UNIT-2 Surveying

Surveying:
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.

APPLICATIONS OF SURVEYING

Some of the important applications of surveying are listed below:

- Astronomical survey helps in the study of astronomical movements of planets and for calculating local standard times.
- Maps prepared for countries, states and districts, etc. avoid disputes.
- Plans prepared record the property boundaries of private, public and government which help in avoiding unnecessary controversies.
- Topographical maps showing natural features like rivers, streams, hills, forests help in planning irrigation projects and flood control measures.
- Road maps help travelers and tourists to plan their programmers.
- Locality plan help in identifying location of houses and offices in the area.
- Maps and plans help in planning and estimating various transportation projects like roads, bridges, railways and airports.
- For planning and executing water supply and sanitary projects one has to go for surveying first.
- Marine and hydrographic surveys help in planning navigation routes and harbours.
- For making final payments in large projects surveying is to be carried out.
- Military surveys help in strategic planning.
- For exploring mineral wealth mine surveys are required.
- Geological surveys are necessary for determining different strata in the earth's crust so that proper location is found for reservoirs.
- Archaeological surveys are required for unearthing relics of antiquity.

OBJECTIVES OF SURVEYING:

- To collect field data;
- To prepare plan or map of the area surveyed;
- To analyse and to calculate the field parameters for setting out operation of actual engineering works.
- To set out field parameters at the site for further engineering works.

MEASUREMENTS

Linear measurements are horizontal or vertical only. Here angular measurements are also involved. Commonly used linear units in surveying are kilometre, metre and millimetres. For measurement of angles sexagesimal system is used. In this 1 circumference = 360 degrees.

MEASUREMENT OF HORIZONTAL DISTANCES

APPROXIMATE METHODS OF DISTANCE MEASUREMENTS

Approximate methods of direct measurements are listed below:

1. Pacing
2. Measurement with passometer
3. Measurement with pedometer
4. Measurement with odometer
5. Measurement with speedometer

PACING: The surveyor walks along the line to be measured and counts number of steps. Then the distance measured is equal to no. ofsteps multiplied by 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.

PASSOMETER: A passometer is a watch – like instrument which should be carried vertically in the shirt pocket or tied to a leg. Mechanism of the instrument gets operated by the motion of the body and records number of paces. Thus, the problem of counting paces is eliminated.

PEDOMETER: It is a instrument similar to passometer, but it recordsthe distances instead of paces. In this before walking zero setting is made and length of pace is set depending upon the person.

ODOMETER: It is an instrument which is attached to the wheel of a cycle or other vehicle. It records number of revolutions made by the wheel. Knowing the circumference of the wheel, the distance travelled may be found.

SPEEDOMETER: Odometer may be calibrated to give distance directly, if it is used for a particular vehicle. This is called speedometer

Horizontal distance measured by **chain or tape** in surveying.

Chain:

The chains are composed of 10 pieces of 4 mm diameter galvanized mild steel wires bent into rings at one end and joined to each other by three circular or oval shaped rings. These rings give flexibility to the chain. The ends of the chain are provided with brass handles with swivel joints, so that the chain can be turned without twisting.

The length of a link is the distance between centres of two consecutive middle rings while the length of the chain is from outside of one handle to the outside of the other handle.

The different types of chains used are:

1. Gunter or surveyor's chain
2. Revenue chain
3. Engineer's chain
4. Metric chain and
5. Steel band.

Gunter or surveyor's chain: It is a 66 ft long chain divided in 10 links. It was used for land measurement and for making milestones along the roads since 10 square chains is equal to one acre and 10chain lengths are equal to one furlong (1/8th of a mile)

Revenue chain: Revenue chain is 33 ft long and is divided in 16 links. It is used for measuring fields in cadastral surveys.

Engineer's chain: It is 100 ft long chain with 100 links. Hence, it is convenient in all engineering surveys to record readings in foot units.

Metric chain: Metric chains of length 5 m and 10m are also available but commonly used metric chains are of 20 m. They have 100 links with talleys at every 2 m. simple rings are provided at every one metre length except wherever tallies are provided. A groove is cut on the outside surface of the brass handle so that insertion of arrow marks gives correct position of end of chain. The total length of chain is marked on the brass handle.

Steel Band: It is also known as band chain. It consists of a ribbon of steel of 12 to 16 mm width and 0.3 to 0.6 mm thickness. The steel ribbon is wound around on 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 is adopted.

TAPES

Tapes are used for measuring lines and offsets and are classified depending on the materials used as:

1. Cloth or linen tape
2. Metallic tape
3. Steel tape and
4. Invar tape.

Cloth or linen tape: 12 to 15 mm wide cloth or linen is varnished to resist moisture and graduations are marked. They are provided with brass handle at the ends. End to end length of brass handles is the total length of tape. They are available in the length of 10 m, 20 m, 25 m and 30 m, these tapes are light and flexible and hence easy to handle. However because of the following disadvantages. They are not popular is use:

1. Due to moisture or dampness they shrink
2. Extend due to stretching
3. Not strong
4. Likely to twist and tangle

Metallic tape: These are made up of varnished strip of waterproof linen interwoven with small wires of brass, copper or bronze. They are provided with handle at the end. About 100 m lengths to 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. On one side of tape markings are made to indicate distance from the end of handle. Red and black coloured markings are used for indicating full metres and its fractions in centimeters

Steel tape: Steel tape consists of 6 to 10 mm wide strip with metal ring at free end and wound in well sewn leather or a corrosion resistant metal case. A suitable winding device is provided.

The tapes are marked legibly on one side only indicating 5 mm, centimeters, decimeters and metres clearly. The end 10 cm length is marked with millimeters also. The tapes are available in 1 m, 2 m , 10 m, 2 0 m, 30 m, and 50 m lengths.

Steel tapes are superior to a metallic tape as for as accuracy is concerned, however, they are delicate. Care should be taken to wipe the tape clean before winding. They should be oiled regularly to prevent corrosion.

Invar tape: It is made up of an alloy of nickel (36%) and steel, which has very low coefficient of thermal expansion. The width of the tape is 6 mm. it is available in 30 m, 50 m and 100 m lengths. It is the most accurate tape but is expensive. It is delicate and hence should be handled with care. It undergoes change in length due to continuous use, which is known, as creep of the material. Hence, it is necessary to ascertain its true length, if it is old. This tape is used for base line measurement in surveying.

ANGULAR MEASUREMENTS:

The direction of a survey line may be defined by

1. Horizontal angle between the line and adjacent to it or
2. The angle between a reference line called meridian and the survey line. The reference line is called meridian and the angle between the line and the meridian is called bearing.

- The direction of a survey line can either be established with relation to each other or with relation to any meridian. The first will give angle between two lines. The second will give the bearing of the line.
- The common instruments used for direction measurements are prismatic and surveyor's compass. The common instruments used for angle measurements are theodolite and sextant

Meridian: Meridian is a standard direction from which, the bearings of survey lines are measured. There are three types of meridians.
1) True meridian
2) Magnetic meridian
3) Arbitrary meridian.

True meridian: It is a line of intersection of earth's surface formed by a plane passing through north and south poles and the given place.
Magnetic meridian: It is the direction indicted by a freely suspended magnetic needle.
Arbitrary meridian: It is any convenient direction assumed as meridian for measuring bearings of survey lines.

Bearing
It is a horizontal angle made by the survey line with reference to the meridian, based on the meridian the bearings are three types.
1) True bearing 2) Magnetic bearing 3) Arbitrary bearing

True bearing: The angle made by a survey line with reference to true meridian is called true bearing. It is always remains constant.

Magnetic bearing: The angle made by a survey line with reference to magnetic meridian is called magnetic bearing. It changes from place to place and time.

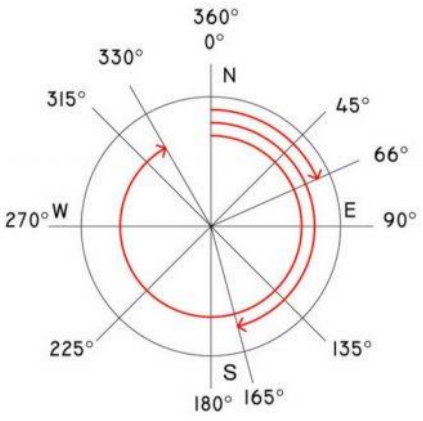
Arbitrary bearing: The angle made by a survey line with reference to arbitrary meridian is called arbitrary bearing.

Representation of Bearing

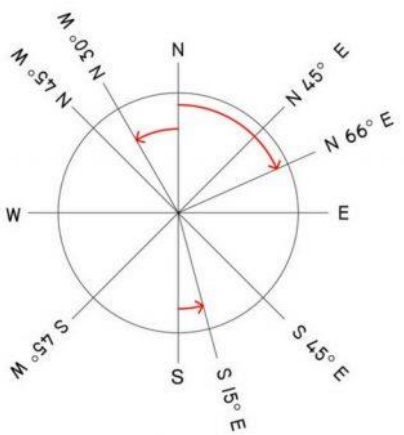
Bearings are expressed in the following two systems.
1) Whole circle bearings system.
2) Quadrantal bearings system

1) Whole Circle Bearing:
In this system, the bearing of a line is always measured clock wise from the direction of the north of the meridian towards the line around the circle.

2) Quadrantal Bearings:
In this system the bearings of a line is measured from either the north or the south, clock wise or counter clockwise which ever is nearer to the line towards the east or west. The angle at any station in a plane is divided into four quadrants by two lines at right angles to each other. These are the north south and east west lines. The bearing is reckoned from 0^0 to 90^0 in each quadrant. Quadrantal bearings are also called as reduced bearings.



Whole Circle Bearing



Quadrantal Bearing

Conversion of Whole Circle bearings into Quadrantal Bearings:

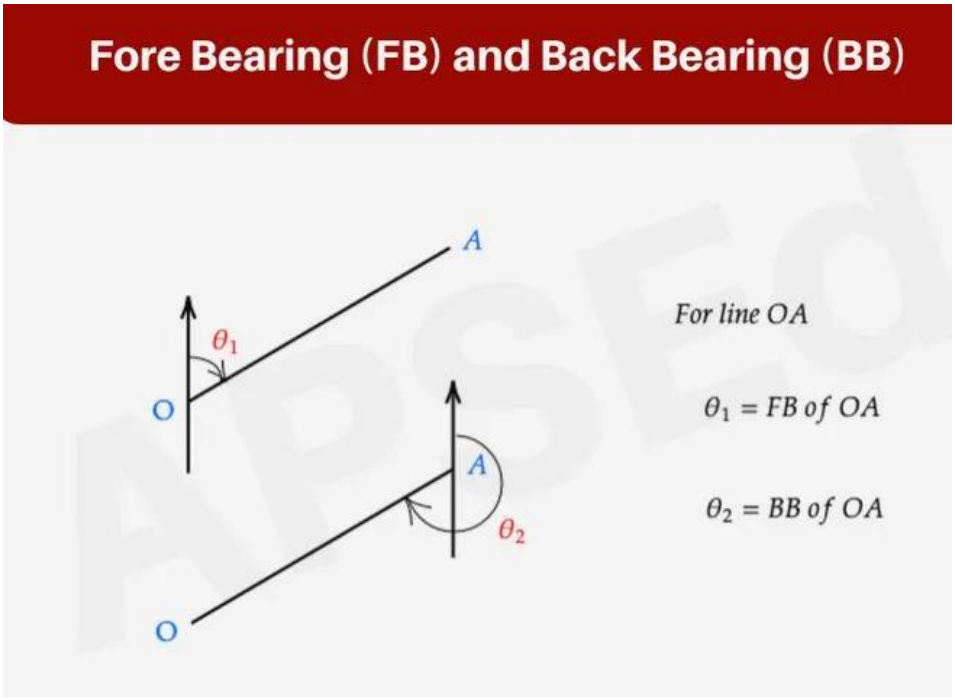
The whole circle bearing of a line can be converted to quadrantal bearing by reducing it to an angle less than 90^0 which has the same numerical value of the trigonometric functions. Rule of conversion of whole circle bearings into quadrantal bearing.

S.No	W.C.B	QUADRANT	RULE
1	Between 0^0 to 90^0	N-E	Q.B = W.C.B
2	Between 90^0 to 180^0	S-E	Q.B = 180^0 -W.C.B
3	Between 180^0 to 270^0	S-W	Q.B = W.C.B - 180^0
4	Between 270^0 to 360^0	N-W	Q.B = 360^0 -W.C.B

Fore Bearing (FB):
The bearings measured in the progress of surveying i.e. in the forward direction of survey lines is known as forebearing or forward bearing.

Back Bearing (BB):
The bearings measured in opposite to the progress of surveying i.e. in backward direction of survey line is known as Backward Bearing.

The difference between the fore bearing and back bearing of a line is 180^0
.
Back bearing =fore bearing ± 180^0



1. Convert the following Whole Circle Bearing to Quadrantal Bearing.

a) $22^0 30'$ and b) 220^0

Solution (a): WCB = 22^0 30'

You can check the conversion table, which tells if the WCB value is between 0 and 90 degrees then the Reduced bearing value is the same. Hence the bearing value of the line OA in the Quadrantal system will be the same but designated as **N $22^0$30'E**.

Solution (b): WCB = 220^0

You can check the conversion table. The WCB values lie between 180 and 270 degrees. The conversion is R.B = R.B = WCB -180^0 in S-W direction;

Hence, R.B = **220^0** - 180^0 = 40^0

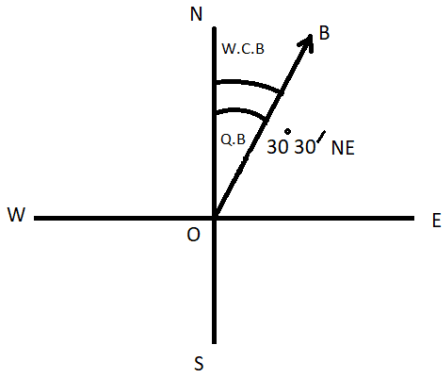
Then R.B = S 40^0 W

Convert Quadrantal Bearings to Whole Circle Bearing:

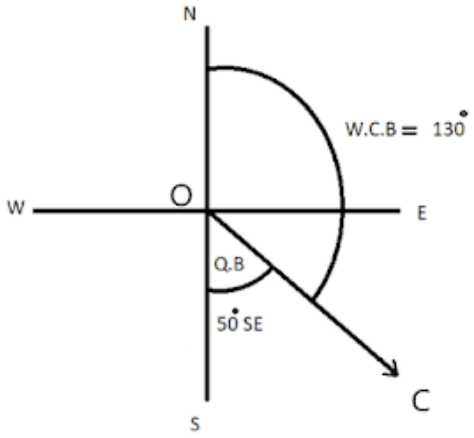
Convert the following quadrantal bearing into whole circle bearing:

1. N 30°30' E
2. S 50° E
3. S 20°45' W
4. N 25° W

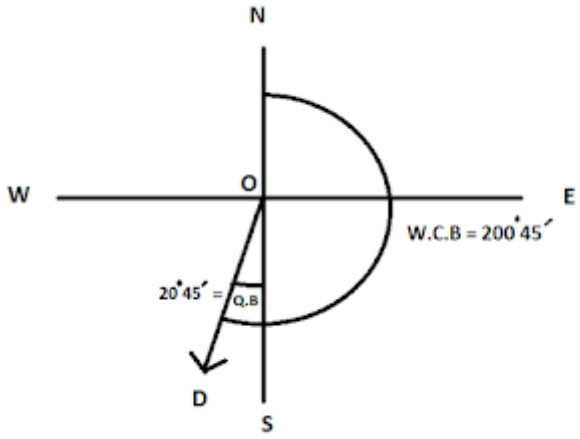
1. Line OB, W.C.B = 30°30'



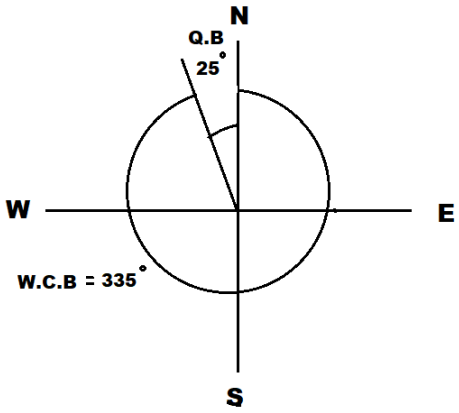
2. **Line OC, W.C.B =180° – 50° = 130°**



3. **Line OD, W.C.B = 180° + 20°45' = 200°45'**



4. **Line OE, W.C.B = 360° – 25° = 335°**



LEVELLING:

Levelling is the art of determining the elevation of given points above or below a datum line or establishing in given points of required height above or below the datum line. It evolves measurement in vertical plane.

Definition of basic term's used in levelling:

Level surface: Any surface parallel to the mean spheroid of the earth is called level surface and the line drawn on level surface is known as level line.

Horizontal surface: Any surface tangential to level surface at a given point is called - Horizontal surface at point. Hence horizontal line is at right angles to plumb line.

Vertical surface: It is the line connecting the point & centre of earth. Vertical & horizontal line is normal to each other.

Elevation (R.L) : Vertical distance above or below an arbitrarily assumed level surface or datum.

Bench Mark (B.M) : Relatively permanent point of reference whose elevations with reference to some assume datum known. It is used either as a starting point for levelling or as a point upon which to close as a check.

Mean Sea Level : It is the average height of the sea for all the stages or tides calculated for 19 years in India.

Datum: The point or the surface with respect to which levels of other points or planes are calculated is called – Datum or surface.

Mean sea level (MSL): Mean Sea level is the average height of sea of all stages of tides. Any particular place is derived by averaging over a long period of 19 years. In India the mean's sea level used is that at Karachi (Pakistan). In all important survey this is taken as datum.

Reduced level: Levels of various points are taken as heights above the datum surface are known as – Reduced level.

Bench mark: Bench mark is a relatively permanent point of reference whose Elevation w.r.t some assumed datum is known. There are four types of bench mark
1. G.T.S (Great trigonometry survey)
2. Permanent bench mark
3. Arbitrary bench mark.
4. Temporary bench mark.

LEVELLING INSTRUMENTS:

1. Level
2. Levelling staff

A level is an instrument giving horizontal line of sight & magnifying the reading far away from it. It consist of following 4 parts.
1. Telescope to provide line of sight.
2. Level tube to make the line of sight horizontal.
3. The leveling head to bring the bubble in its centre of run.
4. A tripod to support instrument

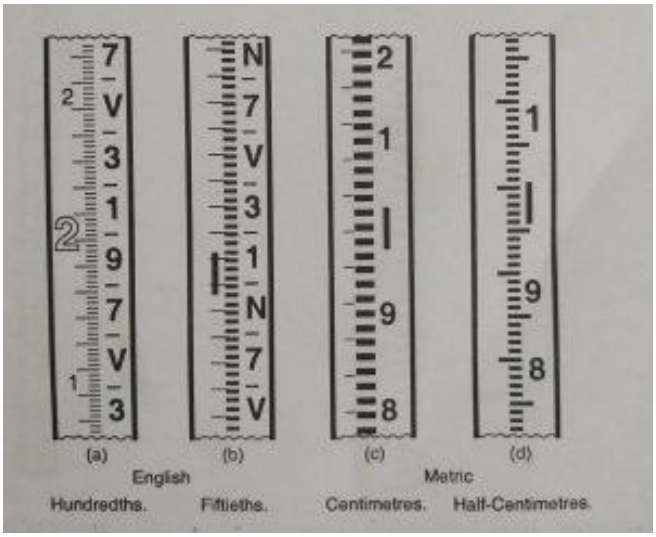
Types of Levelling Staff used in Surveying:

A levelling staff is a straight rectangular rod having graduations, the foot of the staff representing zero reading. The purpose of a level in to establish a horizontal line of sight. The purpose of the levelling staff is to determine the amount by which the station is above or below the line of sight. Types of Levelling staves may be divided into two classes

- **Self-reading staff**
- **Target staff**

A self-reading staff is the one which can be read directly by the instrument man through the telescope. A target staff, on the other hand, contains a moving target against which reading is taken by staff man.

1.Self-reading staff:
There are usually three forms of self-reading staff. They are solid staff, folding staff and telescopic staff. The figure below a and b show the pattern of solid staff in English units while c and d show that in the metric unit. The most common form of the smallest division is of0.01ft or 5mm. However, some staves may have fine graduations up to 2mm. The staff is generally made of well-seasoned wood having a length of 10 feet or 3 metres.



2.Target Staff:
Target staff is another type of levelling staff. Fig 9.14 shows a target staff having a sliding target equipped with vernier. The rod consists of two sliding lengths, the lower one of approx 7ft and the upper one of 6 ft. The rod is graduated in feet, tenths and hundreds and the vernier of the target enable the readings to be taken up to thousand parts of a foot.

For taking reading the level man directs the staff man to raise or lower the target till it is bisected by the line of sight. The staff holder then clamps the target and takes the reading.

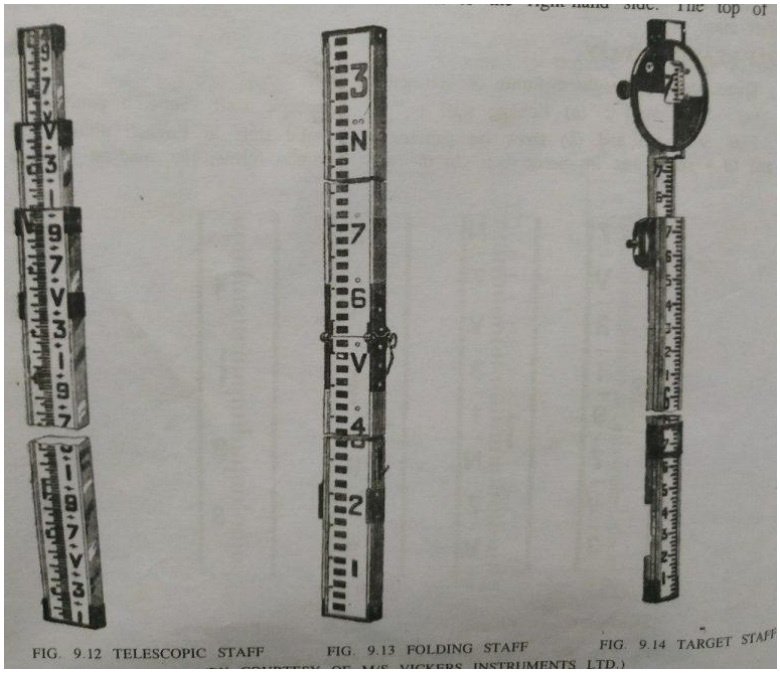


FIG. 9.12 TELESCOPIC STAFF FIG. 9.13 FOLDING STAFF FIG. 9.14 TARGET STAFF

TERMS USED IN LEVELLING:

1. Station: Station is the point where leveling staff is held & not the point where level is kept.

2. Height of instrument: For any set up of the level the height of instrument is the elevation of the plane of sight respect to assumed datum. This also known as – plane of collimation.

3. Back sight: It is sight taken on a level staff held at a point of known elevation with an intension of determining plane of collimation or sight.

4. Intermediate sight (I.S): Sight taken on after taking back sights before taking last sight from an instrument station is known as – intermediate sight. The sight is also known as +ve sight (add)

5. Fore sight (F.S): This is the last reading – taken from instrument just before shifting the instrument. This is also – ve sight.

6. Change point (C.P): This is a point on which both fore sight & back sight are taken.

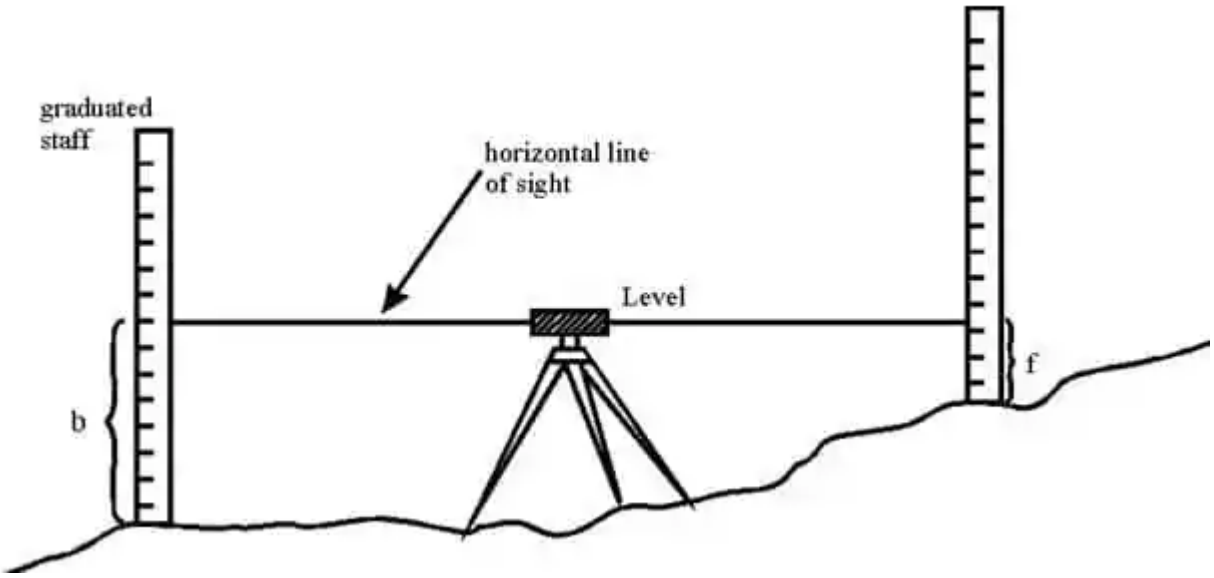
7. Reduced level: Reduced level of a point is the level of the point with respect to assumed datum.

METHODS OF LEVELLING:

In this method, measurements are observed directly from leveling instrument. Based on the observation points and instrument positions direct leveling is divided into different types as follows:

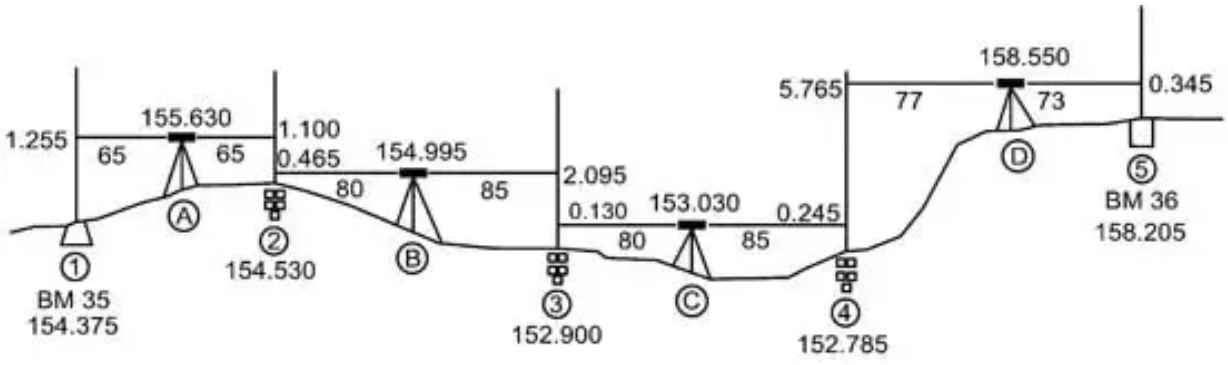
1. Simple leveling
2. Differential leveling
3. Fly leveling
4. Profile leveling
5. Reciprocal leveling

Simple Leveling:
It is a simple and basic form of leveling in which the leveling instrument is placed between the points which elevation is to be find. Leveling rods are placed at that points and sighted them through leveling instrument. It is performed only when the points are nearer to each other without any obstacles.



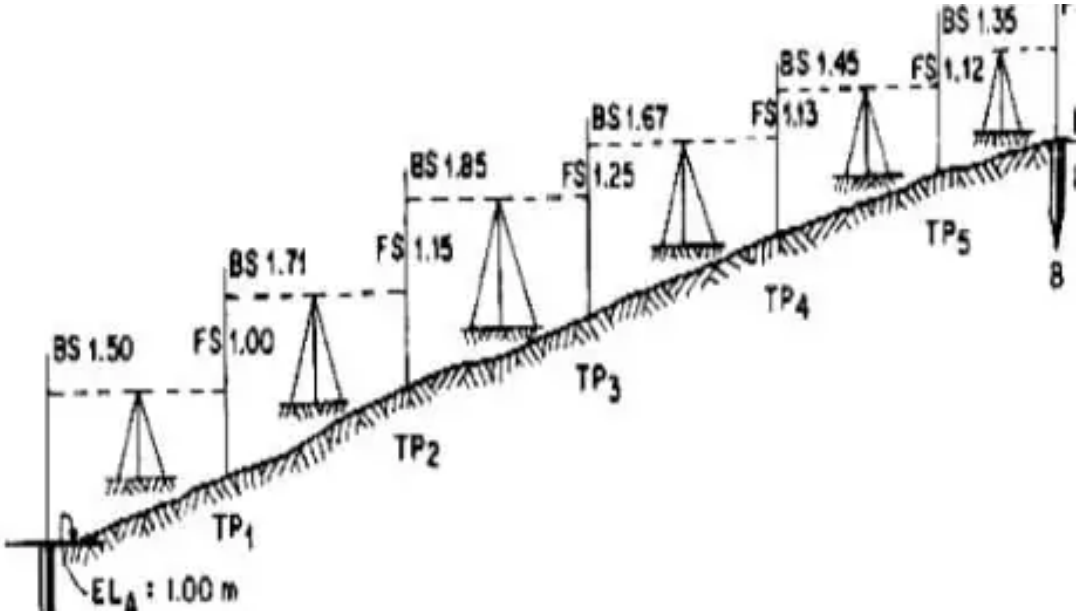
Differential Leveling:

Differential leveling is performed when the distance between two points is more. In this process, number of inter stations are located and instrument is shifted to each station and observed the elevation of inter station points. Finally difference between original two points is determined.

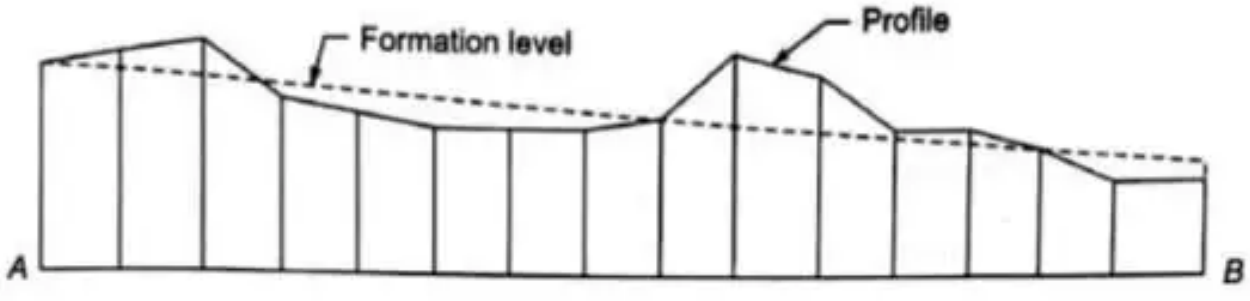


Fly Leveling:

Fly leveling is conducted when the benchmark is very far from the work station. In such case, a temporary bench mark is located at the work station which is located based on the original benchmark. Even it is not highly precise it is used for determining approximate level.



Profile Leveling:
Profile leveling is generally adopted to find elevation of points along a line such as for road, rails or rivers etc. In this case, readings of intermediate stations are taken and reduced level of each station is found. From this cross section of the alignment is drawn.



Reciprocal Leveling:
When it is not possible to locate the leveling instrument in between the inter visible points, reciprocal leveling is performed. This case appears in case of ponds or rivers etc. in case of reciprocal leveling, instrument is set nearer to 1st station and sighted towards 2nd station.