CHAPTER 06

Plane Table Surveying

6.1 Introduction

- In this method of surveying, the work of taking the measurements and plotting the plan is done in the field only.
- It is a quick method of surveying. The advantage of this method is that the plan as plotted in the field can be compared with the actual field plan on the spot. Thus mistakes can be detected at the initial stage itself.
- It is a rough method of surveying and is generally not recommended where a high level of precision is required.
- It is usually used for filling in the details in between the stations which are already established by other more precise methods like the theodolite traverse or triangulation. It is mainly used for topographical maps preparation.

6.2 Plane Table and its Types

- Plane table consists of a drawing board mounted on a tripod.
- The size of the board is usually 750 mm × 600 mm with a thickness of about 20 mm.
- Depending on the method of fixing the board on the tripod, there are many different types of plane table which are as enumerated below:

6.2.1 Simple Plane Table

- This plane table is used for survey works of less importance.
- It is provided with an aluminium racer ring underneath the board at the center of the board.
- There is a threaded socket in the racer which accommodates the screw passing through the head of the aluminium casting fitted to the tripod. The screw is provided with a wing nut which allows to orient the plane table in the horizontal plane.
- The plane table can be rotated in the horizontal plane and can be clamped in any orientation.
- After placing the board on the tripod, the plane table is levelled.
- This type of table is also called as traverse table.

6.2.2 Johnson Plane Table

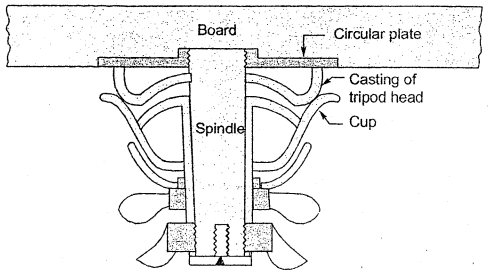


Fig. 6.1 *Johnson plane table*

- This is an improvement over the simple plane table and is provided with a special head called as Johnson head.
- This is fitted on the top of the tripod. The benefit of Johnson head is that it helps in quick levelling and also provides an independent horizontal motion.
- Johnson head consists of a ball and socket joint and a vertical spindle. There is a circular brass plate on the underside of the board.
- It is quite useful for accurate plane table surveying and large scale mapping.
- The main benefit of Johnson table is that it can be precisely levelled and centered.

6.2.3 Coast Plane Table

- This is the most precise plane table which is used for long distance plane table surveying and is thus used for large scale maps.
- The drawing board is attached to a metal casting which is fixed to a levelling head.
- The board is levelled by three levelling screws.
- For fixing the board in any position in the horizontal plane, there is the provision of clamp screw and a tangent screw.
- **Limitation:** The major limitation of this coast table is that the tripod is quite heavy.

6.3 Alidade

- An alidade is a straight edge ruler provided with a sighting device. It is used for sighting the objects and drawing the lines on the drawing sheet.
- Alidades are mainly of two types viz. **plain alidade** and **telescopic alidade.**

6.3.1 Plain Alidade

- It is a 450 mm long straight edge ruler made of wood or metal.
- One of the ruler edge is beveled and graduated. This edge is called as **fiducial edge.**
- At each end, alidade is provided with a sighting vane. The sight vanes are hinged at the lower ends so that they can be folded down on the ruler when not in use. The sight vanes on unfolding take normal position to the plane of the ruler. The object vane is open and is fitted with a thin wire at the center.

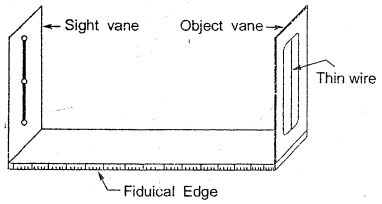


Fig. 6.2 *Plane alidade*

Limitation: This alidade is not so much precise and is not suitable for hilly areas since the inclination of the line of sight is very limited through the alidade and is being limited to height of object vane.

6.3.2 Telescopic Alidade

- This alidade consists of a telescope mounted on a column fitted to the straight edge ruler.
- The telescope rotates about a horizontal axis resting on A frames or standards.
- A level tube is provided on the straight edge for levelling purposes. For measurement of vertical angles, a vertical circle is provided with the telescope.
- Small movements are made possible with the provision of tangent screw.
- The line of sight of the telescope is aligned along the fiducial edge of the ruler.
- Object is sighted through the telescope and distance of the object is scaled off in that direction along the ruler's edge.
- **Advantages:** Telescopic alidade when provided with stadia diaphragm can be used as tacheometer for computing the horizontal distances and also elevations. For determining the direction of magnetic meridian, a trough compass is also provided.

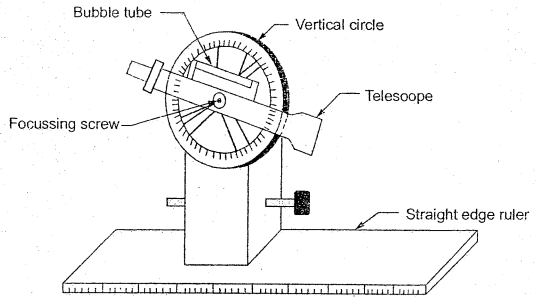


Fig. 6.3 *Telescopic alidade*

6.4 Plumbing Fork

- A plumbing fork is a *U* shaped metal piece used for centering the plane table over the station.
- The end of the upper arm of the fork is made pointed which is placed on the drawing sheet.
- The lower end of the fork is provided with a plumb bob. The point of upper arm and plumb bob are in the same vertical line.
- **Uses:** The plumb bob is used for centering the plane table over the station and also for transferring the ground point to the drawing sheet.

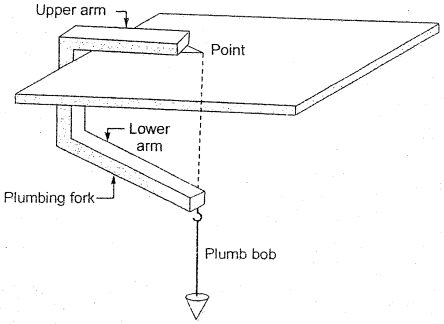


Fig. 6.4 *Plumbing fork*

6.5 Level Tube

- The premost essential condition of plane table surveying is that plane table must be levelled.
- Thus level tube is used to check the level of the plane table.

- Level tube can be either of cylinder type of the circular type. Level of the plane table is checked by placing the level tube on the plane table in two orthogonal directions.
- When the bubble of the level tube comes in the center, then the plane table is levelled.

6.6 Trough Compass

- The trough compass is used to orient the plane table along the magnetic meridian.
- It consists of a rectangular box of size 80 to 150 mm length by 30 mm width and is covered on the top with a glass. Inside the box, at the center, there is a magnetic needle resting on a pivot made of hard material.
- At the two extremes of the trough compass along the length, two graduated scales are provided with readings ranging from 0° at the center to 5° on either side of 0°.
- The larger edges of the trough compass are straight and plain so that they can be used as edges of a ruler for the purpose of drawing the line or for placing the trough compass on a already drawn line on the drawing sheet.
- A brake pin is provided on one side of the compass to dampen the needle vibrations. At the bottom of the trough compass, there is a screw which is used to lift the magnetic needle from the pivot when not in use.

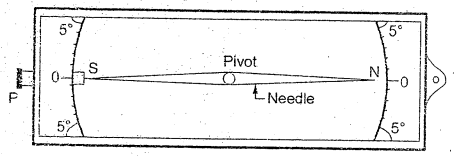


Fig. 6.5 *Trough Compass*

6.7 Drawing Sheet

- The drawing sheet or the drawing paper is fixed on the board by means of umbrella pins or clamps. Sometimes, adhesive tapes are also used but they damage the corners of the drawing sheet on removal of adhesive tapes.
- The drawing sheet must be thick enough to bear the rubbing action of the base of the alidade. It should be well seasoned to minimize the effects of variations in humidity, temperature etc., since these variations cause expansion or contraction of the drawing sheet thereby changing the scale of the drawing.
- Now a days, fiber glass sheet or paper backed with aluminium sheets are used in order to have a permanent and accurate record.

6.8 Pencil and Eraser

- The pencil to be used for drawing purpose must be hard (preferably 4H or 6H) and sharp. A piece of fine grained sand paper can also be used for sharpening the pencil. A good quality soft rubber eraser is used for erasing purposes.

6.9 Terminologies in Plane Tabling

(a) Centering

- It is the process of setting up the plane table in such a way that the plotted position 'o' on the drawing sheet corresponding to the ground station '*O*' is exactly over the station.

(b) Orientation

- It is the process of aligning the plane table by rotating it in the horizontal plane in such a way that all the plotted lines are parallel to the corresponding ground lines.
- Orientation of the plane table is done by using a trough compass by backsighting or resection as discussed in later sections of this chapter.

(c) Back Sight

- It is the sight taken from the plane table station to another station whose position has already been plotted on the drawing sheet.
- In order to take the back sight of a station (say *Q*), when the plane table is centered over the station *P*, the alidade is placed along the plotted line *pq*. Plane table is then rotated till the station *Q* is bisected. Thus the plane table is oriented by back sighting.

(d) Fore Sight

- It is the sight taken from the plane table station to another station whose position has not been marked on the drawing sheet.

(e) Radiation

- It is the method of locating a point by drawing a radial line from the plane table station to the station under consideration. For this, the plane table is set up and oriented. Then a ray is drawn in the direction of that point using the alidade. A length equal to distance of that point is cut off to a suitable scale.

(f) Intersection

- It is the method of locating the point by intersection of two rays drawn from two different stations. It is used when it is not possible or it is difficult to measure the radial distance of the unknown point due to some obstruction and the radiation method cannot be used.

(g) Resection

- It is the method of locating a station occupied by the plane table when the position of that station has not been earlier plotted on the drawing sheet when the plane table occupied other stations.
- It is done by sighting two points whose position has earlier been plotted in the **two-point problem**. Alternatively, it can be done by sighting three points whose positions have earlier been plotted in the **three point problem**. Two-point problem and three point problem are discussed in later sections of this chapter.

(h) Plane Table Traversing

- The method of traversing which employs a plane table is referred to as plane table traversing.
- The traverse is directly plotted on the drawing sheet by drawing traverse lines with the help of an alidade.
- In plane table traversing, **NO angle measurements** are done.

6.10 Setting up of the Plane Table

- Reconnaissance of the area to be surveyed is required before selecting the plane table stations.
- Obstructed sights are avoided and plane table stations should be on the firm ground.
- After selecting the plane table stations, the plane table is set up which involves the following processes:

(a) Fixing the Plane Table

- The legs of the tripod are spread and shoes are pushed through the ground.
- The top of the tripod must be at a convenient height (preferable 1.2 m), depending on the height of the surveyor.
- The drawing board is fixed on the tripod and the clamp is tightened.

(b) Centering the Plane Table

- It is the process of setting up the plane table on the ground station such that the plotted point on the drawing sheet is exactly over the ground station.
- For this, the pointed leg of the plumbing fork is made to coincide with the plotted point on the drawing sheet and table is shifted till the plumb bob is exactly over the ground station.
- For the starting point (say *A*), the plane table is set up over the station with plumb bob exactly over the ground station *A*. A point '*a*' is then plotted on the drawing sheet at the pointed end of the upper leg.

(c) Levelling the Plane Table

- It is done by moving the legs of the tripod.
- In case of Johnson plane table, the table is accurately levelled with the help of ball and socket head provided in the plane table.
- In case of Coast survey plane table, levelling is done by adjusting the levelling screws.

6.11 Orienting the Plane Table

- When the plane table is set up at a station other than the starting station, it is required to be oriented so that the plotted lines on the drawing sheet are parallel to the corresponding ground lines.
- However the process of orientation disturbs the centering of the plane table and thus both the processes of centering and orientation are done simultaneously. The following methods are used for orienting the plane table:

(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) Orientation by Two-Point and Three-Point Problem

These methods of orienting the plane table are discussed in **section 6.16.3 and 6.16.9.**

6.12 Radiation

- In the radiation method, the points are located by drawing radial lines from the plane table station.
- The distances of these points are measured and scaled off on the respective radial lines to locate the points.

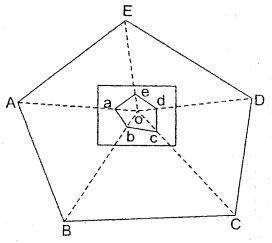


Fig. 6.6 *Radiation method*

6.12.1 Use of Method of Radiation

- The radiation method is quite suitable for survey of small areas which can be controlled from a central station using the plane table.

6.13 Intersection

- In this method, the point is located on the drawing sheet by drawing rays from two plane table stations to that point and marking the point of intersection of the two rays.

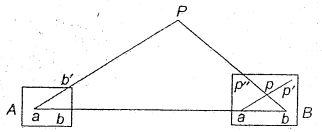


Fig. 6.7 *Intersection method*

6.14 Plane Table Traversing

- 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.

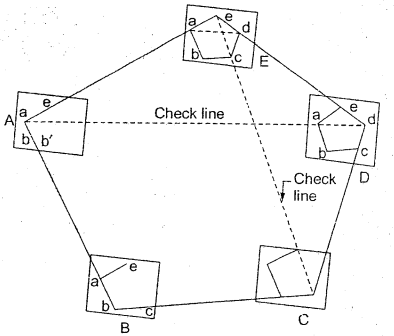


Fig. 6.8 *Plane table traversing*

- The measured traverse lines are plotted directly on the paper to some suitable scale.

6.14.1 Check Lines

- In order to check the accuracy of the plane table traverse, few check lines are also taken. At any station, check line can be taken by sighting at any preceding station.
- For example in Fig. 6.8, check line *'da'* from station *D* to *A* when plane table is at station *D*. If the plane table traverse is accurate, the check line *'da'* will pass through the plotted position of station *A* i.e. *'a'* on the drawing paper.

6.14.2 Error of Closure

- For a closed traverse, the error of closure can be determined by plotting the starting station *A* from the last station (say *E*).
- The error of closure is the distance between the starting position '*a*' and the final plotted position '*a*'' i.e. distance '*aa*''.
- This error of closure (if in permissible limits) is adjusted graphically as is done in the compass traverse.

6.15 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.

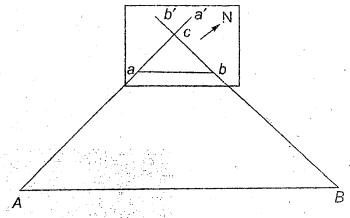


Fig.6.9 *Resection method of orienting the plane table*

- As shown in the **Fig. 6.9**, 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:
- 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*.

6.16 Methods of Resection

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

6.16.1 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. 6.9**:

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.

6.16.2 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. 6.10**.

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.

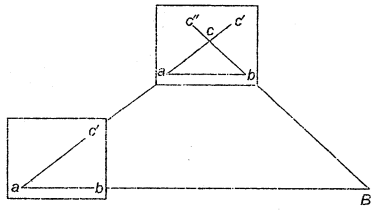


Fig. 6.10 *Back ray method of resection*

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*.

6.16.3 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

6.16.3.1 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*.

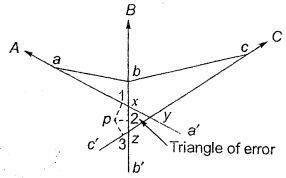


Fig. 6.11 *Trial and error method of three point problem*

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*'.

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.

Supplementary Lehmann's Rules

Apart from the above two basic Lehmann's rules, there are many supplementary rules which are quite helpful in order to determine the correct location of point *p* occupied by the plane table.

Supplementary Rule 1: If the plane table station *P* is outside the great triangle *ABC* passing through the stations *A*, *B* and *C*, then the triangle of error will also be outside the great triangle *'abc'* formed by joining the plotted positions *'a'*, *'b'* and *'c'*.

Supplementary Rule 2: If the plane table station *P* is inside the great triangle *ABC* then the triangle of error will also be inside the great triangle '*abc*'.

Supplementary Rule 3: If point *P* lies on the great circle passing through the points *A*, *B* and *C* then the position of point *P* cannot be determined from the three point problem since the problem becomes indeterminate as the three rays will intersect at a point irrespective of the plane table orientation.

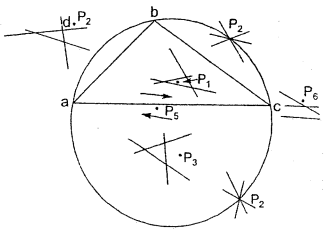


Fig. 6.12 *Supplementary Lehman's rules*

Supplementary Rule 4: If the point *P* lies outside the great circle passing through *A*, *B* and *C* then the point *'p'* is obtained by intersection of the two rays drawn to the nearer points and the point *p* are on the same side of the ray to the most distant point.

Supplementary Rule 5: If the point P is outside the great triangle *ABC* but lies inside the great circle passing through *A*, *B* and *C*, then the ray to the middle point lies between *'p'* and point '*e*' obtained by the intersection of the rays to the other two extreme points.

Supplementary Rule 6: If point *P* lies on or near one side (say *AC*) of the great triangle *ABC*, then point *'p'* will be between the two parallel rays drawn to pints *A* and *C* and it will be on the same side of each of the rays.

Supplementary Rule 7: If point *P* lies on or near the prolongation of the line (say *AC*), then the point *'p'* lies outside the parallel rays and on the same side of all the rays.

Supplementary Rule 8: If *A*, *B* and *C* lie on a straight line the great circle gets converted to a straight line and the great circle will have abc as its arc with an infinite radius.

6.16.3.2 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 'p_1' on the tracing sheet as per convenience to represent the station *P*.

Step 4. Pivot the alidade on 'p_1' 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. 6.13.

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 'p_1' 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.

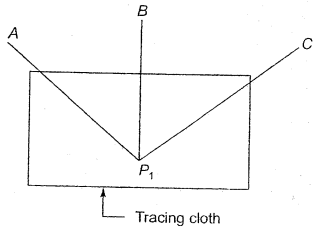
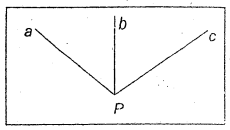


Fig. 6.13 *Mechanical method of three point problem*

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.



Plan

Fig. 6.14 *Check for mechanical method of three point problem*

6.16.3.3 The Graphical Method of Three Point Problem

Of the many graphical methods available for the three point problem, the **Bessel's solution** of inscribed quadrilateral is the most prevalent. The procedure for the use of this method is as described below:

Step 1. Set up the plane table at station *P* and level it.

Step 2. Place the alidade along '*ca*' with point '*a*' towards *A* and turn the table till the station *A* is bisected. Clamp the table in this position.

Step 3. Center the alidade on '*c*' and sight station *B* and draw a ray *'cb'* along the fiducial edge of the alidade. The resulting ray will not pass through '*b*'.

Step 4. Place the fiducial edge of the alidade along *'ac'* with '*a*' towards '*c*'. Turn the table till station *C* is bisected. Clamp the table in this position. Pivot the alidade on '*a*' and sight station *B*. Draw a ray *'ad'* intersecting the ray *'cb'* at point '*d*'.

Step 5. Place the fiducial edge of the alidade along bd and turn the table till *B* is bisected. Clamp the table in this position. Thus the table is now truly oriented.

Step 6. Centre the alidade on '*a*' and sight station *A*. Draw a ray through '*a*' intersecting the ray db produced at '*p*'. The point '*p*' thus represent the station *P*.

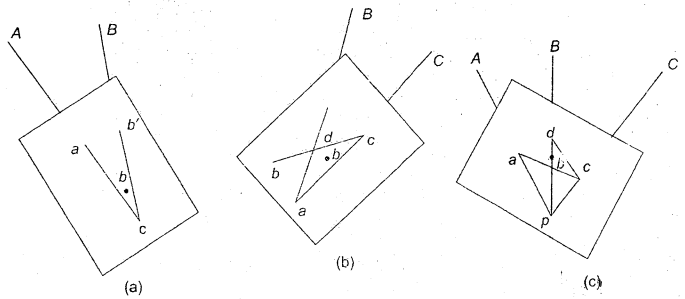


Fig. 6.15 *Graphical method of three point problem*

6.16.3.4 Strength of Fix in Three Point Problem

- By the term strength of fix, it implies the accuracy with which a point can be plotted in three point problem. This fix will depend on the relative positions of known points like *A*, *B* and *C* and on the plane table station *P*.
- Thus it should always be tried to select the plane table station in such a way so as to have a strong fix.

6.16.4 Two Point Problem

- In two point problem, the plane table is oriented at station *C* by sighting two stations *A* and *B* whose positions has already been plotted on the plan.
- Unlike three point problem, here observations are taken to two prominent points *A* and *B* instead of three points.
- Now with the positions of stations *A* and *B* already plotted on plan as points '*a*' and '*b*', the following steps are followed:

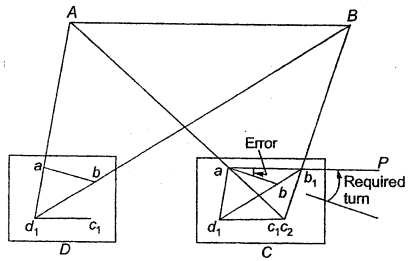


Fig. 6.16 *Two point problem*

Step 1. Choose a suitable subsidiary station D near station *C* such that ∠*CAD* and ∠*CBD* are neither too acute nor too obtuse. Set up the plane table at station *D*. Level it. Using a magnetic compass or by rough eye judgment, orient the plane table approximately. Thus plotted line '*ab*' is approximately parallel to the field line *AB*. Clamp the table in this position.

Step 2. Pivot the alidade on '*a*' and sight *A*. Draw a ray through '*a*'. Similarly pivot the alidade at '*b*' and sight *B*. Draw a ray through '*b*' intersecting the ray through '*a*' at 'd_1'. This point 'd_1' gives the approximate position of ground station *D*. Transfer the point 'd_1' to ground using the plumbing fork and a peg.

Step 3. With the alidade pivoted at 'd_1', sight the station *C*. Draw ray 'd_1c_1' to represent *DC*. Mark the position of 'c_1' approximately.

Step 4. Shift the plane table to station *C* and center it. At this position, the point 'c_1' is just above *C*. Orient the plane table by back sighting at *D*.

Step 5. Pivot the alidade against '*a*' and sight *A*. Draw ray 'ac_2' to intersect the ray 'd_1c_1' produced at 'c_2'. This point 'c_2' gives the approximate position of station *C*.

Step 6. Pivot the alidade against 'c_2' and sight *B*. Draw ray 'c_2b_1' through 'c_2'. Because of approximate orientation, the ray 'c_2b_1' will not pass through the correct position '*b*'. Thus point 'b_1' gives the approximate position of *B* with respect to orientation made at station *D*. Also the length '*ab*' is the true representation of the field line *AB*, the orientation error is equal to '$b_1$ab' between the plot lines *'ab'* and 'ab_1'.

Step 7. In order to eliminate the error due to orientation, place the alidade along 'ab_1'. Place the ranging rod at station *P* located at some distance from the plane table and in line with 'ab_1'.

Step 8. Place the alidade along *'ab'* and turn the plane table till the ranging rod at *P* is bisected. Clamp the table in this position. Thus, now the orientation of plane table is correct and plotted line *'ab'* is exactly parallel to field line *AB*.

Step 9. In order to locate the true position of station *C*, center the alidade on '*a*' and sight *A*. Draw a ray *'ca'* through '*a*'. Similarly, center the alidade at '*b*' and sight *B*. Draw ray *'cb'* through '*b*'. The intersection of the rays *'cb'* and *'ca'* gives the true position of station *C* i.e. '*c*'.

Drawbacks of Two Point Problem

(a) As shown in the figure above, the distance from P to C is usually limited due to many reasons, two point method does not give accurate results.

(b) Two point problems involve more work as compared to three point problems.

6.17 Contouring in Plane Table Surveying

- In plane table traversing, contouring can be done very conveniently.
- The details of the various points on the plan are located by radiation or intersection.
- The levels of the various points are determined from a telescopic alidade or by the use of other methods.
- Points are located on the plan from the calculated horizontal distances.
- The elevations of the various points so computed are marked on the plan.
- The contours are then plotted by interpolation.

6.18 Errors in Plane Tabling

1. **Instrumental errors:** The plane table, alidade etc. must be in perfect adjustment. The instrumental errors occur due to the following reasons:
   (a) Surface of the plane table not being plane.
   (b) Fiducial edge of the alidade not perfectly straight.
   (c) Sluggish magnetic needle will give an error in orientation of the plane table.
   (d) Sight vanes when not perpendicular to the base of the alidade will introduce an error in the sighting.
   (e) Defective level tube will give an erroneous horizontal positioning of the plane table when the bubble is at the center.
   (f) Poor quality of drawing sheet will undergo more shrinkage and expansion and thus plot obtained will not be correct.
2. **Errors in sighting:** Erroneous sighting arise due to the following reasons:
   (a) Centering error which occurs when the plane table is not accurately centered.
   (b) Levelling error which occurs when the plane table is not properly levelled. In this case, the sight vanes will not be perpendicular to the alidade and sight vanes will be inclined to the vertical.
   (c) Orientation error occurs if the plane table is not properly oriented at the plane table station. Due to this, the resulting plot will be erroneous.
   (d) Loosely clamped table may disturb the orientation of the plane table between the sights and error will crept in.
   (e) Plotting error occurs when the alidade is not pivoted at the exact point. Here in this case, the rays drawn will not be correct.
   (f) Instability error which occurs when the tripod on which the table is clamped is not firmly held on to the ground. Thus, select the plane table station at a location where the ground is firm and unyielding.

6.19 Advantages and Disadvantages of Plane Table Surveying

Advantages:

(a) It is very suitable for plotting small scale maps directly in the field.
(b) Since plotting is done in the field only and thus no field book is required. Furthermore, the accidental omission of any prominent detail of the area to be surveyed is avoided since surveyor has the full view of the field.
(c) The plotted map can be compared with the actual field plan on the field itself.
(d) By the provision of suitable check lines, the errors in measurement and plotting can be detected easily in the field.
(e) Because of simple instruments, not much skill is required for taking the observations.
(f) Since no angular measurements are made and thus error while reading the angles from the instruments are prevented.
(g) The biggest advantage of this method is that it can be used in magnetically affected area also where compass surveying cannot be used.
(h) Plane table surveying is usually more rapid and less expensive than other methods of surveying.
(i) Contours and other features can be plotted in the field itself and can be checked there in the field only.

Disadvantages:

(a) This method of surveying is not at all suitable for wet climates for quite obvious reasons.
(b) It is not a precise method of surveying as compared to other methods.
(c) The instruments and the associated accessories of the plane table are quite heavy and bulky which the surveyor needs to carry along with.
(d) As the height of plane table is up to the waist only and thus sight distances are less than the distances measured with compass or a theodolite.
(e) In the event of absence of any field data, replotting of the plan is very difficult.

6.20 Plane Table Traverse versus Theodolite Traverse

Theodolite Traverse	Plane Table Traverse
Angles are measured with theodolite.	Direction of traverse line is drawn with the help of alidade.
More precise.	Less precise.
Suitable for large area.	Not suitable for large area.

6.21 Plane Table Traverse versus Chain Traverse

Plane Table Traverse	Chain Traverse
Suitable for small area.	Comparatively large area can be covered.
Suitable for undulating terrain.	Suitable for flat terrain.
Least possibility to miss out any detail since plotting is done simultaneously.	There exists a possibility to skip any detail.

Objective Brain Teasers

Q.1 The major source of error while mapping a small scale map by plane tabling is:
(a) Long sight
(b) Drawing sheet getting shrinked
(c) Error in centering
(d) All of the above

Q.2 A building is located on the far end of the river and is not accessible. The building can be located by:
(a) Traversing (b) Resection
(c) Intersection (d) Radiation

Q.3 As compared to three point problem, two point problem is:
(a) More labour demanding
(b) Fast
(c) Precise
(d) All of the above

Q.4 Two point and three point problem are the methods of:
(a) Orientation only
(b) Resection only
(c) Traversing
(d) Resection and orientation

Q.5 In plane tabling, the instrument used for finding the horizontal distance without actual measurement is:
(a) Clinometer (b) Telescopic alidade
(c) Plane alidade (d) Tacheometer

Q.6 Plane table surveying is most suitable for surveying of:
(i) Small scale map.
(ii) Medium scale map.
(iii) Large scale map.
of the above statements, the correct one is/are:
(a) (i) and (ii) only (b) (iii) only
(c) (iii) only (d) (ii) only

Q.7 The most accurate method of orientation by three point problem is:
(a) Graphical method
(b) Trial and error method
(c) Tracing paper method
(d) None of the above

Q.8 When plotted position of an instrument station is not known, then the most accurate method of orientation of plane table is attained by:
(a) Back sighting
(b) Trough compass
(c) Observation of three well defined points
(d) Observation of two well defined points

Q.9 For survey broken boundaries with a plane table, the most apt method is :
(a) Intersection (b) Radiation
(c) Open traversing (d) Resection

Q.10 In Lehmann's rule, while looking towards the station, the plane table location to be fixed is always to the:
(a) Left of each of the rays
(b) Right of each of the rays
(c) Left or right of each of the rays
(d) Left or right of the ray to the most distant station

Q.11 While setting up a plane table, the orientation is done by:
(a) sighting the farthest point
(b) sighting the nearest point
(c) sighting the previous point
(d) any of the above

Q.12 The method of three point problem fails when an instrument station lies on:
(a) Segments formed by great circle and great triangle
(b) great circle
(c) centroid of great triangle
(d) all of the above

Q.13 A minaret is located on other side of a river which is inaccessible. It can be located by:
(a) Resection (b) Traversing
(c) Radiation (d) Intersection

Q.14 Consider the following statements:
(i) In plane table method, contour maps can be prepared quickly.
(ii) Plane table is more stable than a theodolite.
(iii) Plane table can be used to locate the points more accurately than a theodolite.
of the above statements, the correct one is:
(a) (i) only (b) (iii) only
(c) (i) and (iii) (d) (ii) and (iii)

Q.15 The accuracy of survey work of small area being done with plane tabling can be increased by tacheometer by using the _____ method.
(a) Resection (b) Radiation
(c) Traversing (d) Intersection

Q.16 In plane tabling, the very first operation is:
(a) Leveling (b) Orientation
(c) Centering (d) Radiation

Q.17 The process of determining the plotted position of a station occupied by plane table by sights take towards points of known location is called
(a) Resection (b) Radiation
(c) Intersection (d) Orientation

Q.18 Major source of error in small scale mapping by plane traverse is:
(a) Long sights
(b) Inaccurate centering
(c) Shrinkage of drawing sheet
(d) Inaccurate orientation

Q.19 Fiducial edge is related to which of the following instrument?
(a) Trough compass
(b) Theodolite
(c) Alidade
(d) Tacheometer

Q.20 In which of the following method, it is required to go to the plotted station in resection?
(a) Back ray method
(b) Three point problem
(c) Two point problem
(d) Intersection

Q.21 The instrument used in plane tabling for determining the horizontal distances without actual measurements in the field is _____.
(a) Theodolite
(b) Tacheometer
(c) Telescopic alidade
(d) Plain alidade

Answers

1. (c)	2. (c)	3. (a)	4. (d)	5. (b)
6. (a)	7. (b)	8. (c)	9. (a)	10. (c)
11. (c)	12. (b)	13. (d)	14. (a)	15. (c)
16. (c)	17. (b)	18. (b)	19. (c)	20. (a)
21. (c)				

■■■■