CHAP-1 INTRODUCTION Date:-12/01/20

Surveying is the art of determining the relative position of different objects on the surface of the earth by measuring the horizontal distance between them, and by preparing a map to any suitable scale. Thus, in this discipline, the measurements are taken only in the horizontal plane.

Levelling

Levelling is the art of determining the relative vertical distance of different points on the surface of the earth. Therefore, in levelling, the measurements are taken only in the vertical plane

Objects of surveying

* The aim of surveying is to prepare a map to show the relative positions of the objects on the surface of the earth.
* The map is drawn to some suitable scale.
* It shows the natural features of a country, such as towns, villages, roads, railways, rivers, etc.

* Maps may also include details of different engineering works, such as roads, railways, irrigation canals, etc.

Uses of Surveying

Surveying may be used for the following various applications:-

(i) To prepare a topographical map which shows the hills, valleys, rivers, villages, towns, forests, etc. of a country.

(ii) To prepare a cadastral map showing the boundaries of fields, houses and other properties.

(iii) To prepare an engineering map which shows the details of engineering works such as roads, railways, reservoirs, irrigation canals, etc.

(iv) To prepare a military map showing the road and railway communications with different parts of a country. Such a map also shows the different strategic points important for the defence of a country.

(v) To prepare a contour map to determine the capacity of a reservoir and to find

the best possible routes for roads, railways etc.

(vi) To prepare a geological map showing areas including underground resources.

(vii) To prepare an archaeological map including places where ancient relics exist.

CLASSIFICATION OF SURVEYING

Primary classification :- Surveying is primarily classified as under:-

(i) plane surveying
(ii) Geodetic surveying

(i) plane surveying :- In plane surveying the curvature of the earth is not taken into consideration. This is because plane survey is carried out over a small area.

→ plane surveying is done on an area of less than 250 km^2.

→ plane surveying is conducted by state agencies like the irrigation department, Railway department, etc.

→ In such surveying, a line joining is any two points is considered straight.

(ii) Geodetic surveying :- In geodetic surveying, the curvature of the earth is taken into consideration. It is extended over a large area.

→ Geodetic surveying is conducted by the survey of India department, and is carried out over an area exceeding 250 km^2.

→ The line joining any two points is considered a curved line.

Secondary Classification

(1) Based on instruments :-

(a) Chain surveying

(b) Compass surveying

(c) Plane table surveying

(d) Theodolite surveying

(e) Tacheometric surveying

(f) photographic surveying

(2) Based on methods :-

(a) Triangulation surveying

(b) Traverse surveying

(3) Based on objects :-

(a) Geological surveying

(b) Mine surveying

(c) Archaeological surveying
(d) Military surveying.

(4) Based on nature of field :-
(a) Land surveying
(b) Marine surveying
(c) Astronomical surveying.

Principles of surveying

Various methods of surveying are established on very simple fundamental principle. The surveying basic principles can be stated under two aspects.

→ To locate the position of a point by measurement from two reference point.
→ To work from whole to part.

Precision and accuracy of measurements

Accuracy

* How close you are to be actual value
* depends on the person measuring.
* Calculated by the formula : % error = $(YV - AV) \times 100 \div AV$.

Where, YV is your measure value and AV is the accepted value.

Precision

* How finely tuned your measurements

are on how close they can be to each other.

* Depends on the measuring tool.
* Determined by the number of significant digits.

Instruments used

The main surveying instruments is use around the world are the theodolite, measuring tape, total station, 3D scanners, GPS / GNSS, Level and rod.

→ Most instruments screw onto a tripod when in use.

→ Electronic distance measurement (EDM) has made the task of measuring even a long distance with high level accuracy a simple operation.

→ Two types of EDM :- (i) Electro-optical
(ii) Microwave instrument

Measurement of Distance

Distance measures length. For example, the distance of a road is how long the road is in the metric system of measurement, the most common units of distance are millimeters, centimeters, meters and kilometers.

Leader and Follower

The chainman at the forward end of the chain, who drags the chain forward, is known as the leader. The duties of the leader are as follows :-

(1) To drag the chain forward with some arrows and a ranging rod,

(2) To fix arrows on the ground at the end of every chain,

(3) To obey the instructions of the follower.

The chainman at the rear end of the chain who holds the zero end of the chain at the station, is known as the follower. The duties of the follower are as follows :-

(1) To direct the leader at the time of ranging,

(2) To carry the rear handle of the chain,

(3) To pickup the arrows inserted by the leader.

Types of chain

A chain is prepared with 100 or 150 pieces of galvanised mild steel

wire of 4mm diameter.

→ The ends of the pieces are bent to form loops.

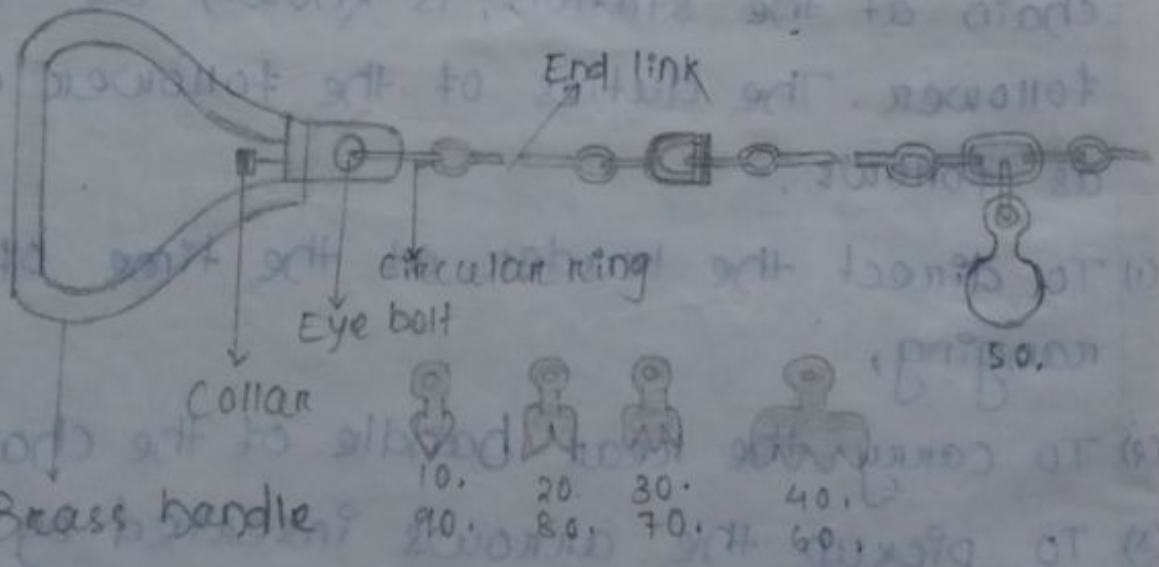
→ Then the pieces are connected together with the help of three oval rings, which make the chain flexible.

→ Two brass handles are provided at the two ends of the chain.

→ Tallies are provided at every 10 or 25 links for facility of counting.

→ 'One link' means the distance between the centres of adjacent middle rings.

CHAIN



The swivel joint allows rotation of the handle preventing the deformation due to twist in the end link.

(9)

The following are the different types of chains :- (a) Metric chain,
(b) steel band,
(c) Engineer's chain,
(d) Gunter's chain,
(e) Revenue chain.

(a) Metric chain :- Metric chains are available in length of 20m and 30m.

→ The 20m chain is divide into 100 links, each of 0.2m.

→ Tallies are provided at every 10 links (2m).

→ This chain is suitable for measuring distances along fairly level ground.

(b) Steel band :- It consists of a ribbon of steel of 16 mm width and of 20 or 30m length.

→ It has a brass handle at each end.

→ It is graduated in metres, decemetres and centimetres on one side and has 0.2m links on the other.

→ The steel band is used in projects 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 one ft.

→ Tallies are provided at every 10 links (10 ft) the central tally being round.

→ Such chains were previously used for all engineering works.

(d) Gunter's chain :- It is 66 ft long and divided into 100 links.

→ So, each link is 0.66 ft.

→ It was previously used for measuring distances in miles and furlongs.

(e) Revenue chain :- The revenue chain is 33 ft long and divided into 10 links.

→ It is mainly used in cadastral survey.

Advantages of chains

* They can be read easily and quickly.
* They can withstand wear and tear.
* They can be easily repaired or rectified in the field.

Disadvantages

* They are heavy and take too much time to open or fold.
* They become longer or shorter due to continuous use.

* when the measurement is taken in suspension, the chain sags excessively.

Advantages of steel bands

* They are very light and easy to open or fold.
* They maintain their standard length even after continuous use.
* when the measurement is taken in suspension, they sag slightly.

Disadvantages

* If handled carelessly, they break easily.
* They cannot be repaired in the field.
* They cannot be read easily.

Types of Tapes

The following are the different types of tapes:- (a) Cloth or linen tape
(b) Metallic tape
(c) steel tape
(d) Invar tape

(a) Cloth or linen tape:- Such a tape is made of closely woven linen and is varnished to resist moisture.

→ It is 15 mm wide and available in lengths

of 10 and 15 m.

→ This tape is generally used for measuring offsets and for ordinary works.

(b) Metallic tape :- When linen tape is reinforced with brass or copper wires to make it durable then it is called a metal tape.

→ This tape is available in lengths of 15, 20 m.

→ It is wound on a leather case with a brass handle at the end.

→ It is commonly used for all survey works

(c) Steel tape :- The steel tape is made of steel ribbon of width varying from 6 to 16mm

→ The commonly available lengths are 10, 20, 30 and 50 m.

→ It is graduated in metres, decimetres and centimetres.

→ It is not used in the field, but chiefly for standardising chains and for measurements in constructional works.

(d) Invar tape :- Invar tape is made of an alloy of steel (64%) and nickel (36%).

→ It is thermal co-efficients is very low.
→ Therefore, it is not affected by change to temperature.
→ It is made in the form of a ribbon of 6mm width and is available in lengths of 30, 50 and 100 m.
→ It is used at places where maximum precision is required.
→ It is generally used in the triangulation survey conducted by the survey of india department.

Errors and mistakes in linear measurement

Linear measurement

In engineering survey, the linear horizontal distance is to be measured to complete a survey. The measurement of this linear horizontal distance between two points on the earth surface is known as linear measurement.

* Linear measurement can be achieved by various instruments.
* Errors in chaining may be caused due to variation in temperature and pull, defects in instruments, etc. They may be either :- (i) compensating or (ii) cumulative.

(ii) Compensating errors :- Errors which may occur in both directions 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 such errors may be caused by :-

(a) Incorrect holding of the chain.
(b) Horizontality and verticality of steps not being properly maintained during the stepping operation.
(c) Fractional parts of the chain or tape not being uniform throughout its length, and
(d) In-accurate measurement of right angles with chain and tape.

(iii) Cumulative errors :- Errors which may occur in the same direction and which finally tend to accumulate are said to be cumulative.

* They seriously affect the accuracy of the work and are proportional to the length of the line (L).
* The errors may be positive or negative.

Positive errors :- when the measured length is more than the actual length, (when the chain is too short), the error is said to be positive.

* Such errors occur due to :-

(a) The length of chain or tape being shorter than the standard length,

(b) Slope correction not being applied,

(c) Correction for sag not being made,

(d) Measurement being taken with faulty alignment, and

(e) Measurement being taken in high winds with the tape in suspension.

Negative errors :- When the measured length of the line is less than the actual length (when the chain is too long), the error is said to be negative.

* These errors occur when the length of the chain on tape is greater than the standard length due to the following reasons :-

(a) The opening of rings, joints,

(b) The applied pull being much greater than the standard pull,

(c) The temperature during measurement being much higher than the standard temperature,

(d) Wearing of connecting rings, and
(e) Elongation of the links due to heavy pull.

Mistakes :- Errors occurring due to the carelessness of the chainman are called 'mistakes'.

* The following are a few common mistakes:-

(a) Displacement of arrows :- Once an arrow is withdrawn from the ground during chaining, it may not be replaced in proper position, if required due to some reason

(b) A full chain length may be omitted or added. This happens when arrows are lost or wrongly counted.

(c) A reading may be taken from the wrong end of the chain. This happens when the tooth of the tally is noted without observing the central tally.

(d) Some numbers may be called wrongly. for example, 50.2 may be called as "fifty two" without the decimal point being mentioned.

(e) The numbers may be read from the wrong direction ; for instance, a '6' may be read as '9'.

(f) While making entries in the field book, the figures may be interchanged due to carelessness; for instance; 245 may be entered instead of 254.

Precautions against Errors and mistakes

The following precautions should be taken to guard against errors and mistakes.

(i) The point where the arrow is fixed on the ground should be marked with a cross(x).

(ii) The zero end of the chain or tape should be properly held.

(iii) During chaining, the number of arrows carried by the follower and leader should always tally with the total numbers of arrows taken.

(iv) While noting the measurement from the chain, the teeth of the tally should be verified with respect to the correct end.

(v) The chainman should call the measurement loudly and distinctly and the surveyor should repeat them while booking.

(vi) Measurements should not be taken with the tape in suspension in high winds.

(vii) In stepping operations, horizontality and verticality should be properly maintained.

(viii) Ranging should be done accurately.

(ix) No measurement should be taken with the chain in suspension.

(x) Care should be taken so that the chain is properly extended.

Classification of linear measurement

Linear measurement can be classified as :- (1) Direct measuring instrument
(2) Indirect measuring instrument

* Direct measuring instrument have two type:
① Graduate
② Non-Graduate

Sources of errors and remedies

Sources of systematic error may be imperfect calibration of measurement instruments (zero error), changes in the environment which interfere with the measurement process and sometimes imperf methods of observating can be either zero error or percentage error.

Chain and Tape connections

Temperature Connection (C_t)

This connection is necessary because the length of the tape or chain may increase or decrease due to rise or fall of temperature during measurement. The connection is given by the expression:

$$C_t = \alpha (T_m - T_o) L$$

Where,

C_t = Connection for temperature in m

α = Co-efficient of thermal expansion

T_m = Temperature during measurement in degree centigrade or celsius

T_o = Temperature at which the tape was standardised in degree centigrade or celsius.

L = Length of tape, in metres

$\alpha = 11 \times 10^{-6}$

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 vary

according to the variation of applied pull, and hence necessary correction should be applied. This correction is given by the expression:-

$$C_p = \frac{(P_m - P_0)L}{A \times E}$$

Where,

C_p = pull correction in metres

P_m - pull applied during measurement in kg

P_0 = pull at which the tape was standardised, in kilograms

A = Cross-sectional area of tape in Square centimetres.

E - Modulus of elasticity or Young's Modulus

L - Length of tape in metre

③ Sag correction (C_s)

This correction is necessary when the measurement is taken with the tape in suspension. It is given by the expression

$$C_s = \frac{L W^2}{24 P_m^2} \quad \text{or} \quad C_s = \frac{L (WL)^2}{24 P_m^2}$$

where,

C_s - sag correction in metres

L = Length of tape or chain, in metres

w = weight of tape per unit length, in kg/m

W = Total weight of tape, in kg

P_m - pull applied during measurement, in kg

n = number of spans (sign is always negative)

① Correction Applied to incorrect length

It is given by the expression

True length of line (TL) = $\frac{L'}{L} \times ML$

where,

L - standard or true length of chain

L' - True length ± error

= L ± e (e = error in chain or tape, when it is too long or too short)

TL - True length of line

ML = measured length

problem-1

The distance between two points measured with a 20m chain, was recorded as 327 m. It was afterwards found that the chain was 3cm too long

what was the true distance between the points?

Sol Given data:

True length of chain, $L = 20\,m$

Errors in chain, $e = 3\,cm = 0.03\,m$, too long

$L' = L + e = 20 + 0.03 = 20.03\,m$

measured length $= 327\,m$

True length of line $= \frac{L'}{L} \times ML$

$= \frac{20.03}{20} \times 327$

$= 327.49\,m$

Que A steel tape was exactly 30 m long at 20°C when supported throughout its length under a pull of 10 kg. A line was measured with this tape under a pull of 15 kg and at a mean temperature of 32°C and found to be 780 m long. The cross-sectional area of the tape $= 0.03\,cm^2$, and its total weight $= 0.693\,kg$. For steel $= 11 \times 10^{-6}$ per°C and E for steel $= 2.1 \times 10^{-6}\,kg/cm^2$. Compute the true length of the line if the tape was supported during measurement (a) at every 30 m, and (b) at every 15 m.

Sol? Given data

$L = 30\ m$ $\quad A = 0.03$

$T_0 = 20°C$ $\quad \alpha = 11 \times 10^{-6}$ per °C

$P_0 = 10\ kg$ $\quad E = 2.1 \times 10^6\ kg/cm^2$

$P_m = 15\ kg$ $\quad W = 0.693\ kg$

$T_m = 32°C$ $\quad ML = 780\ m$

(a) When supported at every 30 m.

Total connection per tape length is to be found out first, Hence, $n = 1$

(i) Temperature connection, $C_t = \alpha (T_m - T_0) L$

$C_t = 11 \times 10^{-6} (32 - 20) \times 30$

$= 3.96 \times 10^{-3}$

$= 0.00396\ m$ (+ve)

(ii) pull connection, $C_p = \dfrac{(P_m - P_0) L}{A \times E}$

$= \dfrac{(15 - 10) \times 30}{0.03 \times 2.1 \times 10^6}$

$= \dfrac{150}{0.03 \times 2.1 \times 10^6}$

$= \dfrac{150}{63000}$

$= 2.380 \times 10^{-3}$

$= 0.00238\ m$ (+ve)

(iii) Sag correction, $C_s = \frac{L W^2}{24 n^2 P_m^2}$

$= \frac{30 \times (0.693)^2}{24 \times 1^2 \times 15^2} = 0.00267$ m (-ve)

Total correction = +0.00396 + 0.00238 − 0.00267

= +0.00367 m (too long)

$L' = L + e = 30 + 0.00367$ m

= 30.00367 m

True length $= \frac{L'}{L} \times ML = \frac{30.00367}{30} \times 780$

= 780.094 m

(b) When support at every 15 m.

Here, span $n = 2$

Let us find out the correction per tape length.

(i) Temperature correction = 0.00396 m

(ii) Pull correction = 0.00238 m

(iii) Sag correction $= \frac{LW^2}{24 n^2 P_m^2} = \frac{30 \times (0.693)^2}{24 \times 2^2 \times 15^2} = 0.00067$ m

Total correction = +0.00396 + 0.00238 − 0.00067

= +0.00567 m

$L' = L + e = 30 + 0.00567$ m = 30.00567

True length $= \frac{30.00567}{30} \times 780 = 780.147$ m

Que A 20 m steel tape was standardised on flat ground, at a used in catenary at a temperature of 30°C and under a pull of P kg. The cross-sectional area of the tape is 0.22 cm^2, & its total weight is 400g. The young's modulus and coefficient of linear expansion of steel are $2.1 \times 10^6 kg/cm^2$ and 11×10^{-6} per°C respectively. Find the correct horizontal distance if P is equal to 10 kg.

Sol Given data :-

$L = 20m$	$A = 0.02 (cm)^2$
$T_0 = 20°C$	$\alpha = 11 \times 10^{-6}$ per°C
$P_0 = 15kg$	$E = 2.1 \times 10^6 kg/cm^2$
$P_m = 30°C$	$W = 400g = 0.4kg$
$P = 10kg$	$D = 1$

Here, applied pull $P = 10 kg$

(a) Temperature correction, $C_t = \alpha (T_m - T_0) L$

$= 11 \times 10^{-6} (30 - 20) 20$

$= 11 \times 10^{-6} \times 10 \times 20$

$= 0.00220 m$ (+ve)

(b) pull correction, $C_p = \dfrac{(P - P_0) L}{A \times E}$

$= \dfrac{(10 - 15) 20}{0.02 \times 2.1 \times 10^6}$

$= \frac{5 \times 20}{0.02 \times 2.1 \times 10^6}$

$= -0.00238$ m)

(c) Sag correction, $C_s = \frac{LW^2}{24n^2P^2}$ $(n = 1)$

$= \frac{20 \times (0.4)^2}{24 \times 10^2}$

$= 0.00133$ m) (-ve)

Total correction $= +0.00220 - 0.00238 - 0.00133$

$= -0.00151$ m)

Correct horizontal distance,

$= 20 - 0.00151$

$= 19.99849$ m)

CHAP-2 CHAIN & CHAIN SURVEYING

Equipment and accessories for chaining

The following equipment are required for conducting chain surveys:-

1. Metric chain (20m) = 1 no.
2. Arrows = 10 nos.
3. Metallic tape (15m) = 1 no.
4. Ranging rods = 3 nos.
5. Offset rod = 1 no.
6. Clinometer = 1 no.
7. plumb bob with thread = 1 no.
8. Cross staff or optical square = 1 no.
9. Prismatic compass withstand = 1 no.
10. Wooden pegs = 10 nos.
11. Mallet = 1 no.
12. field book = 1 no.
13. Good pencil = 1 no.
14. pen knife = 1 no.
15. Eraser (rubber) = 1 no.

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

→ Ranging must be done before a survey line is chained.

→ Ranging may be done by direct observation

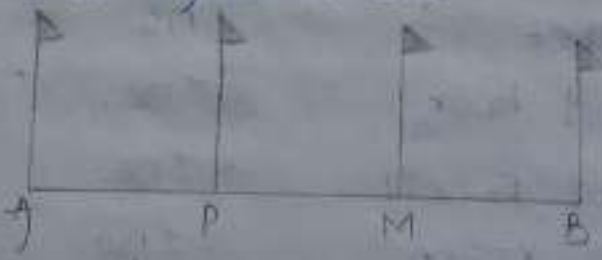
by the naked eye or by line ranger or by theodolite.

→ Generally, ranging is done by the naked eye with the help of three ranging rods.

* 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.

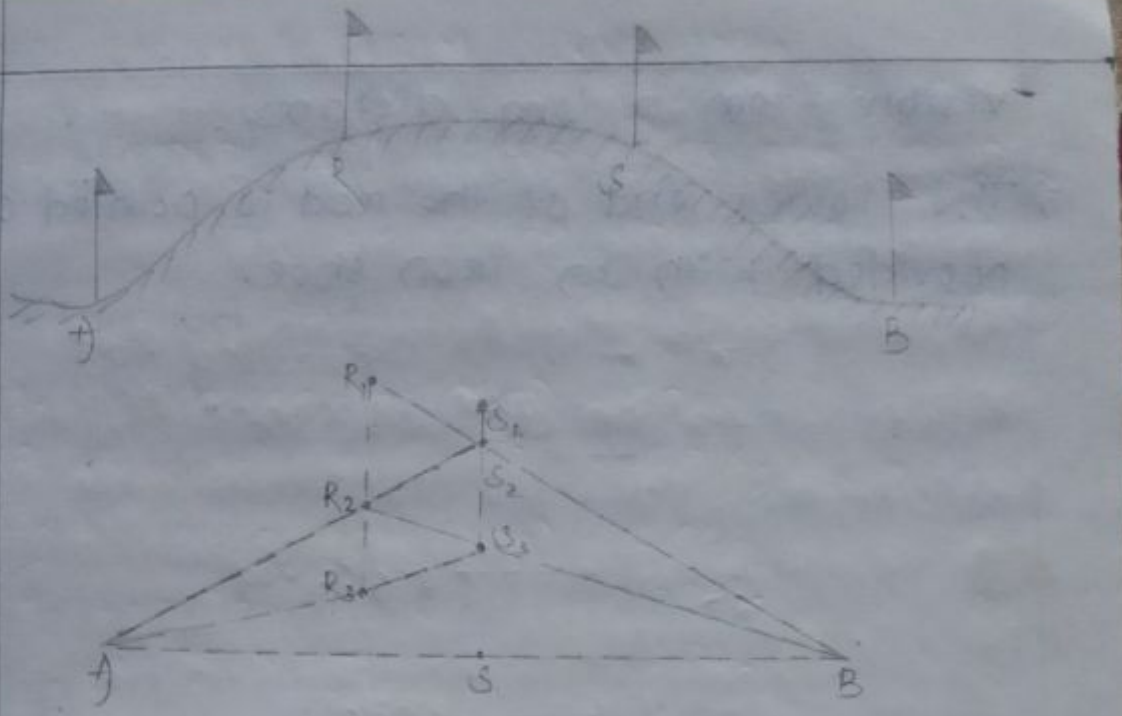
→ Direct ranging is possible when the end stations are intervisible.



(Direct Ranging)

② Indirect or Reciprocal Ranging :- When the end stations are not intervisible due to there being high ground between them, intermediate ranging rods are fixed on the line in an indirect way.

→ This method is known as indirect ranging or reciprocal ranging.



Reciprocal Ranging

Ranging Rods

Roads which are cesed for ranging a line are known as ranging rods.

→ Such rods are made of seasoned timber or seasoned bamboo.

→ Sometimes GI pipes of 25 mm diameter are also cesed as ranging rods.

→ They are generally circular in section, of 25mm diameter and 2m length.

→ Sometimes wooden ranging rods are square in section.

→ The rod is divided into equal parts of 20 cm each and the divisions are painted black and white or red and white alternately so that the rod is

visible from a long distance.

→ The lower end of the rod is pointed or provided with an iron shoe.

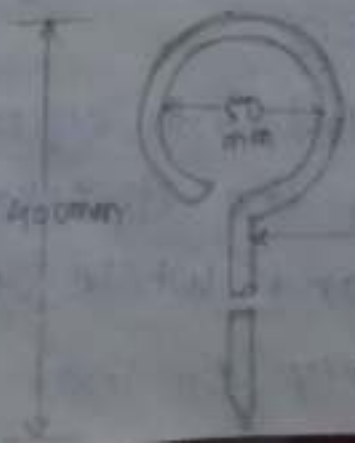
ARROWS

Arrows are made of tempered steel wire of 4mm diameter.

→ One end of the arrow is bent into a ring of 50 mm diameter and the other end is pointed.

→ Its overall length is 400 mm.

→ Arrows are used for counting the number of chains while measuring a chain line.



Principle of chain surveying

The principle of chain surveying is triangulation. This means that the area to be surveyed is divided into a number of small triangles which should be well conditioned.

→ In chain surveying, the sides of the triangles are measured directly on the field by chain or tape and no angular measurements are taken. Here, the tie lines and check lines control the accuracy of work.

→ It should be noted that plotting triangles requires no angular measurements to be made, if the three sides are known

Chain surveying is recommended when:

(i) The ground surface is more or less level.

(ii) A small area is to be surveyed.

(iii) A small-scale map is to be prepared

(iv) The formation of well-conditioned triangles is easy.

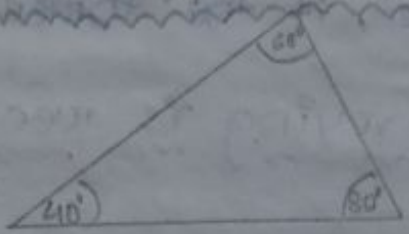
chain surveying is unsuitable when:

(i) The area is crowded with many details,
(ii) The area consists of too many undulations,
(iii) The area is very large, and
(iv) The formation of well-conditioned triangles becomes difficult due to obstacles.

Well-conditioned & Ill-conditioned Triangles

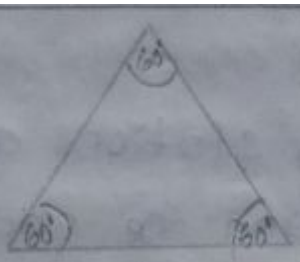
→ A triangle is said to be well conditioned when no angle in it is less than 30° or greater than 120°. An equilateral triangle is considered to be the best-condition or ideal triangle.

Well conditioned Triangle

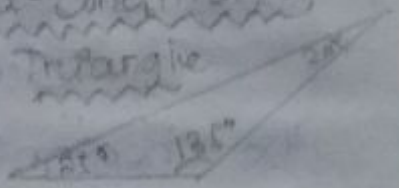


→ Well-conditioned triangles are preferred because their apex points are very sharp and can be located by a single 'dot'.

→ In such a case, there is no possibility of relative displacement of the plotted point.



Ideal Triangle



→ Ill-conditioned triangles :- A triangle in which an angle is less than 30° or more than 120° is said to be ill-conditioned.

→ Ill-conditioned triangles are not used in chain surveying.

→ This is because their apex point are not sharp and well defined, which is why a slight displacement of these points may cause considerable error in plotting.

Reconnaissance Survey & Index Sketch

The neat hand sketch of the area which is prepared during reconnaissance survey is known as the index-sketch or key plan.

→ The index sketch shows the skeleton of the survey work.

→ It indicates the main survey stations, sub-stations, tie stations, base line, arrangement for framework of triangles and the approximate positions of different objects.

* Survey stations

Survey stations are the points at the beginning and the end of a chain line. They may also occur at any convenient points on the chain line. Such stations may be :- (i) Main stations
(ii) Subsidiary stations, and
(iii) Tie stations

(i) Main stations :- station taken along the boundary of an area as controlling points are known as main station.

→ The lines joining the main stations are called main survey lines.

→ The main survey lines should cover the whole area to be surveyed.

→ The main stations are denoted by 'Δ' with letters A, B, C, D, etc.

→ The chain lines are denoted by "—.—.—"

(ii) Subsidiary stations :- Stations which are on the main survey lines or any other survey lines are known as subsidiary stations.

→ These stations are denoted by '⊙' with letters S_1, S_2, S_3, etc.

ii) Tie stations :- These are also subsidiary stations taken on the main survey lines. Lines joining the tie stations are known as tie lines.

→ Sometimes tie lines are taken to locate interior details.

→ Tie stations are denoted by '⊙' with letters T_1, T_2, T_3, etc.

* Base line

The line on which the frame work of the survey is built is known as the base line. It is the most important lines of the survey.

→ Generally, the longest of the main survey lines is considered the base line.

→ This line should be taken through fairly level ground, and should be measured very carefully and accurately.

→ The magnetic bearings of the base line are taken to fix the north line of the map.

* 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.

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.

→ They may be of two kinds :-

(i) perpendicular, and

(ii) oblique

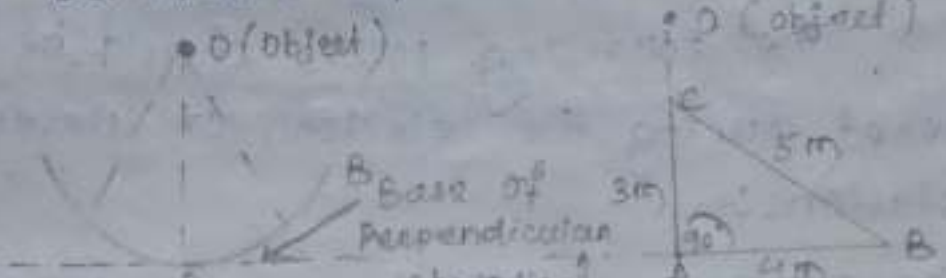
(i) perpendicular offsets :- when the lateral measurements are taken perpendicular to the chain line, they are known as perpendicular offsets.

perpendicular offsets may be taken in the following ways :-

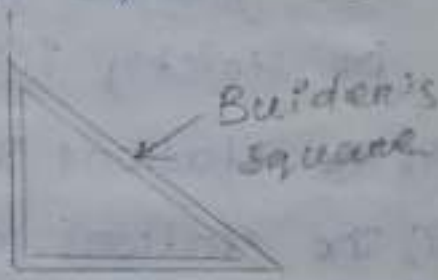
(a) By setting a perpendicular by swinging a tape from the object to the chain line. The point of minimum reading on the tape will be the base of the perpendicular

(b) By setting a right angle in the ratio 3:4:5

(c) By setting a right angle with the help of builder's square or tri-square.



(d) By setting a right angle by Cross-staff or optical square.



(iii) Oblique Offsets :- Any offsets not perpendicular to the chain line is said to the oblique. Oblique offsets are taken when the objects are at a long distance from the chain line or when it is not possible to set up a right angle due to some difficulties.

→ When the triangle abp is plotted, the apex point p will represent the position of the corner of the building.

Perpendicular offsets are preferred for the following reasons :-

(a) They can be taken very quickly.
(b) The progress of survey is not hampered.
(c) The entry in the field book becomes easy.
(d) The plotting of the offsets also becomes easy.

Selection of Surveying stations

The following points should be remembered during the selection of survey stations:-

(i) The stations should be so selected that the general principle of surveying may be strictly followed.
(ii) The stations should be intervisible.
(iii) The stations should be selected in such a way that well-conditioned triangles may be formed.
(iv) The base line should be the longest of the main survey lines.
(v) The survey lines should be taken through fairly level ground, as far as practicable.
(vi) The main survey lines should pass close to the boundary line of the area to be surveyed.
(vii) The survey lines should be taken close to the ~~base~~ objects so that they can be

located by short offsets.

(viii) The tie stations should be suitably selected to fix the directions of adjacent sides.

(ix) The subsidiary stations should be suitably selected for taking check lines.

(x) station should be so selected that obstacles to chaining are avoided as far as possible.

(xi) The survey lines should not be very close to main roads, as survey work may then be interrupted by traffic.

The field book :- The notebook in which field measurements are noted is known as the 'field book'. The size of the field book is 20 cm x 12cm and it opens lengthwise. field books may be of two types :-

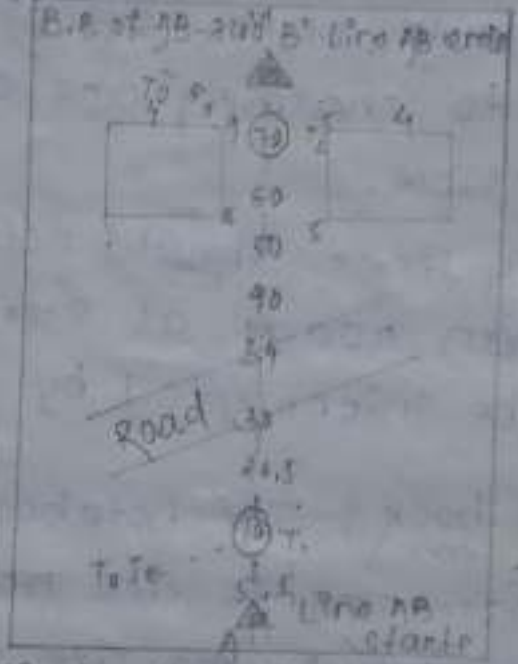
(i) single-line, and

(ii) Double-line.

(1) Single-line field book :- In this type of field book, a single red line is drawn through the middle of each page. This line represents the chain line & the chainages are written on it.

→ The recording of the field book is started from the last page and continued towards the first page.

→ The main stations are marked by 'Δ' and subsidiary stations on the stations are marked by '⊙'.



All dimension in metres

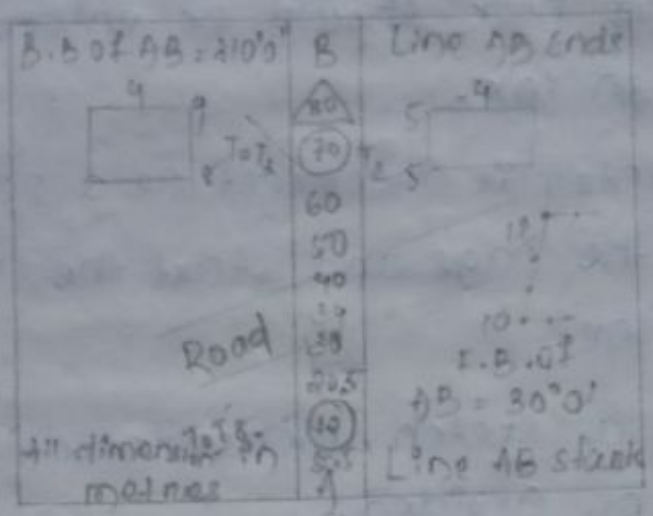
Single-line field book

② Double-line field book: In this type of field book, two red lines, 1.5 cm a part, are drawn through the middle of each page. This column represents the chain line, and the chainages are written in it.

→ The recording is began from the last page and continued towards the first.

→ The main stations are marked by 'Δ' and subsidiary on the stations by '⊙'.

→ This type of field book is commonly used.



Double-Line field book

Precautions to be taken while Entering the field book:-

(i) All measurements should be noted as soon as they are taken.

(ii) Each chainline should be recorded on a separate page. Normally, it should start from the bottom of one page and end on the top of another. No line should be started from any intermediate position.

(iii) Overwriting should be avoided.

(iv) figures & handwriting should be neat and legible.

(v) Index sketch, object sketch and notes should be clear.

(vi) Reference sketches should be given in the field book, so that the station

can be located when required.

(viii) The field book should be entered in pencil and not in ink.

(viii) If an entry is incorrect or a page damaged, cancel the page and start the entry from a new one.

(ix) Erasing a sketch, measurement or note should be avoided.

(x) The surveyor should face the direction of chaining so that the left-hand & right-hand objects can be recorded without any confusion.

(xi) The field book should be carefully preserved.

(xii) The field book should contain the following:- (a) Name, (b) location, and (c) date of survey; (d) name of party members, and (e) page index of chain line.

Obstacle in chaining

A chain line may be interrupted in the following situations:-

(1) when chaining is free, but vision is obstructed.

(2) when chaining is obstructed, but vision is free, and

(3) When chaining and vision are both obstructed.

(i) chaining free but vision obstructed

Such a problems arises when a rising ground or a jungle area intercepts the chain line.

Theoretically, the perpendiculars at D and E will meet the chain line at D_1 and E_1. Now, the distances PC, PD, PE & CC_1 are measured.

chaining free but vision obstructed

From triangles PDD_1 and PCC_1,

$$\frac{DD_1}{PD} = \frac{CC_1}{PC}$$

$$DD_1 = \frac{CC_1}{PC} \times PD$$

Again, from triangles PEE_1 & PCC_1,

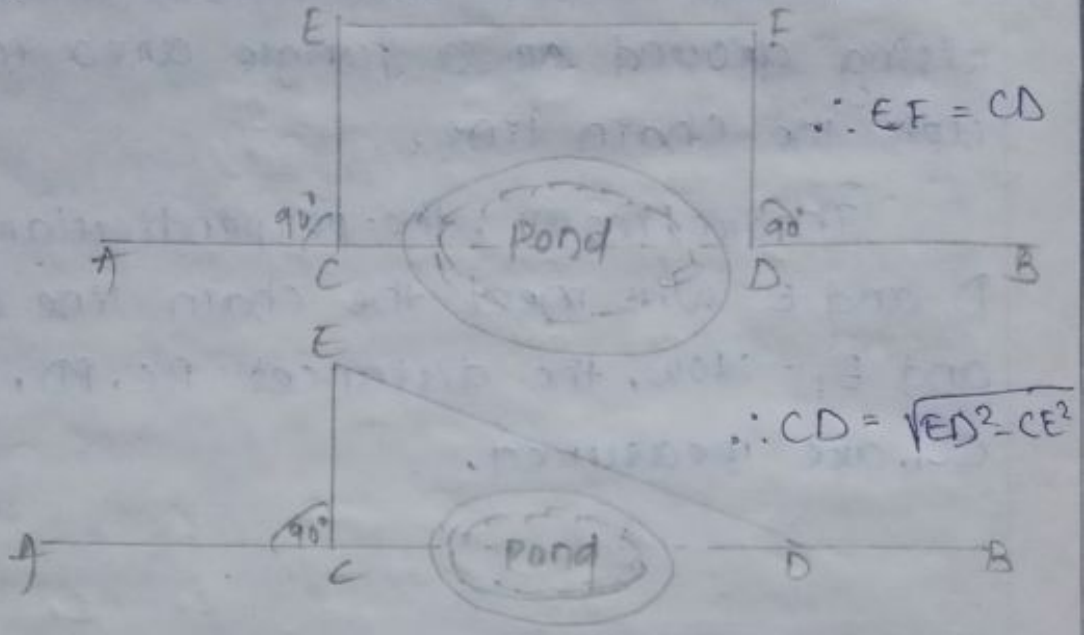
$$\frac{EE_1}{PE} = \frac{CC_1}{PC}$$

$$EE_1 = \frac{CC_1}{PC} \times PE$$

Distance $PE_1 = \sqrt{PE^2 + EE_1^2}$

(2) Chaining obstructed but vision free

Such a problem arises when a pond or a river comes across the chain line.



CROSS-STAFF AND OPTICAL SQUARE

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

① open
② french
③ Adjustable

The open cross-staff is commonly used.

* Open cross-staff :- The open cross-staff consists of four metal arms with vertical slits.

* Optical square :- An optical square is

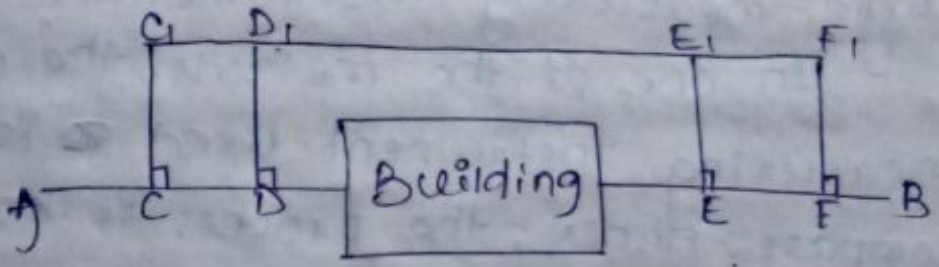
also used for setting out right angles. It consists of a small circular metal box of 5 cm diameter and 1.25 cm depth.

→ It has a metal cover which slides round the box to cover the slits.

→ The following are the internal arrangements of the optical square.

(3) chaining and vision both obstructed

Such a problem arises when a building comes across the chain line.



Suppose AB is the chain line.

Then, $E_1E = F_1F = D_1D = C_1C$

Thus, the points C, D, E, & F will lie on the same line AB.

Here, $DE = D_1E_1$

The distance D_1E_1 is measured, and is equal to the required distance DE

ANGULAR MEASUREMENT AND COMPASS SURVEYING

INTRODUCTION & PURPOSE

In chain surveying, the area to be surveyed is divided into a number of triangles. This method is suitable for fairly level ground covering small areas. But when the area is large, undulating and crowded with many details, triangulation is not possible. In such an area, the method of traversing is adopted.

In traversing, the framework consists of a number of connected lines. The lengths are measured by chain or tape and the directions identified by angle-measuring instruments.

In one of the methods, the angle measuring instrument used is the compass. Hence, the process is known as compass traversing.

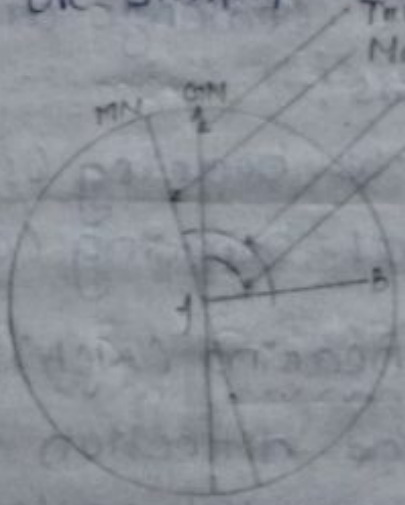
Definitions

(i) True Meridian:- The line or plane passing through the geographical north pole, geographical south pole and any point on the surface of the earth is known as the 'true meridian' or 'geographical meridian'.

→ The angle between the true meridian & a line is known as 'true bearing' of the line. It is also known as the 'azimuth'.

② Magnetic Meridian :- When a magnetic needle is suspended freely and balanced properly, unaffected by magnetic substances, it indicates 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'.



Meridians

③ Arbitrary Meridian :- Sometimes for the survey of a small area, a convenient direction is assumed as a meridian, known as the 'arbitrary meridian'.

→ The angle between the arbitary meridian and a line is known as the 'arbitrary bearing of the line.

④ Grid Meridian :- Sometimes, for preparing a map, some state agencies assume several lines parallel to the true meridian for a particular zone.

→ These lines are termed grid lines 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 bearings are designated by two systems :-

(a) Whole circle bearing (WCB)

(b) Quadrantal bearing (QB).

(a) Whole circle Bearing (WCB) :- A bearing that defines the direction of a survey line by its horizontal angle measured clockwise from true north pole is known as whole-circle-bearing.

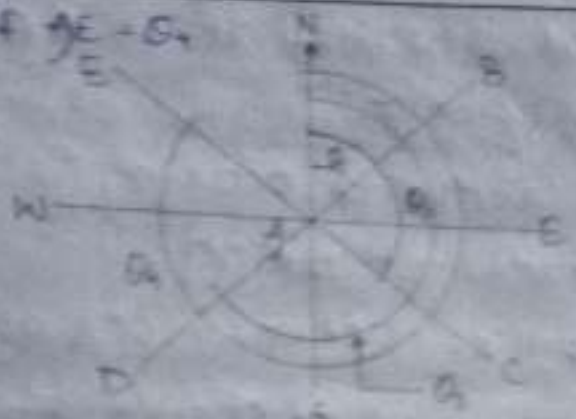
→ Such a bearing may have any value between 0° and 360°.

→ for example, WCB of AB = θ_1

WCB of AC = θ_2

WCB of AD = θ_3

WCB of AE = θ_4

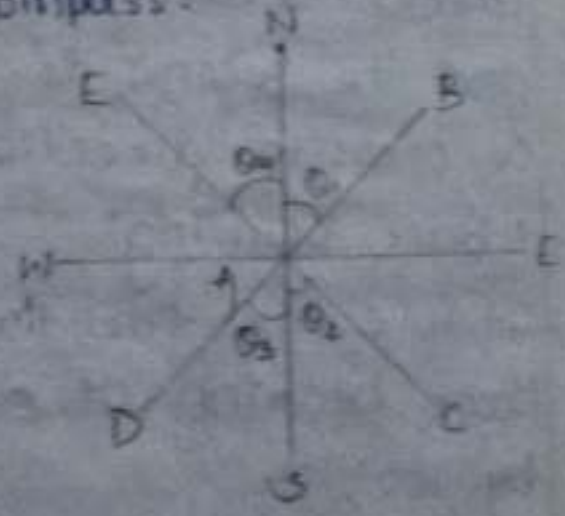


Whole Circle Bearing (WCB)

(b) **Quadrantal Bearing (QB)** :- The magnetic bearing of a line measured clockwise or counter clockwise from the North pole or south pole towards the East or west, is known as the 'quadrantal bearing' of the line.

→ This system consists of four quadrants- NE, SE, SW & NW. The value of a quadrantal bearing lies between 0° & 90°.

→ Quadrantal bearing are obtained by the surveyor's compass.



for example,

QB of AB = N θ_1 E

QB of AC = S θ_2 E

QB of AD = S θ_3 W

QB of AE = N θ_4 W

(c) **Reduced Bearing (RB)** : When the whole circle bearing of a line is converted to

quadrantal bearing, it is termed the 'reduced bearing'.

→ Thus, the reduced bearing is similar to the quadrantal bearing.

→ Its value lies between 0° & 90°.

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

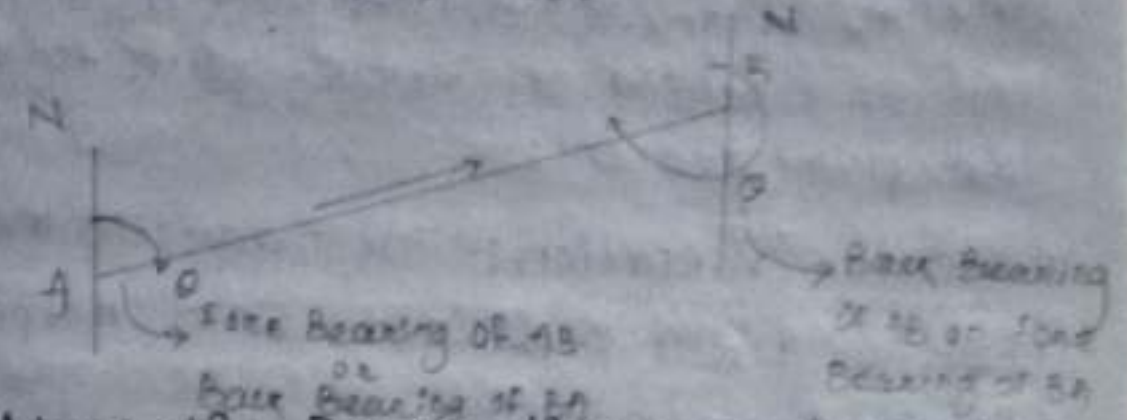
(7) Fore & Back Bearing:- Every line has two bearings:- one is observed along the progress of the survey or forward direction, and is called 'fore bearing' and the second is observed in the reverse or opposite direction and is called 'back bearing'.

→ It is clear that the fore bearing and back bearing of a line differ exactly by 180°;

Back bearing = Fore Bearing ± 180°

→ use positive sign when fore bearing is

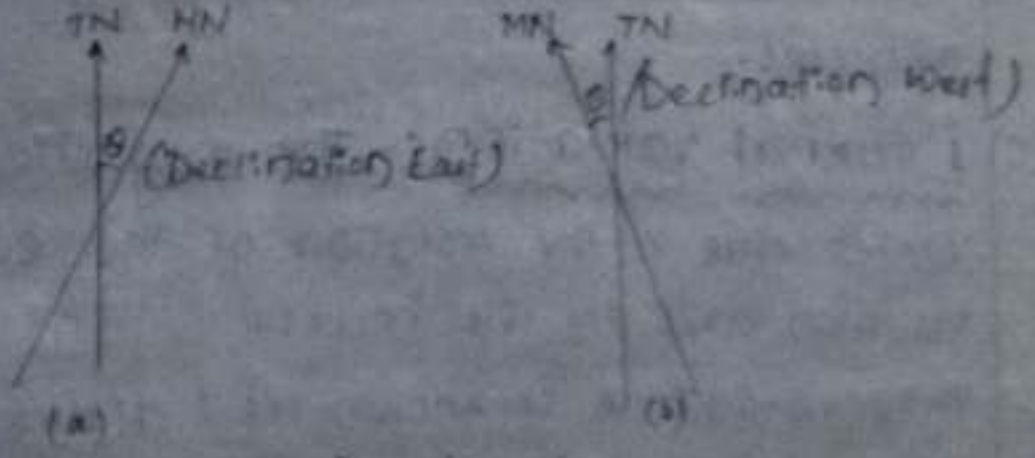
less than 180° and use negative sign when it is more than 180°.



(8) Magnetic Declination :- The horizontal angle between the magnetic meridian and true meridian is known as 'magnetic declination'.

→ When the north end of the magnetic needle is pointed towards the west side of the true meridian, the position is termed declination west (Ⓓw).

→ When the north end of the magnetic needle is pointed towards the east side of the true meridian, the position is termed declination East (Ⓓe).



Magnetic Declination

(9) Variation of Magnetic Declination

The magnetic declination at a place is not constant. It varies due to the following reasons:-

(a) Secular variation:- The magnetic meridian behaves like a pendulum with respect to the true meridian.

→ After every 100 years or so, it swings from one direction to the opposite direction & hence the declination varies. This variation is known as 'Secular variation'.

(b) Annual variation:- The magnetic declination varies due to the rotation of the earth, with its axis inclined, in an elliptical path around the sun during a year.

→ This variation is known as 'annual variation'.

→ The amount of variation is about 1 to 2 minutes.

(c) Diurnal variation:- The magnetic declination varies due to the rotation of the earth on its own axis in 24 hours.

→ This variation is known as 'diurnal variation'. The amount of variation is

found to be about 3 to 12 minutes.

(d) Irregular variation :- The magnetic declination is found to vary suddenly due to some natural causes, such as earthquakes, volcanic eruptions and so on. This variation is known as 'Irregular variation'.

Types of compass

There are two types of compass:

① The prismatic compass, and
② The surveyor's compass.

① The prismatic compass :- In this compass, the readings are taken with the help of a prism. The following are the essential parts of this compass.

(a) Compass Box :- The compass Box is a circular metallic box of 8 to 10cm diameter. A pivot with a sharp point is provided at the centre of the box.

(b) Magnetic Needle and Graduated Ring :-

The magnetic needle is made of a broad magnetised iron bar. The bar is pointed at both ends.

The magnetic needle is attached to a graduated aluminium ring.

→ The ring is graduated from 0° to 360° clockwise
→ ways, 0° is marked at the south, 90° at the west, 180° at the north and 270° at the east.
→ The degrees are again subdivided into half degrees.

(c) Sight vane and prism :- The sight vane and the reflecting prism are fixed diametrically to the box. The sight vane is hinged with the metal box and consists of a horsehair at the centre.

→ The prism consists of a sighting slit at the end and two small circular holes, one at the bottom of the prism & the other at side of the observer's eye.

(d) Dark Glasses :- Two dark glasses are provided with the prism. The red glass is meant for sighting luminous objects at night and the blue glass for reducing the strain on the observer's eye in bright daylight.

(e) Adjustable Mirror :- A mirror is provided with the sight vane. The mirror can be lowered or raised, and can also be inclined.

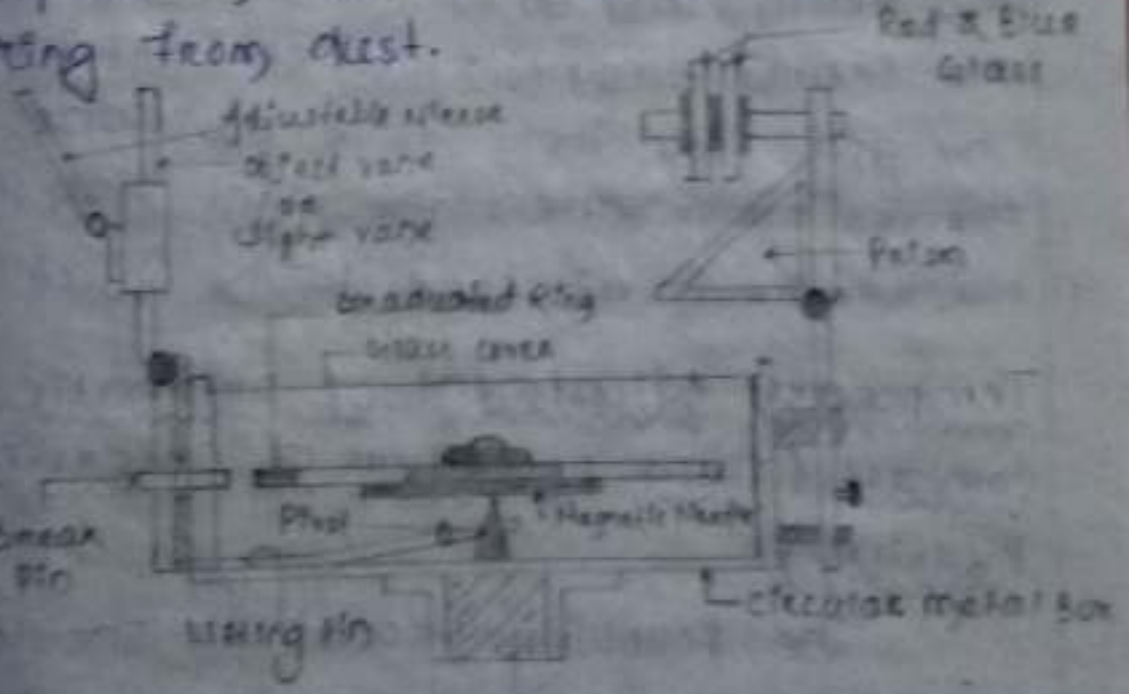
→ If any object is too low or too high with respect to line of sight, the mirror can be adjusted to observe it through reflection

(f) Brake pin:- A brake pin is provided just at the base of the sight vane. If pressed gently, it stops the oscillations of the ring

(g) Lifting pin:- A lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin.

→ The lifting pin then lifts the magnetic needle out of the pivot point to prevent damage to the pivot head.

(h) Glass cover:- A glass cover is provided on top of the box to protect the aluminium ring from dust.



Prismatic compass

(a) 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 the naked eye.

(b) It consists of an eye-vane (in place of prism) with a fine sight slit.

(c) The graduated aluminium ring is attached to the circular box. It is not fixed to the magnetic needle.

(d) The magnetic needle moves freely over the pivot. The needle shows the reading on the graduated ring.

(e) The ring is graduated from 0° to 90° in four quadrants. 0° marked at the north and south, and 90° at the east & west. The letters E (east) & W (west) are interchanged from their true positions. The figures are written the right way up.

(f) No mirror is attached to the object vane.