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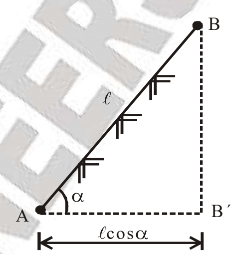
# CONTENTS

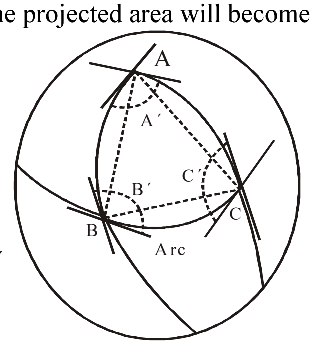
# CHAPTER - 1
# *FUNDAMENTALS OF SURVEYING*

## 1.1 INTRODUCTION
1. Surveying may be defined as the method of making measurements of the relative positions of, natural and man-made features on earth’s surface and the presentation of this information either graphically or numerically.
2. The commonest methods of presentation are by means of a Plan or Map.
3. Both Plans and Maps are the graphical representation of the features on a horizontal plane.
4. Plan is a large scale representation whereas Map is a small scale representation.
5. Height information can be added either as spot heights, which are individual heights of points, or as contours which give a less detailed but better visual representation of the area.

## 1.2 PLANE AND GEODETIC SURVEYING
1. Surveying is divided primarily into Geodetic surveying & Plane surveying.
2. In Geodetic surveying, large areas of earth's surface are involved and the curvature of earth is taken into account.
3. In Plane surveying, relatively small areas are under consideration, and it is assumed that the earth's surface is flat.
4. In Plane surveying, measurements plotted will represent the projection on the horizontal plane of the actual field measurements.

**Example.** AB is plotted as AB
(i) A horizontal plane is normal to the direction of gravity (as defined by a **Plumb bob** at that point).
(ii) However, such a plane will infect be tangential to the earth's surface at that point.
Thus, if a large area is considered, the deseripency will become apparent between the area of the horizontal plane and the actual curved area of the earth's surface.
(iii) In the above figure if actual area is ABC, the projected area will become A’B’C’.



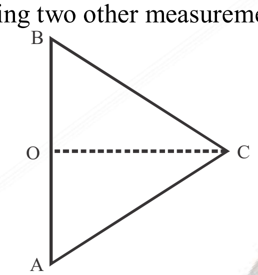




That Arc AC will be projected as Chord A’C’ represented by dotted line. If Arc AB = 18.5 km then Chord A’B’ will be 1.52 cm shorter than Arc Ab.

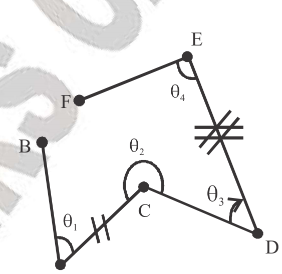
# CHAPTER - 2
# *COMPASS SURVEYING*

## 2.1 INTRODUCTION

From the fundamental principle of surveying we know that on any area of land to he surveyed, it is always possible to choose two points and to measure distance between them. Other points can be located relative to the 1st line by taking two other measurements.




1. The line AB is called **base line** and all measurements are taken from this line.
2. In chain surveying point 'C' was located by taking only distance measurements.
3. However in compass surveying point 'C' is located by taking measurement of angle between BA and AC and measurement of length AC or angle-between AB & BC, BA & AC.
4. When the whole area to be surveyed cannot be seen from this one line, additional lines have to be defined relative to the 1st, using again two measurements. The points of the junctions of these lines are called **Control Points**, and together with the lines they constitute a framework or control. This method of establishing the control points is called control surveying.
5. In chain surveying the control network consisted of series of triangles of survey lines.
6. In compass surveying points C, D, E, F are established by measuring lengths AC, CD, DE, EF etc & angles $\theta_1$, $\theta_2$, $\theta_3$, $\theta_4$ etc.




7. This method of establishing points C, D, E, F etc successively by taking linear & angular measurements is called traversing.
8. Where lines AB, BC, CD, DE. EF etc are called traverse lines.
9. In traverse surveying the frame work consists of a series of connected lines forming an open or closed polygon. Accordingly, the traverse is called open traverse or closed traverse.

### 2.1.1 Closed Traverse

1. A closed traverse starts from a station and closes either on the same station or another station whose location is already known.
2. As shown below figure (a), the traverse starts from the station A and closes on the same station. It forms a closed polygon. This type of closed traverse is called as a loop traverse.

# CHAPTER - 3
# *THEODOLITE*

## 3.1 INTRODUCTION
1. A theodolite is an important instrument used for measuring horizontal and vertical angles in surveying.
2. It can also be used for a number of surveying operations, such as prolonging a line, measuring distances indirectly and levelling.

## 3.2 CLASSIFICATION
Theodolites can be classified into transit and non-transit theodolites.

### 3.2.1 Transit Theodolite
A theodolite is said to be a transit one when its telescope can he rotated through 1SO$^{Q}$ in a vertical plane about its horizontal axis. Thus, directing the telescope in exactly opposite direction.

### 3.2.2 Non-Transit Theodolite
A theodolite is said to be a non-transit one when its telescope cannot be rotated through 180° in a vertical plane about its horizontal axis. Such theodolites are obsolete nowadays

## 3.3 TYPES OF THEODOLITE
Theodolites can also be classified into two types as follows:

**1. Vernier Theodolites**

In vernier theodolites, verniers are used for taking the readings. These theodolites are most commonly used in general work. Most of the vernier theodolites can read angles up to 20". (i.e., the least count of theodolite is 20")

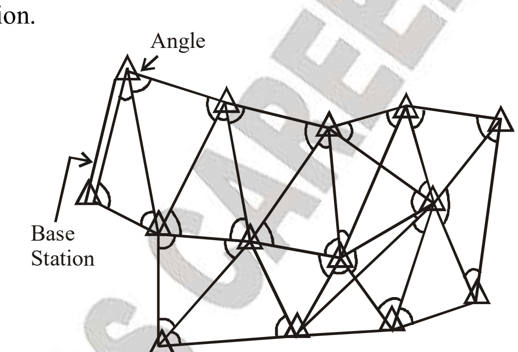
**2. Precise Optical Theodolites**

Precise optical theodolite is fitted with an optical system which is used to read both horizontal and vertical angles precisely. These Theodolites are having a micrometer for taking readings and are also called as Microptic Theodolites.
These theodolites are used for precise work. Most of these theodolites can read angles up to 1 or less. The size of a theodolite is defined by the size its lower graduated circle. For example a 20 cm theodolite means the diameter of the graduated circle of the lower plate is 2(1 cm. Generally the size of the theodolites varies from 8 to 25 cm.

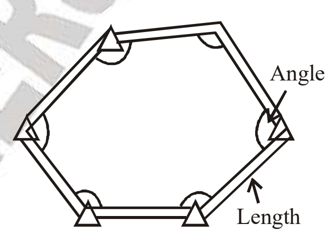
# CHAPTER - 4
## *TRAVERSING*

### 4.1 INTRODUCTION
A traverse is a series of connected lines whose length and direction are measured in field. The field work in a theodolite traverse consists of
1. Reconnaissance,
2. Selection and marking of stations
3. Measurement of traverse lines
4. Angular measurements
5. Picking up the details

(i)A theodolite traverse is commonly used for providing a horizontal control system to determine the relative positions of the various points on the surface of the earth.
(ii)Earlier when sophisticated distance measurement instruments were not available, we relied on triangulation. (A method where one base line was measured and all angles-are measured to find out lengths of other lines).
(iii)However with the advent of Electronic Distance Measurement Instruments (EDMI), traversing is fast replacing triangulation.



Triangulation



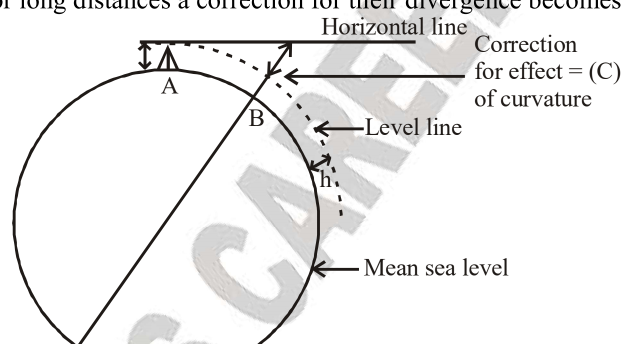
Traversing

Traverses are classified as
(a) Closed traverse
(b) Opened traverse
(Already discussed in chapter of compass surveying)

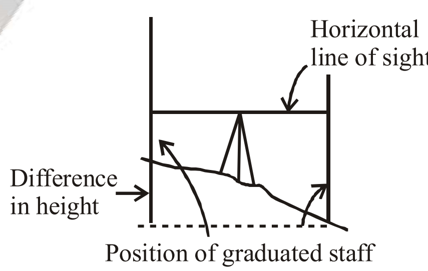
# CHAPTER - 5
# *LEVELLING*

## 5.1 INTRODUCTION

1. Levelling is the operation required in the determination or, more strictly, the comparison of heights of points on the surface of the earth.
2. If a whole series of heights is given relative to a plane, this plane is called a datum, and in topographical work the datum used is the mean level of the sea, because it makes international comparison of heights possible.
3. The value for mean sea level (m.s.l.) as datum is obtained by averaging the elevations of high and low tides, at several points, for a long period of time, about 19 years.
4. The vertical heights of points above or below a datum are referred to as levels.
5. A level line is one that is at a constant height relative to mean sea level, and because it follows the mean surface of the earth it must be a curved line.
6. A horizontal line is tangential to the level line at any particular point, because it is perpendicular to the direction of gravity at that point. For short distances these two hues considered to coincide with each other; but for long distances a correction for their divergence becomes necessary.




7. Thus although point A & B are both at mean sea level in the previous figure due to curvature of level line (curvature of earth), it will be misconstruced that point B is below mean sea level. Thus it is clear that why correction is required for the effect of curvature.
8. The difference in the readings on the vertically held graduated staff where it is intersected by the horizontal line of sight is a direct measure of the difference in height between the two staff stations.

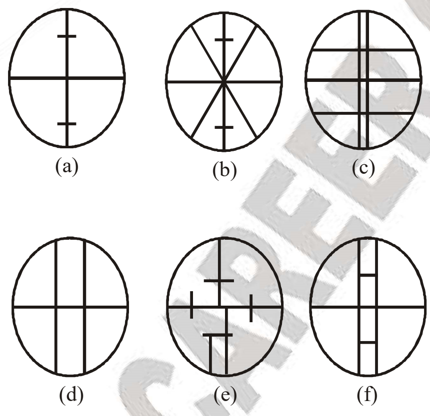



9. **Elevation:** It is the vertical distance of the point above or below the datum surface. It should be noted that the vertical distances are measured along the direction of gravity.

# CHAPTER - 6
# *TACHEOMETRY*

## 6.1 INTRODUCTION
1. Tacheometry is defined as an optical distance measurement method. The other names given to Tacheometry are Tachymetry of Telemetry.
2. As compared to chaining on flat grounds, the accuracy of tacheometric distance is low, but on rough and steep grounds the accuracy is more.

## 6.2 TACHEOMETER
It is a transit theodolite fitted with stadia diaphragm. The stadia diaphragm consists of two stadia hairs at equal distances, one above and the other below the horizontal hair of the cross.




Stadia diaphragms

### 6.2.1 Important Characteristics of Tacheometer
1. Value of the multiplying constant, k = 100.
2. Value of the additive constant, C = 0.
3. Telescope should be fitted with an anallactic lens.
4. Magnification power of the eyepiece is kept high.

### 6.2.2 Stadia Rod
1. It is also called as vertical slave.
2. It is a 5-15 m long rod, graduated in decimals of metre.
3. For small distances up to 100 m. an ordinary leveling staff may be used but beyond this a stadia rod is used, since the graduations of an ordinary levelling staff become indistinct.
4. The staff can be held either vertical or normal to the

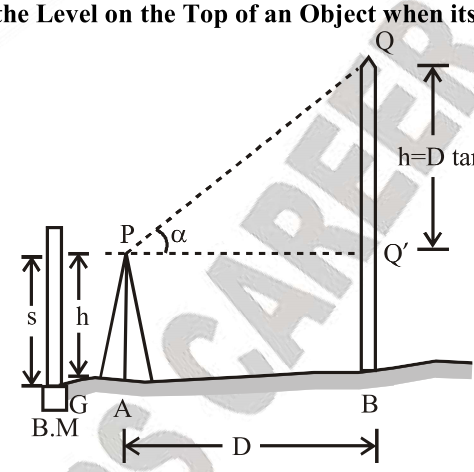
The staff is held normal to the line of sight can be judged when staff in intercept is minimum.

# CHAPTER - 7
## *TRIGONOMETRIC LEVELLING*

### 7.1 INTRODUCTION

1. Trigonometric levelling is m indirect method of levelling in which the relative elevations of various points are determined from the vertical angles and horizontal distances measured with a thedolite and a tape respectively.
2. The height of a point above the plane of collimation is determined from the horizontal distance of the point from the instrument station and the vertical angle.
3. Trigonometric levelling is not as accurate as direct levelling. It is generally used in topographic work and in areas where direct levelling is difficult. The use of tacheometers has made trigonometric levelling easy, as the horizontal distances are also calculated indirectly from the observations made, and, therefore, these need not be measured in the field.

#### 7.1.1 Determination of the Level on the Top of an Object when its Base is accessible




1.Let the base B of the chimney is accessible, and the horizontal distance D between the instrument station A and the base B can be measured using a tape. Let Q be the top of chimney whose elevation is to be calculated. Let G be the bench mark (B.M.)
2.Set up the theodolite over A. Take a backsight on the B.M. and determine the height of instrument
3.R.L. of the line of collimation R.L. of B.M. + s where s is the reading on the staff.
4.If the line of collimation intersects the chimney at Q′, the distance PQ' is same as the horizontal distance D.
5.Sight the top Q of the chimney, and measure the angle of elevation α. In the triangle PQQ′,
$QQ' = D \tan\alpha$
$\therefore$ R.L. of the top of the chimney = R.L. of B.M. + s + D tanα

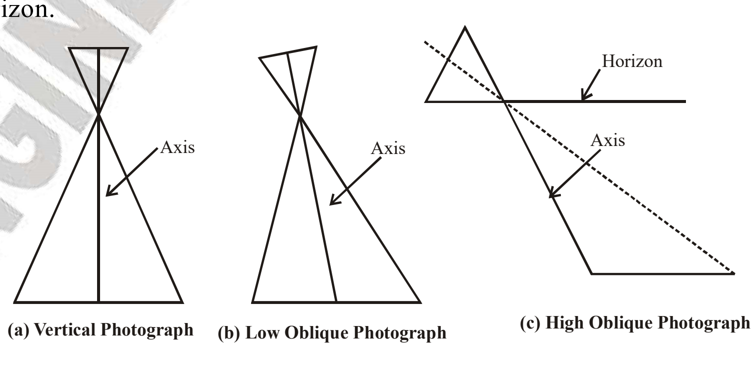
# CHAPTER - 8
# *PHOTOGRAMMETRY*

## 8.1 INTRODUCTION
1. Photogrammetry is the science of obtaining information about physical objects through process of recording, measuring and interpreting of photographs of the area.
2. Aerial photogrammetry is the branch of photogrammetry in which photographs of the area are taken with a camera mounted on an aircraft.
3. Terrestrial photogrammetry is the branch of the photogrammetry in which photographs are taken with a camera fixed on or near the ground. It is also called as Ground Photogrammetry.
4. In Terrestrial photogrammetry the instrument used is a photo-theodolite, a combination of a photographic camera fitted on a tripod with its axis horizontal and a theodolite.
5. Use of terrestrial photogrammetry is limited to the plotting of special features eg. vertical cliff, mountaineous terrain etc. However, aerial photograph is used for topographical surveys, preliminary route surveys, i.e. highways, railways pipelines, etc., forest and agricultural surveys.
6. The main advantages of aerial photogrammetry are the speed with which an area is covered, the ease with which topography of inaccessible areas can be detailed, there is no possibility of omitting any field data, and the tremendous amount of details shown.

## 8.2 TYPES OF PHOTOGRAPHS
Aerial photographs are classified into two types:
1. Vertical photographs
2. Oblique photographs

### 8.2.1 Vertical Photographs
1. Vertical photographs are taken when the camera axis is vertical i.e. it coincides with line of the gravity of camera.
2. When the camera axis is perfectly vertical, the photo plane is parallel to the datum plane and the resulting photograph is truly vertical photograph. When the camera axis is tilted slightly from vertical, the resulting photograph is known as tilted photograph. The tilt is generally less than $1^o$ and rarely exceeds $3^o$. This tilt is unintentional.

### 8.2.2 Oblique Aerial Photographs
1. Oblique aerial photographs are taken with a camera axis considerably inclined to the vertical. The camera axis is intentionally kept oblique from the vertical.
2. A low oblique photographs does not include the horizon. Whereas a high oblique photograph includes the horizon.



**(a) Vertical Photograph** **(b) Low Oblique Photograph** **(c) High Oblique Photograph**

# CHAPTER - 9
# *CURVES*

## 9.1 INTRODUCTION

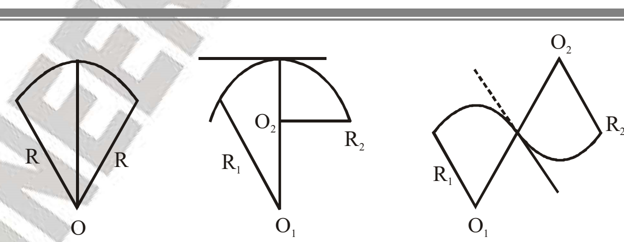
1. The initial design of the curved (i.e. a route) is generally based on a series of connected straight lines. In the final design, a curve is provided at the intersection of the straight lines to provide a gradual change in the direction.
2. A horizontal curve is provided at the point where the two straight lines intersect, in the horizontal plane. Generally the horizontal curves provided are circular in nature.
3. A vertical curve is provided at the point where the two straight lines at different gradients intersect in the vertical plane. The vertical curve provides a smooth change in the gradients. Generally the vertical curves provided are generally parabolic in nature.

### 9.1.1 Types of Horizontal Curves

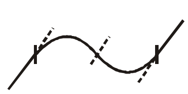
Horizontal Curves are of three types:
1. Simple circular curve
2. Compound curve
3. Reverse curve

***1. Simple Circular Curve:*** It consists of a arc of the-circle. This curve is tangential to two straight lines of the route.
***2.Compound Curve:*** It consists of two circular arcs of different radii with their centres of curvature on the same side of the common tangent.
***3.Reverse Curve:*** It consists of two circular arcs (either of same or different radii) with their centre's of curvature on the opposite side of the common tangent.
(a) Reverse curve are provided on the routes when the two straight lines are parallel or when angle between them is very small, for example hilly roads.

| |
|---|
| Compound and reverse curves are provide for low speed, roods and railways. |



Simple circular curve (Plan) | Compound curve (Plan) | Reverse Curve (Plan)



# CHAPTER - 10
# *CONTOURING*

## 10.1 INTRODUCTION
The relative position of points in a plane is represented by a map. The value of the map is even more if the relief (variation in the elevation of earth's surface) is also included along with their relative positions.
There are two methods by which the conformation of the ground may be presented on a map.
1. By delineating the surface slopes by shading, intended to given an impression of relative relief. The relative elevations of the points are not indicated in this case.
2. By plotting the contour lines (imaginary line passing through points of equal elevations) on maps. These lines are arranged such that the form of the earth's surface can be portrayed with greater accuracy and thoroughness, and can be readily be interpreted.
Contours are used by engineers in a many ways.

## 10.2 USE OF CONTOURS
1. Proper and precise location of engineering works such as roads, canals, etc.
2. In location of water supply, water distribution and to solve the problems of steam pollution.
3. In planning and designing of dams, reservoirs, aqueducts, transmission lines, etc.
4. In selection of sites for new industrial plants.
5. Determining the intervisibility of stations.
6. Determining the profile of the country along any direction.
7. To estimate the quantity of cutting, filling, and the capacity of reservoirs.

## 10.3 DEFINITION OF CONTOUR
A contour may be defined as an imaginary line passing through points of equal elevation on the earth surface.
A contour line may also be defined as the intersection of a level surface with the surface of the earth.
Contour lines on a plan illustrate the topography of the ground.
When the contours are drawn underwater, they are termed as submarine contours, fathoms. Or bathymetric curves.

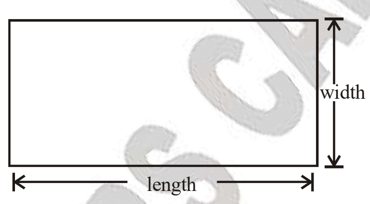
# CHAPTER - 11
## *AREA AND VOLUME*

### 11.1 INTRODUCTION
One of the objectives of many of the survey is to obtain quantities such as areas and volumes.

#### 11.1.1 Measurement of Area
The method selected for computation of area depends upon the shape of the tract and the accuracy desired. Foremost reasons for making land surveys for the determination of area.
Prevalent methods of measurement of area are:
1. By Field Measurements
2. By Plan Measurements
(i) If the plan is enclosed by straight lines, it can be divided into geometrical figures e.g. Triangle, Rectangle, Square etc. The area of these figures can be determined by using appropriate formulas.
(ii) But, if the boundaries are irregular, then approximate methods are being used.

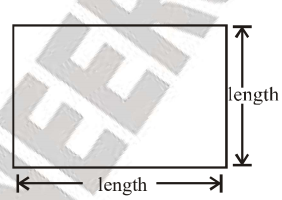
> Plainmeter is used to determine area of irregular shape.

#### 11.1.2 Computation of Area of Geometrical Figures
***1. Rectangle***



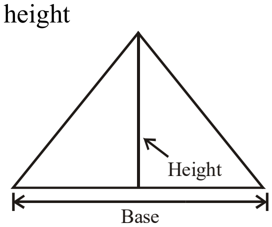

A = length × width

***2. Square***




A = length × length

***3. Triangle***
A = base × half of the perpendicular height




***4. Parallelogram***

# CHAPTER - 12
## *THEORY OF ERROR*

**12.1 INTRODUCTION**
1.Measurements of angles and distances are made in various surveying operations.
2.It is impossible to determine the true values of these quantities because some type of errors always creep in every measurement.
3.The errors occur due to imperfection in instruments, due to human limitations, due to environmental changes or due to carelessness
4.As a quality surveyor our aim should be to minimize these errors while taking observation.
5.Still the errors which creep in should be eliminated or their effects should be corrected.

**12.2 TYPES OF ERRORS**
The errors can be classified into three types:
1. Gross errors or mistakes
2. Systematic or cumulative errors
3. Accidental or random errors

**1. Gross Errors (Mistakes)**
Mistakes occur due to inexperience or carelessness of the surveyor. Mistakes are quite random both is occurrence and magnitude but by careful work and by adopting standard procedures and methods, these mistakes can be avoided.

**2. Systematic Errors**
The systematic errors always follow some pattern which may be some mathematical or physical law.
(i)The systematic errors are of same magnitude and nature in the identical conditions.
(ii)The systematic errors can be computed and suitable corrections applied.
(iii)For example, the error in the length of the steel tape due to change in temperature is a systematic error.
(iv)Surveying instruments should be so designed and used that, systematic errors are automatically eliminated.
(v)For example, most of the systematic errors in measurement of angles with a thodolite can be eliminated by taking both the face readings.
(vi)The systematic errors which cannot be eliminated must be evaluated and a suitable correction should be applied, as in the case of the error due to temperature changes in the measurement of a distance with a steel tape.
(vii)Systematic errors are also called as cumulative errors.

**3. Accidental (or Random) Errors**
(i) Accidental errors occur due to lack of perfection in human eye.
(ii) For example, while measuring a distance with a steel tape marked in centimeters, if one has to estimate the distance in millimeters, he might estimate a distance of 5 mm as 6 mm or 4 mm because the eye cannot judge the exact division.
(iii)The accidental errors tend to cancel out each other when a large number of such measurements are made because there is as much change of their being positive as being negative.

# CHAPTER - 13
# *PLANE TABLE*

## 13.1 INTRODUCTION
1.The plane table is an instrument used for surveying by a graphical method in which the field work and plotting are done simultaneously.
2.The main feature of plane tabling is that the topographic features to be mapped are in full view. Hence no chance of missing of any important detail.
3.It is suitable for small and medium scale- mapping (1 : 10,000 to 1: 2, 50,000). Where the great accuracy is not required. It is also used for plotting the topographical maps in the field.
4.Before commencing a plane table survey, the instrument stations are fixed to cover the entire area.
5.These stations may be fixed by surveying a trigonometrical framework, establishing a network of control points on a pattern to suit the scale at which plane tabling is carried out.
6.The elevations of these points are determined with the help of leveling.
7.A surveyor starts filling in details from any of these control points, one by one, and traverses all the control points.
8.The finished maps so produced are known as topographic maps.
9.This graphical method of producing topographic maps is known as cartographic surveying.
10.It should be noted that all the measurements made are plotted directly on the drawing sheet instead of recording in the field book.
11.The principle used in plane table surveying is that an unknown point of interest can be established by measuring its directions from known points.

### 13.1.1 Advantages
1. The sighting and plotting are done simultaneously. Therefore, there is no risk of omitting necessary details.
2. The error and mistakes in plotting can be checked by drawing the check lines.
3. Irregular objects can also be plotted accurately as the lay of land is in view.
4. It is most rapid and useful for filling in details.
5. No great skill is required.
6. It is very advantageous in areas, where compass survey is not reliable e.g. area affected by magnetic fields.

### 13.1.2 Disadvantages
1. It is not suitable for, work in a wet climate and in a densely wooded country.
2. The absence of measurements (field notes) causes inconvenience, if the survey is to be replotted to some different scale.
3. Plane table is heavy and akward to carry and the accessories are likely to be lost.
4. It does not give very accurate results.

## 13.2 ALIDADE
An alidade is a straight-edge ruler having some sighting device, it is used for sighting the objects and drawing the lines.
Plain Alidade it is a straight-edge ruler about 450 mm long, made of a metal or wood. One of the edges is beveled and graduated. The alidade is provided with a sight vane at each end. The sight vanes have hinges at the lower end so that they can be folded down on the ruler when not in use.

# CHAPTER - 14

# *ENGINEERING INSTRUMENTS*

## 14.1 HAND LEVEL

1.A hand level is a small leveling instrument which is held in hand while leveling.
2.It is used for approximate determination of elevations in reconnaissance, preliminary, surveying for locating contours on the ground, and for taking short cross-sections in profile levelling.

## 14.2 ABNEY LEVEL

1. An Abney level is an improved version of the hand level. It can be used as a hand level for levelling, and as a clinometers for measuring slopes. It is a quite light and compact instrument.
2. The vertical scale is extended type

## 14.3 INDIAN PATTERN CLINOMETER

1. The Indian Pattern Clinometer, also called the tangent clinometers, is a simple instrument used for determining the difference of elevations of the two points by measuring the inclination of the line of sight.
2. It is specially useful for plane tabling.

## 14.4 CEYLON GHAT TRACER

1. The Ceylon ghat tracer is a simple instrument used for measuring the slopes.
2. It is specially useful for setting out a grade contour on a given gradient in the preliminary survey of a road in a hilly area.

## 14.5 SEXTANT

1. A sextant is an instrument used for measurement of the horizontal and vertical angles.
2. The distinguishing feature of a sextant is the arrangement of two mirrors which enables the observer to sight two different objects simultaneously.

There are two types of sextants
1. Nautical sextant and
2. Box sextant

### 14.5.1 Nautical Sextant

It has two glasses called Index glass and Horizon glass. If the angle of inclination between Index glass and Horizon glass is angle $\theta$ then angle between two sides objects in the ground will be $2\theta$.

#### *14.5.1.1 Used of Nautical Sextant*

1.The nautical sextant measures angle in the plane of the two objects and the telescope. It is unlike a theodolite (or a compass) which measures the angle in a horizontal plane. Therefore, the nautical sextant is a more versatile instrument.
2. An angle can be measured while the observer is on a ship or a boat.
3. It is specially useful for navigation and astronomical purposes.
4. The angle measured between the two objects at different elevations can be reduced to the horizontal angle, if required.