic and sedimentary rocks.

| Texture of Igneous Rocks | | |
|---------------------------------|--|------------------|
| Texture | Description | Example |
| Equigranular | It consists of almost equidimensional mineral grains | Granite, Gabbro |
| Porphyritic | It consist of few large, well developed mineral grains | Granite porphery |

| | | |
|-------------------------------------|--|----------------------|
| Glassy texture | It consists of amorphous surface with rich in silica (SiO_2) and rapid solidification of lava/magma in volcanic igneous rocks | Rhyolite, Obsidian |
| Vesicular/ Amygdaloidal texture | It consist of pores or vesicles due to release of gaseous substances | |
| Texture of Sedimentary Rocks | | |
| Massive | Amorphous or very fine –grained and breaks with concentric curves | limestone |
| Fossiliferous | It consists of fossil remains buried, cemented together | Limestone |
| Concretionary | Hard and Soft clay with iron oxide or aluminium oxide | Laterite |
| Texture of Metamorphic Rocks | | |
| Granulose | It consists of interlocking of shapeless grains or crystalline minerals | Quartzite, Marble |
| Schistose | It consists of flaky, foliated grains or layers twisted or curved | |
| Gneissose | It consists of alternate bands of light coloured and dark coloured mineral | Gneiss, Augen gneiss |

3. Grain size:

Fine: Grain diameter 1 mm or less

Medium: Grain diameter 1 mm to 5 mm

Coarse: Grain diameter 5 mm and above

4. Mineral Composition:

The combination and proportion of the mineral component in Rock, Mineral compositions can be divided in two types:

- a. Essential minerals: These are essential for description, identification and classification, of Rocks. Ex : Quartz, Feldspar, Mica. Augite, Calcite, Talc, Chlorite.
- b. Accessary minerals: These may be present/obsent. Ex: Mica, Magnite, Iron pyrite, Garnet.

5. Cementing Material: (Exclusively for Sedimentary Rocks)

Natural binding material deposited in between component sedimentary pebbles, fragments, grains and/or fossil remains.

| | |
|--------------|--|
| Calcareous | It imparts white colour and pale colour to sand stones and can be known by acid test |
| Feriginous | Imparts shades of brown, red, or yellow colour to sand stone |
| Argillaceous | It provides only weak cohesion for sand particles, which fall of rubbing the sand stone |
| Siliceous | Resembles calcareous cementing material but provides competence and durability to sand stone |
| Glaucontic | It provides green colour to sand stone |

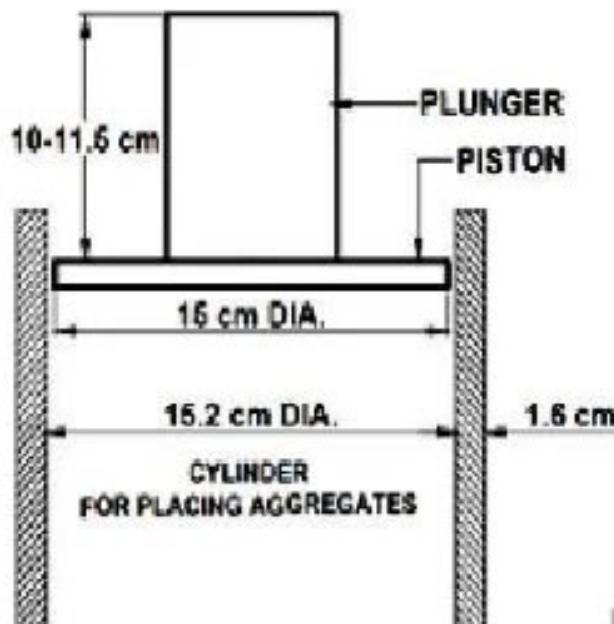
Experiment - 3

TESTS ON AGGREGATES

1. Aggregate Crushing Test:

The strength of aggregate is defined as the resistance of the aggregate against gradual loading. The strength of aggregate is determined by the Crushing Value Test on aggregates. The aggregates passing through a 12.5 mm IS sieve and retained on a 10 mm IS sieve are taken. These aggregates are subjected to gradual loading of 40 tonnes with the help of a plunger. The crushed aggregates are then passed through a 2.36 mm sieve. The weight of the aggregates passing through the 2.36 mm sieve, expressed as the percentage of the total weight of aggregates, is referred to as Aggregate Crushing Value (ACV). Lesser is the ACV, more will be the strength of aggregate. ACV less than 10 indicates exceptionally strong aggregate whereas, ACV greater than 35 indicates weak aggregate.

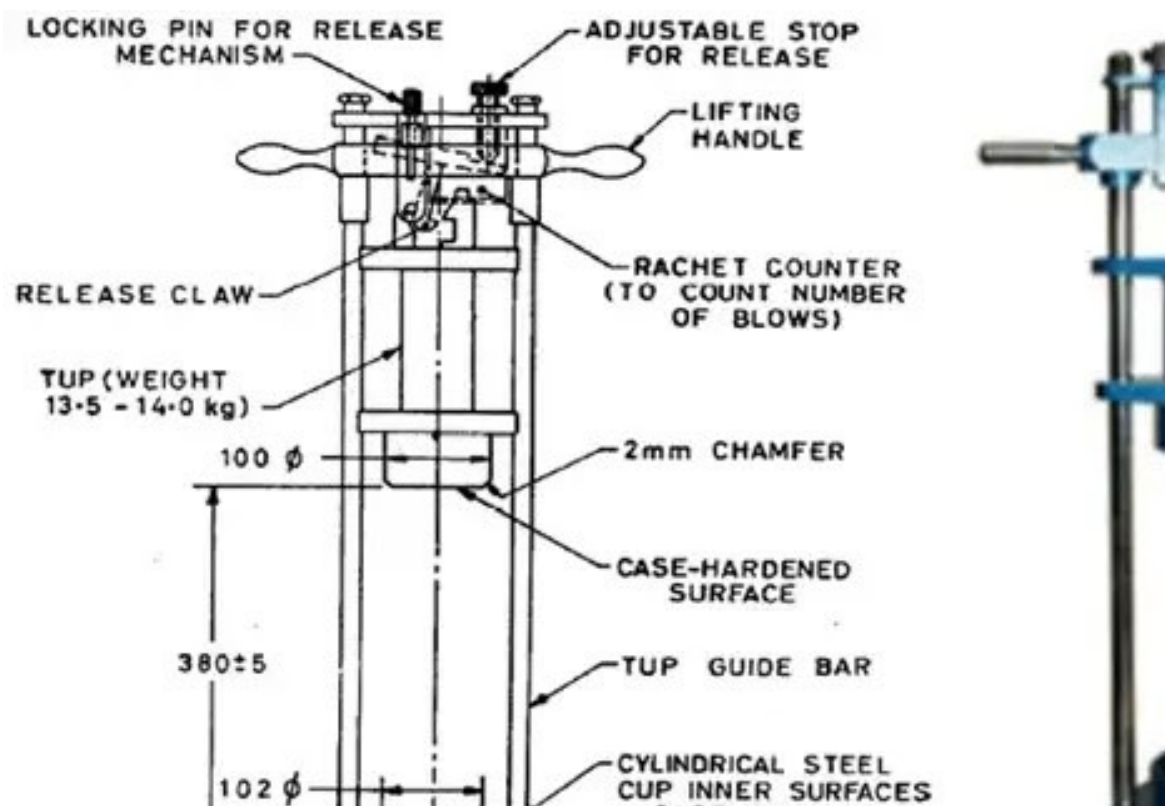
Aggregate Crushing Value (ACV) = $\frac{\text{weight of material passing through 2.36 mm sieve}}{\text{weight of total aggregate}}$



2. Aggregate Impact Test

The toughness of the aggregate is defined as the ability to resist impact loading. The toughness of the aggregate is determined by Impact Value Test on aggregates. The aggregates passing through a 12.5 mm IS sieve and retained on a 10 mm IS sieve are taken. This sample of aggregate is subjected to 15 blows with the help of a metallic hammer having a mass of 13.5-14 kg, free-falling from a height of 38 cm. The aggregates after impact are passed through the sieve of size 2.36 mm. The weight of aggregates passing through the 2.36 mm sieve, expressed as the percentage of the total weight of aggregates is referred to as Aggregate Impact Value (AIV). Lesser is the AIV, more will be the toughness of the aggregate. The AIV of aggregate should not exceed 30% for wearing course, 35% for bituminous macadam and 40% for water-bound macadam.

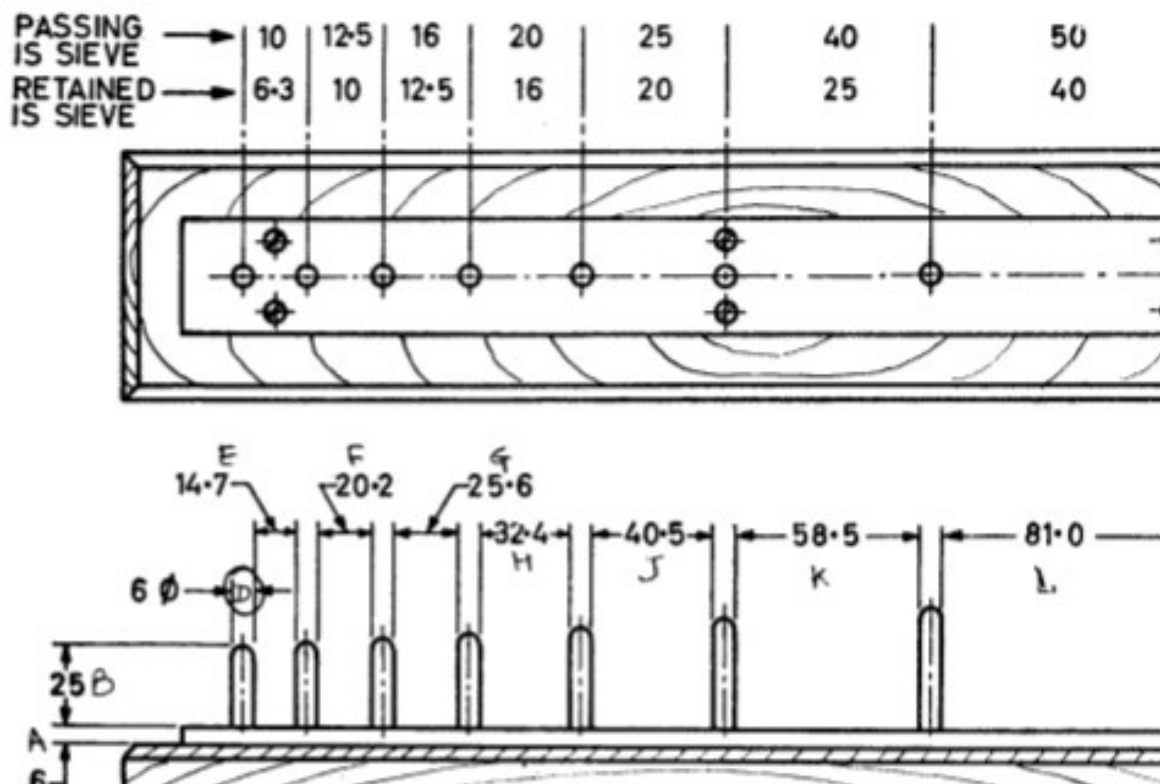
Aggregate Impact Value (AIV) = $\frac{\text{weight of material passing through 2.36 mm sieve}}{\text{weight of total aggregate}}$



3. Elongation Index Test

The elongation index of the aggregates is defined as the percentage by weight of the aggregates present in the sample having their greatest size greater than 1.8 times of their mean size. Elongation index test on aggregates is performed using Length Gauge. This test does not apply to aggregates with a size of less than 6.3 mm. An aggregate sample having a minimum of 200 pieces is considered and each aggregate is passed through the respective gauges of the length gauge. The weight of aggregates retained over various gauges is noted which when expressed in terms of the total weight of the aggregates is referred to as Elongation Index.

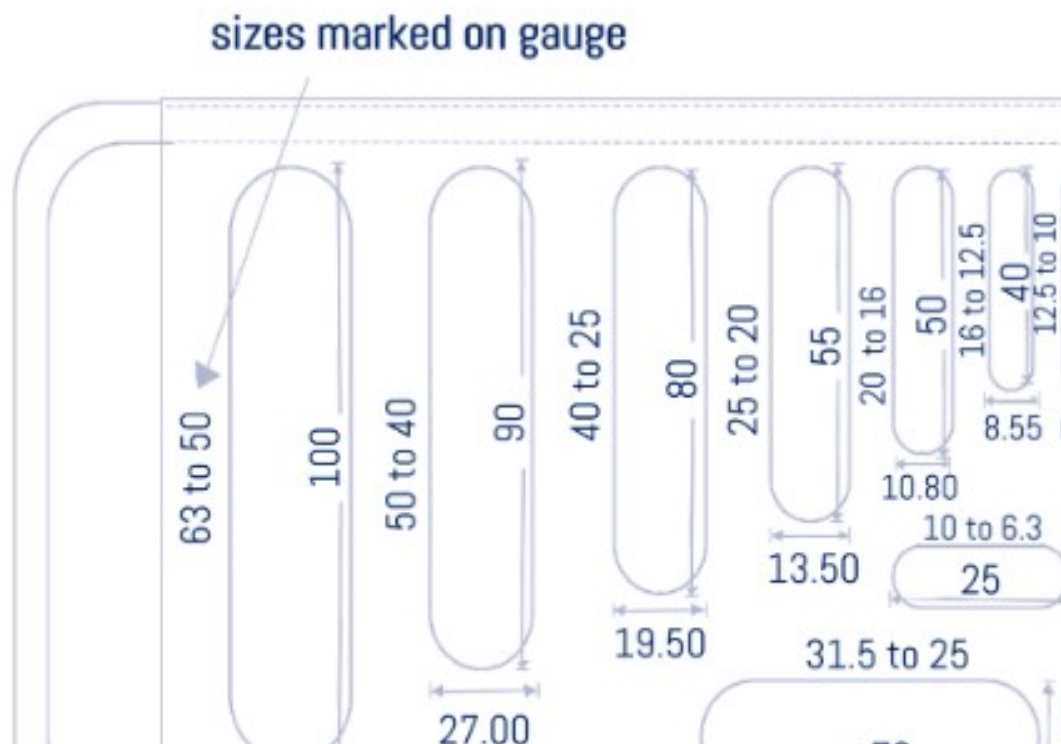
Elongation Index = $\frac{\text{Weight of material retained on various gauges}}{\text{Total weight of the sample}}$



4. Flakiness Index Test

The flakiness index of the aggregates is defined as the percentage by weight of the aggregates in the sample whose least dimension is less than 0.6 times the mean dimension. The flakiness index test on aggregates is performed using Thickness Gauge. This test does not apply to aggregates with a size of less than 6.3 mm. An aggregate sample having a minimum of 200 pieces is considered and each aggregate is passed through respective gauges of the thickness gauge. The weight of the aggregates passing through various gauges is noted which when expressed as a percentage of the total weight of aggregate sample is referred to as Flakiness Index.

Flakiness Index = $\frac{\text{Weight of material passing the various gauges}}{\text{Total weight of the sample}}$



Experiment – 4

TESTS ON BRICKS

1. Absorption Test on Bricks

24-hour Immersion Cold Water Brick Test:

- The dry specimen is put in an oven maintained at a temperature of 105 to 115o C, till it attains substantially constant mass.
- After cooling the specimen at room temperature weight of the specimen was recorded as W1.
- The dry specimen is then immersed completely in the water at a temperature of $27 \pm 2^{\circ}\text{C}$ for 24 hours.
- Take out specimens from the water and wipe all water from its surface with a wet cloth.
- Complete weighing of the specimen, 3 minutes after the specimen has been removed from the water.
- Let this weight be W2.
- Water absorption after 24 hours of immersion in cold water is given by $(W2 - W1) \times 100 / W1$

5-hour Boiling Water Brick Test:

- The brick sample is dried in an oven at 105 to 115o C till it attains constant mass.
- Cool the brick sample at room temperature and record its weight (W1).
- The brick is immersed in boiling water for 5 hours.
- With brick immersed in water is allowed to cool at $27 \pm 2^{\circ}\text{C}$.
- The brick sample is taken out and wiped with a damp cloth.

- Complete the weighing of the specimen in three minutes. Let it be W3.
- Water absorption, percent by mass, is given by $(W3 - W1) \times 100 / W1$



2. Compressive Test on Brick:

- For this test well brunt clay brick is selected.
- The top and bottom faces of bricks are ground to provide a smooth and even surface for the test.
- The brick sample is then placed in water at room temperature.
- Clean top flogs of brick and fills them with cement mortar (1 part cement and 1 part clean coarse sand of grade 3 mm and down), store under damp jute bags for 24 hours, and then immerse in clean water for 3 days.
- Take out the brick sample and clean the extra water from the surface.
- Place brick sample between two plywood sheets, each 3 mm thick, with flat faces horizontal and mortar-filled faces facing upwards.

- The brick sample between plywood sheets is carefully set in the center of the compression testing machine.
- Fix the gauge of the machine and tighten it and start applying the axial load at a uniform rate of 140 kg/cm² per minute till failure.
- The maximum load on the dial gauge at the failure of the brick sample is noted.
- Compressive strength = maximum load at failure/ Base area of Brick.



3. Sieve Analysis of Fine Aggregate

Sieve analysis for fine aggregate requires the following test apparatus.

- I.S. Sieve (size 10mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 microns, 300 microns and 150 microns with lid and pan)
- Oven
- Balance 0.01 g accuracy

- Tray
- Brush
- Mechanical sieve shaker

Test procedure:

- Take 1 kg of representative sample out of 10 kilograms with the help of the quartering method.
- Arrange the sieve set in such a manner so that the largest size sieve should be at the topmost and the smallest one at the bottom(10mm sieve at the top and all other sizes of sieves are arranged in decreasing manner. i.e., 4.75mm, 2.36 mm, 1.18mm, 600 μ m, 300 μ m, 150 μ m), and below 150 μ m sieve, a pan is fixed.
- After putting 1kg of the sample into the topmost sieve, close the lid, and then the whole sieve set is arranged in a sieve shaker.
- Sieve analysis for fine aggregate is carried out by sieving the sample aggregate in a sieve shaker for not less than 10 minutes.
- At the end of sieving, find the mass of fine aggregate material retained on each sieve.

| Sieve Size (mm) | Retained Wt.(gm) | Retained % (Col.IIx100/W) | Cumulative Retained % | % of Passing (100-col.IV) | Specified Limit as per MORTH | Specified Limit as per MORTH | Specified Limit as per MORTH |
|-----------------|------------------|---------------------------|-----------------------|---------------------------|------------------------------|------------------------------|------------------------------|
| I | II | III | IV | V | Zone-I | Zone-II | Zone-III |
| 10 | | | | | | | |
| 4.75 | | | | | | | |
| 2.36 | | | | | | | |
| 1.18 | | | | | | | |
| 0.600 | | | | | | | |
| 0.300 | | | | | | | |
| 0.150 | | | | | | | |
| Pan | | | | | | | |



| IS Sieve Size | Per cent by Weight Passing the Sieve | | |
|---------------|--------------------------------------|---------|----------|
| | Zone I | Zone II | Zone III |
| 10 mm | 100 | 100 | 100 |
| 4.75 mm | 90-100 | 90-100 | 90-100 |
| 2.36 mm | 60-95 | 75-100 | 85-100 |
| 1.18 mm | 30-70 | 55-90 | 75-100 |
| 600 micron | 15-34 | 35-59 | 60-79 |
| 300 micron | 5-20 | 8-30 | 12-40 |
| 150 micron | 0-10 | 0-10 | 0-10 |

Experiment – 5

GEOLOGIC MAPS STUDIES

What is a geological map?

A geological map is a specialized type of map that displays the distribution of geological features and materials on or below the Earth's surface. It is typically created by geologists and other earth scientists to represent the geology of a particular area, and can show the location, type, and age of rock formations, as well as the presence of faults, folds, mineral deposits, and other geological features. Geological maps are an essential tool in geological research, mineral exploration, and natural resource management, as they provide valuable information about the structure and composition of the Earth's crust.

What is the purpose of a geological map?

The primary purpose of a geological map is to provide a visual representation of the distribution of different rock types, structures, and other geological features across a particular area. This information is essential for many different types of geological studies, such as mineral exploration, oil and gas exploration, groundwater management, and engineering geology.

Geological maps can also be used to identify potential hazards such as landslides, earthquakes, and volcanic eruptions. By understanding the geological history and structure of an area, scientists can make predictions about the likelihood of these hazards occurring, and take steps to mitigate their potential impact.

In addition to these scientific applications, geological maps can also be useful for land-use planning, environmental management, and other practical applications. For example, a geological map can help identify areas where it may be safe to build structures or where groundwater resources may be located.

Overall, geological maps are a crucial tool for understanding the Earth's surface and subsurface, and for making informed decisions about natural resource management, hazard mitigation, and environmental protection.

How do you read a geological map?

To read a geological map, follow these general steps:

Read the map legend: The map legend explains the symbols, colors, and patterns used on the map to represent different rock types, geologic features, and other information.

Identify rock types: Look for areas on the map that are colored or patterned differently, indicating different rock types. Pay attention to the map key to understand what each color or pattern represents.

Determine geologic structures: Look for features such as folds, faults, and joints, which are often represented by lines or patterns on the map. These structures can give insights into the deformation history of the rocks.

Locate key features: Identify the locations of features such as mines, wells, outcrops, and geologic formations, which can provide important context for understanding the geology of the area.

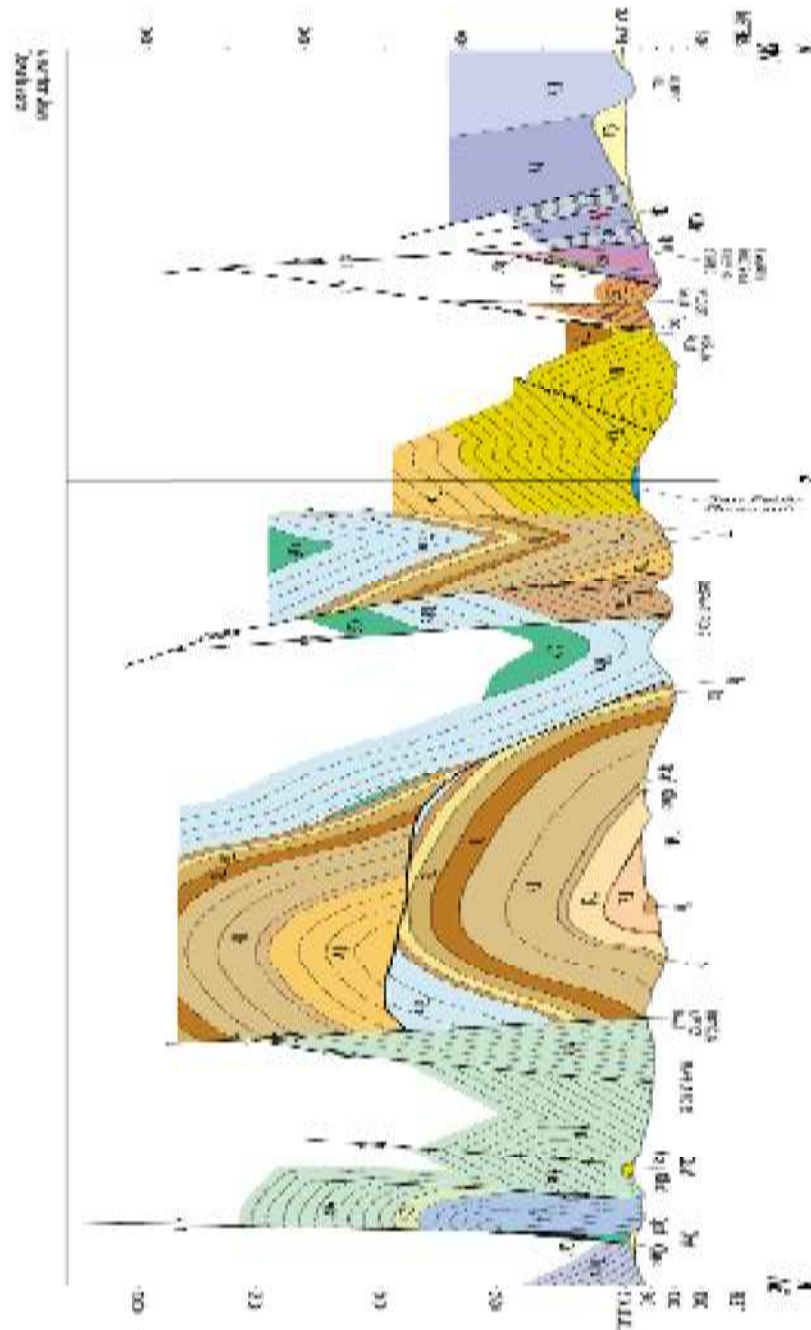
Consider the scale and projection of the map: Geological maps can vary in scale and projection, which can affect the level of detail and accuracy of the information presented. It is important to understand the limitations and potential biases of the map.

Interpret the geologic history: Based on the information gathered from the map, attempt to reconstruct the geologic history of the area, including the types of rocks present, the sequence of events, and the forces that shaped the landscape.

What is a geological cross-section?

A geological cross-section is a two-dimensional representation of the subsurface geology of an area. It shows the vertical arrangement of the rock layers and other geological features beneath the Earth's surface. Cross-sections are typically constructed by combining information from geological maps, boreholes, and geophysical data. They are commonly used by geologists to visualize the geology of an area and to help understand the spatial relationships between different rock

units and geological features. Cross-sections can also be used to estimate the thickness and depth of rock layers, and to identify potential geological hazards such as faults or unstable ground conditions.



Geological Investigations for Dam:

Generally dam axis should be chosen perpendicular to the strike of the geological structures.

- Steep beds upstream is favourable for foundation, if bed dips moderately upstream, the day may shear off along the bedding plane.
- Dam founded on the limb of an anticline dipping upstream is favourable but on the limb of a syncline with a downstream plunge is unsuitable.
- Fault zone is an unstable zone. If permeable bed is present and dam rests on beds dipping moderately downstream, water can percolate through the beds and fault. It is difficult to seal a fault zone and prevent leakage.
- Highly jointed rocks even though hard may be worse than a soil foundation. It reduces the strength of rock and creates problem related to leakage.
- Valley slopes along the dam axis should be free from existing any type of landslides or possible unsuitability of slopes.
- Earthquake shocks cause slope failures, landslides, loss of contact of the dam with its abutment, sliding of dam itself and failure of dam.
- Seismic zonation map must be consulted during the site investigation. In seismically active area, it is necessary to assess the degree of earthquake tremors and design must include provisions for the added loading and increased stresses.
- Recognition and delineation of active faults and analysis of historical records of past occurrences are among many seismological investigations to be carried out.
- Construction of a dam requires large quantity of construction materials like soil, rock, concrete and aggregates. The most economical type of dam will often be the one for which materials are to be found in sufficient quantity with a reasonable distance from the site. So availability of such materials nearby the proposed site should be assessed.

- Permeability test of the foundation material should be carried out during site selection. Water tightness of the dam is an important factor so permeability of foundation material should be within tolerance limit.
- Buried channels or valley abandoned by the rivers in the past and now filled with alluvial deposit contain numerous large boulder which allow passage to the impounded water. Careful exploration including drilling and seismic sounding can be used to such hidden topography.
- Construction of a dam modifies the ecosystem and hydrological regimes of both upstream and downstream.
- Erosion and landslide in reservoir basin, evaporation lost, reservoir-induced seismicity, destruction of flora and fauna, resettlement of displaced people which should be investigated and should be kept at minimum.

Geological Investigations for Tunnels:

Tunnel • Tunnel is a nearly horizontal underground passage which is open at both ends. • Tunnels are of different types according to their uses like traffic tunnel, hydropower headrace tunnel and public utility tunnels etc. • Tunnels can be driven or holed through a rock or earth mass by method used in mining, including blasting. • In soft ground tunnels may be excavated by boring machines with the walls being supported by liner plates.

Geological investigations are very essential in selection of tunnel site. Following are the classifications-

(a) Selection of Tunnel Route (Alignment):

There might be available many alternate alignments that could connect two points through a tunnel. However, the final choice would be greatly dependent on the geological constitution along and around different alternatives: the alignment having least geologically negative factors would be the obvious choice.

(b) Selection of Excavation Method:

Tunnelling is a complicated process in any situation and involves huge costs which would multiply manifolds if proper planning is not exercised before starting the actual excavation. And the excavation methods are intimately linked with the type of rocks to be excavated. Choice of the right method will, therefore, be possible only when the nature of the rocks and the ground all along the alignment is fully known. This is one of the most important aim and object of geological investigations.

(c) Selection of Design for the Tunnel:

The ultimate dimensions and design parameters of a proposed tunnel are controlled, besides other factors, by geological constitution of the area along the alignment. Whether the tunnel is to be circular, D-Shaped, horse-shoe shaped or rectangular or combination of one or more of these outlines, is more often dictated by the geology of the alignment than by any other single factor.

Thus, in self-supporting and strong rocks, either, D-shape or horse-shoe shape may be conveniently adopted but these shapes would be practically unsuitable in soft ground or even in weak rocks with unequal lateral pressure. In those cases circular outline may be the first choice.

(d) Assessment of Cost and Stability:

These aspects of the tunnelling projects are also closely interlinked with the first three considerations. Since geological investigations will determine the line of actual excavation, the method of excavation and the dimensions of excavation as also the supporting system (lining) of the excavation, all estimates about the cost of the project would depend on the geological details.

Similarly tunnels passing through hard and massive rocks even when left unsupported may be regarded as stable. However, those passing through difficult grounds, although these might have been massively strengthened by secondary support system, might still collapse or bulge at places or even completely fail, if geological situation is not perceived properly.

(e) Assessment of Environmental Hazards:

The process of tunnelling, whether through rocks or through soft ground, and for whatsoever purpose, involves disturbing the environment of an area in more than one way. The tunnelling methods might involve vibrations induced through blasting or ground cutting and drilling, producing abnormal quantities of dust and last but not the least, interference with water supply system of the nearby areas.

A correct appreciation of geological set up of the area, especially where tunnel alignment happens to be close to the populated zones, would enable the engineer for planning and implementing plans aimed at minimizing the environmental hazards in a successful manner.

A. Preliminary Surveys:

These are conducted by the routine geological, geophysical and geochemical methods. In modern practice and for major tunnelling projects such fast techniques as aerial photography and seismic surveying are commonly adopted in combination with the routine surface methods.

Following geological characters are broadly established for the entire area in which the tunnel project is to be located as a result of preliminary surveys:

- (a) The general topography of the area marking the highest and the lowest points, occurrence of valleys, depressions, bare and covered slopes, slide areas, and in hilly regions and cold climates, the snow-line.
- (b) The lithology of the area, meaning thereby, the composition, attitude and thickness of rock formations which constitute the area.
- (c) The hydrological conditions in the area, such as depth of water table, possibility of occurrence of major and minor aquifers of simple type and of artesian type and the likely hydrostatic heads along different possible routes or alignments.
- (d) The structural condition of the rock, that is, extent and attitude of major structural features such as folding, faulting, unconformities, jointing and shearing planes, if developed. Existence of buried valleys is also established during the preliminary surveys.

In addition, such surveys would also reveal occurrence of reserves of rocks that could be beneficially used for construction programmes (lining etc.) in the tunnel project.

It is obvious that with the help of above information, the engineers could propose a number of alternative tunnel routes to connect the two places, and in most cases, even decide about the general run of the tunnel.

B. Detailed Surveys:

Once the general run of the tunnel has been decided, planning for its construction begins. Such plans require fairly accurate data about the rocks or the ground to be excavated for passing through.

Such data are obtained by:

- (i) Bore-hole drilling, along proposed alignments and up to desired depths; the number of bore-holes may run into dozens, scores or even hundreds, depending upon the length of the tunnel; rock samples obtained from bore holes are analysed for their mechanical and geochemical properties in the laboratories;
- (ii) Drilling exploratory shafts and adits, which allow direct approach to the desired tunnel for visual inspection in addition to the usual advantages of drilling;
- (iii) Driving pilot tunnels, which are essentially exploratory in nature but could better be used as a main route if found suitable by subsequent enlargement.

The actual number of bore holes and shafts and adits and their depth and length are decided by the length and location of the proposed tunnel. For tunnels with little overburden, these may be driven close to the proposed tunnel. For very long and deep tunnels, economic considerations limit their number.

Information supplied by them has to be corroborated with that obtained by indirect methods such as seismic surveys. The shafts and adit borings are costly affairs but are very necessary. Often some of these could be merged with the main project subsequently as useful elements, such as for ventilation and allied purposes.

Geological Profile of Tunnels:

When all the geological information gathered from preliminary and detailed surveys is plotted along a longitudinal section, the axis of the proposed tunnel being the section line, a geological profile is obtained. It is the most important geological record available with the project engineer and in fact his single most important guideline in the tunnel project.

Such a profile generally provides information regarding the following aspects of the proposed route:

- (i) Location and depth of exploratory bore holes and shafts etc.
- (ii) Types of rocks and their geochemical characters such as whether consolidated or unconsolidated, fissured and decayed or fresh;
- (iii) Structure of rocks, that is, whether stratified, or massive, horizontal or inclined, and if inclined, degree and direction of inclination; folding and faulting with full details.
- (iv) Hydrological conditions along the profile line; whether the line is above or below the water table and its relation to any aquifer that is likely to be intercepted;
- (v) Ground temperature conditions, projected down to the tunnel axis based on calculations and observations.

Geological Investigation for site selection of Bridge

❖ A bridge may be defined as a structure built over a river, a dry valley, low land or an estuary or any depressed part of the land to provide a link between the two opposite sides. It is essentially a communication link on a road or railway track or a highway. Bridges] especially over major rivers and in hilly and mountainous areas are very important civil engineering structures. Their role in socio-economic development and defence strategies can hardly be overemphasized.

In most cases the location of a bridge is decided more by socio-economic factors than by geological considerations. Thus, there are seven bridges over the River

Jhelum connecting the two parts of Srinagar city (in Kashmir) within a total distance of 5 km. On the contrary, there is only one bridge over the River Chenab (at Ramban, Jammu Province) connecting the valley of Kashmir with rest of the country.

That may be true for most of the other big cities, states and countries of the world. In other words, within big cities divided by rivers or streams, a bridge has to be placed where it is needed, irrespective of the subsurface geology. However, on highways, there is often some flexibility available in the choice of placement of a bridge.

This is unlike tunnels, where alignment is primarily and essentially controlled by geological considerations. But, in the case of bridges also, the design, stability and durability depend, to a great extent, on the subsurface geological conditions that must be properly investigated and cautiously interpreted.

In any major bridge construction project, the designer is keen to place the bridge abutments and piers on as sound, strong and stable rock foundation below as possible.

This being so, the geological characters that need to investigate and thoroughly established are:

- (a) The depth to the bed rock;
- (b) The nature of the bed rock;
- (c) The structural disposition of rocks.

(a) Depth to Bed Rock:

In most cases, the river bed below the water is covered by varying thickness of unconsolidated natural deposits of sand, gravels and boulders.

Such loose materials are not safe as foundations for bridge piers for at least two reasons:

Firstly, piers placed directly on them would be unstable;

Secondly, the cover material is liable to be removed due to scouring by river water.

As such, the pier must be placed on stable foundation, preferably of rock, under a suitable thickness of cover material so that it is safe from scour by river water.

The height of pier from under the span to the foundation level, therefore, depends on the 'depth of the bed rock' below the river water.

Such sound bed rocks might be available within a depth varying from 5 to 20 meters below a river bed or they might not at all be available even up to 100 meter or more. All that depends on the local geology which has to be investigated and understood.

To achieve this, drill holes are made all along the centre line of the proposed bridge, even on the right or left of it, till they reach the sound rock sequence or up to a reasonable depth. Utmost care is needed not to mistake isolated big boulders buried underneath the river bed as the bed rock. Boulders are rocks but they are not bed rocks and cannot be trusted as foundations for bridge piers.

(b) Nature of Bed Rock:

The very first rock encountered below the bed cover material may not be suitable as a foundation.

It should be kept in mind that three types of loads are to be borne by a bridge pier foundation:

- i. The compressive, vertical loads due to the weight of the bridge span and that of pier material;
- ii. The horizontal loads due to the thrust of the water flowing above as transmitted directly and through the pier;
- iii. The dynamic, complex load, often inclined and shearing in character, due to heavy traffic on the bridge.

Consequently, the bed rock selected as foundation for the pier must be strong enough to bear the sum total of all these loads, not temporarily, but throughout the proposed life of the bridge.

The nature of the bed rock is commonly determined through study of petrological characters and engineering properties, especially the strength values, using the core

samples obtained during drilling of test bore holes. In fact complete and very useful geological profiles could be prepared all along the centre line of the proposed bridge from the study of such core logs.

These (profiles) would depict complete sequence (and even structural disposition) of the rock formations existing below the surface material up to a desired depth. A decision to place the pier on a particular rock at a particular depth is then matter of judgement and design requirements.

Most igneous and massive type of sedimentary and metamorphic rocks is quite strong, stable and durable as foundations for bridge piers and abutments. The group of weak rocks which might behave badly in the presence of water includes such types as cavernous limestones, chalk, friable sandstones especially with clayey cements, shales, clays, slates, schists and the layers of peat and compressible organic material. Many of them are amenable to treatment by artificial methods.

Analysis of Geological Features like Fault and Fold:

INTRODUCTION

Geographical profiles of a contour map gives a "side view" of the landscape along a section on the map. It gives a visual representation of data. Maps are two-dimensional but contour maps represent three dimensional areas in two dimensional map.

The movement of tectonic plates due to convection inside the Earth's cause the plates to collide or move away causing compressive or tension stress on the surface. When the stress developed become greater than the strength of the rock, the rock breaks and a fault forms. The sudden rupturing causes an earthquake, whereas, the small fault segments links up gradually and forms a larger fault plane. During deformation of rocks, if it bends instead of breaking it give rise to formation of folds. The length of faults range from a few centimeters to many hundreds of kilometers, and displacement may range from less than a centimeter to several hundred kilometers along the fracture surface. In some cases, the

movement is distributed over a fault zone composed of many individual faults that occupy a belt hundreds of meters wide.

Faults may be horizontal, vertical, or inclined at any angle. When rocks slip past each other in faulting, the upper or overlying block along the fault plane is called the hanging wall, or headwall, the block below is called the footwall.

Based on direction of slip, faults can be categorized as:

Strike-slip fault

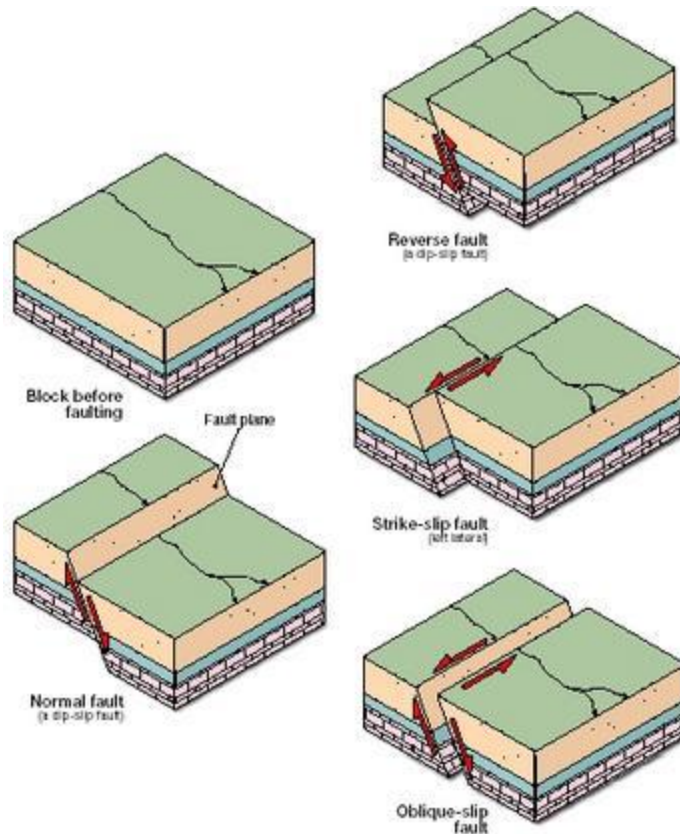
In a strike-slip fault the fault surface is usually near vertical and the footwall moves laterally either left or right with very little vertical motion. Strike-slip faults with left-lateral motion are also known as sinistral faults.

Dip-slip faults

Dip-slip faults can be either normal or reverse. In a normal fault, the hanging wall moves downward, relative to the footwall. A downthrown block between two normal faults dipping towards each other is a graben. An upthrown block between two normal faults dipping away from each other is a horst. Low-angle normal faults with regional tectonic significance may be designated detachment faults.

Oblique-slip fault

A fault which has a component of dip-slip and a component of strike-slip is termed an oblique-slip fault. Nearly all faults have some component of both dip-slip and strike-slip, so defining a fault as oblique requires both dip and strike components to be measurable and significant.

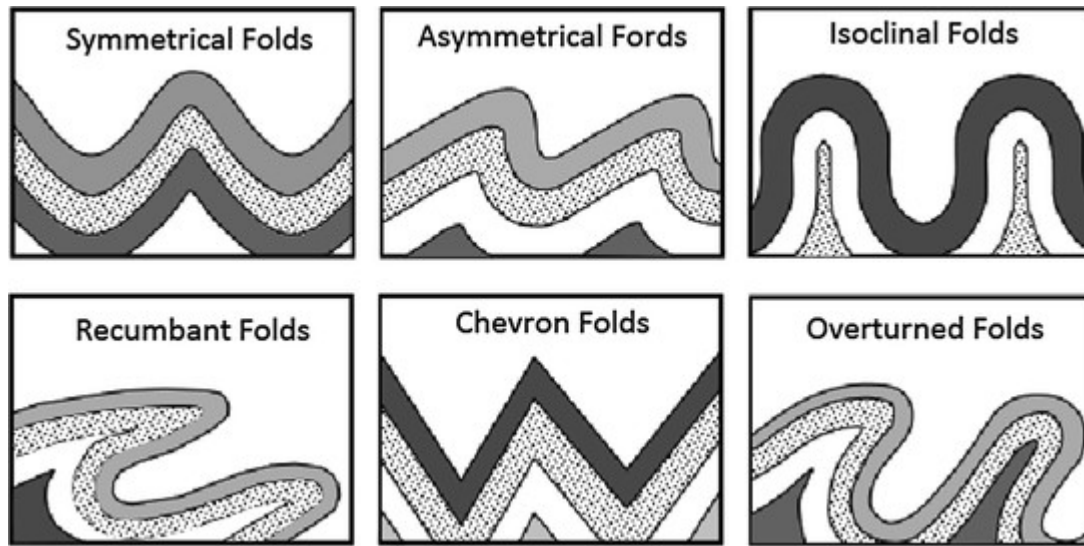


Types of Faults

If the rock bends instead of breaking it give rise to formation of folds. The tectonic folding may arise mainly due to tangential compression. The primary force acts at right angles to the trend of folds under the influence of the tangential stresses developing folds in three ways namely flexural folding, flowage folding and shear folding. Flexural folding occurs when competent or stronger rocks are thrown into folds due to their sliding against each other under the influence of lateral compression. Flowage folding occurs in incompetent or weaker plastic type of rocks such as clays, shales, gypsum and rock salt etc. folding is attributed to shearing stresses rather than simple compression. Shear folding is attributed to shearing stresses rather than simple compression.

The folds can also be classified into many types based on many other factors. Some of them are,

- **Anticline:** It consist the oldest rock materials in the core and youngest material in the top of the fold, also called as ridge type fold.
- **Syncline:** It consist the youngest rock materials in the core and older material in the top of the fold, also called as sinking type fold.
- **Monocline:** Fold in knee that only has one flank.
- **Symmetrical:** Occurs when the angle between the two flanks with the horizontal is approximately the same.
- **Asymmetrical:** Occurs when the two sides of rocks have distinctly different inclinations.
- **Inclined:** Occurs when the axial plane forms an angle with the vertical.
- **Recumbent:** Occurs when the axial plane is almost horizontal.
- **Isoclinal:** Occurs when the thickness of each layer does not vary along the fold. Origin to bending stresses attributed type.
- **Antiform:** It is a linear type of folds. The strata dip is not close to the axial center and there is no information of its age.
- **Synoform:** It is a linear type of folds with the strip data moving in the axial center direction.
- **Dome:** It is a nonlinear type of fold moving the strata dip from the center in every direction consisting oldest strata in the center.
- **Basin:** It is a nonlinear with strata dip moving toward the center in all the directions consisting youngest strata in the center.
- **Chevron:** It is a linear type of fold oriented toward the long angle.



Types of Folds

Borehole Problems:

INTRODUCTION

A topographic map is a two-dimensional representation of a portion of the three-dimensional surface of the earth. A topographic profile of the earth surface is obtained from topographic profiling. Topographic Profile is a cross-sectional view along a line drawn through a portion of a topographic map. Topographic map alone provides details of underground features such as dip, strike, thickness of the rock formations etc, which will be useful for many practical analyses. Geologic graphics is the computation of dip, strike and other measurable structural parameters of rock masses by geometrical methods from the topographic map. Geologic graphics helps determination of the geology of an area comprising of the rock formations, their two dimensional configuration, thickness and sequence at or below the ground surface which are the most important geological data for planning and execution of earth works like cuttings, quarrying, underground works and improvement of site conditions, design, construction and maintenance of complex, costly and vital engineering structures.

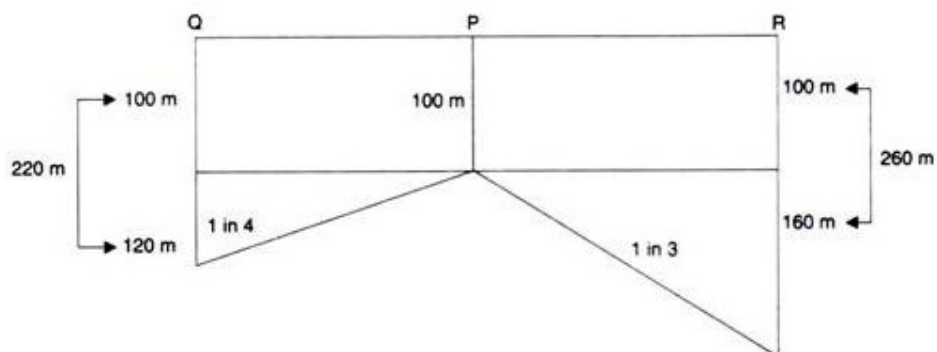
Borehole is one such structure, which provides information about the composition of the ground. Typically, a borehole is used as:

- Down hole heat exchangers
 - Groundwater wells
 - Production wells for hydrocarbons, natural gas or petroleum
 - Pumping of grout for example, concrete for drilled piles
- a. The underground water
 - b. the cuttings
 - c. the drilling advance rate
 - d. measurements in the borehole

With down hole surveys, a sensor or a camera is passed down the hole to a appropriate depth. Some practical methods also make it possible to test the surrounding rock in the borehole. The underground property can also be analyzed by using a topographic map of the area and by identifying the type of rock features, its thickness etc., and the depth of the borehole can be estimated.

Examples:

1. Three boreholes are sunk at 3 points of an equilateral triangle whose sides are 480 m each. Is West of Q and R is North of midpoint PQ. Boreholes and R-reach the upper surface of a rich coal seam at 100 m, 220 m, and 260 m depths respectively.
 - (a) Determine the attitude (dip and strike) of the coal seam.
 - (b) Another borehole is sunk at S, midpoint of QR. Determine at what depth the borehole S reaches the coal seam.



Gradient of PQ

$$120/480 = 1 \text{ in } 4$$

Gradient of PR

$$160/480 = 1 \text{ in } 3$$

Procedure:

Construct an equilateral triangle with a suitable scale. Show the positions of the boreholes. The coal seam is reached at point P and Q at 100 m and 220 m. So the coal seam dips from P to Q. To determine the inclination (gradient) along PQ construct trough sketch depth diagram and determine the gradient, it is 120 m in 480 m. So it is 1 in 4.

Similarly, construct the depth diagram along PR it is 160 m in 480 m i.e., 1 in 3. Take convenient scale and mark 4 units (cms) along PQ and 3 units (cms) along PR from P. They are A and B. Join AB and extend. It is the true strike direction (TSD).

Draw a perpendicular to AB from P. It cuts AB at C. Measure PC it is 2.85 cms i.e., the gradient is 1 in 2.85. It is true dip.

To determine the direction of true dip, measure the angles $CPQ = 45^\circ$. So direction of true dip is the complementary angle from north direction so $(90^\circ - 45^\circ) 45^\circ$. So it is $N45^\circ E$ or NE.

True dip 1 in 2.85 along NE.

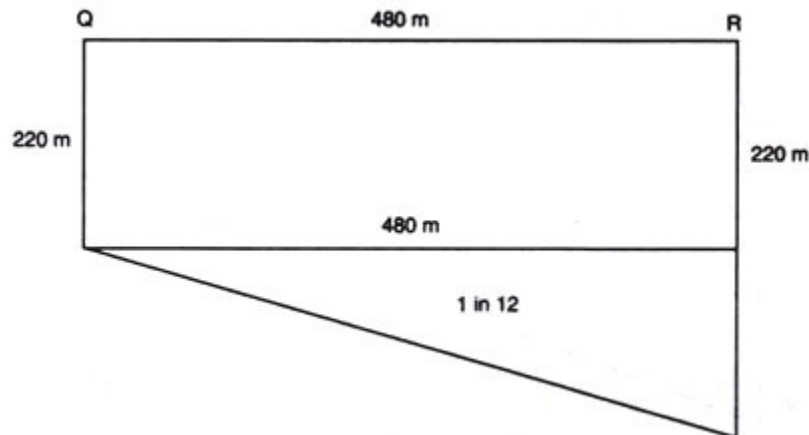
Strike = SE and NW.

To determine the depth at which the borehole 5 reaches the coal seam, join PS it intersects AB line (true strike direction) at T. Measure PT with units selected it is 3 cms. So the gradient along PT 'is 1 in 3. Measure PS it is 4.2 cms = 420 m.

Depth Horizontal distance PS x Gradient + Depth of Borehole at P

$$= 420 \times \frac{1}{3} + 100 = 140 + 100 = 240 \text{ m}$$

To check whether this calculation is correct or not, let us find out the gradient of coal seam along QR.



True depth = 1 in 2.55 along North 30°E

Strike = $\text{N}60^\circ\text{W}$ and $\text{S}60^\circ\text{E}$

Depth of unknown point P = Horizontal distance x Gradient + Depth of borehole at minimum depth

$$= 216 \times \frac{1}{2.7} + 15$$

$$= 80 + 15 = 95 \text{ m}$$

2. Three boreholes are sunk at SW, SE, and NW corners of square level ground. The side of the square is 150 m long. The boreholes are X, Y, Z respectively. The boreholes meet the coal seam at 15 m in X, 45 m in Y, and 60 m in Z.

(a) Determine the attitude of the coal seam.

(b) Fourth borehole is proposed at P, the NE corner of the square land. Calculate at what depth, the borehole encounters the coal seam.

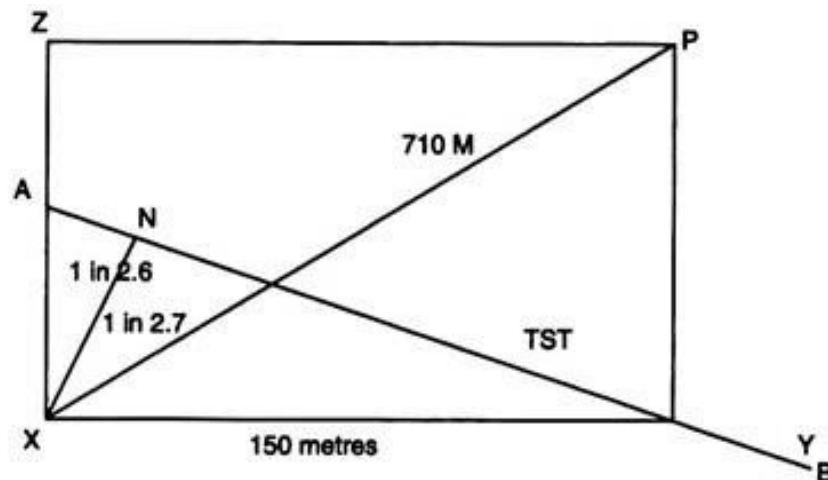
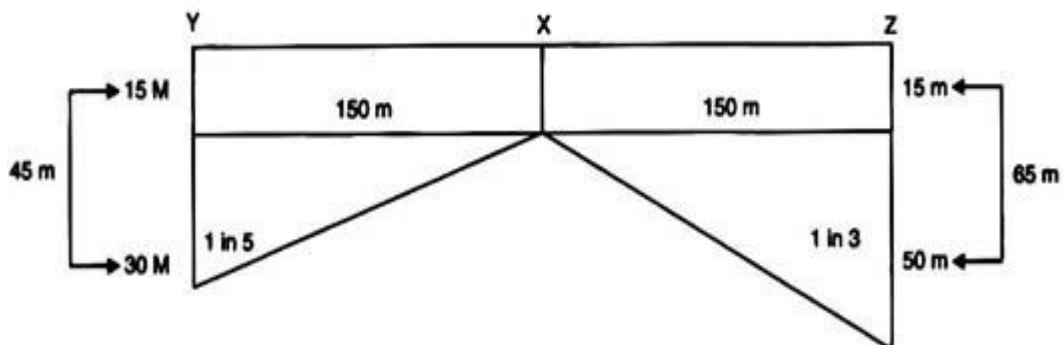
Depth Diagram

Gradient of XY = $30/150 = 1$ in 5

Gradient of XZ = $50/150 = 1$ in 3

Scale 1cm = 30 m

Gradient Scale 1 cm = 1unit



True depth = 1 in 2.55 along North 30° E

Strike = $N60^\circ$ W and $S60^\circ$ E

Depth of unknown point P = Horizontal distance x Gradient + Depth of borehole at minimum depth

$$= 216 \times 1/2.7 + 15$$

$$= 80 + 15 = 95 \text{ m.}$$

Experiment - 6

GEOSPATIAL DATA ANALYSIS

Study of Topographical Maps Topographic maps are general reference maps. They are also called ordnance maps. These maps are ideal for researchers, planners, administrators, defence personal, hikers, tourists and for class room purpose. They give clear details of actually surveyed natural and manmade features. These maps are drawn to scale. Geographical knowledge and clear understanding of conventional signs and symbols is essential to understand and interpret a Survey of India Topographical sheet. A topographic sheet is usually interpreted under the following sub headings:

- Marginal information
- Relief
- Drainage
- Natural and Man made
- Vegetation
- Land use
- Settlement
- Transport and communication

1. **Marginal Information** The marginal information includes the topographical sheet number, direction, its location, grid references, latitudinal and longitudinal extent in degrees, minutes and seconds, scale, the districts, covered, contour interval etc.,

2. **Relief** Relief refers to the general topography of the area under study. First, the landforms like mountains, hills, plateaus along with the peaks, ridges should be identified and the general direction of slope can be determined. The contour values

and patterns have to be studied. Spot heights, bench marks etc help in understanding the height of certain areas.

3. ***Drainage*** Drainage of an area can be understood by observing the characteristics of the rivers, their tributaries, drainage pattern.

4. ***Vegetation*** Important trees are shown by special symbols. Trees, grasses and shrubs are all shown in green colour. Agricultural land is shown in yellow colour.

5. ***Land use*** Land use includes the use of land under different categories like agriculture, pasture, barren land and forest area. Other land use categories could be mining, industry, trade, tourism, fishing or cattle rearing. It also informs us about the presence (location) of airports, railway stations, schools offices, trade centres, electric substations, etc. Sometimes, land use is directly mentioned, for example, brick kiln, limestone quarry, etc. At other times it has to be inferred.

6. ***Settlements*** The size, shape, pattern site, position and function of settlements should be considered while interpreting a topographical sheet because all these aspects are interdependent. Settlements could be dispersed or scattered, compact or nucleated type. They may be radial or linear in pattern. They are also studied under the following heads, based on their size and the activities the population is engaged in. Permanent settlements are shown by solid squares and temporary ones in outlines of squares.

- Rural settlements: They can be compact, semi compact, dispersed or linear, etc.
- Urban settlements: It is the capital city, administrative town, trade centre, port town, religious or tourist station or a hill station.

7. ***The basic occupations*** that the people are probably engaged in, can be understood after the land use pattern and the type of settlement have been understood.

8. ***Transport and communication*** The means of transport and communication being used can be identified from the presence of national and state highways, district and village roads, cart tracks, camel tracks, footpaths, railways, waterways, telephone and telegraph lines, post offices, etc. Roads are not drawn true to scale. Metalled roads are shown by double lines, and unmetalled by broken double lines.

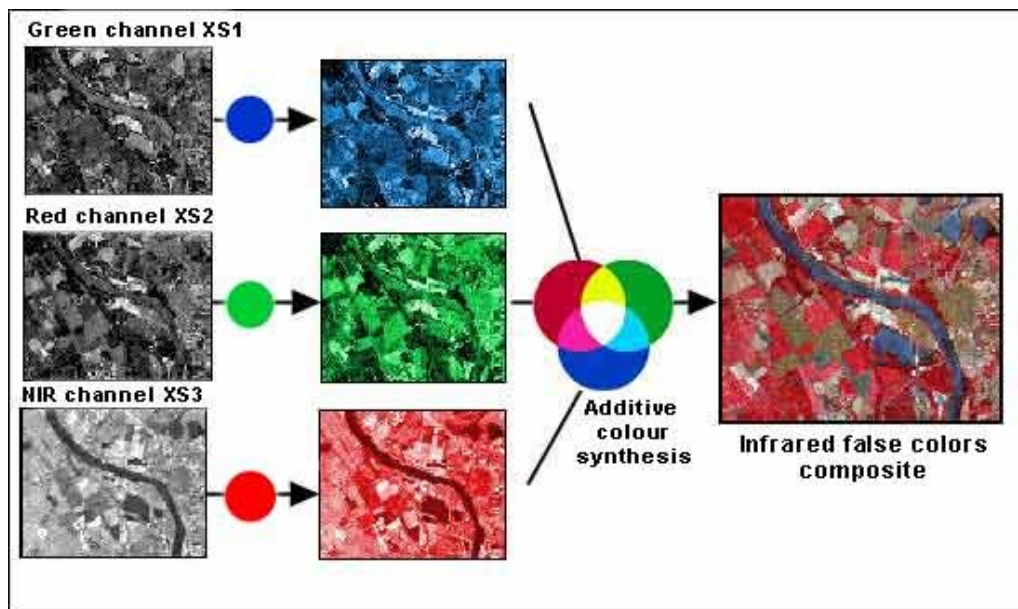
Foot path shown by red dots and cart track by single broken lines. Different kinds of railways are shown by different signs

False Colour Composite (FCC) :

A false color image is one in which the R,G, and B values do not correspond to the true colors of red, green and blue. The most commonly seen false-color images display the very-near infrared as red, red as green, and green as blue.

An artificially generated colour image in which blue, green and red colours are assigned to the wavelength regions to which they do not belong in nature. For example, in standard a False Colour Composite blue is assigned to green radiations (0.5 to $0.6 \mu\text{m}$), green is assigned to red radiations (0.6 to $0.7 \mu\text{m}$) and red is assigned to Near Infrared radiation (0.7 to $0.8 \mu\text{m}$).

This false colour composite scheme allows vegetation to be detected readily in the image. vegetation appears in different shades of red depending on the types and conditions of the vegetation, since it has a high reflectance in the NIR band



| S. No | Earth Surface Features. | . Colour(In Standard FCC |
|-------|--|------------------------------|
| 1 | Healthy Vegetation and Cultivated Areas | |
| | Evergreen | Red to magenta |
| | Deciduous | Brown to red |
| | Scrubs | Light brown with red patches |
| | Cropped land | Pink to Bright red |
| | Fallow land | Light blue to white |
| | Wetland vegetation | Blue to grey |
| 2 | Waterbody | |
| | Clear water | Dark blue to black |
| | Turbid waterbody | Light blue |
| 3 | Built – up area | |
| | . High density | Dark blue to bluish green |
| | Low density | Light blue |
| 4 | Waste lands/Rock outcrops | |
| | Rock outcrops | Light brown |
| | Sandy deserts/River sand/ | Light blue to white |
| | Salt affected Deep ravines | Dark green |
| | Shallow ravines | Light green |
| | Water logged/Wet lands | Mottled black |

• **False Colour Composite (FCC)** • Any other combination of colours •

E.g., Blue band – Red; Red band – Green; Green band – Blue • E.g., Blue band – Red; Red band

– Green; NIR band – Blue •

Standard False Colour Composite (FCC) •

E.g., NIR band – Red; Red band – Green; Green band – Blue • In IRS: Band 4 – Red; Band 3 – Green; Band 2 – Blue

Advantages of FCC

Allow us to visualize the wavelengths the human eye does not see (near the infrared range). Human eyes could only separate up to 30 shades of gray color, so This band combination is valuable for gauging plant health. plants reflect near infrared and green light, while absorbing red. Since they reflect more near infrared than green, plant- covered land appears deep red extracting information from gray-scale color visually is a bit difficult and resulting less information. The use of bands, such as near infrared, increases spectral separation and can enhance the interpretability of data.

Application

the monitoring of forest fires. Surfaces with elevated temperatures, such as forest fires and calderas of volcanoes, saturate the image in medium IR channels and are displayed in shades of red or yellow.

Study of vegetation health

Our four most common false-color band combinations are:

1. Near infrared (red), green (blue), red (green). This is a traditional and popular band combination useful in seeing changes in plant health.
2. Shortwave infrared (red), near infrared (green), and green (blue), often used to show floods or newly burned land.
3. Blue (red), two different shortwave infrared bands (green and blue). We use this to differentiate between snow, ice, and clouds.
4. Thermal infrared, usually shown in tones of gray to illustrate temperature.

True Colour Composite (TCC)

Our eyes can only see a very small portion of the spectrum of light that surrounds us. This portion is called the “visible spectrum”, for which we have assigned names to the various shades of colour that we can see. Scientific

instruments onboard satellites have sensors of light outside of our visible range in the electromagnetic spectrum, like infrared and ultraviolet light. But of course, even if we can produce an image from an infrared sensor, our eyes can't see infrared. To visualise what objects look like with infrared eyes, we have to use colours from our visible spectrum and map them to what the infrared sensors detect.

An image is a “**True Colour**” composite if the colours in the image are the same colours that we see with our eyes — that is, a combination of red, green, and blue (RGB) light intensities. Our computer screens can represent one pixel as a set of RGB values, where each band is an integer from 0 to 255. For example, the following shade of green is represented as Red=229, Green=255, and Blue=204.

Meanwhile, an image is a “**False Colour**” composite if the colours in the image are a representation of the invisible band of light that was captured.

Remote sensors in satellites can “see” the invisible light from the sun's radiation to the earth by measuring how much of that light is reflected from the earth's surface. As a classic example, infrared light bounces off surfaces with higher levels of vegetation, but is absorbed by water. That means that a remote infrared sensor will see brighter light in a forested area, but oceans and other bodies of water on earth will appear dark.

Now, if we were to display that image in the infrared band, we can only do so with the colours in our visible bands. There are two ways to do this:

1. Display infrared in one visible band, like greyscale, such that higher infrared reflectance would show as lighter grey, while lower infrared reflectance would appear darker grey to black; or
2. Display infrared as a combination of three visible bands: Red, Green, and Blue.

The image on the left below is a true colour composite of an area on earth. The image on the right is a greyscale composite image of that same area captured in infrared. Most of the time, it is difficult for the naked eye to clearly identify the boundary between bodies of water and land from a true colour composite

because of the mixing of colours. With false colour composites, these boundaries are much sharper because different types of surfaces reflect invisible light at much varied levels.



Composite images of Metro Manila and its neighbouring Laguna Lake. On the left: a true colour composite shows the water as green as its surrounding land areas, which could make the lake difficult to spot when we zoom out the map. On the right: The same image in the infrared band, represented by greyscale, which shows the higher contrast of the lake with its surrounding land area because of the difference in reflectiveness of infrared light on water and on land.

Just as we use a word processor to write documents and deal with words on a computer, we can use a **GIS application** to deal with **spatial information** on a computer. GIS stands for ‘**Geographical Information System**’.

A GIS consists of:

- **Digital Data** — the geographical information that you will view and analyse using computer hardware and software.

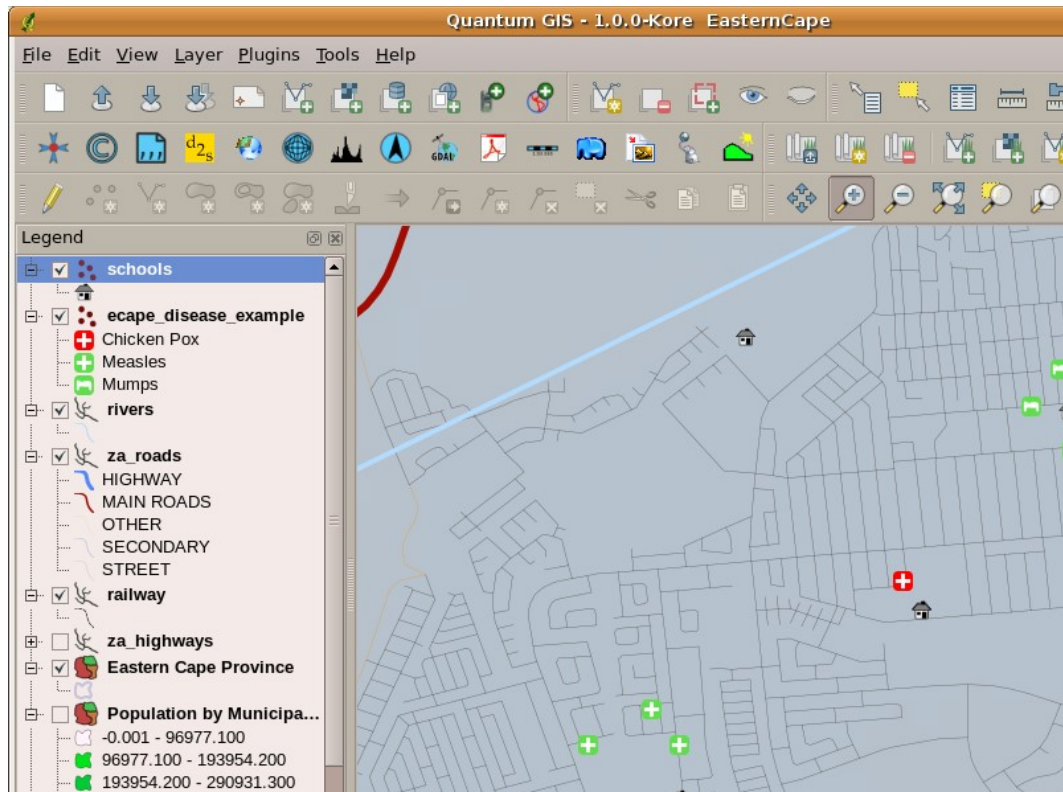
- **Computer Hardware** — computers used for storing data, displaying graphics and processing data.
- **Computer Software** — computer programs that run on the computer hardware and allow you to work with digital data. A software program that forms part of the GIS is called a GIS Application.

With a GIS application you can open digital maps on your computer, create new spatial information to add to a map, create printed maps customised to your needs and perform spatial analysis.

Let's look at a little example of how GIS can be useful. Imagine you are a health worker and you make a note of the date and place of residence of every patient you treat.

| Longitude | Latitude | Disease | Date |
|-----------|------------|-------------|------------|
| 26.870436 | -31.909519 | Mumps | 13/12/2008 |
| 26.868682 | -31.909259 | Mumps | 24/12/2008 |
| 26.867707 | -31.910494 | Mumps | 22/01/2009 |
| 26.854908 | -31.920759 | Measles | 11/01/2009 |
| 26.855817 | -31.921929 | Measles | 26/01/2009 |
| 26.852764 | -31.921929 | Measles | 10/02/2009 |
| 26.854778 | -31.925112 | Measles | 22/02/2009 |
| 26.869072 | -31.911988 | Mumps | 02/02/2009 |
| 26.863354 | -31.916406 | Chicken Pox | 26/02/2009 |

If you look at the table above you will quickly see that there were a lot of measles cases in January and February. Our health worker recorded the location of each patient's house by noting its latitude and longitude in the table. Using this data in a GIS Application, we can quickly understand a lot more about the patterns of illness:



Example showing disease records in a GIS application. It is easy to see that the mumps patients all live close to each other.

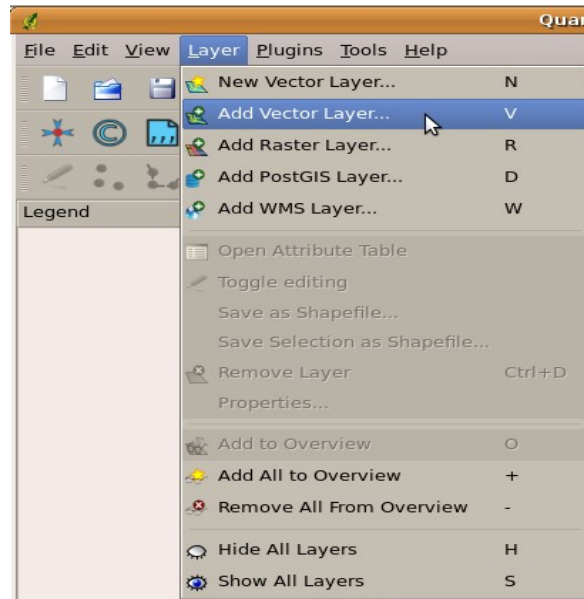
More about GIS

GIS is a relatively new field — it started in the 1970's. It used to be that computerised GIS was only available to companies and universities that had expensive computer equipment. These days, anyone with a personal computer or laptop can use GIS software. Over time GIS Applications have also become easier to use — it used to require a lot of training to use a GIS Application, but now it is much easier to get started in GIS even for amateurs and casual users. As we described above, GIS is more than just software, it refers to all aspects of managing and using digital geographical data. In the tutorials that follow we will be focusing on GIS Software.

What is GIS Software / a GIS Application

You can see an example of what a **GIS Application** looks like [Fig. 2.10](#). GIS Applications are normally programs with a graphical user interface that can be

manipulated using the mouse and keyboard. The application provides **menus** near to the top of the window (**Project**, **Edit**, etc.) which, when clicked using the mouse, show a panel of **actions**. These actions provide a way for you to tell the GIS Application what you want to do. For example you may use the menus to tell the GIS Application to add a new layer to the display output.



Application menus, when clicked with the mouse, expand to show a list of actions that can be carried out. [↗](#)

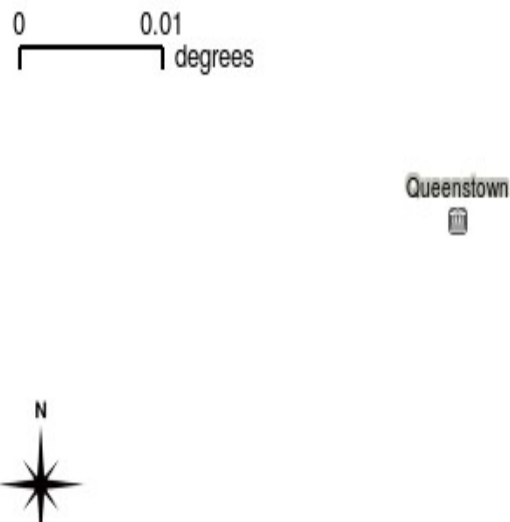
Toolbars (rows of small pictures that can be clicked with the mouse) normally sit just below the menus and provide a quicker way to use frequently needed actions.



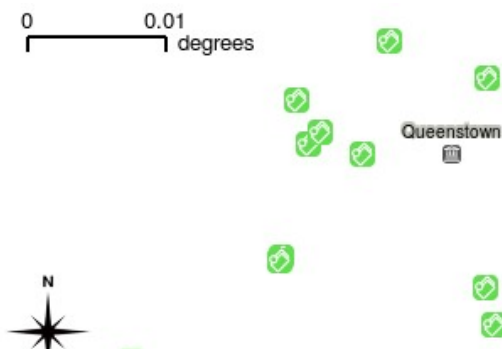
Toolbars provide quick access to commonly used functions. Holding your mouse over a picture will usually tell you what will happen when you click on it. [↗](#)

A common function of GIS Applications is to display **map layers**. Map layers are stored as files on a disk or as records in a database. Normally each map layer will represent something in the real world — a roads layer for example will have data about the street network.

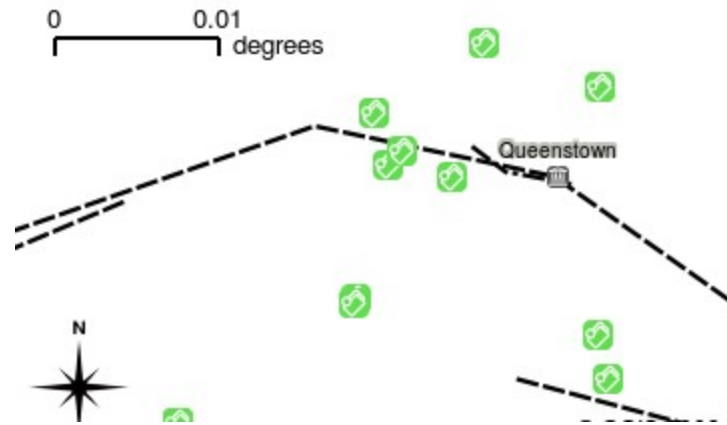
When you open a layer in the GIS Application it will appear in the **map view**. The map view shows a graphic representing your layer. When you add more than one layer to a map view, the layers are overlaid on top of each other. Look at figures [Fig. 2.13](#), [Fig. 2.14](#), [Fig. 2.15](#) and [Fig. 2.16](#) to see a map view that has several layers being added to it. An important function of the map view is to allow you to zoom in to magnify, zoom out to see a greater area and move around (panning) in the map.



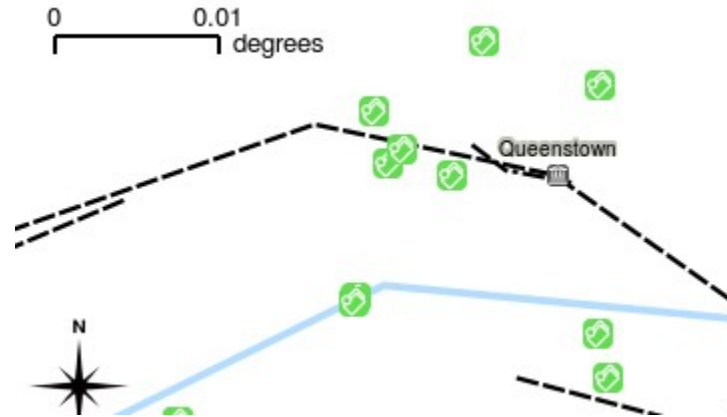
A map view with several layers being added to it. A towns layer added to the map view. [↗](#)



A map view with several layers being added to it. A schools layer added to the map view [↗](#)



A map view with several layers being added to it. A railways layer added to the map view



A map view with several layers being added to it. A rivers layer added to the map view

Another common feature of GIS Applications is the **map legend**. The map legend provides a list of layers that have been loaded in the GIS Application. Unlike a paper map legend, the map legend or ‘layers list’ in the GIS Application provides a way to re-order, hide, show and group layers. Changing the layer order is done by clicking on a layer in the legend, holding the mouse button down and then dragging the layer to a new position. In figures [Fig. 2.18](#) and [Fig. 2.19](#) the map legend is shown as the area to the left of the GIS Application window. By changing the layer order, the way that layers are drawn can be adjusted — in this case so that rivers are drawn below the roads instead of over them.

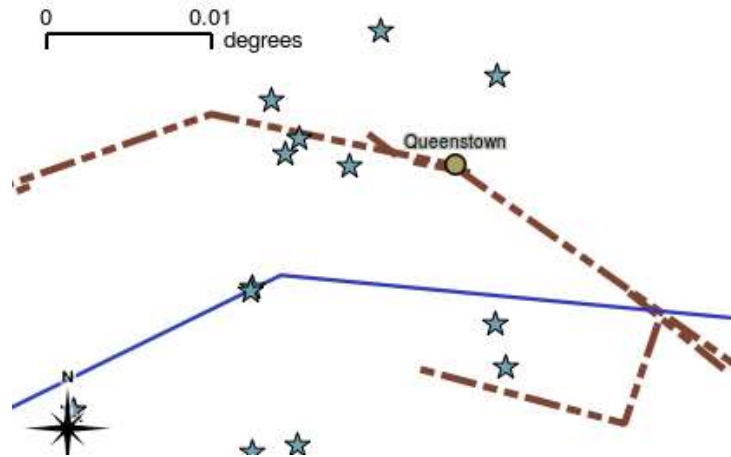


Fig. GIS Software let you easily change symbology — the way information is displayed. [↗](#)

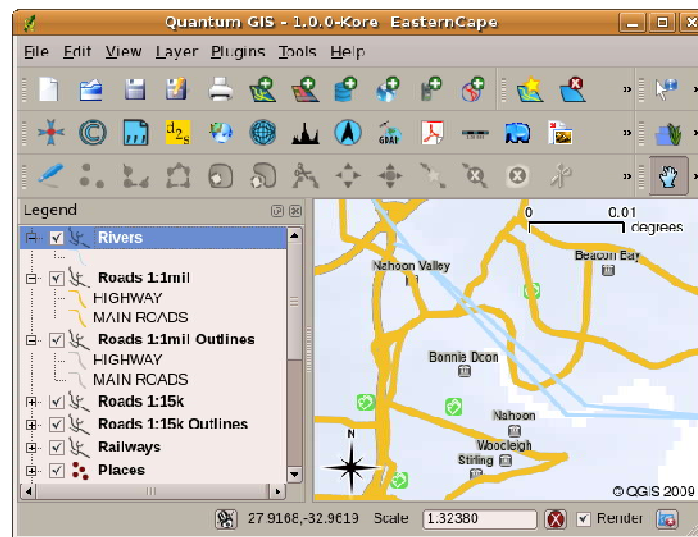


Fig. Changing the layer order allows to adjust the way that layers are drawn. Before changing the layer order, rivers are drawn on top of roads [↗](#)

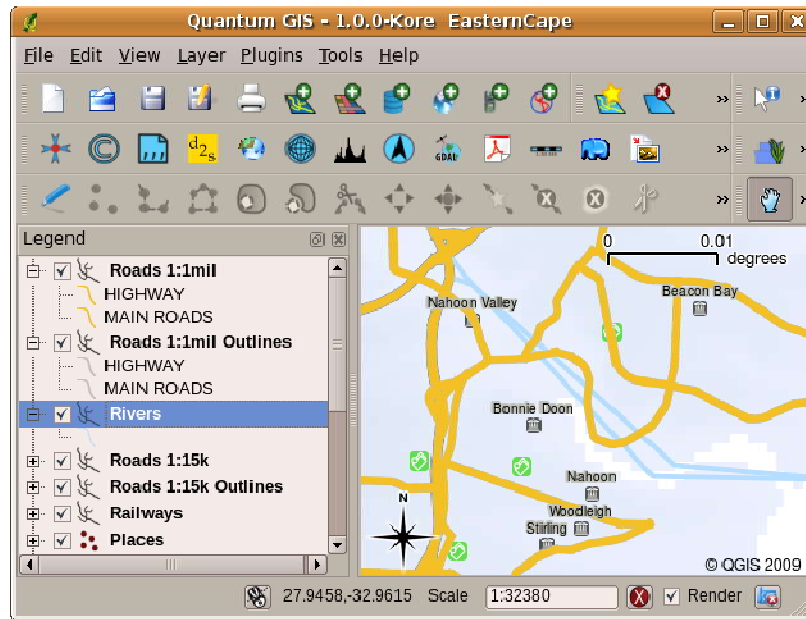


Fig. 2.19 Changing the layer order allows to adjust the way that layers are drawn. After changing the layer order, rivers are drawn underneath roads [↗](#)

GIS Data

Now that we know what a GIS is and what a GIS Application can do, let's talk about **GIS data**. Data is another word for **information**. The information we use in a GIS normally has a geographical aspect to it. Think of our example above, about the health care worker. She created a table to record diseases that looked like this:

| Longitude | Latitude | Disease | Date |
|-----------|------------|---------|------------|
| 26.870436 | -31.909519 | Mumps | 13/12/2008 |

The longitude and latitude columns hold **geographical data**. The disease and date columns hold **non-geographical data**.

A common feature of GIS is that they allow you to associate information (non-geographical data) with places (geographical data). In fact, the GIS Application can store many pieces of information which are associated with each place — something that paper maps are not very good at. For example, our health care worker could store the person's age and gender on her table. When the GIS Application draws the layer, you can tell it to draw the layer based on gender, or

based on disease type, and so on. So, with a GIS Application we have a way to easily change the appearance of the maps we created based on the non-geographical data associated with places.

GIS Systems work with many different types of data. **Vector data** is stored as a series of **X, Y** coordinate pairs inside the computer's memory. Vector data is used to represent points, lines and areas. Illustration [Fig. 2.20](#) shows different types of vector data being viewed in a GIS application. In the tutorials that follow we will be exploring vector data in more detail.

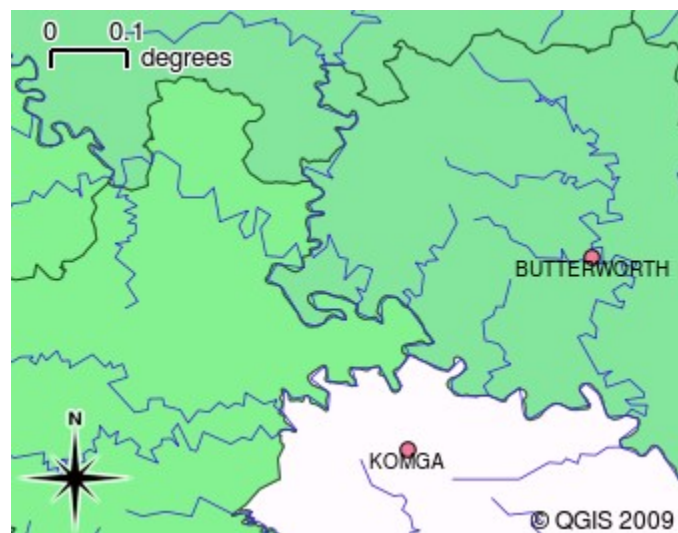


Fig. *Vector data is used to represent points (e.g. towns), lines (e.g. rivers) and polygons (e.g. municipal boundaries).*

Raster data are stored as a grid of values. There are many satellites circling the earth and the photographs they take are a kind of raster data that can be viewed in a GIS. One important difference between raster and vector data is that if you zoom in too much on a raster image, it will start to appear ‘blocky’ (see illustrations [Fig. 2.21](#) and [Fig. 2.22](#)). In fact these blocks are the individual cells of the data grid that makes up the raster image. We will be looking at raster data in greater detail in later tutorials.



Fig. 2.21 *Raster data are often images taken by satellites. Here we can see mountains in the Eastern Cape.*



Fig. 2.22 *The same raster data, but this time zoomed in. The grid nature of the data can be seen.*

What have we learned

Let's wrap up what we covered in this worksheet:

- A **GIS** is a system of computer hardware, computer software and geographical data.

- A **GIS Application** allows you to view geographical data and is an important part of the GIS.
- A GIS Application normally consists of a **menu bar**, **toolbars**, a **map view** and a **legend**.
- **Vector** and **raster** data are geographical data used in a GIS application.
- **Geographical** data can have associated **non-geographical** data.

Now you try

Here are some ideas for you to try with your learners:

- **Geography:** Describe the concept of GIS to your learners as outlined in this tutorial. Ask them to try to think of 3 reasons why it might be handy to use a GIS instead of paper maps. Here are some that we could think of:
 - GIS Applications allow you to create many different types of maps from the same data.
 - GIS is a great visualisation tool that can show you things about your data and how they are related in space (e.g. those disease outbreaks we saw earlier).
 - Paper maps need to be filed and are time consuming to view. The GIS can hold a very large amount of map data and make it quick and easy to find a place you are interested in.

Geography: Can you and your learners think of how raster data from satellites could be useful? Here are some ideas we had:

- During natural disasters, raster data can be useful to show where the impacted areas are. For example a recent satellite image taken during a flood can help to show where people may need rescuing.
- Sometimes people do bad things to the the environment, like dumping dangerous chemicals that kill plants and animals. Using raster data from satellites can help us to monitor for these type of problems.
- Town planners can use raster data from satellites to see where informal settlements are and to help in planning infrastructure.

Something to think about

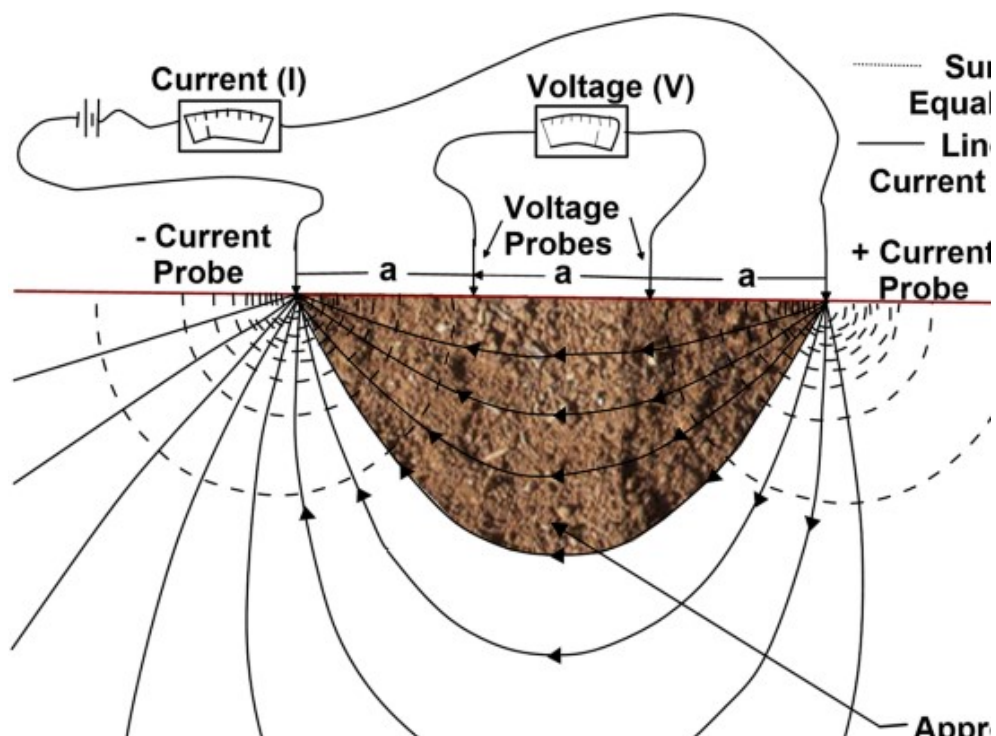
If you don't have a computer available, many of the topics we cover in this tutorial can be reproduced using an overhead and transparency as it uses the same technique of layering information. However, to properly understand GIS it is always better to learn it using a computer.

Experiment - 7

GEOPHYSICAL EXPLORATION

Electrical resistivity method:

It is one of the types of geophysical methods in civil engineering. It is based on the measurement and recording of changes in the mean resistivity or apparent specific resistance of various soil. The resistivity of soils is a complicated function of porosity, permeability, ions present in the pore water, and clay mineralization. The most common electrical methods used in hydrogeological and environmental investigations are vertical electrical sounding (resistivity sounding) and resistivity profiling. The resistivity ρ is defined as the resistance between the opposite faces of a unit cube of material. The variations in resistivity can be detected significantly between different types of soil strata, above or below the water table, between unfissured rock and soil, between voids and soil or rock.



Electrical Resistivity Method is used to know the following:

- To determine the depth of groundwater table.

- To determine the depth to bedrock or overburden thickness.
- To determine map stratigraphy.
- To determine map clay aquitards.
- To determine the vertical extent of certain types of soil and groundwater construction.
- To estimate landfill thickness.

The test is carried out by driving four metal spikes to serve as electrodes into the ground along a straight line at equal intervals. Here, the electrode spacing is kept fixed. The measurements are taken at successive intervals along a profile. Data are generally presented as profiles or contour maps and interpreted qualitatively.

The test is carried out by driving four metal spikes to serve as electrodes into the ground in a straight line in equal intervals. Current from the battery flows through the soil between the outer two electrodes. It produces electric current within the soil. The potential difference E between the two electrodes is then measured. The resistivity Ω is measured by the following equation

$$\rho = 2\pi DE/I$$

Here, D is expressed in cm, E is in volts, I is in amperes, and ρ is in ohm-cm.

In an area of a large volume of soil, the apparent resistivity is measured as a weighted average of true resistivity up to a depth of D . The soil close to the surface is more heavily weighted than the soil at greater depths. If a stratum of low resistivity overlies a stratum of higher resistivity, the current is forced to flow closer to the ground surface. It results a higher voltage drop and hence a higher value of apparent resistivity. It would be just the opposite if a stratum of high resistivity lies above the stratum of low resistivity.

When the variation of resistivity with depth is required, the method of sounding is used. This provides rough estimates of the types and depths of strata. A series of readings are taken with each successive readings corresponding to the increased equal spacing of electrodes. The center of four electrodes is kept at a fixed point. As the spacing is increased, the resistivity is greatly influenced by the depth of soil. If the resistivity increases with an increase in spacing of electrodes, it can be said that the underlying stratum is having high resistivity. But if the resistivity

decreases, it can be said that the lower resistivity of the underlying stratum is beginning to influence the reading. If its influence is observed over a greater spacing of the electrodes, the thickness of the stratum is larger.

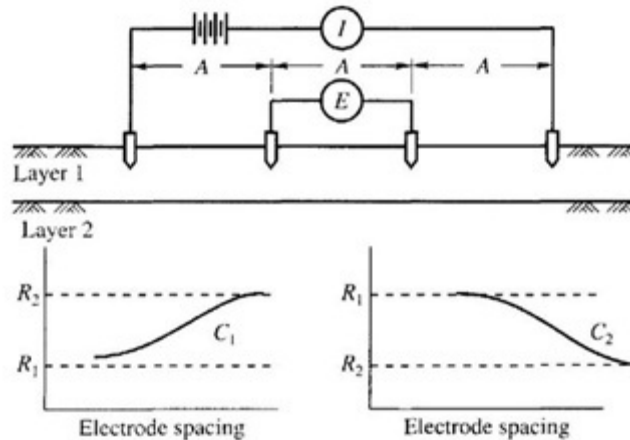


Fig 2: Electrical resistivity method and graphs

Apparent resistivity is plotted against electrode spacing in a log-log graph. If the resistivity of the upper layer is lower than that of the lower layer, a curve type A is obtained. The curves become asymptotic to lines representing the true resistivities R_1 and R_2 of the representative layers. Approximate layer thickness can be obtained by comparing the observed curve of resistivity versus electrode spacing with a set of standard curves.

The profiling method is used when the lateral variation of soil strata is to be investigated. A series of readings are taken, keeping the electrode spacing the same, the four electrodes are moved laterally as a unit for successive reading. Apparent resistivity is plotted against the center position of the four electrodes, to a natural scale. These plots can be used to locate the positions of the soil of high or low resistivity.