RRB JE

RAILWAY RECRUITMENT BOARD

CIVIL ENGINEERING

SURVEYING

SELF STUDY MATERIAL

CIVIL ENGINEERING FOR ALL

SURVEYING

Surveying is the process of analyzing and recording the characteristics of a land area span to help design a plan or map for construction. It is defined as the science of making measurements of the earth specifically the surface of the earth. This is being carried out by finding the spatial location (relative/absolute) of points on or near the surface of the earth.

Different methods and instruments are being used to facilitate the work of surveying.

The primary aim of field surveying are to-

(i) measure the horizontal distance between points.
(ii) measure the vertical elevation between points.
(iii) find out the relative direction of lines by measuring horizontal angles with reference to any arbitary direction and
(iv) To find out absolute direction by measuring horizontal angles with reference to a fixed direction.

FUNDAMENTALS OF MAPPING:-

Following are the mapping fundamentals:-

(i) Scales
(ii) Generalisation of details
(iii) Conventional symbols
(iv) Plotting accuracy
(v) Rectangular coordinate system.

OVERVIEW OF LAND SURVEYING :-

The fundamental objective of land surveying is to prepare a plan or map of an area. The map thus prepared serves as the primary source of information about the surface of the earth for further engineering work. The data required for making of a map gets collected through field surveying. To start field surveying it is required to know very accurately, the geographical coordinates (latitude, longitude) of at least one point, known as control point and the length as well as azimuth of a line, known as baseline. The latitude of the point and the azimuth of the line are determined through astronomical survey and longitude from time measurement. The length of the line is measured with a distance measuring instrument.

INDIAN,TOPOGRAPHIC MAPS:-

Topographic maps provides the graphical portrayal of an object present on the surface of the earth. These maps also provide the preliminary information about a terrian and thus very useful for engineering work.

CLASSIFICATION OF SURVEYING:-

A. Primary Classification : Surveying is primarily classified as under.

1. Plane surveying and 2. Geodetic surveying

1. Plane Surveying : In plane surveying the curvature of the earth is not taken into consideration because it is carried out over a small area. So, the surface of the earth is considered as plane. In such surveying, a line joining any two points is considered as plane. In such surveying, a line joining any two points is considered to be straight line. The triangle form by any three points is considered as a plane triangle and the angles of the triangle are assumed to be plane angles.

Geodetic Surveying : In geodetic surveying the curvature of the earth is taken into consideration. It is extended over a large area. The line joining any two points is considered as a curved line. The triangle formed by any three points is considered to be spherical and the angle of the triangle formed of any three points is considered to be spherical and the angles of the triangle are assumed to be spherical angle. Geodetic surveying is conducted by the survey of India department, and is carried out over an area exceeding 250 km^2.

(i) Topographical surveying, is done to determine the natural features of a country.
(ii) Cadastral surveying, is conduted in order to determine the boundaries of fields, estates, house etc.

General Principle of Surveying

The general Principle of Surveying are to

1. work from the whole to the part, and
2. locate a new station by at least two measurements (linear or angular) from fixed reference point.

According to the first principle, the whole area is first enclosed by main station (controlling stations) and main survey line (controlling lines). The area is then divided into a number of parts by forming conditioned triangles. A nearly equilateral triangle is considered to be the best well- conditioned triangle. The main survey line is measured very accurately as a standard chain. Then the sides of the triangle are measured. The purpose of above process is to avoid accumulation of error.

Methods of Linear Measurement

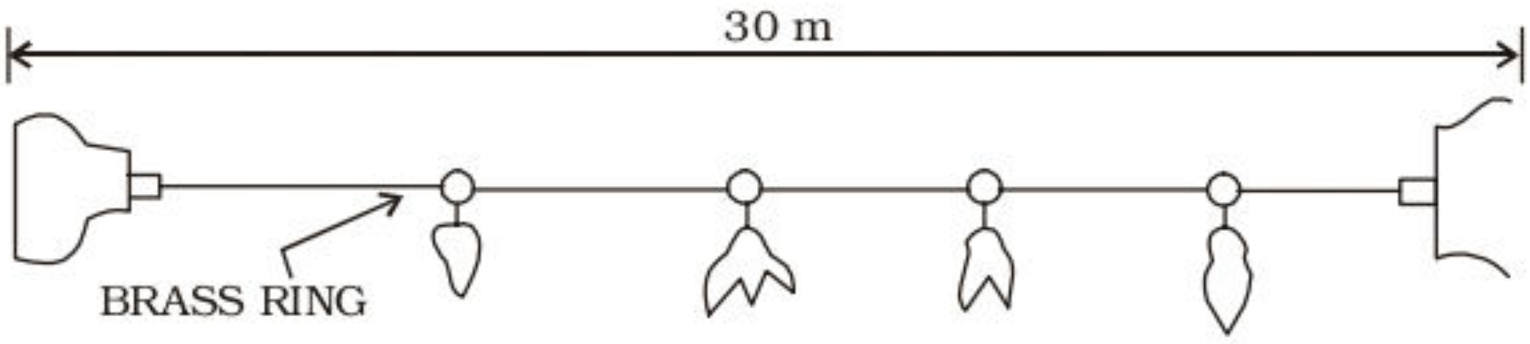
1. By pacing or stepping
2. By passometer
3. By speedometer
4. By peramabulator
5. By chaining

Chains : A chain is prepared with 100 or 150 pieces of galvanised mild steel wire of diameter 4 mm.

The following are the different types of chain.

(a) Metric Chain : Metric chains are available in length of 20m and 30m. The 20m chain is divided into 100 link each of 0.2m. Tallies are provided at every 10 link 2m. This chain is suitable for measuring distances along fairly leveled ground.

As per ISI recommendations, tallies should be provided after every 5m and brass rings, after every central tally two teeth and the tallies on opposite sides of it haveing one tooth each.



AT EVERY METRE

→	0	5m	10m	15m	20m	25m	30m
←	30m	25m	20m	15m	10m	5m	0

(b) Steel Band : It consists of a steel ribbon of width 16 mm and of length 20 or 30 m. It has a brass handle at each end. It is graduated in metres, decimetres, and centimetres on one side and has 0.2 m links on the other. The steel band is used in project where more accuracy is required.

(c) Engineer's Chain : The engineer's chain is 100 ft long and is divided into 100 links. So each link is of 1ft. Tallies provided at very 10 links (10N), central tally bend round. Such chain were previously used for all engineering work.

(d) Gunter's Chain : It is 66 ft long and divided in to 100 links. So, each link is of 0.66 ft.

(e) Revenue Chain : The revenue chain is 33 ft long and divided into 16 links. It is mainly used in candastral survey.

Ranging : The process of establishing intermediate pair on a straight line between two end points is known as ranging.

Ranging may be of two kinds.

(1) Direct and

(2) Indirect or reciprocal

1. Direct Ranging : When intermediate ranging rods are fixed on a straight line by direct observation from end stations, the process is known as direct ranging. Direct ranging is possible when the end stations are intervisible.

2. Indirect or Reciprocal ranging : When the end static are not intervisible due to there being high ground between them, intermediate ranging rods are fixed on the line an indirect way. This methods is known as indirect ranging or reciprocal ranging.

1. Compensating errors : Error which may occur in both direction (i.e. both positive and negative) and which finally tend to compensate are known as compensating errors. These errors do not affect survey work seriously. They are proportional to $\sqrt{L}$, where L is the length of the line.

2. Cumulative errors : Errors which may occur in the said direction and which finally tend to accumulate are said to be cumulative.

3. Mistakes : Errors occuring due to the carelessness error, the chainman are called 'mistakes'.

CHAIN AND TAPE CORRECTIONS

A. Tape Correction

1. Temperature correction (c_t) : This correction is necessary because the length of the tape or chain may be increased or decreased due to rise or fall of temperature during measurement. The correction is given by expression:-

$$c_t = \alpha\,(T_m - T_o)L$$

Where,

c_t = correction for temperature in metres.

α = coefficient of thermal expansion.

$\sqrt{m}$ = temperature during measurement in degrees centigrade or celsius.

T_o = temperature at which the tape was standardised, in degrees centigrade or celcius.

L = Length of tape in metres. The sign of correction may be positive or negative according as T_m is greater or less than T_o.

2. Pull Correction (C_P) : During measurement, the applied pull may be either more or less than the pull at which the chain or tape was standardised. Due to the elastic property of materials, the strain will view according to the variation of applied pull and hence necessary correction should be applied. This correction is given by the expression.

$$C_p \quad \frac{(P_m \quad P_0)L}{A \quad E}$$

C_P = Pull correction in metres.

P_m = Pull applied during measurement in kilograms.

P_0 = Pull at which the tape was standradised, in kilograms.

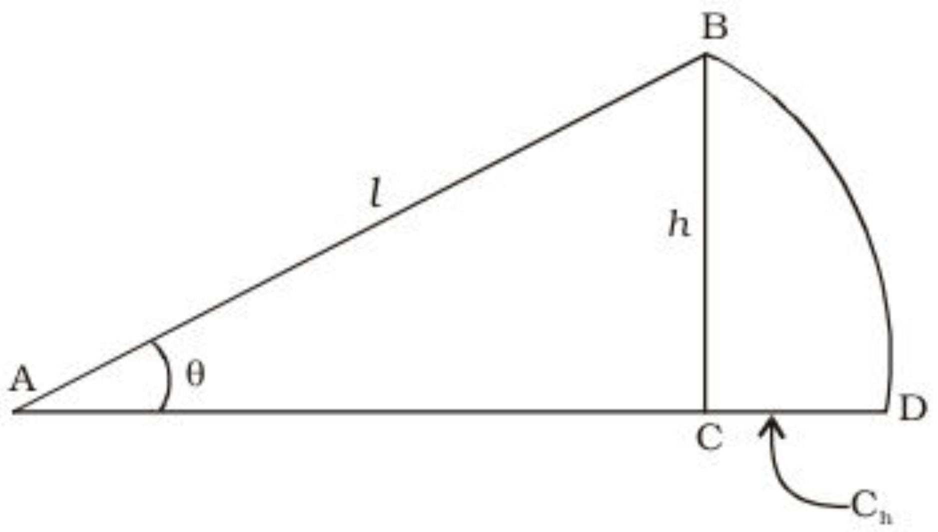
L = Length of tape in metre

A = Cross-sectional area of tape, in square centimetre.

E = Modulus of elasticity (Young's modulus)

The sign of correction will be positive or negative according as P_m greater or less than P_0.

3. Slope Correction (C_n) : Slope correction is calculated as follows.



$C_h = 1 \quad \sqrt{1^2 \quad h^2}$ (exact) ...(1)

$= 1\ (1 - \cos\theta)$ (exact) ...(2)

$= \dfrac{h^2}{2l}$ (approx)

4. Sag Correction (C_s) : This correction is necessary when the measurement is taken with the tape in suspension (i.e. in the from of a centenary). It is given by the expression

$$C_S = \frac{L(WL)^2}{24n^2P_m^2} \quad \text{...(1)}$$

when unit weight is given

and, $C_S = \dfrac{LW^2}{24n^2P_m^2}$

when total weight is given.

Where, C_S = sag correction, in metres.

L = length of tape or chain in metres.

w = weight of tape per unit length, in kilogram per metre.

W = total weight of tape, in kilograms

n = number of spans

P_m = Pull applied during measurment, in kilograms. The sign of correction is always negative.

Representative fraction (RF) : The ratio of the distance during to the corresponding actual length of the object is known as the representative fraction,

$$RF = \frac{\text{distance of object}}{\text{corresponding actual distance of object}}$$

(both distance in same units) is incorrect

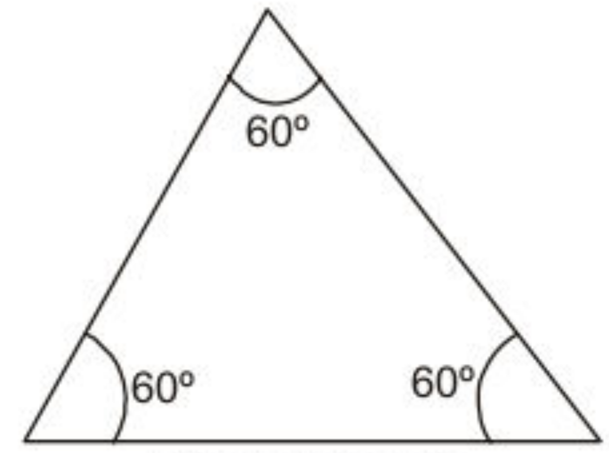
For example,

If a scale is 1 cm = 10 m, then

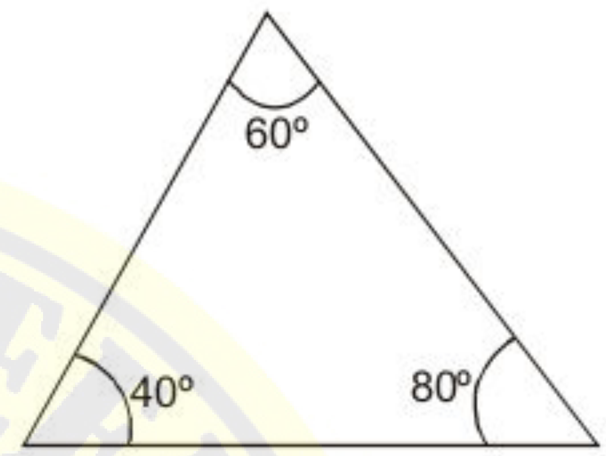
$$RF = \frac{1}{10 \quad 100} \quad \frac{1}{1000}$$

PRINCIPLE OF CHAIN SURVEYING

The principle of chain surveying is triangulation. A triangle is said to be well-conditioned when no angle in it is less than 30° or greater than 120°.

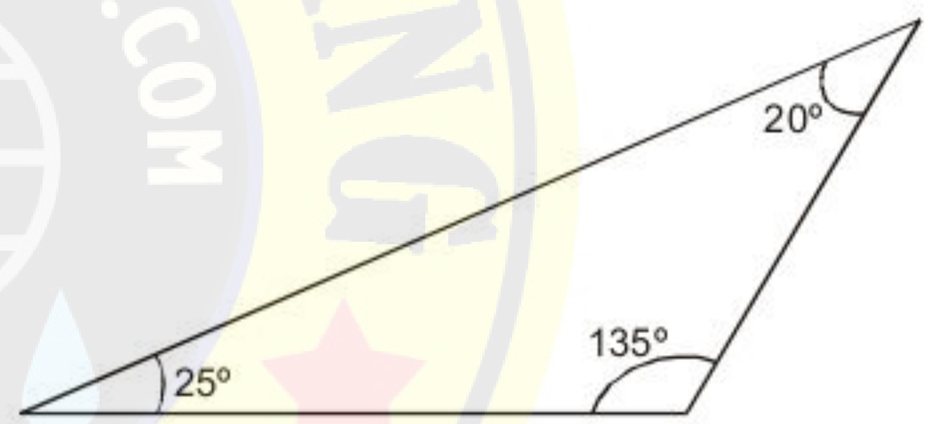


(a) Ideal triangle



(b) Well-conditioned of Triangle

A triangle in which an angle is less than 30° or more than 120° is said to be conditioned.



(c) Conditioned Triangle

A. Survey Stations

These are :

1. Main Stations : Stations taken along the boundary of an area as controlling points are known as 'main stations.' The lines joining the main stations are called main survey lines.

2. Subsidiary Stations : Stations which are on the main survey line or any other survey line are known as "subsidiary stations". These stations are taken to run subsidiary line for dividing the area into triangle.

3. Tie Stations : These are also subsidiary stations taken on the main survey line. Lines joining the tie stations are known as tie lines. These lines are mainly taken to fix the directions of adjacent sides of chain survey map.

B. Base Line : The line on which the work of the survey is built is known as the 'base line.' It is the most important line of the survey. Generally, the longest of the main survey lines is considerd to be the base line. This line should be taken through fairly level ground, and had to be measured very carefully and accurately.

C. Check Line : The line joining the apex point of a triangle to some fixed point on its base is known as the 'check line'. It is taken to check the accuracy of the triangle. Sometimes this line helps to locate interior details.

D. Offset : The lateral measurement taken from an object to the chain line is known as 'offset'. Offsets are taken to locate objects with reference to the chain line.

Cross-Staff : The cross-staff is a simple instrument for setting out right angles. There are three types of cross-staff.

Optical Square : An optical square is also used for setting out right angles. It consists of a small circular metal box of diameter 5 cm and depth 1.25 cm. It has a metal cover which slides over the box to cover the slits.

Principle : According to the principle of reflection the angle between the first incident ray and the last reflected ray is twice the angle between the mirrors. In this case, the angle between the mirrors fixed at 45°. So, the angle between the horizon sight and index sight will be 90°.

Compass Traversing : In chain surveying the area to be surveyed is divided into number of triangles. This method is suitable for fairly level ground covering small areas. But when the area is large, undulating and crowed with many detail triangulation (which is the principle of chain survey) is not possible. In such an area, the method of traversing is adopted.

Definitions

1. True Meridian : The line or plane passing round the geographical north pole, geographical south pole and any point on the surface of the earth is known 'true meridian' of geographical meridian.

2. Magnetic Meridian : When a magnetic needle is suspended freely and balanced properly, unaffected by magnetic substance, it indicate a direction. This direction is known as the 'magnetic meridian'.

The angle between the magnetic meridian and a line is known as the 'magnetic bearing' or simply the bearing of the line.

3. Arbitrary Meridian : Sometimes for the survey of small area, a convenient direction is assumed as a meridian known as the 'arbitrary meridian'. Sometimes the star line of a survey is taken as the arbitary meridian. The angle between the arbitrary meridian and a line known as the 'arbitrary bearing of the line.

4. Grid Meridian : Sometimes, for preparing a map some state agencies assume several line parallel to the meridian for a particular zone. These lines are termed as 'grid line' and the central line the 'grid meridian'. The bearing of a line with respect to the grid meridian is known as the 'grid bearing' of the line.

5. Designation of Magnetic Bearing : Magnetic bearing are designated by two systems.

(a) Whole Circle Bearing (WCB) : The magnetic bearing of line measured clockwise from the north pole towards the line, is known as the 'whole circle bearing' of the line. Such a bearing may have any value between 0° an 360°. The whole circle bearing of a line is obtained by prismatic compass.

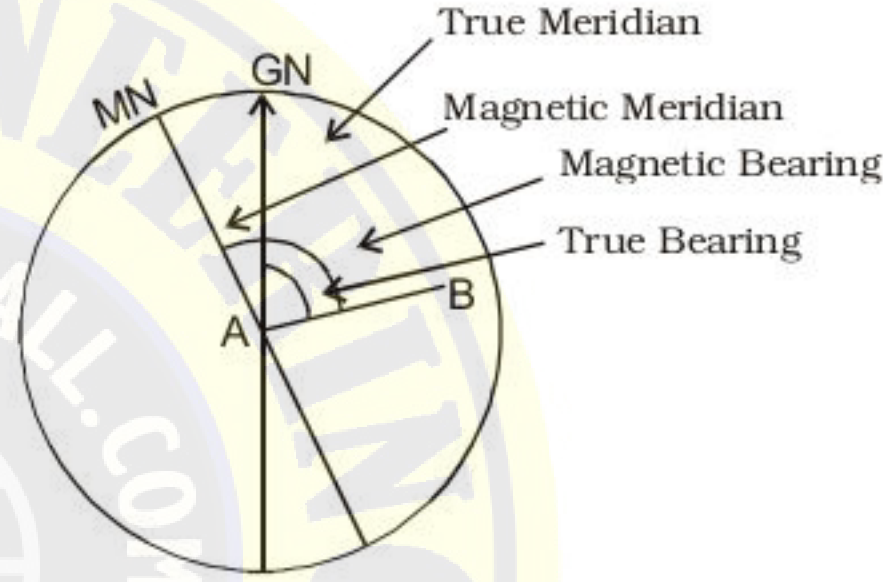
WCB of AB = θ_1

WCB of AC = θ_2

WCB of AD = θ_3

WCB of AE = θ_4

(b) Quadrantal Bearing (QB) : The magnetic bearing of a line measured clockwise or counter clockwise from the north pole or south pole (whichever is nearer the line) towards the east or west is known as the 'quandrantal bearing' of the line. This system consists of four quadrants–NE, SE, SW and NW. The value of a quandrantal bearing lies between 0° and 90°.



6. Reduced bearing (RB) : When the whole circle bearing of a line is converted to quandrantal bearing, it is termed the 'reduced bearing'. Thus, the reduced bearing is similar to the quandrantal bearing. Its value lies between 0° and 90° but the quadrants should be mentioned for proper designation the following table should be remembered for conversion of WCB to RB.

WCB between	Corresponding RB	Quadrant
0° and 90°	RB = WCB	NE
90° and 180°	RB = 180°– WCB	SE
180° and 270°	RB = WCB– 180°	SW
270° and 360°	RB = 360°– WCB	NW

7. Fore and back bearing : The bearing of line measure in the direction of the progress of survey is called on 'fore bearing' (FB) of the line.

The bearing of the measured in the direction opposite to the survey is called the 'back bearing' (BB) of the line.

For example

FB of AB = θ

BB of AB = θ_1

Remember the following :

(a) In the WCB system the difference between the FB and BB should be exactly 180°. Remember the following relation.

$$BB = FB \pm 180°$$

Use the positive sign when FB is less than 180°, and the negative sign when it is more than 180°.

(b) In the quandrantal bearing (reduced bearing) system the FB and BB are numerically equal but the quadrant are just opposite.

For example if the FB of AB is N 30° E, then it's BB is 30°.

8. Magnetic declination : The horizontal angle between the magnetic meridian and true meridian is known as 'magnetic declinaton'.

When the north end of the magnetic needle is pointed towards the west side of the true meridian, the position is termed 'declination west' ("QW). When the north end of the magnetic needle is pointed towards the east side of the true meridian, the position is termed as 'Declination East' (QE).

9. Isogonic and agnoic lines : Line passing through point of equal declination are known as 'isogonic' lines.

The line passing through points of zero declination is said to 'agonic' line.

10. Dip of the magnetic needle : If a needle is perfectly balanced before magnetisation, it does not remain in the balanced position after it is magnetised. This is due to the magnetic influence of the earth. The needle found to be inclined towards the pole. This Inclination of the needle with the horizontal is known as the 'dip of the magnetic needle'.

It is found that the north end of the needle is deflected down towards in the northern hemisphere and then its south end is deflected downwards in southern hemisphere. The needle is just horizontal at the equal.

11. Local attraction : A magnetic needle indicates the north direction when freely suspended or pivoted. But if the needle come near some magnetic substances, to be deflected from its true direction, and does not show the actual north. This disturbing influence of magnetic substances is known as 'local attraction'.

If the FB and BB of a line do not differ by 180°, the needle is said to be affected by local attraction provided there is no instrumental error.

Principle of Compass Surveying : The principle of compass surveying is traversing, that involves a series of connected lines. The magnetic bearings of the line are measured by prismatic compass and the distance of the lines are measured by chain.

Compass surveying is recommended when,

1. A large area to be surveyed
2. The course of a river or coast line to be surveyed and
3. The area is crowded with many details and triangulation is not possible.

Traversing : As mentroned above, surveying that involves a series of connected line is known as traversing. The sides of the traverse are known as traverse legs.

Methods of Traversing : Traverse survey may be conducted by the following methods:

1. Chain traversing (by chain angle).
2. Compass traversing (by free needle).
3. Theodolite traversing (by fast needle) and
4. Plane table traversing (by plane table).

Types of Compass : There are two types of compass

1. The Prismatic Compass : In this compass, the radi are taken with the help of a prism. The following are the essential parts of this compass.

(a) Compass Box
(b) Magnetic needle and graduated ring
(c) Sight vane and Prism
(d) Dark glasses
(e) Adjustable mirror
(f) Brake pin
(g) Liffting pin

2. The Surveyor's Compass : The surveyor's compass is similar to the prismatic compass except for the following points,

(a) There is no prism on it. Readings are taken with naked eye.
(b) It consists of an eye-vane (in place of prism) with a fine sight slit.

Determination of true being and magnetic bearing :

(a) True bearing = magnetic bearing ± declination

Note : Use the positive sign when declination in east and the negative sign when declination in west.

(b) Magnetic bearing = true bearing ± declination

Note : Use the positive sign when declination west, and the negative sign when declination east.

Adjustment of Closing error : When closed traverse is plotted, the finishing and starting point may not consider. The distance by which traverse fails to close is said to be the closing error such as error may occur due to mistakes made in the measurement of length and bearing of the lines, or because of an error in ploting.

If the closing error exceeds a certain permissible limit the field work should be repeated. But when the error is within the permissible limit, it is adjusted graphically by Bowditch's rule.

PLANE TABLE SURVEYING

Principle : The principle of plane tabling is parallelism that the rays drawn form stations to objects on the paper are parallel to the lines from the station to the objects on the ground. Plane tabling is a graphical method of surveying.

Accessories of Plane Table

1. The Plane Table
2. The Alidade

The function of alidade is to view objects. Which theroy's are drawn with respective edge of view.

3. The Spirit Level : The sprit level is a small metal tube containing a small bubble of sprit. The bubble is visible on the top along a graduated glass tube. The spirit level is meant for levelling the plane table.

4. The Compass

5. U–fork or plumbing fork with Plumbob : The U-fork is a metal strip bent in the shape of a 'U' (hair pin) having equal arms length.meank to center table over a station.

Methods of Plane Tabling

The following are the four methods of Plane tabling.

1. Radiation : This method is suitable for locating the objects from a single stations. In this method, rays are drawn from the station to be objects, and the distance from the station to the objects are measured and plotted to any suitable scale along the respective rays.

2. The Intersection Method : This method is suitable for locating in accessible points by the intersection of the rays drawn from two instrument stations.

3. The Traversing Method : This method is suitable for connecting the traverse station. This is similar to compare traversing or theodalite traversing. But here fielding and pointing are done simultaneously with the help of the reaction and intersection methods.

4. The Reaction Method : This method is suitable for establishing new stations at a place in order to locate missing details.

Special Methods of Resection

If no station pegs are found on the field, some special methods of reaction are applied in order to establish a new station for ploting the missing object. The methods are based on.

1. The two–point problem and
2. The three–point problem

1. The Two-point Problem : In this problem, two well-defined points whose positions have already been plotted on the plane are selected. Then by perfectly bisecting these points, a new station is established at the required position.

2. The Three-point Problem : In this problem, three well-defined points are selected whose positions have already been plotted on the maps. Then, by per-cent, station is established at the required position.

LEVELLING

Object : The aim of levelling is to determine the relative heights of different objects on or below the surface of the earth and to determine the undulation of the ground surface.

Definitions

1. Levelling : The art of determining the relative heights of different points on or below the surface of the earth is known as levelling. Thus, levelling deals with measurements in the vertical plane.

2. Level Surface : Any surface parallel to the mean spheroidal surface of the earth is said to be a level surface. Such a surface is obviously curved. The water surface of a still lake is also considered to be a level surface.

3. Level line : Any line lying on a level surface is called a level line. This line is normal to the plumb line (direction of gravity) at all points.

4. Horizontal Plane : Any plane tangential to the level surface at any point is known as the horizontal plane. It is perpendicular to the plumb line which indicates the direction of gravity.

5. Horizontal line : Any line lying on the horizontal plane is said to be a horizontal line. It is a straight line, tangential to the level line.

6. Vertical Line : The direction indicated by a Plumb line (the direction of gravity) is known as the vertical.

7. Vertical Plane : Any plane passing through the vertical line is known as the vertical plane.

8. Datum surface or line : This is an imaginary level surface or level line from which the vertical distance of different points (above or below this line) are measured. In India the datum adopted form the given Trigonometrical survey (GTS) is the mean sea level (MSC) at Karachi.

9. Reduced level (RL) : The vertical distance of point above or below the datum line is known as the reduced level (RL) of that point. The RL of a point may be positive or negative according to as the point is above or below the datum.

10. Line of collimation : It is an imaginary line passing through the intersection of the cross-hairs at the diaphragm and the optical centre of the objects glass and its continuation. It is also known as the line of sight.

11. Axis of the telescope : It is an imaginary line passing through the optical centre of the object glass and the optical centre of the eye-piece.

12. Axis of bubble tube : It is an imaginary line tangential to the longitudinal curve of the bubble tube at its middle point.

13. Bench-marks (BM) : These are fixed points or marks of known RL determined with reference to the datum line. These are very important marks. These survey as open in projects are involvedin roadways, railway etc.

Bench-marks may be of four type (a) GTS (b) Permanent (c) temporary and (d) arbitary.

14. Backsight reading (BS) : This is the first staff reading taken in any set up of the instrument after the levelling has been perfectly done. This reading is always taken on a point of known RL, on a bench-mark or change point.

15. Foresight reading (FS) : It is the last staff reading in any set up of the instrument, and indicates the shifting of the latter.

16. Intermediate Sight Reading (IS) : It is any other state reading between the BS and FS in the same set up of the instrument.

17. Change Point (CP) : This point indicates the shifting of the instrument. At this point, an FS is taken from one setting and BS from the next setting.

18. Height of Instrument (HI) : When the levelling instrument is properly levelled, the RL of the line of collination is known as the height of the instrument. This is obtained by adding the BS reading to the RL or CP on which the staff reading was taken.

19. Focussing : The operation of setting the eye-piece end the object glass is at a proper distance apart for clear vision of the object is known as focussing. This is done by turning the focussing screw clockwise or anticlockwise.

20. Diaphragm : The diaphragm is a brass ring fitted inside the telescope, just in front of the eyepiece. It can be adjusted by four screws. The ring carries the cross-hair, which gets magnified when viewed through the eye-piece.

Types of Levelling Operation

1. Simple Levelling : When the difference of level between two points is determined by setting the levelling instrument midway between the points, the process is called simple levelling.

2. Differential Levelling : Differential levelling is adopted when (i) the points are a great distance apart (ii) the difference of elevation between the points is large, (iii) there are obstacles between the points.

3. Fly levelling : When differential levelling is done in order to connect benchmark to the starting point of the aligment of any project, it is called fly levelling. Fly levelling is also done to connect the BM to any intermediate point of the aligment for checking the accuracy of the work.

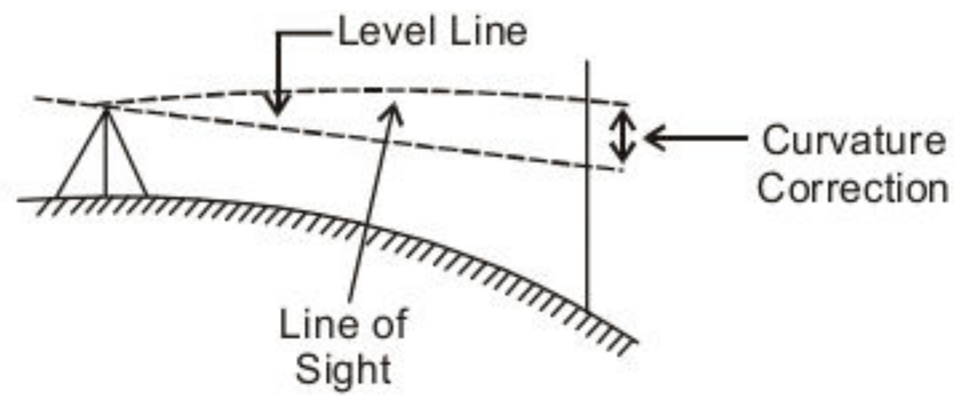
4. Longitudinal or Profile Levelling : The operation of taking levels along the centreline of any aligment (roads, railway, etc.) at regular intervals is known as longitudinal levelling.

5. Cross-sectional levelling : The operation of taking levels transverse to the direction of longitudinal levelling, is known as across-sectional levelling. The cross-sections are taken at regular interval (such 20m, 40m, 50m etc.) along the alignment. In cross-sectional, levelling is done in order to know the nature of the ground across the centre line of any aligment.

6. Check-Levelling : The fly levelling done at the end of day's work to connect the finishing point with the starting point on that particular day is known as check levelling.

CORRECTIONS TO BE APPLIED

1. Curvature Correction : For long sights, the curvature of the earth affects small staff readings. The line of sight is horizontal, but the level line is curved and parallel to the mean spheroidal surface of the earth.



Curvature correction, $C_c \quad \frac{D^2}{2R}$

C_e^2 is neglected being very small as compared to the diameter of the earth.

$$C_C = \frac{D^2 \quad 100}{12{,}742} = 0.0785D^2 \text{ m (negative)}$$

Hence, True staff reading = Observed staff reading curvature correction.

2. Refraction Correction: Rays of light are refracted when they pass through layers of air of varying density so, when long sights taken, the line of sight is refracted towards the surface of the earth in a curved path. The radius of the curve is seven time that of the earth under normal atmospheric condition due to the effect of refraction, object appear higher than they rellay are. But the effect of curvature varies being affected by number of atmospheric conditions such as air density, moisture, etc.

However, on an average the refraction correction is taken as one–seventh of the curvature correction.

$$C_r \quad \frac{1}{7} \quad \frac{D^2}{2R}$$

Refraction correction, $C_r = \frac{1}{7} \times 0.0785\ D^2$

$= 0.0112\ D^2$m

Refraction correction is always additive (i.e. positve) True staff reading = Observed staff reading + Refraction is as follows :

Combined correction = curvature correction + reflection correction.

3. Combined Correction : The combined effect of curvature and refraction is as follows.

Combined correction = curvature correction + refraction correction

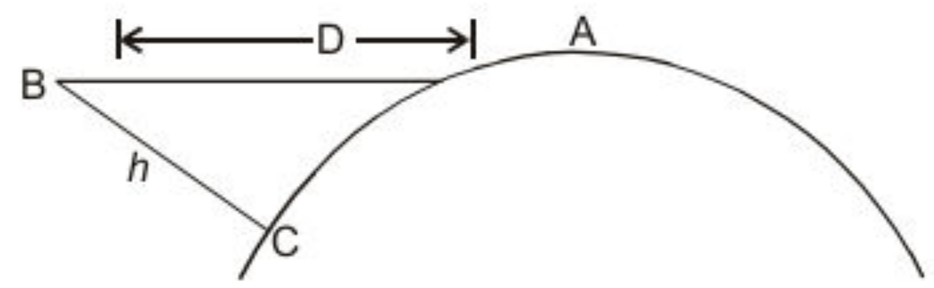
$= -\ 0.0785\ D^2 + 0.0112D^2 = -\ 0.0673D^2$m

So, combined correction is always subtractive (negative) true staff reading = observed staff reading – combined correction.

Combined correction may also be expressed as :

$$\frac{D^2}{2R} \quad \frac{1}{7} \quad \frac{D^2}{2R} \quad \frac{6}{7} \cdot \frac{D^2}{2R} \text{ (negative)}$$

4. Visible horizon distance



Considering curvature and reflection corrections.

$$h = 0.0673\,D^2$$

$$D \sqrt{\frac{h}{0.0673}}$$

6. Sensitiveness of the bubble : The term sensitive in the context of a bubble means the effects caused by the deviation of the bubble per division of the graduation of the bubble tube.

Sensitiveness is expressed in term of the radius of curvature of the upper surface of the tube or by an angle through which the axis is tilted for the deflection of one division of the graduation.

Reciprocal Levelling : But in the case of a river or valley, it is not possible to set up the level midway between two points on opposite banks. In such cases, the method of reciprocal levelling is adopted, which involves reciprocal observation from both bank of the river or valley.

Methods of calculations of reduced Level

The following are the two system of calculating reduced level

1. The collimation system or height of instrument system (HI).

2. The rise – and – fall system.

1. The Collimation System : Arithmetical check $\Sigma BS - \Sigma FS$ = Last RL – 1st RL.

The difference between the sum of back sights and that of fore sights must be equal to the difference between the last RL and the first RL. This check varies the calculation of the RL of the HI and that of the change point. There is no check on the RLS of the intermediate points.

2. The rise and fall system : Airthmetical check :

$\Sigma BS - \Sigma FS = \Sigma rise - \Sigma fall$ = last RL – 1st RL

In this method, the difference between the sum of BS_S and that of FS_S, the difference between the sum of rises and that of falls and the difference between the last RL, and the first RL must be equal.

The arithmetical check is meant only for the accuracy of calculation to be verified. It does not verify the accuracy of field work. There is a complete check or the RL_S of intermediate points in the rise and fall system.

Comparision of the two system.

Collimation System	Rise-and-Fall System
1. It is rapid as it involves few calculations	1. It is laborious, involving several calculations.
2. There is no check on the RL of intermediate points.	2. There is a check on the RL of intermediate point.
3. Errors in intermediates RLS cannot be detected.	3. Errors in intermediate RLS can be detected as all the points are corrected.
4. There are two checks on the accuracy of RL calculation.	4. There are three checks on the accuracy of RL calculations.
5. This system is suitable for longitudinal where there are a number of intermediate sights.	5. This system is suitable for ply levelling where there are no intermediate sights.

Considering the above points, the rise-and-fall system is always preferred as there is no possibilitiy of any error in the calculation of RLS in the intermediate points.

Determination of Stadia Constant

From the theory of the telescope, it is known that

$$D = (f/i) \times s + (f + d)$$

Where,

D = distance between vertical axis of telescope of staff

f = focal length of objects glass

i = length of image

s = difference of reading between the lower and and higher stadiss.

d = distance between optical centre and vertices axis of telescope.

The quantity (f/i) is known as the multiplying constant and its value is usually 100. The quantity $(f + d)$ is called the additive constant and its value is normally zero. But sometimes, its value lies between 20 and 30 cm.

Contouring

1. Contour line : The line of intersection of a level surface with the ground surface is known as the contour line or simply the contour. It can also be defined as a line passing through points of equal reduce level.

2. Contour Interval : The vertical distance between any two consecutive contours is known as a countour interval.

3. Horizontal Equivalent : The horizontal distance between any two consecutive contonours is known as horizontal equivalent. It is not constant but varies according to the steepness of ground.

Characteristics of Contours

1. In fig. 1, the contour lines are closer near the top of a hill or high ground and wide apart near the foot. This indicates a very steep slope towards the peak and a flatter slope towards the foot.

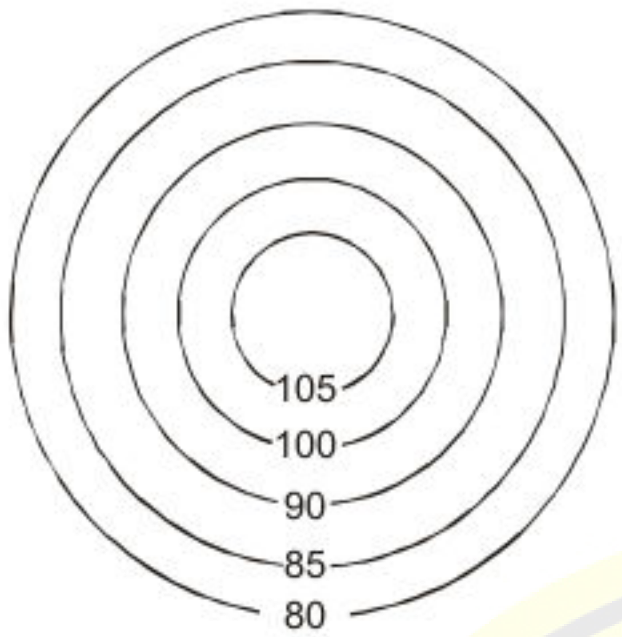


Fig. 1. Hill

2. In fig. 2, the contour line are closer near the bank of a pond or depression and wide apart toward the centre. This indicates a steep slope near the bank and a flatter slope at the centre.

3. Uniformly spaced, contour lines indicate a uniform slope (fig 3)

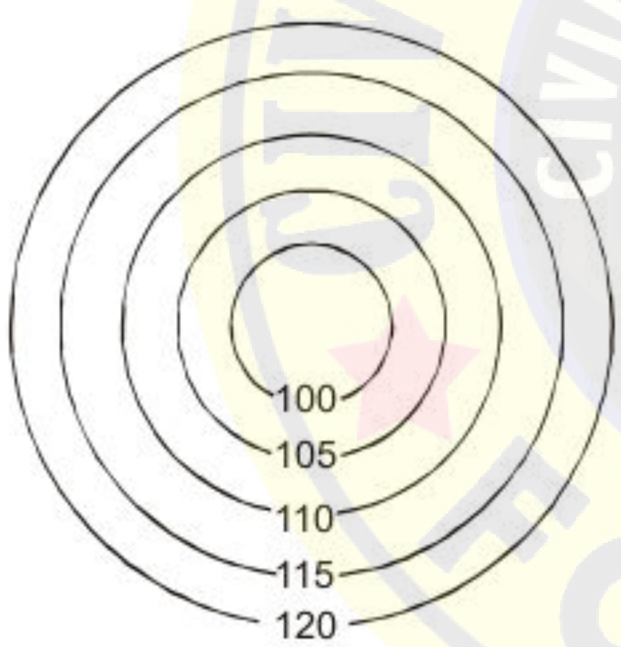


Fig. 2. Depression

4. Contour line always form a closed circuit. But these lines may be within or outside the limits of the map (fig. 4)

Fig. 3

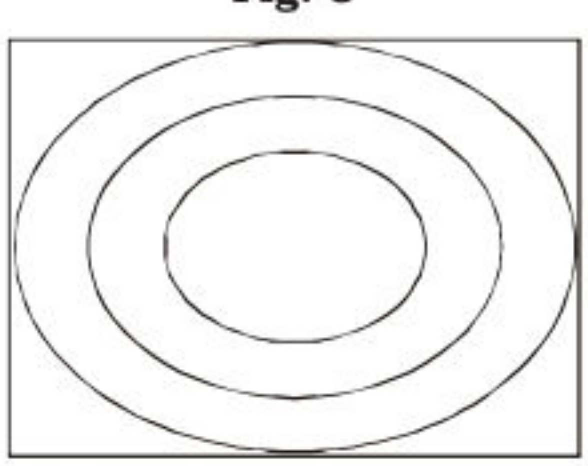


Fig. 4

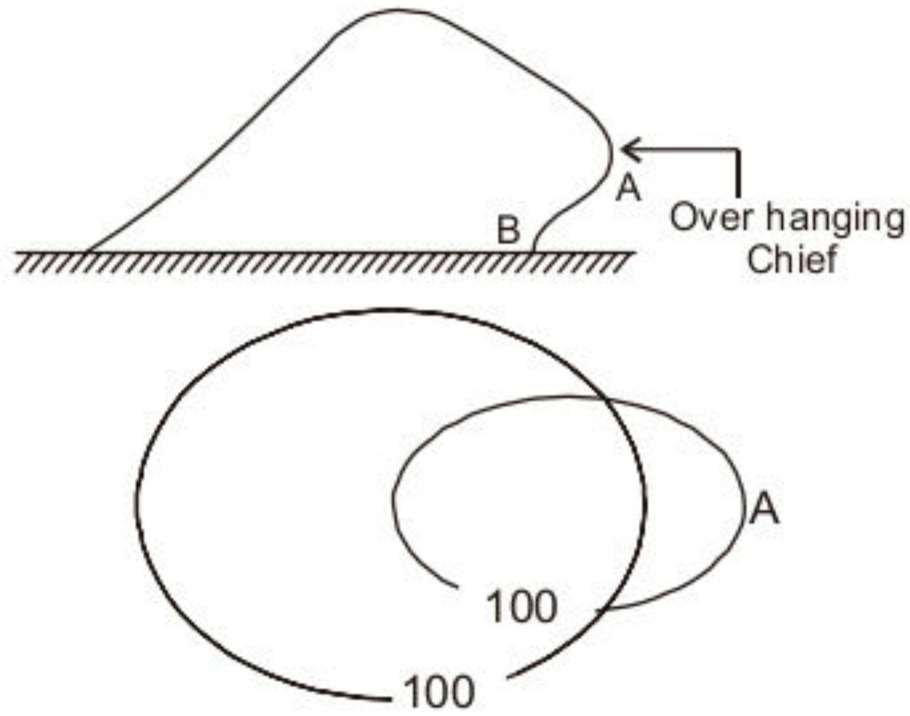


Fig. 5

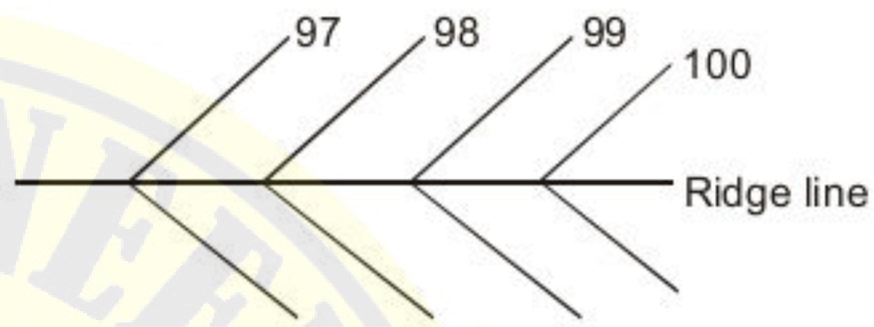


Fig. 6. Ridge Line

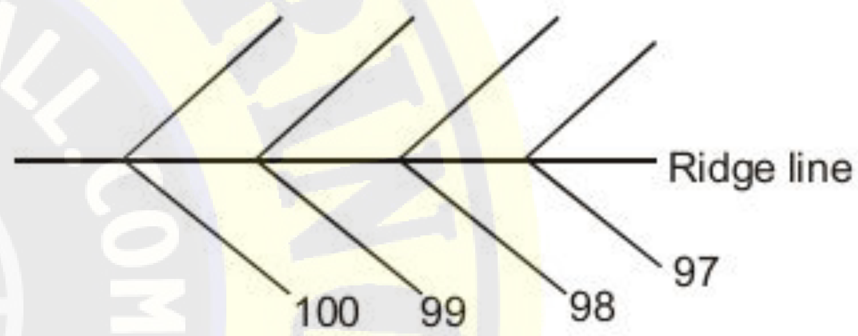


Fig. 7. Valley Line

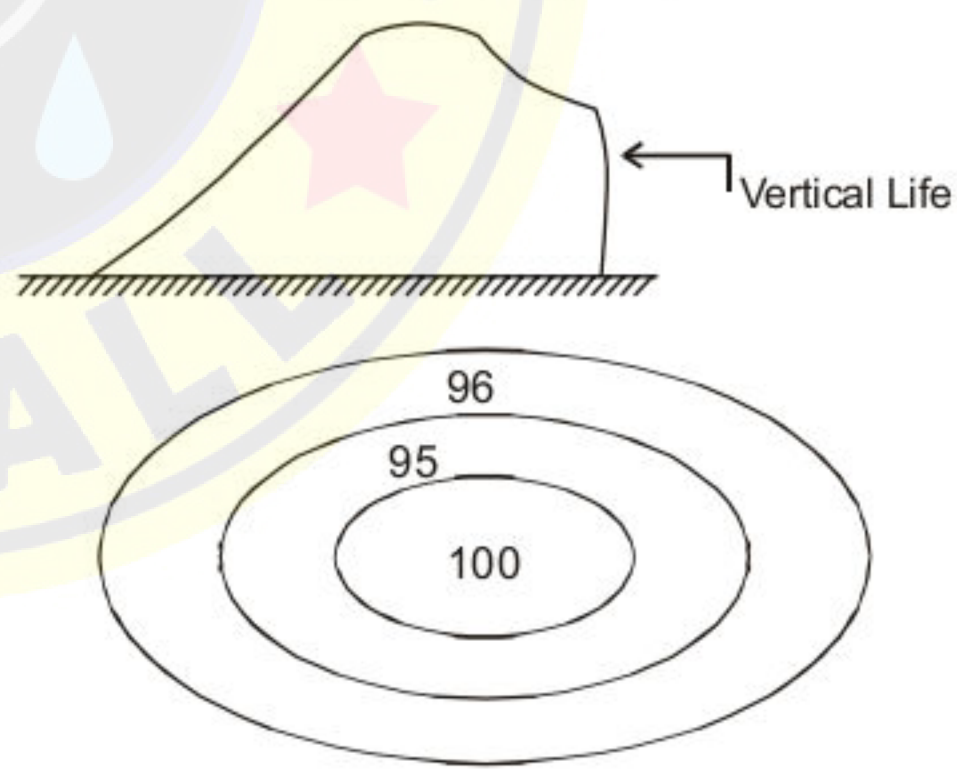


Fig. 8

5. Contour lines cannot cross one another, except in the case of an overhanging cliff. But the overlapping portion must be shown by a dotted line (fig. 5)

6. When the higher value are inside the loop, it indicates a ridge line. Contour line and cross ridge lines are at right angles (fig. 6).

7. When the lower values are inside the loop, it indicates a valley line at right angles.

8. Contour lines meeting at a point indicate a vertical cliff (fig. 8).

Formula for Calculation of Volume

A. Trapezoidal Rule (Average and Area Rule)

Volume (cutting or filling),

$$V = \frac{D}{2}\{A_1 \quad AN \quad 2(A_2 \quad A_3 \; \ldots \; A_{n \; 1})\}$$

$$\text{Volume} = \frac{\text{Common distance}}{2}$$

{area of 1st section + area of last section + 2 (sum of area of other section}.

B. Prismoidal Formula

Volume (cutting or filling)

$$V = \frac{D}{3}\{A_1 + A_n + 4(A_2 + A_4) + A_{n-1}\} + 2(A_3 + A_5 + \ldots + A_{n-2})$$

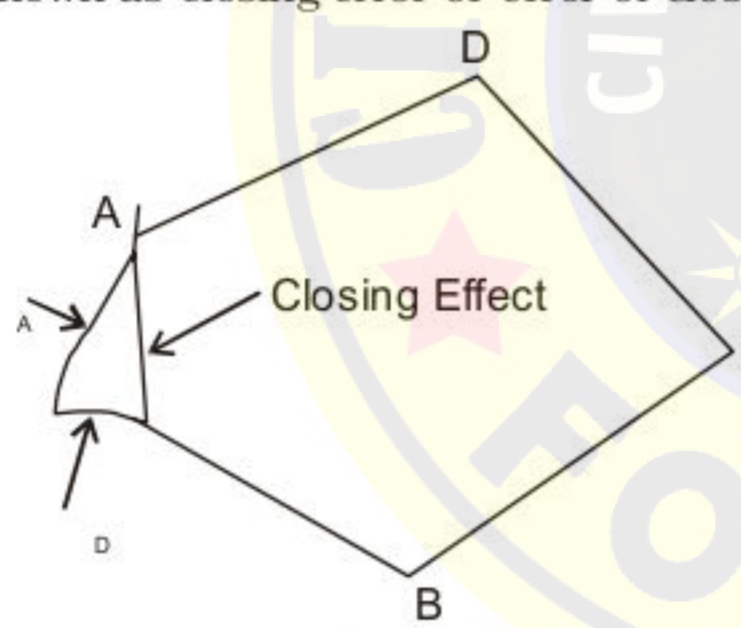
$$V = \frac{\text{Common distance}}{3}$$

{Area of 1st section + area last section + 4 (sum of area of even section) + 2 (sum of area of odd section)}.

The prismoidal formula is applicable when there is an odd number of sections. If the number of section is even, the end strip is treated separetely and the area is calculated according to the trapeziodal rule.

Closing Error and its Limitation

In a closed traverse, the algebraic sum of latitude must be equal to zero, and so should the algebraic sum of departure. The distance by which a traverse fails to close is known as closing error or error of closure.



$$\text{Closing error, } AA_1 = \sqrt{(\ L)^2 \quad (\ D)^2}$$

L = lattitude

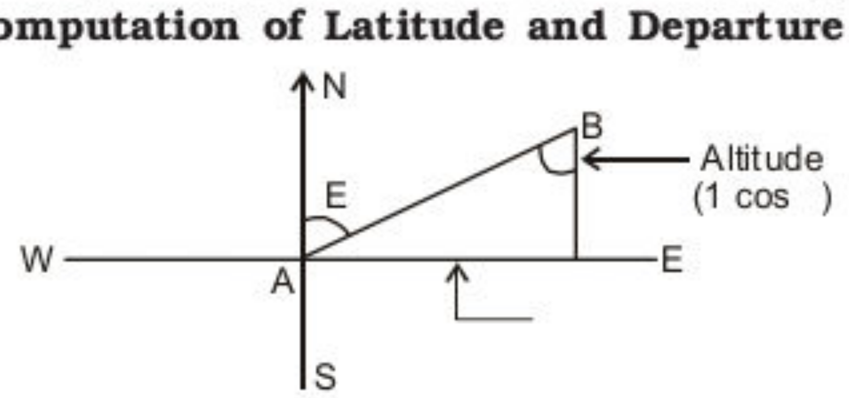
D = departure

$$\text{Relative clossing error} = \frac{\text{closing error}}{\text{perimeter of traverse}}$$

$$\tan\theta = \frac{D}{L}$$

where, θ indicaters the direction of closing error.

Computation of Latitude and Departure



Balancing of Traverse

1. Bowditch's rule : By this rule the total error (in latitude or departure) is distributed in proportion to the length of the traverse legs. This is the most common methods, of traverse adjustment.

(a) Correction to latitude of any side

$$= \frac{\text{Length of that side}}{\text{Perimeter of traverse}} \times \text{total error in latitude}$$

(b) Correction to departure of any side

$$= \frac{\text{Length of that side}}{\text{Perimeter of traverse}} \times \text{total error in departure.}$$

2. Transit rule

(a) Correction to latitude of any side

$$= \frac{\text{latitude of that side}}{\text{arithmetical sum of all latitudes}} \times \text{total error in latitude}$$

(b) Correction to departure of any side

$$= \frac{\text{departure of that side}}{\text{arithmetical sum of all departure}} \times \text{total error in departures.}$$

THEODOLITE TRAVERSING:- A traverse is a series connected lines whose lengths and directions are measured in the field.

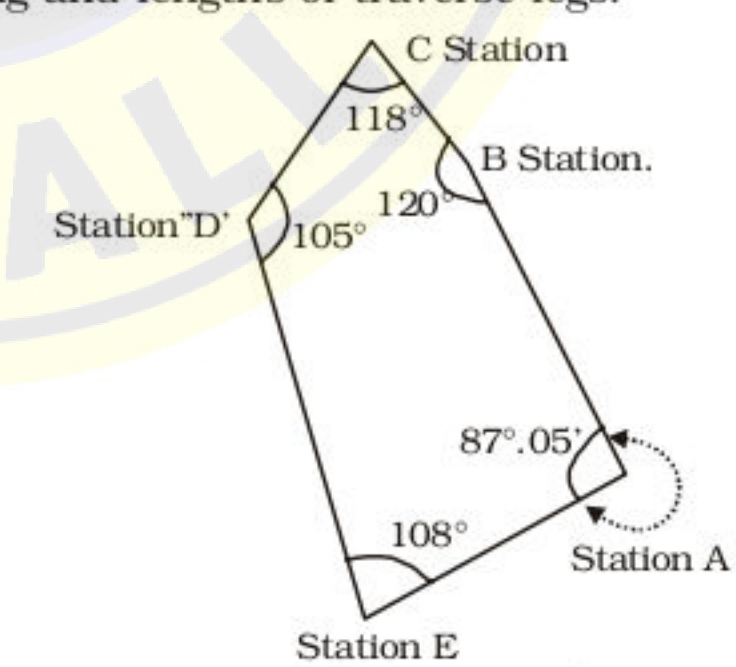
The system of surveying in which the angles are measured with the help of a theodalite is called Theodalite surveying.

(1) DEFFERENT METHODS OF TRAVERSING:-

Fast angle method:-

In this method, the magnetic meridian is established only at the starting station.

This method is used to measure the magnetic bearing and lengths of traverse legs.



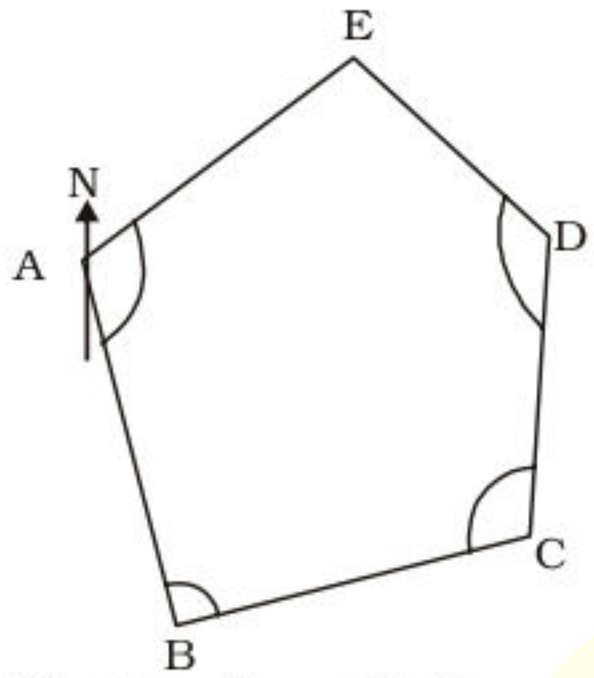
Enterior angle = 272°55'

Loose needle method:-

- In the loose needle method, the direction of the magnetic meridian is established at each traverse station and the direction of the line is determined with reference to the magnetic meridian.
- In this method the linear measurement are done with the help of chain or tape.
- It is also known as "Free Needle Method".

Included angle Method:-

- This method is more accurate than the fast needle method. Traversing by method of included angles is the most commonly used method.
- In this method, the magnetic bearing of any one line is measured in the field.



Direct angle method:-

- This method is similar to the method of included angles explained in the preceeding section.
- However in this method direct angles or the angles to the right are measured.
- This method is generally used to open traverse.

Deflection angle method:-

This method is suitable for open traverse and is mostly employed in the survey of rivers, coastline, roadways, railway, canols etc.

PERMANENT ADJUSTMENT OF DUMPY LEVEL:-

The objective of permanent adjustment of level is to establish the fixed relationship between its fundamental lines.

Followings are the fundamental axis of levelling instrument.

(i) The axis of bubble tube.
(ii) The line of collimation
(iii) The vertical axis
(iv) The axis of telescope

(1) **The desired relationships are**:-

(i) The line of collimation should be parallel to bubble tube axis.
(ii) The line of collimation and axis of telescope should coinside with each other.
(iii) The bubble axis should be perpendicular to vertical axis so that the bubble traverses i.e, remains in the central position for all directions of the telescope.

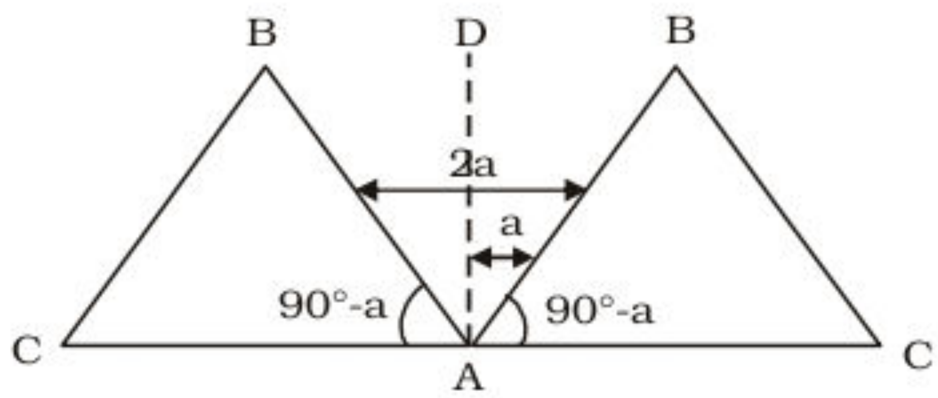
(2) **Each adjustment involves following two steps**

(i) A test to determine the error.
(ii) An adjustment or correction of the above error.

(3) **Principle of Reversal**:-

This principle states that "If any error exists in certain parts of the instrument, it is doubled on reversing i.e, revolving through 180°, the position of that part.

Another use of this method is that, even though the instrument is out of adjustment, accurate results can be obtained by reversing and taking the mean of two observations.



(4) **FIRST ADJUSTMENT**:- To make the axis of the bubble tube perpendicular to vertical axis.

The object of this adjustments is to ensure that if the instrument is once levelled up, then the bubble remains in centre of its run for all positions of the telescope.

Following are the necessities of this adjustment:-

(i) The adjustment is made only for the convenience of taking reading quickly.
(ii) Since it is necessary that the bubble should be central while taking any reading.
(iii) Much time is wasted if these adjustment is not made, as in that case bubble has to be brought in centre every time for each pointing of telescope.

TEMPORARY ADJUSTMEN OF DUMPY LEVEL :

The adjustment to be made at every setting of the instrument are called temporary adjustment. 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

Setting:- Tripod stand is set on the ground firmly such that 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 instrument is provide used to with a less sensitive circular bubble on tribranch for this purpose.

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

(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) **Focussing the objective:-** For this telescope is directed towards the staff and focusing screw is turned till the reading appears clear and sharp.

TACHEOMETRIC SURVEY :

Tacheometric survey is a method of measuring both horizontal distance and vertical elevation of a point in the distance, whithout the use of sophisticated technology, such as electronic distance measurement (EDM) or satellite transmillions.

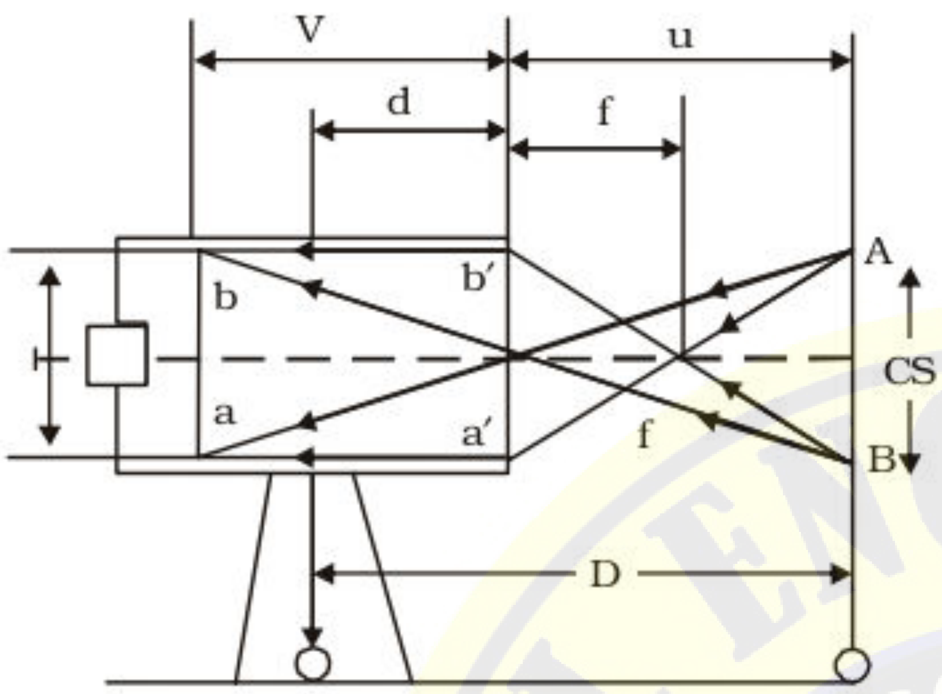
(1) **Fixed hair method**:-

(i) This is a method of finding the distance and elevation of staff from the theodolite (Tacheometer).

(ii) Different formulas are used in finding distance for different cases.

Some cases are disscussed as follows:-

Case1:- When line of sight is horizontal and staff is held vertically:-



Where A,B = Point on staff cut but upper and lower hair

a,b = upper and lower cross hair

ab = i = Stadia interval

AB = s = Staff intercept

D= Distance from axis of tachometer to staff

D= distance between optical center and axis of tachometer

Proof

Fom similar triangle Δ ABf and Δ a' b'f

Wet get,

$$\frac{fC}{AB} = \frac{f_o}{a^1b^1}$$

$$fc = \frac{f_o \times AB}{a^1b^1} = \frac{f \times s}{i} \; (\therefore f_o = f;\ AB = S;\ a^1b^1 = i)$$

Now total distance (D) = fc + f + d = $\frac{f \times s}{i} + f + d$.

Now as i, f and d are constants, we can write that the total horizontal distance.

i.e, D = K. S + C

Where, K = multiplying constant,

C = f+d = additive constant,

Here, vertical distance is zero

(2) **Stadia constants**:-

Stadia or tacheometric constants are :-

(i) A = $\frac{f}{i}$, where f = focal length of the lens,

i = stadia intercept.

The value of multiplying constant is generally 100.

(ii) **Additive constant** :

B . = (f + d), where f = focal length of the lens,

d = horizontal distance between instrument axis to optical centre of a lens.

The value of additive constant varies from 0.15m to 0.60 m.

CURVE SETTING:

Based on the insturment used in setting out the curves on the ground, there are two method:-

(i) Linear method

(ii) Angular method

Linear method:- In these methods only tape or chain is used for setting out the curve. No angle measuring instrument is used.

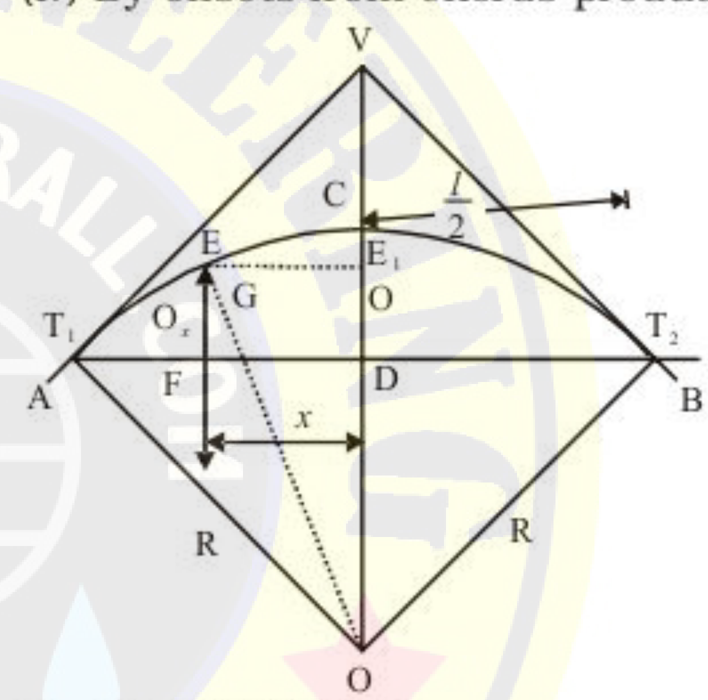
Main linear methods are:-

(i) By offsets from the long chord

(ii) By successive bisection of arcs.

(iii) By offset from the tangents.

(iv) By offsets from chords produced.



R = radius of curve,

O_0 = mid ordinate

O_x = Ordinate at distance 'X' from the mid point of the chord T_1 and T_2 = Tangent point.

$$O_o = R - \sqrt{R^2 - \left(\frac{l}{2}\right)^2},\quad O_x = \sqrt{(R^2 - x^2)} - (R - O_o)$$

Angular Method:-

This method is used when the length of curve is large. The Angular methods are:-

(i) Rankine method of tangential angles.

(ii) Two theodolite method.

(iii) Tacheometric method.

ADVANCED SURVEY EQUIPMENT

INTRODUCTION :-

Revolutionary changes have taken place in last few years in surveying instruments that are used for measuring level differences,distances and angles. This has become possible because of introduction of electronics in there measurements. With rapid advancements in the technology and availability of cheaper and innovative electronic components, there instruments have become affordable and easy to use.

DIGITAL LEVEL :

Traditionally various types of levels have been used for measurment of elevation differences such as :-

→ Dumpy level,
→ Tilting level,
→ Automatic level,

Recently electronic digital levels have evolved as a result of development in electronics and digital image processing.

Digital level use electronic image processing to evaluate the special bar-coded staff reading. The observes is in effect replaced by a detector diode array, which derives a signal pattern from the bar-coded levelling staff. This bar-coded pattern is converted into elevation and distance values using a digital image matching procedure within the instrument. Automatic data conversion eliminates personal errors in reading the staff and the field data is stored by the instruments on its recording meduim, thus further eliminated booking errors.

Electronic Distance Measuring Instrument (EDMIs)

→ EDMIS were first introduced in 1950's by Geodimeterinc. Early instruments were large, heavy, complicated and expensive. Improvements in electronic have given lighter, simpler and less expensive instruments. EDMIs can be manufactured for use with theodolites (both digital and optical) or as an independent unit. There can be mounted on standard units or theodolites or can also be tribrach mounted.

Principle of EDMI :-

The general principle involves sending a modulated electromagnetic (EM) beam for one transmitter at the master station to a reflector at the remote station and receiving it back at the master station. The instrument measures slope distance between transmitter and receiver by modulating the continuous carries wave at different frequencies, and then measuring the phase difference at the master station between the outgoing and the incoming signals. This establishes the following relationship for a double distance (2D).

$$2D = m \quad + \frac{\quad}{2} \quad + K$$

Where 'm' is unknown integer number of complete wavelength contained within double distance, ' ' is the measured phase difference and   is modulation wavelength and 'K' is constant. Multiple modulation frequencies are used to evaluate m, the ambiguity.

various EDMIs in use are based on two methods:-

(i) Using timed pulse techniques such as those used in variety of radar instruments.
(ii) Using measurements of a phase difference which may be equated to one part of a cycle expressed in units of time or length.

AERIAL SURVEY :-

Aerial survey is a method of collecting geomatics or other imaginary by using airplanes, helicopters, UAVS, balloons or other aerial methods. Typical type of data collected include aerial photography, Lidar, remote sensing (using various visible and invisible bands of the electromagnetic spectrum, such as infrared, gamma or ultraviolet) and also geophysical data (Such as aeromagnetic surveys and gravity). Aerial & Survey can provide information on many things not visible from the ground.

Remote Sensing :

A typical remote sensing system consists of the following sub-system (a) Scene (b) Sensor (c) Processing (ground) segment.

The electromagnetic (EM) energy forms the fundamental component of a Rs. System. The following steps indicates how remotely sensed data gets converted into useful information:-

(i) Source of EM energy (Sun/Self emission : transmitter on board sensor.
(ii) Transmission of energy from the source to the surface of the earth and its interaction with the atmosphere (absorption scattering).
(iii) Interaction of EMR with the earth surface (reflection, absorbtion, transmission) or re-emission/self emission.
(iv) Transmission of reflected/emitted energy from the surface to the remote sensor through the intervening atmosphere.
(v) Recording of EMR at the sensor and transmission of the recorded information (sensor data output) to the ground.
(vi) Preprocessing, processing, analysis and interpretation of sensor data.
(vii) Integration of interpreted data with other data sources for deriving managment alternatives and applications.

Since the launch of TIRUS-1considerable developments have taken place in remote sensing technology with recent efforts directed in the following main areas :-

(i) Increase in spatial resolution in civilian domain leading to an increase in accuracy and precision of remotely sensed data.
(ii) Explosion in Rs. application.
(iii) use of smaller and cheaper satellites with faster response to achieve mission objectives.
(iv) Involvement of commercial operators in space segment.

The following four properties are used for interpretation of Rs. information :-

(i) **Spectral :-** Wavelength or frequency, refractiveor emissive propertes of objects during interaction of EMR.
(ii) **Spatial :-** Viewing angle of sensor, shape and size of the object, position, site, distribution, texture.
(iii) **Temporal :-** Changes in time and position which affect spectral and spatial properties.
(iv) **Polarization :-** Object effects in relation to the polarization conditions of the transmitter and receiver.

□□□