JHARKHAND RAI UNIVERSITY

CIVIL ENGINEERING

LAB MANUAL

SURVEYING -II

DEPARTMENT OF CIVIL ENGINEERING

LIST OF EXPERIMENT

EXPERIMENT NO.1

AIM:-Study of plane table surveying equipment and accessories

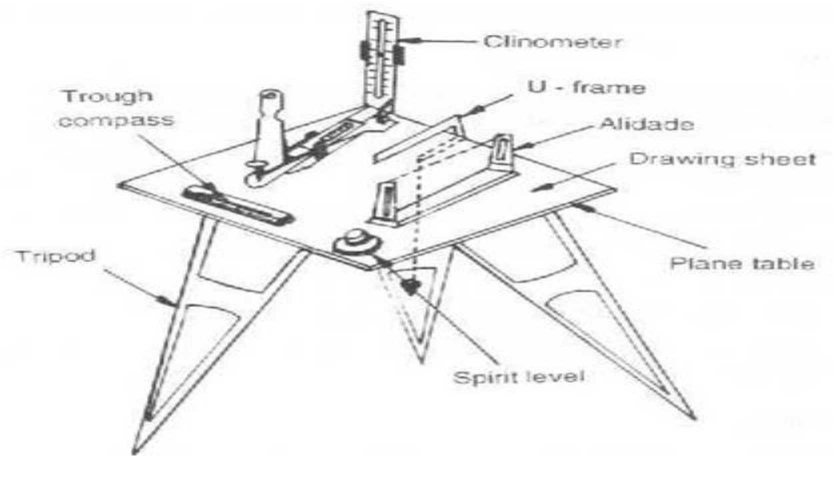
THEORY:

In plane table surveying, a plane table is used for taking the measurements and for plotting the plan in the field. A plane table consists of a drawing board mounted on a tripod. Plane table surveying is a method in which the field observations and plotting of the plan proceed simultaneously. Thus the plan is plotted as the survey progresses. It is unlike other methods of surveying, such as compass surveying and chain surveying, in which the plan is plotted in the office after taking the measurements in the field.

The main feature of plane table surveying is that the plotting is done in the field where all the stations and other features are in the view of the surveyor, and he can compare the plan and plotted details with actual features on the ground. Thus, the mistakes are easily detected.

1) EQUIPMENT AND ACCESSORIES:

- The following instruments are used in plane table survey
- The plane table with leveling head having arrangements for *(a)* leveling, *(b)* rotation about vertical axis, and *(c)* clamping in any required position.
- Alidade for sighting
- Plumbing fork and plumb bob.
- Spirit level.
- Compass.
- Drawing paper with a rainproof cover.



The Plane Table

Three distinct types of tables (board and tripod) having devices for levelling the plane table and controlling its orientation are in common use

(i) The Traverse Table, *(ii)* the Johnson Table and *(iii)* the Coast Survey Table.

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. The table is leveled by adjusting tripod legs, usually by eye-estimation.

Johnson Table : This consists of a drawing board usually 45 x 60 cm or 60 x 75 cm. The head consists of a ball-and-socket joint and a vertical spindle with two thumb screws on the underside. The ball-and-socket joint is operated by the upper thumb screw. When the upper screw is free, the table may be tilted about the ball-and-socket for leveling. The clamp is then tightened to fix the board in a horizontal position. When the lower screw is loosened, the table may be rotated about the vertical axis and can thus be oriented.

The 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. The table can be turned about the vertical axis and can be fixed in any direction very accurately with the help of a clamp and tangent screw

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 is 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. Both the slits thus provide a definite line of sight which can be made to pass through the object to be sighted. The alidade can be rotated about the point representing the instrument station on the sheet so that the line of sight passes through the object to be sighted. A line is then drawn against the working edge (known as the *fiducial edge)* of the alidade.

Telescopic Alidade*:* The telescopic alidade is used when it is required to take inclined sights. Also the accuracy and range of sights are increased by its use. It essentially consists of a small telescope with a level tube and graduated arc mounted on horizontal axis.

Plumbing Fork

The plumbing fork, used in large scale work, is meant for centering 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. Also, in the beginning of the work, it is meant for transferring the ground point on to the sheet so that the plotted point and the ground station are in the same vertical line.

The fork consists of a hair pin-shaped light metal frame having arms of equal length, in which a plumb-bob is suspended from the end of the lower-arm. The fitting can be placed with the upper arm lying on the top of the table and the lower arm below it, the table being centered when the plumb-bob hangs freely over the ground mark and the pointed end of the upper arm coincides with the equivalent point on the plan.

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. The table is levelled by placing the level on the board in two positions at right angles and getting the bubble central in both positions.

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 trough 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.

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. The changes in the humidity of the atmosphere produces expansion and contraction in different directions and thus alter the scale and distort the map. To overcome this difficulty, sometimes two sheets are mounted with their grains at right angles and with a sheet of muslin between them. Single sheet must be seasoned previous of the use by exposing it alternatively to a damp and a dry atmosphere. For work of high precision, fiber glass sheets or paper backed with sheet aluminum are often used.

The other equipment and accessories used are chain, tape, ranging rods, pegs and hammer.

2) TERMINOLOGY:

Radiation

In this method the instrument is setup at a station and rays are drawn to various stations which are to be plotted. The distances are cut to a suitable scale after actual linear measurements on the ground are taken.

Traversing

In this method the table is set at each of the stations in succession. A foresight is taken to the next station and the distance is cut to a suitably chosen scale.

Intersection

In this method two stations are so selected that all the other stations to be plotted are visible from these. The line joining these two stations is called base line. The length of this line is measured very accurately. Rays are drawn from these stations to the stations to be plotted. The intersection of the rays from the two stations gives the positions of the stations to be plotted on the drawing sheet. Sometimes, this method is also termed as graphical triangulation.

Resection

It is a method of orientation employed when the table occupies a position not yet located on the drawing sheet. Therefore, it can be defined as the process of locating the instrument station occupied by the plane table by drawing rays from the stations whose positions have already been plotted on the drawing sheet. The resection of two rays will be the point representing the station to be located, provided the orientation at the station to be plotted is correct, which is seldom achieved. The problem can be solved by any of the methods such as resection after orientation by back ray, by two points, or by three points.

3) TEMPORARY ADUSTMENTS:

Three operations are needed

Fixing

Fixing the table to the tripod.

Setting

(i) Leveling the table *(ii)* Centering *(iii)* Orientation.

Leveling

For small-scale work, leveling is done by estimation. For work of accuracy, an ordinary spirit level may be used. The table is leveled by placing the level on the board in two positions at right angles and getting the bubble central in both directions. For more precise work, a Johnson Table or Coast Survey Table may be used.

Centering

The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground. The operation is known as centering the plane table. As already described this is done by using a plumbing fork.

Orientation

Orientation is the process of putting the, plane-table into some fixed direction so that line representing a certain direction on the plan is parallel to that direction on the ground. *This is* essential, condition to be fulfilled when more than one instrument station is to be used. If orientation is not done, the table will not be parallel to itself at different positions resulting in an overall distortion of the map. The processes of centering and orientation are dependent on each other. For orientation, the table will have to be rotated about its vertical axis, thus disturbing the centering. If precise work requires that the plotted point should be exactly over the ground point, repeated orientation and shifting of the whole table are necessary.

There are two main methods of orienting the plane table:

(i) Orientation by means of trough compass.

(ii) Orientation by means of back sighting.

Sighting the points

Points are sighted using alidade

4) ERRORS IN PLANE TABLING:

The degree of precision to be attained in plane tabling depends upon the character of the survey, the quality of the instrument, the system adopted and upon the degree to which accuracy is deliberately sacrificed for speed. The various sources of errors may be classified as:

1. Instrumental Errors: Errors due to bad quality of the instrument.

2. Errors due to manipulation and sighting: These include
   a) Non-horizontality of board: The effect of non-horizontality of board is more severe when the difference in elevation between the points sighted is more.
   b) Defective sighting: The accuracy of plane table mapping depends largely upon the precision with which points are sighted. The plain alidade with open sight is much inferior to the telescopic alidade in the definition of the line of sight.
   c) Defective orientation: Orientation done with compass is unreliable, as there is every possibility of local attraction. Erroneous orientation contribute towards distortion of the survey. This orientation should be checked at as many stations as possible by sighting distant prominent objects already plotted.
   d) Movement of board between sights: Due to carelessness of the observer, the table may be disturbed between any two sights resulting in the disturbance of orientation. To reduce the possibility of such movement the clamp should be firmly applied. It is always advisable to check the orientation at the end of the observation from a station.
   e) It is very essential to have a proper conception of the extent of error introduced by inaccurate centering, as it avoids unnecessary waste of time in setting up the table by repeated trials.

5) PRECAUTIONS:

In every fieldwork exercise relevant precautions have to be taken to minimize the errors that are mentioned in the previous paragraphs.

6) APPLICATIONS:

Maps can be produced directly with the plane table with complete networks of control points fixed with it and the whole of the detail filled in. This method can be used for the filling in of detail or the revision of plans when the control points have already been fixed by traversing or triangulation. This method can also be used for location of contour-lines

EXPERIMENT:-2

AIM: Three point problem in plane table surveying.

APPARATUS: Plane table alidade, plumbing fork, plumb bob, ranging rod, drawing sheet etc.

THEORY : The experiment consist in finding the location of the station occupied by a plane table on the sheet, by means of sighting to three well-defined points of known location on the sheet as well as on the ground.

Principle:- The three point problem consists in locating on the plan the position of the instrument station on the ground by means of observation to three well defined points whose positions have been already plotted on the plan. Suppose A, B, &C are the three points which have been plotted as a, b, & c on the plan & the t able is set up at T from which A, B, & C are visible. It is required to plot on the plan the position t of the instrument station T. Care should be taken that station T should not lie on great circle passing through ABC. The problem may be solved by (1) Mechanically (2) Graphically (Bessel's method & (3) by trial & error method. However here Bessel's method shall be adopted.

Bessel's method: - This method is simplest & most commonly used.

1. After setting & leveling the table, the alidade is placed along the line ca & the board turned until A is sighted being towards A. the table is then clamped. With the alidade centered on C,B is sighted & a ray CB is down along the edge of the alidade.
2. When the alidade placed along ac, the board is turned until the line of sight bisects c, c being towards C & then clamped. With the alidade touching a, B is sighted & a ray a B is drawn through a; intersecting the ray previously drawn through in the point d.
3. With the alidade along bd, the table is turned until B is bisected & then clamped. The table is now oriented & t must lie on db & also on Aa & Cc. with the alidade centered on a, A is bisected & a lay is drawn through a intersecting the ray bd in t, which represent the instrument station T.

To check the orientation, the alidade is pivoted on c &C is bisected The ray Cc should now pass through t, if the work is correct

RESULT: The location of the station on given point is found on sheet

EXPERIMENT NO.3

Aim:- To determine the multiplying constant and additive constant of the given theodolite.

Principle:- The stadia intercept at any point in horizontal sight at tacheometer is proportional at to its distance from the instrument . The distance and stadia intercept is related to each other through the equation D = KS+ C ,

Where D = Distance between instrument station and staff
C= Additive constant
K= Multiplying constant

S= Staff intercept

Instruments used:-Theodolite, arrows, pegs and ranging rods, leveling staff

Procedure:-

1.Stretch the chain in the field and drive pegs at 5m, 10m, &15m interval

2.Set the theodolite at the zero end and do the temporary adjustments.
3.Keep the staff on the pegs and observe the corresponding staff intercepts with horizontal site.

4.Substitute the values of distance (**D**) and staff intercept (***s***) for different points in the equation **D = Ks + C**, where k & s are the tacheometric constants. **k** is the multiplying constant & **C** is the additive constant.

Observation table

Sl.No.	Distance	Staff intercept	Computed value of" K"	Computed value of "C"

5.Solve the successive pairs of equations to get the value of **k** & **C** and find out the average of these values.

Result:-

Multiplying constant, **k** =
Additive constant, **C** =

EXPERIMENT 4

AIM: Measurement of vertical Angles with Theodolite

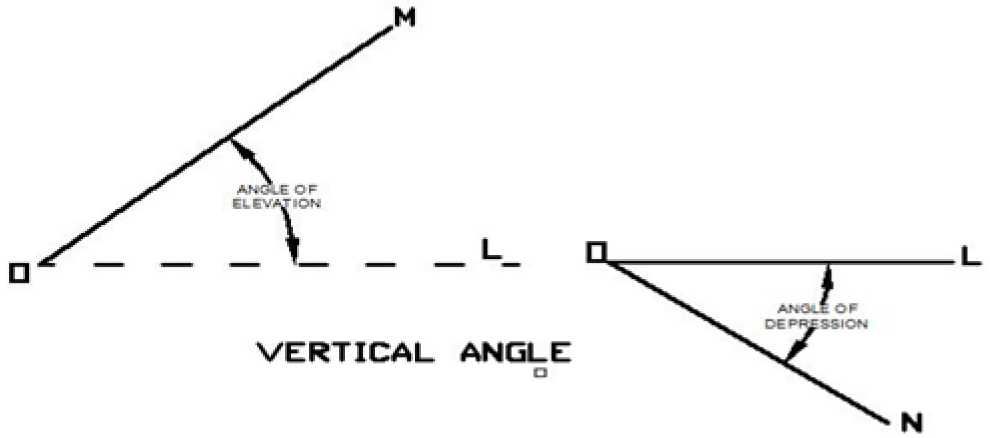
APPARATUS:- Theodolite, three ranging rods.

THEORY: Theodolite is an instrument designed for the measurement of horizontal and vertical angle. It is most precise instrument also used for laying of horizontal angles. Locating points on line prolonging the survey line establishing the gradient, determination of difference in the elevation setting out curve.

Principle:- A vertical angle is the angle between the inclined line of sight to an object and the horizontal. It may be an angle of elevation or on angle of depression according as the point is above or below the horizontal plane passing through the trunnion axis of the instrument. To measure angle of elevation or depression LOM shown in fig. proceed as follows:

Procedure:-

1. Set up the theodolite at station point O and level it accurately with reference to the altitude level.
2. Set vertical verniers C and D exactly to zero by using the vertical circle clamp and tangent screw, while the altitude level should remain in the centre of its run. Also the face of the theodolite should be left.
3. Release the vertical circle clamp screw and rotate the telescope in vertical plane so as to bisect the object M. tighten the vertical circle clamp and exactly bisect the object by slow motion screw.
4. Read both verniers C and D. the mean of the tow readings gives the value of the required angle.
5. Similar observation may be made with other face. The average of the tow values thus obtained gives the value of the required angle which is free from instrumental errors.
6. Similarly the angle of depression can be measured following the above steps



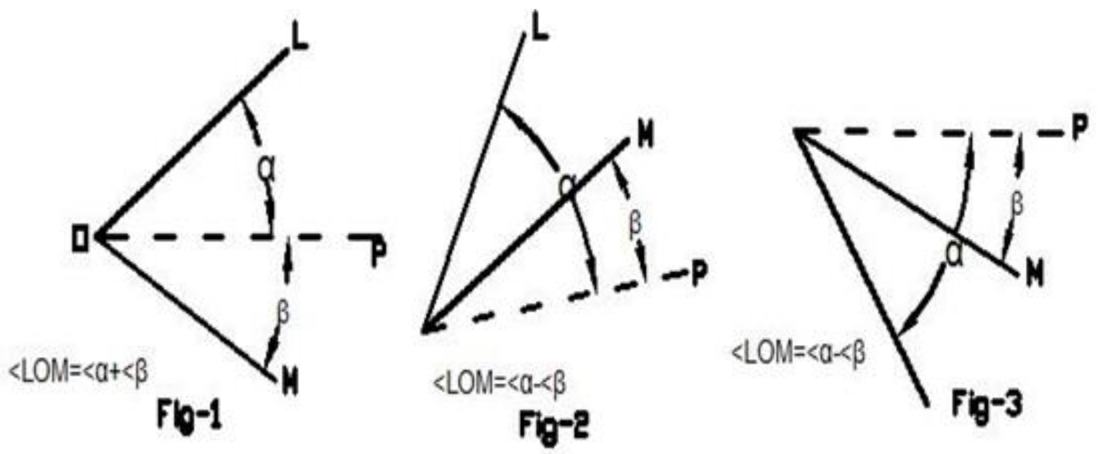
Precautions:-

To measure the vertical angle between two points L and M sometimes it is required to measure vertical angle between two points L and M. There can be three possibilities

(a) One point is above the line of sight and the other is below the line of sight then angle LOM as shown in fig will be equal to (<α +<β)

(b) Both the points are above the line of sight. Then the angle LOM= <α -<β (Refer Fig 2)

(c) Both the points are below the line of sight, then the angle LOM= <α -<β (Refer Fig 3)



To measure the angle between two points L and M proceed as follows

1. Set the theodolite at station point O and accurately level it.
2. Bisect the flag at L as explained already and take the reading on the verniers C and D.Calculate the mean angle.
3. Bisect the flag at M as before and take the reading on the verniers C and D. Calculate the mean angle.
4. The sum or difference of these angles will give the value of the vertical angle between points L and M as shown in the figure (4)

Observation table:-

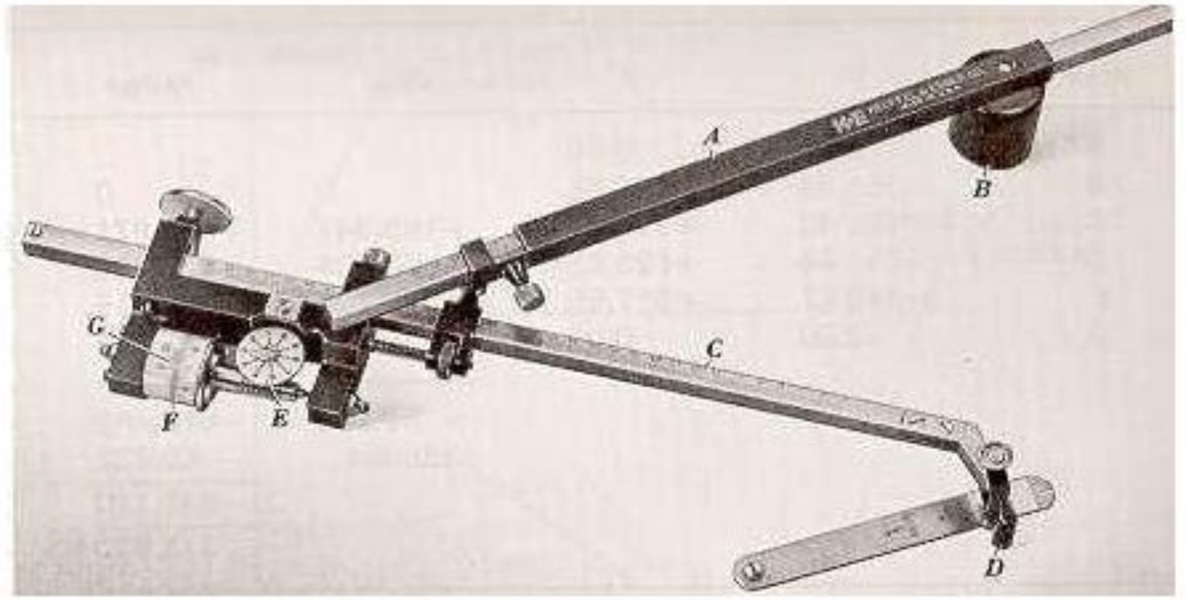
S.N.	Instrument Station	Sighted to	Face left readings			
			Venier C 0,I,II	Venier D 0,I,II	Mean Angle	Vertical Angle
	o	P				
	(+ve)L					
	(-ve)M					

S.N.	Instrument Station	Sighted to	Face Right readings				Average Vertical Angle 0,I,II	Remarks
			Venier C 0,I,II	Venier D 0,I,II	Mean Angle 0,I,II	Vertical Angle 0,I,II		
	o	P						
	(+ve)L							
	(-ve)M							

Result:- The average value of vertical angle

EXPERIMENT No. 5

AIM: Study of plannimeter
APPARATUS: Plannimeter
FIGURE:



Plannimeter: A plannimeter is a mechanical integrator is used by engineer for measuring area of figure which is been plotted scale particularly when the boundaries are irregular are curved mathematically it is difficult to find the area of such irregular figures. Plannimeter is largely used for finding the areas of contour in determining the capacity of storage server.
Construction: These are several types of Plannimeter but the ampler polar Plannimeter is in most common use & is described as-

It consists of two arms hinged at a point one is known is anchor arm & it is at fixed length. It has a needle point called the anchor point which is fixed in paper & hold in position by detachable small weight the other arm is called trussing arm. it carries a tracing point which is moved along the periphery of the figure of which the area is to be found out . Tracing arm is adjustable is length the tracing arm is set to position given by the manufacturer according to scale used the total normal displacement is measured b rolling wheel. The rolling wheel carries graduated drum divided into 100 parts. The verniers are provided to read 1/10th parts of the rolling wheel. The wheel is connected by gears is the counting disc. The counting disc measure one revolution at every 10 turns of the rolling wheel each complete reading is a figure of four digits. The zero of rolling wheel is apposite to the zero at verniers. Actually the marks of rise should be opposite to index mark due to imperfection of the wheel gear. Instrument is equipped with magnifying lance to read verniers & a check bar or flat bar for testing the Plannimeter
Reading on Plannimeter:

Each complete reading on Plannimeter is a figure of digits. Let the reading be 4.375 the first digit 4 is read on the disc the second digit 3 is read on the rolling wheel (main scale) the third digit 7 is read on the falling wheel (main scale) & the last is fourth digit 5 is read on the verniers scale beside the main scale of rolling wheel position of measuring unit (setting of tracing arm) the position of tracing arm is adjustable according to given position by the manufacture for the different scalar. The position of measuring unit will figure may be obtained directly in m2 or hectors by marking use of multiplying scale factor.

Method of using Plannimeter:

The Plannimeter is used in determining the areas of the figure in 2 ways.

1.By placing the anchor point outside the figure.

2.By placing the anchor point inside the figure.

Procedure:-

1.Set out the index arm on the tracing arm to the given scale as per manufactures instruction exactly b using clamp & fine motion screw. Stretch the sheet making free from wrinkleness.

2.Fixed the anchor point of firmly on paper inside & for small outside keep.

3.Mark the points on the boundaries of the figure & set tracing arm exactly over it.

4.Now take the initial reading i.e. the reading on dial & wheel & verniers.

5.Move the tracing point along the periphery of the figure & stop at the starting point.

6.While tracing point is moved note the number of times the zero index mark in clockwise & anticlockwise direction. Again take the reading of on dial wheel & verniers that will be final reading.

7.The calculated area (A) = m (FR-IR +10N+C)

Where,

M=multiplying constant which is different scales

N=number of times the zero of dial passes the fixed index mark use the +ve sign when moves clockwise & -ve sign moves anticlockwise.

C= constant of instrument supplied by manufacture & different for different scales & it is offset when anchor point is kept inside otherwise it is taken zero if it is kept outside.

FR=Final reading.

IB= Initial reading.

Area of the zero circles i.e. Mc is defined as the correction circle which is defined as a circle found the circumference at which if the tracing point is moved wheel will slide without rotation in a reading. This is possible when tracing arm is placed in such a position relative to the anchor of arm that the plane of the roller passes thought the anchored point the multiply constant of Plannimeter is equal to the number of unit of per revolution of the roller.

RESULT: - Plannimeter has been used to measured irregular figure.

EXPERIMENT NO.6

AIM: To Study of Box sextant

APPARATUS: Box sextant

FIGURE :

It is reflected type of instrument capable of measuring angle up to 1200 & reads to one Minutes.

Construction: - it consist of –

1. A box about 7.5 cm in dia & 4cm in depth
2. A cover which server as a handle when occurred to the bottom.
3. A horizontal glass having the lower half & the nipper half.
4. An index glass wholly.
5. A Oliver all graduated from 00 to 1400 degrees & half degrees.
6. An index arm carries a verniers which reads to single minute.
7. An adjustable magnifying glass.
8. A milled handle screw to rotate the index glass & index arm.
9. An eye hole in a sliding arm.
10. A pair of colored glasses for use when observations are taken on the brought object or the sun.
11. A telescope for a long distance sighting.
12. A slot in the side of the box through which entrees the rays from the object sighted.
13. A bay for adjusting the instrument.

Uses:- The box sextant is a compact hand instrument by setting the verniers to 90^0 it may be used as a optical square (equipment) For a chain survey it is very useful for measuring chain angles. Locating inaccessible point at measuring angles for checking purpose.

PROCEDURE:-

When measuring angles between the two objects at a station hold the instrument is the right hand over the station & look through the eye lenses at the left hand object through the lower position of the horizontal angle. The middle headed screw slowly until the image of the right hand object seen is the upper silvered half of the horizon glass is with left hand.

Note :- The reading of verniers which gives the value of the required angle.

RESULT:- Box sextant is studied.

EXPERIMENT NO.7

AIM: Determination of horizontal distance between two inaccessible points with theodolite.

PRINCIPLE: Distance between two inaccessible point P & Q can be found by taking any base line AB, measuring < PAQ ,<QAB ,<ABP and <PBQ, measures length of base line accurately and using " sine rule" for finding length of PA,PB,QA & QB and finally length of PQ from triangle PAQ and Triangle PBQ by cosine rule.

APPARATUS:- Theodolite , three ranging rods, tapes & arrows.

PROCEDURE:-

It is required find the distance between two points P and Q . Both P and Q are inaccessible.

1.Select two stations *A* and *B* on the ground such that line *AB* is nearly parallel to line PQ.

2.Measure the distance *AB.*

3.Centre the theodolite over station *A* and observe the angle between the lines *AP*, *AQ* and AB and record them.

4.Centre the prismatic compass over station *B* and observe the angle between the lines *BA*, *BP* and *BQ* and record them .Thus angles γ and δ can be obtained.

OBSERVATION TABLE

Sl.no.	Name of station	Name of angles	Initial reading at	Final reading at	Angle measure
1	A	< PAQ <QAB	(P) $0^0$0'0" (Q) $15^0$10'30"	(Q) $15^0$10'30" (B) $40^0$15'0"	$15^0$10'30" $25^0$4'30"
2	B	<ABP <PBQ	(A) $0^0$0'0" (B) $10^0$4'30"	(P) $10^0$4'30" (A) $45^0$50'15"	$10^0$4'30" $35^0$45'45"

Computation of sides

Sl. No.	Name of angle	Name of sides	Name of opposite angle	Length of side
1	ABP	AB PA PB	<APQ <PBQ <PAB	
2	AQB	AB AQ BQ	<AQB <ABQ <QAB	

$$\text{COS}<\text{PAB}= \frac{\text{PA2}+\text{AQ2}-\text{PQ2}}{2.PA.AQ}$$

PQ = $\sqrt{PA2 + AQ2 - 2PA.AQ\ COSPAQ}$

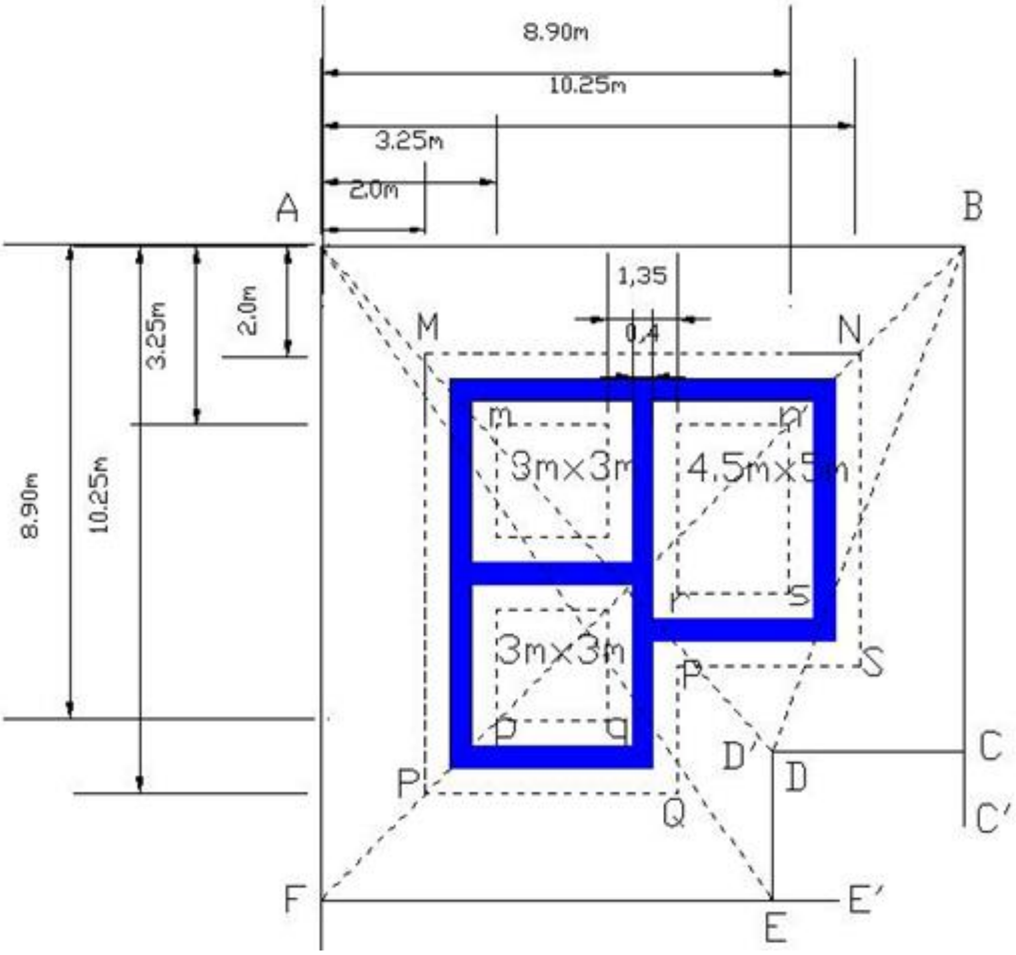
PQ = $\sqrt{PB2 + BQ2 - 2\ PA.B.Q\ COSPBQ}$

RESULT:- Length of line PQ = $\frac{\text{length of triangle PAQ+QAB}}{\mathbf{2}}$

EXPERIMENT NO.8

AIM : To give Layout for given plan of building.

Equipment: Pegs, Nails, Lime, Wooden Mallet.



Theory: - When plans are ready for the works, the works are to be executed .To start with any structure first of all ,trenches for the foundation are to excavated. To excavate these trenches, the outline of excavation are defined on the ground, the process of defining the outlines of the excavation on the ground is known as setting out of works or lining out of works.

To set any structure or work whether it may be building, culvert, pipeline or sewer line, the plan showing the width of the foundation trench, for various walls, distance of the corners from some definite line etc. is required. This plan called foundation plan (Fig) .The distances and they are with reference to lines AB and AF.

<u>PROCEDURE :-</u>

To start with the setting out of building ,first of all a point A is fixed and then line AB is oriented in the required direction .Thus having fixed the direction of the line AB, two pegs A and B are driven at distance of 12.25m,apart (This distance calculated from the plan). Wire nails are driven at the centers of the pegs. Again the distance between the wire nails is checked and which should be equal to 12.25m. A cord is stretched along AB and ends are secured to these wire nails at A and B, perpendicular AF' and BC' are setout. Perpendicular may be set with a tape by 3-4-5 method or theodolite may be used if the work is important.

Along AF’ and BC’, point F and C are fixed at 12.80m and 10.30m, from A&B respectively .The perpendicular are then set at C and F and point D and E are fixed along CD’ and FE’ at a calculated distance from C and F respectively . The stakes are driven at these point C, D, E, and F and wire nails are driven at the centers of these stakes. A cord is stretched all along ABCDEF.

To check up the work, the diagonal AE, AD, bF, and Bd are actually measured and these measured values should agree with their corresponding calculated lengths. Otherwise the setting out work should be repeated and stakes should be refixed at their correct positions.

After fixing up all the pegs and stretching the cord the corners M,N,P etc and m,n,p etc. are to be located . The point A is considered as the origin and the lines

AB and AF as the axes of the co-ordinates. The co-ordinates of all the corners M,N,P etc., and m, n, p, etc. are calculated with reference to A as origin .

For example Co-ordinates of M.N.P are (2,2),(2,10.25) and (10.25,2) respectively and those for m,n,p are (3.35,3.35),(3.35,8.90) and (8.90,3.35) respectively. With these co-ordinates, point M,N,P,m,n,p etc., are set and pegs are driven at these points. The cord are stretched around the wire nails at M,N,P,Q,R,S and m,n,p,r,s indicating peripheries. The outline of the peripheries are marked with lime spread.

Now the lime lines on the ground indicate the trenches for the various walls and the excavation may be started .if during the progress of the work, the lines marked are disturbed, it may be checked or reset with help of reference line ABCDEF