SURVEYING
MODULE-III

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Semester Questions Topic Wise

Assignment for you?

Module III

CONTOURING: -

1. WHAT is contour line?
2. What are the characteristics of contour lines?
3. What is contour gradient?
4. Define contour interval and horizontal equivalent?
5. Why is not horizontal equivalent constant?
6. What is objective of preparing contour map?
7. What is use of contour map?
8. How you will determine steep slope and flat slope from a contour map?
9. What is interpolation of contours? What is the type?
10. Draw vertical cliff an overhanging cliff?

THEODOLITE SURVEY: -

11. What is telescope? write its purpose?
12. Difference between ridge line and valley line?
13. Compare direct-indirect method of contouring?
14. Explain the types of theodolite?
15. Draw neat sketch of a transit theodolite?
16. What is least count of theodolite?
17. State any four uses of a theodolite?
18. What is meant by face left and face right?
19. What does swing of telescope means?
20. What is meant by transiting?
21. What are the different sources of error while using theodolite?

B.Tech(Civil Engineering) Detail Syllabus For Admission Batch 2015-16

(PCI3I102) Survey (3-0-1)

Module I (10 classes)

Linear measurement and chain survey: Use of chains and tapes for measurement of correct length of lines, direct and indirect ranging, chaining along sloping ground. Obstacle in chaining, errors and their elimination.

Compass surveying: Use of prismatic compass, temporary adjustment, bearing of a line, local attractions, correction of bearing

Module II (8 classes)

Levelling: Use of dumpy level and levelling staff.Temporary and Permanent adjustment of dumpy level, Reduction of levels by height of instrument and rise and fall method. Curvature and refraction error, sensitiveness of level tube, reciprocal levelling, levelling difficulties and common errors, Automatic and Electronic or Digital levels

Module III (10 classes)

Contouring: Contour interval and horizontal equivalent, characteristics of contours, methods of contouring- different and indirect method, contour gradient

Theodolite Survey: Use of theodolite, temporary adjustment, measuring horizontal and vertical angles, theodolite traversing

Module IV (8 classes)

Modern Surveying Instruments – Electromagnetic Spectrum, Radar, Electronic Distance Measurement, EDM Equipment, Corrections to measurement, Digital Theodolite, Total Stations, Introduction to Remote Sensing and GIS

Text Books

1. Surveying &Levelling. Vol-I by T.P.Kanethar&S.V.Kulkarni, Pune VidyarthiGrihaPrakashan
2. Surveying and Leveling by R. Subramanian, Oxford University Press
3. Surveying- Vol.I, by B.C. Punmia, Laxmi Publications

Reference Books

1. Surveying Vol-1 by R Agor, Khanna Publishers
2. A Textbook of Surveying, C. Venkatramaiah, Universities Press
4. Surveying AndLevelling, N.N. Basak, McGraw-Hill Education

MODULE-III

CONTOURING

While introducing surveying, it was mentioned that showing natural and manmade features on land in a plan is topographic surveying. Instead of showing the features only in their plan view if their positions in elevation are also shown, it will enhance the value of topographic map. The various methods tried to show the relative vertical positions of features in a plan are shading, spot heights, hatching and contour lines, of all these methods commonly used method is by drawing contour line in the plan.

A contour line is an imaginary line which connects points of equal elevations. Such lines are drawn on the plan of the area. Since the water in a still lake is a level surface, its periphery represents a contour line Fig, shows a lake with water surface at a level of 110 m. Its periphery in the plan represents a contour line RL 110 m. if water level goes down by 5 m, the periphery of water shows, contour line of RL 105 m. when periphery of water surface in the pond for various levels are down, it becomes contour map of ground level of the lake.

While conducting surveying, if levels of various points on the ground are also taken, it is possible to draw ground features in the plan as well as draw the contour lines of different elevations. The field and office work involved in drawing contour lines is called contouring.

CONTOUR INTERVALS

The vertical distance between two consecutive contour lines is called contour interval.

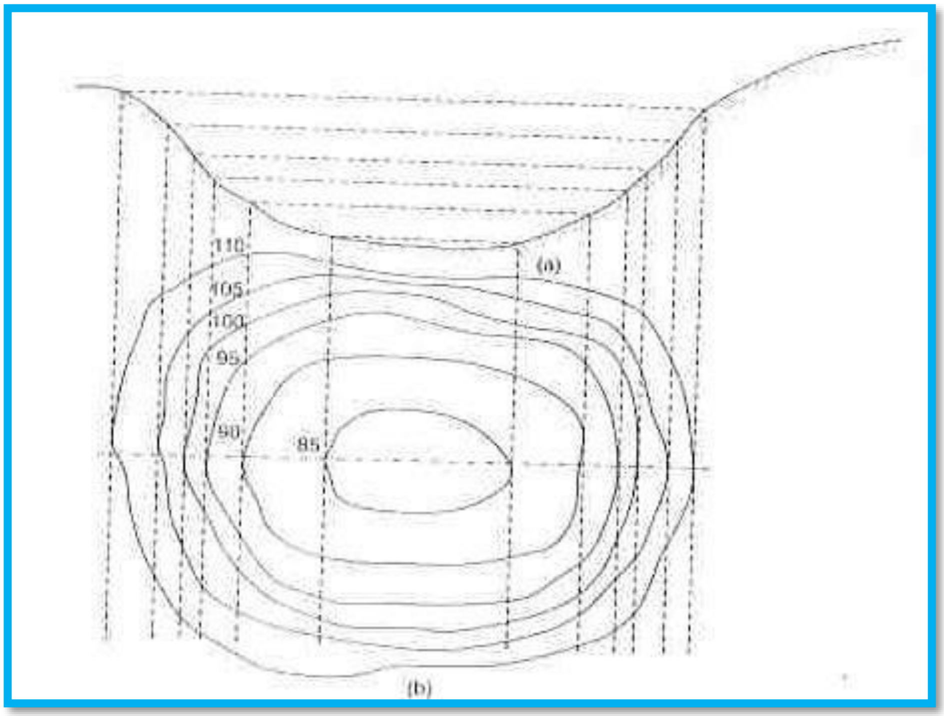
The horizontal distance between two points on any two consecutive contours is called horizontal equivalent. Obviously, contour interval divided by horizontal equivalent will give slope of the ground along the lien joining those two points. If the contour interval is small, the undulation of ground is known better. At the same time smaller the contour interval, cost of the survey project is larger. Choice of contour interval for a plan depends upon the following:

i) Nature of the ground

ii) Purpose and extent of map

iii) Scale of map and

iv) Time and funds available



i) **Nature of ground:** If the ground is flat, contour interval selected is small. If the ground is undulating large contour interval is selected, if not done so, the contour lines come too close to each other.

ii) **Purpose and extent of Map:** If survey is intended for detailed earth work calculation small contour interval is preferred. In such case the extent of survey is generally small. For example, in developing building sites. In case of location surveys for roads, railways, sewage lines and for reservoirs contour interval selected is large. In such cases generally the extent of survey is also large.

iii) **Scale of map:** Contour interval selected is inversely proportional to the scale of map. Smaller the scale, larger is the contour interval and larger the scale, smaller the contour interval.

iv) **Time and funds available:** If contour interval are small more time is required in the field work and office work. Hence, requirement of funds is more. If there is limitation of time and fund lager contour interval may be selected.

Considering the above points contour intervals suggested for different purposes are shown in table 1 while table 2 shows suggested scales for different nature of ground and scale.

Purpose of survey	**Scale**	**Contour intervals (mm)**
Building sites	1:1000 or less	0.2 to 0.5
Town planning, reservoir, etc.	1:5000 to 1:10000	0.5 to 0.2
Location surveys	1:5000 to 1:20000	1 to 3

Table 1: Contour intervals for survey of different purposes

CHARACTERISTICS OF CONTOURS

The Contours have the following characteristics:

1. Contour lines must close, not necessarily in the limits of the plan
2. Widely spaced contour indicates flat surface
3. Closely spaced contour indicates steep ground
4. Equally spaced contour indicates uniform slope
5. Irregular contours indicate uneven surface
6. Approximately concentric closed contours with decreasing values towards centre indicate pond.

7. Concentric closed contours with increasing values towards centre, indicate hills
8. Contour lines with V – shape with convexity towards higher ground indicate valley
9. Contour lines with U – shape with convexity towards lower ground indicate ridge.

10. Contour lines generally do not meet or intersect each other.
11. If contour lines are meeting each other in some portion, it shows existence of vertical cliff or wall in that portion.
12. If contour lines cross each other, it shows existence of overhanging cliff or a cave.
13. Contours do not have sharp turnings.
14. The direction fo the steepest slope at a point on the contour is at right angles to the contour.

METHODS OF CONTOURING

Contouring consists of finding elevations of various points in the area surveyed. At the same time the horizontal positions of those points should also be found. Thus, it needs vertical control and horizontal control in the work. For vertical control levels, theodolite or clinometers may be used while for horizontal controls chain, compass, plane table or theodolite are used Bases on the instruments used, there can be different methods of surveying.

However, broadly speaking there are two methods of surveying: i) Direct methods, ii) Indirect methods.

Direct method involves finding vertical and horizontal controls of the points which lie on the selected contour line. In indirect method, the levels are taken at some selected points, their levels are reduced and the horizontal controls also carried out. After locating these points in plan, reduced levels are marked and contour lines are interpolated between selected points.

DIRECT METHOD OF CONTOURING

Since in this method points on a selected contour are traced first and then horizontal controls are established this method is also known as tracing out contours. This method is slow, tedious but accurate. It is suitable for small areas.

For vertical control leveling instrument is commonly used. An instrument station is established at a commanding point in the area by taking fly level from a nearby bench mark. Height of the instrument is calculated and the staff reading required for a particular contour is found. For example, if the height of the instrument is 90.8 m, the staff reading for 90 m contour is 0.8m for 89 m it is 1.8 m, for 88 m contour it is 2.8m and for 87m contour the staff reading is 3.8m the instrument man asks staff an to move up o down in the area till the required staff reading is found. For horizontal control for that point is usually exercised with plane table survey. Then staff man is directed to another point on the same contour. After locating few points, plane table person draws eh contour line. Simultaneously 2 – 4 contour lines are traced in the area levelling instrument can command. Then instrument station is shifted by taking change point. Shifting of leveling and plane table need not be simultaneous. For getting speed in levlling, sometime hand level or on Abney level are used. In this method, after locating a first point on a contour lien say 90 m contour lien the surveyor stands on that point with hand level suspended at a convenient height. For convenient reading the height may b e 1.5 m then a pole with marking at 0.5 m, 1.5 m and 2.5 m may be held at various points in the area to locate contours of 91 m, 90 m, 89 m. for every point selected horizontal control is exercised and plotted. This method is fast but it is at the cost of accuracy.

INDIRECT CONTOURING

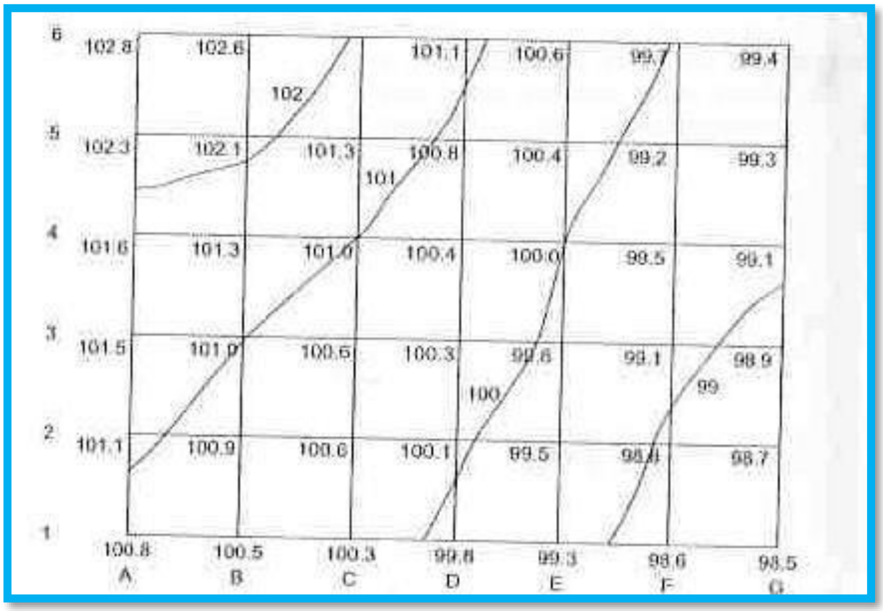
As stated earlier in this method points are selected first and their levels are found. For selecting points any one of the following methods may be used:

i) Method of squares
ii) Cross – section method or
iii) Radial line method.

METHOD OF SQUARES

This method is suitable, if the area to be surveyed is not very large and undulation of the ground is not much. In this method the area is divided into a number of squares and all grid points are marked.

Commonly used size of squares varies from 5 m * 5 m to 20 m * 20 m . By leveling reduced levels of all grid points are obtained. The grid of squares is plotted, reduced levels of all grid points marked and contour lines interpolated.

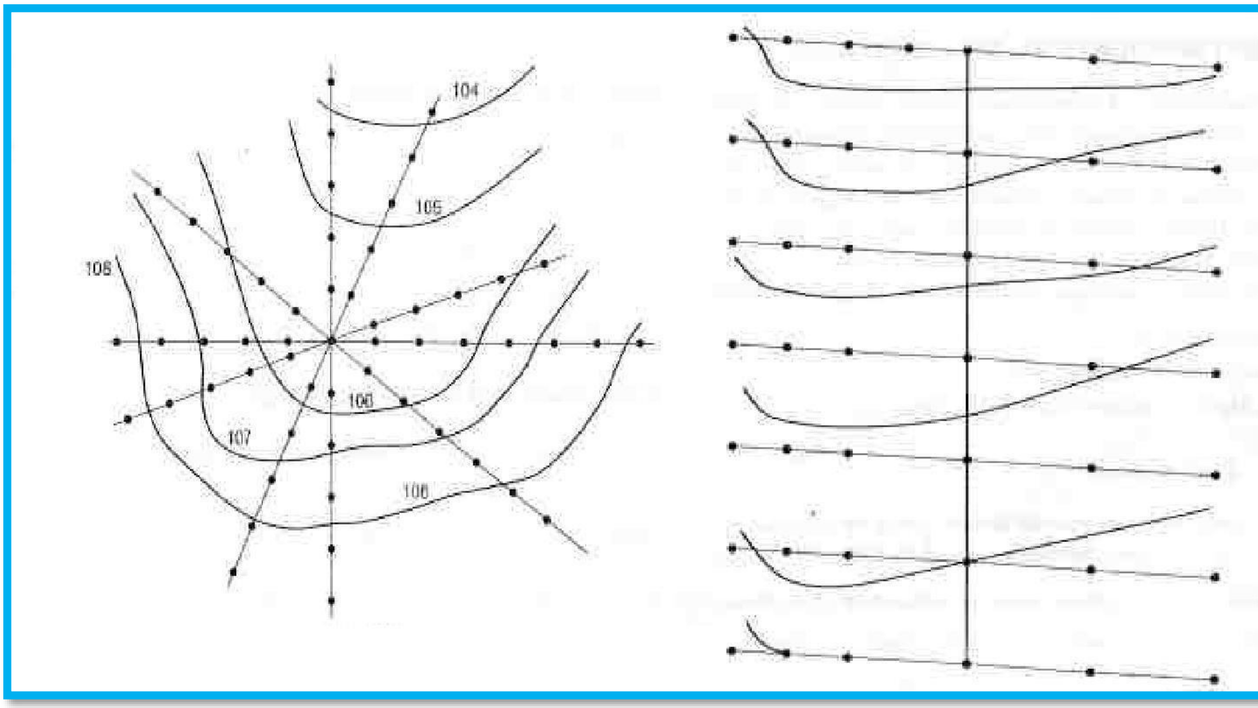


CROSS – SECTION METHOD

In this method also a selected lien cross – sectional readings are taken at regular interval. By usual leveling procedure reduced levels of all selected points on cross sections are found. They are marked on drawing sheets and then contours are interpolated. The spacing of cross – section depends upon the nature of the ground, scale of the map and the contour interval. It varies from 20 m to 100 m. the cross sections may be at closer intervals whenever abrupt changes in levels take place. It may be noted that cross – sectional points always need not be at 90^0 to main line. They may be at different angles also but that angle should be carefully noted down in the field book. This method is suitable for road and railway projects.

RADIAL LINE METHOD

In this method from a selected point radial lines at known intervals are taken. Level readings are taken on every ray at regular interval reduced levels are found and contour maps plotted. Instead of using level and tape, both vertical and horizontal controls can be exercised with tachometry so that larger area can be easily covered in single setting. This method is ideally suited for hilly areas.



INTERPOLATION OF CONTOURS

After finding RL of many points on the ground and plotted the position of those points. Points on contour lines are identified assuming uniform slope between any two neighboring points is uniform. In other words, the points on contour lines are interpolated linearly between the two neighboring points. For example, in Fig 100th contour lies between points D3 and E2 assuming ground slopes uniformly form 100.3 it 99.8 between these two points contour point is located for this purpose any one of the following three methods may be used.

i) Estimation

ii) Arithmetic calculation

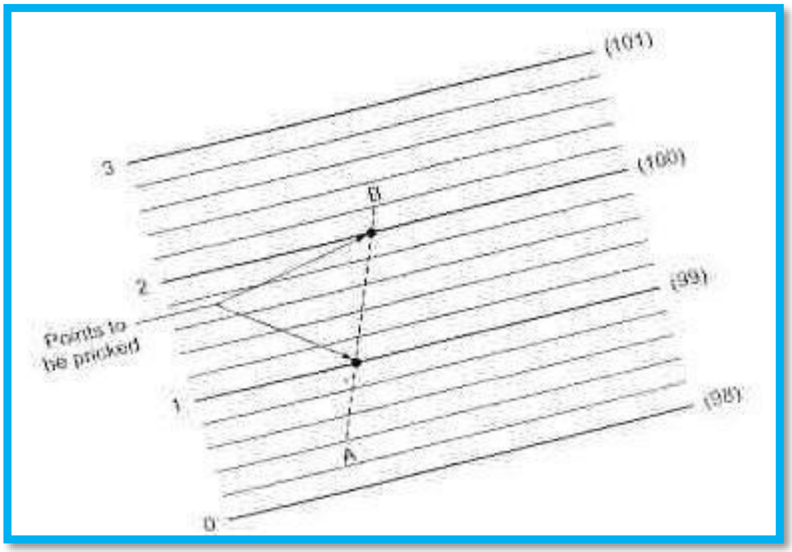
iii) Mechanical or Graphical method.

Estimation: By eye judgment or estimation the point on contour is located between the two points. For example, between D3 and E3 where elevations are 100.3 and 99.8 m, the contour point is estimated at a distance. From E3. Similarly, the point on DL E2 where RLs are 100.1 and 99.5 the point should be at a distance This method is rough and is used for small – scale works. However, it is very fast.

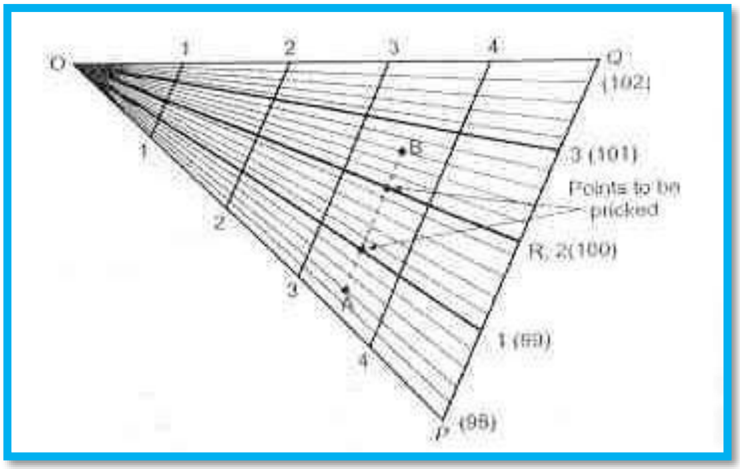
Arithmetic calculation: In this method, instead of estimating the position of points on contour, arithmetic calculations are made for locating the points on contour.

Mechanical or Graphical method: Any one of the following two methods are used for linearly interpolating contour points using tracing sheet.

Method 1: On a tracing sheet several parallel lines are drawn at regular interval. Every fifth or tenth line is made dark for easy counting. If RL of A is 98. 4 m and that of B is 100.2 m assume bottom most dark line represents 98 m RL and every parallel line is at 0.2 m intervals. Then hold a point on second parallel line on A. Rotate tracing sheet so that 100.2th parallel line passes through point B. then intersection of dark lines on AB represents the points on 99 m and 100 m contours similarly. Contour points along any line connecting two – level points can be obtained and contour lines interpolated and pricked. This method maintains the accuracy of arithmetic calculations, at the same time is fast also.



Method II: In this method a line PQ is drawn on a tracing sheet from the mid – point of PQ say R a perpendicular line RO is drawn. ‘O’ is selected at any convenient distance. PQ is divided into a number of equal parts, say 20 parts. Then the radial lines from ‘O’ to these equally spaced points are drawn. A number of guide lines 1-1, 2-2, etc. are drawn parallel to PQ. To interpolate between two points A and B on drawing sheet, tracing sheet is held with its guide lines parallel to AB. OQ is assigned a contour lien point just below that of RL of A. Of dark lines are at every 5-ray interval, and contours are required at every 1 m interval, the interval between two consecutive rays is 0.2 m. Appropriate ray is made to appear on A and tracing sheet is rotated till the ray corresponding to B coincides with B. Then the contour points on AB correspond to the dark lines’ intersection with AB. These points are produced and the contour points on lien AB are obtained. Thus, in this case also exact interpolation is made mechanically.



DRAWING CONTOURS

After locating contour points between a network of guide points, smooth contour lines are drawn connecting corresponding points. For drawing contour lines French curves should be used. A surveyor should not lose the sight of characteristics of the contours. Brown color is preferred to draw the contours so that they can be easily distinguished from other features; Every fifth contour is made thicker for easy readability. On every contour line its elevation is written either above, below or by breaking the line. If map size is large, it is written at the ends also. However, in writing these elevations uniformly should be maintained.

CONTOUR GRADIENT

A contour gradient is a line having uniform slope on the ground. Method of plotting contour gradient on a plan and identifying it on the ground are discussed below.

i) **Contour gradient on a map:** The contour lines are at 1 m interval and the map is to a scale of 1:500. Since slope is assumed uniform between two contour lines, the length of gradient line between two contour lines should be equivalent to 20 m on the ground, it should be 20/500 m on paper, 40 mm from starting point a draw an arc of radius 40 mm to interest next contour line at b. from b this procedure is repeated to get point c line joining a, b, c… is the desired gradient line.

ii) **Contour gradient on ground:** For setting contour gradient on ground level a clinometer may be used. If a clinometer is used, it is set at the required slope. A person stands near point A, suspends the sloping clinometers at a convenient height to view. The looks through clinometers, and directs a person holding ranging pole, which is tied with a target at the same height as the height of instrument from the ground point A. Tape is used to maintain the required distance from A. after getting next point B, the clinometers is shifted to point B and the staff man moves to next probable point. The procedure is continued till the last point is established. The method is fast but any small angular error gets magnified.

USES OF CONTOUR MAPS

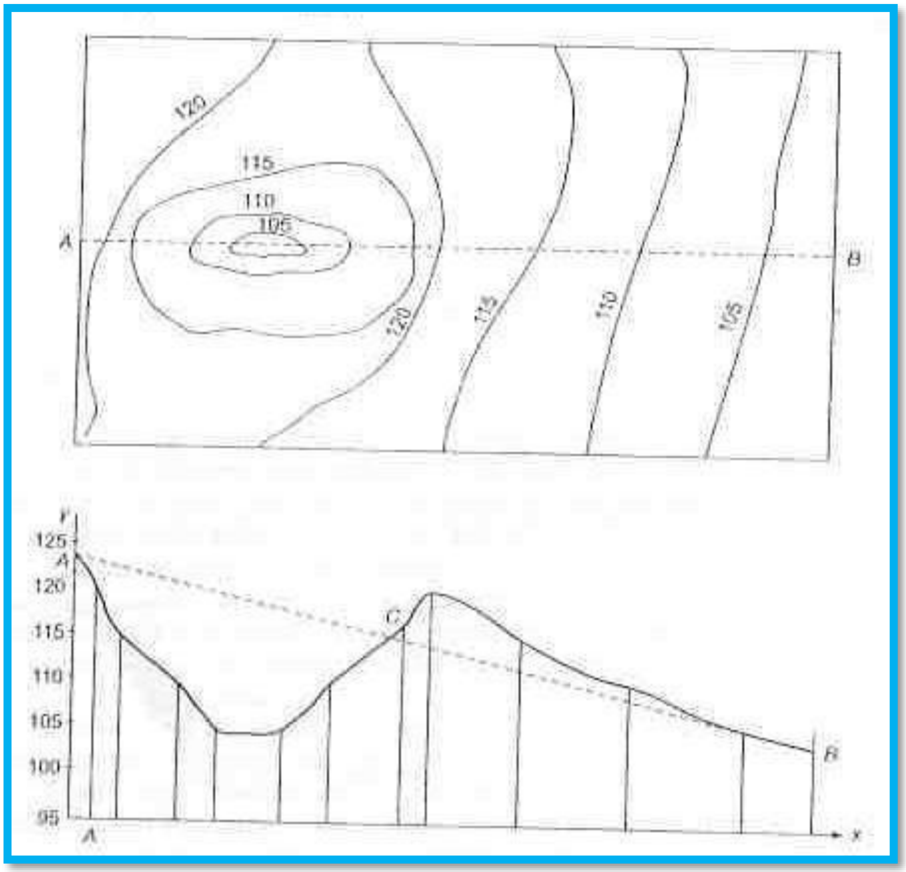
Contour maps are extremely useful for various civil engineering works as explained below:

i) **Preliminary selection of project sites**:

Characteristics of contour lines give considerable information about nature of ground. Sitting in the office studying contour lines, a civil engineer decides various possible sites for his project.

ii) **Drawing of sections**:

From contour plan, it is possible to study profile of the ground along any line, which is normally required for earthwork calculation along a formation ground. Intersection of line AB with contour lines are projected on the x – axis. Along the y – axis the corresponding heights as found from contour lines are mar4ked and then the profile of the ground is obtained.



iii) **Determination of indivisibility:**

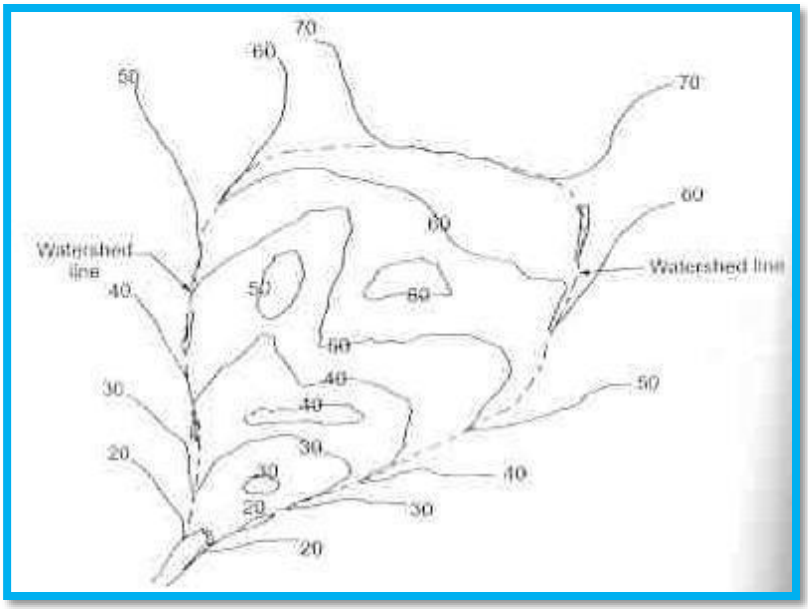
If indivisibility of any two points is to be checked, using contour, profile of the ground along the line joining those two points can be drawn. Then the line joining those two points is drawn. If the ground portion is above this portion, the two stations are not intervisible.

iv) **Location of routes:**

The routes of railway, road, canal or sewer lines can be decided with the help of contour maps. After deciding the gradient of the route, it can be set on the map as explained.

v) Determining catchment Area;

The area on which fallen rainwater drains into river at a particular point is called catchment area of the river at that point. This area can be determined from contour plans. The catchment area is also known as drainage area. First the line that separates the catchment basin from the rest of area is drawn. This is called watershed time. It normally follows ridge line. Then the area within watershed line is measured. This area is extremely useful in studying flood level and quantity of water flow in the river.



vi) **Calculation of reservoir capacity:**

The submerged area and the capacity of a proposed reservoir by building bund or dam can be found by using contour maps. After determining the height of the dam its full reservoir level is known. Then area between any two contour lines and the dam line is measured by using plan meter thus if A1,A2, ……An are the areas within contours and h is the contour interval reservoir capacity is given.

SOLVED QUESTION AND ANSWERS

1. INTERPOLATION OF CONTOURS

After finding RL of many points on the ground and plotted the position of those points. Points on contour lines are identified assuming uniform slope between any two neighboring points is uniform. In other words, the points on contour lines are interpolated linearly between the two neighboring points. For example, in Fig 100th contour lies between points D and E assuming ground slopes uniformly form 100.3 it 99.8 between these two points contour point is located for this purpose any one of the following three methods may be used.

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For example, between D and E where elevations are 100.3 and 99.8 m, the contour point is estimated at a distance. From E. Similarly, the point on D E where RLs are 100.1 and 99.5 the point should be at a distance This method is rough and is used for small – scale works. However, it is very fast. Arithmetic calculation: In this method, instead of estimating the position of points on contour, arithmetic calculations are made for locating the points on contour. Mechanical or Graphical method: Any one of the following two methods are used for linearly interpolating contour points using tracing sheet.

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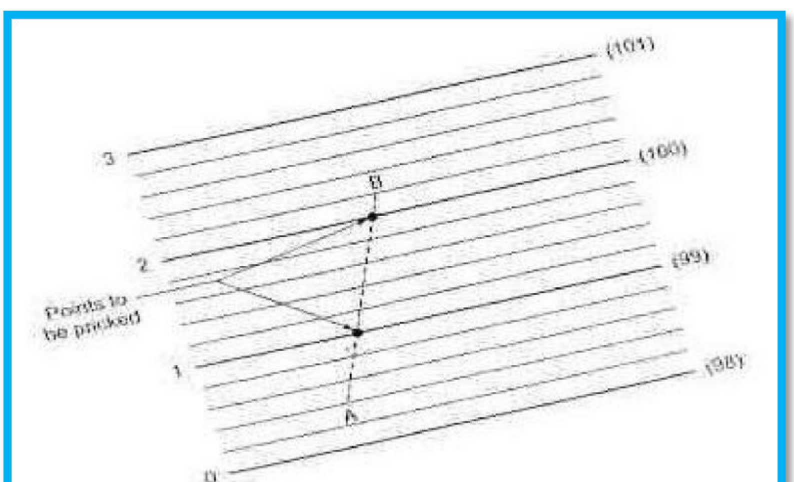


Method 2: In this method a line PQ is drawn on a tracing sheet from the mid – point of PQ says R a perpendicular line RO is drawn. 'O' is selected at any convenient distance. PQ is divided into a number of equal parts, say 20 parts. Then the radial lines from 'O' to these equally spaced points are drawn. A number of guide lines 1-1, 2-2, etc. are drawn parallel to PQ. To interpolate between two points A and B on drawing sheet, tracing sheet is held with its guide lines parallel to AB. OQ is assigned a contour lien point just below that of RL of A. Of dark lines are at every 5-ray interval, and contours are required at every 1 m interval, the interval between two consecutive rays is 0.2 m. Appropriate ray is made to appear on A and tracing sheet is rotated till the ray corresponding to B coincides with B. Then the contour points on AB correspond to the dark lines' intersection with AB. These points are produced and the contour points on line AB are obtained. Thus, in this case also exact interpolation is made mechanically.

2. How do you trace a contour gradient of 1 in 50 on a map having contour interval 2.0 m.

i) Contour gradient on a map: The contour lines are at 20 m interval and the map is to a scale of 1:500. Since slope is assumed uniform between two contour lines, the length of gradient line between two contour lines should be equivalent to 50 m on the ground, it should be 50/500 m on paper, 40 mm from starting point a draw an arc of radius 40 mm to interest next contour line at b. from b this procedure is repeated to get point c line joining a,b,c… is the desired gradient line.

ii) Contour gradient on ground: For setting contour gradient on ground level a clinometer may be used. If a clinometer is used, it is set at the required slope. A person stands near point A, suspends the sloping clinometers at a convenient height to view. The looks through clinometers, and directs a person holding ranging pole, which is tied with a target at the same height as the height of instrument from the ground point A. Tape is used to maintain the required distance from A. after getting next point B, the clinometers is shifted to point B and the staff man moves to next probable point. The procedure is continued till the last point is established. The method is fast but any small angular error

THEODOLITE SURVEY

Theodolite and types

Theodolite is the most precise survey instrument used commonly by engineers for measuring horizontal and vertical angles accurately

Theodolites are broadly classified into two as

1.Transit

2.Non-transit

1.Transit theodolite: A theodolite in which if the telescope can be resolved through a complete resolute about its horizontal axis in the vertical plane is called as a transit theodolite.

2.Non transit theodolite: This kind of theodolites are plain or ‘Y’ theodolites, in which the telescope cannot be transited.

Theodolites are also classified into two as

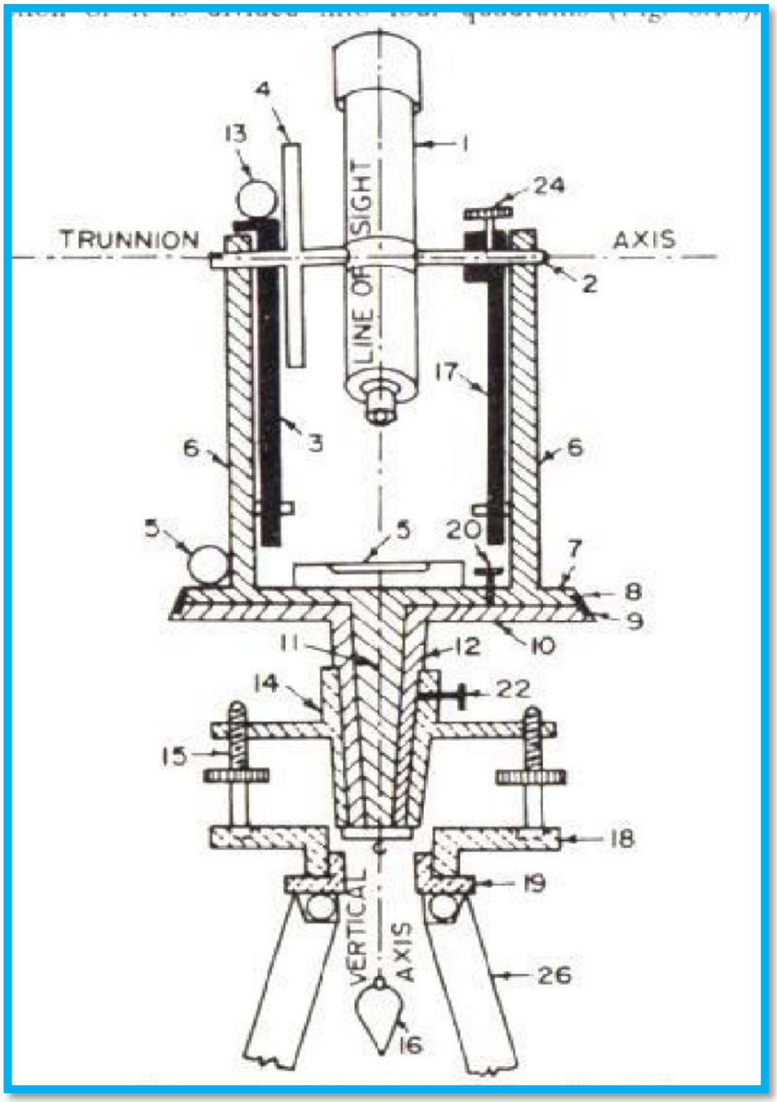
1.Vernier theodolites

2.Micrometer theodolites, based on the system used to observe the reading.

1.Vernier theodolite: Vernier’s are used to measure accurately the horizontal and vertical angles. A 20” Vernier theodolite is usually used.

2.Micrometer theodolite: An optical system or a micrometer is used to read the angles in this case. The precision can be as high as 1”

* Fundamental Axis and part of transit theodolite



Parts of theodolite

1.Telescope: The telescope of the theodolite is mounted on a spindle known as “Trunnion axis”. In most of the transit theodolite an internal focusing telescope is used. It consists of object glass, a diaphragm and an eye-piece. The main functions of the telescope is to provide line of sight.

2.The vertical circle: The vertical circle is rigidly connected to the transverse axis of the telescope and moves as the telescope is raised or depressed. It is graduated in degrees with graduations at 20’. Graduation in each quadrant is numbered from 0’ to 90’ in the opposite directions from the two zeros placed at the horizontal diameter of the circle.

3.The index frame or T-frame or Vernier frame: It consists of a vertical portion called dipping arm and a horizontal portion called an index arm. The 2 venires of the vertical circle are fixed to the two ends of the index arm. The index arm can be rotated slightly for adjustment purpose, with the help of clip screw.

4. The standard or A-Frame: Two standards resembling the letter A are mounted on the upper plates. The trunnion axis of the telescope is supported on these. The T-Frame and the arm of vertical circle clamp are also attached to A-Frame.

5.Levelling head: It consists of 2 parts namely

a) Tribrach- It is the upper triangular plate which carries 3 levelling screws at the

three ends of the triangle.

b) Trivet or the lower plate (foot plate) used three grooves to accommodate the 3 levelling screws.

The leveling head has 3 main functions namely

1.To support the main part of the instrument

2.To attach the theodolite to the tripod

3.To provide a mean for leveling.

6.The two spindles: Inner spindle is conical and fits into the outer spindle which is hollow. Inner spindle is also called upper axis and outer spindle is called lower axis.

7.The lower plate (scale plate): It carries the circular scale which is graduated from 0-360'.It is attached to the outer spindle which turns in a bearing within the tribrach of the leveling head.It is fixed using lower clamping screws lower tangent screws enable slow motion of the outer spindle.

8.Upper plate (Vernier plate): It is attached to the inner axis and carries 2 Vernier's with magnifiers at two extremities diametrically opposite. Upper damping screw and a corresponding tangent screw are used for moving upper plate.

9.The plate levels: The upper plate carries one or 2 plate levels which can be centered with the help of foot screws.

10.Accessories:

a) Tripod: with 3solid legs

b) Plumb bob: for centering

c)Compass: tubular or trough

d)Striding level: for testing the horizontality of the transit axis or trunnion axis.

Fundamental lines

These are basically 2 planes and 5 lines in a theodolite. The planes are horizontal plane with the horizontal circle and Vernier; and vertical plane with vertical circle and Vernier.

The fundamental lines are

1.Vertical axis

2.Horizontal axis

3.Line of collimation (line of sight)

4.Axis of plate level

5.Axis of altitude level

6.Axis of striding level, if provided

Definitions and Terms

1. centering: Setting the theodolite exactly over an instrument station so that its vertical axis lies immediately above the station point is called centering

2. The vertical axis: It is the axis about which the instrument can be rotated in a horizontal plane.

3.The horizontal axis: It is the trunnion axis about which the telescope

4.Line of sight or line of collimation: It is the imaginary line passing through the intersection of the cross hairs (vertical and horizontal) and the optical center of the object glass and its continuation

5.Axis of level tube: It is also called as bubble line; it is the straight tangential line to the longitudinal curve of the level tube at its center

6.Axis of the altitude level tube: It is the axis of the level tube in altitude spirit level

7.Transiting: It is the process of turning the telescope vertical plane through 180' about the trunnion axis. This process is also known as plunging or reversing.

8.Swinging the telescope: It is the process of turning the telescope in horizontal plane. If the telescope is rotated in clock wise direction, it is known as right swing and other wise left swing.

9.Face right observation: If the vertical circle is to the left of the observer, then the observation is ca;;ed as face left

10.Face right observation: If vertical circle is to the right of the observer, then the observation called as face right.

10.Telescope normal and telescope inverted: If the telescope is in such a way that the face is left and bubble is up, then it is said to be in normal position or direct. If the face is right and bubble is down then the telescope is said to be in inverted position or reversed position. Vertical circle to the right of the observer, if originally to the left and vice versa.it is done by first revolving the telescope through 180' in a vertical plane and then rotating it through 180' in the horizontal plane, ie first transiting and then swinging the telescope.

Temporary adjustments of a transit theodolite.

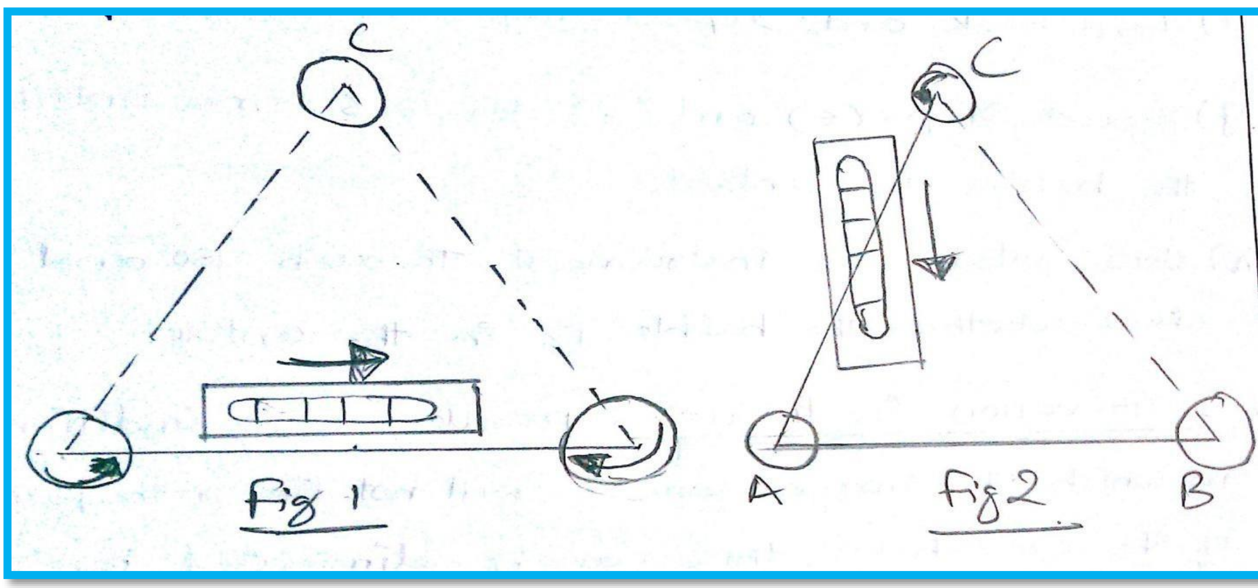
The temporary adjustments of a transit theodolite is done by 3 important operations.

1. **Setting up:** The instrument has to be settled up properly on the station point. The tripod stand should be approximately leveled before fixing the instrument. This is achieved with the help of moving the legs of the tripod. There is a small spirit level on the tripod head for the leveling of tripod. Centering of the instrument over the station mark is achieved by a plumb bob or by using optical plummet.

2. **Levelling up:** After centering and approximate leveling, accurate leveling is to be carried out with the help of the foot screws and using the plate level tube.in this step the vertical axis of the instrument is made truly vertical. Levelling the instrument depends on the number of foot screws available.

For a screw head, the procedure for leveling is as follows:

a) Turn the upper plate until the longitudinal axis of the plate level is parallel to the line joining any two foot screws(let it be A and B)



b) hold the 2-foot screws A and B between the thumb and the fore fingers of each hand and turn them uniformly so that the thumb moves either towards each other until the bubble is central. Bubble moves in the direction of the left foot screw.

c)Turn the upper plate through 90' until the axis of the level passes over the position of the third leveling screw C d)Turn this leveling screw until the bubble is central

e) Return the upper plate to original position (fig1) and repeat step(b)

f) Turn back and repeat step (c)

g) Repeat steps (e) and (f) for 2-3 times until the bubble is central.

h) Now rotate the instrument through 180' and check whether the bubble is in the center.

3. Elimination of Parallax: Parallax is a condition in which the image is formed will not lie on the plane of the cross hair, this can be eliminated by focusing the eye-piece and the objective.

For focusing the eye-piece, hold a white paper Infront of the objective and move eye-piece in or out, until the cross-hairs are distinctly visible. Objective lenses focused by rotating the focusing screw, until the image appears clear and sharp.

Measurement of Horizontal Angles

Theodolites are majorly used to measure horizontal and vertical angles. Horizontal angles are usually, measured by using any of these methods.

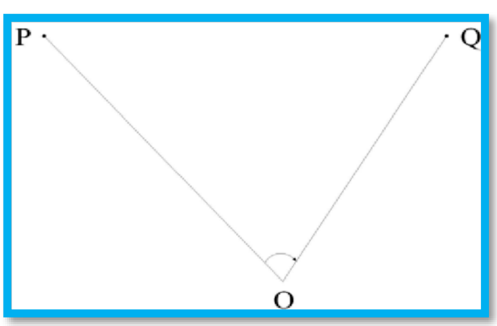
1.Ordinary method

2.Method of repetition

3.Method of reiteration

1.Ordinary Method

FIG



To measure an angle POQ, THE FOLLOWING PROCEDURE IS USED.

1.Set up the instrument at 0, Set it up, level it accurately and perform the temporary adjustments

2.Release the upper clamp screw and lower clamp screw. Turn the upper and lower plates such that the Vernier A reads ‘zero’ (0) and the Vernier circle is to the left of the observer. Clamp both the plates and bring the Vernier A to zero to coincide with the main scale zero using the upper tangent screw. Check the reading on Vernier A, it should read 180’

3.Loosen the lower clamp and rotate the telescope to view point P. Clamp lower plate and using lower slow-motion screw sight P exactly. Check the readings on both the Vernier to see that it had not changed.

4.unclamp the upper clamp and rotate the instrument clock-wise until point Q is bisected tighten the clamp and using tangent screw bisect Q accurately.

5.Reading is observed from Verners A and B. Reading of A Vernier gives angle POQ and B Vernier gives 180’+POQ

Read degeminates and seconds from the Vernier scale by observing which line on the Vernier scale is having correct coincidence with the reading in the main scale.

In a 20’ transit theodolite ,the least count is 20” or the minimum reading which can be measured from the scale is 20”.The reading coinciding with the Vernier-zero is considered to be the main scale reading .If there is no exact coincidence for the Vernier zero line ,then the reading to the immediate left of the Vernier scale, on the main scale should be considered. This reading should be added with the Vernier reading for the total value.

Reading on main scale=128’ 40’

Reading on Vernier scale=3’ 00”

Therefore, total reading =128’40’+3’00”

=128’43’00”

In B scale, the degree reading is not required, whereas the minutes reading from the main scale is noted and add with Vernier reading and this will give the B scale reading.

6.Enter the readings in a field book of tabular format

Tabular Column

Instrument	Sighted	Face: Left										Swing Right Face: Right											
		A			B		Mean			No of repetitions	H/e angle			A			B		Mean of No of repetitions			No of repetitions
		°	'	"	'	"	°	'	"	No	°	'	"	°	'	"	°	"	°	'	"	No
O	P	0	0	0	0	0	0	0	0													
	Q																					

7.Change the face by transiting and repeat the same process.

8.The mean of the 2 Vernier reading gives the angle on face right

10.Average horizontal angle is calculated from the mean horizontal angle of face left and face right values.

Repetition Method

This method is used for very accurate work. In this method, the same angle is added several times mechanically and the total angle is divided by no of repetitions to obtain the correct value of angle. There are 2 methods by which this method can be conducted

To measure an angle POQ by the method of repetition, the following procedure is adopted

1.Obtain the first reading of the angle following the procedure outlined in the previous method. Read and record the value.

2.Loosen lower clamp, and turn the telescope clockwise to sight P again and bisect properly using lower tangent scew. check the Vernier and see that the readings are not changed.

3.Unclamp the upper clamp and turn the instrument clockwise and sight Q again

4.Repeat the process for 3 times

5.consider the average horizontal angle for face left by dividing the final reading by three

6.change face and make 3 more repetitions find the average angle.

7. Total average angle is obtained by adding up the results of 2 faces and then dividing by 2

For high precision surveys, repetition method can be conducted in two ways

a) the angle is measured respectively for six times, keeping the telescope normal (face left) and then calculating the average.

b) In another way, angle is measured clockwise by first 3 with clockwise with face left and last 3 with telescope inverted. Then in anticlockwise also 3 face left and face right observations are taken.

Elimination of errors by method of repetition

The following errors are eliminated by adopting method of repetition

a) Errors due to eccentricity of Vernier’s and centers by measuring both Vernier readings.

b) Errors due to line of collimation not being perpendicular to the horizontal axis of the telescope.

c)Errors due to horizontal axis of telescope not being perpendicular to the vertical axis.

d)Error due to the line of collimation not coinciding with the axis of the telescope

These 3 errors can be eliminated by changing their face of the theodolite.

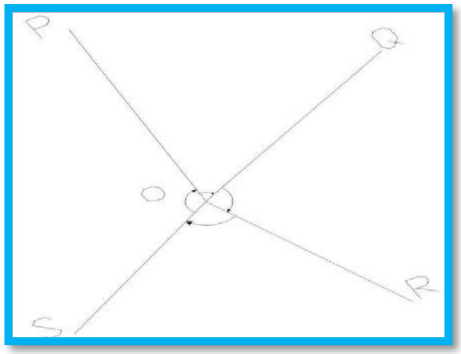
e) Errors due to inaccurate graduations this can be eliminated by taking 2 Vernier readings

f) Error due to inaccurate bisection of the object this eliminated by taking repeated readings.

Reiteration Method

This method is also known as direction method or method of series several angles are measured successively and finally the horizon is closed.

To measure a series of angles AOB, BOC, COD etc. by reiteration, this procedure is fallowed



1.Set the instrument at O, level it and center it.

2.Measure the angle AOB in the same way as already explained.

3.similarly bisect the successive ranging rods C, D etc and keep on observing the readings. Each included angle is obtained by taking the difference of 2 consecutive readings.

Angle BOC= angle AOC – angle AOB

4.Finally close the horizon by sighting A. The reading in the Vernier should be zero (360).If not ,note down the reading and distribute it evenly to all angles.

Repeat the same steps in other face

The sets of reading are usually taken first in clockwise direction and then after changing the face in anticlockwise direction.

MEASUREMENT OF VERTICAL ANGLES

A vertical angle is an angle between the included line of sight and horizontal. The instrument has to be leveled with respect to the altitude bubble for measuring vertical angles

1.Level the instrument with reference to plate level

2.keep the altitude bubble tube parallel to 2-foot screws and bring the bubble central. Rotate telescope 90’ and adjust the bubble using the 3rd foot screw. Repeat the procedure till the bubble is central.

3.loose the vertical clamp screw, rotate the telescope in vertical plane .to sight the object use tangent screw for correct bisections.

4.read Vernier C and D mean gives correct vertical angle.

5.change the face and continue the procedure.

If the vertical angle is measured above the horizontal line, it is called angle of elevation or in other case as angle of depression.

Uses of Theodolite

Theodolite is not only used for measuring horizontal angles and vertical angles. But it is also used for the following:

1.To measure a magnetic bearing of a line

2.To measure direct angles

3.To measure deflection angles

4.To prolong a straight line

5.To run a straight line between 2 points

6.To locate the intersection points of 2 straight line

7.To lay off a horizontal angle etc.

. **Reference books: -**

- Surveying Volume 1, **S.K. Duggal.**
- Surveying Volume-I, **B.C. Punima,**
- A Text Book of Surveying and Levelling, **R. Agor.**
- Surveying and leveling, **N.N. Basak**