

OPSC-AEE 2020

Odisha Public Service Commission
Assistant Executive Engineer

Civil Engineering

Surveying

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**



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Surveying

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Plane Table Surveying

8.1 Introduction

- Plane table surveying is a graphical method of surveying in which field work and plotting are done simultaneously.
- It is mainly used for small and medium scale mapping (1 : 10000 to 1 : 250,000)
- It is also used for plotting the topographical maps in the field.
- Before starting plane table survey at first control stations are establish to cover entire area, then after a suitable scale is decided.
- After that surveyor starts collecting detail from either of the point and traverses all the stations.
- Elevation of points of observation are determined with the help of levelling, Indian clinometer, telescope and alidade.
- The finished map so produced are known as topographic maps and this graphical method of producing topographic maps is known as cartography.
- It should be noted that all the measurements made are plotted directly on the drawing sheet instead of recording in the field book.
- The principle used in plane table surveying is that an unknown point of interest can be established by measuring it directions from known points.

8.2 Advantages

- The sighting and plotting are done simultaneously hence there is no chance of missing any detail.
- Irregular objects can also be plotted accurately as the lay of land is in view.
- It is most rapid and useful for filling in details.
- The error and mistakes in plotting can be checked by drawing the check lines.
- No great skill is required.
- It is less costly in comparison to theodolite survey.
- It is very advantages in areas, where compass survey is not reliable e.g. area affected by magnetic field.

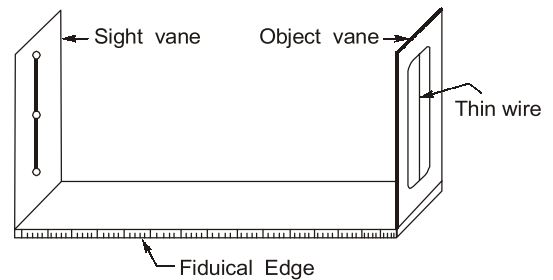
8.3 Disadvantages

- It is not suitable for, work in a wet climate and in a densely wooded country.
- Plane table is heavy and awkward to carry and the accessories are likely to be lost.
- It does not give very accurate result.
- It becomes difficult, if plan or map is to be plotted on some different scale due to absence of field notes.

8.4 Accessories Used in Plane Table Surveying

- (i) **Plane table board:** It consists of a drawing board mounted on a tripod which can be clamped in any position with the help of wing nut.
- (ii) **Tripod:** An open frame type light tripod is usually used in the simplest form of plane tables, levelling of the board is achieved with the tripod legs and checking the horizontality of the board with the help of two spirit levels fixed at right angles to each other in a block of wood.

- (iii) **Alidade:** Alidade is a straight edge ruler used for sighting the objects and drawing lines with object vane and sight vane. Line of sight will be parallel to the fiducial edge.

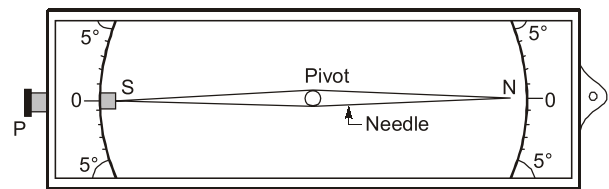


- (iv) **Level tube/ Spirit level**

- The essential condition in plane table surveying is that the board should be level, this level tube is either tubular or of the circular type.
- It is placed on the board in two positions mutually at right angles and the bubble is centered in each position to make the board horizontal.

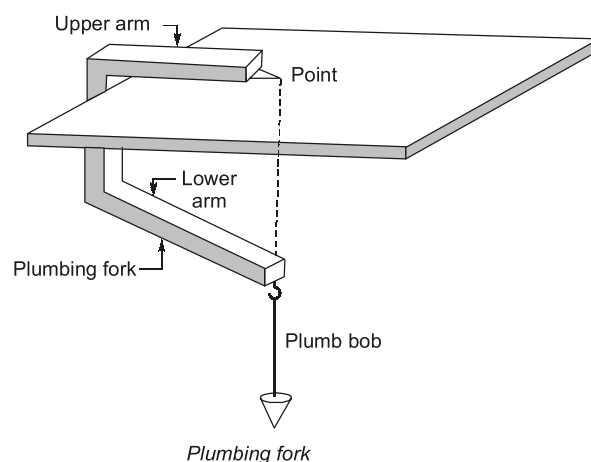
- (v) **Trough compass**

- It is used to orient the plane table w.r.t. magnetic meridian.
- Side of trough compass should be parallel and plane such that they can be used as a ruler or for placing the compass such that it coincides with the line already drawn in N-S direction.



- At the extremities of the trough compass, there are graduated scales with zero at the centre and marking upto 5° on either side of the zero line.

- (vi) **Plumbing form**



- Plumbing form is a U-shaped metal frame.
- Point of upper arm and plumb line are in same vertical line.
- Plumbing fork can be used for the following purpose.

- (a) Centering the plane table over the station occupied by it which is already plotted on the drawing sheet.
- (b) Transferring ground point on the drawing sheet.
- (vi) **Drawing Sheet** : The drawing sheet used should be of the best quality to withstand rubbing scrubbing.

8.5 Setting up the Plane Table

Following operations are included in setting up of the plane table.

1. Centering

- It is the operation of bringing the plotted station point exactly over the ground station
- A plumbing fork is used for checking the centering.

NOTE: Exact centering is important for large scale mapping only. For small scale mapping, an error in centering of about 30 cm is permissible.

2. Levelling

- It is the operation of bringing the plane table in horizontal plane.
- Level the board with the help of a spirit level.

3. Orientation

(a) Orientation with a Trough Compass

- When the plane table occupies the starting station, the trough compass is placed on the drawing sheet and rotated till the needle of the trough compass points to zero.
- A line is drawn parallel to the long edge of the trough compass which represents the magnetic meridian.
- In order to orient the plane table at other stations, trough compass is placed on the drawing sheet with its long edge along the line representing the magnetic meridian.
- Plane table is then rotated till the needle ends point to zero. Plane table is then clamped at this position.
- **Drawback:** This method of orientation is not very accurate.

(b) **Orientation by Back-Sighting** : In this, the plane table is oriented by back sighting. Let the plane table is set up at station Q on the line PQ which has already been plotted as ' pq ' on the drawing sheet when the plane table was set up at station P . The alidade is placed along the plotted line ' qp ' and the plane table is rotated till the line of sight bisects the ranging rod at P . Plane table is then clamped at this position.

(c) **Resection** : The method of resection will be discussed later in this chapter in details.

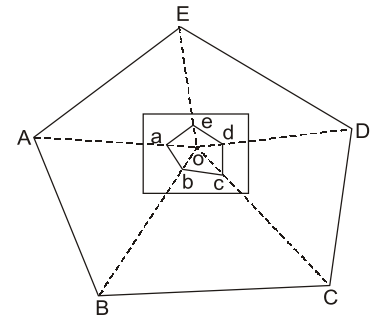
8.6 Method of Plane Table Survey

The method of surveying with a plane table include:

- (i) Radiation
- (ii) Traversing
- (iii) Intersection and
- (iv) Resection

(i) Radiation

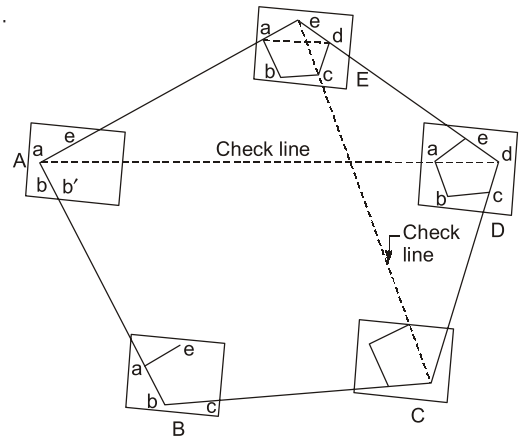
- In this method instrument is set up at a station and rays are drawn to various stations which are to be plotted, then distances are cut on a suitable scale after actual measurement.
- It is suitable for small area, and all station should be visible and accessible from the plane table station.



Radiation method

(ii) Traversing

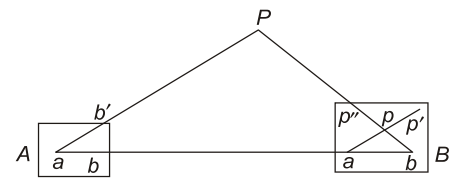
- This method of traversing is same as compass traverse and theodolite traverse.
- A plane table traverse is a very rough type of traverse and is used generally for depicting the topographical details directly on the plane table.
- Traverse consists of a series of straight lines connected together.
- In plane table traversing, the angles are not measured but are in fact plotted directly.
- Plane table traversing is run between the stations whose positions have previously been fixed by some other precise methods like the theodolite traverse or the triangulation.
- The plane table is set successively on the traverse stations and back sight is taken on the preceding station followed by foresight on the following station.
- The measured traverse lines are plotted directly on the paper to some suitable scale.



Plane table traversing

(iii) Intersection

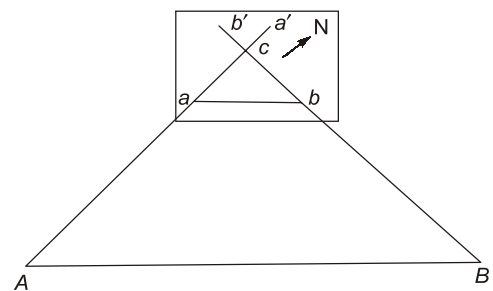
- This is a method of locating a point on the drawing sheet by the intersection of two rays drawn from two different stations.
- It is also called as graphical triangulation.
- It is preferred when
 - distance between stations is very large
 - stations are inaccessible or ground is undulating



Intersection method

(iv) Resection

- It is the process of determining the location of the station that is being occupied by the instrument.
- In resection, the position of the station that is being occupied by the instrument (i.e. plane table) is located with respect to the stations whose locations have already been plotted.
- As shown in the Fig. plane table occupies the station C whose position has not been plotted on the paper when the table occupied other stations. For locating the position of station C on the paper, the following procedure is adopted.



Resection method of orienting the plane table

- Let there be two stations A and B whose positions ' a ' and ' b ' has been marked on the paper and both the stations are visible from station C . In case the orientation of plane table at station C is correct then the intersection of the rays from ' a ' and ' b ' will give the location of station C i.e. ' c '. Thus the main problem reduces to that of obtaining the correct orientation at C .

(Method of Resection)

- (a) Compass method
- (b) Back ray method
- (c) Three point problem
- (d) Two point problem

8.6.1 Compass Method of Resection

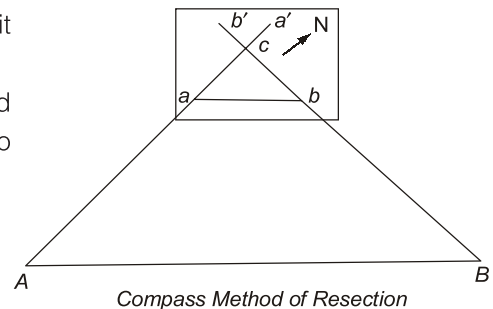
- This method of resection is used for relatively small works where the orientation errors in plane table do not significantly affect the location of plane table.
- This method assumes that the direction of magnetic meridian has already been marked when the plane table occupied the stations A and B .
- Further, it is assumed that the area is not magnetically disturbed.

The following steps are followed as shown in Fig.

Step 1. Set up the plane table at station C . Level it and orient it roughly by the judgment of eye.

Step 2. Place the trough compass along the meridian line and rotate the plane table until the needle points to zero mark of the scale. Clamp the table at this position.

Step 3. Pivot the alidade at ' a ' and sight the ranging rod at A . Draw a ray ' aa'' ' towards A . This ray is called as the **resection line** or the **resector**. It is the ray drawn through the plotted position ' a ' of known station A towards the plane table at C .



Step 4. Pivot the alidade on ' b ' and sight the ranging rod at B . Draw a ray ' bb'' ' towards B .

Step 5. The intersection of the rays ' aa'' ' and ' bb'' ' gives the position of station C i.e. ' c ' on the paper.

8.6.2 Back Ray Method of Resection

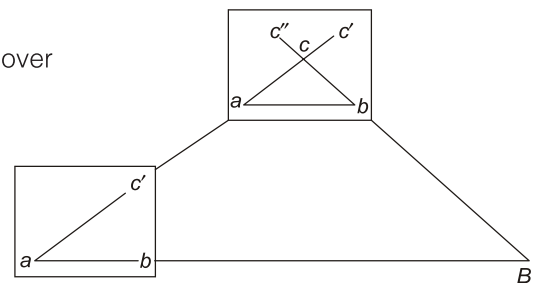
- This method can be used only if the plane table station C is already selected and a ray has been drawn from one of the stations (say A or B) towards the station C but exact location of station C is not marked on the ray.

The following steps are followed as shown in Fig.

Step 1. Set up the plane table at A . Level it and center it over the plotted point ' a '.

Step 2. Pivot the alidade at ' a ' along ' ab '. Orient the table by rotating it until the ranging rod at B is bisected. Clamp the plane table in this position.

Step 3. Pivot the alidade at ' a ' and sight the ranging rod at station C . Draw a ray towards C . Determine roughly the position of C and mark ' c'' ' on the ray.



Step 4. Relocate the plane table to station C . Level it. Set the plane table such that the rough position ' c'' ' is exactly over the station C . Orient the plane table by taking back sight towards A . Clamp the plane table at this position.

Step 5. Pivot the alidade on ' b ' and sight the ranging rod at station B and draw a ray ' $c''b'$ '.

Step 6. The intersection of the rays ' ac ' and ' $c''b$ ' gives the position of plane table station C .

- This method is suitable when there exists a prominent land mark such as a chimney or a building etc. which can be taken as station B .
- This method is useful for large scale mapping when long rays can be drawn. The accuracy of the point ' c ' depends on the correct position of point ' c ' and correct initial setting of plane table at station C .

8.6.3 Three Point Problem of Resection

- This method is employed in case the surveyor wants to set up a table at a particular station (say P) towards which no rays had been drawn when the plane table occupied other stations. Here the back ray method cannot be used because the ray was not drawn towards P when the plane table occupied other stations.
- The three point problem can be used if three well defined points A , B and C whose positions a , b and c has already been plotted on the plan/map and which are visible from the plane table station P . The following methods are used for the solution of three point problem:

(a) Trial and error method	(b) Mechanical method
(c) Graphical method	(d) Analytical method
(e) Geometrical construction method	

Trial and Error Method of Three Point Problem:

- The main feature of three point problem is to orient the plane table at station P occupied by it after sighting towards the stations A , B and C .
- In this method, the correct orientation is attained after several trials.

This trial and error method is also known as **Lehmann's Method**.

The following steps are followed in the trial and error method / Lehmann's method:

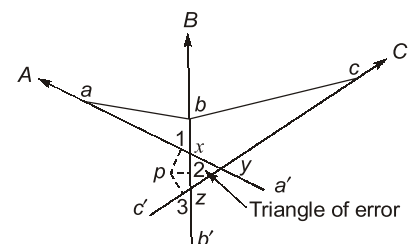
- Step 1.** Set up the plane table at station P . Orient it approximately by eye judgment or by a trough compass if magnetic meridian has already been drawn on the plan when the plane table occupied other stations. Level the plane table at station P .
- Step 2.** Pivot the alidade at ' a ' and sight station A . Draw a resection line ' aa' '.
- Step 3.** Pivot the alidade at ' b ' and sight the station B . Draw a resection line ' bb' '.
- Step 4.** Pivot the alidade at ' c ' and sight the station C . Draw the resection line ' cc' '.
- Step 5.** Find the point of intersection of rays ' aa' ', ' bb' ' and ' cc' '.

These three rays will not intersect at a single point until the orientation of the plane table is correct.

The three rays will form a triangle xyz which is called as the triangle of error. This triangle is to be reduced to a point ' p ' by doing so many trials so that the three rays intersect. Then the point of intersection ' p ' will then represent the correct location of the station P .

The correct position of the point ' p ' is determined from the triangle of error xyz by applying the Lehmann's rule.

Lehmann's Rules : In this, there are two basic rules and some supplementary rules. The basic rules are quite sufficient to determine the exact position of ' p '.



Trial and error method of three point problem

Basic Rule 1: The point 'p' is on the same side of all the three resection lines aa', bb' and cc'. When the surveyor face towards the stations A, B and C, the point 'p' lies either on the right or left of all the resection lines.

Basic Rule 2: The distance of point 'p' from a resection line is proportional to the length of that line. From the above figure,

$$\frac{p1}{pa} = \frac{p2}{pb} = \frac{p3}{pc}$$

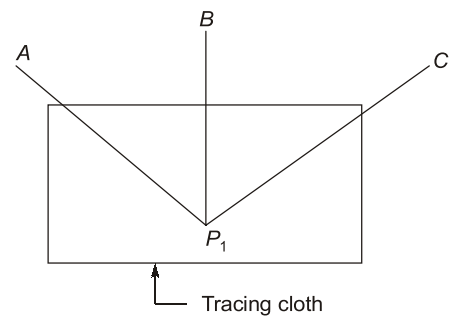
The above basic rules apply in general to any location of the plane table except when the plane table station P is on the great circle passing through A, B and C.

- Step 6.** Select a point 'p' which satisfy the above basic rules which gives the approximate position 'p'. Keep the alidade along 'p'a' and rotate the plane table to sight the station A. Clamp the plane table at this position.
- Step 7.** Pivot the alidade at point b and sight station B and draw a ray. Similarly pivot the alidade at 'c' and sight C and draw a ray.
- Step 8.** Find the intersection of the three rays so drawn. These rays will form a smaller triangle of error than the previous triangle of error.
- Step 9.** Select a point 'p"' satisfying the above two basic rules.
Repeat the above steps till the triangle of error reduces to a point 'p'. Thus the location of point P is determined on the plan / map. Now this gives the correct orientation of the plane table.

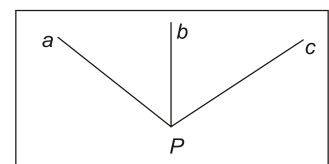
The Mechanical Method of Three Point Problem:

The solution of three point problem using mechanical method employs a tracing cloth. The following steps are followed:

- Step 1.** Set up the plane table at station P whose location is required to be located and orient the plane table approximately using a compass or by eye judgment. Clamp the table at this position.
- Step 2.** Spread a sheet of tracing sheet on the plan and hold down/fasten the sheet on the plan.
- Step 3.** Mark point 'p1' on the tracing sheet as per convenience to represent the station P.
- Step 4.** Pivot the alidade on 'p1' and sight the station A and draw a ray. Similarly sight the station B and C and draw the respective rays as shown in **Fig.**
- Step 5.** Unfasten the tracing sheet from the plan and move it over the plan till all the three rays pass through the plotted points 'a', 'b' and 'c'. Prick the point 'p1' on the tracing sheet with a fine pin/needle to obtain the position 'p' on the paper.
- Step 6.** Place the alidade on 'p' with the fiducial edge along pa and turn the plane table till station A is bisected. This gives the correct orientation of the plane table.



Mechanical method of three point problem



Plan

Check for mechanical method of three point problem

CHECK: As a cross-check for the plotted position p, sight the station B with alidade centered at b and draw a ray. Similarly sight the station C with alidade centered at c and draw a ray. These rays should pass through 'p' if the plotted position 'p' is correct else the small triangle of error is removed by the trial and error procedure as described earlier.