UNIT-I

Q. Describe STONES.

Ans-Stone is a 'naturally available building material' which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block. It has been used to construct small residential buildings to large palaces and temples all over the world.

Red Fort, Taj Mahal, Vidhan Sabha at Bangalore and several palaces of medieval age all over India are the famous stone buildings.

Q. Describe Type of Stones

Ans-Stones used for civil engineering works may be classified in the following three ways:

• Geological

• Physical

• Chemical

Geological Classification

Based on their origin of formation stones are classified into three main groups—Igneous, sedimentary and metamorphic rocks.

(i) Igneous Rocks: These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. Granite, trap and basalt are the rocks belonging to this category, Granites are formed by slow cooling of the lava under thick cover on the top. Hence they have crystalline surface. The cooling of

lava at the top surface of earth results into non-crystalline and glassy texture. Trap and basalt belong to this category.

(ii) Sedimentary Rocks: Due to weathering action of water, wind and frost existing rocks disintegrates. The disintegrated material is carried by wind and water; the water being most powerful medium. Flowing water deposits its suspended materials at some points of obstacles to its flow. These deposited layers of materials get consolidated under pressure and by heat. Chemical agents also contribute to the cementing of the deposits. The rocks thus formed are more uniform, fine grained and compact in their nature. They represent a bedded or stratified structure in general. Sand stones, lime stones, mudstones etc. belong to this class of rock.

(iii) Metamorphic Rocks: Previously formed igneous and sedimentary rocks undergo changes due to metamorphic action of pressure and internal heat. For example due to metamorphic action granite becomes greisses, trap and basalt change to schist and laterite, lime stone changes to marble, sand stone becomes quartzite and mud stone becomes slate.

Physical Classification

Based on the structure, the rocks may be classified as:

• Stratified rocks

• Unstratified rocks

(i) Stratified Rocks: These rocks are having layered structure. They possess planes of stratification or cleavage. They can be easily split along these planes. Sand stones, lime stones, slate etc. are the examples of this class of stones.

(ii) Unstratified Rocks: These rocks are not stratified. They possess crystalline and compact grains. They cannot be split in to thin slab. Granite, trap, marble etc. are the examples of this type of rocks.

(iii) Foliated Rocks: These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks. This type of structure is very common in case of metamorphic rocks.

Chemical Classification

On the basis of their chemical composition engineers prefer to classify rocks as:

• Silicious rocks

• Argillaceous rocks and

• Calcareous rocks

(i) Silicious rocks: The main content of these rocks is silica. They are hard and durable. Examples of such rocks are granite, trap, sand stones etc.

(ii) Argillaceous rocks: The main constituent of these rocks is argil i.e., clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

(iii) Calcareous rocks: The main constituent of these rocks is calcium carbonate. Limestone is a calcareous rock of sedimentary origin while marble is a calcareous rock of metamorphic origin

Q. Describe the Properties of Stones

Ans-The following properties of the stones should be looked into before selecting them for engineering works:

(i) Structure: The structure of the stone may be stratified (layered) or unstratified. Structured stones should be easily dressed and suitable for super structure. Unstratified stones are hard and difficult to dress. They are preferred for the foundation works.

(ii) Texture: Fine grained stones with homogeneous distribution look attractive and hence they are used for carving. Such stones are usually strong and durable.

(iii) Density: Denser stones are stronger. Light weight stones are weak. Hence stones with specific gravity less than 2.4 are considered unsuitable for buildings.

(iv) Appearance: A stone with uniform and attractive colour is durable, if grains are compact. Marble and granite get very good appearance, when polished. Hence they are used for face works in buildings.

(v) Strength: Strength is an important property to be looked into before selecting stone as building block. Indian standard code recommends, a minimum crushing strength of 3.5 N/mm2 for any building block. Table 1.1 shows the crushing strength of various stones. Due to non-uniformity of the material, usually a factor of safety of 10 is used to find the permissible stress in a stone. Hence even laterite canbe used safely for a single storey building, because in such structures expected load can hardly give a stress of 0.15 N/mm2. However in stone masonry buildings care should be taken to check the stresses when the beams (Concentrated Loads) are placed on laterite wall.

(vi) Hardness: It is an important property to be considered when stone is used for flooring and pavement. Coefficient of hardness is to be found by conducting test on standard specimen in Dory'stesting machine. For road works coefficient of hardness should be at least 17. For building works stones with coefficient of hardness less than 14 should not be used.

(vii) Percentage wear: It is measured by attrition test. It is an important property to be considered in selecting aggregate for road works and railway ballast. A good stone should not show wear of more than 2%.

(viii) Porosity and Absorption: All stones have pores and hence absorb water. The reaction of water with material of stone cause disintegration. Absorption test is specified as percentage of water absorbed by the stone when it is immersed under water for 24 hours. For a good stone it should be as small as possible and in no case more than 5.

(ix) Weathering: Rain and wind cause loss of good appearance of stones. Hence stones with good weather resistance should be used for face works.

(x) Toughness: The resistance to impact is called toughness. It is determined by impact test. Stones with toughness index more than 19 are preferred for road works. Toughness index 13 to 19 are considered as medium tough and stones with toughness index less than 13 are poor stones.

(xi) Resistance to Fire: Sand stones resist fire better. Argillaceous materials, though poor in strength, are good in resisting fire.

(xii) **Ease in Dressing**: Cost of dressing contributes to cost of stone masonry to a great extent. Dressing is easy in stones with lesser strength. Hence an engineer should look into sufficient strength rather than high strength while selecting stones for building works.

Q. Explain the Uses of Stones.

Ans-Stones are used in the following civil engineering constructions:

(i) Stone masonry is used for the construction of foundations, walls, columns and arches.

(ii) Stones are used for flooring.

(iii) Stone slabs are used as damp proof courses, lintels and even as roofing materials.

(iv) Stones with good appearance are used for the face works of buildings. Polished marbles and granite are commonly used for face works.

(v) Stones are used for paving of roads, footpaths and open spaces round the buildings.

(vi) Stones are also used in the constructions of piers and abutments of bridges, dams and retaining walls.

(vii) Crushed stones with graved are used to provide base course for roads. When mixed with tar they form finishing coat.

(viii) Crushed stones are used in the following works also:

(a) As a basic inert material in concrete

(b) For making artificial stones and building blocks

(c) As railway ballast.

Q. Name Common Building Stones.

Ans-The following are the some of commonly used stones:

(i) Basalt and trap (ii) Granite

(iii) Sand stone (iv) Slate

(v) Laterite (vi) Marble

(vii) Gneiss (viii) Quartzite.

Q. What is CEMENT?

Cement is a commonly used binding material in the construction. The cement is obtained by burning amixture of calcarious (calcium) and argillaceous (clay) material at a very high temperature and then grinding the clinker so produced to a fine powder. It was first produced by a mason Joseph Aspdin in England in 1924. He patented it as portland cement.

Q. Describe Types of Cement?

In addition to ordinary portland cement there are many varieties of cement. Important varieties are

briefly explained below:

(i) White Cement: The cement when made free from colouring oxides of iron, maganese and chlorium results into white cement. In the manufacture of this cement, the oil fuel is used instead of coal for burning. White cement is used for the floor finishes, plastering, ornamental works etc. In swimming pools white cement is used to replace glazed tiles. It is used for fixing marbles and glazed tiles.

(ii) Coloured Cement: The cements of desired colours are produced by intimately mixing pigments with ordinary cement. The chlorium oxide gives green colour. Cobalt produce blue colour. Iron oxide with different proportion produce brown, red or yellow colour. Addition of manganese dioxide gives black or brown coloured cement. These cements are used for giving finishing touches to floors, walls, window sills, roofs etc.

(iii) Quick Setting Cement: Quick setting cement is produced by reducing the percentage of gypsum and adding a small amount of aluminium sulphate during the manufacture of cement. Finer grinding also adds to quick setting property. This cement starts setting within 5 minutes after adding water and becomes hard mass within 30 minutes. This cement is used to lay concrete under static or slowly running water.

(iv) Rapid Hardening Cement: This cement can be produced by increasing lime content and burning at high temperature while manufacturing cement. Grinding to very fine is also necessary. Though the initial and final setting time of this cement is the same as that of portland cement, it gains strength in early days. This property helps in earlier removal of form works and speed in construction activity.

(v) Low Heat Cement: In mass concrete works like construction of dams, heat produced due to hydration of cement will not get dispersed easily. This may give rise to cracks. Hence in such construction site is preferable to use low heat cement. This cement contains low percentage (5%) of tricalcium aluminate(C3A) and higher percentage (46%) of dicalcium silicate (C2S).

(vi) Pozzulana Cement: Pozzulana is a volcanic power found in Italy. It can be processed from shales and certain types of clay also. In this cement pozzulana material is 10 to 30 per cent. It can resist action of sulphate. It releases less heat during setting. It imparts higher degree of water tightness. Its tensile strength is high but compressive strength is low. It is used for mass concrete works. It is also used in sewage line works.

(vii) Expanding Cement: This cement expands as it sets. This property is achieved by adding expanding medium like sulpho aluminate and a stabilizing agent to ordinary cement. This is used for filling the cracks in concrete structures.

(viii) High Alumina Cement: It is manufactured by calcining a mixture of lime and bauxite. It is more resistant to sulphate and acid attack. It develops almost full strength within 24 hours of adding water. It is used for under water works.

(ix) Blast Furnace Cement: In the manufacture of pig iron, slag comes out as a waste product. By grinding clinkers of cement with about 60 to 65 per cent of slag, this cement is produced. The properties of this cement are more or less same as ordinary cement, but it is cheap, since it utilize waste product. This cement is durable but it gains the strength slowly and hence needs longer period of curing.

(x) Acid Resistant Cement: This cement is produced by adding acid resistant aggregated such as quartz, quartzite, sodium silicate or soluble glass. This cement has good resistance to action of acid and water. It is commonly used in the construction of chemical factories.

(xi) Sulphate Resistant Cement: By keeping the percentage of tricalcium aluminate C3A below five per cent in ordinary cement this cement is produced. It is used in the construction of structures which are likely to be damaged by alkaline conditions. Examples of such structures are canals, culverts etc.

(xii) Fly Ash Blended Cement: Fly ash is a byproduct in thermal stations. The particles of fly ash are very minute and they fly in the air, creating air pollution problems. Thermal power stations have to spend lot of money to arrest fly ash and

dispose safely. It is found that one of the best way to dispose flyash is to mix it with cement in controlled condition and derive some of the beneficiary effects on cement. Now-a-days cement factories produce the fly ash in their own thermal stations or borrow it from other thermal stations and further process it to make it suitable to blend with cement. 20 to 30% flyash is used for blending.

Fly ash blended cements have superior quality of resistance to weathering action. The ultimate strength gained is the same as that with ordinary portland cement. However strength gained in the initial stage is slow. Birla plus, Birla star, A.C.C. Suraksha are some of the brand name of blended cement.

Q. What are the Properties of Ordinary Portland Cement.

(i) Chemical properties: Portland cement consists of the following chemical compounds:

(a) Tricalcium silicate 3 CaO.SiO2 (C3S) 40%

(b) Dicalcium silicate 2CaO.SiO2 (C2S) 30%

(c) Tricalcium aluminate 3CaO.Al2O3 (C3A) 11%

(d) Tetracalcium aluminate 4CaO.Al2O3.Fe2O3 (C3AF) 11%

There may be small quantities of impurifies present such as calcium oxide (CaO) and magnesiumoxide (MgO).

Q. Describe Hydration of cement?

Ans-When water is added to cement, C3A is the first to react and cause initial set. It generates great amount of heat. C3S hydrates early and develops strength in the first 28 days. It also generates heat. C2Sis the next to hydrate. It hydrates slowly and is responsible for increase in ultimate strength. C4AF is comparatively inactive compound.

Q. Describe the Physical properties of Cement?

Physical properties: The following physical properties should be checked before selecting a portland cement for the civil engineering works. IS 269–1967 specifies the method of testing and prescribes the limits:

(a) Fineness (b) Setting time

(c) Soundness (d) Crushing strength.

(a) Fineness: It is measured in terms of percentage of weight retained after sieving the cement through 90 micron sieve or by surface area of cement in square centimeters per gramme of cement.

According to IS code specification weight retained on the sieve should not be more than 10 per cent. In terms of specific surface should not be less than 2250 cm^2/gm.**(b) Setting time**: A period of 30 minutes as minimum setting time for initial setting and a maximum period of 600 minutes as maximum setting time is specified by IS code, provided the tests are conducted as per the procedure prescribed by IS 269-1967.

(c) Soundness: Once the concrete has hardened it is necessary to ensure that no volumetric changes takes place. The cement is said to be unsound, if it exhibits volumetric instability after hardening.

IS code recommends test with Le Chatelier mould for testing this property. At the end of the test, the indicator of Le Chatelier mould should not expand by more than 10 mm.

(d)Crushing strength: For this mortar cubes are made with standard sand and tested in compression testing machine as per the specification of IS code. The minimum strength specified is16 N/mm2 after 3 days and 22 N/mm2 after 7 days of curing.

Q. Describe Fineness Tests on Cement

Ans-Fineness Test: MATERIAL REQUIRED-Cement sample (300gms), Weighing balance, I.S.Sieve No.9 (90micron).

THEORY- Fineness of cement is measured either in terms of

1- Percentage of weight retained after sieving cement through 90 micron sieve.
2- Surface area of cement in cm^2 per gm. I.S. 269-1967 specifies that the maximum residue after sieving through a 90 micron IS sieve should be limited to 10% by weight for ordinary Portland cement and 5% by weight for rapid hardening cement.

PROCEDURE- Take 100 gms of cement. Place the cement in IS sieve No. 9 (90 micron). Sieve the cement by gentle motion of the wrist, for about 15 minutes. Weigh the residue retained on sieve, which should not be more than 10% by weight of the cement sample.

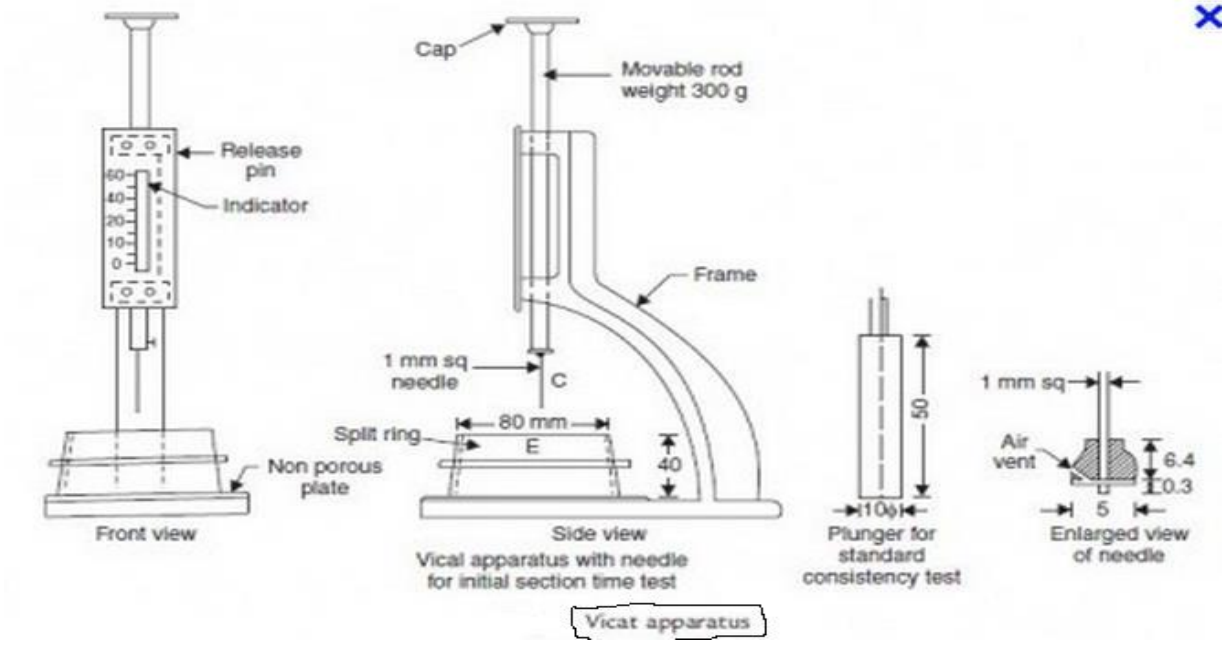
$$\text{Fineness of Cement} = \frac{\text{Residual Weight}}{\text{Initial Weight}} \times 100$$

PRECAUTIONS

1- Cement sample should be taken out from gunny bag stored in cool and dry place.
2- Before the lab test of cement check the quality of cement by physical inspection.

Q. Describe Standard Consistency Tests on Cement

Ans-APPARATUS& MATERIAL REQUIRED- Vicat's apparatus, Cement sample, Water, Plunger, Mould, Glass plate, Weighing machine.



THEORY- Consistency is the amount of water to make the cement paste workable. The normal consistency of cement is 28 to 30%.

PROCEDURE- Take 300 gm cement specimen and add 30% of water by the weight of cement or 90 gm of water to it. Mix the water and add cement on a non-porous surface (glass plate), mixing should be done thoroughly and fix the mould of Vicat's apparatus. The interval between the addition of watr to the common cement and fixing the mould is known as time of gauzing. Plunger is attached to the movable rod of Vicat's apparatus. The plunger is gently lowered. The settlement of plunger is noted. If the penetration of plunger into the cement paste is between 5 to 7 mm from the bottom of the mould then water added in the cement is correct and if the penetration is not proper then repeat the same process with different percentage of water till the desired penetration is obtained.

PRECAUTIONS

1- Cement should be taken out from gunny bag.
2- It should be stored in cool and dry place.
3- Before actual test in lab the quality of cement should be determined by physical inspection.

Q. Describe Initial & Final Setting Time Tests on Cement.

Ans- APPARATUS AND MATERIAL REQUIRED- Cement sample, Water, Weighing machine, Vicat's Apparatus.

THEORY- This test is used to detect the deterioration of cement due to storage. The initial setting time of cement is defined as the time taken from the moment when water is added to cement to the moment when the needle of 1 mm square cross sectional area fails to penetrate beyond 33 to 35 mm from top of the mould.

The final setting time of cement is defined as the time taken from the moment when water is added to cement to the moment, the collar fails to make impression on the surface of cement paste.

PROCEDURE- To find initial setting time, take 300 gms of cement and 0.85 times the water required for making the paste of normal consistency. Mix it properly and fill the mould. Attach ht e needle of 1 mm square cross sectional area to the rod of vicat's apparatus. Place the filled mould. Release the rod quickly without any jerk, allow it to penetrate into the cement paste and note down the penetration. In the beginning the needle penetrates completely. It is then taken out and dropped at a fresh place. This procedure is repeated at regular intervals till the needle fails to penetrate beyond 33 to 35 mm from top. The time elapsed when the water was added to cement and the moment when the needle fails to penetrate beyond 33 to 35 mm in the paste is known as initial setting time

To find out the final setting time of cement, the needle is replaced by the collar attachment. The needle is brought in touch with the paste in the mould and released quickly. When the attachment fails to make any impression on the surface of paste then final setting time is said to have taken place.

PRECAUTIONS

1- Cement should be taken out from gunny bag.
2- Penetration should apply gradually.
3- Time should be noted carefully

Q. Describe the Uses of Cement.

Cement is used widely for the construction of various structures. Some of them are listed below:

(i) Cement slurry is used for filling cracks in concrete structures.

(ii) Cement mortar is used for masonry work, plastering and pointing.

(iii) Cement concrete is used for the construction of various structures like buildings, bridges, water tanks, tunnels, docks, harbors etc.

(iv) Cement is used to manufacture lamp posts, telephone posts, railway sleepers, piles etc.

(v) For manufacturing cement pipes, garden seats, dust bins, flower pots etc. cement is commonly

used.

(vi) It is useful for the construction of roads, footpaths, courts for various sports etc.

Q. Define Bricks.

Ans- Brick is made by burning clay at high temperature in a kiln. Bricks are used in construction of walls, pillars etc. The brick might be made from clay, lime-and-sand, concrete, or shaped stone.

Q. What are Brick Sizes?

Ans-Modular Size (INDIAN STANDARD) of Bricks are i) 19 cm x 9 cm x 9 cm ii) 19 cm x 9 cm x 4 cm

Nominal Size (With mortar Joints of 1 cm), Size of bricks are i) 20 cm x 10 cm x 10 cm ii) 20 cm x 10 cm x 5 cm

Bricks available in most part of the country still are

9" x 4 ½" x 3"and are known as field bricks or traditional bricks.

Q. What is Brick Weight?

Ans-Weight of such a brick is about 3.0 kg.

Q. What is Brick Frog portion?

Ans-Brick's Frog

An indent called frog, 1 – 2 cm deep is provided for 9 cm height bricks only.

Frog is not provided in 4 cm high bricks.

Purpose of providing frog :-

1) To form a key for holding the mortar and therefore, the bricks are laid with frogs on top.

2) Manufacturer of bricks also put their logo in frog.

Q. Describe the ingredients of Good Brick Earth and their role.

Ans-INGREDIENTS to make good brick making earth are

1) Alumina

This is one of the main Constituents of clay.

It can readily absorb water and provide plasticity to the clay.

It should be present within 20 to 30 % .

If content is more than the limit, then raw bricks are liable to warp and shrink in the process of drying and burning.

2) Silica

Silica may exist in clay as free sand or it may exist as silicate of alumina. Silica content in brick earth shall be 50 % to 60 % Excess of silica causes brick to become brittle.

3) Lime

Small quantity of lime (less than 5%) is useful.

Shrinkage of raw bricks is prevented by lime.

Presence of lime helps in fusion of sand at high temperature in the kiln.

The brick particles can bind well by fused sand.

Lime should be added in finely divided form and not in lumps.

4) Magnesia

It is present in very small extent.

Magnesia reduces shrinkage of bricks.

Excess of Magnesia results in decay of bricks.

5) Iron Oxide

5% to 6% of Iron Oxide is desirable in brick earth.

It helps to bind the brick particles making the brick hard and strong.

Red colour of brick shows iron oxide is present at the above limit.

Q. Describe Manufacturing of bricks.

Ans-Making the Bricks:-

1. **Material Procurement:**

The clay is mined and stored in the open.

This makes the clay soft and removes unwanted oxides.

2. **Tempering:**

This clay is then mixed with water to get the right consistency for moulding.

Mixing is done manually with hands and feet. Sometimes and in certain areas, animal driven pug mills are used.

3. **Moulding**:

A lump of clay mix is taken, rolled in sand and slapped into the mould. The clay can be moulded in two ways :- 1) Hand moulding.

2) **Machine Moulding.**

Hand Moulding

Moulding the clay is done by using wooden or steel moulds.

Wooden mould consists of rectangular wooden box opened at top and bottom.

Internal dimensions of mould are made 6 mm greater than required dimensions. This is because the raw bricks shrink in the process of drying and burning.

Bricks made by Hand moulding may be :-

1) Ground moulding bricks

2)Table moulded bricks

Ground moulded Bricks

In case of ground moulded bricks, ground should be leveled and a thin sand is spread over the ground.

The mould is wetted in water and placed on ground firmly.

The tempered clay is now dropped into the mould.

Any surplus clay is removed using steel plate.

Now the mould is lifted up leaving the raw brick on the ground.

In this way, whole prepared ground is covered by raw bricks.

Table moulded Bricks

Same procedure is followed as in case of ground moulded bricks. In this case, moulding is done over a table 2m x 1m

The brick obtained on the table are moved to a convenient place for drying.

Machine moulding

In case of machine molding, the clay is fed to the moulding machine. As clay moves through it, it is compressed and cut into strips by wires and brick blocks are formed.

4. Drying:

The mould is emptied onto the drying area, where the bricks are arranged in a herring bone pattern to dry in the sun.

Every two days they are turned over to facilitate uniform drying and prevent warping. After two weeks they are ready to be burnt

5. Firing:

The raw bricks are arranged in a kiln and insulation is provided with a mud pack.

Fire holes left to ignite the kiln are later sealed to keep the heat inside. This is maintained for a week.

6. Sorting:

After the kiln is disassembled, the bricks are sorted according to colour.

Colour is an indication of the level of burning.

Over burnt bricks are used for paving or covering the kiln while slightly under burnt bricks are used for building inner walls or burnt once again in the next kiln.

Q. Describe the Characteristics of Good Bricks.

Ans-(i)Colour: Colour should be uniform and bright(red or cherry)

(ii)Shape: Bricks should have plane faces. They should have sharp and true right angled corners.

(iii)Size: Bricks should be of standard sizes as prescribed by codes.

(iv)Texture: They should possess fine, dense and uniform texture. They should not possess, cavities, loose grit and un-burnt lime.

(v)Soundness: When struck with hammer or with another brick, it should produce metallic sound.

(vi)Hardness: Finger scratching should not produce any impression on the brick.

(vii)Strength: Crushing strength of brick should not be less than 3.5 N/mm2.

A field test for strength is that when dropped from a height of 0.9 m to 1.0 m on a hard ground, the brick should not break into pieces.

(viii)Water Absorption: After immersing the brick in water for 24 hours, water absorption should not be more than 20 per cent by weight. For class-I bricks works this limit is 15 per cent.

(ix) Efflorescence: Bricks should not show white patches when soaked in water for 24 hours and then allowed to dry in shade. White patches are due to the presence of sulphate of calcium, magnesium and potassium. They keep the masonry permanently in damp and wet conditions

(x)Sound Insulation: Heavier bricks are poor insulators of sound while light weight and hollow bricks provide good sound insulation.

(xi)Fire Resistance: Fire resistance of bricks is usually good. In fact bricks are used to encase steel columns to protect them from fire.

Q. Describe the Tests on Bricks.

Ans-Laboratory tests may be conducted on the bricks to find their suitability:

(i) Compressive strength / Compression test.

(ii) Absorption (iii) Shape and size and (iv) Efflorescence.

Compression test

The brick specimen are immersed in water for 24 hours.

The frog of the brick is filled flush with 1:3 cement mortar and the specimen is stored in damp jute bag for 24 hours and then immersed in clean water for 24 hours.•

The specimen is placed in compression testing machine with 6 mm plywood on top and bottom of it to get uniform load on the specimen.•

The crushing load is noted.• Then load is applied axially at increasing rate of 14 N/mm2 per minute till failure •

Then the Compressive strength is the ratio of load at failure to the area of brick loaded.•

Expected Strength is 105 N/mm2• Average of five specimen is taken as the crushing strength. • .i.e. Compressive Strength = (Max. Load / Loaded area of Brick) •

Water Absorption test

This is a test to determine the percentage of water absorption which gives degree of burning.•

Brick specimen are weighed dry. Then they are immersed in water for a period of 24 hours.•

The specimen are taken out and wiped with cloth.•

The weight of each specimen in wet condition is determined.•

Water Absorption % = (Wt of water absorbed / Wt of dry specimen) x 100•

Q. Describe theTypes of Bricks.

Ans-Building Bricks – used for construction of walls

Paving Bricks- These are vitrified bricks used as pavers

Fire Bricks – Specially made to withstand High Temperatures. Example- Silica Bricks used in furnace.

Especially Shaped Bricks- Bricks of special shapes are manufactured to meet the requirements of different situations.

Q. Describe theClassification of Bricks Based on their Quality.

Ans-The bricks used in construction are classified as:

(i) First class bricks

(ii) Second class bricks

(iii) Third class bricks and

(iv) Fourth class bricks

First Class Bricks:

These bricks are of standard shape and size. They are burnt in kilns.

They fulfill all desirable properties of bricks.

Second Class Bricks:

These bricks are ground moulded and burnt in kilns. The edges may not be sharp and uniform.

The surface may be somewhat rough. Such bricks are commonly used for the construction of walls which are going to be plastered.

Third Class Bricks:

These bricks are ground moulded and burnt in clamps.

Their edges are somewhat distorted.

They produce dull sound when struck together.

They are used for temporary and unimportant structures.

Fourth Class Bricks:

These are the over burnt bricks. They are dark in colour.

The shape is irregular.

They are used as aggregates for concrete in foundations, floors and roads.

Q. What is TIMBER?

Ans-Timber refers to wood used for construction works. In fact the word timber is derived from an oldEnglish word 'Timbrian' which means 'to build'. A tree that yields good wood for construction is called'Standing Timber.' After felling a tree, its branches are cut and its stem is roughly converted into piecesof suitable length, so that it can be transported to timber yard. This form of timber is known as roughtimber.

Q. Give the Classification of Timberbased on Mode of Growth.

Ans-On the basis of mode of growth trees are classifiedas

(a) Exogeneous and

(b) Endogeneous

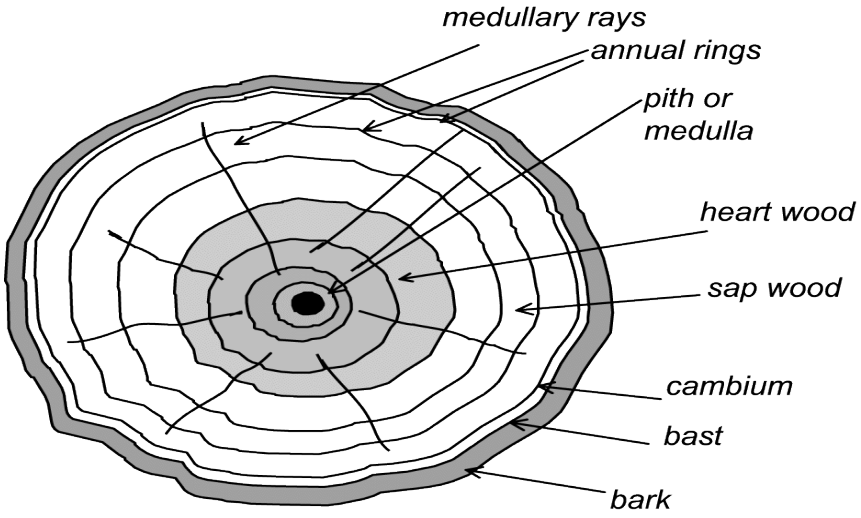
(a) Exogeneous Trees: These trees grow outward by adding distinct consecutive ring every year. These rings are known as annual rings. Hence it is possible to find the age of timber by counting these annual rings. These trees may be further divided into (1) coniferrous and (2) deciduous.

Coniferrous trees are having cone shaped leaves and fruits. The leaves do not fall till new ones are grown. They yield soft wood.

Deciduous trees are having broad leaves. These leaves fall in autumn and new ones appear in springs. They yield strong wood and hence they are commonly used in building construction.

Q. Describe various parts of Timber?

Ans-



The tree trunk showing growth rings

1. **Pith**: It is the inner most part of the tree and hence the oldest part of exogeneous tree when the plant becomes old, the pith dies and becomes fibrous and dark. It varies in size and shape.

2. **Heart Wood**: This is the portion surrounding pith. It is dark in colour and strong. This portion is useful for various engineering purpose. This is the dead part of wood. It consists of several annular rings.

3. **Sap Wood**: It is the layer next to heart wood. It denotes recent growth and contains sap. It takes active part in the growth of trees by allowing sap to move in upward direction. The annual rings of sap wood are less sharply divided and are light in colour. The sap wood is also known as alburnum.

4. **Cambium Layer**: It is a thin layer of fresh sap lying between sap wood and the inner bark. It contains sap which is not yet converted into sap wood. If the bark is removed and cambium layer is exposed to atmosphere, cells cease to be active and tree dies.

5. **Inner Bark**: It is a inner skin of tree protecting the cambium layer. It gives protection to cambium layer.

6. **Outer Bark**: It is the outer skin of the tree and consists of wood fibres. Sometimes it contains fissures and cracks.

7. **Medullary Rays**: These are thin radial fibres extending from pith to cambium layer. They hold annular rings together. In some of trees they are broken and some other they may not be prominent.

(b) **Endogeneous Trees**: These trees grow inwards. Fresh fibrous mass is in the inner mostportion. Examples of endogenous trees are bamboo and cane. They are not useful for structural works.

Q. Explain Seasoning of Timber.

Ans-This is a process by which moisture content in a freshly cut tree is reduced to a suitable level. By doing so the durability of timber is increased.

Q. Explain methods Seasoning of Timber.

Ans-The various methods of seasoning used may be classified into:

(i) Natural seasoning

(ii) Artificial seasoning.

(i) **Natural Seasoning**: It may be air seasoning or water seasoning. Air seasoning is carried out in a shed with a platform. On about 300 mm high platform timber balks are stacked .Care is taken to see that there is proper air circulation around each timber balk. Over a period, in a natural process moisture content reduces. A well seasoned timber contains only 15% moisture. This is a slow but a good process of seasoning.

(ii) **Artificial Seasoning**: In this method timber is seasoned in a chamber with regulated heat controlled humidity and proper air circulation. Seasoning can be completed in 4 to 5 days only. Kiln is an airtight chamber. Timber to be seasoned is placed inside it. Then fully saturated air with a temperature 35°C to 38°C is forced in the kiln. The heat gradually reaches

In side timber. Then relative humidity is gradually reduced and temperature is increased, and maintained till desired degree of moisture content is achieved.

Q. Describe different Defects in Timber.

Ans Various defects which are likely to occur in timber may be grouped into the following three-

(i) Due to natural forces

(ii)**Due to defective seasoning and conversions**.

(iii) **Due to attack by fungi and insects.**

(i) Defects due to Natural Forces: The following defects are caused by natural forces:
(a)Knots
(b)Shakes
(c)Windcracks
(d) Upsets
(a) Knots: When a tree grows, many of its branches fall and the stump of these branches in the trunk is covered. In the sawn pieces of timber the stump of fallen branches appear as knots. Knots are dark and hard pieces. Grains are distorted in this portion. Figure 1.9 shows some varieties of knots. If the knot is intact with surrounding wood, it is called live knot. If it is not held firmly it is dead knot.

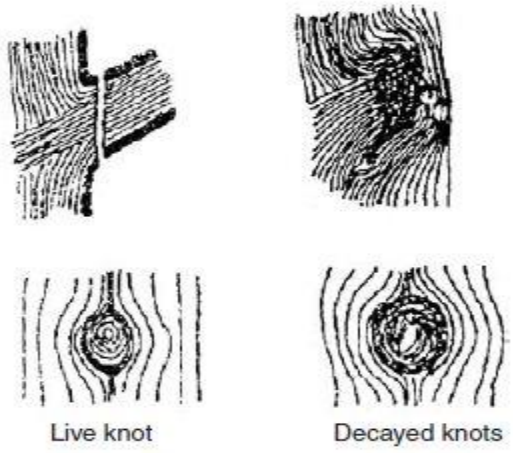


Fig. 1.9. Knots

(b) Shakes: The shakes are cracks in the timber which appear due to excessive heat, frost or twisting due to wind during the growth of a tree. Depending upon the shape and the positions shakes can be classified as star shake, cup shake, ring shakes and heart shakes [Ref. Fig. 1.10]

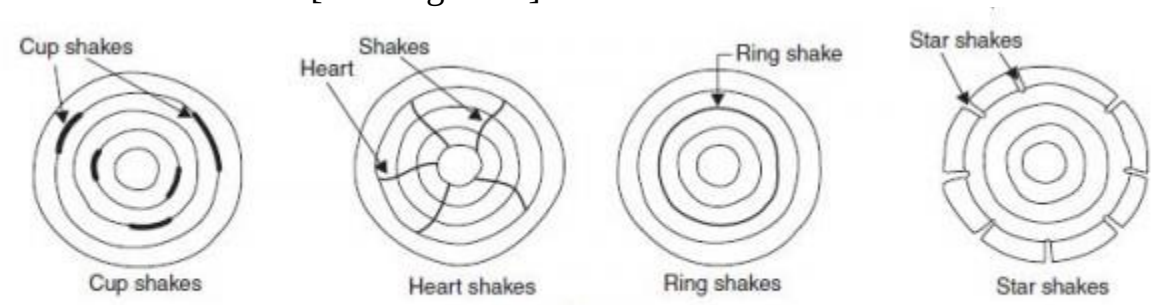


Fig. 1.10. Shakes

(c) Wind Cracks: These are the cracks on the outside of a log due to the shrinkage of the exterior surface. They appear as shown in Fig. 1.11.

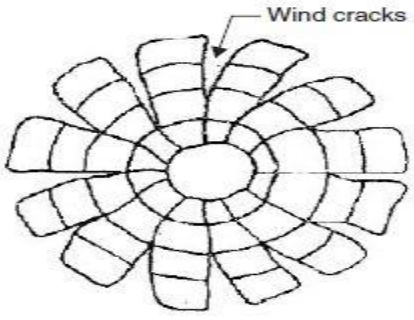


Fig. 1.11. Wind cracks

(d) Upsets: Figure 1.12 shows a typical upset in a timber. This type ofdefect is due to excessive compression in the tree when it was young. Upset is an injury by crushing. This is also known as rupture.

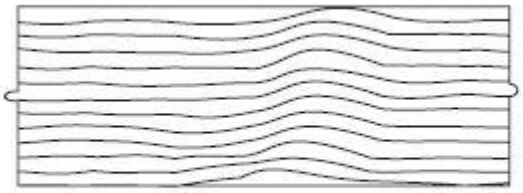


Fig. 1.12. Upset

(ii) Defects due to Defective Seasoning and Conversion: If seasoning is not uniform, the converted timber may warp and twist in various directions. Sometimes honey combing and even cracks appear. This type of defects are more susceptible in case of kiln seasoning.
In the process of converting timber to commercial sizes and shapes the following types of defects are likely to arise: chip marks, torn grain etc.

(iii) Defects due to Fungi and Insects Attack: Fungi are minute microscopic plant organism. They grow in wood if moisture content is more than 20°C and exposed to air. Due to fungi attack rotting of wood, takes place. Wood becomes weak and stains appear on it.
Beetles, marine borers and termites (white ants) are the insects which eat wood and weaken the timber. Some woods like teak have chemicals in their compositions and resist such attacks.
termites.

Q. What are the Uses of Timber.

Ans-Timber is used for the following works:

1. For heavy construction works like columns, trusses, piles.

2. For light construction works like doors, windows, flooring and roofing.

3. For other permanent works like for railway sleepers, fencing poles

4. For temporary works in construction like scaffolding, centering, shoring and strutting, packingof materials.

5. For decorative works like showcases and furnitures.

6. For body works of buses, lorries, trains and boats

7. For industrial uses like pulps (used in making papers), card boards, wall papers

8. For making sports goods and musical instruments.

Q.- Define concrete.

Ans- Plain concrete, commonly known as concrete, is an intimate mixture of binding material, fine aggregate, coarse aggregate and water in predetermined proportions. This can be easily moulded to desired shape and size before it loses plasticity and hardens. Plain concrete is strong in compression but very weak in tension.

Q.- What are the main ingredients of concrete?

Ans-Major ingredients of concrete are:
1. Binding material (like cement, lime, polymer)
2. Fine aggregate (sand)
3. Coarse aggregates (crushed stone, jelly)
4. Water.

A small quantity of admixtures like air entraining agents, water proofing agents, workability agents etc. may also be added to impart special properties to the plain concrete mixture.

Q. Describe Curing of Concrete.

Ans- Curing may be defined as the process of maintaining satisfactory moisture and temperature conditions for freshly placed concrete for some specified time for proper hardening of concrete. Curing in the early ages of concrete is more important. Curing for 14 days is very important. Better to continue it for 7 to 14 days more. If curing is not done properly, the strength of concrete reduces. Cracks develop due shrinkage.
The durability of concrete structure reduces.
The following curing methods are employed:

(a) Spraying of water
(b) Covering the surface with wet gunny bags, straw etc.
(c) Ponding
(d) Steam curing and
(e) Application of curing compounds.

(a) **Spraying of water**: Walls, columns, plastered surfaces are cured by sprinkling water.

(b) **Wet covering the surface**: Columns and other vertical surfaces may be cured by covering the surfaces with wet gunny bags or straw.

(c) **Ponding**: The horizontal surfaces like slab and floors are cured by stagnating the water to a height of 25 to 50 mm by providing temporary small hunds with mortar.

(d**) Steam curing**: In the manufacture of pre-fabricated concrete units steam is passed over the units kept in closed chambers. It accelerates curing process, resulting into the reduction of curing period.

(e) **Application of curing compounds**: Compounds like calcium chloride may be applied on the curing surface. The compound shows affinity to the moisture and retains it on the surface. It keeps the concrete surface wet for a long time.

Q. What do you understand by workability of Concrete?

Ans-Workability: This is defined as the ease with which concrete can be compacted fully without segregating and bleeding. It can also be defined as the amount of internal work required to fully compact the concrete to optimum density. The workability depends upon the quantity of water, grading, shape and the percentage of the aggregates present in the concrete.

Q. Describe Segregation property of Concrete.

Ans- Separation of coarse particles from the green/fresh/Soft concrete is called segregation.

This may happen due to lack of sufficient quantity of finer particles in concrete or due to throwing of the concrete from greater heights at the time of placing the concrete.

Because of the segregation, the cohesiveness (Sticking/glue property) of the concrete is lost and honey combing (voids in hardened concrete) results.

Ultimately it results in the loss of strength of hardened concrete. Hence utmost care is to be taken to avoid segregation.

Q. Describe Bleeding property of Concrete.

Ans-Bleeding(Property of green/fresh concrete)

This refers to the appearance of the water along with cement particles on the surface of the freshly laid concrete.

This happens when there is excessive quantity of water in the mix or due to excessive compaction.

Bleeding causes the formation of pores and renders the concrete weak.

Bleeding can be avoided by suitably controlling the quantity of water in the concrete and by using finer grading of aggregates.

Q. Describe Slump test (For measuring workability) of Concrete.

Ans- This test is conducted to determine the workability of concrete.

It needs a slump cone for test.

Slump cone is a vessel in the shape of a frustum of a cone with diameter at bottom 200 mm and 50 mm at top and 300 mm high.

This cone is kept over a impervious platform and is filled with concrete in four layers.

Each layer is tamped with a 16 mm pointed rod for 25 times.

After filling completely the cone is gently pulled up.

The decrease in the height of the concrete is called slump.

Higher the slump, more workable is the concrete.

Q.Describe Water Cement Ratio.

Ans- The single most important indicator of strength is the ratio of the weight of mixing water (Free water available for the reaction with cement) to that of cement in the mixture.

The strength of concrete is only dependent upon water/cement ratio provided the mix is workable.

A minimum w/c ratio (water-to-cement ratio) of about 0.3 by weight is necessary to ensure that the water comes into contact with all cement particles (thus assuring complete hydration).

Water Cement ratio vs compressive strength

Strength decreases with increase in water cement ratio

* The practical range of the w/c ratio is from about 0.3 to over 0.8.

* A ratio of 0.3 is very stiff (unless super plasticizers are used).

* A ratio of 0.8 makes a wet and fairly weak concrete.

* Concrete with a higher w/c ratio is also more susceptible to cracking and shrinkage.

* Shrinkage leads to micro-cracks, which are zones of weakness.

* Once the fresh concrete is placed, excess water is squeezed out of the paste by the weight of the aggregate and the cement paste itself.

* When there is a large excess of water, that water bleeds out onto the surface.

* The micro channels and passages that were created inside the concrete to allow that water to flow become weak zones and micro-cracks.

* This will result in low strength of concrete.

Q. Describe Mortar.

Ans-Mortar is an intimate mixture of binding material, fine aggregate and water. When water is added to thedry mixture of binding material and the inert material, binding material develops the property that bindsnot only the inert material but also the surrounding stones and bricks.

If the cement is the bindingmaterial, then the mortar is known as cement mortar. Other mortars commonly used are lime mortar andmud mortar.

The inert material used is sand.

SAND

Sand is a natural product which is obtained as river sand, nalla sand and pit sand. However sea sand

should not be used for the following reasons:

1. It contains salt and hence structure will remain damp. The mortar is affected by efflorenscence and blisters appear.

2. It contains shells and other organic matter, which decompose after some time, reducing the

life of the mortar.

Sand may be obtained artificially by crushing hard stones. Usually artificial sand is obtained

as a by-product while crushing stones to get jelly (coarse aggregate).

Sand is used in mortar and concrete for the following purpose:

1. It sub-divides the paste of binding material into thin films and allows it to adhere and spread.

2. It fills up the gap between the building blocks and spreads the binding material.

3. It adds to the density of the mortar.

4. It prevents the shrinkage of the cementing material.

5. It allows carbon dioxide from the atmosphere to reach some depth and thereby improve setting power.

6. The cost of cementing material per unit volume is reduced as this low cost material increases the volume of mortar.

7. Silica of sand contributes to formation of silicates resulting into the hardened mass.

The properties of good sand are:

1. It should be chemically inert.

2. It should be free from organic or vegetable matter.

3. It should be free from salt.

4. It should contain sharp, angular and coarse grains.

5. It should be well graded.

6. It should be hard.

CEMENT MORTAR

For preparing mortar, first a mixture of cement and sand is made thoroughly mixing them in dry condition. Water is gradually added and mixed with shovels. The cement to sand proportion recommended for various works is as shown in Table

Cement to sand proportions for various works

S. No.	Works	Cement: Sand
1	Masonry works	1:6 to 1:8
2	Plastering masonry	1:3 to 1:4
3	Plastering concrete	1:3
4	Pointing	1:2 to 1:3

Properties of Cement Mortar: The following are the important properties of cement mortar:

1. When water is added to the dry mixture of cement and sand, hydration of cement starts and it binds sand particles and also the surrounding surfaces of masonry and concrete.

2. A mix richer than 1:3 is prone to shrinkage.

3. Well proportioned mortar provides impervious surface.

4. Leaner mix is not capable of closing the voids in sand and hence the plastered surface is porous.

5. The strength of mortar depends upon the proportion of cement and sand. Strengths obtained with various proportion of cement and sand is shown in Table

S. No.	Cement: Sand	Compressive Strength
1	1:3	10 N/mm2
2	1:4	7.5 N/mm2
3	1:5	5.0 N/mm2
4	1:6	3.0 N/mm2

5	1:8	0.7 N/mm2

Uses of Cement Mortar

Mortar is used

1. to bind masonry units like stone, bricks, cement blocks.

2. to plaster slab and walls make them impervious.

3. to give neat finishing to walls and concrete works.

4. for pointing masonry joints.

5. for preparing building blocks.

6. as a filler material in ferro cement works.

7. to fill joints and cracks in walls.

8. as a filler material in stone masonry.

2.3 LIME MORTAR

Fat lime and hydraulic limes are used for making lime mortar. If fat lime is used sand mixed is normally2 to 3 times its volume. If hydraulic lime is used sand mixed is only 2 times the volume of lime. Limeis prepared by pounding, if quantity required is small or by grinding, if the required quantity is more.

MUD MORTAR

Clay lumps are collected and are wetted with water and allowed to mature for 1 or 2 days. It is kneadedwell until it attains required consistency. Sometimes fibrous materials like gobber are added in the mix.It prevents cracks in the plaster. If plaster is to be used for outer walls, it is sprayed or painted withbitumen.It is cheap

mortar. Its durability is less. It is normally used for the construction of temporary sheds and cheap houses in rural areas.

2.5 SPECIAL MORTAR

The following are some of the special mortars:

1. Cement clay mortar

2. Gauged mortar

3. Decorative mortar.

1. Cement Clay Mortar: Quality of clay mortar can be improved by adding cement to the mix. Normal proportion of clay to cement is 1:1. It maintains the economy to some extent and there is ufficient improvements in the durability of mud-mortar.

2. Gauged Mortar: It is the mortar obtained by adding cement to lime mortar. The usual proportion of cement, lime and sand are 1:1:6, 1:2:9 and 1:3:12. This mortar is to be used within half an hour after mixing cement. Obviously, it is cheaper than cement mortar and its quality is between that of cement mortar and lime mortar.

3. Decorative Mortar: These mortars are obtained by using coloured cement. They are used to give pleasant appearance to outer walls.

Q. Describe the ELEMENTS OF A BUILDING.

Ans-The following are the basic elements of a building:

1. Foundation

2. Plinth

3. Walls and columns

4. Sills, lintels and chejjas

5. Doors and windows

6. Floors

7. Roofs

8. Steps, stairs and lifts

9. Finishing work

10. Building services.

Q. What is foundation.

Ans- Foundation: Foundation is the most important part of the building. Building activity starts with digging the ground for foundation and then building it. It is the lower most part of the building. It transfers the load of the building to the ground. Its main functions and requirements are:

(a) Distribute the load from the structure to soil evenly and safely.

(b) To anchor the building to the ground so that under lateral loads building will not move.(c) It prevents the building from overturning due to lateral forces.

(d) It gives level surface for the construction of super structure.

Types of foundations:

Broadly Classified to two types:

1) Shallow foundation : Depth ≤ Breadth

2) Deep foundation : Depth > Breadth

Q. What do you understand by term Plinth.

Ans- Plinth: The portion of the wall between the ground level and the ground floor level is called plinth. It is usually of stone masonry. If the foundation is on piles, a plinth beam is cast to support wall above floor level. At the top of plinth a damp proof course is provided. It is usually 75 mm thick plain concrete course.

The function of the plinth is to keep the ground floor above ground level, free of dampness. Its height is not less than 450 mm. It is required that plinth level is at least 150 mm above the road level, so that connections to underground drainage system can be made.

Q. What are the BASIC REQUIREMENTS OF A BUILDING.

Ans-The planning and construction of a building should be aimed at fulfilling the following requirements:

1. Strength and stability

2. Dimensional stability

3. Resistance to dampness

4. Resistance to fire

5. Heat insulation

6. Sound insulation

7. Protection against termite attack

8. Durability

9. Security against burglary

10. Lighting and ventilation

11. Comforts and convenience

12. Economy.

Q.What are Principles of planning of buildings .

Ans- Principles of planning of buildings may be grouped into

1. Orientation

2. Energy efficiency

3. Utility

4. Other requirements of the building.

Q. What do understand by ORIENTATION of building.

Ans-Orientation means setting out the plan of the building with respect to north-south and east-west directions to provide an opportunity to user to enjoy sun-shine and breeze when required and to avoid the same whenever not required. This is also known as planning the aspect of a building. Aspect means arrangement of doors, windows in the external wall to make good use of nature.

Kitchen should have eastern aspect to enjoy morning sunshine, means, kitchen should be located on the eastern side of the building to make use of morning sun rays.

The following are the required aspects for various parts of the building in the northern hemisphere of earth:

(a) Kitchen–eastern aspect.

(b) Dining room–southern aspect to enjoy winter sun.

(c) Drawing and living room–southern or south-eastern aspect to enjoy winter sun.

(d) Bed rooms–western or south-western aspect to enjoy breez in summer.

(e) Reading room, class room, stairs, northern aspect to enjoy diffused light.

The following suggestions should be kept in mind in the orientation of a building in India:

(a) Place long walls towards north-south and short walls in east-west directions so as to reduce the area exposed to direct sun rays.

(b) Provide verandah and balcony on east and west.

(c) Provide chejjas on doors and windows on southern side to protect them from sun's rays.

Q. What do understand by ENERGY EFFICIENCY of building.

Ans-A building should be planned in such a manner that it gives maximum day lighting, ventilation and heatinsulation. If these requirements are fulfilled, requirement of electric energy comes down.

(a) Light: Natural light provides hygenic atmosphere. Light should not be glaring but it should

be uniformly distributed. Providing windows and ventilators of appropriate size at suitable positions

contributes a lot for natural lighting. For residential buildings window area to floor area should not be

less than 1/10th while for school buildings it should not be less than 1/5th of floor area. For factory

buildings north light trusses should be provided to get maximum diffused light.

(b) Ventilation: Ventilation is the circulation of the air in the building. Natural ventilation can be

achieved by selecting and positioning of doors, windows and ventilators at suitable places. Always

cross ventilations should be planned suitably. Provision of ventilators at roof level helps in driving out

hot airs. In case it is not possible to achieve natural ventilation for any part of the building provide ordinary or exhaust fans.

(c) Heat Insulation: Thicker exterior walls provide insulation against heat. Proper ventilation also helps in achieving heat insulation. Sun shades provided to doors, windows and ventilators help in achieving heat insulation. In factories and assembly halls height should be more to reduce temperature inside the building. The position of furnaces in the factories should be located away from the other partsof the factory. The openings should be provided at higher level in the wall to remove hot air.

Q. What do understand by term Bearing capacity of Soil.

Ans-Bearing Capacity is the ability of a soil to support a load from foundation without causing a shear failure or excessive settlement.

Ultimate Bearing Capacity(UBC): It's the gross pressure at the base of foundation at which the soil fails in shear. It's not used for design because it has a big value.

Net Safe Bearing Capacity: Ultimate Bearing capacity divided by factor of safety.

Safe Bearing Capacity(SBC): Ultimate Bearing capacity divided by the factor of safety. The factor of safety varies between 2 and 5, depending upon the importance of the structure and the soil profile at the site.

The factor of safety should be applied to the net ultimate bearing capacity and the surcharge pressure due to depth of the foundation should be added to get the safe bearing capacity.

SBC= (UBC/ factor of safety) + surcharge pressure due to depth of foundation

Q. Differentiate between Load bearing Structure andFramed structure.

Ans-Load bearing Structure A load bearing masonry structure has load bearing walls which receive the load and

transmit the same to the ground through their foundations. These load bearing walls supports the entire load including their self weight. Foundations for load bearing walls may be of two types:

i) Simple strip footing

ii) Strip footing with masonry offsets (Stepped footing).

A framed structure has columns erected which in turn are braced together by beams and slab. Space between column and beams are filled by panel walls. Foundations for framed structures are of two types:

Isolated footing

spread footing'

Load bearing Structure Foundation Suitable up to three floors .

A framed structure Suitable for any number of floors

Load bearing Structure -Cost is less.

A framed structure- Cost is more

Load bearing Structure -Less space

A framed structure-More space

Load bearing Structure -Not suitable for all types of soil.

A framed structure-Suitable for any type of soil.

Advantages of framed construction:

 They are meant for multistoried buildings

 Framed structures provide greater floor area. The walls and partition walls which are thin resulting

- Additions and alterations can be more easily done in the case of framed structures.
- Construction time is less in framed constructions
- They can resist earth quake shocks better than a load bearing structure.

UNIT-2

SURVEYING

Q. What is Surveying?

Ans-Surveying is the art of making measurements of objects on, above or beneath the ground to show their relative positions on paper. The relative position required is either horizontal, or vertical, or both.

Less precisely the term Surveying is used to the measurement of objects in their horizontal positions. Measurements to determine their relative vertical positions is known as **leveling.**

Q. What is the Object of Surveying?

Ans-Object of surveying is to show relative positions of various objects of an areaon paper and produce plan or map of that area.

Q. What are the uses of Surveying?

Ans- Various uses of surveying are listed below:

(i) Plans prepared to record property lines of private, public and government lands help in avoidingunnecessary controversies.

(ii) Maps prepared for marking boundaries of countries, states, districts etc., avoid disputes.

(iii) Locality plans help in identifying location of houses and offices in the area.

(iv) Road maps help travellers and tourist.

(v) Topographic maps showing natural features like rivers, streams, hills, forests help in planning. Irrigation projects and flood control measures.

(vi) For planning and estimating project works like roads, bridges, railways, airports, water supply and waste water disposal surveying is required.

(vii) Marine and hydrographic survey helps in planning navigation routes and harbors.

(viii) Military survey is required for strategic planning.

(ix) Mine surveys are required for exploring mineral wealth.

(x) Geological surveys are necessary for determining different strata in the earth crust so that proper location is found for reservoirs.

(xi) Archeological surveys are useful for unearthing relics of antiquity.

Q. What are the PRIMARY DIVISIONS IN SURVEYING?

The earth is an oblate spheroid, length of equatorial axis being 12756.75 km and polar axis being

12713.80 km. Since the difference between these two axes and irregularities on the earth surface are very small compared to these two axes, the earth may be treated as a sphere. The gravitational force is always directed towards the centre of the earth.

The survey in which earth curvature is neglected is called **Plane Surveying** and the survey in which earth's curvature is considered is known as **Geodetic Surveying**.

Q. What are the FUNDAMENTAL PRINCIPLES OF SURVEYING?

Ans-FUNDAMENTAL PRINCIPLES OF SURVEYING

To get accurate results in surveying one should follow the following fundamental principles:

(i) Work from whole to part

(ii) Take extra care in fixing new control points.

1-**Work from Whole to Part**

In surveying large areas, a system of control points are identified and they are located with high precision.Then secondary control points are located using lesser precise methods. The details of the localised areas are measured and plotted with respect to the secondary control points. This is called working from whole to part. This principle in surveying helps in localising the errors. If the surveying is carried out by adding localised areas errors accumulated and may become unacceptable when large area is covered.

2-Fixing point **C** with respect to already fixed points **A** and B by measuring sides, angles or setting perpendiculars.Extra Care in Fixing New Control Points

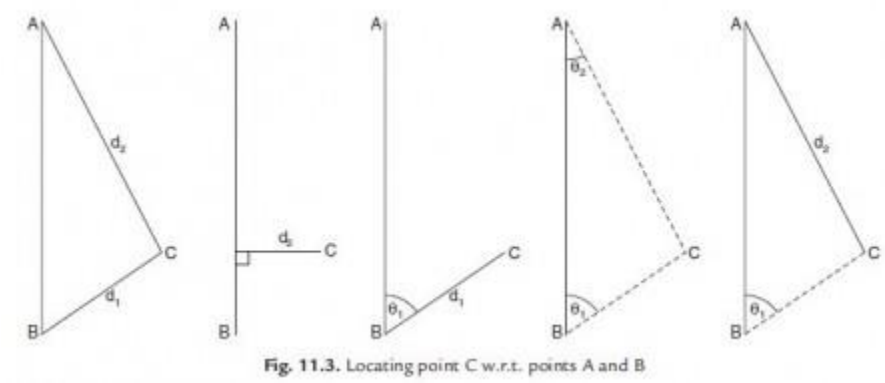


Fig. 11.3. Locating point C w.r.t. points A and B

Figure shows the various methods of fixing point C with respect to already fixed points A and B by measuring sides, angles or setting perpendiculars. For fixing new control points (stations) with respect to already fixed points at least two independent process should be followed. If A and B are already located control points and with respect to them new control point C is to be located, apart from the minimum measurements required as shown in Fig. One more measurement should be taken. Measuring the lengths of check lines and tie lines will also serve this purpose

Q. Give the Classification of Surveying.

CLASSIFICATION OF SURVEYING

Surveying may be classified on the following basis:

(i) Nature of the survey field

(ii) Object of survey

(iii) Instruments used and

(iv) The methods employed.

Q. Give the Classification of Surveying on Nature of Survey Field.

ANS-**Classification Based on Nature of Survey Field**

On this basis survey may be classified as land survey, marine or hydraulic survey and astronomical survey.

Land Survey. It involves measurement of various objects on land. This type of survey may be further classified as given below:

(a) Topographic Survey: It is meant for plotting natural features like rivers, lakes, forests and hills as well as manmade features like roads, railways, towns, villages and canals.

(b) Cadastral Survey: It is for marking the boundaries of municipalities, villages, talukas, districts,

states etc. The survey made to mark properties of individuals also come under this category.

(c) City Survey: The survey made in connection with the construction of streets, water supply and sewage lines fall under this category.

Marine or Hydrographic Survey. Survey conducted to find depth of water at various points in bodies of water like sea, river and lakes fall under this category. Finding depth of water at specified points is known as sounding.

Astronomical Survey. Observations made to heavenly bodies like sun, stars etc., to locate absolute positions of points on the earth and for the purpose of calculating local time is known as astronomical survey.

Q. Give the Classification of Surveyingon Object of Survey.

Ans-Classification Based on Object of Survey

On the basis of object of survey the classification can be as engineering survey, military survey, mines survey, geological survey and archeological survey.

(a) **Engineering Survey**: The objective of this type of survey is to collect data for designing civil engineering projects like roads, railways, irrigation, water supply and sewage disposals. These surveys

are further sub-divided into:

Reconnaissance Survey for determining feasibility and estimation of the scheme.

Preliminary Survey for collecting more information to estimate the cost of the project, and

Location Survey to set the work on the ground.

(b) **Military Survey**: This survey is meant for working out plans of strategic importance.

(c) **Mines Survey**: This is used for exploring mineral wealth.

(d) Geological Survey: This survey is for finding different strata in the earth's crust.

(e) **Archeological Survey**: This survey is for unearthing relics of antiquity.

Q. Give the Classification of Surveyingon Methods Employed.

Ans-Classification Based on Methods Employed

Based on the instruments used, surveying may be classified as:

(i) Chain survey

(ii) Compass survey

(iii) Plane table survey

(iv) Theodolite survey

(v) Tacheometric survey

(vi) Modern survey using electronic distance meters and total station

(vii) Photographic and Aerial survey

Q. Give the Classification of Surveyingon Methods Employed.

Ans-Classification Based on Methods Employed

On this basis surveying is classified as triangulation and traversing.

(i) **Triangulation**: In this method control points are established through a network of triangles.

(ii) **Traversing**: In this scheme of establishing control points consists of a series of connected points established through linear and angular measurements. If the last line meets the starting point it is called as closed traverse. If it does not meet, it is known as open traverse.

Q. What are Plans and Maps?

Ans-PLANS AND MAPS

As in the surveying the objective of measurements is to show relative positions of various objects on paper. Such representations on paper are called plan or map. A plan may be defined as the graphical representation of the features on, near or below the surface of the earth as projected on a horizontal plane to a suitable scale..

If the area to be represented is small, distortion is less and large scale can be used. Such representations are called **plans**.

If the area to be represented is large, small, scales are to be used and distortion is large. Representation of larger areas are called **maps**.

Q.-What are the METHODS OF LINEAR MEASUREMENTS?

Ans-Various methods used for linear measurements may be grouped as:

(i) Approximate

(ii) Using chain or tape

(iii) By optical means and

(iv) Using electromagnetic distance measurement instruments.

Q.- What are the Approximates Methods of Linear Measurements?

Ans-These methods are used in reconnaissance survey or to detect major mistakes committed while measuring with better methods. On smooth roads they can give results within 1 per cent error. These approximate

measurements may be by:

(i) pacing

(ii) using passometer

(iii) using pedometer

(iv) using odometer or by

(v) using speedometer.

(i) Pacing: In this method surveyor walks along the line to be measured and counts the number of steps. Then the distance measured is equal to number of steps × average length of a step.

Average length of a step can be found by walking along a known length. A normal man takes a step of length 0.75 m to 0.8 m.

(ii) Using Passometer: A passometer is a watch-like instrument which is carried vertically in the pocket of shirt or tied to a leg. It records number of steps taken. Thus the problem of counting number of steps is eliminated in this approximate method of linear measurement.

(iii) Using Pedometer: This instrument is similar to passometer but it can record the distance instead of number of steps. In this, zero setting and setting of step length is made before walking.

(iv) Odometer: This instrument is attached to the wheel of a cycle or other vehicle. It records the number of revolutions made by the wheel. Knowing the circumference of the wheel, the distance travelled may be found.

(v) Speedometer: Odometer calibrated to give distance directly is called speedometer. This is to be used for particular vehicle only. All automobiles are provided with speedometers. By running the vehicle along the line to be measured distance can be found.

Q.- Describe Chain.

Ans-Measurement of distances using chain or tape is termed as chaining. This is the accurate and commonly employed method in surveying.

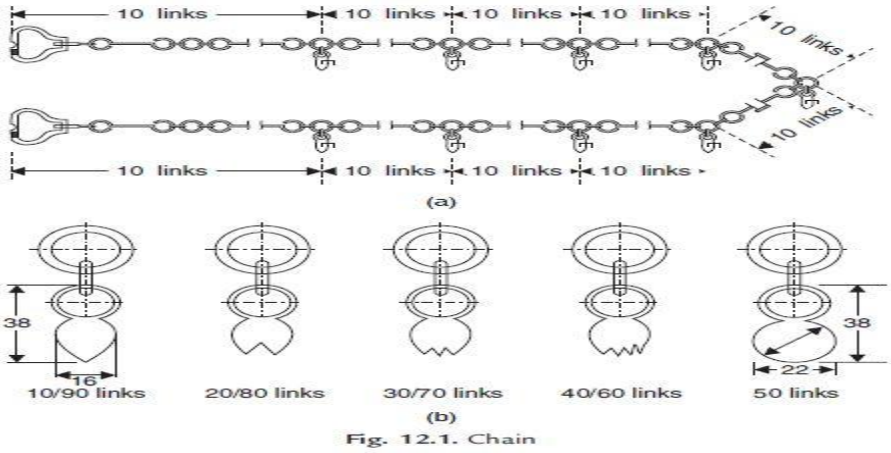


Fig. 12.1. Chain

(i) Chains: The chains are composed of 100 pieces of 4 mm diameter galvanised mild steel wires bent into rings at the end and joined to each other by three circular or oval shaped rings. These rings give flexibility to the chain. The ends of chains are provided with swivel joints so that the chain can be turned without twisting. To facilitate easy reading of the chain, brass tallies are provided. End of 10th link from each end is provided with a talley of one tooth, 20th link is provided with a talley of two teeth; 30th link with a talley of three teeth; 40th link with a talley of 4 teeth and themiddle of chain is provided with a talley of circular shape It is to be noted that

(i) length of a link is the distance between centres of two consecutive middle rings.

(ii) the length of the chain is from outside of one handle to the outside of the other handle.

Commonly used metric chains are of 20 m length. They have 100 links with talleys at every 2 m. Each link is of 0.2 m length. Simple rings are provided at every one metre length except wherever tallies are provided. The total length of chain is marked on the brass handle.

Steel Band: It is also known as band chain. It consists of steel of 12 to 16 mm width and 0.3 to0.6 mm thickness. The steel ribbon is wound around an open steel

cross or in a metal reel .Metric steel bands are available in lengths of 20 m and 30 m. Any one of the following two methods of markings are used:

(i) Providing brass studs at every 0.2 m and numbering at every metre. Last links from either end are subdivided in cm and mm.

(ii) Etching graduations as meters, decimeters and centimeters on one side of the band and 0.2 m links on the other side.

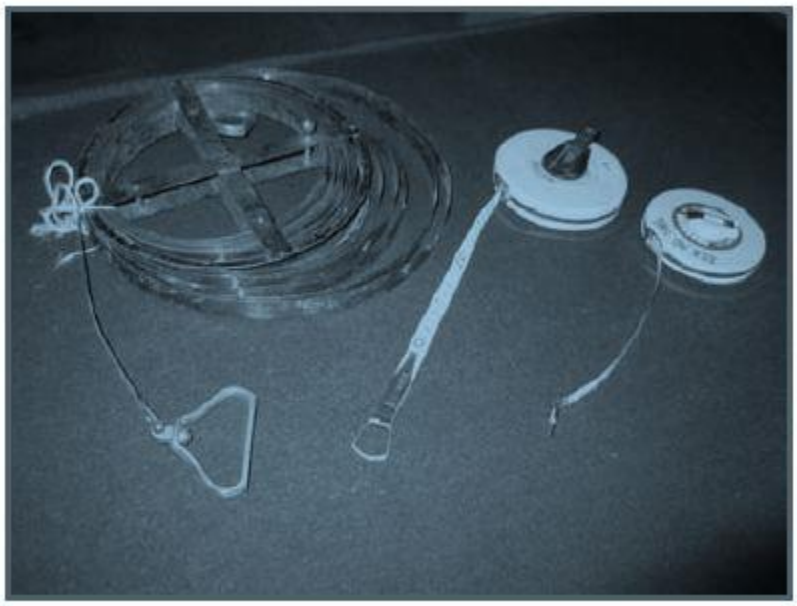


Plate 12.1

Q. Describe various type of Tapes used in Linear measurements.

Ans-Tapes: Depending upon the materials used, they are classified as:

(i) cloth or linen tape

(ii) metallic tape

(iii) steel tape and

(iv) invar tape

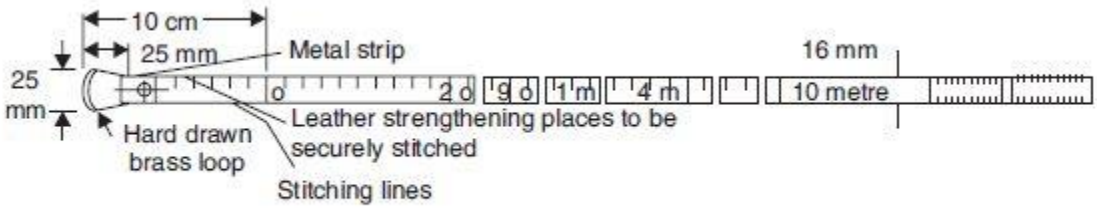


Fig. 12.2. Metallic tape

(i) Cloth or Linen Tape: 12 to 15 mm wide cloth or linen is varnished and graduations are marked. They are provided with brass handle at the ends. They are available in length of 10 m, 20 m,25 m and 30 m. These tapes are light and flexible. However because of the following disadvantages they are not popular:

(i) Due to moisture they shrink.

(ii) Due to stretching they extend.

(iii) They are not strong.

(iv) They are likely to twist.

(ii) Metallic Tape: They are made up of varnished strip of waterproof linen interwoven with small wires of brass, copper or bronze. End 100 mm length of tapes are provided with leather or suitable strong plastic materials. Tapes of length 10 m, 20 m, 30 m and 50 m are available in a case of leather or corrosion resistant metal fitted with a winding device. Red and black coloured markings are used for indicating full metres and its fractions in centimetres. These tapes are light, flexible and not easily broken. These tapes are commonly used in surveying.

(iii) Steel Tape: A steel tape consists of 6 to 10 mm wide strip with metal ring at free end and wound in a leather or corrosion resistant metal case. It is provided with a suitable winding device. Tapesare marked indicating 5 mm, centimetres, decimetres and metres. The end 10 cm length is marked with millimetres also. 10 m, 20 m, 30 m, or 50 m tapes are used in surveying Steel tapes are superior to metallic tapes as far as accuracy is concerned.

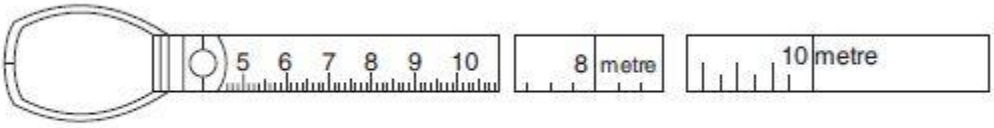


Fig. 12.3. Steel tape

However they are delicate. Care should be taken to wipe clean before winding. They should be oiled regularly to prevent corrosion.

(iv) Invar Tape: Invar is an alloy of nickel (36%) and steel. It's coefficient of thermal expansion is low. Hence errors due to variation in temperature do not affect measurements much. The width of tape is 6 mm. It is available in length 30 m, 50 m and 100 m. It is accurate but expensive.

Q.- Give various instruments used in Chaining.

Ans-The following instruments are required for measurements with chain and tape:

(i) Arrows (ii) Pegs

(iii) Ranging rods and ranging poles (iv) Offset rods

(v) Laths(vi) Whites

(vii) Plumb bobs and (viii) Line ranger.

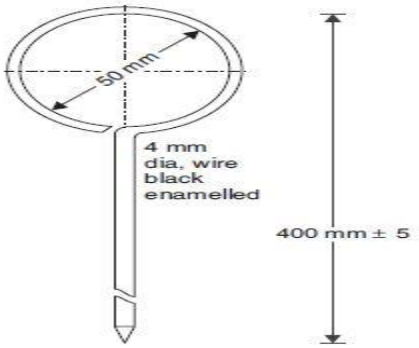


Fig. 12.5. Arrows

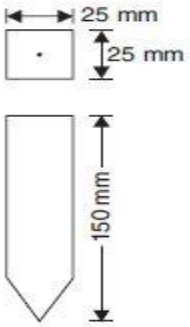


Fig. 12.6. Pegs

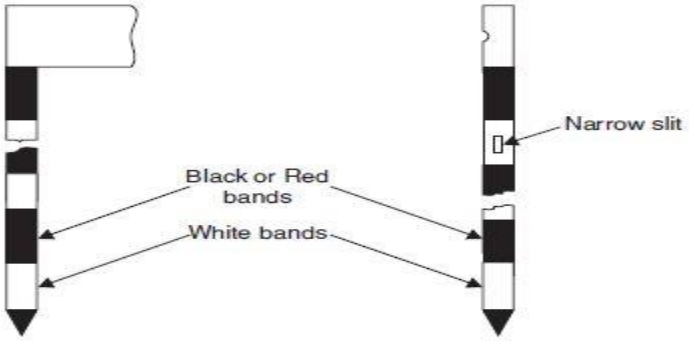


Fig. 12.7 Ranging rod

Fig. 12.8. Offset rod

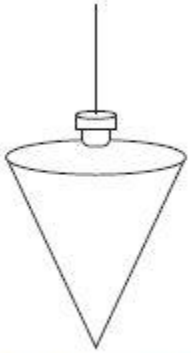


Fig. 12.9. Plumb bob

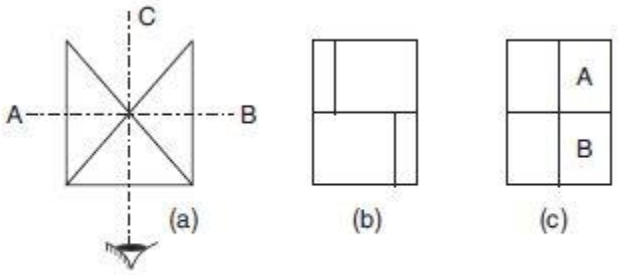


Fig. 12.10. Line ranger

Q.In which areas CHAIN SURVEYING is suitable?

Chain survey is suitable in the following cases:

(i) Area to be surveyed is comparatively small

(ii) Ground is fairly level

(iii) Area is open and

(iv) Details to be filled up are simple and less.

Q.- Describe the principle of chain Surveying.

Ans- The principle of Chain Surveying is Triangulation. In chain surveying only linear measurements are made i.e. no angular measurements are made. Since triangle is the only figure that can be plotted with measurement of sides only, in chain surveying the area to be surveyed should be covered with a network of triangles. No angle of the network triangles should be less than 30º to precisely get plotted position of a station with respect to already plotted positions of other station. As far as possible angles should be close to 60º. However, the arrangements of triangles to be adopted depends on the shape, topography, natural and artificial obstacles in the field.

Q. Give various Technical Terms used in Chain Surveying.

Ans-Various technical terms used in connection with the network of the triangles in surveying are explained below:

Station: Station is a point of importance at the beginning or at the end of a survey line.

Main station: These are the stations at the beginning or at the end of lines forming main skeleton. They are denoted as A, B, C etc.

Subsidiary or tie stations: These are the stations selected on main lines to run auxiliary/secondary lines for the purpose of locating interior details. These stations are denoted as a, b, c, ..., etc., or as 1, 2,3, ... etc.

Base line: It is the most important line and is the longest. Usually it is the line plotted first and then frame work of triangles are built on it.

Detail lines: If the important objects are far away from the main lines, the offsets are too long,resulting into inaccuracies and taking more time for the measurements. In such cases the secondarylines are run by selecting secondary stations on main lines. Such lines are called detail lines.

Check lines: These are the lines connecting main station and a substation on opposite side or thelines connecting to substations on the sides of main lines. The purpose of measuring such lines is tocheck the accuracy with which main stations are located.

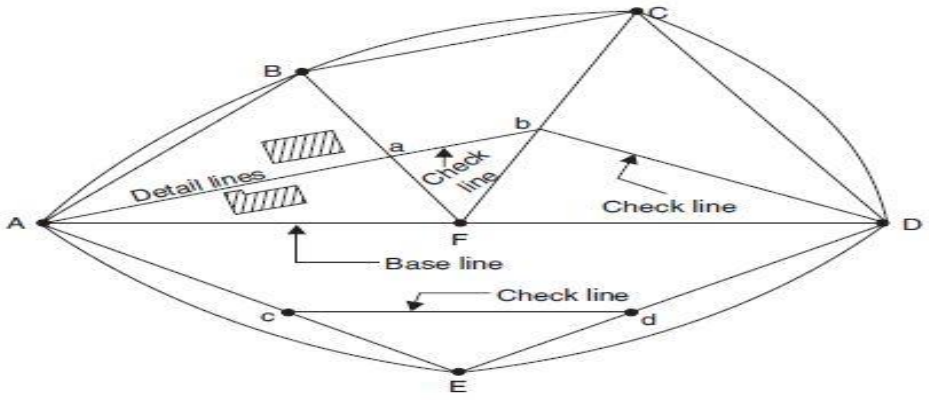


Fig. 12.11. Network of triangles

Q. How the Stations are selected?

Ans-The following points should be considered in selecting station points:

(i) It should be visible from at least two or more stations.

(ii) As far as possible main lines should run on level ground.

(iii) All triangles should be well conditioned (No angle less than 30º).

(iv) Main network should have as few lines as possible.

(v) Each main triangle should have at least one check line.

(vi) Obstacles to ranging and chaining should be avoided.

(vii) Sides of the larger triangles should pass as close to boundary lines as possible.

(viii) Trespassing and frequent crossing of the roads should be avoided.

Q.- What are Offsets?

Lateral measurements to chain lines for locating ground features are known as offsets. For this purpose perpendicular or oblique offsets may be taken. If the object to be located (say road) is curved more number of offsets should be taken. For measuring offsets tapes are commonly used. There are 2 types of offsets-

1-Oblique offsets

2-Perpendicularoffsets

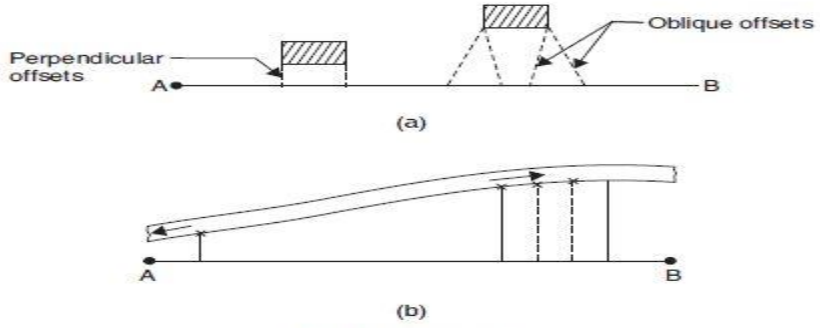


Fig. 12.12. Offsets

Q.- Describe methods for setting perpendicular offsets.

For setting perpendicular offsets any one of the following methods are used:

(i) Swinging

(ii) Using cross staffs

(iii) Using optical or prism square.

Perpendicular Offset by Swinging

Chain is stretched along the survey line. An assistant holds the end of tape on the object. Surveyors wings the tape on chain line and selects the point on chain where offset distance is the least and notes chain reading as well as offset reading in a field book on a neat sketch of the object.

Perpendicular Offsets Using Cross Staffs

All cross staffs are having two perpendicular lines of sights. The cross staffs are mounted on stand. First line of sight is set along the chain line and without disturbing setting right angle line of sight is checked to locate the object. With open cross staff it is possible to set perpendicular only, while with french cross staff even 45º angle can be set. Adjustable cross staff can be used to set any angle also, since there are graduations and upper drum can be rotated over lower drum.

Perpendicular Offsets Using Optical Square and Prism Square

These instruments are based on the optical principle that if two mirrors are at angle 'θ' to each other, they reflect a ray at angle '2θ'. Optical Square consists of a metal box about 50 mm in diameter and 125 mm deep. In the rim of the box there are three openings:

(i) a pin hole at E

(ii) a small rectangular slot at G, and

(iii) a large rectangular slot at F.

A and B are the two mirrors placed at 45º to each other. Hence the image of an object at F which falls on A gets reflected and emerges at E which is at right angles to the line FA. The mirror A which is opposite to the opening at F is fully silvered. It is fitted to a frame which is attached to the bottom plate.

If necessary this mirror can be adjusted by inserting a key on the top of the cover. The mirror B which is in the line with EG is silvered in the top half and plain in the bottom half. It is firmly attached to the bottom plate of the box. The ranging rod at

Q is directly sighted by eye at E in the bottom half of the B which is a plain glass. At the same time in the top half of B, the reflected ray of the object at P is sighted. When the image of P is in the same vertical line as the object at Q, then the lines PA is at right angles to the line EB. This instrument can be used for finding foot of the perpendicular or to set a right angle.

In prism square, instead of two mirrors at 45º to each other a prism which has two faces at 45º toeach other is used. Its advantage is it will not go out of adjustment even after long usage.

Q. Describe Field Book used in Surveying.

Ans-All observations and measurements taken during chain surveying are to be recorded in a standard field book. It is a oblong book of size 200 mm × 120 mm, which can be carried in the pocket.
There are two forms of the book (i) single line and (ii) double line. The pages of a single book are having a red line along the length of the paper in the middle of the width. It indicates the chain line.
All chainages are written across it. The space on either side of the line is used for sketching the object and for noting offset distances. In double line book there are two blue lines with a space of 15 to 20 mm is the middle of each book. The space between the two lines is utilised for noting the chainages. Figure 12.17 shows typical pages of a field books.

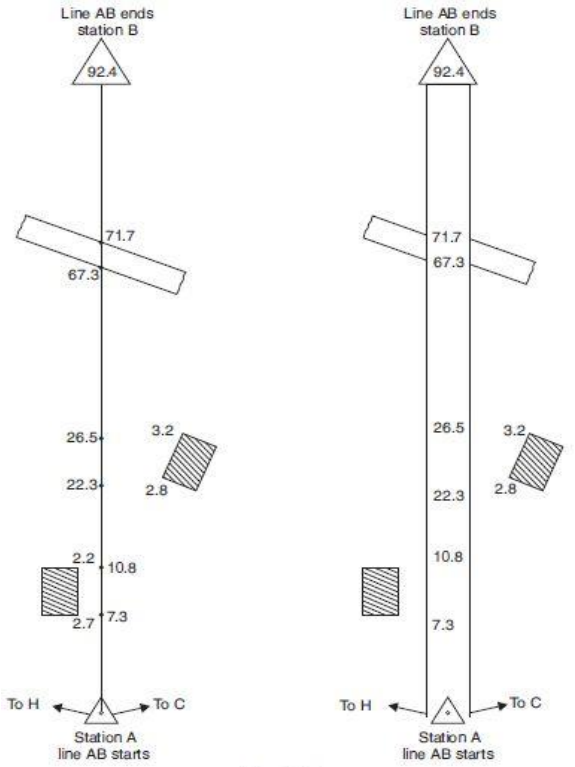


Fig. 12.17

Q.-What are the details entered in the field book?

Ans- As soon as the survey party arrives in the field the following details are entered in the field book:
(i) Title of the survey work
(ii) The date of survey
(iii) The names of the members of the party.
The field work may be divided into the following:
(i) Reconnaissance survey.
(ii) Marking stations, drawing reference sketches.
(iii) Line by line surveying.

Q.What is Ranging of a line.

When a survey line is longer than a chain length, it is necessary to align intermediate points on chain line so that the measurements are along the line. The process of locating intermediate points on survey line is known as ranging. There are two methods of ranging viz., direct ranging and reciprocal ranging.

Q. Describe methods of Ranging?

Ans-Direct Ranging

There are two methods of ranging viz., direct ranging and reciprocal ranging. If the first and last points are inter visible this method is possible. Figure 12.18 shows the intervisible stations A and B in which an intermediate point C is to be located. Point C is selected at a distance slightly less than a chain length. At points A and B ranging rods are fixed. The assistant holds another ranging rod near C. Surveyor positions himself approximately 2 m behind station A and looking along line AB directs the assistant to move at right angles to the line AB till he aligns the ranging rod along AB. Then surveyor instructs the assistant to mark that point and stretch the chain along AC.

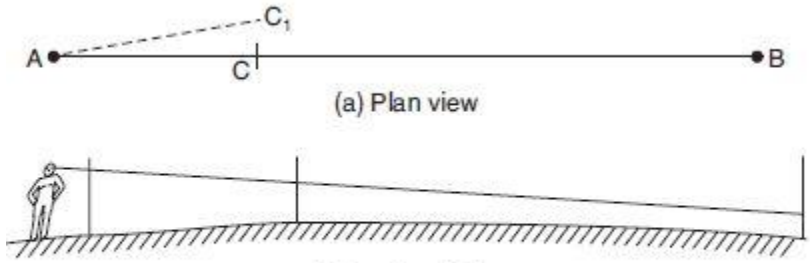


Fig. 12.18. Direct ranging

Indirect or Reciprocal Levelling

Due to intervening ground, if the ranging rod at B is not visible from station A, reciprocal ranging may be resorted. Figure 12.19 shows this scheme of ranging. It needs two assistants one at point M and another at point N, where from those points both station A and station B are visible. It needs one surveyor at A and another at B. To start with M and N are approximately selected, say M1 and N1. Then surveyor near end A ranges person near M to position M2 such that AM2N1 are in a line. Then surveyor at B directs person at N, to move to N2 such that BN2M2 are in a line. The process is repeated till AMNB are in a line.

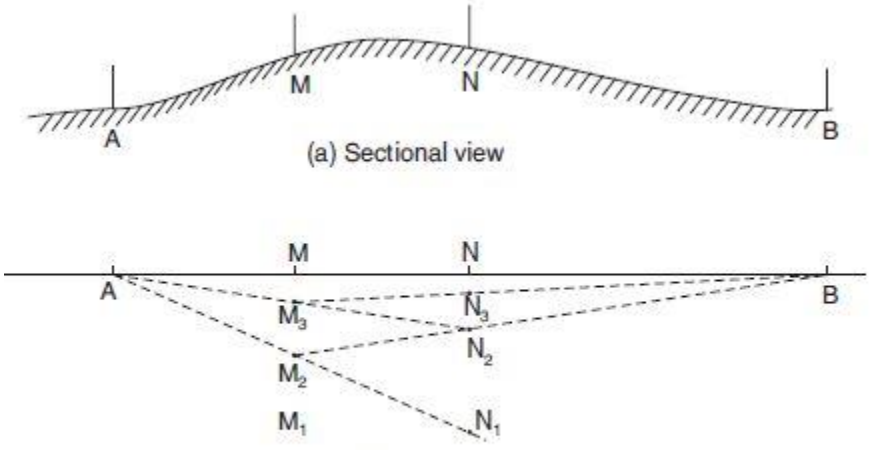


Fig. 12.19. Reciprocal ranging

Q. What are various Obstacles to Chaining?

Various obstacles to chaining may be grouped into:
(i) Obstacles to ranging (chaining free-vision obstructed)
(ii) Obstacles to chaining (chaining obstructed-vision free)
(iii) Obstacles to both ranging and chaining.

Q. Describe various methods of overcoming these Obstacles?

Various methods of overcoming these obstacles are explained is this article.

Obstacles to Ranging

These obstacles can be further classified into the following categories:
(a) Both ends of the line are visible from some intermediate points. Intervening ground is an example of such obstacle. By resorting to reciprocal ranging this difficulty can be overcome.
(b) Both ends of the line may not be visible from intermediate points on the line, but may be visible from a point slightly away from the line. Intervening trees and bushes are the examples of such obstacles. This obstacle to chaining may be overcome by measuring along a random line as shown in Fig. 12.20. In this case required length

$$EB = \sqrt{EC^2 + CB^2}$$

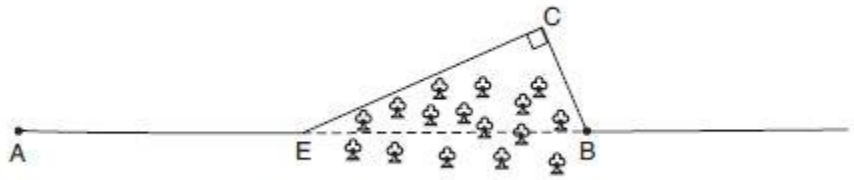


Fig. 12.20. Obstacle to ranging

Obstacles to Chaining

In this type the ends of lines are visible but chaining is obstructed. Examples of such obstructions are ponds, lakes, marshy land etc. Various geometric properties may be used to find obstructed length CB.

Obstacles to Both Chaining and Ranging

Building is a typical example of this obstacle. Referring to Fig. 12.22, line AB is to be continued beyond the obstacle, say as GH. Four possible methods are presented below:

(a) Set perpendiculars AC, BD such that AC = BD [Fig. 12.22 (a)]. Extend line CD to F. Drop perpendiculars EG and FH to line CF such that EG = FH = AC. GH is the continuation of line AB and DE = BG.

(b) Referring to Fig. 12.22 (b), set BC ⊥ to AB. Select D on extended line of AC. Set perpendicular DH such that AD = DH. Select point E on DH such that DE = DC. Then arcs of length EG = BC and arc of length HG = AB are drawn from E and H respectively and G is located. GH is continuation of AB and BG = CE. (c) Referring to Fig. 12.22 (c), C is located such that AC = BC = AB. Extend AC to D and construct equilateral triangle DEF. Extend DF to H such that DH = DA. Locate convenient point I on HD and construct equilateral triangle to locate G. Then GH is the continuation of line AB and length BG

is given by

BG = AH – AB – GH = AD – AB – GH

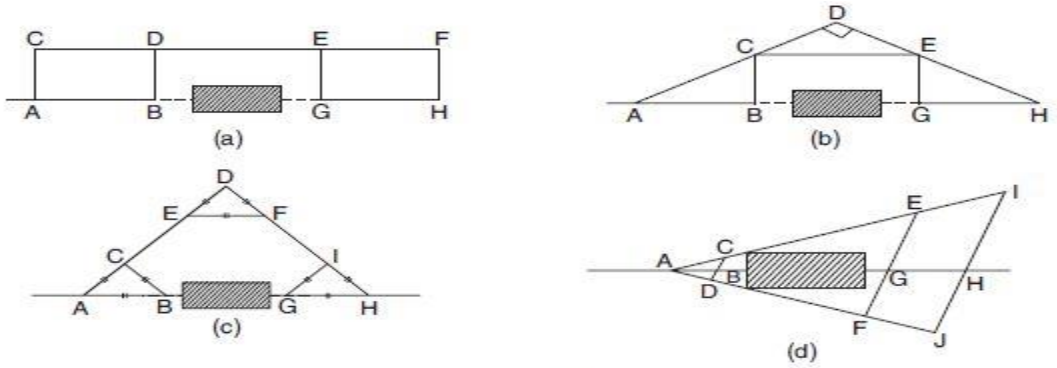


Fig. 12.22. Obstacles to both ranging and chaining

Q. Describe various errors in Chaining?

Errors in chaining may be classified as:
(i) Personal errors
(ii) Compensating errors, and
(iii) Cumulating errors.

Personal Errors

Wrong reading, wrong recording, reading from wrong end of chain etc., are personal errors. These errors are serious errors and cannot be detected easily. Care should be taken to avoid such errors.

Compensating Errors

These errors may be sometimes positive and sometimes negative. Hence they are likely to get compensated when large number of readings are taken. The magnitude of such errors can be estimated by theory of probability. The following are the examples of such errors:
(i) Incorrect marking of the end of a chain.
(ii) Fractional part of chain may not be correct though total length is corrected.
(iii) Graduations in tape may not be exactly same throughout.
(iv) In the method of stepping while measuring sloping ground, plumbing may be crude.

Cumulative Errors

The errors, that occur always in the same direction are called cumulative errors. In each reading the error may be small, but when large number of measurements are made they may be considerable, since the error is always on one side. Examples of such errors are:

(i) Bad ranging
(ii) Bad straightening
(iii) Erroneous length of chain
(iv) Temperature variation
(v) Variation in applied pull
(vi) Non-horizontality
(vii) Sag in the chain, if suspended for measuring horizontal distance on a sloping ground.

Errors (i), (ii), (vi) and (vii) are always +ve since they make measured length more than actual.

Errors (iii), (iv) and (v) may be +ve or –ve.

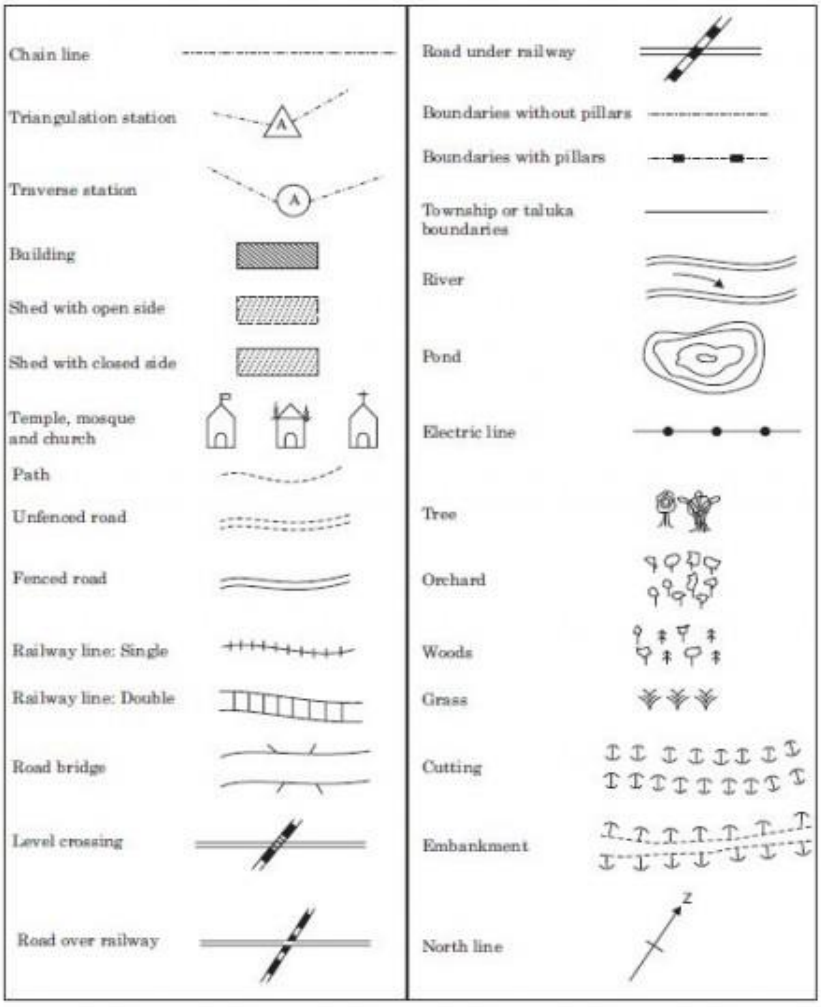
Q.- What are corrections that may be found for the measured lengths of tape:

Ans.-(i) Corrections for absolute length
(ii) Corrections for pull
(iii) Corrections for temperature
(iv) Corrections for slope and
(v) Corrections for sag

Q.Specify different symbols used in Surveying?

Ans.- IS 962—1989, 'code of practice for architectural and building drawings' has specified standard symbols for various objects as shown in Table. If coloured plans are to be made, the code recommends light washes of the following shades:

For roads – Burnt sienna
For buildings – Light grey
For compound walls – Indigo
For water – Borders edged with Prussian blue
For trees – Green.



Q. What are the disadvantages of Chain Surveying?

Ans-Disadvantage of chain surveying is that, in it only distances are measured and hence area is to becovered with a network of triangles. If the length as well as angle of a line can be measured with respectto a known direction then it is possible to plot a line, independent of length of other lines. Hence, in suchcases there is no compulsion of going for a network of triangles only.

COMPASS SURVEY

Q. What is Compass Surveying?

Ans- . Compass is an instrument which can be used to measure the direction of a survey line with respect to magnetic north-south. The magnetic north-south direction which is the reference direction is called meridian (reference direction) and the angle between the line and the meridian is called bearing. Use of compass for measuring direction of a line simplifies the surveying to a great extent.

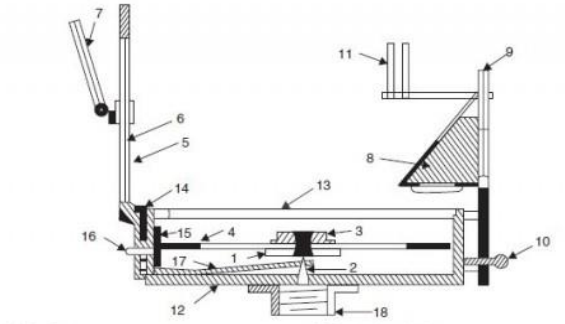
Q.- Mention different types of Compass.
Ans-The types of compass that are used commonly are:
(i) Prismatic compass; and
(ii) Surveyor compass.

Q.- Describe Prismatic Compass.

Ans-**Prismatic Compass**

Figure shows the cross-section of a typical prismatic compass

A magnetic needle of broad form (1) is balanced on a hard and pointed steel pivot (2). The top of the pointed pivot is protected with agate cap (3).



1. Needle
2. Pivot
3. Agate cap
4. Graduated disc
5. Slit metal frame
6. Horse hair
7. Mirror
8. Reflecting prism with cap
9. Eye vane
10. Focussing stud
11. Dark sunglasses
12. Box
13. Glass cover
14. Lifting pin
15. Light spring
16. Brake pin or knob
17. Lifting lever
18. Support to fit on tripod

Fig. 13.1. Prismatic compass

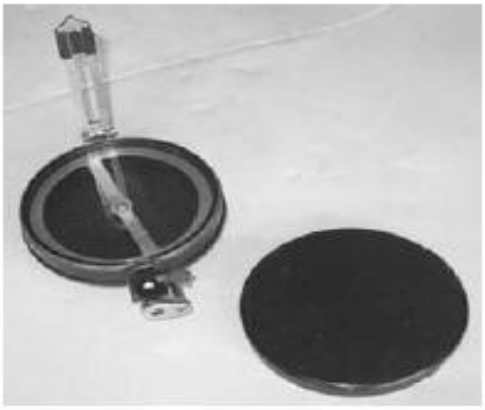


Plate 13.1 Prismatic compass

An aluminium graduated disk (4) is fixed to the top of the needle. The graduations are from zero to 360° in clockwise direction when read from top. The direction of north is treated as zero degrees, east as 90°, south as 180° and west as 270°. However, while taking the readings observations are at the other end of line of sight. Hence, the readings are shifted by 180° and graduations are marked as shown in Fig. 13.2. The graduations are marked inverted because they are read through a prism.

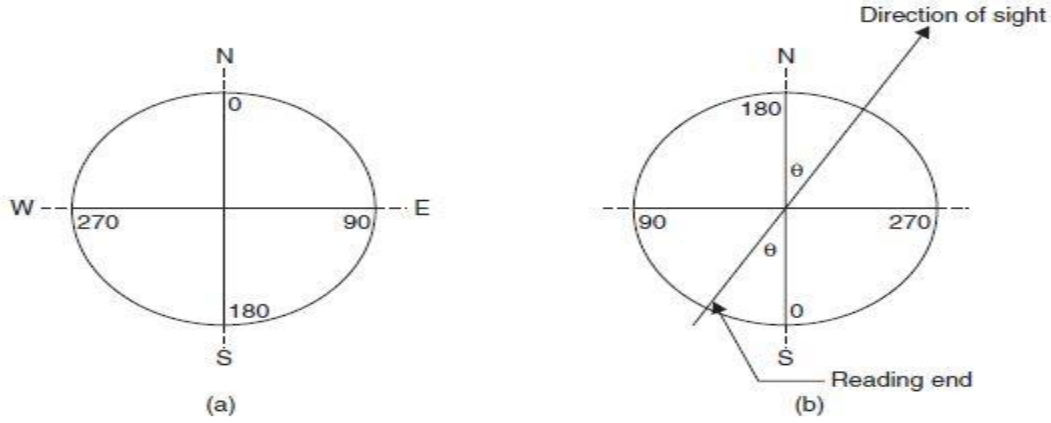


Fig. 13.2

The line of sight consists of object unit and the reading unit. Object unit consists of a slit metal
frame (5) hinged to the box. In the centre the slit is provided with a horse hair or a fine wire or thread
(6). The metal frame is provided with a hinged mirror (7), which can be placed upward or downward on
the frame. It can be slided along the frame. The mirror can be adjusted to view objects too high or too
low from the position of compass. Reading unit is provided at diametrically opposite edge. It consists of a prism (8) with a sighting eye vane (9). The prism magnifies the readings on the graduation disk just
below it. For focusing, the prism is lowered or raised on the frame carrying it and then fixed with the stud (10). Dark sunglasses (11) provided near the line of sight can be interposed if the object to be sighted is bright (e.g., sun).
The bottom of the box (12) which is about 85 mm to 110 mm supports the pivot of needle firmly at its centre. The object vane and the prism are supported on the sides of the box. The box is provided with a glass (13) lid which protects the graduation disc at the same time permit the direct reading from the top. When the object vane is folded on the glass top it presses a lifting pin (14) which activates lifting lever (15) lifts the needle off the pivot. Thus, it prevents undue wear of pivot point. While taking reading, if graduation disc vibrates, it can be dampened with a spring (16). For pressing spring a knobor brake pin (17) is provided on the box. When not in use prism can be folded over the edge of the box. The box is provided with a lid to close it when the compass is not in use. The box is provided with a socket to fit it on the top of a tripod.

Q.- Describe Surveyors Compass.

Surveyors Compass

In this type of compass graduation disc is fixed to the box and magnetic needle is free to rotate above it.

There is no prism provided at viewing end, but has a narrow slit. After fixing the line of sight, the reading is directly taken from the top of the glass cover. Hence, graduations are written directly (not inverted). In this compass graduations are from zero to 90°, zero being to north or south and 90° being to east and west. An angle of 20° to north direction to the east is written as N 20° E, and an angle of 40° to east from south is written as S 40° E. Always first direction indicated is north or south and the last letter indicates east or west direction. In this system graduated circle rotates with line of sight and magnetic needle is always towards north. The reading is taken at the tip of needle. Hence, on the compass east and west are marked interchanged and marked shows the photograph of a surveyors compass.

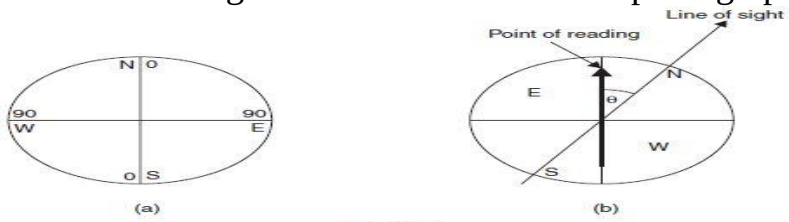


Fig. 13.3

Plate 13.2 Surveyor's compass

Q.-Differentiate between Prismatic Compass and Surveyors Compass

The difference between prismatic and surveyor's compass are listed in Table

Sr. No.	*Prismatic Compass*	*Surveyors Compass*
1.	Graduation circle is fixed to broad type needle. Hence, it will not rotate with the line of sight.	Graduation circle is fixed to the box. Hence, it rotates with the line of sight.
2.	There is a prism at viewing end.	At viewing end there is no prism. There is only a slit.
3.	Sighting and reading can be done simultaneously.	Sighting and viewing cannot be done simultaneously.
4.	The magnetic needle do not act as an index.	Magnetic needle acts as index while reading.
5.	The graduations are in whole circle bearing.	The graduations are in quadrantal system.
6.	Graduations are marked inverted since its reflection is read through prism.	Graduations are marked directly. They are not inverted.
7.	The reading is taken through a prism.	The reading is taken by directly viewing from top glass.
8.	Tripod may or may not be used. It can be held on a stretched hand also.	Tripod is essential for using it.

Q. Describe temporary adjustments of Compass?

To take a reading from a compass, the following temporary adjustments are required:

(i) Centring: The compass should be fixed to the stand and set over the station. To centre the compass legs of the tripod stand should be moved inward-outward or in a circumferential direction. To check centring plumb may be used or a pebble dropped from the centre of the compass.

(ii) Levelling: In compass survey perfect levelling is not necessary, but it should be sufficient to permit free suspension of magnetic needle. For checking levelling a bubble level is provided in many compasses. After centring bubble should be ensured in the middle of the circle provided for it in the level. If it is not within that circle, circumferential movements may be provided to the legs of tripod so that without disturbing centring the levelling is achieved.

(iii) Focussing the prism: In prismatic compass, to focus the prism on graduated

circle, its attachment is slided up or down till the readings are clearly visible. There is no such requirement in surveyors compass.

Q.- Mention steps that are required for observing bearing of a line,

The following steps are required for observing bearing of a line, say, AB:
(i) Centre the compass over A.
(ii) Level the compass.
(iii) Focus the prism, if prismatic compass is used.
(iv) Rotate the box till ranging rod at B is sighted through the line of sight.
(v) Bring the needle to rest using knob.
(vi) Take the reading and note it in the field book.
Care should be taken to see that the line of sight is not disturbed between the line of sighting the object and the time of reading the bearing.

Q.Describe Bearing of a Line?

Bearing of a line is the horizontal angle made by the line with respect to a reference direction, the reference direction being known as **meridian**.

Q.Describe Magnetic meridian, True meridian, Magnetic bearing and True bearing?

Ans-The direction shown by a freely suspended and properly balanced magnetic needle is called **magnetic meridian** and the horizontal angle made by a line with this meridian is known as **magnetic bearing**.
The points of intersection of earth's axis with surface of the earth are known as geographic north and south pole. The line passing through geographic north, south and the point on earth is called **true meridian** at that point and the angle made by a line passing through that point is called **true bearing**.

Q.Describe Fore bearing and Back bearing?

Ans-While traversing along lines A, B, C, D …, the bearing of lime AB is called fore bearing of AB
and the bearing of BA is called back bearing. Fore bearing and back bearing differ by 180°.

Q.- Describe Whole Circle Bearing and Quadrant Bearing(QB) or Reduced Bearing(RB).

Ans-In whole circle bearing (WCB) the bearing of a line at any point is measured with respect to a meridian. Its value varies from zero to 360°, increasing in clockwise direction. Zero is north direction, 90° is east, 180° is south and 270° is west This type of bearing is used in prismatic compass.

In reduced bearing (RB) system, bearings are measured from north or south direction towards east or west. Hence, angles are from 0 to 90° as shown in Fig. 13.3. This system of measuring bearings is used in Surveyor's compass and it is also known as Quadrantal Bearing (QB). The bearing measured is designated with letter N or S in the beginning to indicate whether it is from north or south. The letter E or W written after the angle indicates whether the bearing read is towards east or west, respectively.
The conversion of the bearing from one system to the other system can be easily carried out by drawing a sketch to indicate WCB or RB as shown in Fig. 13.4. It may be observed that conversion table is as given below:

Quadrant in which bearing lies	*Conversion relation*
NE	$\alpha = \theta$
SE	$\alpha = 180° - \theta$
SW	$\alpha = \theta - 180°$
NW	$\alpha = 360° - \theta$

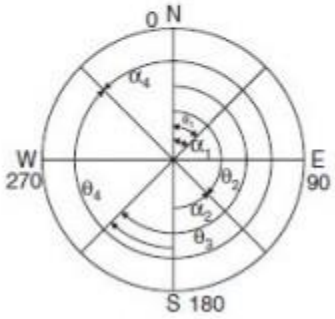


Fig. 13.4

Q.- Convert the following reduced bearings into whole circle bearings:

(i) N 65° E (ii) S 43° 15′ E

(iii) S 52° 30′ W (iv) N 32° 42′ W

Ans: Let 'θ' be whole circle bearing.

(i) Since it is in NE quadrant,

θ = α = 65° Ans.

(ii) Since it is in south east quadrant

43° 15′ = 180° – θ

or θ = 180° – 43° 15′ = 136° 45′ Ans.

(iii) Since it is in SW quadrant

52° 30′ = θ – 180°

or θ = 180° + 52° 30′ = 232° 30′

Q.-The following fore bearings were observed for lines, AB, BC, CD, DE, EF and FG respectively. Determine their back bearings:

(i) 148° (ii) 65°

(iii) 285° (iv) 215°

(v) N 36° W (vi) S 40° E

Solution: The difference between fore bearing and the back bearing of a line must be 180°. Noting that

in WCB angle is from 0° to 360°, we find back bearing = fore bearing ± 180°

+ 180° is used if θ is less than 180° and

– 180° is used when θ is more than 180°.

Hence

(i) BB of AB = 145° + 180° = 325°

(ii) BB of BC = 65° + 180° = 245°

(iii) BB of CD = 285° – 180° = 105°

(iv) BB of DE = 215° – 180° = 35°

In case of RB, back bearing of a line can be obtained by interchanging N and S at the same time

E and W. Thus

(v) BB of EF = S 36° E

(vi) BB of FG = N 40° W.

Q. What is Local Attraction?
Ans-However, local objects like electric wires and objects of steel attract magnetic needle towards themselves.
Thus, needle is forced to show slightly different direction. This disturbance is called local attraction.
The list of materials which cause local attraction are:
(i) magnetic rock or iron ore,
(ii) steel structures, iron poles, rails, electric poles and wires,
(iii) key bunch, knife, iron buttons, steel rimmed spectacles, and
(iv) chain, arrows, hammer, clearing axe etc.
Q.- How will you detect Local Attraction?

Ans-For detecting local attraction it is necessary to take both fore bearing and back bearing for each line. If the difference is exactly 180°, the two stations may be considered as not affected by local attraction. If difference is not 180°, better to go back to the previous station and check the fore bearing. If that reading is same as earlier, it may be concluded that there is local attraction at one or both stations.

Q.- Define Magnetic Declination?

Ans-The magnetic meridian and the true meridian may not coincide with each other in a place. The horizontal angle between these two meridians is known as magnetic declination. The magnetic north at a place may be towards east or west of true north. If it is towards east, it is known as eastern or +ve declination. Western declination is known as –ve declination. Eastern declination is to be added to observed magnetic bearings to get true meridian. To find magnetic declination at a point true meridian should be established from astronomical observations and magnetic meridian by a compass. Maps are made with respect to true meridian.

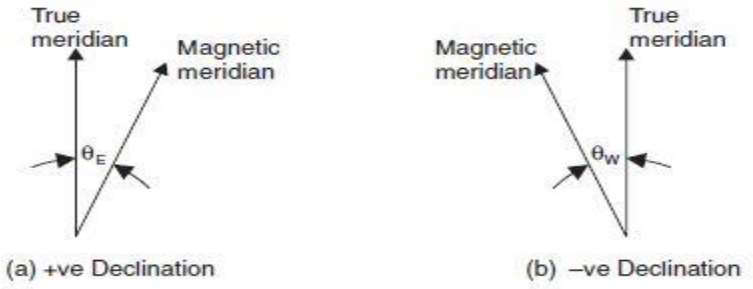


Fig. 13.7. Magnetic declination

Q.- Define Isogonic lines and Agonic Lines?

Ans-The lines joining the points at which declination is the same at the given time are called 'Isogonic Lines'. Lines joining points of zero declinations are called 'Agonic Lines'. The isogonic lines are quite irregular near geographic poles. The isogonic charts show lines of equal annual change in declination.

Q.- Define Magnetic Dip?

Ans-A perfectly balanced, freely suspended magnetic needle dips towards its northern end in northern hemisphere and towards its southern end in southern hemisphere. If it is at north pole, the needle takes vertical position. The vertical angle between the horizontal and the direction shown by a perfectly balanced and freely suspended needle is known as the magnetic dip at that place. Its value is 0° at equator and 90° at magnetic poles. To counteract the dip, a sliding rider (weight) is provided on the needle.

Q.- Mention instruments required for chain and compass survey?

Ans-The following are required for chain and compass survey:
(i) Compass and stand
(ii) Chain and tape
(iii) 10 arrows
(iv) 5 to 6 ranging rods
(v) Ranging poles
(vi) Pegs and hammer
(vii) Plumb bobs
(viii) Line ranger, cross staff etc.

Q.- Mention important points of Field Work.

Ans-Field work involves:
(i) reconnaissance survey
(ii) preparation of location sketches of stations
(iii) measurement of directions
(iv) measurement of lengths and offsets, and
(v) recording measurements.
(i) Reconnaissance Survey: The entire area to be surveyed is inspected to select survey stations.

PLANE TABLE SURVEY

Q. What are the accessories used in Plane Table Survey?

Ans-The following accessories are required to carry out plane table survey:
1. Alidade
2. Plumbing fork with plumb bob.
3. Spirit level
4. Trough compass
5. Drawing sheets and accessories for drawing.

Q.- Describe various instruments used in Plane Table Survey?

Ans- The most commonly used plane table is shown in Fig. It consists of a well seasoned wooden table top mounted on a tripod. The table top can rotate about vertical axis freely. Whenever necessary table can be clamped in the desired orientation. The table can be levelled by adjusting tripod legs.

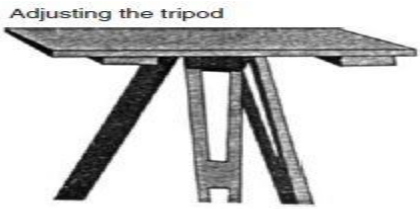


Fig. 14.1. Plane table with stand

Alidade

It is a straight edge ruler having some form of sighting device. One edge of the ruler is bevelled and is graduated. Always this edge is used for drawing line of sight. Depending on the type of line of sight
there are two types of alidade:
(a) Plain alidade (b) Telescopic alidade

Plain Alidade: Figure shows a typical plain adidate. A sight vane is provided at each end of the ruler. The vane with narrow slit serves as eye vane and the other with wide slit and having a thin wire at its centre serves as object vane. The two vanes are provided with hinges at the ends of ruler so that when not in use they can be folded on the ruler. Plain alidade is not suitable in surveying hilly areas as the inclination of line of sight in this case is limited.

Fig. 14.2. Plane alidade

Telescopic Alidade: It consists of a telescope mounted on a column fixed to theruler

The line of sight through the telescope is kept parallel to the bevelled edge of the ruler. The telescope is provided with a level tube and vertical graduation arc. If horizontal sight is required bubble in the level tube is kept at the centre. If inclined

sights are required vertical graduation helps in noting the inclination of the line of sight. By providing telescope the range and the accuracy of line of sight is increased.

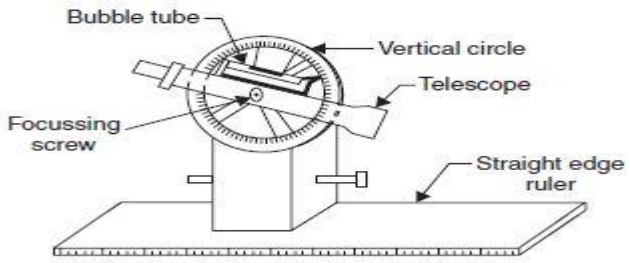


Fig. 14.3. Telescopic alidade

Plumbing Fork and Plumb Bob

Figure shows a typical plumbing fork with a plum bob. Plumbing fork is a U-shaped metal frame with a upper horizontal arm and a lower inclined arm. The upper arm is provided with a pointer at the end while the lower arm is provided with a hook to suspend plumb bob. When the plumbing fork is kept on the plane table the vertical line (line of plumb bob) passes through the pointed edge of upper arm. The plumb bob helps in transferring the ground point to the drawing sheet and vice versa also.

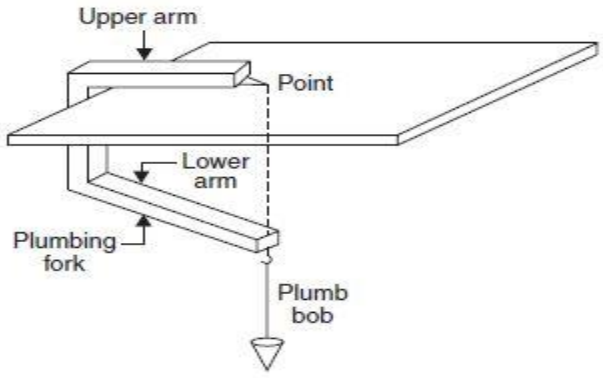


Fig. 14.4. Plumbing fork and plumb bob.

Spirit Level

A flat based spirit level is used to level the plane table during surveying (Fig.

14.5). To get perfect level, spirit level should show central position for bubble tube when checked with its positions in any two mutually perpendicular direction.

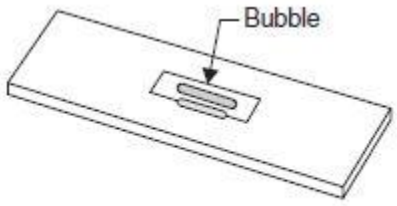


Fig. 14.5. Spirit level

Trough Compass

It consists of a 80 to 150 mm long and 30 mm wide box carrying a freely suspended needle at its centre (Ref. Fig. 14.6). At the ends of the needle graduations are marked on the box to indicate zero to five degrees on either side of the centre. The box is provided with glass top to prevent oscillation of the needle by wind. When needle is centred (reading 0–0), the line of needle is parallel to the edge of the box. Hence marking on the edges in this state indicates magnetic north–south direction.

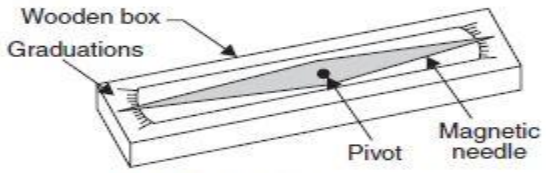


Fig. 14.6. Trough compass

Drawing Sheet and Accessories for Drawing

A good quality, seasoned drawing sheet should be used for plane table surveying. The drawing sheet may be rolled when not in use, but should never is folded. For important works fibre glass sheets or paper backed with thin aluminium sheets are used.

Clips clamps, adhesive tapes may be used for fixing drawing sheet to the plane

table. Sharp hard pencil, good quality eraser, pencil cutter and sand paper to keep pencil point sharp are other accessories required for the drawing work. If necessary, plastic sheet should be carried to cover the drawing sheet from rain and dust.

Q.Mention various operations to be carried out before starting Plane Table Survey?

Ans- After fixing the table top to the stand and drawing sheet to the table, the following operations are to be carried out before map making:
1.Centering
2.Levelling
3. Orientation.

Q. Describe method of orientation?

Ans-Orientation is the process of setting plane table over a station such that all the lines already plotted are parallel to corresponding lines on the ground. Accuracy of plane table survey mainly depends upon the accuracy of orientation of plane table at each station point. It can be achieved by any one of the following methods:
(a)using trough compass
(b) by back sighting
(c) by solving two point or three point problems.
The first two methods are commonly used while the third method is used occationally. The third method is explained under the article methods of plane tabling by resection.

(a) Orientation Using Trough Compass: When the survey work starts, the plane table is set on first station and the table is oriented by rough judgement such that the plotted position of the area falls in the middle portion of the paper. Then the table is clamped and the north direction is marked on right hand side top corner of

drawing sheet. Trough compass is used to identify north direction. This orientation is to be maintained at all subsequent stations. After centering and levelling the table trough compass is kept along the marked north direction and the table is rotated to get freely suspended magnetic needle centred. After achieving it the table is clamped.

This method of orientation is considered rough, since the local attraction to magnetic needle affects the orientation. This method is used as preliminary orientation and finer tuning is made by observing the already plotted points.

(b) Orientation by Back Sighting: It is the commonly used method in plane table surveying.

After completing surveying from plane table set at A, if table is to be shifted to next station B, a line is drawn from the plotted position of station A towards station B. Then distance AB is measured scaled down and plotted position of station B is obtained. Then table is shifted to station B, centred, levelled. Then keeping alidade along BA, station A is sighted and the table is clamped. Thus the orientation of the table is achieved by back sighting. Orientation may be checked by observing already plotted objects.

Q. Describe the METHODS OF PLANE TABLING

Ans-The following four methods are available for carrying out plane table survey:

1. Radiation

2. Intersection

3. Traversing

4. Resection.

The first two methods are employed for locating details while the other two methods are used forlocating position of plane table station on drawing sheet.

Q. What are the ERRORS IN PLANE TABLE SURVEYING?

Ans-The errors may be grouped into the instrumental and personal errors.

Instrumental Errors

1. The surface of plane table not perfectly plane.
2. Bevelled edge of alidade not straight.
3. Sight vanes of alidade not perfectly perpendicular to the base.
4. Plane table clamp being loose.
5. Magnetic compass being sluggish.
6. Drawing sheet being of poor quality.

Personal Errors

1. Centering errors
2. Levelling errors
3. Orientation errors
4. Sighting errors
5. Errors in measurement
6. Plotting errors
7. Errors due to instability of tripod.

Q. What are the ADVANTAGES AND LIMITATIONS OF PLANE TABLE SURVEY?

Ans-Advantages are

1. Possibility of omitting measurement is eliminated.

2. The surveyor can compare the plotted work in the field then and there only.

3. Irregular objects are plotted more accurately, since they are seen while plotting.

4. Booking errors are eliminated.

5. Local attractions do not influence the plotting.

6. No great skill is required to produce satisfactory maps.

7. Method is fast.

8. No costly instruments are required.

Limitations are

1. Survey cannot be conducted in wet weather and rainy days.

2. Plane table is cumbersome and heavy to carry.

3. It needs many accessories.

4. It is less accurate.

5. Reproduction of map to different scale is difficult.

Level and Levelling

Q. Define Levelling?

Ans-Elevation measurements involve measurements in vertical plane. It is also known as levelling. It may

be defined as the art of determining the elevations of given points above or below a datum line or

establishing given points of required heights above or below the datum line.

Q. Describe OBJECT AND USES OF LEVELLING.

Ans-The the object of leveling is-

(i) to determine the elevations of given points with respect to a datum

(ii) to establish the points of required height above or below the datum line.

Uses of levelling are

(i) to determine or to set the plinth level of a building.

(ii) to decide or set the road, railway, canal or sewage line alignment.

(iii) to determine or to set various levels of dams, towers, etc.

(iv) to determine the capacity of a reservoir.

Q. Describe various terms used in Levelling.

Ans-Before studying the art of levelling, it is necessary to clearly understand the following terms used in levelling:

1. **Level Surface**: A surface parallel to the mean spheroid of the earth is called a level surface and the line drawn on the level surface is known as a level line.

Hence all points lying on a level surface are equidistant from the centre of the earth surface.

2. Horizontal Surface: A surface tangential to level surface at a given point is called horizontal surface at that point. Hence a horizontal line is at right angles to the plumb line at that point

3. Vertical Line: A vertical line at a point is the line connecting the point to the centre of the earth. It is the plumb line at that point. Vertical and horizontal lines at a point are at right angles to each other .

4. Datum: The level of a point or the surface with respect to which levels of other points or planes are calculated, is called a datum or datum surface.

5**. Mean Sea Level (MSL):** MSL is the average height of the sea for all stages of the tides. At any particular place MSL is established by finding the mean sea level (free of tides) after averaging tide heights over a long period of at least 19 years. In India MSL used is that established at Karachi, presently, in Pakistan. In all important surveys this is used as datum.

6. Reduced Levels (RL): The level of a point taken as height above the datum surface is known as RL of that point.

7. Benchmarks: A benchmark is a relatively permanent reference point, the elevation of which is known. It is used as a starting point for levelling or as a

point upon which to close for a check. The following are the different types of benchmarks used in surveying:

(a) GTS benchmarks (b) Permanent benchmarks

(c) Arbitrary benchmarks and (d) Temporary benchmarks.

(a) GTS Benchmark: The long form of GTS benchmark is Great Trigonometrical Survey benchmark. These benchmarks are established by national agency. In India, the department of Survey of India is entrusted with such works. GTS benchmarks

are established all over the country with highest precision survey, the datum being mean sea level. A bronze plate provided on the top of a concrete pedastal with elevation engraved on it serves as benchmark. It is well protected with masonry structure built around it so that its position is not disturbed by animals or by any unauthorized person.

(b) Permanent Benchmark: These are the benchmarks established by state government agencies like PWD. They are established with reference to GTS benchmarks. They are usually on the corner of plinth of public buildings.

(c) Arbitrary Benchmark: In many engineering projects the difference in elevations of neighboring points is more important than their reduced level with respect to mean sea level. In such cases a relatively permanent point, like plinth of a building or corner of a culvert, are taken as benchmarks, their level assumed arbitrarily such as 100.0 m, 300.0 m, etc.

(d) Temporary Benchmark: This type of benchmark is established at the end of the day's work, so that the next day work may be continued from that point.

LEVELLING INSTRUMENTS

A level is an instrument giving horizontal line of sight and magnifying the reading at a far away distance.

It consists of the following parts:

(i) A telescope to provide a line of sight

(ii) A level tube to make the line of sight horizontal and

(iii) A levelling head to level the instrument.

The following types of levels are available:

(i) Dumpy level (ii) Wye (or, Y) level

(iii) Cooke's reversible level (iv) Cushing's level

(v) Tilting level and (vi) Auto level.

LEVELLING STAFF

Along with a level, a levelling staff is also required for levelling. The levelling staff is a rectangular rod

having graduations. The staff is provided with a metal shoes at its bottom to resist wear and tear. The

foot of the shoe represents zero reading. Levelling staff may be divided into two groups:

(i) Self reading staff (ii) Target staff.

(i) Self reading staff: This staff reading is directly read by the instrument man through telescope.

In a metric system staff, one metre length is divided into 200 subdivisions, each of uniform thickness of 5 mm. All divisions are marked with black in a white background. Metres and decimetres are written in red colour)]. The following three types of self reading staffs are available:

(a) Solid staff: It is a single piece of 3 m.

(b) Folding staff: A staff of two pieces each of 2 m which can be folded one over the other.

(c) Telescopic staff: A staff of 3 pieces with upper one solid and lower two hollow. The upper part can slide into the central one and the central part can go into the lower part. Each length can be pulled up and held in position by means of brass spring. The total length may be 4 m or 5 m

(ii) Target staff: If the sighting distance is more, instrument man finds it difficult to read self reading staff. In such case a target staff shown in may be used. Target

staff is similar to self reading staff, but provided with a movable target. Target is a circular or oval shape, painted red and white in alternate quadrant. It is fitted with a vernier at the centre. The instrument man directs the person holding target staff to move the target, till its centre is in the horizontal line of sight. Then target man reads the target and is recorded.

Q.-Describe the METHODS OF LEVELLING?

The following methods are used to determine the difference in elevation of various points:

(i) Barometric levelling (ii) Hypsometric levelling

(iii) Direct levelling and (iv) Indirect levelling.

Barometric Levelling

This method depends on the principle that atmospheric pressure depends upon the elevation of place.

Barometer is used to measure the atmospheric pressure and hence elevation is computed. However it is not accurate method since the atmospheric pressure depends upon season and temperature also. It may be used in exploratory surveys.

Hypsometric Levelling

This is based on the principle that boiling point of water decreases with the elevation of the place. Hence the elevation difference between two points may be found by noting the difference in boiling point of water in the two places. This method is also useful only for exploratory survey.

Direct Levelling

It is common form of levelling in all engineering projects. In this method horizontal sight is taken on a graduated staff and the difference in the elevation of line of sight and ground at which staff is held are found. Knowing the height of

line of sight from the instrument station the difference in the elevations of instrument station and the ground on which staff is held can be found.

Q, Describe the TERMS USED IN DIRECT METHOD OF LEVELLING

Ans-The following terms are used in direct method of levelling:

(i) **Plane of Collimation**: It is the reduced level of plane of sight with respect to the datum selected. It is also known as 'height of instrument'. It should not be confused with the height of telescope from the ground where the instrument is set.

(ii) **Back Sight (BS)**: It is the sight taken on a level staff held on the point of known elevation with an intension of determining the plane of collimation. It is always the first reading after the instrument is set in a place. It is also known as plus sight, since this reading is to be added to RL of the point (Benchmark or change point) to get plane of collimation.

(iii) **Intermediate Sight (IS)**: Sights taken on staff after back sight (first sight) and before the last sight (fore sight) are known as intermediate sights. The intension of taking these readings is to find the reduced levels of the points where staff is held. These sights are known as'minus sights' since the IS reading is to be subtracted from plane of collimation to get RL of the point where staff is held.

(iv) **Fore Sight (FS)**: This is the last reading taken from the instrument station before shifting it or just before ending the work. This is also a minus sight.

(v) **Change Point (CP)**: This is also known as turning point (TP). This is a point on which both fore sights and back sights are taken. After taking fore sight on this point instrument is set at some other convenient point and back sight is taken on the staff held at the same point. The two readings help in establishing the new plane of collimation with respect to the earlier datum. Since there is time gap between taking the two sights on the change point, it is advisable to select change point on a well defined point.

Q. Describe TEMPORARY ADJUSTMENTS OF A LEVEL.

Ans-The adjustments to be made at every setting of the instrument are called temporary adjustments. The following three adjustments are required for the instrument whenever set over a new point before taking a reading:

(i) Setting (ii) Levelling and

(iii) Focussing.

1 Setting

Tripod stand is set on the ground firmly so that its top is at a convenient height. Then the level is fixed on its top. By turning tripod legs radially or circumferentially, the instrument is approximately levelled. Some instruments are provided with a less sensitive circular bubble on tribrach for this purpose.

Levelling

The procedure of accurate levelling with three levelling screw is as given below:

(i) Loosen the clamp and turn the telescope until the bubble axis is parallel to the line joiningany two screws.

(ii) Turn the two screws inward or outward equally and simultaneously till bubble is centred.

(iii) Turn the telescope by 90° so that it lies over the third screw and level the instrument by operating the third screw.

(iv) Turn back the telescope to its original position and check the bubble. Repeat steps (ii) to (iv) till bubble is centred for both positions of the telescope.

(v) Rotate the instrument by 180°. Check the levelling.

Focussing

Focussing is necessary to eliminate parallax while taking reading on the staff. The following two steps are required in focusing:

(i) Focusing the eyepiece: For this, hold a sheet of white paper in front of telescope and rotate eyepiece in or out till the cross hairs are seen sharp and distinct.

(ii) Focusing the objective: For this telescope is directed towards the staff and the focusingScrew is turned till the reading appears clear and sharp.

Q. Describe the typesTYPES OF DIRECT LEVELLING.

The following are the different types of direct levelling:

(i) Simple levelling (ii) Differential levelling

(iii) Fly levelling (iv) Profile levelling

(v) Cross sectioning and (vi) Reciprocal levelling.

Q. Define contour lines and also give their characteristics and uses?

Ans-A contour line is a imaginary line which connects points of equal elevation. Such lines are drawn on the plan of an area after establishing reduced levels of several points in the area. The contour lines in an area are drawn keeping difference in elevation of between two consecutive lines constant. For example, Fig. 1 shows contours in an area with contour interval of 1 m. On contour lines the level of lines is also written.

Fig.1 Contours

Q. Describe Characteristics of Contours.

Ans-The contours have the following characteristics:

1. Contour lines must close, not necessarily in the limits of the plan.
2. Widely spaced contour indicates flat surface.

3. Closely spaced contour indicates steep ground.

4. Equally spaced contour indicates uniform slope.

5. Irregular contours indicate uneven surface.
6. Approximately concentric closed contours with decreasing values towards centre (Fig.1) indicate a pond.

7. Approximately concentric closed contours with increasing values towards centre indicate hills.

8. Contour lines with U-shape with convexity towards lower ground indicate ridge (Fig. 2).

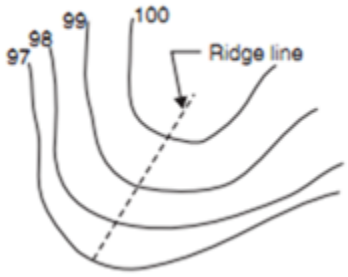


Fig. 2

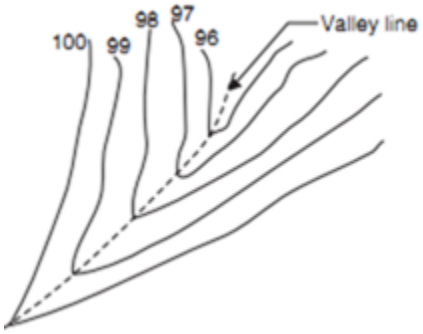


Fig. 3

9. Contour lines with V-shaped with convexity towards higher ground indicate valley (Fig.3).
10. Contour lines generally do not meet or intersect each other.
11. If contour lines are meeting in some portion, it shows existence of a vertical cliff (Fig. 4).

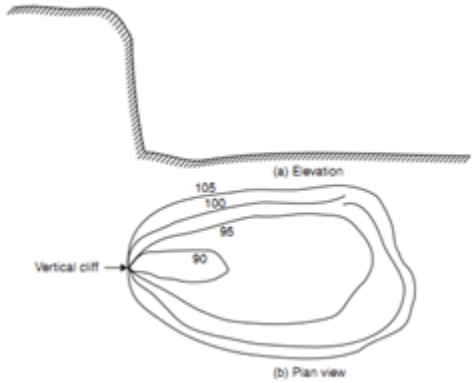


Fig. 4

12. If contour lines cross each other, it shows existence of overhanging cliffs or a cave (Fig. 5).

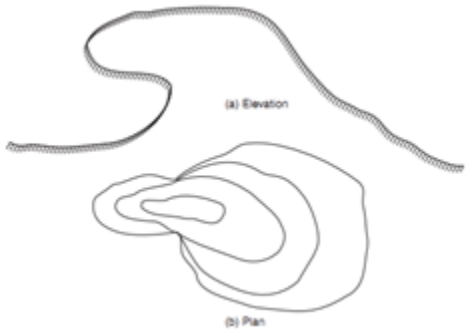


Fig. 5

Q.Describe theUses of Contour Maps

Ans-Contour maps are extremely useful for various engineering works:

1. A civil engineer studies the contours and finds out the nature of the ground to identify. Suitable site for the project works to be taken up.
2. By drawing the section in the plan, it is possible to find out profile of the ground along that line. It helps in finding out depth of cutting and filling, if formation level of road/railway is decided.
3. Intervisibility of any two points can be found by drawing profile of the ground along that line.
4. The routes of the railway, road, canal or sewer lines can be decided so as to minimize and balance earthworks.
5. Catchment area and hence quantity of water flow at any point of nalla or river can be found. This study is very important in locating bunds, dams and also to find out flood levels.
6. From the contours, it is possible to determine the capacity of a reservoir.

Theodilite

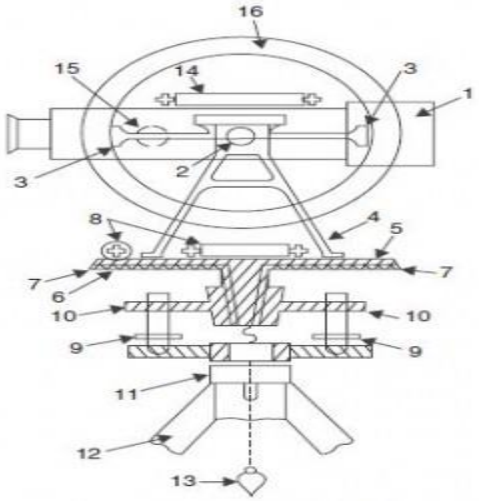
Q.DescribeTheodilite its parts and uses?

Ans-It is a commonly used instrument for measuring horizontal and vertical angles. It is used for prolonging a line, levelling and even for measuring the distances indirectly (techeometry). Using verniers angles can be read accurately up to 20″. Precise theodolites are available which can read angles up to even 1″ accuracy. They use optical principle for more accurate instruments.

Q.**DescribeParts of a Vernier Theodolite.**

Ans-Figure shows a sectional view of a typical vernier theodolite and plate 16.1 shows photograph of such theodolite. Main parts of such a theodolite are

1. **Telescope**: A telescope is mounted on a horizontal axis (trunnian axis) hence it can rotate in vertical plane. Its length varies from 100 mm 175 mm and its diameteris 38 mm at objective end. Its functions is to provide a line of sight.



1. Telescope
2. Trunnian axis
3. Vernier frame
4. Standards or A-Frame
5. Upper plate
6. Lower plate
7. Vernier
8. Plate level
9. Foot crews
10. Levelling head
11. Tripod head
12. Tripod
13. Plumb bob
14. Altitude level
15. Focussing screw
16. Vertical circle

Fig. 16.1. Sectional view of a transit theodolite

Vertical Circle: A vertical circle graduated up to an accuracy of 20′ is rigidly connected to the telescope and hence moves with it when the telescope is rotated in vertical plane. The graduations are in quadrantal system, 0-0 line being horizontal (Ref. Fig. 16.2).

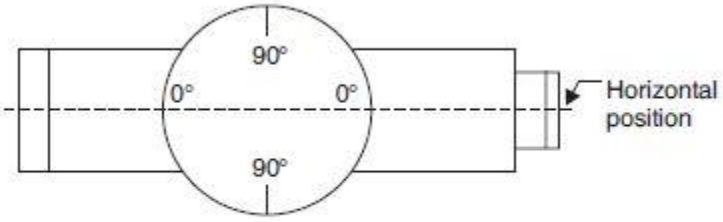


Fig. 16.2

Vernier Frame: It is a T-shaped frame (Fig. 16.3) consisting of a vertical arm and a horizontal arm. With the help of the climping screws the vertical frame and hence the telescope can be clamped at desired angle. Vertical frame is also known as T-frame or index frame.
The vernier arm is known as index arm. At the ends it carries verniers C and D so as to read graduations on vertical circle. They are provided with glass magnifiers. Altitude bubble tube is fitted over the horizontal arm.

Standards or A-Frame: The frames supporting telescope are in the form of English letter 'A'. This frame allows telescope to rotate on its trunnian axis in vertical frame. The T-frame and the clamps are also fixed to this frame.

5. **Upper Plate** [Fig. 16.4]: Upper plate supports standards on its top surface. On lower side it is attached to a inner spindle which rotates in the outer spindle of lower plate. Using upper clamp, upper plate can be clamped to lower plate. Using tangent screws, it is possible to give slight relative motion between the two plates, even afterclamping. Two diametrically opposite verniers A and B fixed to upper plate help in reading horizontal circle graduations. They are provided with magnifying glasses.

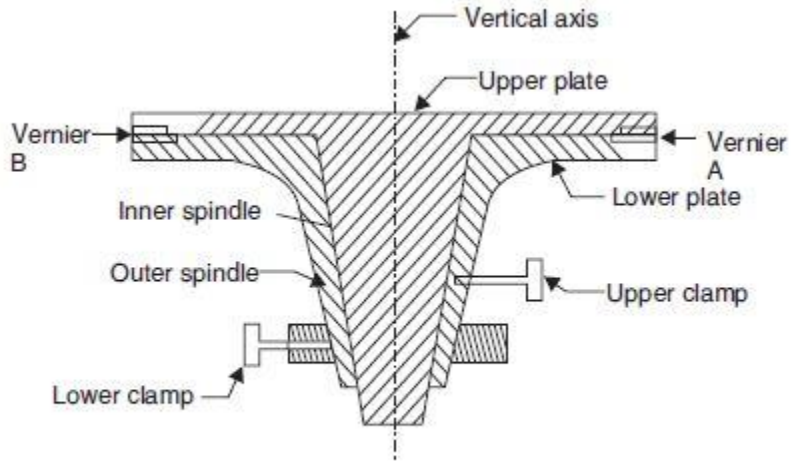


Fig. 16.4

Lower Plate: The lower plate, attached to the outer spindle carries a graduated circle at its bevelled edge. Graduations are up to an accuracy of 20′. It can be clamped at any desired position using lower clamps. If upper clamp is locked and the lower one is loosened the two plates rotate together. If the upper clamp is loosened and lower clamp locked, upper plate alone rotates. This mechanism is utilised in measuring horizontal angle.

7. **Plate Level**: One or two plate level tubes are mounted on the upper plate. If the two level tubes are provided they will be at right angles to each other one of them being parallel to trunnion axis. These levels help in making the vertical axis of the instrument truely vertical.

8. **Levelling Head**: It consists of two parallel triangular plates known as tribratch plates. The upper tribratch plate is provided with three levelling screws—each one carried by a arm of tribratch plate. By operating screws the levelling of upper plate and hence telescope can be ensured. The lower tribratch can be fitted into a tripod head.

9. **Tripod**: Theodolite is always used by mounting it on a tripod. The legs of tripod may be solid or framed. At the lower end the legs are provided with steel shoes to get good grip with the ground. The top of tripod is provided with external screw to which the lower tribratch plate can be screwed. When not in use tripod head may be protected with a steel cap, provided for this purpose.

10. **Plumb Bob**: A hook is provided at the middle of lower tribratch plate from which a plumb bob can be suspended. It facilitates exact centering of the theodolite on a station.

11. **Shifting Head**: It is provided below the lower plate. In this, one plate slides over another over a small area of about 10 mm radius. The two plates can be tightened in the desired position. It facilitates exact centering of the instruments.

12. **Magnetic Compass**: In some theodolites a magnetic compass is fixed on one of the strands. It is useful if readings are to be recorded with magnetic north as meridian.

Q. Describe the use of Theodolite.

Ans-1-Theodolite is used for measuring horizontal and vertical angles.
2- Measuring deflection angles.
3- Measuring magnetic bearing.
4-Measuring horizontal distance between two points.
5-Finding the vertical height of an object.
6- Finding the difference in elevation between various points.
7- Ranging a line.

Q. Mention Types of Theodilite.

Ans-Theodolites may be either ***transit* or *non-transit.***

1-**Transit theodolites** (or just 'Transits') are those in which the telescope can rotate in a complete circle in the vertical plane, whereas

2-the rotation in the same plane is restricted to a semi-circle for **Non-Transit theodolites.**

Q-Describe the method of measurement of horizontal angle?

Ans-Measurement of Horizontal Angle
The procedure is explained for measuring horizontal angle θ = PQR at station Q (Ref. Fig. 16.5)

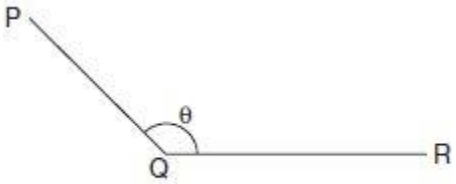


Fig. 16.5

1. Set the theodolite at Q with vertical circle to the left of the line of sight and complete all temporary adjustments.
2. Release both upper and lower clamps and turn upper plate to get 0° on the main scale. Then clamp main screw and using tangent screw get exactly zero reading. At this stage vernier A reads 0° and vernier B reads 180°.
3. Through telescope take line of sight to signal at P and lock the lower clamp. Use tangent screw for exact bisection.
4. Release the upper clamp and swing telescope to bisect signal at R. Lock upper clamp and use tangent screen to get exact bisection of R.
5. Read verniers A and B. The reading of vernier A gives desired angle PQR directly, while 180° is to be subtracted from the reading of vernier B to get the angle PQR.
6. Transit (move by 180° in vertical plane) the telescope to make vertical circle to the right of telescope. Repeat steps 2 to 5 to get two more values for the angle.

7. The average of 4 values found for θ, give the horizontal angle. Two values obtained with face left and two obtained with face right position of vertical circle are called one set of readings.
8. If more precision is required the angle may be measured repeatedly. i.e., after step 5, release lower clamp, sight signal at P, then lock lower clamp, release upper clamp and swing the telescope to signal at Q. The reading of vernier A doubles. The angle measured by vernier B is also doubled. Any number of repetitions may be made and average taken. Similar readings are then taken with face right also. Finally average angle is found and is taken as desired angle 'Q'. This is called method of repetition.
9. There is another method of getting precise horizontal angles. It is called method of reiteration.
If a number of angles are to be measured from a station this technique is used (Fig. 16.6).
With zero reading of vernier A signal at P is sighted exactly and lower clamp and its tangent screw are locked. Then θ1 is measured by sighting Q and noted. Then θ2, θ3 and θ4 are measured by unlocking upper clamp and bisecting signals at R, S and P. The angles are calculated and checked to see that sum is 360º. In each case both verniers are read and similar process is carried out by changing the face (face left and face right).

Q- **Describe the method of measurement of Vertical angle?**

Ans-Measurement of Vertical Angle

Horizontal sight is taken as zero vertical angle. Angle of elevations are noted as +ve angles and angle of depression as –ve angles.
To measure vertical angle the following procedure may be followed:
1. Complete all temporary adjustment at the required station.
2. Take up levelling of the instrument with respect to altitude level provided on the Aframe.
This levelling process is similar to that used for levelling dumpy level i.e., first altitude level is kept parallel to any two levelling screws and operating those two screws bubble is brought to centre. Then by rotating telescope, level tube is brought at right angles to the original position and is levelled with the third screw. The procedure is repeated till bubble is centred in both positions.
3. Then loosen the vertical circle clamp, bisect P and lock the clamp. Read verniers C and D to get vertical angle. Take the average as the actual vertical angle.

Theodolites may be either *transit* or *non-transit*. Transit theodolites (or just 'Transits') are those in which the telescope can rotate in a complete circle in the vertical plane, whereas the rotation in the same plane is restricted to a semi-circle for non-transit theodolites.

UNIT-3

Q. Define contour lines and also give their characteristics and uses?
Ans-A contour line is a imaginary line which connects points of equal elevation. Such lines are drawn on the plan of an area after establishing reduced levels of several points in the area. The contour lines in an area are drawn keeping difference in elevation of between two consecutive lines constant. For example, Fig. 1 shows contours in an area with contour interval of 1 m. On contour lines the level of lines is also written.

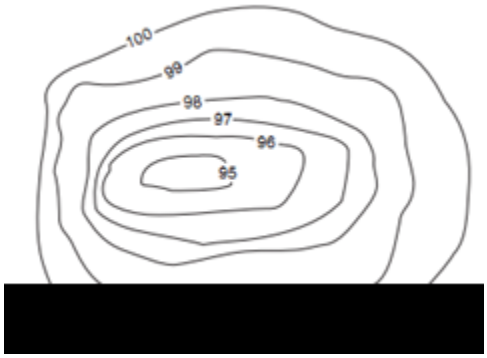


Fig.1 Contours

Q. Describe Characteristics of Contours.
Ans-The contours have the following characteristics:

1. Contour lines must close, not necessarily in the limits of the plan.
2. Widely spaced contour indicates flat surface.

3. Closely spaced contour indicates steep ground.

4. Equally spaced contour indicates uniform slope.

5. Irregular contours indicate uneven surface.
6. Approximately concentric closed contours with decreasing values towards centre (Fig.1) indicate a pond.

7. Approximately concentric closed contours with increasing values towards centre indicate hills.

8. Contour lines with U-shape with convexity towards lower ground indicate ridge (Fig. 2).

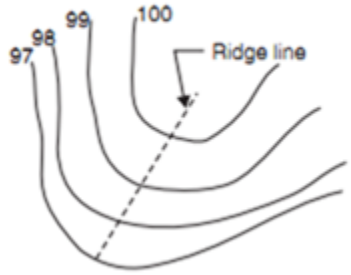


Fig. 2

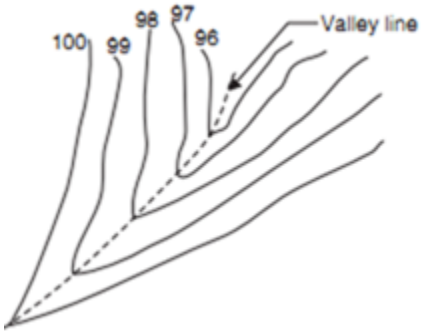


Fig. 3

9. Contour lines with V-shaped with convexity towards higher ground indicate valley (Fig.3).

10. Contour lines generally do not meet or intersect each other.

11. If contour lines are meeting in some portion, it shows existence of a vertical cliff (Fig. 4).

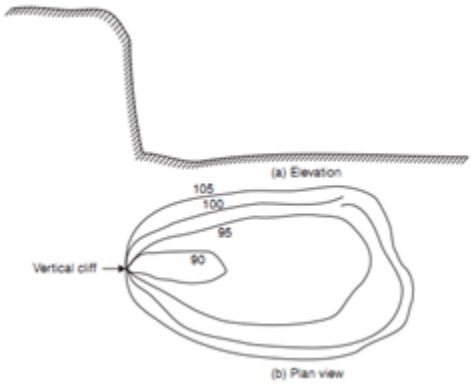


Fig. 4

12. If contour lines cross each other, it shows existence of overhanging cliffs or a cave (Fig. 5).

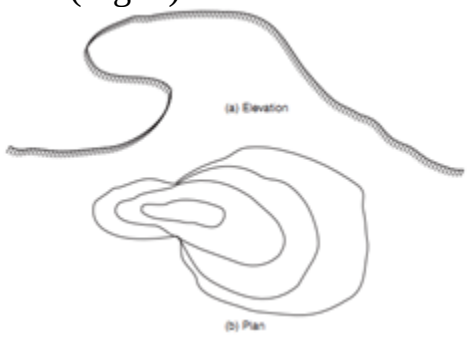


Fig. 5

Q. Describe the Uses of Contour Maps

Ans-Contour maps are extremely useful for various engineering works:

7. A civil engineer studies the contours and finds out the nature of the ground to identify. Suitable site for the project works to be taken up.
8. By drawing the section in the plan, it is possible to find out profile of the ground along that line. It helps in finding out depth of cutting and filling, if formation level of road/railway is decided.
9. Intervisibility of any two points can be found by drawing profile of the ground along that line.
10. The routes of the railway, road, canal or sewer lines can be decided so as to minimize and balance earthworks.

11. Catchment area and hence quantity of water flow at any point of nalla or river can be found. This study is very important in locating bunds, dams and also to find out flood levels.
12. From the contours, it is possible to determine the capacity of a reservoir.

LNCT GROUP OF COLLEGES
"WORKING TOWARDS BEING THE BEST"

Basic Civil Engg & Mechanics (BT-204)

Prof. Sunil Kumar Vishwkarma (+916263021339)