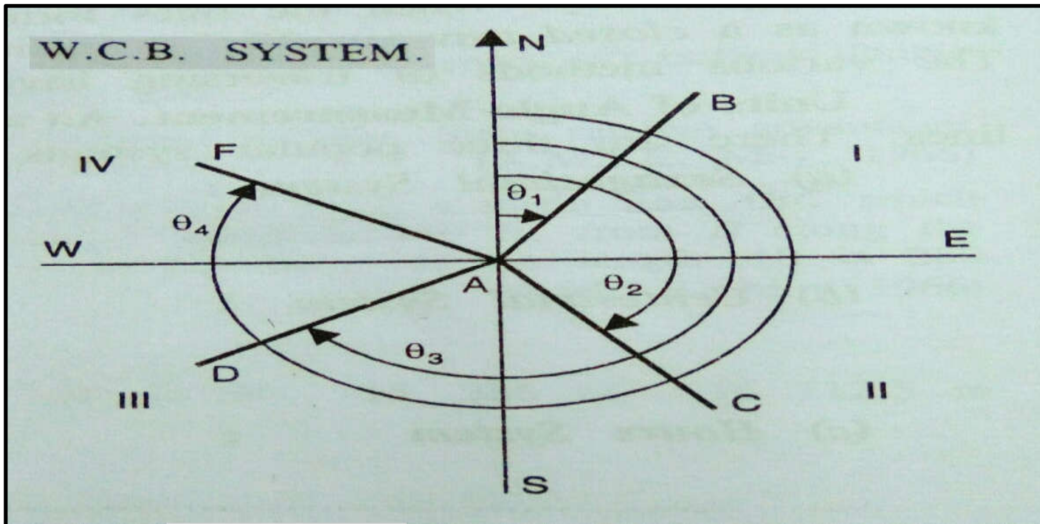
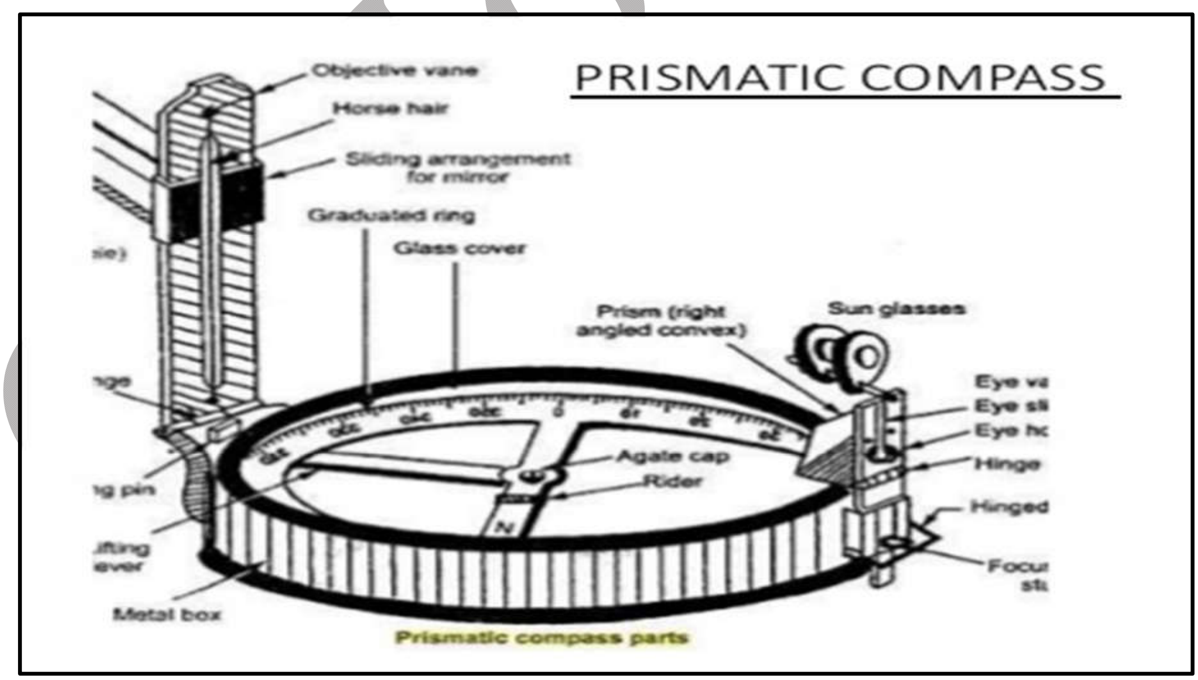
Whole Circle Bearing:

In civil engineering surveying, bearing is very important to get the direction of a survey line. The whole circle bearing (W.C.B) is a common notation system of bearings. The definition of the whole circle bearing along with the measuring formula and example is discussed below.

What is Whole Circle Bearing (W.C.B)?

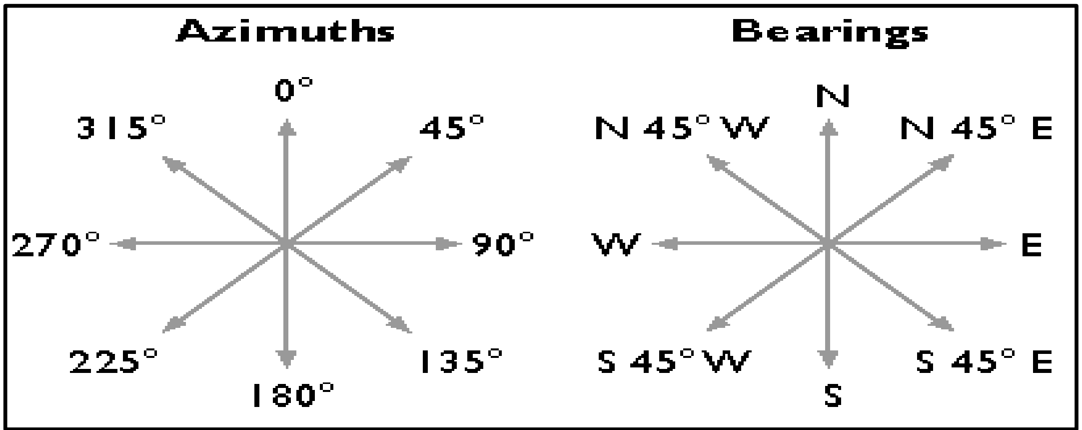


The horizontal angle made by a line with the magnetic north in the clockwise direction is the ***whole circle bearing*** of the line. This system is also known as the ***azimuthal system***. In this system, only the north direction is used as reference meridian.



Whole Circle Bearing Formula

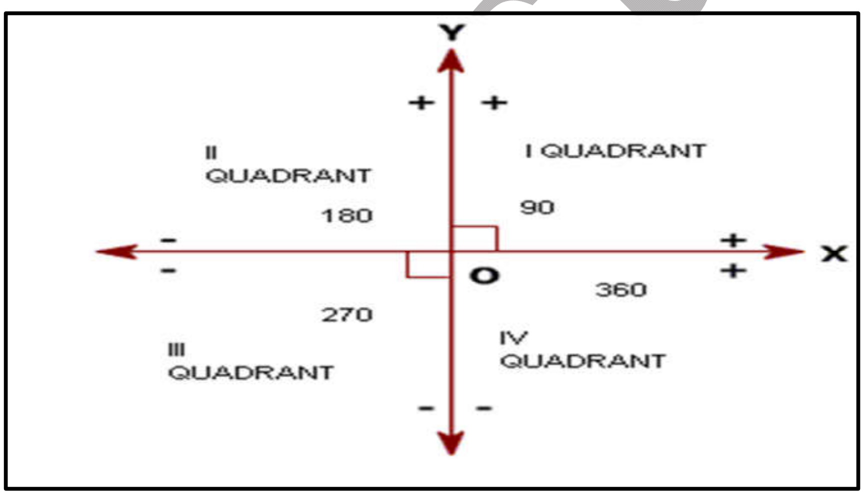
In whole circle bearing, the value of the bearing varies from 0° to 360°. Just measure the angle between true north line to the survey line to find the WCB. Don't forget to measure the clockwise angle in determining the whole circle bearing.



If a survey line falls in the first quadrant, its WCB varies from 0° to 90°. Similarly, in the second quadrant, WCB value varies from 90° to 180°; in the third quadrant, WCB value varies from 180° to 270°; in the fourth quadrant, WCB value varies from 270° to 360°.

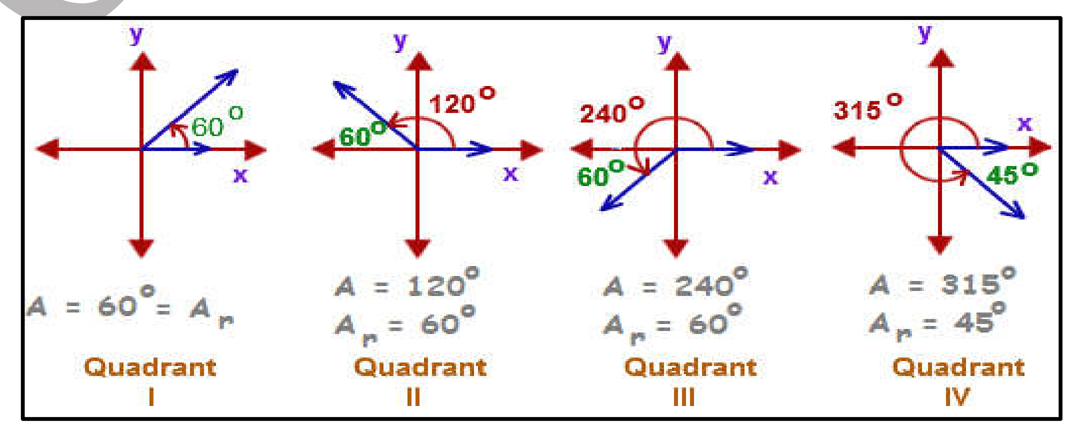
Quadrantal Bearing (Reduced Bearing):

In civil engineering surveying, bearing is the process to get the direction of a survey line. The quadrantal bearing is a common notation system of bearings. it is also known as the reduced bearing. As the name indicates, quadrantal bearing depends upon the quadratic position of a line.



What is Quadrantal Bearing or Reduced Bearing?

The horizontal angle made by a line with the magnetic north or south (whichever is closer from the line) in the eastward or westward direction is the ***Quadrantal Bearing*** **or** ***Reduced Bearing*** of the line.



In quadrantal bearing or reduced bearing, both north and south are considered as reference meridians. Depending upon the position of a survey line, the direction of the reference meridian to the line can be either clockwise or anticlockwise. In the expression of the reduced bearing value of a line, quadrant has to be mentioned in which the line lies.

Difference Between Whole Circle Bearing and Quadrantal Bearing:

Whole Circle Bearing and Quadrantal Bearing (Reduced Bearing) are two different types of bearing measurement used in surveying. To choose between these two types of bearing measurement a surveyor must know the differences between them. The main differences between Whole Circle Bearing and Quadrantal Bearing (Reduced Bearing) are given below.

Whole Circle Bearing	Quadrantal Bearing/Reduced Bearing
The horizontal angle made by a line with the magnetic north in the clockwise direction is the whole circle bearing of the line.	The horizontal angle made by a line with the magnetic north or south (whichever is closer from the line) in the eastward or westward direction is the Quadrantal Bearing or Reduced Bearing of the line
Only the magnetic north line is considered as reference line in whole circle bearing system.	Both magnetic north and south lines are considered as reference line in quadrantal bearing system.
The clockwise angle from the reference line is Only taken	Both clockwise and anti-clockwise angle from the reference line is Only taken
The value of the whole circle bearing varies from 0° to 360°	The value of the reduced bearing varies from 0° to 90°
Example: 26°, 121°, 245°, 350° etc.	Example: N26°E, S59°E, S65°W, N10°W etc.

CONVERSION OF W.C.B. INTO R.B.

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

CONVERSION OF R.B. INTO W.C.B.

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

Traverse Surveying

Traverse Surveying is a popular method of surveying. This article includes the definition of traverse surveying along with its classification, errors in traversing, checks, the completed method of traversing and plotting of traverse survey.

Definition

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

Types of Traversing

There are two types of traverse surveying. They are:

1. **Closed traverse**: When the lines form a circuit which ends at the starting point, it is known as a closed traverse.
2. **Open traverse:** When the lines form a circuit ends elsewhere except starting point, it is said to be an open traverse.

Suitability

The closed traverse is suitable for locating the boundaries of lakes, woods, etc and for a survey of large areas. the open traverse is suitable for surveying a long narrow strip of land as required for a road of the canal or the coastline.

Methods of Traversing

There are several methods of traversing, depending on the instruments used in determining the relative directions of the traverse lines. The following are the principal methods:

1. Chain traversing
2. Chain and compass traversing
3. Transit type traversing a) By fast needle method b) By measurement of angles between the lines
4. Plane table traversing

Brief descriptions of these traverse surveying methods are given below:

Chain Traversing

The method in which the whole work is done with chain and tape is called chain traversing. No angle measurement is used and the directions of the lines are fixed entirely by linear measurements Angles fixed by linear or tie measurements are known as chain angles. The method is unsuitable for accurate work and is generally used if an angle measuring instruments such as a compass, sextant or theodolite is available.

Chain and Compass Traversing

In chain and compass traversing, the magnetic bearings of the survey lines are measured by a compass and the lengths of the lines are measured either with a chain or with a tape. The direction of the magnetic meridian is established at each traverse station independently. The method is also known as a tree or loose needle method.

Traversing by Fast Needle Method

The method in which the magnetic bearings of traverse lines are measured by a theodolite fitted with s compass is called traversing by fast needle method. The direction of the magnetic meridian is not established at each station but instead, the magnetic bearings of the lines are measured with a reference so that direction of the magnetic meridian established at the first station. There are three methods of observing the bearings of lines by fast needle method.

1. Direct method with transiting,
2. Direct method without transiting,
3. Back bearing method.

Traversing by Direct Observation of Angles

In this method, the angles between the lines are directly measured by a theodolite and the magnetic bearing of other lines can be calculated in this method. The angles measured at different stations may be either

1. Included Angles and
2. Deflection Angles

Traversing by Included Angle

An included angle at a station is either of the two angles formed n\by two survey lines meeting there and these angles should be measured clockwise. The method consists simply in measuring each angle directly from a back sight on the preceding station. The angled may also be measured by repetition. The angles measured from the back station may be interior or exterior depending on the direction of progress.

Traverse by Deflection Angles

A deflection angle is an angle in which a survey line makes with the prolongation of the preceding line. It is designated as right (R) or left (L) as it is measured clockwise or anti-clockwise from the prolongation of the previous line. This type of traversing is more suitable for the survey of roads, railways, pipe-lines, etc where the survey lines make small deflection angles.

Errors in Traversing

The errors involved in closed traversing are two kinds:

1. Linear Error and
2. Angular Error

The most satisfactory method of checking the linear measurements consists in chaining each survey line a second time, preferably in the reverse direction on different dates and by different parties. The following are checks for the angular work:

A. **Travers by included angles:**
    - The sum of measured interior angles should be equal to (2N-4), where N=number of sides of the traverse.
    - If the exterior angles are measured, their sum should be equal to (2N=4)p/2

B. **Travers by deflection angles:** The algebraic sum of the deflection angles should be equal to 360°, taking the right hand and deflection angles as a positive and left-hand angle as negative.

C. **Traversing by direct observation of bearings:** The force bearing of the last line should be equal to its back bearing ±180° measured from the initial station.

Plotting a Traverse Survey

There are two principal methods of traverse survey:

1. Angles and distance method: This method is of three types.

   a. By protractor
   b. By the tangent of the angle
   c. By the chord of the angle.
2. Co-ordinate method.

Dumpy Level Survey

Surveying is a very important part of civil engineering. Knowledge of surveying is incomplete without the knowledge of leveling. The dumpy level is a commonly used leveling instrument. To be acquainted with this leveling instrument and learn how to operate it one should read the following article carefully.

What is Dumpy Level?

The dumpy level is an optical surveying leveling instrument consisting a telescope tube firmly secured in two collars fixed by adjusting screws to the stage by the vertical spindle.

The telescope of dumpy level can rotate only in a horizontal plane. Relative elevation of different points of a surveying land is determined with dumpy level.

English civil engineer William Gravatt is considered as the inventor of the dumpy level. He invented dumpy level in 1832 while using the conventional Y level.

A dumpy level is also called a builder's level, an automatic level.

Use of Dumpy Levels in Surveying

The dumpy level is mainly used in surveying for the following purposes:

- To determine relative height and distance among different locations of a surveying land.
- To determine relative distance among different locations of a surveying land.

Advantages of Dumpy Level Survey

The dumpy level is a widely used surveying instrument in surveying. The advantages which have made the dumpy level so popular is given below.

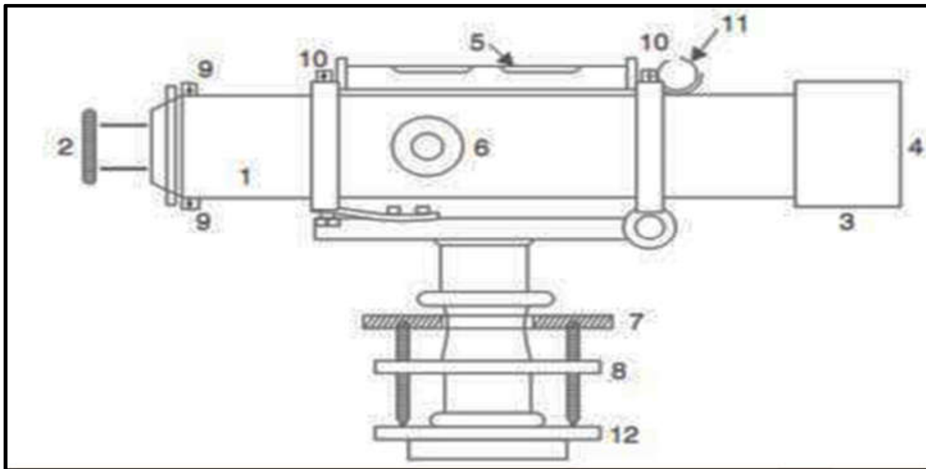
- Simple construction with fewer movable parts.
- Fewer adjustments to be made.
- Due to the rigidity of dumpy levels, it retains its two adjustment for a long time.
- High optical power.

Disadvantages of Dumpy Level Survey

There are few limitation or disadvantages of dumpy level. These limitations are given below.

- Civil Engineers may find it difficult in making accurate measurements.
- Difficulty in using.

Parts of Dumpy Levels



Following are the main parts of dumpy level instrument.

1. Telescope	7. Foot Screws
2. Eye-Piece	8. Upper parallel Plate
3. Ray Shade	9. Diaphragm Adjusting Screws
4. Objective End	10. Bubble Tube Adjusting Screws
5. Longitudinal Bubble	11. Transverse Bubble Tube
6. Focusing Screws	12. Foot Plate

How to Use a Dumpy Level for Surveying

To conduct dumpy level survey the following instruments is required.

- Dumpy Level
- Tripod
- Meter staff or English staffs

Also, an assistant will be required for a dumpy level survey. Once everything is ready, the following steps should be followed for a successful dumpy level survey.

- At first, the tripod is configured properly to hold the dumpy level. The tripod height should be adjusted until it is on the eye level. Then, legs of the tripod should be moved to a balanced position to hold the instrument properly. Finally, tripod legs should be fixed by pressing them to the ground.
- The dumpy level instrument is set up on the top of the tripod. Foot screw is used to screw the device tightly on the tripod. As the level head is very sensitive, special care is required in this step.
- To work properly, it is very important to make the dumpy level completely horizontal. Using foot-screws (leveling screws) the dumpy level is set to a leveled condition. Leveling screws should be adjusted until the alignment bubble is in the center of the marker.
- The operator looks through the eyepiece of the telescope.

- An assistant holds an E meter or staff vertical at the point under measurement. Usually, this staff has both imperial and metric measurements. The 'E' on the staff is equivalent to five centimeters.
- The elevations (levels) of different points is gathered with the help of the instrument and staff.
- Measurement generally starts from a benchmark with the known height determined by a previous survey, or an arbitrary point with an assumed height.

Theodolite surveying:

To measure something from closely we might need a theodolite. This instrument really needed for building constructional work. In the field of civil engineering, workers need this to measure each and all works can be done in proper ways. So, now you have questions on your mind –what is this and why the workers need to use in building constructional works?

What is Theodolite?

Theodolite is a measurement instrument utilized in surveying to determine horizontal and vertical angles with the tiny low telescope that may move within the horizontal and vertical planes.

It is an electronic machine which looks sort of a tiny telescope. It is extensively used for the measurement of vertical and horizontal angles for scaling functions and within the housing industry. The accuracy with that these angles may be measured ranges from 5mins to 0.1 secs. It is utilized in triangulation networks.

Theodolites are employed everyplace from construction sites to main road points. It measures angles using age-old principles of pure mathematics and assists surveyors in establishing precise locations.

Uses of Theodolite in Surveying

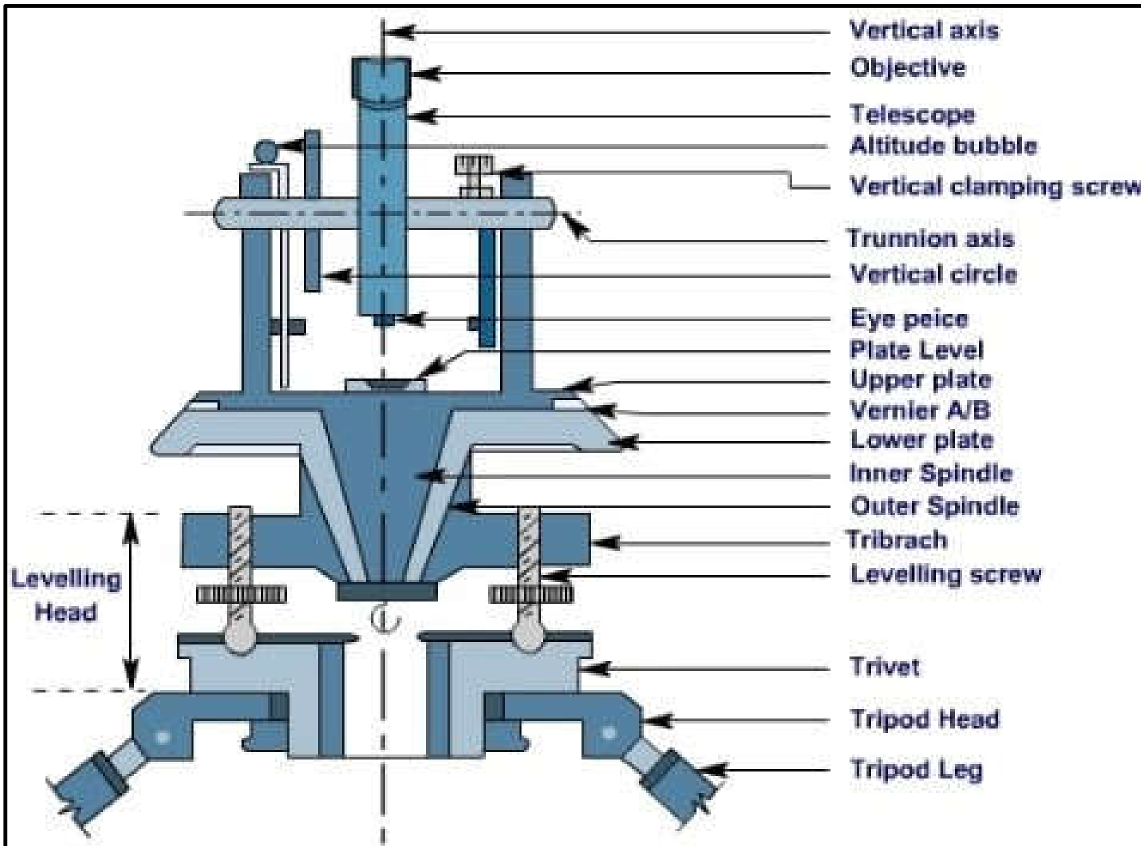
Theodolite uses for many purposes, but mainly it is used for measuring angles, scaling points of constructional works. For example, to determine highway points, huge buildings' escalating edges theodolites are used. Depending on the job nature and the accuracy required, theodolite produces more curved of readings, using paradoxical faces and swings or different positions for perfect measuring survey.

Followings are the major uses of theodolite:

- Measuring horizontal and vertical angles
- Locating points on a line
- Finding the difference in the level
- Prolonging survey lines
- Ranging curves
- Setting out grades
- Tachometric surveying

The theodolite helps us a good within the engineering field. This instrument plays a major role in measurement horizontal angles, vertical angles, bearing, etc. To use theodolite, it is necessary to know about theodolite parts, types of theodolite and for what it is used wisely in the field.

Parts of Theodolite and their Functions



Telescope

A telescope is a focusing instrument which has object piece at one end and eye piece at the other end. It rotates about horizontal axis in vertical plane. The graduations are up to an accuracy of 20'.

Vertical Circle

Vertical circle is fitted to telescope and moves simultaneously with telescope. It has graduation in each quadrant numbered from 0 to 90degrees.

Index Frame

It is also called as t-frame or vernier frame. It consists two arms vertical and horizontal. Vertical arm helps to lock the telescope at desired level and horizontal arm is useful to take the measurements of vertical angles.

The Standards

The standards are the frames which supports telescope and allow it to rotate about vertical axis. Generally, these are in letter A-shape. So, standards are also called as A-frame.

The Upper Plate

This is also called as vernier plate. The top surface of upper plate gives support to the standards. It also consists an upper clamping screw with respect to tangents screw which helps to fixing it to the lower plate.

When the upper clamping screw is tightened both upper and lower plates are attached and moved together with some relative motion because of upper tangent screw. The upper [late also consists two verniers with magnifiers which are arranged diagonally. It is attached tow inner spindle.

The Lower Plate

This is also called as scale plate. Because it contains a scale on which 0 to 360 readings are graduated. It is attached to the outer spindle and consists lower clamping screw. If lower clamp screw is loosened and upper clamp screw is tightened, both plates can rotate together.

Similarly, if lower clamping screw is tightened and upper clamp is loosened then, only upper plate is movable and lower plate is fixed with tribratch plate.

The Leveling Head

The leveling head contains two parallel triangular plates called as tribratch plates. The upper one is known as upper tribratch plate and is used to level the upper plate and telescope with the help of leveling screws provided at its three ends. The lower one is called as lower tribratch plate and is attached to the tripod stand.

The Shifting Head

Shifting head also contains two parallel plates which are moved one over the other with in small area. Shifting head lies below the lower plate. It is useful to centering the whole instrument over the station.

Plate Level

Plate levels are carried by the upper plate which are right angles to each other with one of them is parallel to trunnion axis. These plate levels help the telescope to settle in exact vertical position.

Tripod

Tripod is nothing but a stand on which theodolite is mounted. It should place in such a way that theodolite should be in exact leveled position. The tripod has legs with steel shoes at their ends. These hold the ground strongly without any movement when placed.

Tripod has an external screw which helps to attach the theodolite by tribratch plate in fixed position.

Plumb Bob

Plumb bob is tool having a cone shaped weight attached to a long thread. The weight is hanged using thread from the center of tripod stand and centering of theodolite is done.

Magnetic Compass

Simpler theodolites may contain circular compass box in the center of upper plate. When we select north as reference meridian it will be useful.

Classification of Theodolites

Theodolites may be classified as;

A. i) Transit Theodolite. ii) Non-Transit Theodolite.

B. i) Vernier Theodolites. ii) Micrometer Theodolites.

A. Transit Theodolite: A theodolite is called a transit theodolite when its telescope can be transited i.e revolved through a complete revolution about its horizontal axis in the vertical plane, whereas in a Non-Transit type, the telescope cannot be transited. They are inferior in utility and have now become *obsolete.* B. Vernier Theodolite: For reading the graduated circle if verniers are used ,the theodolite is called as a Vernier Theodolite. Whereas, if a *micrometer* is provided to read the graduated circle the same is called as a Micrometer Theodolite. Vernier type theodolites are commonly used.

Size of Theodolite

A theodolite is designated by diameter of the graduated circle on the lower plate. The common sizes are *8cm to 12 cm* while *14 cm to 25 cm* instrument are used for *triangulation work*. Greater accuracy is achieved with larger theodolites as they have bigger graduated circle with larger divisions hence used where the survey works require high degree of accuracy.

Description of A Transit Vernier Theodolite

A Transit Vernier theodolite essentially consist of the following:

1. Levelling Head.
2. Lower Circular Plate.
3. Upper Plate.
4. Telescope.
5. Vernier Scale.
6. T- Frame.
7. Plumb –bob.
8. Tripod Stand.

Terms Used in Manipulating A Transit Vernier Theodolite

1.Centering: Centering means setting the theodolite exactly over an instrument- station so that its vertical axis lies immediately above the station- mark. It can be done by means of plumb bob suspended from a small hook attached to the vertical axis of the theodolite. The centre shifting arrangement if provided with the instrument helps in easy and rapid performance of the centring.

2. Transiting: Transiting is also known as *plunging* or *reversing*. It is the process of turning the telescope about its horizontal axis through 1800 in the vertical plane thus bringing it upside down and making it point, exactly in opposite direction.

3. Swinging the telescope: It means turning the telescope about its vertical axis in the horizontal plane. A swing is called *right* or *left* according as the telescope is rotated clockwise or counter clockwise.

4. Face Left: If the vertical circle of the instrument is on the left side of the observer while taking a reading, the position is called the *face left* and the observation taken on the horizontal or vertical circle in this position, is known as the *face left observation.*

5. Face Right: If the vertical circle of the instrument is on the right side of the observer while taking a reading, the position is called the *face right* and the observation taken on the horizontal or vertical circle in this position, is known as the *face right observation.*

6. Changing Face: It is the operation of bringing the vertical circle to the right of the observer, if originally it is to the left, and vice – versa. It is done in two steps; Firstly, revolve the telescope through 1800 in a vertical plane and then rotate it through 1800 in the horizontal plane i.e., first transit the telescope and then swing it through 180^0.

7. Line of Collimation: It is also known as the line of sight. It is an imaginary line joining the intersection of the cross- hairs of the diaphragm to the optical centre of the object- glass and its continuation.

8. Axis of the telescope: It is also known an imaginary line joining the optical centre of the object- glass to the centre of eye piece.

9. Axis of the Level Tube: It is also called the bubble line. It is a *straight* line *tangential* to the *longitudinal curve* of the level tube at the centre of the tube. It is horizontal when the bubble is in the centre.

10. Vertical Axis: It is the axis about which the telescope can be rotated in the horizontal plane.

11. Horizontal Axis: It is the axis about which the telescope can be rotated in the vertical plane. It is also called the *trunion axis.*

The adjustments of a theodolite are of two kinds: -

1) Permanent adjustments: The permanent adjustments are made to establish the relationship between the *fundamental lines* of the theodolite and, once made, they last for a long time. They are essential for the accuracy of observations.

1. Permanent adjustments: The permanent adjustments in case of a transit theodolites are: -

i) Adjustment of Horizontal Plate Levels: The axis of the plate levels must be perpendicular to the vertical axis.

ii) Collimation Adjustment: The line of collimation should coincide with the axis of the telescope and the axis of the objective slide and should be at right angles to the horizontal axis.

iii) Horizontal axis adjustment: The horizontal axis must be perpendicular to the vertical axis.

iv) Adjustment of Telescope Level or the Altitude Level Plate Levels: The axis of the telescope levels or the altitude level must be parallel to the line of collimation.

v) Vertical Circle Index Adjustment: The vertical circle Vernier must read zero when the line of collimation is horizontal.

2. Temporary Adjustment: The temporary adjustments are made at each set up of the instrument before we start taking observations with the instrument. There are three temporary adjustments of a theodolite: -

i) Centering.

ii) Levelling.

iii) Focussing