LECTURE NOTES

MINE SURVEY - I

FOR 4TH SEMESTER MINING ENGINEERING STUDENTS

PREPARED BY-

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MINE SURVEY - I

1.0 SCALES:

The area that is surveyed is vast and, therefore, plans are made to some scale. Scale is the fixed ratio that every distance on the plan bears with corresponding distance on the ground. Scale can be represented by the following methods :

(1) One cm on the plan represents some whole number of meters on the ground, such as 1 cm = 10 m etc. This type of scale is called engineer's scale.

(2) One unit of length on the plan represents some number of same units of length on the ground, such as 1/1000, etc. this ratio of map distance to the corresponding ground distance is independent of units of measurement and is called representative fraction. The representative fraction (abbreviated as R.F.) can be very easily found for a given engineer's scale.

(3) An alternative way of representing the scale is to draw on the plan a graphical scale. A graphical scale is a line sub-divided into plan distance corresponding to convenient units of length on the ground.

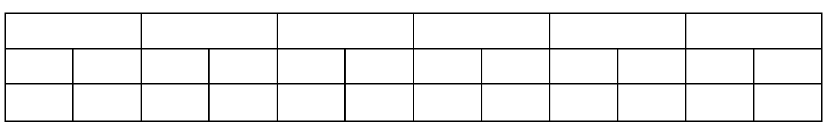
If the plan or map is to be used after a few years, the numerical scales may not give accurate results if the sheet or paper shrinks. However, if a graphical scale is also drawn, it will shrink proportionately and the distances can be found accurately. That is why, scales are always drawn on all survey maps.

1.1 PLAIN SCALE:- A plain scale is one on which it is possible to measure two dimension only, such as units and length, metres and decimeters, miles and furlongs, etc.

Example: Construct a plain scale cm to 3 metres and show on it 47 metres.

Construction:

Take a 20 cm length and divide it into 6 parts, each representing 10 metres. Subdivided the first left hand division into 10 equal parts, each reading 1 metre. Place zero of the scale between the subdivided parts and the undivided part and mark the scale as shown in below. To take 47 metres, place one leg of the divider at 40 and the other at 7, as shown in below.



PLAIN SCALE (Scale 1 cm = 3 m)

1.2 DIAGONAL SCALE:- On a diagonal scale, it is possible to measure three dimensions such as metres, decimeters and centimeters unit, tenths and hundredths; yards, feet and inches etc. A short length is divided into a number of parts by using the principle of similar triangles in which like sides are proportional.

Example: Construct a diagonal scale 1 cm = 3 m to read metres and decimeters and show on that 33.3 metres.

Construction:

Take 20 cm length and divide it into 6 equal parts, each part representing 10 metres. Subdivide the first left hand part into 10 divisions, each representing 1 metre. At the left of the first sub division erect a perpendicular of any suitable length (say 5 cm) and divide it into 10 equal parts and draw through these lines parallel to the scale. Subdivide the top parallel line into ten divisions (each representing 1 metre) and join these diagonally to the corresponding sub-divisions on the first parallel line as shown in below. Where a distance of 33.3 metres has been marked.

1.0						
0.9						
0.8						
0.7						
0.6						
0.5						
0.4						
0.3						
0.2						
0.1						
0.0	10	0	10	20	30	40 50

DIAGONAL SCALE (Scale 1 cm = 3 m)

1.3 VERNIER SCALE: The vernier, invented in 1613 by Pierre Vernier, is a device for measuring the fractional part of one of the smallest divisions of a graduated scale. It usually consists of a small auxiliary scale which slides along side the main scale. The principle of vernier is based on the fact that the eye can perceive without strain and with considerable precision when two graduations coincide to form one continuous straight line. The vernier carries an index mark which forms the zero of the vernier.

If the graduations of the main scale are numbered in one direction only, the vernier used is called a single vernier, extending in one direction. If the graduations of the main scale are numbered in both the directions, the vernier used is called double vernier, extending in both the directions, having its index mark in the middle.

The divisions of the vernier are either just a little smaller or a little larger than the divisions of the main scale. The fineness of reading or leas count of the vernier is equal to the difference between the smallest division on the main scale and smallest division on the vernier.

Whether single or double, a vernier can primarily be divided into the following two classes:

(a) Direct Vernier: A direct vernier is the one which extends or increases in the same direction as that of the main scale and in which the smallest division on the vernier is shorted than the smallest division on the main scale.

(b) Retrograde Vernier: A retrograde vernier is the one which extends or increases in opposite direction as that of the main scale and in which the smallest division of the vernier is longer than the smallest division on the main scale.

2.0 CHAIN SURVEY:

Chain surveying is that type of surveying in which only linear measurements are made in the field. This type of surveying is suitable for surveys of small extent on open ground to secure data for exact description of the boundaries of a piece of land or to take simple details.

2.4 Explain principle of chain surveying:

The principle of chain surveying is to provide skeleton or from work consisting of a number of connected triangles.

If the length of the three sides of triangle are known then the triangle can be plotted accurately to scale by setting out one side and striking areas of the appropriate length from each end.

The exact arrangement of triangle to be adopted depends upon the shape and configuration of the ground and natural obstacles.

It allows that the triangle should be as nearly equilateral as possible and such triangle being known as well conditional or well shaped triangle.

In chaining triangulation the area to be surveyed is first divided into large triangle which are surveyed with greatest accuracy.

Further the area is sub-divided into frame work of triangles to get more details.

In this way accumulation of error is prevented and there a better controls.

2.5 Describe instruments used and checking their correctness:

1. Chain: Chain are formed of straight links of galvanized mild, steel wire bend into rings at the end and joined each other by three small circular or civil wire rings. These rings offer the ability to the chain.
2. Tapes: These are for more accurate measurement and are classed according to the material of which they are made.

   i) Liner tape   ii) Metallic tape   iii) Steel tape   iv) Invar tape.
3. Arrows: Arrows or marking pins are made of stout steel wire and generally to arrows are supplied with a chain. An arrow is inserted into the ground after every chain length measured on the ground.
4. Pegs: Wooden pegs are used to mark the positions of the station or terminal points or a survey line. They are made of steel timber, generally 2.5 cm or 3 cm square and 15 cm long, tapered at the end. They are driven in the ground with the help of a wooden hammer and kept about 4 cm projection above the surface.
5. Ranging Rods: Ranging rods have a length of either 2 or 3 inch, the 2 metre length being more common. They are shot at the bottom with a heavy iron point, and are pointed in alternative bands of wither black or white or red and white or black, red and white in succession, each band being 20 cm deep so that on occasion the rod can be used for rough measurement of short length. Ranging rods are used to range some intermediate points in the survey line.
6. Ranging Poles: Ranging poles are similar to ranging rods except that they are longer and of greater diameter and are used in case of very long lines. Generally they are not pointed, but in all cases they are provided with a large flag. Their length vary from 4 t 8 meter, and diameter from 6 to 10 cm. The foot each pole is sun about set quite vertical by aid of a plumb bob.
7. Offset Rods: An offset rod is similar to a ranging rod and has a length of 3 m. They are around wooden rods, shod with pointed iron shoe at one end and provided with a notch or a hook at the other. The rod is mainly used for measuring rough offsets nearly. It has also two narrow slots passing through the centre of the section, and set at right angles to one another at the eye level for aligning the offset line.
8. Butt Rod: A butt rod is also used for measuring offsets, but it is often used by building surveyor. It generally consists of two lath each of 1 yard or 1 m in length loosely riveted together. The join is also provided with a spring catch to keep the rod extended. The rod is pointed black. The divisions of feet and inches are marked out with white and red point.

TYPES OF CHAIN:

Following are various types of chain use :-

1. Metric Chain: These are generally available in length of 5, 10, 20 and 30 metres. To enable the reading of fraction of a chain without much difficulty fallies are fixed at every metre length for chain of 5 m and 10 m length and at every five metre length for chain of 20 m and 30 m length.
2. Surveyor chain: A surveyor chain or Goiter's chain is 66 ft long and consists of links, each link being 0.6 ft or 7.92 inches long.

   10 square chain = 1 acre

   10 Goiter's chain = 1 fur long

80 Goiter's chain = 1 mile.

3. <u>Engineer's chain</u>: The engineers chain is 100 ft long and consists of 100 links, each links being 1st long. At every 10 links brass tags are fastened with notices on the tags indicating the number of 10 link segment between the tag and end of the chain. The distance measured are recorded in feet and decimals.

4. <u>Revenue chain</u>: The revenue chain is 33 ft long and consist of 16 links each link being 2*1/6 ft long. The chain is mainly used for measuring fields in cadastral survey.

5. <u>Steel band or band chain</u>: The steel band consists of a long narrow strip of blue steel of uniform of 0.3 to 0.6 mm. Metric steel bands are available in length of 20 or 30 m. It is divided by brass stud at every 20 cm and numbered at every metre.

2.6 <u>Explain ranging and chaining of a line.</u>

While measuring the length of a survey line or chain line the chain or tape must be stretched straight along the time joining its two terminal stations. If the length of line is less than the length of the chain there will be no difficult, in doing so. If however the length of the line exceeds the length of the chain, some intermediate point will have to be established in line with the two terminal points before chaining is started. The process of fixing or establishing such intermediate points is known as ranging. There are two methods of ranging:

1. <u>Direct Ranging</u>: It is done when the two ends of the survey lines are inter visible. In such cases, ranging can either be done by eye or through some optical instrument such as a line ranger or a theodolite :

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Let A and B be the two points at the ends of a survey line. One ranging rod is erected at the point B while the surveyor stands with another ranging rod at point A, holding the rod at about half metre length. The assistant then goes with another ranging rod and established the rod at a distance not greater than one chain length from A. The surveyor at A then signals the assistant to move transverse to the chain line, till he is in line with A and B.

2. <u>Indirect Ranging</u>: Indirect or Reciprocal ranging is resorted to when both the end of the survey line are not inter visible either due to high intervening ground or due to long distance between them. In such a case ranging is done indirectly by selecting two intermediate point M1 and N1 very near to the chain line in such a way that from M1 both N1 and B are visible and from N1 Both M1 and A are visible.

Two surveyors station themselves at M1 and N1 with ranging rods. The person at M1 then direct the person at N1 to move to a new position N2 in line with M, B. The person at N2 then directs the person at M1 to move to a new position M2 in time with N2A. Thus, the two persons are now at M2 and N2 which are nearer to the chain line than the position M1 and N1. The process is repeated till the points M and N are located in such a way that the person at N finds the person at N in line with MB, and the person at N finds person at M in line with NA. After having established M and N, other points can be fixed by direct ranging.

<u>CHAINING OF A LINE:</u> In all chaining operation two men called chain men are required. The chain man at the forward end of the chain is called the leader and the other is known as the

follower.

The duties of the leaders are :-

i. To drag the chain forward.
ii. To insert arrows at the end of every chain.
iii. To obey instruction of the followers.

The duties of the followers are :-

i. To place the leader in line with the ranging rod or pole at the forwards station.
ii. To call out instruction to the leader.
iii. Always to carry the near handles in high and not to allow it to drag on the ground.
iv. To pick up the arrow inserted by the leader.

2.7 <u>Calculate errors in chaining.</u>

Error in chaining :

Let L = ture length of the chain
L1 = Actual length

Correction to measured length :

Let l1 = measured length of the line
l = actual or true length of the line

true length of the line= measured length of the line X

correction of area :

Let A1 = measured area of the ground
A = actual or true area.

The area = measured are X

Or A = A1

M1 = , links,

O = 10 AA1 = 1.5 links.

If the slop is measured by leveling it is generally expressed as ‘l’ in ‘n’ nearing their by arise of ‘l’ unit vertically for ‘n’ unit of horizontal distance.

radius.

A1 = 500^2 = 50 / n^2
In the slop is l in 10, AA1 = $50/10^2$ = 0.5 links.

2.10 D<u>escribe use of optical square and line ranger and checking optical square for correctness.</u>

<u>OPTICAL SQUARE:</u> Optical square is some what more convenient and accurate instrument than the cross staff for setting out a line at right angles to another line.

It consists of a circular box with three slits at E, F and G. In line with the opening E and G, a glass silvered at the bottom, is fixed facing the opening E. Opposite to the opening F, a silvered glass is fixed at A making an angle of 45° to the previous glass. A ray from the ranging rod at Q passes through the lower un-silvered portion of the mirror at B, and is seen directly by eye at the slit E. Another ray from the object at P is received by the mirror at A and is reflected towards the
Mirror at B which reflects it towards the

eye. Thus, the images of P and Q are visible at B. If both the images are in the same vertical line as shown in figure, the line PD and QD will be at right angles α with the mirror at A,

∠ ACB = 45 ° or

∠ ABC = 180° - (45° + α) = 135° - α

By law of reflection

∠ Ebb1 = ∠ABC = 135° - α

Hence

∠ ABE = 180° - 2(135° - α) = 2 α - 90°

Also ∠DAB = 180° - 2α

From Δ ABD, ∠ ADB

= 180° - (2α - 90°) – (180° - 2α)

= 180° - 2α + 90° – 180° + 2α = 90°

Thus, if the images of P and Q lie in the same vertical line, as shown in fig, the line PD and QD will be at right angles to each other.

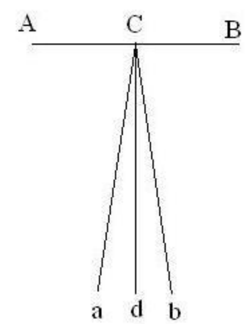
Checking of optical square:

i. Hold the instrument in hand at any intermediate point C on AB, sign a pole held at A and direct an assistant to fix a ranging rod at a , such that the images of the ranging rods at a and A coincide in the instrument.

ii. Turn round to face B and sight the ranging rod at 'a'. If the Image of the ranging rod at B coincides with the image of Ranging rod at 'a' the instrument is in adjustment.

iii. If not direct the assistant to move to a new position b so that both the images coincide. Most a point 'd' on the ground mid-way between 'a' and 'b'. Fix a ranging rod at 'd'.

iv. Turn the adjustable mirror till the image of the ranging rod at 'd' coincide with the ranging rod at B. Repeat the test till correct .



LINE RANGING: A line ranger consist of either two plane mirror or two right angled scales prism placed one above the other. The diagonals at the two prism are silvered so as to reflect the incidental rays. A handle with a hook is provided at the bottom to hold the instrument in hand to transfer the point on the ground with the help of plumb bob.

To range a point 'p' two rough rods are fixed at the end 'A' and 'B' the surveyor at 'p' holds the time ranger prism 'a b c' receives the the rays from 'A' which are the observer. Thus rods at 'A' and 'B' which may not be in the same vertical line. The point 'p' is then transferred to the ground with the help of a plumb bob.

Thus, the instrument can be conveniently used for fixing intermediate points on a long line without going to either end.

2.11 Describe offsets and their measurement:

OFFSET: The lateral distance of an object or ground feature measured from a survey line is called an offset.

There are two types of offset.

Perpendicular offset: When the angle of offset from a point on the chain line is 90° it is called perpendicular offset.

- ⇨ It involves less measuring on the ground.
- ⇨ Offset exceeding 15 m should be set out by means of a cross staff.

⇨ A tape or an offset rod may be used for measuring offset.
⇨ Two measuring are necessary for offsetting
   i. Distance from the beginning of the chain line.
   ii. The distance from the chain lime to the object.
⇨ As it is difficult to distinguish distance less than 0.25 mm on paper, the limit of precision in plotting is 0.25 m.

Oblique offset: When the angle of offset from a point on the chain line is other than 90° its call an oblique offsets.

⇨ It should be taken the corner of the build or the adjusting properties.
⇨ It also taken to check the accuracy of perpendicular offset.

2.14 Explain field booking and plotting of chain survey:

FIELD BOOKING: The note book in which the chain or tape measurement or sketches and other field data are recorded for further reference is called field book.

A. It is about 20 cm X 12 cm in size and opens lengthwise.
B. There are two types of field book.
   i) Single line field book. ii) Double line field book.

Single line field book: The field book is which a single red line is ruled down in the middle of each page is called single line field book.

This line represents the chain line, against which the length of line changes for offsets are taken.

It is used for a comparatively large scale and most detailed dimension work.

Double line field book: In this type of field book two of violet line is ruled down in the middle of each page is called double line field book.

The double line field book is mostly commonly used for ordinary work.

The distance along the chain line being entered between the two lines of the page.

PLOTING OF CHAIN SURVEY: It means representing on paper to a suitable scale the already surveyed areas. It consists in drawing plans and section using conventional signs.

Procedure

i) Leave a margin 2 – 5 cm all round the drawing sheet.
ii) Choose a suitable scales so as to enable to whole area to be plotted with in the sheet.
iii) Plot the skeleton framework of triangle selection the largest line as a base line.
iv) Draw the north line at the top left hand corner.
v) Fill the whole of the frame work with details.

3.0 COMPASS SURVEY:

3.1 Describe prismatic compass, its adjustments and use.

PRISMATIC COMPASS: Prismatic compass is the most convenient and portable form of magnetic compass which can either be used as a band instrument or can be fitted on a tripod.

The main parts of the prismatic compass are:

1) Box, 2) Needle, 3) Graduated ring 4) Object vane 5) Eye van 6) Prism
7) Prism cap 8) Glass cover 9) Lifting pin 10) Lifting lever 11) Brake pin
12) Spring brake 13) Mirror 14) Pivot 15) Agate cap 16) Focusing stud
17) Sun glass.

Construction of prismatic compass:

i. the magnetic needle is attached to be circular ring or compass card made up of aluminum, a non-magnetic substances.
ii. When the needle is on the pivot it will orient itself in the magnetic meridian and therefore, the N and S ends of the ring will be in this direction.

iii. The line of sight is defined by the objective vane and the eye slit, both attached to the compass box.
iv. A triangular prism is fitted below the eye slit, having suitable arrangement for focusing to suit different eye sights.
v. The prism has both horizontal and vertical faces convex, so that a magnified image of the ring graduation is formed.
vi. The 0° or 360° reading is therefore, engraved on the south end of the ring, so that bearing of the magnetic meridian is read ad 0° with the help of the prism which is vertically above south in this particular position.
vii. The readings increase is clock wise direction from 0° at south end to 90° at west end 180° at north end and 270° at east end.

Adjustment of prismatic compass:

The following are the adjustment usually necessary in the prismatic compass.

(a) Permanent Adjustment: The permanent adjustment of prismatic compass are almost the same as that of the surveyor's compass except that there are no bubble tubes to be adjusted and the needle cannot be straight end. The sight vanes are generally not adjustable.
(b) Temporary Adjustment: Temporary adjustment are those adjustment which have to be made at every set up of the instrument. They comprise the following :

i. Centring: Centring is the process of keeping the instrument exactly over the station. Ordinary prismatic compass is not provided with fine centring device as id generally fitted to engineer's theodolite. The centring is invariably done by adjusting or manipulating the legs of the tripod. A plumb-bob may be used to judge the centring and it is not available, it may be judged by dropping a pebble from the centre of the bottom of the instrument.
ii. Levelling: The compass should be leveled by eye by means of a ball and socket joint. If the instrument is a hand instrument, it must be held in hand in such a way that graduated disc is swinging freely and appears to be level as judged from the top edge of the case.
iii. Focusing the prism: The prism attachment is slide dip or down for focusing till the reading are seen to be sharp and clear.

Advantages of prismatic compass: The greatest advantage of prismatic compass is that both sighting the object as well as reading circle can be done simultaneously without changing the position of the eye. The circle is read at the reading at which the fair line appears to cut the graduate ring.

3.2 Explain true meridian, magnetic meridian, grid line meridian, arbitrary meridian.

TRUE MERIDIAN: True meridian through a point is the line in which a plane, passing that point and the north and south poles, intersects with surface of the earth. It, thus, passes through the true north and south. The direction of true meridian through a point can be established by astronomical observations.

MAGNETIC MERIDIAN: Magnetic meridian through a point is the direction shown by a freely floating on balanced magnetic needle free from all other attractive forces. The direction of magnetic meridian can be established with the help of a magnetic compass.

ARBITRARY MERIDIAN: Arbitrary meridian is any convenient direction towards a permanent and premier mark or signal, such as a church spire or top of a chimney. Such meridian are used to determine the relative position of line in a small area.

3.3 Explain W.C.B. and Q.B. and conversion from one to other

DESIGNATION OF BEARING:

The common system of notation of bearing are:

(a) The whole circle bearing (W.C.B.) system or Azimuthal system.
(b) The Quadrantal system (Q.B.) system

The Whole Circle Bearing System: In this system, the bearing of a line is measured with magnetic north (or with south) in clockwise direction. The value of the bearing thus varies from 0° to 360°. Prismatic compass is graduated on this system. In India and U.K., the W.C.B. is measured clockwise with magnetic north.

Referring to Fig, the W.C.B. of AB is θ1, of AC is θ2, of AD is θ3 and of AF is θ4.

The Quadrantal Bearing System: In this system, the bearing of a line is measured eastward or westward from north or south, whichever is nearer. Thus, both North or South are used as reference meridians and the directions can be either clockwise or anticlockwise depending upon the position of the line. In this system, therefore, the quadrant, in which the line lies, will have to be mentioned. These bearings are observed by Surveyor's compass.

Referring Fig. the Q.B. of the line AB is α and is written as N α E, the bearing being measured with reference to North meridian (since it is nearer), towards East. The bearing of AC is β and is written as S β E, it being measured with reference of South and in anticlockwise direction towards East. Similarly, the bearing of AD and AF are respectively S θ W and N Φ W.

Thus , in the quadrantal system, the reference meridian is prefixed and the direction of measurement (Eastward or Westward) is affixed to the numerical value of the bearing. The Q.B. of a line varies from 0° to 90°. The bearing of this system are known as Reduced Bearing (R.B.)

CONVERSION OF BEARING FROM ONE SYSTEM TO THE OTHER

The conversion of W.C.B. into R.B. can be expressed in the following table :

Line	W.C.B. between	Rule for R.B.	Quadrant
AB	0° and 90°	R.B. = W.C.B.	NE
AC	90° and 180°	R.B. = 180° - W.C.B.	SE
AD	180° and 270°	R.B. = W.C.B. - 180°	SW
AF	270° and 360°	R.B. = 360° - W.C.B.	NW

The conversion of R.B. into W.C.B. can be expressed in the following table :

Line	R.B.	Rule for W.C.B.	W.C.B. between
AB	N α E	W.C.B. = R.B.	0° and 90°
AC	S β E	W.C.B. = 180° - R.B.	90° and 180°
AD	S θ W	W.C.B. = 180° + R.B.	180° and 270°
AF	N Φ W	W.C.B. = 360° - R.B.	270° and 360°

3.3.1 Find out fore and back bearing and their conversion.

The bearing of line, whether expressed in W.C.B. system or in Q.B. system, differs according as the observation is made from one end of the line or from the other. If the bearing of a line AB is measured from A towards B, it is known as forward bearing or Fore Bearing (F.B.). If the bearing of the line AB is measured from B towards A, it is known as backward bearing or Back Bearing (B.B.), since it is measured in backward direction.

CONVERSION:

Considering first the W.C.B. system and referring to Fig. (a), the back bearing of line AB is Φ an fore bearing of AB is θ. Evidently $\Phi = 180° + \theta$. Similarly, from Fig. (b), the back bearing of CD is Φ and fore bearing θ, hence, $\Phi = \theta - 180°$. Thus, in general, it can be stated that B.B. = F.B. $\pm$ 180°, using plus sign when F.B. is less than 180° and minus sign when F.B. is greater than 180°.

Again, considering the Q.B. system and referring to Fig (c), the fore bearing of line AB is N θ E and, therefore, the back bearing is equal to S θ W. Similarly, from Fig. (d), the fore bearing of the line CD is S θ W and back bearing is equal to N θ E. Thus, it can be stated that to convert the fore bearing to back bearing, it is only necessary to change the caradinal points by substituting N for S, and E for W and vice versa, the numerical value of the bearing remaining the same.

CALCULATION OF ANGLES FROM BEARING

Knowing the bearing of two lines, the angle between the two can very easily be calculated with the help of a diagram.

Ref. to Fig. 5.5 (a), the included angle a between the lines AC and AB = θ2 – θ1 = F.B. of onle line – F.B. of the other line, both bearings being measured from a common point A. Ref to Fig. 5.5 (b), the angle α = (180° + θ1) – θ1 = B.B. of previous line – F.B. of next line.

Let us consider the quadrantal bearing. Referring to Fig. 5.6 (a) in which both the bearings have been measured to the same side of common meridian, the included angle α = θ2 – θ1. In Fig. 5.6 (b), both he bearing have been measured to the opposite sides of the common meridian, and included angle α = θ1 + θ2. In Fig. 5.6 (c) both the bearing have been measured to the same side of different meridians and the included angle α = 180° - (θ2 + θ1). In fig 5.6 (d), both the bearing have been measured to the opposite sides of different meridians, and angle α = 180° - (θ1 – θ2).

been measured, the bearing of the lines can be calculated provided the bearing of any one line is also measured.

Referring to Fig. 5.7, let α, β, γ, δ, be the included angles measured clockwise from back stations and θ1 be the measured bearing of the line AB.

The bearing of the next line BC = θ2 = θ1 + α - 180°

The bearing of the next line CD = θ3 = θ2 + β - 180°

The bearing of the next line DE = θ4 = θ3 + γ - 180°

The bearing of the next line EF = θ5 = θ4 + δ - 180°

As is evident from Fig. 5.7, (θ1 + α) , (θ2 + β), and (θ3 + γ) are more than 180° while (θ4 + δ) is less than 180°. Hence in order to calculate the bearing of the next line, the following statement can be made :

“Add the measured clockwise angles to the bearing of the previous line. If the sum is more than 180°. If he sum is less than 180°, add 180° “.

In a closed traverse, clockwise angles will be obtained if we proceed round the traverse in the anti-clockwise direction.

3.4 Define Local Attraction:

Local attraction is a term used to denote any influence, which prevents the needle from pointing to the magnetic North in a given locality.

Some of the sources, wires carrying electric current, steel structures, railroad rails, underground iron pipes, keys, steel-bowed spectacles, metal button, axes, chains, steel tapes etc, which may be lying on the ground nearby.

3.4.1 Determine local attraction and necessary correction to the bearings.

Determination of Local Attraction: The local attraction at a particular place can be detected by observing the fore and back bearing of each line and finding its difference. If the difference between fore and back bearing is 180°, it may be taken that both the stations are free from local attraction, provided there are no observational and instrumental errors. If the difference is other than 180°, the fore bearing should be measured again to find out whether the discrepancy is due to avoidable attraction from the articles on person, chains, tapes etc. If the difference still remains, the local attraction exists at one or both the stations.

Necessary correction to the bearings:

First Method:- In this method, the bearing of the lines are calculated on the basis of the bearing of that line which has a difference of 180° in its fore and back bearings. It is, however, assumed that there are no observational and other instrumental errors. The amount and direction of error due to local attraction at each of the affected station is found. If, however, there is no such line in which the two bearings differ by 180°, the correction should be made from the mean value of the bearing of that line in which there is least discrepancy between the back sight and fore sight readings.

If the bearings are expressed in quadrant system, the corrections must be applied in proper direction. In 1st and 3rd quadrants, the numerical value of bearings increase in clockwise direction while they increase in anti-clockwise direction in 2nd and 4th quadrants. Positive corrections are applied clockwise and negative corrections counter-clockwise.

Second Methods:- This is more a general method and is based on the fact that though the bearings measured at a station may be incorrect due to local attraction, the included angle calculated from the bearings will be correct since the amount of error is the same for all the bearing measured at the station. The included angles between the lines are calculated at all the stations. If the traverse is a closed one, the sum of the internal included angles must be (2n – 4) right angles. If there is any discrepancy in this, observational and instrumental errors also exist. Such error is distributed equally to all the angles. Proceeding now with the line, the bearing of which differ by 180°, the bearing of all other lines are calculated.

ERRORS IN COMPASS SURVEY:

The errors may be classified as :

(a) Instrumental errors: they are those which arise due to the faulty adjustments of the instruments. They may be due to the following reasons.

1. The needle not being perfectly straight
2. Pivot being bent.
3. Sluggish needle.
4. Blunt pivot point.
5. Improper balancing weight.
6. Plane of sight not being vertical.
7. Line of sight not passing through the centers of the right.

(b) Personal errors: They may be due to the following reasons.

1. Inaccurate leveling of the compass box.
2. Inaccurate centring.
3. Inaccurate bisection of signals.
4. Carelessness in reading and recording.

(c) Natural errors: They may be due to the following reasons:

1. Variation in declination.
2. Local attraction due to proximity of local attraction forces.
3. Magnetic changes in the atmosphere due to clouds and storms.
4. Irregular variations due to magnetic storms etc.

3.5 Explain closed and open compass surveying and its plotting.

TRAVERSING:-Traversing is that type of survey in which a number of connected survey lines form the framework and the directions and lengths of the survey lines are measured with the help of an angle (or direction) measuring instrument and a tape (or chain) respectively.

Closed traverse of Compass surveying: When the lines form a circuit which ends at the starting point its known as a closed traverse or compass surveying.

The closed traverse is suitable for locating the boundaries of lakes, woods, etc. and for the surveying of large areas.

Open traverse or compass surveying: If the circuit ends else where it is known as open traverse or compass surveying.

The open traverse is suitable for surveying a long narrow strip of land as required for a road or canal or the coast line.

Plotting a Traverse Survey: There are two principal methods of plotting a traverse survey: (1) The angle and distance method, (2) The co-ordinate method.

(1) Angle and Distance Method: In this method, distances between stations are laid off to scale and angles (or bearing). This method is suitable for the small surveys, and is much interior to the co-ordinate method in respect of accuracy of plotting. The more commonly used angle and distance methods of plotting an angle (or bearing) are (a) By Protractor.

(b) By the tangent of the angle.
(c) By the chord of the angle.

(a) The protector method: The use of the protector in plotting direct angles, deflection angles, bearings protector is seldom divided more finely than 10’ or 15’ which accords with the accuracy of compass traversing. A good form of protractor for plotting survey lines is the large circular cord board type, 40 to 60 cm in diameter.

(b) The tangent method: The tangent method is a trigonometric method based upon the fact that in right angled triangle, the perpendicular = base X Tan θ, where ‘θ’ is the angle. From the end of the base, a perpendicular is set off, the length of the perpendicular being equal to base X tan θ.

The station point is joined to the point so obtained the line so obtained includes θ with the given side. The values of tan θ are taken from the table of natural tangents.

If the angle is little over 90°, 90° of its plotted by erecting a perpendicular and the remainder by the tangent method, using the perpendicular as a base.

(c) The chord method: This is a geometrical method of laying off an angle. Let it be required to draw line AD at an angle θ to be the line AB in figure. With 'A' as centre, draw an arc of any convenient radius (r) to cut the line AB in b. With "b" as centre draw and arc of radius (r') to cut the previous arc in d, the radius r' being given by $r' = 2r \sin \theta/2$.

Join Ad, thus getting the direction of AD at an inclination of θ to AB. The length of chords of angles corresponding to unit radius can be taken from the table of chords. It an angle is greater than 90 the construction should be done only for the part less than 90° because the intersections for greater angles become unsatisfactory.

(2) Co-ordinate Method: In this method, survey stations are plotted by calculating their co-ordinates. This method is by far the most practical and accurate one for plotting traverses or any other extensive system of horizontal control. The biggest advantage in this method of plotting. The biggest advantage in this method of plotting is that the closing error can be eliminated by balancing, prior to plotting. The methods of calculating the co-ordinates and of balancing a traverse are discussed in the next article.

3.7 Explain adjustment of closing error in compass traversing.

CLOSING ERROR: If a closed traverse is plotted according to the field measurement, the end point of the traverse will not coincide exactly with the starting point. Such errors is known as closing error.

In a closed traverse, the algebraic sum of the latitudes (i.e, ΣL) should be zero and the algebraic sum of the departure (i.e, ΣD) should be zero.

The error of closure for such a traverse may be ascertained by finding ΣL and ΣD, both of these being the components of error "e" parallel and perpendicular to the meridian.

Thus,

Closing error, $e = AA' = \sqrt{(\Sigma L)^2 + (\Sigma D)^2}$

The direction of closing error is given by $\tan \delta = \Sigma D / \Sigma L$

The sign of ΣD and ΣL will thus define the quadrant in which the closing error lies. The relative error of closure, the term sometimes used,

$$Is = \frac{\text{Error of closure}}{\text{Perimeter of traverse}} = \frac{e}{P} = \frac{1}{P/e)}$$

Adjustment of the Angular Error: Bearing calculating latitudes and departures, the traverse angles should be adjusted to satisfy geometric conditions.

In a closed traverse, the sum of interior angles should be equal to (2N-4) right angles (or the algebraic sum of deflection angles should be 360°). If the angles are measured with the same degree of precision, the error in the sum of angles may be distributed equally to each angle of the traverse. If the angular error is small, it may be arbitrarily distributed among two or three angles.

Adjustment of Bearing: In a closed traverse in which bearings are observed, the closing error in bearing may be determined by comparing the two bearing of the last line as observed at the first and last station of traverse. Let e be the closing error in bearing of last line of a closed traverse having N sides. We get

Correction for first line= e / N
Correction for second line = 2e / N
Correction for third line = 3e / N
Correction for last line= Ne / N = e.

4.0 PLANE TABLE SURVEY

4.1 Define plane table and its accessories.

Plane tabling is a graphical method of survey in which the field observations and plotting proceed simultaneously. It is means of making a manuscript map in the field while the ground can be seen by the topography and without intermediate steps of recording and transcribing field notes of recording and transcribing field motes. It can be used to the own control systems by triangulation or traverse and by lines of levels.

Instrument used:

1. The plane table with leveling head having arrangement for (a) leveling, (b) rotation about vertical axis, (c) clamping in any required positon
2. Alidade for sighting.
3. Plumbing fork and plumb bob.
4. Spirit level.
5. Compass.
6. Drawing paper with a rainproof cover.

(1) The plane table: Three distinct types of tables (board and tripod) having devices for leveling the plane table and controlling its orientation are in common use.

The traverse table: The traverse table consists of a small drawing board mounted on a light tripod in such a way that the board can be rotated about the vertical axis and can be clamped in any position.

Johnson Table: This consists of a drawing board usually 45X60 cm or 60X75 cm. The head consists of a ball and socket joint and a vertical spindle with two thumb screws on the underside.

Coast survey Table: This table is superior to the above two types and is generally used for work of high precision. The leveling of the table is done very accurately with the help of the three foot screws.

(2) Alidade: A plane table alidade is a straight edge with some form of sighting device. Two types are used. (i) Plain alidade and (ii) Telescopic alidade.

Plain alidade: It generally consist of a metal or wooden rule with two vanes at the ends. The two vanes or sights are hinged to fold down on the rule when the alidade is not in use. One of the vanes is provided with a narrow slit while the other is open and carries a hair or thin wire. The alidade can be rotated sbout the point representing the instrument station on the sheet so that the line of sight passes through the object to be sighted.

Telescopic alidade: The telescopic alidade is used when it is required to take inclines sight. Also the accuracy and range of sights and increased by its use. It essentially consists of a small telescope with a level tube and graduated are mounted on horizontal axis. The horizontal axis rests on a flame fitted with verniers fixed in position in the same manner as that in a transit. All the parts are finally supported on a heavy rule. One side of which is used as the working edge along which line may be drawn.

(3) Plumbing Fork: The plumbing fork used in large scale work is meant for cenring the table over the point or station occupied by the plane table when the plotted position of that point is already

known on the sheet.

(4) Spirit level: A small spirit level may be used for ascertaining if the table is properly level. The level may be either of the tubular variety or of the circular type, essentially with a flat base so that it can be laid on the table and is truly level when the bubble is central.

(5) Compass: The compass is used for orienting the plane table to magnetic north. The compass used with a plane table is a trough compass in which the longer sides of the through are parallel and flat so that either side can be used as a ruler or laid down to coincide with a straight line drawn on the paper.

(6) Drawing paper: The drawing paper used for plane tabling must be of superior quality so that it may have minimum effect of changes in the humidity of the atmosphere.

4.2 Describe orientation by back sighting.

Orientation can be done precisely by sighting the points already plotted on the sheet. Two cases may arise :

(a) When it is possible to set the plane table on the point already plotted on the sheet by way of observation from previous station.

(b) When it is not possible to set the plane table in the point.

To orient the table at the next station, say B, represented on the paper by a point ‘b’ plotted by means of line ‘ab’ drawn from a previous station A, the alidade is kept on the line ‘ba’ and the table is turned about its vertical axis in such a way that the line of sight passes through the ground station A. When this is achieved, the plotted line ‘ab’ will be coinciding with the the ground line AB and the table will be oriented. The table is then clamped in position.

The method is equivalent to that employed in azimuth traversing with the transit. Greater precision is obtainable than with the compass, but an error in direction of a line is transferred to succeeding lines.

4.3 Describe various methods of plane table survey.

Methods of plane tabling can be divided into four distinct heads :

1. Radiation 2. Intersection 3. Traversing 4. Resection

The first two methods are generally employed for locating the details while the other two methods are used for locating the plane table stations:

RADIATION: In this method, a ray is drawn from the instrument station towards the point, the distance is measured between the instrument station and that point, and the point is located by plotting to some scale the distance so measured. Evidently, the method is more suitable when the distances are small and one single instrument can control the points to be detailed. The method has a wider scope if the distances are obtained tacheometrically with the help of telescopic alidade.

INTERSECTION: Intersection is resorted to when the distance between the point and the instrument station is either too large or cannot be measured accurately due to some field condition. The location of an object is determined by sighting at the object from two plane table stations and drawing the rays. The intersection of these rays will give the position of the object. It is therefore between the two instrument stations is measured and plotted on the sheet to some scale. The line joining the two instrument stations is known as the base line. No linear measurement other than that of the base line is made. The point of intersection of the two rays forms the vertex of a triangle having the two rays as two sides and the base line as the third line of the triangle. Due to this reason, intersection is also sometimes known as graphic triangulation.

TRAVERSING: Plane table traverse involves the same principles as a transit traverse. At each successive station the table is set, a foresight is taken to the following station and its location is plotted by measuring the distance between the two stations as in the radiation method described earlier. Hence, traversing is not much different from radiation as far as working principles are concerned — the only difference is that in the case of radiation the observations are taken to those points which are to be detailed or mapped while in the case of traversing the observations are made to those points which will subsequently be used as instrument stations. The method is widely used to lay down survey lines between the instrument stations of a closed or unclosed traverse.

RESECTION: Resection is the process of determining the plotted position of the station occupied by the plane table, by means of sights taken towards known points, locations of which have been plotted.

The method consists in drawing two rays to the two points of known location on the plan after the table has been oriented. The rays drawn from the un-plotted location of the station to the points of known location are called resectors, the intersection of which gives the required location of the instrument station. If the table is not correctly oriented at the station to be located on the map, the intersection of the two resectors will not give the correct location on the station.

4.4 Explain two point problem.

Statement: Location of the position on the plan, of the station occupied by the plane table by means of observation to two well defined points, whose position have been previously plotted on the plan.

Let us take two point A and B, the plotted position of which are known. Let C be the point to be plotted. The whole problem is to orient the table at C.

1. Choose an auxiliary point D near C, to assist the orientation at C. Set the table at D in such a way that ab is approximately parallel to AB.
2. Keep the alidade at a and sight A. Draw the resector. Similarly draw a resector from b and B to intersect the previous one in d. The position of d is thus got, the degree of accuracy of which depends upon the approximation that has been made in keeping ab parallel to Ab. Transfer the point d to the gund and drive a peg.
3. Keep the alidade at d and sight C. Draw the ray mark a point c, on the ray by estimation to represent the distance DC.
4. Shift the table to C, orient it by taking backsight to D and centre it with reference to C. The orientation is, thus the same as it was at D.
5. Keep the alidade pivoted at a and sight it to A. Draw the ray to intersect with the previously drawn ray from D in C. Thus C is the point representing the station C, with reference to

6. Pivoting the alidade about C, sight B. Draw the ray to intersect with the approximate representation of B with respect to the orientation made at D.
7. After having oriented the table as above, drawn a resector from a to A and another from b to B, the intersection of which will give the position c occupied by the table.

It is to be noted here that unless the point P is choosen infinitely distant, ab and ab' can not be made parallel. Since the distance of P from C is limited due to other considerations, two point problems does not give much accurate result. At the same time, more labour is involved because the table is also to be set on one more station to assist the orientation.

4.5 Explain three point problems and its solution by tracing paper method.

Statement: Location of the position, on the plan of the station occupied by the plan table by means of observation of three well defined point whose positions have been previously plotted on the plan.

In other words, it is required to orient the table at the station with respect to three visible point already located on the plan. Let P be the instrument station and A,B,C, be the point which are located as a,b,c, respectively an the plan. The table is said to be correctly oriented at P when the three resetors through a,b, and c meet at a point and not in a triangle. The intersection of the three resectors in a point gives the location of the instrument station. Thus in three poin problems, orientation and resection are accomplished in the same operation.

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The method involves the use of a tracing paper and is therefore also known as tracing paper method.

Procedure: Let A,B,C, be the known points and a,b,c, be their plotted positions, Let P be the position of the instrument station to be located on the map.

1. Set the table on P. Orient the table approximately with eye so that ab is parallel to AB.
2. Fix a tracing paper on the sheet and mark on it P' as the approximate location of P with the help of plumbing fork.

3. Pivoting the alidade at P', sight A.B C in turn and draw the corresponding lines P'a', P'b' and P'c' on the tracing paper. These lines will not pass through a, b and c as the orientation is approximate.
4. Loose the tracing paper and rotate it on the drawing paper in such a way that the lines P'a', P'b' and P'c' pass through a, b and c respectively.
5. To test the orientation, keep the alidade along pb. If the orientation is correct the line of sight will pass through B, similarly, the line of sight will pass through C when the alidade is kept on PC.

4.5 **<u>Describe advantages and disadvantages of plane table.</u>**

<u>Advantages:</u>

1. The plan is drawn by the out door surveyor himself, while the country is before his eyes, and therefore, there is no possibility of omitting the necessary measurement.
2. The surveyor can compare plotted work with the actual features of the area.
3. Since the area is in view, contour and irregular object may be represented accurately.
4. It is particularly useful in magnetic areas, where compass may not be used.
5. It is simple and hence cheaper than the theodolite or any other type of survey.
6. It is most suitable for small scale maps.
7. No great skill is required to produce a satisfactory map and the work may be entrusted to a subordinate.

<u>Disadvantages:</u>

1. Since notes of measurement are not recorded it is a great inconvenience if the map is required to be reproduced to some different scale.
2. The plane tabling is not intended for very accurate work.
3. It is essentially a tropical instrument.
4. It is most inconvenience in rainy season and in wet climate.
5. Due to heaviness, it is in convenient to transport.
6. Since there are so many accessories, there is every likelihood of these being lost.

5.0 COMPUTATION OF AREAS

5.1 Explain methods of determining areas.

The following are the general methods of calculating areas :

1. By computations based directly on field measurement :

These include :

(a) By dividing the area into a number of triangles.
(b) By offsets to base line
(c) By latitudes and departures :
    (i) By double meridian distance (D.M.D.) method)
    (ii) By double parallel distance (D.P.D. method)
(d) By co-ordinates.

2. By computation based on measurement scaled from a map.
3. By mechanical method : usually by means of a planimeter.

Areas computed by sub-division into triangles: In this method, the area is divided into a number of triangles, and the area of each triangle is calculated. The total area of the tract will then be equal to the sum of areas of individual triangles. This method is suitable only for work of small nature where the determination of the closing error of the figure is not important, and hence the computation of latitudes and departure is necessary. The accuracy of the field work, in such cases, may be determined by measuring the diagonal in the field and comparing its length to the computed length.

Areas from offsets to a base line: This method is suitable for long marrow strips of land. The offsets are measured from the boundary to the base line or a survey line at regular intervals. The method can also be applied to a plotted plan from which the offsets to a line can be scaled off. The area may be calculated by the following rules:

(i) Mid-ordinate rule (ii) Average ordinate rule (iii) Trapezoidal rule (iv) Simpson's one third rule.

Area by double meridian distances: This method is the one most often for computing the area of a closed traverse. This method is known as D.M.D. method. To calculate the area by this method, the latitudes and departures of each line of the traverse are calculated. The traverse is then balanced. A reference meridian is then assumed to pass through the most westerly station of the traverse and the double meridian distances of the lines are computed.

Area by double parallel distances and departures: A parallel distance of any line of a traverse is the perpendicular distance from the middle point of that line to a reference line at right angles to the meridian. The double parallel distance (D.P.D.) of any line is the sum of the parallel distances of its ends. The principles of finding area by D.M.D. method and D.P.D. nethod are identical. The rules derived above may be changed to get the corresponding rules for D.P.D. method, by substituting D.P.D. for D.M.D. and departure for latitude. The method is employed as an independent method of checking area computed by D.M.D. method.

Area computed from map measurement:

(a) By sub-division of the area into geometric figures: The area of the plan is sub-divided into common geometric figures, such as triangles, rectangles, squares, trapezoids etc.
(b) By sub-division into squares: The method consists in drawing squares on a tracing paper each square representing some definite number of square meters. The tracing paper is placed on the drawing and the number of squares enclosed in the figure are calculated. The positions of the fractional squares at the curved boundary are estimated. The total area of the figure will then be equal to the total number of squares multiplied by the factor represented by each square.
(c) By division into trapezoids: In this method, a number of parallel lines, at tracing paper. The constant between the consecutive parallel lines represents some distance in metres or links. Midway between each pair of lines there is drawn another pair of lines in a different colour of dotted. The tracing is then placed on the drawing in such a way that the area is exactly enclosed between two of the parallel lines. The figure is thus divided into a number of strips.

Area by planimeter: A palnimeter is an instrument which mesures the area of plan of any shape very accurately. There are two types of planimeters: (1) Amsler Polar Planimeter, and (2) Roller Planimeter. The polar planimeter is most commonly used.

5.2 Find out areas from offset to a base line using.

5.2.1 Mid ordinate rule:

The mid ordinate method is used with the assumption that the boundaries between the extremities of the ordinates are straight lines. The base line is divided into a number of divisions and the ordinates are measured at the mid-point of each division.

The area is calculated by the formula.

Area = Δ = Average ordinate X Length of base

$$= \frac{O_1 + O_2 + O_3 + \ldots\ldots\ldots + O_n}{n} L = (O_1 + O_2 + O_3 + \ldots\ldots\ldots + O_n)\, d = d\Sigma O$$

where $O_1, O_2 \ldots$ = the ordinates at the mid-points of each division

ΣO = sum of the mid-ordinates ; n = number of divisions

L = length of base line = nd ; d = distance of each division.

This rule also assumes that the boundaries beween the extremities of the ordinates are straight lines. The offsets are measured to each of the points of the divisions of the base line.

The area is given by Δ = Average ordinate X length of the base

$$= \left(\frac{O_0 + O_1 \ldots\ldots\ldots\ldots + O_n}{n + 1} \right) L = \frac{L}{(n + 1)} \Sigma O$$

where O_0 = ordinate at one end of the base.

O_n = ordinate at the other end of the base divided into n equal divisions.

$O_1, O_2 \ldots\ldots$ = ordinates at the end of each division.

5.2.3 Trapezoidal Rule:

This rule is based on the assumption that the figures are trapezoids. The rule is more accurate than the previous two rules which are approximate versions of the trapezoidal rules.

The area of the first trapezoid is given by $\Delta_1 = \frac{O_0 + O_1}{2} d$

Similarly, the area of the 2^{nd} trapezoid is $\Delta_2 = \frac{O_1 + O_2}{2} d$

The area of the last trapezoid is $\Delta_n = \frac{O_{n-1} + O_n}{} d$

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Hence the total area of the figure is

$$\Delta = \Delta 1 + \Delta 2 \ldots\ldots\ldots + \Delta n = \frac{O_0 + O_1}{2} d + \frac{O_1 + O_2}{2} d + \ldots\ldots + \frac{O_{n-1} + O_n}{2} d$$

5.2.3 Simpson's One-third Rule:

This rule assumes that the short length of boundary between the ordinates are parabolic arcs. The methods is more useful when the boundary line departs considerable from the straight line. Thus in Fig the area between the line AB and the curve DFC may be considered to be equal to the area of the trapezoid ABCD plus the area of the segment between the parabolic are DFC and the corresponding chord DC.

Let O_0, O_1, O_2 = any three consecutive ordinates taken at regular interval of d.

Through F, draw a line EG parallel to the chord DG to cut the ordinates in E and G.

$$\text{Area of trapezoid ABCD} = \frac{O_0 + O_2}{2} . 2d$$

Simpson's one third rule may be stated as follows : The area is equal to the sum of the two end ordinates plus four times the sum of the even intermediate ordinates + twice the sum of the odd intermediate ordinates, the whole multiplied by one-third the common interval between them.

5.3 Compute area by planimeter.

A planimeter is an instrument which measures the area of plan of any shape very accurately. There are two types of planimeters

1. Amsler polar planimeter 2. Roller planimeter.

Planimeter consists of two arms hinged at a point known as the pivot point. One of the two arms carries an anchor at its end, and is known as the anchor arm. The other arm carries a tracing point at its end and is known as the tracing arm.

To find the area of the plan, the anchor point is either placed outside the area or it is placed inside the area. A point is then marked on the boundary of area and the tracing point kept exactly over it. The initial reading of the wheel is then taken. The tracing point is now moved chock wise along the boundary till it comes to the starting point. The final reading of the drum is taken the area of the figure is then calculated the following formula.

Area $(\Delta) = M (F - 1 \pm 10 N + C)$

Where F = Final reading ; I = Initial reading.

N = The number of times the zero mark of the dial passes the fixed index mark. Use plus sign if the zero mark of the dial passes the index mark in a clockwise direction and minus sign when it passes in the anti-clockwise direction.

M = A multiplying constant, also sometimes known as the planimeter constant. It is equal to the area per revolution of the roller.

C = Constant of the instrument which when multiplied by M, gives the area of zero circle. The constant C is to be added only when the anchor point is inside the area.

6.0 COMPUTATION OF VOLUMES:

6.1 Compute volume from cross section.

This is the most widely used method. The total volume is divided into a series of solids by the planes of cross sections. The fundamental solids on which measurement is based are the prism, wedge and prismoid. The spacing of the section depends upon the character of the ground and the acuuracy required in the measurement. The area of cross section taken along the line are first calculated by standard formulas.

The various cross section may be classed as :

1. Level section. 2. Two level section 3. Side hill two level section
4. Three level section 5. Multi level section.

6.2 Find out volume using:

(a) Prismoidal formula: The volumes of the prismoids between successive cross section are detained either by trapezoidal formula or by prismoidal formula. We shall first derive an expression for prismoidal formula.

A prismoid is defined as a solid whose end faces lie in parallel planes and consist of any two polygons, not necessarily of the same number of sides the longitudinal faces being surface extended between the end planes.

The longitudinal faces take the form of triangles, parallelogrms, or trapezium.

Let d= length of the prismoid measured perpendicular to the two end parallel planes.
A1= are of cross section of one end plane,
A2= area of cross section of the other end plane,

M= the mid area = the area of the plane midway between the end planes and parallel to them.

In given figure, let A_1, B_1, C_1, D_1, be one end plane and A_2, B_2, C_2, D_2, be another end plane parallel to the previous one. Let P Q R S T represent a plane midway between the end faces and parallel to them. Let Am be the area of mid-section. Select any point O in the plane of the mid-section and join it to the vertices of both the end planes. The prismoid is thus divided into a number of pyramids, having the apex at A and bases on end and side faces. The total volume of the prismoid will therefore be equal to the sum of the volume of the pyramids.

(b) <u>The Trapezoidal formula (Average end area method)</u>: This method is based on the assumption that the mid-area is the mean of the end areas. In that case, the volume of the prismoid of above figure is given by $V= d / 2 (A_1 + A_2)$

This is true only if the prismoid is composed of prisms and wedges only and not of pyramids. The mid area of a pyramid is half the average area of the ends; hence the volume of the prismoid (having pyramids also) is over estimated. However, the method of end area may be accepted with sufficient accuracy since actual earth solid may not be exactly a prismoid. In some cases, the volume is calculated and then a correction is applied, the correction being equal to the difference between the volume as calculated and that which could be obtained by the use of the prismoidal formula. The correction is known as the prismoidal correction.

Let us now calculate the volume of earth work between a number of sections having areas A_1, A_2, ……….A_n, speed at a constant distance d.

Volume between first two sections = $d / 2 (A_1 + A_2)$
Volume between next two sections = $d / 2 (A_3 + A_4)$
Volume between last two sections = $d / 2 (A_{n-1} + A_n)$

$$\text{The volume} = V = d \left(\frac{A_1 + A_2}{} + A_2 + A_3 + \ldots\ldots. A_{n-1}\right)$$

(c) Volume from spot Levels: In this method, the field work consists in dividing the area into a number of squares, rectangles or triangles and measuring the levels of their corners before and after the construction. Thus, the depth of excavation or height of filling at every corner is known. Let us assume that the four corners of any one square or rectangle are at different elevations but lie in the same inclined plane. Assume that it is desired to grade down to a level surface a certain distance below the lowest corner. The earth to be moved will be a right truncated prism, with vertical edges at a, b, c and d Figure (a) given below. The the rectangle abcd represents the horizontal projection of the upper inclined base of the prism and also the lower horizontal base.

Let us consider the rectangle abcd of Figure (a). If h_a, h_b, h_c and h_d represent the depth of excavation of the four corners, the volume of the right truncated prism will be given by

$$V = \left(\frac{h_a, + h_b, + h_c + h_d}{4}\right) X A$$

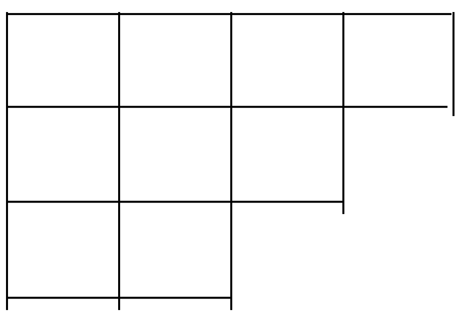
= average height X the horizontal area of the rectangle.

Similarly, let us consider the triangle abc of Figure (b). If h_a, h_b, and h_c are depth of excavation of the three corners, the volume of the truncated triangular prism is given by

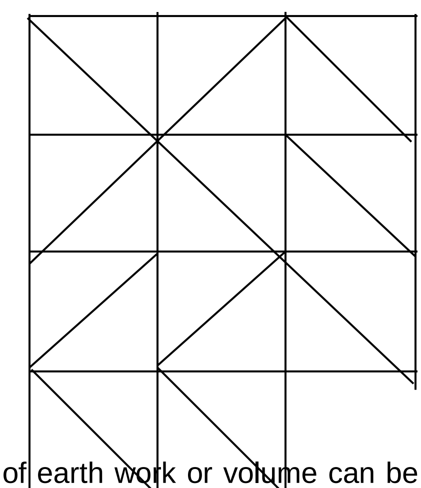
$$V = \left(\frac{h_a, + h_b, + h_c}{4}\right) X A$$

= (average depth) X horizontal area of the triangle.

(a)



(b)



(d) Volume From Contour Plan: The amount of earth work or volume can be calculated by the contour plan area. These are four distinct methods, depending upon the type of the work.

(i) By Cross Section: With the help of the contour plan, cross section of the existing ground surface can be drawn. On the same cross section, the grade line of the proposed work can be drawn and the area of the section can be estimated either by ordinary method or with the help of a planimeter.

(ii) By Equal Depth Contours: In this method, the contours of the finished or graded surface are drawn on the contour map, at the same interval as that of the contours. At every interval as that of the contours. At every point, where the contours of the finished surface intersect a contour of the existing surface the cut or fill can be found by simply subtracting the difference in elevation between the two contours. By joining the point of equal cut or fill a set of lines is obtained. These lines are the horizontal projections of lines cut from the existing surface by planes parallel to the finished surface. The irregular area bounded by each of these lines can be determined by the use of the planimeter. The volume between any two successive area is determined by multiplying the average of the two area by the depth between them.

(iii) By Horizontal Planes: The method consists in determining the volume of earth to be moved between the horizontal planes marked by successive contours.

(iv) Capacity Of Reservoir: This is a typical case of volume in which the finished surface (i.e. surface of water) is level surface. The volume is calculated by assuming it as being divided up into a number of horizontal slice by contour planes. The ground contours and the grade contour, in this case, coincide. The whole area lying within a contour line is measured by planimeter and volume can be calculated.

Let $A_1, A_2, A_3 \ldots\ldots\ldots A_n$ = the area of successive contours.

h = contour interval

v = capacity of reservoir.

Then by trapezoidal formula $v = h\left(\frac{A_1 + A_n}{2} + A_2 + A_3 + \ldots\ldots A_n^{-1}\right)$

By the prismoidal formula $v = h\left(\frac{A_1 + A_n}{2} + A_2 + \ldots\ldots A_n^{-1}\right)$

$$v = h / 3\,(A_1 + 4A_2 + 2A_3 + 4A_4 \ldots\ldots\ldots 2A_n^{-2} + 4A_n^{-1} + A_n)$$

Where n is an odd number.