# VISVESVARAYA TECHNOLOGICAL UNIVERSITY
# BELGAUM

## ENGINEERING SURVEY

## (Subject Code: BCV302)

## LECTURE NOTES

## (MODULE-1)

### III-SEMESTER


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# MODULE 1

## SYLLABUS:

**Engineering surveying** – Definition & importance of surveying for Civil Engineers. Surveying types- Control survey, Topographical surveying, Construction Survey, Cadastral survey, Hydrographic survey, and Underground Survey. Surveying through the ages- Chain surveying, Compass surveying and Plane Table Surveying (concepts and limitations only).

**Measurement of Distance**- Various types of tapes, Laser distance meter, Distance measuring wheel, Electronic Distance measurement, GPS. [RBTL: L1, L2, L3]

## CHAPTER 1: ENGINEERING SURVEYING

### 1.1 Definition & importance of surveying for Civil Engineers.

#### Geoinformatics

Measurement and management of geoinformation is called geoinformatics. Geoinformation is any artificial or natural object/phenomena on, below or above the surface of the earth. Geoinformatics has got two fundamental divisions, measurement of geoinformation and management of Geoinformation. Surveying is basically the measurement of geoinformation.

#### Definition of surveying

Surveying is the art of determining the relative positions of points on above or beneath the surface of the earth by means of direct & indirect measurement of distances, directions & elevation. It also can defined as the, art and science of obtaining quantified and qualified measurements, the interpretation of these measurements and a meaningful presentation of result

The knowledge of surveying is very important in many phases of engineering. The main object of survey is to prepare plan or map so that it may represent the area on a horizontal plane.

#### Objectives and importance of surveying

The aim of surveying is to prepare a map to show the relative positions of the objects on the surface of the earth. The map is drawn to some suitable scale. It shows the natural features of a country, such as

towns, villages, roads, railways, rivers, etc. Maps also include details of different engineering works, such as roads, railways, irrigation canals, etc.

**The objectives of surveying can thus state as follows.**

1. Collect and record data on the relative position of points on the surface of the earth.
2. Compute areas and volumes using this data, required for various purposes.
3. Prepare the plans and maps required for various activities
4. Layout, using survey data, the various engineering works in correct position
5. Check the accuracy of laid-out, built up structure.

The planning and design of all Civil Engineering projects such as construction of highways, bridges, tunnels, dams etc are based upon surveying measurements. Moreover, during execution, project of any magnitude is constructed along the lines and points established by surveying. Thus, surveying is a basic requirement for all Civil Engineering projects

Surveying may be used for the following various applications:

1. To prepare a topographical map which shows the hills, valleys, rivers, villages, towns, forests, etc. of a country.
2. To prepare a cadastral map showing the boundaries of fields, houses and other properties.
3. To prepare an engineering map which shows the details of engineering works such as roads, railways, reservoirs, irrigation canals, etc.
4. To prepare a military map showing the road and railway communications with different parts of a country. Such a map also shows the different strategic points important for the defense of a country.
5. To prepare a contour map to determine the capacity of a reservoir and to find the best possible route for roads, railways, etc.
6. To prepare a geological map showing areas including underground resources.
7. To prepare an archaeological map including places where ancient relics exist.

**Classification of surveys**

## Primary Divisions Of Survey

Primary division of the surveying is made on the basis whether the curvature of the earth is considered or whether the earth is assumed to be a flat pane. Because of the curvature of the earth surface the measured distances on earth surface are curved. However, when the distances are small, compared with the radius of the earth surface, there is no significant difference between the curved surface distance and the corresponding straight line distances and the curvature of the earth can neglected. Surveying is this primarily divided into two types

i. Plane Surveying
ii. Geodetic Surveying

### i. Plane Surveying

It is the type of surveying in which the curvature of the earth is neglected and it is assumed to be a flat surface. All distance and horizontal angles are assumed to be projected onto a horizontal plane. A horizontal plane at point is the plane which is perpendicular to the vertical line at that point. The vertical line is indicated by a freely suspended plumb bob. A single horizontal plane of reference is selected for the entire survey of the small area. Thus the plumb bob lines at all points of the area are assumed to be parallel.

Plane surveying can be safely be used when one is concerned with a small portion of the earth's surface and the areas involved are less than 250 sq. km. In plane surveying, the angles of polygons and triangles are considered as plane angles. Survey conducted for engineering projects falls under this category.

### ii. Geodetic Surveying

It is the type of surveying in which the shape of the earth is taken into account. All geodetic surveys include work of larger magnitude & high degree of precision. The main objective of geodic survey is to determine the precise location of a system of widely spaced points on the surface of the earth. The points so located are used as control station for primary survey.

In geodetic surveying we need reference for measuring the geo information. We cannot take earth surface as reference because earth surface is not definable mathematically. So we need a surface which

is physically adjusting, which is the equipotential surface or a surface which is always perpendicular to the direction gravity. This surface is also called the level surface or geoid. And the physical surface which is the geoid is the mean sea level, or the surface of the water body, because all over the water body, there will be equipotential everywhere - the potential will be same. Because of the variation in the earth mass distribution, the surface of the geoid can is irregular. However, if the irregularities of the surface are neglected, the geoid we can closely approximated as spheroid. The dimension of the spheroid is selected so as to give a good fit to the geoid over a large area. Thus an imaginary surface representing mean sea level extending over the entire surface of the earth is represented by a spheroid (Fig 1.1.1).

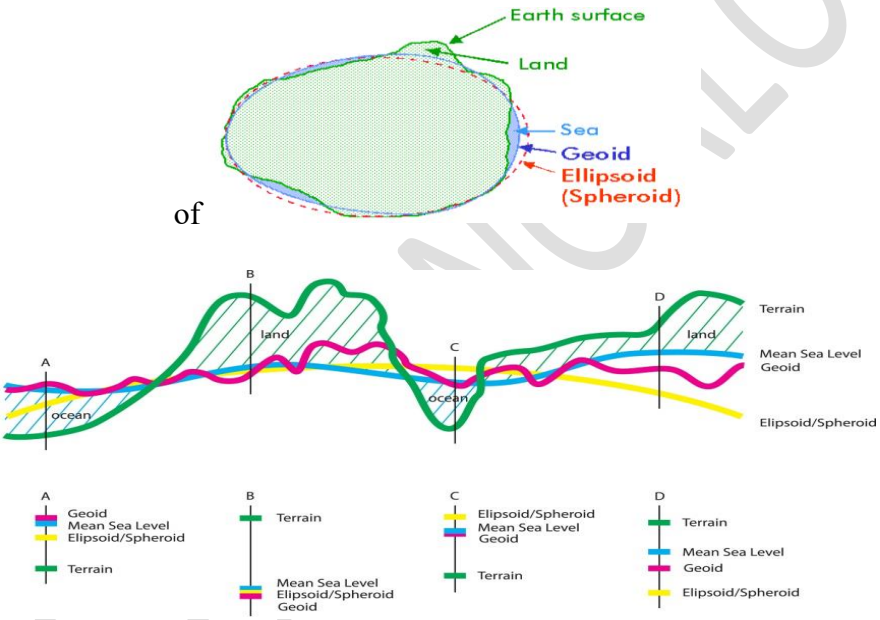



Fig 1.1.1 Spheroid

Consider three points A,B &C on the mean surface of the earth. The lines AB,BC and CA are arcs of great circles passing through the center of earth. The great circle is formed by intersection of a plane passing through the center of earth. The surface within the triangle ABC formed in the Fig 1.1.2 is a spherical triangle. The angles α, β, & γ of the spherical triangles are somewhat more than corresponding angles α', β', & γ' of the plane triangle. In geodic surveying, the distances AB,BC and CA are determined from the spherical triangles using spherical geometry, whereas in plane surveying, these distances are obtained from the plane triangle using plane geometry. Also one important thing we

should keep in mind for plane surveying is, we must always measure the elevations from the geoid, not from the horizontal plane.

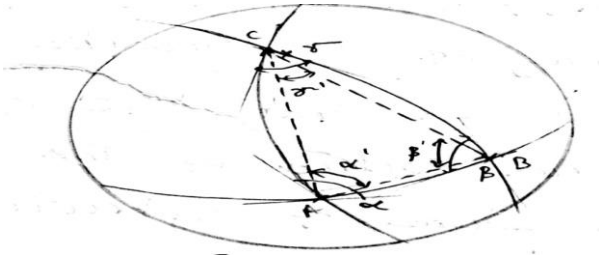


Fig 1.1.2

**Differences between Plain & Geodetic Surveying**

| lain Surveying | eodetic Surveying |
|---|---|
| The earth surface is considered as plain surface. | he earth surface is considered as curved face |
| The curvature of the earth is ignored. | The curvature of the earth is taken into ount |
| Line joining any two stations is considered to be ight | he line joining any two stations is sidered as spherical. |
| The triangles formed by any three points is sidered as plain | he triangle formed by any three points is sidered as spherical. |
| The angles of triangle are considered as plain les. | he angles of the triangle are considered as erical angles |
| Carried out for small area | arried out for large area. |

**Basic Principles of Surveying**

The fundamental principles can be started under the following two aspects:

i. **Location of a point by measurement from two points of Reference:**

The relative positions of the points to be surveyed should be located by measurement from at least two points of reference, the positions of which have already been fixed. If two control points are established first, then a new station can be located by two linear or two angular measurements, or by one linear and one angular measurement. If P and Q are the two reference points on the ground, any other point, such as R, can be located by any of the following direct methods shown in the figure 1.1.3.

(a) Distance PR & QR can be measured & point R can be plotted by swinging the two arcs to the same scale to which PQ has been plotted. The principle is very much used in chain Surveying.

(b) A perpendicular RS can be dropped on the reference line PQ & lengths PS & SR are measured. The point R can be then plotted using set square. This principle is used for defining details.

(c) The distance QR & the angle PQR can be measured & point R is plotted either by means of a protractor or trigonometrically. This principle is used in traversing.

(d) In this method, the distances PR & QR are not measured but angle RPQ & angle RQP are measured with an angle measuring instrument. Knowing the distance PQ, point R is plotted either by means of protractor or by solution of triangle PQR. This principle is very much used in triangulation.

(e) Angle RQP & distance PR are measured & point R is plotted either by protracting an angle & swinging an arc from P or plotted trigonometrically.

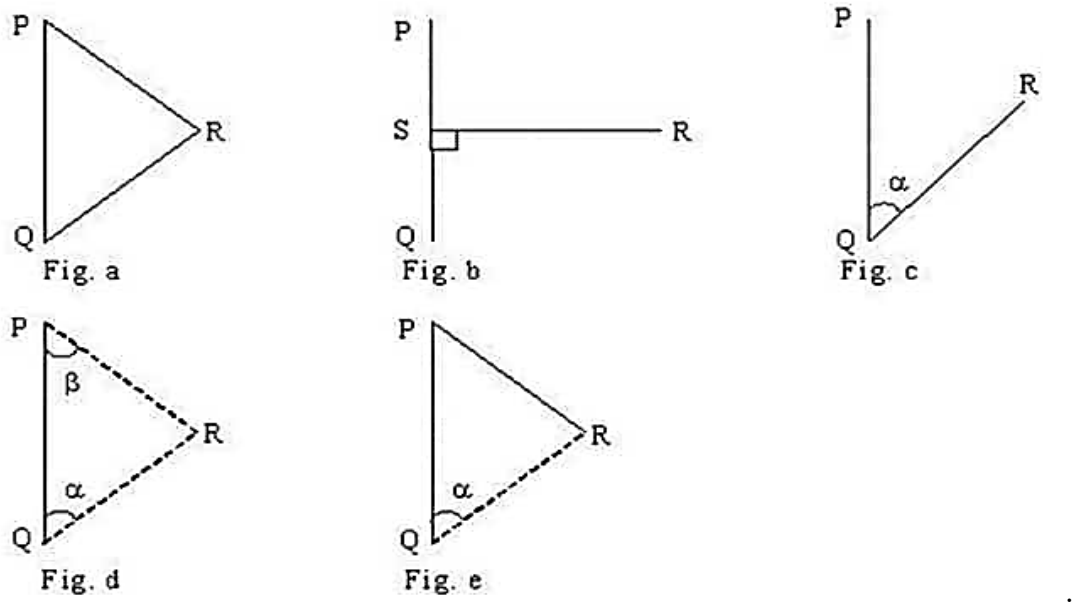



Fig .1.1.3 Location of points

### ii. Working From Whole to Part

The second ruling principle of surveying whether plane or geodetic, is to work from whole to part. It is very essential to establish first a system of control points & to fix them with higher precision. Minor control points can then be established by less precise methods & the details can then be located using these minor control points by running minor traverses etc. The idea of working in this way is to prevent the accumulation of errors & to control & localize minor errors, otherwise, would expand to greater magnitude if the reverse process is followed, thus making the work uncontrollable at the end.

## 1.2 . TYPES OF SURVEYING

a) **CONTROL SURVEY:** A control survey establishes reference locations on land or a construction site. These control points precisely locate and map other land or site characteristics, including buildings, roads, and utilities. Control surveys or survey controls provide reference points as a foundation for diverse building processes. A survey station is a location from which the observations are made.

All other types of surveys, including topographic, right-of-way, aerial mapping, construction layout, boundary surveys, and utility mapping, can be worked on after the control points are established to build control networks.

**What is a control survey?**

Control surveys offer the horizontal and vertical positions of the points used to adjust supplementary surveys. Control surveys set the accuracy benchmark for subsequent and subsidiary surveys to meet.

Each project comprises a series of vertical and horizontal field surveys, including route surveys, photogrammetry, and topographic mapping

Control surveys are used in project planning and construction to ensure accuracy and efficiency. Skilled surveyors perform control surveys utilizing total stations, GPS receivers, and level tools.

Control surveys are classed by accuracy and control point count. The most accurate control surveys are first-order, followed by second-order and third-order. Aerial and geodetic control surveys are also available.

**Types of control survey**

Control surveys can create reference points on land or a construction site. Essential types of control surveys include:

- **First-order control survey:** This is the most accurate kind of control survey, and it's frequently used for big projects or projects that need a lot of accuracies. It connects a network of control points to provide a precise reference system for the project.
- **Second-order control survey:** Although less precise than a first-order survey, this control survey is appropriate for many medium-sized projects. It is frequently used for projects that ask for less accuracy and employ a lesser number of control points.
- **Third-order control survey:** These are the least accurate and often employed for small-scale or less accurate projects. It is appropriate for projects where an approximate location estimate is acceptable because they only use a small number of control points.

**Importance of control survey**

A control survey is important for a lot of reasons. In the field of surveying and mapping, it is used to set up a precise reference frame for the location of points on the Earth's surface. Control surveys are also important for ensuring that other types of surveying and mapping work, such as topographic surveys, boundary surveys, and construction surveys, are accurate and precise. With accurate control surveys, it would be easier to correctly find and measure points on the ground, which could lead to mistakes and inaccuracies in the final survey product. Control surveys keep the integrity of geospatial data over time.

b) **TOPOGRAPHICAL SURVEYING:** Topographical survey, also known as a land survey or topographical land survey also known as contours. Topographical land survey measures and identifies the exact location and specifications of natural and human made features within an area of land. The survey is then drawn up into an appropriate and detailed plan it includes human-made features such as

boundaries, neighbouring buildings, walkways etc. The topographical survey also picks up natural features such as trees, ponds and ground contours.

**Objective of a Topographic Survey**

The main objective of a topographical survey is to provide a detailed map of the natural and man-made features of a piece of land. This information is critical for planning and design, as well as for understanding the natural environment of a site. The survey is used to create a "base map" of the area, which can be used for a wide range of purposes, such as:

- Planning and design of buildings and other structures
- Engineering and construction projects
- Land development and real estate
- Environmental studies
- Natural resource management
- Military and emergency planning

**Procedure in Topographic Surveying**

The procedure for a topographic survey typically includes the following steps:

**Research:** The survey team will research the area to be surveyed, including any existing maps or plans, zoning regulations, and other relevant information.

**Fieldwork:** The survey team will then visit the site and collect data using the appropriate surveying equipment. This will include things like GPS, total stations, aerial drones, and hand levels.

**Processing:** The data collected in the field will then be processed and analyzed to create a detailed map of the area. This will include things like contour lines, spot elevations, and symbols to indicate the locations of different features.

**Final Product**: The final product of the survey will be a detailed map of the area, which can be used for a wide range of purposes.

**Benefits of Topographical Survey**

- Provides detailed information about the natural and man-made features of a site

- Helps with planning and design, as well as understanding the natural environment of a site
- Can be used for a wide range of purposes, including construction, engineering, land development, and real estate
- Can help identify potential issues and hazards, such as flooding or erosion
- Can be used to create 3D models of a site

c) **CONSTRUCTION SURVEY:** A Construction Survey is basically a survey that presents locations and marks for construction activities; the process of executing evaluation and estimation prior to or during construction activities. It is carried out to layout engineering and construction works. Measurements are done for reference points which determine the location of the planned structure or improvements, vertical and horizontal positioning, dimensions, configuration, and to control the elevation of the new structures.

The purpose of doing a construction survey is to maintain and establish the necessary vertical and horizontal control needed for a construction project. It includes taking measurements to ascertain quantities, and then put these measurements in documentation to corroborate the final payments made to the contractor.

Post construction, the survey is used to assess the final position and adequacy of the work, and to compute construction payments and be able to establish "as built" conditions. The "As Built" construction survey is conducted as the construction works are finished to verify the accomplishments as specified on the designs and plans.

d) **CADASTRAL SURVEY:** Cadastral surveying are made for the purpose of delineating of property boundaries and the compilation of data required for the registration of titles to land. Survey is the link between ground boundaries and boundaries in the land registries.

Cadastral surveying involves interpreting and advising on:

- boundary locations
- the status of land, and
- the rights, restrictions and interests in property

This information is recorded for use on plans, maps and other documentation. Accurately recording the information is an important part of the cadastral surveying discipline.

Cadastral surveying also involves the physical delineation of property boundaries and determination of dimensions, areas and certain rights associated with properties. This is regardless of whether they are on land, water or defined by natural or artificial features.

e) **HYDROGRAPHIC SURVEY:** Hydrographic surveying is an important civil engineering service that determines the physical features of an underwater area. Like topographic or land surveys, these surveys use special equipment to measure and define a body of water to support marine construction.

**Purposes of Hydrographic Surveys**

Hydrographic surveys are often needed whenever someone wants to make a significant change to an area of water. This includes projects such as:

- Building docks or marinas
- Dredging
- Waterway planning
- Diversion of water sources
- Removing soils
- Wreck location

**Objectives of Hydrographic Surveying:**

Hydro-graphic surveying is carried out for one or more of the following activities.

1. Measurement of tides for sea coast work e.g., construction of sea defense works, harbours etc, for the establishment of leveling datum and for reducing sounding.
2. Determination of bed depth, by soundings
    - For navigation
    - Location of rocks, sand bars, navigation light.
    - Fro location of under water works volumes of under water excavation etc.
    - In connection with irrigation and land drainage schemes.
3. Determination of direction of current in connection with
    - The location of sewer any pipe or channel that carry waste water out falls.

- Determination of area subject to silt and scour the eating of the place.
- Fornication purposes.
- Measurement of quantity of water and flow of water in connection of water schemes, Power scheme and flood controls.

f) **UNDERGROUND SURVEY:** Underground surveying embraces the survey operations performed beneath the surface of the earth in connection with tunnelling, exploration and construction in subterranean passageways. It is quite different from surveying on the surface.

The following peculiarities of underground surveys indicate how they differ from surface surveys:

- Artificial illumination is required to view instrument crosshairs, to read verniers, to sight targets etc. Because of poor lighting.
- Working space in passageways is often cramped.
- Instrument stations and benchmarks for levelling must often be set into the roof of a passageway to minimize disturbance from the operations being carried on in the workings.
- Instrument stations are set with some difficulty since plugs must be driven into drill holes in rock.
- In many instances the underground workings arc wet, with considerable water dripping from the roofs of passage ways and running along the floors.

**Applications of Underground Surveys**

The major application of underground surveys is in the construction of tunnels and other underground utilities. The tunnel is constructed when open excavation becomes uneconomical usually when it is more than 20 m.

- It Reduces the grade
- It Shortens the distance between given points separated by a dividing mountain or ridge.
- It Meets the demand of-modern rapid transit in a city.
- It Engineering operations to be performed
- It Exact alignment
- It Proper gradient
- It Establishment of permanent stations marking the proposed route.

## 1.3. SURVEYING THROUGH THE AGES

**a) CHAIN SURVEYING:** Chain surveying is the branch of surveying in which only linear measurements are made in the field. This is suitable for the survey of small areas with simple details and an area that is flat. It derives its name from the fact that the principle equipment commonly used is the chain.

### Advantages of Chains in Surveying

- Chain survey is simplest and commonest method used in surveying exercises
- The equipment used to conduct chain survey are simple to use,
- The equipment used in chain survey can easily be replaced. For example measuring rods can be replaced with measuring tape.
- This method does not involve complicated mathematical calculation. I know this is the relief to those who are afraid of mathematics
- In chain survey few people are needed to conduct the survey. Normally chain survey team has three people Booker, leader, and follower.

### Disadvantages of Chains in Surveying

- Simple chain survey cannot be conducted in built up areas and large areas.
- Simple chain survey is subject to several chances of errors of accumulation which may cause by problem of chain. The chain linkage may fail to stretch up properly and result in inaccurate data. Also clogging of chain may read to error in reading.
- It is time consuming
- It may not be conducted in areas with steep slopes or water logged areas. Chain survey is usually conducted in dry areas with gentle slopes. It becomes more complicated when survey is conducted in areas that are too wet.

Chain survey becomes more complicated method when there are raised points (obstacles) in between areas to be surveyed.

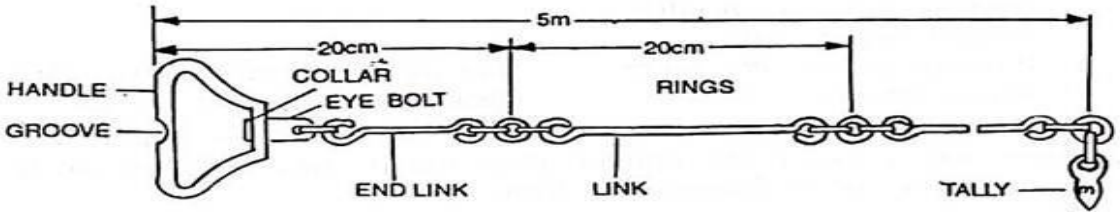
## Principle of Chain Surveying

- The main principle of chain surveying is to divide the survey plot into small survey areas by triangulation method.
- Measure the lengths and angles with tape and compass respectively.
- The measurements are used so that the surveyed drawing can be plotted on paper.
- The chain survey is also known as chain triangulation, since the triangulation method is the principle of chain surveying.
- The triangles that are formed by the triangulation method should resemble with an equilateral triangle shape.
- The formed triangle should be a well-conditioned triangle and those are almost equilateral in shape are known as well-conditioned triangles.
- If there is a triangular survey area and sequence and lengths of its three sides are noted, then the plan of the survey area can be drawn easily.

### Types of Chain in Surveying

The following are the different types of chain in surveying that are commonly used:

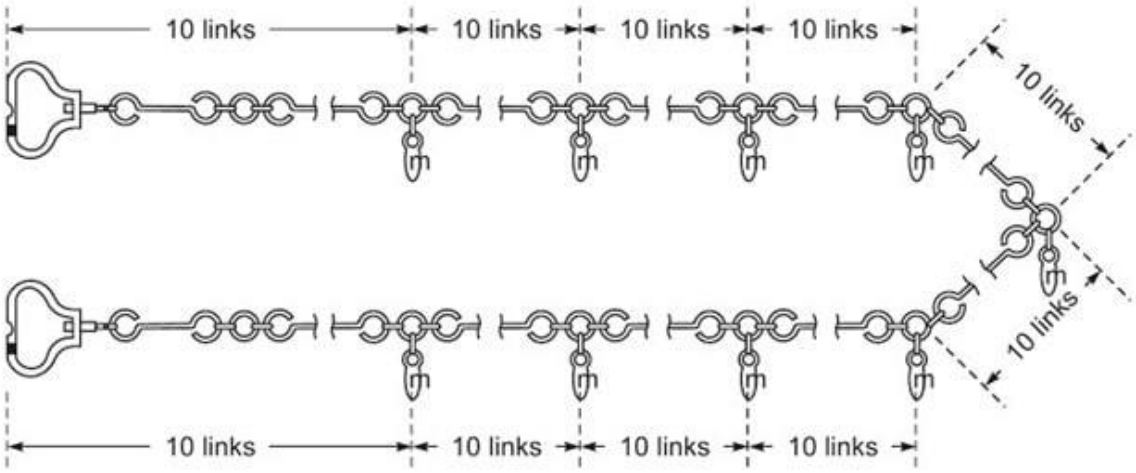
**Metric Chain**: Metric chains are generally available in the lengths of 5 m, 10 m, 20 m and 30 m. In these types of chain in surveying, tallies are fixed at each meter length of 5- and 10-meter chain and each 5 meter length for chains of 20 meter and 30 meter length, so as to enable fraction readings a chain with less trouble. At every meter there is a small brass ring provided, except the places where the tallies are attached.




**Surveyor's Chain or Gunter's Chain:** A Surveyor's chain or a Gunter's chain length is 66 feet and consists of 100 links, each link being 0.66 feet or 7.92 inch in length. In these types of chain in surveying the length of 66 feet was adopted for convenience in length measurement, has 10 sq. chains

are equal to 1 acre. Also when linear measurements are required in furlongs and miles, these chain is more convenient as 10 chains make 1 furlong and 80 chains make 1 mile.

| | |
|---|---|
| 10 Günter's chain | = 1 Furlong |
| 80 Günter's chain | = 1 Mile |
| 10 square Günter's chain | = 1 acre = 43,560 sq. ft. |




(a) 100 link chain

**Engineer's Chain:** An engineer's chain is 100 feet in length and consists of 100 links, each link being 1 foot long. In these types of chain in surveying a brass tag is attached at every ten links with notches on the tags that are demonstrating ten link segments number between tags and end of the chain.

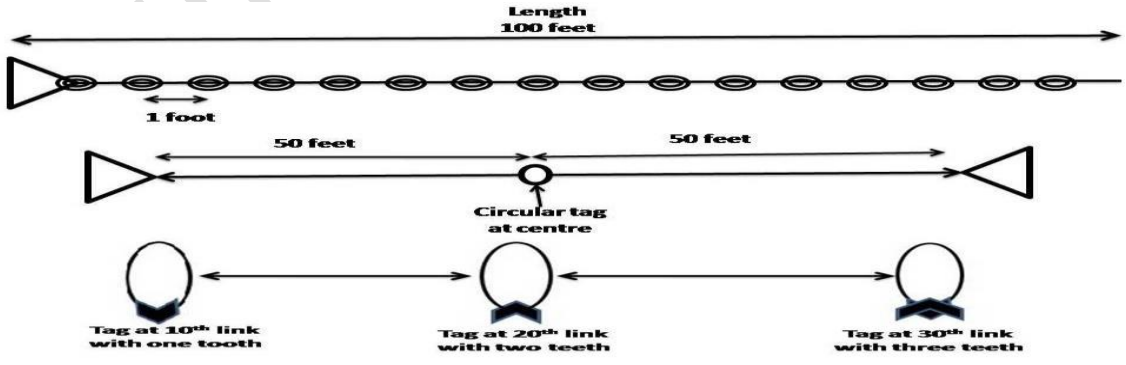
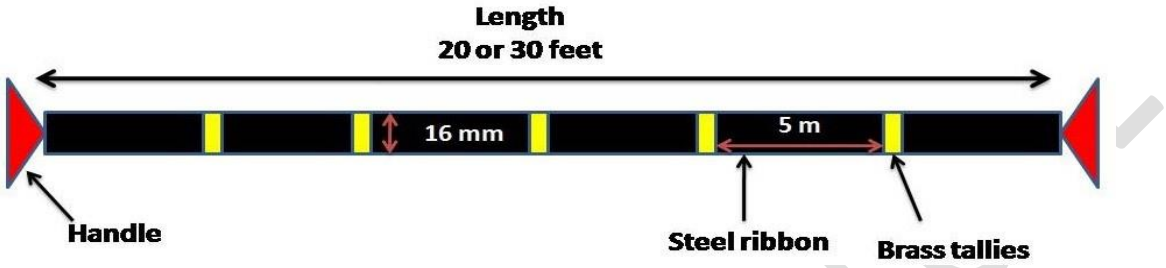



**Fig. Engineer's Chain**

**Revenue Chain:** The revenue chain is 33 feet in length and consists of 16 links each links being 2*1/16 feet long. This types of chain in surveying is used for measuring fields in cadastral survey.

**Steel Band or Band Chain:** These kinds of chain comprise of a long thin portion of steel of uniform width of 12mm to 16mm and thickness of 0.3mm to 0.6mm. This chain is partitioned by brass studs at each 20cm. In these types of chain in surveying, for simple use and workability band chains are twisted on steel crosses or metal staggers from which they can be handily unrolled. These steel bands are accessible in 20m and 30m length and the width of around 12mm to 16mm.




**b) COMPASS SURVEYING:**

According to the method employed, surveying is classified into Triangulation surveying and Traverse surveying. A series of connected survey lines of known lengths and directions is called a traverse. When triangulation is not possible, traversing method is used. In traversing, when compass is used for making angular measurements, it is known as compass traversing or compass surveying.

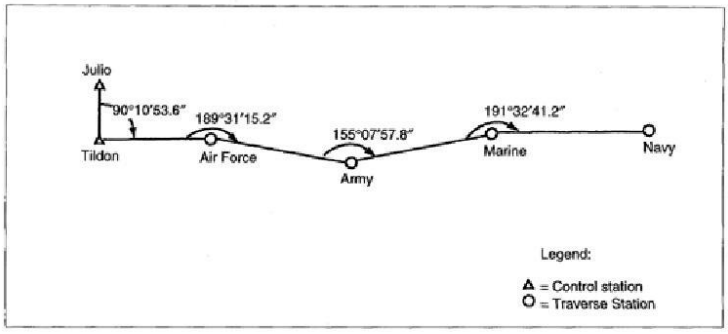
**Principle of Compass Surveying**

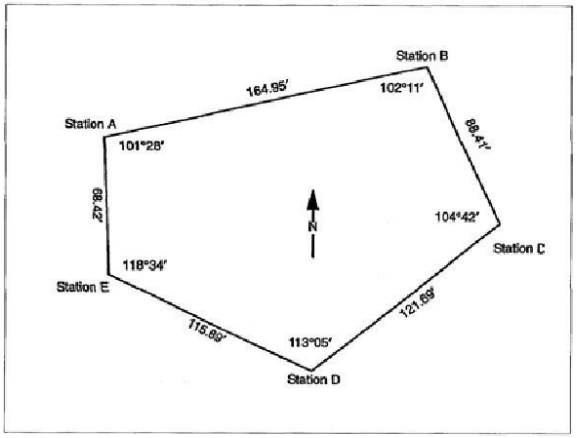
In compass traversing the directions of survey lines are fixed by angular measurements and not by forming a network of triangles. A compass survey is one in which the traverse work consists of series of lines the lengths and directions of which are measured with a chain or a tape, and with an angular instrument respectively.

A traverse may be classified as: a) Closed traverse b) Open traverse

A) Closed traverse: Closed traverse is a traverse in which the sides of a traverse form a closed polygon.

B) Open traverse: An open traverse is a traverse in which the sides of traverse do not form a closed polygon.

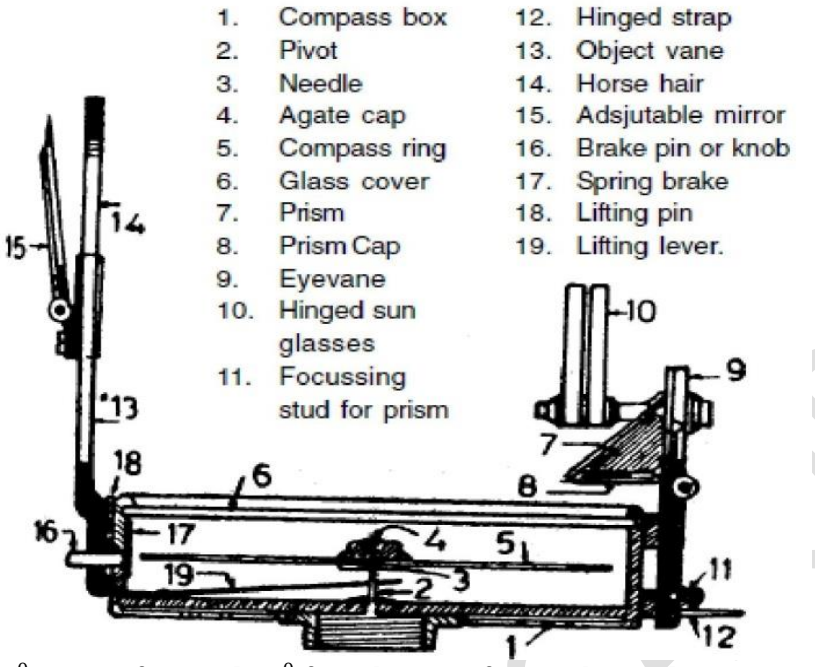



**Description of Prismatic Compass**

The prismatic compass consists of a circular box about 85 to 110 mm diameter. At the center of metal box a needle and pivot is provided. The pivot balances the magnetic

needle which is attached to graduated aluminum ring. The graduations are in degrees to 30 minuets and from $0^0$ to $360^0$ in the clock wise direction. The $0^0$ is marked at south end of magnetic needle because the readings are read at the opposite end of the object. At west it is marked $90^0$, north $180^0$ and east $270^0$ respectively. The graduations are marked inverted because they are viewed through a prism




which is cut to $45^0$ on one face and $90^0$ for other two faces. The readings get reflected through prism resulting in erected image. A sighting slit is provided in the box carrying the prism. This box can be moved up and down for focusing by means of stud. The prism box is hinged so that it can be folded to the rim of the compass box. Two sun glasses are provided to observe bright objects. An object vane is provided in line of sighting slit. It is an open frame with a central vertical horse hair for sighting the object. The object vane is hinged to compass. When it is not in use, it is folded flat on the glass cover. The base of object vane presses the lifting pin bringing the magnetic needle to rest with the help of lifting lever. A brake pin is provided to stop the oscillations of the graduated ring to facilitate the reading of the graduated ring. A glass cover is fitted over the box to protect the needle from dust. The compass is fitted to a tripod stand. A tripod stand consists of a ball and socket joint which helps in leveling the compass quickly.

**Method of using Prismatic Compass:** The compass may be held in the hand, but for better results, it is usually mounted on a tripod which carries a vertical spindle in a ball and socket joint to which the box is screwed. By means of this arrangement the instrument can be quickly leveled and also rotated in a horizontal plane and clamped in any position.

**Working of Prismatic Compass**

This can be used while holding it in hand, but for better accuracy, it is usually mounted on a light tripod which carries a vertical spindle in the ball and socket arrangement to which compass is screwed. By means of this arrangement the compass can be placed in position easily. Its working involves the following steps.

(i) Centering (ii) Levelling, and (iii) observing the bearing

**(i) Centering**

The compass should be centered over the station where the bearing is to be taken by dropping a small piece of stone so that it falls on the top of the peg marking the station.

**(ii) Levelling**

The compass should then be leveled by eye, by means of a ball and socket joint so that the ring may swing quite freely. It should be clamped when leveled.

**(iii) Observing the bearing.**

To observe the bearing of a line AB

1) Centre the compass over the station Aand level it.
2) Having turned up vertical prism and the sighting vane, raise or lower the prism until the graduations are clearly visible.
3) Turn the compass box until the ranging rod at the station B is bisected by the hair when looked through the slit above the prism.
4) When the needle comes to rest, look through the prism and note the reading at which the hair line produced appears to cut the image of the graduated ring which gives the required bearing of the line AB. Readings are usually estimated to the nearest 15'.

**Concept of Meridian, True Median, Magnetic Meridian and Arbitary Meridian**

**Meridian:** Meridian is a standard direction from which, the bearings ofsurvey lines are measured. There are three types of meridians.

1) True meridian
2) Magnetic meridian
3) Arbitrary meridian.

**True meridian:** It is a line of intersection of earth's surface formed by aplane passing through north and south poles and the given place.

**Magnetic meridian:** It is the direction indicted by a freely suspendedmagnetic needle.

**Arbitrary meridian:** It is any convenient direction assumed asmeridian for measuring bearings of survey lines.

**Bearing:**

It is a horizontal angle made by the survey line with reference to the meridian, based on the meridian the bearings are three types.

1) True bearing 2) Magnetic bearing 3) Arbitrary bearing

**True bearing:** The angle made by a survey line with reference to true meridian is called true bearing. It is always remains constant.

**Magnetic bearing:** The angle made by a survey line with reference to magnetic meridian is called magnetic bearing. It changes from place to place and time.

**Arbitrary bearing:** The angle made by a survey line with reference to arbitrary meridian is called arbitrary bearing.

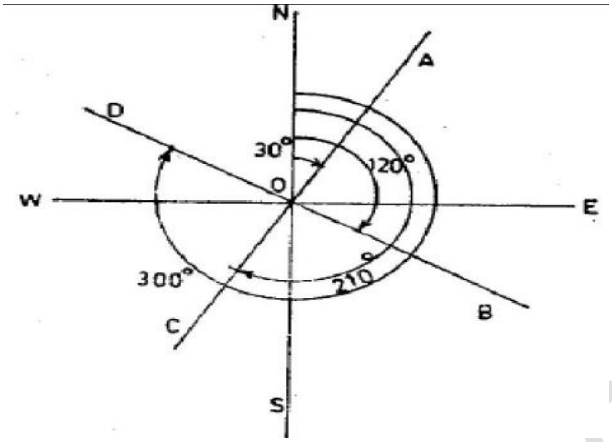
**Representation of Bearing**

Bearings are expressed in the following two systems.

1) Whole circle bearings system.
2) Quadrantal bearings system

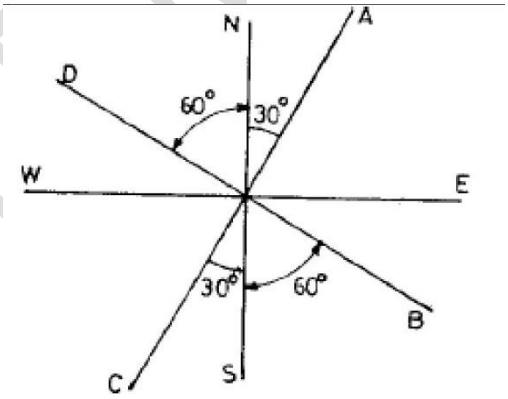
**1) Whole Circle Bearing**

In this system, the bearing of a line is always measured clock wise from the direction of the north of the meridian towards the line around the circle. Whole circle bearings of lines have been shown in fig




**Quadrantal bearings :**

In this system the bearings of a line is measured from either the north or the south, clock wise or counter clockwise which ever is nearer to the line towards the east or west. The angle at any station in a plane is divided into four quadrants by two lines at right angles to each other. These are the north south and east- west lines. The bearing is reckoned from $0^0$ to $90^0$ in each quadrant. Quadrantal bearings of lines have been shown in fig 3.4 Quadrantel bearings are also called as reduced bearings.



**Conversion of Whole Circle bearings into Quadrantal Bearings**

The whole circle bearing of a line can be converted to quadrantal bearing by reducing it to an angle less than $90^0$ which has the same numerical value of the trigonometric functions. Rule of conversion of whole circle bearings into quadrantal bearing.

| S.No. | W.C.B | QUADRANT | RULE |
|---|---|---|---|
| 1. | Between 0° to 90° | N.E | Q.B = W.C.B |
| 2. | Between 90° to 180° | S.E | Q.B = 180°-W.C.B |
| 3. | Between 180° to 270° | S.W | Q.B = W.C.B-180° |
| 4. | Between 270° to 360° | N.W | Q.B = 180°-W.C.B |

**Errors in compass surveying are classified as follows:**

a) Natural Errors

b) Instrumental Errors

**a) Natural Errors:** Natural errors are of two types:

1. Errors of manipulation and sighting

2. Errors due to external influences

**1.** Errors of manipulation and sighting

i) Inaccurate centering of the compass

ii) Inaccurate leveling of the compass box

iii) Imperfect bisection of the ranging rods at stations

iv) Carelessness in reading the graduations

v) Carelessness in recording the observed readings

**2. Errors due to external influences**

i) Magnetic changes in atmosphere on a cloudy or stormy day

ii) Variations in declinations

iii) Local attraction due to proximity of steel structures

**b) Instrumental Errors:**

i) The needle not being perfectly straight

ii) The pivot being bent

iii) The needle being sluggish

iv) The needle not moving freely.

v) The line of sight is not being vertical.

vi) The graduated circle not being horizontal.

vii) The line of sight not passing through the centre of the graduated ringand

viii) The vertical hair being loose.

Compass surveying is an important branch of surveying which is usually adopted in determining the position of an object both by angular and linear measurements. Here angular measurements are taken using a compass and linear measurements are determined using chain or tape.

Some priorities for compass surveying are as following-

- If there is a large area to be surveyed such as the coastal areas or the course line areas of the river.
- If the area is crowded with many details and has many obstacles for conducting chain surveying as triangulation becomes impossible.
- If the surveyor has a specific time limit for conducting the surveying on a large and detailed area.

But there are also some limitations to compass surveying. It is not recommended for the areas that are avoiding public attention and have the presence of iron ore deposits, magnetic substances like metallic or steel structures, electric cables conveying current, etc.

**Errors in Compass Surveying**

Measurements of angles and distances are made in various surveying operations. It is impossible to determine the true values of these quantities because some type of errors always creep in every measurement. The errors occur due to imperfection in instruments, due to human limitations, due to environmental changes or due to carelessness. As quality surveyors, our aim should be to minimise these errors while taking observations. Still, the errors which creep in should be eliminated, or their effects should be corrected.

Errors can arise due to various reasons stated above during the process of surveying are classified as:

- Instrumental errors
- Personal errors
- Natural errors

**Instrumental Errors**

- Instrumental errors arise due to wrong adjustments of the instruments.
- If the line of sight is not proper, there will be faults in sighting and reading.
- If the magnetic needle is not properly straight, there will be faulty readings.

**Personal Errors:** Personal errors, as the name suggests, arise because of the carelessness of the surveyor. Carelessness here signifies;

- Incorrect setting
- Incorrect levelling
- Incorrect centering

**Natural Errors:** Natural errors are occurring due to the various natural causes which affect the working of the compass. It is not within the limit of the surveyor to minimise or eliminate them. They are:

- Local attraction
- Proximity to the magnetic storms
- Declination of needle

**Advantages of Compass Surveying**

- They are portable and lightweight.
- They have fewer settings to fix it on a station
- The error in direction produced in a single survey line does not affect other lines.
- It is suitable to retrace old surveys.
- No electric power is required for the operation of compass surveying.

**Disadvantages of Compass Surveying**

- It is less precise compared to other advanced methods of surveying.
- It is easily subjected to various errors such as errors adjoining to magnetic meridian, local attraction etc.
- Imperfect sighting of the ranging rods and inaccurate levelling also cause an error.

## c) PLANE TABLE SURVEYING

**Principle:-**

The principle of plane tabling is parallelism, meaning that the rays drawn from stations to objectson the paper are parallel to the lines from the stations to the objects on the ground. The relative positions of the objects on the ground are represented by their plotted positions on the paper and lie on the respective rays. The table is always placed at each of the successive stations parallel to the position it occupied at the starting station. Plane tabling is a graphical method of surveying there the field work and plotting are done simultaneously and such survey does not involve the use of a field book.

Plane table survey is mainly suitable for filling interior details when traversing is done by theodolite sometimes traversing by plane table may also be done. But this survey is recommended for the work where great accuracy is not required. As the fitting and fixing arrangement of this instrument is not perfect, most accurate work cannot be expected.

**Accessories of Plane Table:-**

**1. The Plane Table:-**

The plane table is a drawing board of size 750 mm x 600 mm made of well seasoned wood like teak, pine etc. The top surface of the table is well leveled. The bottom surface consists of a threaded circular plate for fixing the table on the tripod stand by a wing nut.

The plane table is meant for fixing a drawing sheet over it. The positions of the objects are located on this sheet by drawing rays and plotting to any suitable scale.

**2. The Alidade:-**

There are two types of alidade.

i) Plain

ii)Telescopic.

**(a) Plain Alidade:-**

The plain alidade consists of a metal or wooden ruler of length about 50 cm. One of its edge is beveled and is known as the fiducial edge. It consists of two vanes at both ends which are hingedwith the ruler. One is known as the ‘object vane’ and carries a horse hair, the other is called the ‘sight vane’ and is provided with a narrow slit.

**(b) Telescopic Alidade:-**

The telescopic alidade consists of a telescope meant for inclined sight or sighting distant objects clearly. This alidade has no vanes at the ends, but is provided with fiducial edge. The function of the alidade is to sight objects. The rays should be drawn along the fiducial ends.

**3. The Spirit Level:-**

The spirit level is a small metal tube containing a small bubble of spirit. The bubble is visible on the top along a graduated glass tube. The spirit level is meant for leveling the plane table.

**4. The Compass:-**

There are two kinds of compass.

(a) The trough compass and
(b) The circular box compass.
(a) The Trough Compass

The trough compass is a rectangular box made of non-magnetic metal containing a magnetic needle pivoted at the centre. This compass consists of a 'D' mark at both ends to locate the N-Sdirection.

**(b) The Circular Box Compass: -**

It carries a pivoted magnetic needle at the center. The circular box is fitted on a square base plate sometimes two bubble tubes are fixed at right angles to each other on the base plate. The compass is meant for marking the north direction of the map.

**5. U-fork or plumbing fork with plumb bob:-**

The U-fork is a metal strip bent in the shape of a 'U' (hair pin) having equal arm lengths, the toparm is pointed and the bottom arm carried a hook for suspending a plumb bob. This is meant forcentering the table over a station.

**Methods of Plane Table Surveying**

Four classes of plane tabling surveys are recognized:

- Radiation method
- Intersection method
- Traversing method,
- Resection method.

**Advantages and Disadvantages of Plane Table Surveying:**

Following are some of the significant advantages and disadvantages of plane table surveying.

Advantages of Plane Table Survey:

(1) Map of the area is plotted in the field, i.e., both the field work and the plotting are done simultaneously.
(2) Field notes of the measurements are not required, and thus the errors in booking are eliminated.
(3) The correctness of plotted work can be checked by check observations in the field.
(4) Office work is only finishing up of the drawing.
(5) Direct measurements of lines and angles are avoided as they are obtained graphically.
(6) Errors due to extended angular observations with angular instruments and incorrect plotting with bad protractors are avoided.

(7) This is suitable in a magnetic area where you cannot rely on the compass survey.

(8) More work will be done in less time and labour.
(9) It is less costly than a theodolite survey.
(10) It is most suitable for preparing small-scale maps.
(11) Contours and irregular objects may be represented accurately.
(12) The reduced levels of points other than the station points of known elevations may be found out with the help of a tangent clinometer.
(13) The survey can be completed very rapidly.
(14) Much skill is not required to prepare a map.
(15) The danger of omitting the necessary measurement is eliminated as the survey is plotted in the field.

**Disadvantages of plane table survey:**

(1) Plane tabling is not suitable for work in wet climates, in places where high winds predominate, and in wooded country.
(2) If the area to be surveyed is large, frequent changes in the size of drawing sheets are required.
(3) Due to changes in temperature, the table is liable to warp.
(4) If the sun is bright, plotting may be difficult due to the strain on the eyes.
(5) It is not very accurate for large-scale surveys as compared to compass and theodolite surveys.
(6) The instruments and its accessories are heavy and cumber-some, and they are likely to be lost.
(7) Since the field notes are not maintained, it is inconvenient to calculate the quantities or re-plot the survey to a different scale if required.
(8) Although the plane table is advantageous in open country, it is inferior to the compass in the thickly wooded lands.
(9) The plane tabling is not intended for accurate work

## 1.4. MEASUREMENT OF DISTANCE

### 1.4.1. Various types of tapes

MEASURING TAPE: Tape is an instrument which is used for horizontal measurement of the land area. Due to proper graduation and easy handling tape provide better and accurate result than chain. Tapes are graduated in millimeters, centimeters, feet and meters. It is available in different lengths that are 5 m, 10 m, 15 m, 25 m, 50 m and 100 m. There are four types of tape available:

- Cloth tape or linen tape
- Metallic tape
- Steel tape
- Invar tape

1. **Cloth tape or linen tape:** - This tape is consists of varnished strip of woven linen of about 12 to 15 mm wide. This tape is available in the lengths of 10 m, 20 m, and 30 m. The measurement taken by this tape does not provide high degree of accuracy. This tape is packed in circular leather case when it is not in use. The one end of tape has a brass ring whose length is also included in the length of the tape.

During use when the tape strip get wet and dirty, it should not be rolled in leather case until it get cleaned and dried. Do not make the continuous exposure tomoisture. It requires two people for operation. One person uses to hold the leather case and other hold the end of tape tightly. The tape strip should not be loose during measurement otherwise it may give wrong result. It should not be much stretched also

otherwise the strength of strip may get reduced.

**2. Metallic tape: -**

A strip of water proof linen inter-woven with small brass, copper or bronze wires and does not stretch as easily as a cloth tape. Due to this reason, it is used for some accuracy of work. Metallic tapes are made in length of 2, 5, 10, 20, 25, 30 and 50 m.


3. **Steel tape: -** Steel tapes vary in quality and accuracy of graduation, but even a poor steel tape is generally superior to a cloth or metallic tape for most of the linearmeasurements that are made in surveying. A steel tape consists of a light strip of width 6 to 10 mm and is more accurately graduated. Steel tapes are available in lengths of 1, 2, 10, 20, 30 and 50 m.

**4. Invar tape: -** Invar tapes a linear measurement of a very high degree of precision, such as measurement of base lines. The invar tape is made of alloy of nickel and steel, and has very low co-efficient of thermal expansion. Invar tapes and bands are more expensive. Invar tapes are normally 6 mm wide and are available in lengths of 20, 30 and 100 m.

### 1.4.2. Laser Distance Meter:

A laser distance meter, also known as a laser rangefinder, is a device used to measure distance accurately using a laser beam. It operates on the principle of emitting a laser pulse towards a target and then measuring the time it takes for the pulse to reflect off the target and return to the device. By calculating the time taken and the speed of light, it determines the distance between the device and the target.

These devices come in various shapes and sizes, from handheld units for smaller measurements to more advanced and precise ones used in construction, surveying, and industrial applications. They are highly accurate, efficient, and offer quick measurements, making them valuable tools in fields where precise distance measurements are crucial. Some laser distance meters also come with additional features like area or volume calculations, Bluetooth connectivity, and data storage capabilities.

**Basic Principles**: A Laser Distance Meter sends out a finely focused pulse of light to the target and detects the reflection. The meter measures the time between those two events and converts this to a distance. The formula is simple: Distance = A (Speed x Time). However the speed of light is 300,000 kms. per second , so to resolve differences of (say) 1 cm, the meter must measure time intervals of the order of billionths of a second. Advantages: A Laser Distance Meter is accurate to within a few

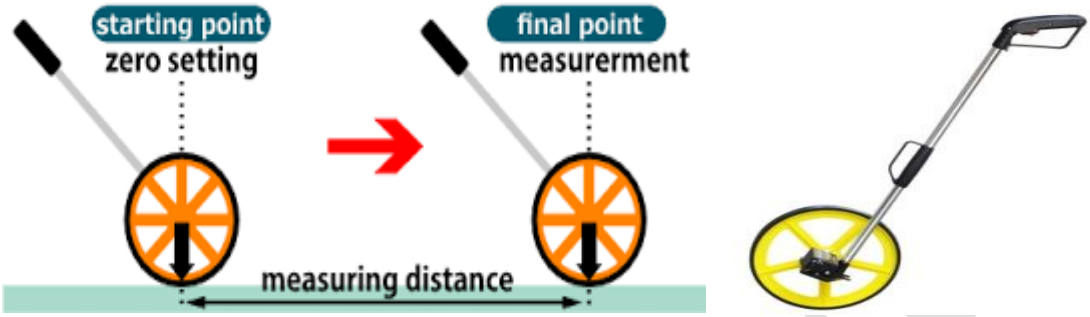
millimeters, certainly equaling a tape for larger distances, and the line is always dead straight. One has a choice of units, and there is no risk of misreading, as with the intermediate marks on a tape. The Laser distance Meter is much faster; just it should be pointed to the target, clicked and the result will be displayed. The job is done is done in just a fraction of the time it would take to use a tape.

Conclusions: A Laser Distance Meter is accurate and quick and requires only one person and one hand. It's easy to use and versatile. Laser distance Meters have on-board processing enabling the device to triangulate and calculate – the Pythagoras principle is laid in it.


**1.4.3. DISTANCE MEASURING WHEEL**: A distance measuring wheel, also known as a surveyor's wheel or a click wheel, is a hand-held device used to measure distances by rolling along the ground. It consists of a wheel attached to a handle or frame and typically features a counter to display the measured distance.

Here's how it works: When you roll the wheel along a surface, the wheel's circumference is known. The rotation of the wheel is translated into distance measurements by a mechanical or digital counter connected to the axle. As the wheel turns, it records the number of rotations, and this data is converted into distance based on the wheel's circumference.

Distance measuring wheels are commonly used in various industries like construction, landscaping, road surveying, and athletics, where quick and straightforward measurements of longer distances are required. They are often preferred for outdoor measurements where using a tape measure might be impractical or inefficient.




## 1.4.4. GLOBAL POSITIONING SYSTEM (GPS)

The global positioning system (GPS) is a network of satellites and receiving devices used to determine the location of something on Earth. Some GPS receivers are so accurate they can establish their location within 1 centimetre (0.4 inches). GPS receivers provide location in latitude, longitude, and altitude.

There are five main uses of GPS:

Location — Determining a position.

Navigation — Getting from one location to another.

Tracking — Monitoring object or personal movement.

Mapping — Creating maps of the world.

Timing — Making it possible to take precise time measurements.

Today, GPS is used to map forests, help farmers harvest their fields and airplane pilots navigate on the ground or in the air. Positioning systems are integral to military applications and for emergency crews to locate people in need of assistance.

## 1.4.5. ELECTRONIC DISTANCE MEASUREMENT:

Electronic Distance Measurement (EDM) is a technique used to measure distances between two points using electromagnetic waves or light. It's commonly employed in surveying, construction, and various engineering applications. EDM instruments use different technologies such as laser, microwave, or infrared waves to determine distances accurately.

Laser-based EDM devices emit laser beams and measure the time it takes for the beam to travel to a target and return. This time measurement, combined with the speed of light, helps calculate the distance accurately. Similarly, microwave and infrared EDM devices use their respective wavelengths to determine distances.

These instruments are highly precise and can measure distances over various ranges, from a few meters to several kilometres, depending on the specific device and technology used. They are crucial in tasks requiring accurate measurements, such as land surveying, construction layout, and civil engineering projects.

## IMPORTANT QUESTIONS

**1.** Define surveying. Explain the basic principles of surveying with neat sketches.

2. Differentiate between Plane and Geodetic Surveying.

3. What are the advantages and disadvantages of plane table surveying?

4. Write a short note on different types of Surveying. a) Cadastral Survey b) Topographical Survey

5.Distinguish between Whole circle bearing and Quadrantal Bearing

6. Differentiate between Prismatic compass and Surveyors Compass

7. List and explain different types of chains and tapes used in surveying

8. Write a short note on EDM and GPS

9. What are the advantages and disadvantages of Compass surveying?