MODULE I

Introduction:

- Surveying is defined as "taking a general view of, by observation and measurement determining the boundaries, size, position, quantity, condition, value etc. of land, estates, building, farms mines etc. and finally presenting the survey data in a suitable form". This covers the work of the valuation surveyor, the quantity surveyor, the building surveyor, the mining surveyor and so forth, as well as the land surveyor.
- Another school of thought define surveying "as the act of making measurement of the relative position of natural and manmade features on earth's surface and the presentation of this information either graphically or numerically.

BASIC PRINCIPLES IN SURVEYING

PRINCIPLE OF WORKING FROM WHOLE TO PART

- It is a fundamental rule to always work from the whole to the part. This implies a precise control surveying as the first consideration followed by subsidiary detail surveying.
- This surveying principle involves laying down an overall system of stations whose positions are fixed to a fairly high degree of accuracy as control, and then the survey of details between the control points may be added on the frame by less elaborate methods.
- Once the overall size has been determined, the smaller areas can be surveyed in the knowledge that they must (and will if care is taken) put into the confines of the main overall frame.
- Errors which may inevitably arise are then contained within the framework of the control points and can be adjusted to it.

Classification on the Basis of Instruments Used.

Based on the instrument used; surveys can be classified into;

i) Chain tape surveys
ii) Compass surveys
iii) Plane table surveys
iv) Theodelite surveys

CHAIN SURVEYING

This is the simplest and oldest form of land surveying of an area using linear measurements only. It can be defined as the process of taking direct measurement, although not necessarily with a chain.

EQUIPMENTS USED IN CHAIN SURVEYING

These equipments can be divided into three, namely

(i) Those used for linear measurement. (Chain, steel band, linear tape)

(ii) Those used for slope angle measurement and for measuring right angle (Eg. Abney level, clinomater, cross staff, optical squares)

(iii) Other items (Ranging rods or poles, arrows, pegs etc).

1. **Chain:-**

The chain is usually made of steel wire, and consists of long links joined by shorter links. It is designed for hard usage, and is sufficiently accurate for measuring the chain lines and offsets of small surveys.
Chains are made up of links which measure 200mm from centre to centre of each middle connecting ring and surveying brass handless are fitted at each end. Tally markers made of plastic or brass are attached at every whole metre position or at each tenth link. To avoid confusion in reading, chains are marked similarly form both end (E.g. Tally for 2m and 18m is

the same) so that measurements may be commenced with either end of the chain
There are three different types of chains used in taking measurement namely:

i. Engineers chain

ii. Gunter's chain

2. Steel Bands:

This may be 30m, 50m or 100m long and 13mm wide. It has handles similar to those on the chain and is wound on a steel cross. It is more accurate but less robust than the chain. The operating tension and temperature for which it was graduated should be indicated on the band.

3 Tapes:

Tapes are used where greater accuracy of measurements are required, such as the setting out of buildings and roads. They are 15m or 30m long marked in metres, centimeter and millimeters. Tapes are classified into three types;

i. **Linen or Linen with steel wire woven into the fabric;**These tapes are liable to stretch in use and should be frequently tested for length. They should never be used on work for which great accuracy is required.

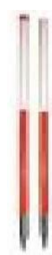
ii. **Fibre Glass Tapes:** These are much stronger than lines and will not stretch in use.

iii. **Steel tapes:** These are much more accurate, and are usually used for setting out buildings and structural steel works. Steel tapes are available in various lengths up to 100m (20m and 30m being the most common) encased in steel or plastic boxes with a recessed winding lever or mounted on open frames with a folding winding lever.

4 **Arrows:**Arrow consists of a piece of steel wire about 0.5m long, and are used for marking temporary stations. A piece of coloured cloth, white or red ribbon is usually attached or tied to the end of the arrow to be clearly seen on the field.

5 **Pegs**Pegs are made of wood 50mm x 50mm and some convenient length. They are used for points which are required to be permanently marked, such as intersection points of survey lines. Pegs are driven with a mallet and nails are set in the tops.

6 **Ranging Rod:**These are poles of circular section 2m, 2.5m or 3m long, painted with characteristic red and white bands which are usually 0.5m long and tipped with a pointed steel shoe to enable them to be driven into the ground. They are used in the measurement of lines with the tape, and for marking any points which need to be seen.



7 **Optical Square:**This instrument is used for setting out lines at right angle to main chain line. It is used where greater accuracy is required. There are two types of optical square, one using two mirrors and the other a prism.

a. The mirror method is constructed based on the fact that a ray of light is reflected from a mirror at the same angle as that at which it strikes the mirror.
b. The prism square method is a simplified form of optical square consisting of a single prism. It is used in the same way as the mirror square, but is rather more accurate.

8 Cross Staff: This consists of two pairs of vanes set at right angle to each other with a wide and narrow slit in each vane. The instrument is mounted upon a pole, so that when it is set up it is at normal eye level. It is also used for setting out lines at right angle to the main chain line.

GENERAL PROCEDURE IN MAKING A CHAIN SURVEY

1. ***Reconnaissance***: Walk over the area to be surveyed and note the general layout, the position of features and the shape of the area.
2. ***Choice of Stations:*** Decide upon the framework to be used and drive in the station pegs to mark the stations selected.
3. ***Station Marking:*** Station marks, where possible should be tied - in to a permanent objects so that they may be easily replaced if moved or easily found during the survey. In soft ground wooden pegs may be used while rails may be used on roads or hard surfaces.
4. ***Witnessing***: This consists of making a sketch of the immediate area around the station showing existing permanent features, the position of the stations and its description and designation. Measurements are then made from at least three surrounding features to the station point and recorded on the sketch.The aim of witnessing is to re-locate a station again at much later date even by others after a long interval.
5. ***Offsetting:-*** Offsets are usually taken perpendicular to chain lines in order to dodge obstacles on the chain line.
6. ***Sketching*** the layout on the last page of the chain book, together with the date and the name of the surveyor, the longest line of the survey is usually taken as the base line and is measured first.

ERRORS IN SURVEYING

- Surveying is a process that involves observations and measurements with a wide range of electronic, optical and mechanical equipment some of which are very sophisticated.
- Despite the best equipments and methods used, it is still impossible to take observations that are completely free of small variations caused by errors which must be guided against or their effects corrected.

TYPES OF ERRORS

1. **Gross Errors**

- These are referred to mistakes or blunders by either the surveyor or his assistants due to carelessness or incompetence.
- On construction sites, mistakes are frequently made by in – experienced Engineers or surveyors who are unfamiliar with the equipment and method they are using.
- These types of errors include miscounting the number of tapes length, wrong booking, sighting wrong target, measuring anticlockwise reading, turning instruments incorrectly, displacement of arrows or station marks etc.
- Gross errors can occur at any stage of survey when observing, booking, computing or plotting and they would have a damaging effect on the results if left uncorrected.
- Gross errors can be eliminated only by careful methods of observing booking and constantly checking both operations.

2. **Systematic or Cumulative Errors**

- These errors are cumulative in effect and are caused by badly adjusted instrument and the physical condition at the time of measurement must be considered in this respect. Expansion of steel, frequently changes in electromagnetic distance (EDM) measuring instrument, etc are just some of these errors.

- Systematic errors have the same magnitude and sign in a series of measurements that are repeated under the same condition, thus contributing negatively or positively to the reading hence, makes the readings shorter or longer.
- This type of error can be eliminated from a measurement using corrections (e.g. effect of tension and temperature on steel tape).
- Another method of removing systematic errors is to calibrate the observing equipment and quantify the error allowing corrections to be made to further observations.
- Observational procedures by re-measuring the quantity with an entirely different method using different instrument can also be used to eliminate the effect of systematic errors.

3. Random or Compensating Errors

- Although every precaution may be taken certain unavoidable errors always exist in any measurement caused usually by human limitation in reading/handling of instruments.
- Random errors cannot be removed from observation but methods can be adopted to ensure that they are kept within acceptable limits.
- In order to analyze random errors or variable, statistical principles must be used and in surveying their effects may be reduced by increasing the number of observations and finding their mean. It is therefore important to assume those random variables are normally distributed.

Corrections to Linear Measurement and their Application:-

The following corrections are to be applied to the linear measurements with a chain or a tape where such accuracy is required.

(i) Pull correction,

(ii) Temperature correction

(iii) Standard length correction

(iv) Sag correction

(v) Slope correction

(vi) Mean sea level correction.

Pull Correction :-

A chain or tape of nominal length 'L' having cross sectional area of the link or that of a tape, as the case may be, equal to A and standardized under a pull P_s is employed to measure a length at a pull P_F. If Young's modulus of elasticity of the material is E the extension of its length is = $\frac{(P_F - P_S)L}{AE}$

The recorded length is less than the actual by this extension. The error is here, -ve, the actual length is obtained by adding the extension to L. the correction is +ve. If P_F is less than P_S the error will be +ve and correction –ve.

Temperature Correction :-

A chain or a tape of nominal length 'L' standardized at temperature T_S and having cross sectional area A is employed to measured length at temperature T_F being the coefficient of linear expansion of the material of the chain or tape per unit rise of temperature ,– T_S)L. the extension = □(T_F

If T_F is more than T_S, recorded length is less than the actual by the amount of extension. The error is –ve and the correction to the length L is +ve by the amount of extension. If the field temperature T_F is less than T_S the error is =+ve and the corrections is –ve.

Sag Correction :-

In case of suspended measurement across a span L the chain or tape sag to take the form of curve known as catenary.

$$C_{Sa} = \frac{(w l_1)^2 l_1}{24 P^2} = \frac{W^2 l}{24 P^2}$$

Where w= weight of the tape per metre length

W= Total weight of the tape

P=pull applied (in N)

l_1 = The length of tape suspended between two supports

l = length of the tape = n l_1 (in m)

Sag correction is always negative.

COMPASS SURVEYING

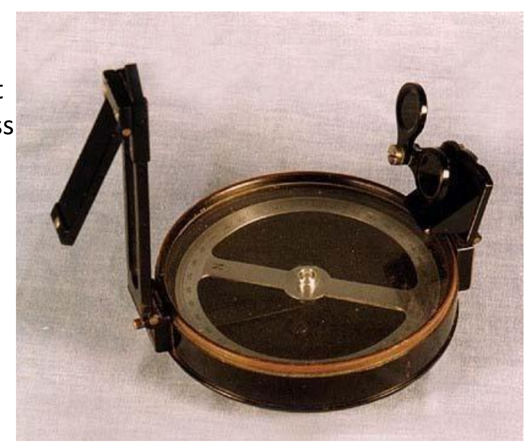
Introduction:

Another type of survey instrument that forms the subject of this section is the compass. Here, we will explain the meaning, types of compass survey and also introduce and discus the concept of bearing.

Objectives

- To introduce the students to the meaning and types of compass survey
- To enable students understand the concept of bearing.

THE PRISMATIC COMPASS



This is an instrument used for the measurement of magnetic bearings. It is small and portable usually carried on the hand. This Prismatic Compass is one of the two main kinds of magnetic compasses included in the collection for the purpose of measuring magnetic bearings, with the other being the Surveyor's Compass. The main difference between the two instruments is that the surveyor's compass is usually larger and more accurate instrument, and is generally used on a stand or tripod.

Temporary adjustment of prismatic compass

- The following procedure should be adopted after fixing the prismatic compass on the tripod for measuring the bearing of a line.
- **Centering :** Centering is the operation in which compass is kept exactly over the station from where the bearing is to be determined. The centering is checked by dropping a small pebble from the underside of the compass. If the pebble falls on the top of the peg then the centering is correct, if not then the centering is corrected by adjusting the legs of the tripod.
- **Leveling :** Leveling of the compass is done with the aim to freely swing the graduated circular ring of the prismatic compass. The ball and socket arrangement on the tripod will help to achieve a proper level of the compass. This can be checked by rolling round pencil on glass cover.

- **Focusing :** the prism is moved up or down in its slide till the graduations on the aluminum ring are seen clear, sharp and perfect focus. The position of the prism will depend upon the vision of the observer.

Magnetic Bearing
The magnetic bearing of a survey line is the angle between the direction of the line and the direction of the magnetic meridian at the beginning of the line.
Magnetic Meridian

- The magnetic meridian at any place is the direction obtained by observing the position of a freely supported magnetized needle when it comes to rest uninfluenced by local attracting forces.
- Magnetic meridians run roughly north –south and follow the varying trend of the earth's magnetic field. The direction of a magnetic meridian does not coincide with the true or geographical meridian which gives the direction of the true North pole except in certain places.

Angle of Declination:It is defined as the angle between the direction of the magnetic meridian and the true meridian at any point.

Bearing

The bearing is the angular direction measured clockwise starting from North with reference to the observer. The reference North may be true or magnetic. While the true bearing is the angular direction measured in a place with the direction of true or geographical north; the magnetic bearing is the angle which it makes with the direction of Magnetic North measured in the clockwise direction.

Error in compass survey (Local attraction & observational error):

- Local attraction is the influence that prevents magnetic needle pointing to magnetic north pole
- Unavoidable substance that affect are
    - Magnetic ore
    - Underground iron pipes
    - High voltage transmission line
    - Electric pole etc.
- Influence caused by avoidable magnetic substance doesn't come under local attraction such as instrument, watch wrist, key etc
- Detection of Local attraction
    - By observing the both bearings of line (F.B. & B.B.) and noting the difference (180^0 in case of W.C.B. & equal magnitude in case of R.B.)
    - We confirm the local attraction only if the difference is not due to observational errors.
- If detected, that has to be eliminated
    - Two methods of elimination
        - First method
        - Second method
- First method
    - Difference of B.B. & F.B. of each lines of traverse is checked to note if they differ by correctly or not.
    - The one having correct difference means that bearing measured in those stations are free from local attraction
    - Correction is accordingly applied to rest of station.
    - If none of the lines have correct difference between F.B. & B.B., the one with minimum error is balanced and repeat the similar procedure.
    - Diagram is good friend again to solve the numerical problem.
- Second method
    - Based on the fact that the interior angle measured on the affected station is right.
    - All the interior angles are measured
    - Check of interior angle – sum of interior angles = (2n-4) x right angle, where n is number of traverse side
    - Errors are distributed and bearing of lines are calculated with the corrected angles from the lines with unaffected station.

<u>MODULE II</u>

<u>LEVELLING</u>

Purpose of levelling: Levelling is the art of finding the relative heights and depths of the objects on the surface of the earth. It is that part of surveying which deals with the measurements in vertical plane. Levelling is of prime importance to an engineer for the purpose of planning, designing and executing various engineering projects such as roads, Railways, canals, dams, water supply and sanitary schemes etc. The Principle of leveling lies in furnishing a horizontal sight and finding the vertical distances of the points above this line. This is done with the help of a level and a levelling staff respectively.

Defination of terms used in levelling-concepts of level surface, Horizontal surface, Vertical surface, Datum, R.L, B.M.

Level Surface: This is a surface parallel to the mean spheroidal surface of the earth is said to be a level surface.The water surface of a still lake is also considered to be a level surface.

Horizontal Plane/surface: Any plane tangential to the level surface at any point is known as the horizontal plane.It is Perpendicular to the plumb line.

VerticalPlane/surface: Any plane passing through the vertical line is known as the vertical Plane.

Datum Surface or Line: This is an imaginary level surface or level line from which the vertical distances of different points(above or below this line) are measured. In India the datum adopted for the Great Trigonometrically Survey(GTS) is the mean sea level(MSL) at Karachi.

Reduced Level(R.L): The vertical distance of appoint above or below the datum line is known as the reduced level of that point.The Rl of a point may be positive or negative according as the point is above or below the datum.

Bench Mark: These are fixed points or marks of known RL determined with reference to the datum line. These are very important marks. They serve as reference points for finding the RL of new points or for conducting leveling operations in projects involving roads, Railways.

Bench mark are of four types.

(a)GTS (Great Trigonometric Survey)Bench mark: This Bench mark s are established by Survey of India at large intervals all over the country(Mumbai). The values of Reduced levels, the relevant positions and the number of benchmarks are given in a catalogue published by this department.

(b)Permanent Bench marks: These are fixed points or marks established by different Government Departments like PWD, Railway, Irrigation, etc..The R.L's of these points are determined with reference to the GTS bench mark., and kept on permanent points like the plinth of building, parapet of a bridge or culvert, and so on.

(c)Arbitrary Bench marks: When the RL's of some fixed points are assumed, they are termed arbitrary bench-mars. These are adopted in small survey operations, when only undulation of the ground surface is required to be determined.

(d)Temporary Bench marks: When the bench marks are established temporarily at the end of a day's work, they are said to be temporary bench marks. They are generally made on the root of a tree, the parapet of a nearby culvert, a furlong post, or on a similar place.

Temporary adjustment of level,taking reading with level:

1.Setting up:Initially the tripod is set up at a convenient height and the instrument is approximately leveled.Some instruments are provided with a small circular bubble on the tribrach to check the approximatelevelling.At this stage the the leveling screw should be at the middle of its run.

2.Levelling up:The instrument is then accurately leveled with the help of leveling screws or foot screws.For instruments with three foot screws the following steps are to be followed.

a)Turn the telescope so that the level tube is parallel to the line joining any two leveling screws.

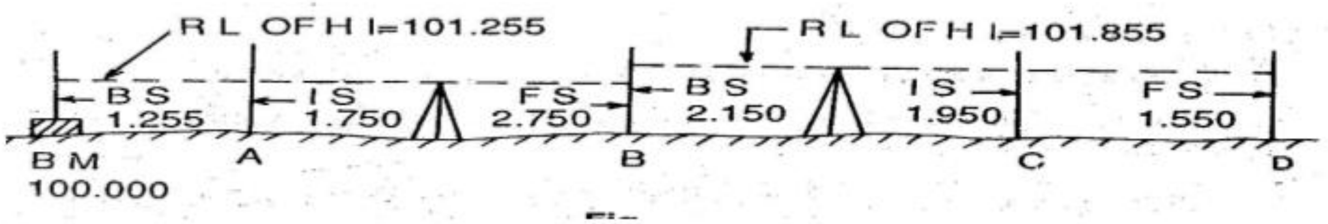
b)bring the bubble to the centre of its run by turning the two leveling screws either both inwards or outwards.

c)Turn the telescope through 90º,so that the level tube is over the third screw or on the line perpendicular to the line joining screws 1 and 2.Bring the bubble to the centre of its run by the third foot screw only rotating either clockwise or anticlockwise.

d)Repeat the process till the bubble is accurately centred in both these conditions.

e)Now turn the telescope through 180º so that it again parallel to leveling screws1 and 2.If the bubble still remains central,the adjustment is all right.If not,the level should be checked for permanent adjustments.

Field Data entry:Level book
A)Height of collimation or Height of Instrument method:



The reduced level of the line of collimation is said to be the height of instrument.In this system,the height of the line of collimation is found by adding the backsight reading to RL of the BM on which the BS is taken. Then the RL of the intermediate points and the change point are obtained by subtracting the respective staff readings from the height of Instrument(HI).The level is then shifted for the next set up and again the height of the line of collimation is obtained by adding the backsight reading to the RL of the change point(which is calculated in the first setup).So the ht.of instrument is different in different set ups of the level.Two adjacent places of collimation.Two adjacent planes of collimation are correlated at the change point by an FS reading from one setting and aBS reading from the next setting.The RLs of of unknown points are to be found out by deducting the staff readings from the RL of the height of instrument.

B)The Rise and Fall method:

In this method,the difference in level between two consecutive points is determined by comparing each forward staff reading with the staff reading at the immediately preceeding point.If the forward staff reading is smaller than the immediately preceeding staff reading,a rise is said to have occurred. The rise is added to the RL of the preceeding point to get the RL of the forward point.If the forward staff reading is greater than the immediately preceeding staff reading, it means there has been a fall.The fall is subtracted from the RL of the preceeding point to get the RL of the forward point.

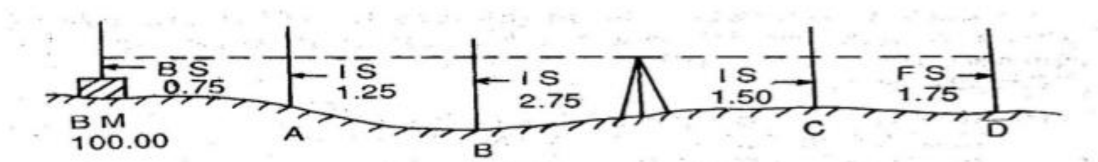


Fig.

Comparison of the two systems:

Sl.No.	Collimation System	Rise and fall system
1.	It is rapid as it involves few calculation	It is labourious,involving several calculations
2.	There is no check on the RL of intermediate points	There is a check on the RL of intermediate points
3.	Errors in immediate RLs cannot be detected	Errors in immediate RLs can be detected as all the points are correlated
4.	There are two checks on the accuracy of RL calculation	There are three checks on the accuracy of RL calculation
5.	This system is suitable for longitudinal levelling where there are a number of intermediate sights.	This system is suitable for fly levelling where there are no intermediate sights.

Efeects of Curvature and refraction:

Leveling instruments provide horizontal line of sight and as a result curvature error occurs.In addition due to refraction in earth's atmosphere the ray gets bent towards the earth introducing refraction errors.Fig. illustrates these errors.Neglecting small instrument HeightSA,OA can be taken as the radius of earth,From Geometry of a circle,AB(2R+AB)=d2,as AB is very small compared to diameter of the earthAB.2R= d2,AB= d2/2R,The dia. Of earth is taken as12734KM,Hence curvature correction:AB=d2/12734Km=0.078 d2 m,d is expressed in Km.The radius of rayIC isbent due to refraction is taken as seven times the radius of earth.The refraction correction is taken as1/7th of the curvature correction.Refraction correction reduces the curvature and correction and hence combined correction is 6/7th of0.078d2m,i,e0.067d2 and d is expressed in Km. The correction is subtractive from staff reading.

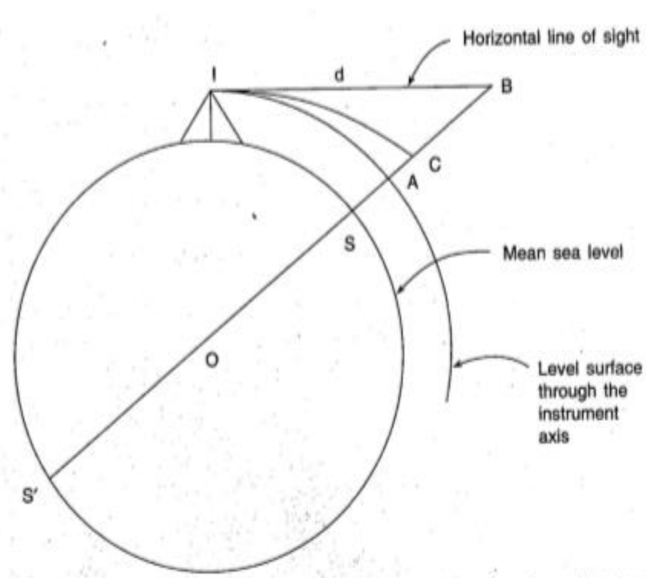
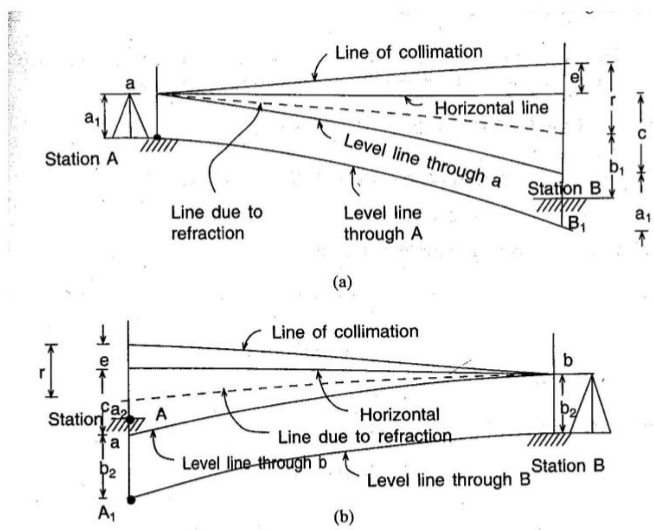


Fig. Curvature and refraction correction: I = instrument station; S = staff station; AB = curvature error; BC = error due to refraction; AC = combined error due to curvature and refraction; SB = staff normal to earth's surface; $IB = d$, distance of the staff from the instrument.

Reciprocal levelling:

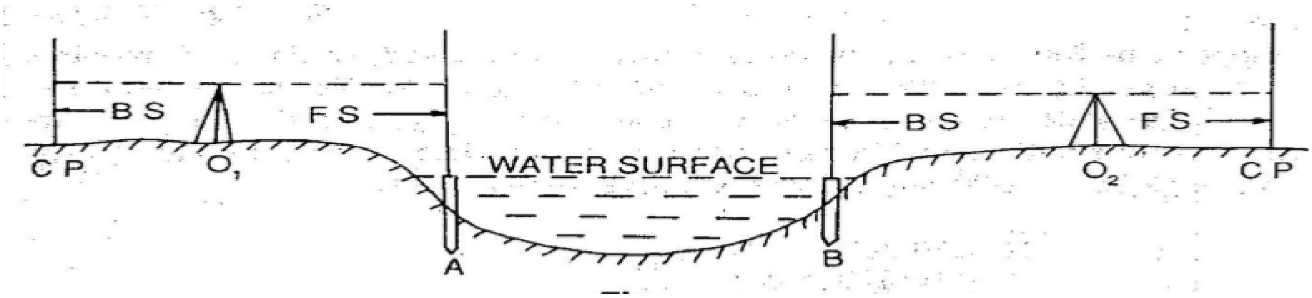
While crossing a river or ravine it is not possible to put the level midway so that the back sight and foresight are equal. Sight distance ,however, is long and errors due ti (i)collimation,(ii)curvature and refraction are likely to occur. To avoid these errors two observations are made.As shown in fig. instrument is placed near station A and observations are made. On staffs at A and B.Similarly instrument is placed near B and staff readings are taken on B and A.



Difficulties in leveling:

1.When the staff is too near the staff:if the staff is held very near the leveling instrument, the graduations of the staff are not visible.In such acse a piece of paper is moved up and down along the staff until the edge of the paper is bisected by the line of collimation.Then the reading is noted from the staff with nacked eye.Sometimes the reading is taken by looking through the object glass.

2.Levelling across a large pond or lake:As the water surface is level,all the points on it will have the same RL.Two pegs A and B are fixed on opposite banks of the lake or Pond.The tops of the pegs are just flush with the water surface.The level is set up at O1and the RL of A is determined by taking the FS on A.The RL of B is assumed to be equal to that of A. Now the level is shifted and set up at O2.Then by taking the BS on Peg B,leveling is continued



3.Levelling across a River:In acse of a flowing water the surface cannot be considered to be level.The water levels on opposite edges will be different. In this case the method of Reciprocal leveling is followed.

4.Levelling across a Solid wall: When leveling is carried across a brick wall, two pegs A and B are driven on either side of the wall just touching it.The level is setup at O1 and astaff reading is taken on A.Let this reading is Ac.Then the height of the wall is measured by staff.Let the ht.be AE.The HI is found out by taking aBS on any BM or CP,Then RL of A=HI-AC,RL of E=RL of A+AE=RL of F(Same level).The level is shifted to some point O2.The staff reading Bd is noted and the Ht. measured.Thus RL of B=RL of F-BF,HI at O2=RL of B+BD,The leveling is then continued

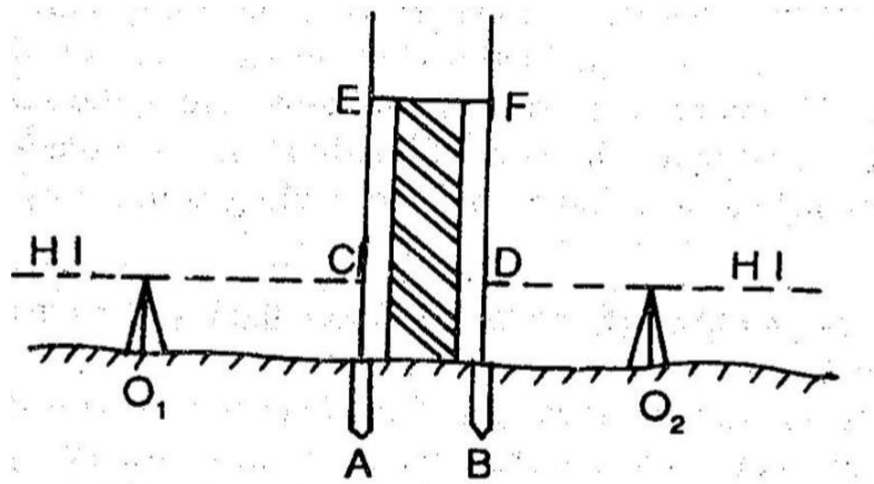
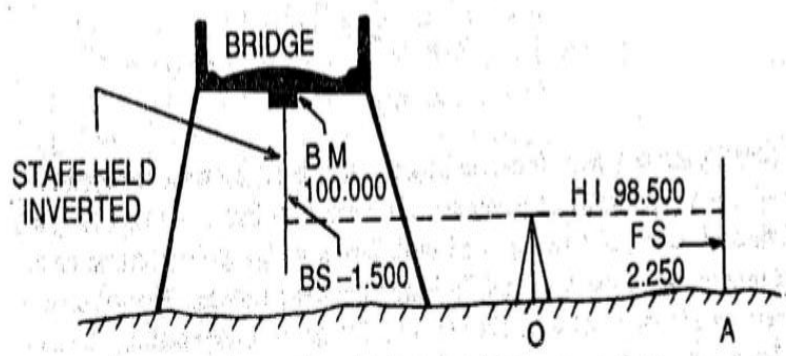


Fig.

by working out the HI of the setting(Ref.Fig)

5.When the BM is above the Line of collimation:This happens when the BM is at bottom of abridge girder or on the bottom surface of aculvert.Suppose theBM exists on the bottom surface of a culvert and that is required to find out the RL of A.The level is Set up at O and the staff is held inverted on the BM.The staff reading is taken and noted with a negative sign.The remark "staff held inverted" is to be entered in the appropriate coloumn.Let the BS and FS readings be1.500 and 2.250 respectively. Now. HI=100.000-1.500=98.500,RL of A=98.500-2.250=95.250.



Fig

6.Levelling along a steep slope:While leveling along a steep slope in a hilly area, it is very difficult to have equal BS and FS

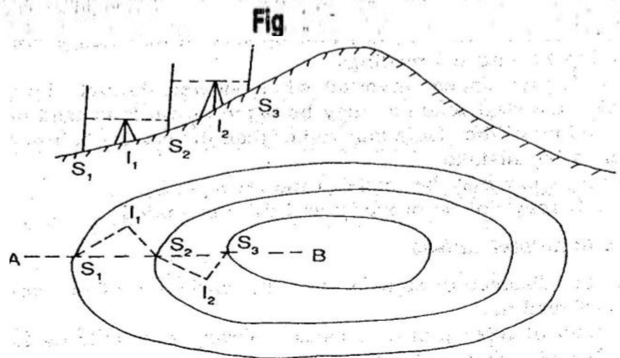


Fig.

distances.In such cases the level should be set up along a Zigzag path so that the BS and FS distances may be kept equal.Let AB be the direction of leveling.I1,I2….are the positions of the level and S1,S2,S3… are the staff position(Ref.Fig.).levelling is continued in this manner and the RLs of the points are calculated.

7.Levelling across arising ground or depression:While levelling across high ground,the level should not be placed on top of this high ground,but on one side so that the line of collimation just passes through the apex. While leveling across a depression, the level should be set up on one side and not at the bottom of the depression.(Ref:Fig.)

Fig

Errors in levelling and precautions:

1.Instrumental errors:(a) The permanent adjustment of the instrument may not be perfect.That is the line of collimation may not be parallel to the axis of the bubble tube.(b)The internal arrangement of the focusing tube is not perfect.(c)The graduation of the leveling staff may not be perfect.

2.Personal errors: (a)The instrument may not be leveled perfectly.(b)The focusing of eye piece and object glass may not be perfect and the parallax may not be eliminated entirely.(c)The position of the staff may be displaced at the change point at the time of taking FS and BS readings.(d)The staff may appear inverted when viewed through the telescope.By mistake,the staff readings may be taken upwards instead of downwards..(e)The reading of the stadia hair rather than the central collimation hair may be taken by mistake.(f)A wrong entry may be made in the level book.(g)The staff may not be properly and fully extended.

3.Errors due to natural Causes:(a)When the distance of sight is too long, the curvature of the earth may effect the staff reading.(b)The effect of refraction may cause a wrong staff reading to be taken.(c)The effect of high winds and a shining Sun may result in a wrong staff reading.

Permissible Errors in Levelling: The precision of levelling is ascertained according to the error of closure.The permissible limit of closing error depends upon the nature of work for which the leveling is to be made.It is expressed as:E=C√,Where,E= closing error in meter,C=the constant,D=distance in Km.The following are the permissible errors for different types of leveling:

Sensitiveness of bubble tube, determination of sensitiveness:

The sensitivity of the level tube depends on the Radius of curvature(R) and usually expressed as θ per unit division(d).This angle may vary from 1” to 2” in the case of precise level,up to 10” to 30” on engineer’s level..This can be determined by in the field by observing the staff readings at aknown distance from the level by changing the bubble position by means of a foot screw

MODULE III

CONTOURING:

Definations of related terms,concepts of contours,characteristics of contours:

Contour Interval: The constant vertical distance between two consecutive contours is called the contour interval.
Horizontal Equivalent: The horizontal distance between any two adjacent contours is called as horizontal equivalent. The contour interval is constant between the consecutive contours while the horizontal equivalent is variable and depends upon the slope of the ground.

OBJECT 0F PREPARING CONTOUR MAP:

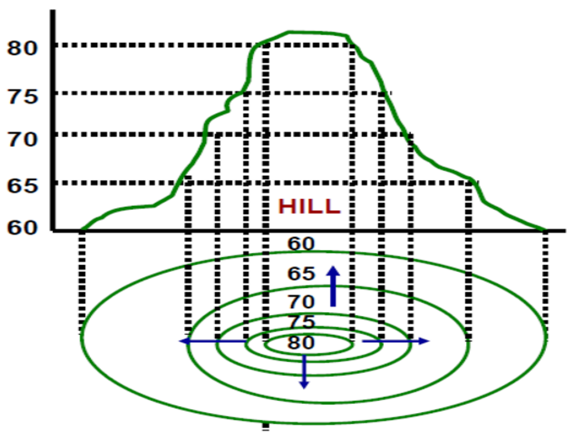
The general map of a country includes the locations of roads, railways rivers Villages, towns, and so on. But the nature of the ground surface cannot be realised, from such a map. However, for all engineering projects involving roads. railways, and so on, a knowledge of the nature of t h e ground surface is required for locat- ing suitable alignments and estimating the volume of earth work. Therefore, the contour map is essential for all engineering project. This is why contour maps are prepared.

USES OF CONTOUR MAP:

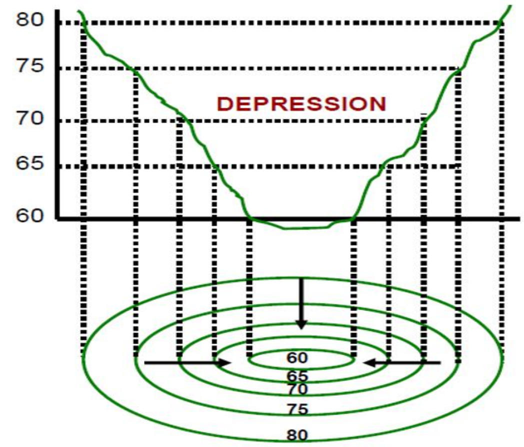
- The following are the specific uses of the contour map: The nature of the ground surface of a country can be understood by studying a contour map. Hence, the possible route of communication between different places can be demarcated.
- A suitable site or an economical alignment can be selected for any engineering project. The capacity of a reservoir or the area of a catchment can be approximately computed.
- The intervisibility or otherwise of different points can be established. A suitable route for a given gradient can be marked on the map.
- A section of the ground surface can be drawn in any direction from the contour map. Quantities of earth work can be approximately computed.

Characteristics of Contours

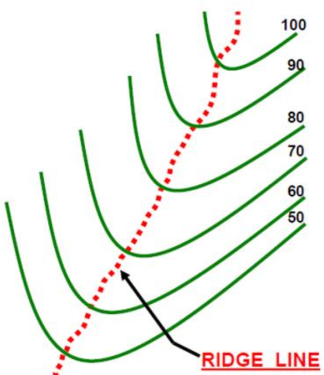
I. All points in a contour line have the same elevation.
II. Flat ground is indicated where the contours are widely separated and steep-slope where they run close together.
III. A uniform slope is indicated when the contour lines are uniformly spaced and
IV. A plane surface when they are straight, parallel and equally spaced.
V. A series of closed contour lines on the map represent a hill , if the higher values are inside
VI. A series of closed contour lines on the map indicate a depression if the higher values are outside
VII. Contour line cross ridge or valley line at right angles. If the higher values are inside the bend or loop in the contour, it indicates a Ridge. If the higher values are outside the bend, it represents a Valley.
VIII. Contour lines cannot merge or cross one another on map except in the case of an overhanging cliff
IX. Contour lines never run into one another except in the case of a vertical cliff. In this case, several contours coincide and the horizontal equivalent becomes zero.

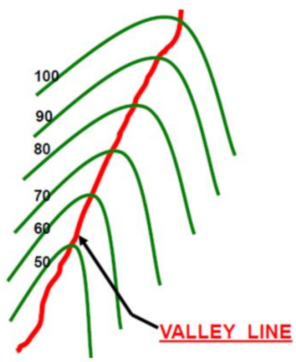


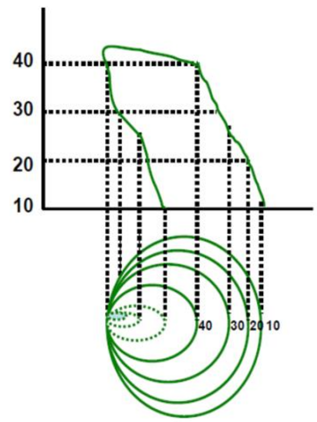
A HILL



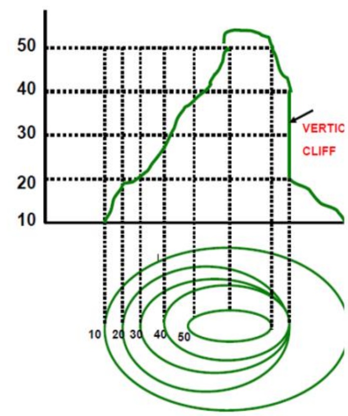
A DEPRESSION







OVERHANGING CLIFF



OVERHANGING CLIFF

METHODS OF CONTOURING

There are mainly two methods of locating contours:(1)Direct Method and (2) Indirect Method.

Direct Method: In this method, the contours to be located are directly traced out in the field by locating and marking a number of points on each contour. These points are then surveyed and plotted on plan and the contours drawn through them.

Indirect Contouring: In this method the points located and surveyed are not necessarily on the contour lines but the spot levels are taken along the series of lines laid out over the area .The spot levels of the several representative points representing hills, depressions, ridge and valley lines and the changes in the slope all over the area to be contoured are also observed. Their positions are then plotted on the plan and the contours drawn by interpolation. This method of contouring is also known as contouring by spot levels.

Comparison of Direct and Indirect Contouring

Direct Method	Indirect Method
Most accurate but slow and tedious	Not so accurate but rapid and less tedious
Expensive	Cheaper
Not suitable for hilly area	Suitable for hilly area
During the work calculations can be done	Calculations are not required in the field
Calculations can not be checked after Contouring	Calculation can be checked as and when required

MODULE IV

INTRODUCTION

An instrument used for measuring horizontal and vertical angles accurately, is known as a theodolite. Theodolite is also use for prolongation or survey line, finding difference in elevation and setting out engineering work requiring higher precision I.e. ranging the highway and railway curves ,aligning tunnels ,etc. PARTS OF A TRANSIT THEODOLITE: -
A transit theodolite consists of the following essential parts:
1) Leveling head: - It consists of two parts i.e. upper tribarch and lower tribarch. (i) The upper tribarch: - It has three arms. Each arm carries a leveling screw.levellingr screw are provided for supporting leveling the instrument. The boss of the upper tribarch is pierced with a female axis in which lower male vertical axis operates. (ii) The lower tribarch: - it has a circular hole through which a plumb bob may be suspended for centering the instrument quickly and accurately.
The three distinct functions of a leveling head are:
(i) To support the main part of the instrument. (ii) To attach the theodolite to the tripod. (iii) To provide a means for leveling the theodolite.
2) Lower plates (or scale plate). The lower plate which is attached to the outer spindle carries a horizontal graduated circle at its beveled edge. It is thefore some time known as the scale plate. It is divided into 360°. Each degree is further divided into ten minutes or twenty minutes arc intervals .
3) Upper plate (or vernier plate): - The upper plate or vernier plate is attached to the inner spindle axis. Two verniers are screwed to the upper plate diametrically opposite. This plate is so constructed that it overlaps and protests the lower plate containing the horizontal circle completely except at the parts exposed just below the verniers. The verniers are fitted with magnifiers. The upper plate supports the Ys or As which provide the bearings to the pivots of the telescope. It carries an upper clamp screw and a corresponding tangent screw for accurately fixing to the lower plate on clamping the upper clamp and unclamping the lower clamp, the instrument may be rotate on this outer spindle without any relative motion between two plates. On the other hand if the lower clamp screw is tightened and upper clamp screw is unclamped, the instrument may be rotate about the inner spindle with a relative motion between the vernier and the graduated scale of the lower plate. This property is utilized for measuring the angle between two settings of the instrument. It may be ensured that the clamping screws are properly tightened before using the tangent screws for a finer setting.
4) The standards (or A frame): - Two standards resembling the English letter A are firmly attached to the upper p[late. The tops of these standards form the bearing of the pivots of the telescope. The standards are made sufficiently high to allow the rotation of the telescope on its horizontal axis in vertical plane. The T-frame and the arm of vertical circle clamp are also attached to the standards.

5) T-frame or index bar:- It is T-shaped and is centered on the horizontal axis of the telescope in the frame of the vertical circle. The two verniers C and D are provided on it at the ends of the horizontal arms, called the index arm. A vertical leg known as clipping arm is provided with a fork and two clipping screw at its lower extremity. The index and clipping arms together are known as T-frame. At the top of this frame, if attached a bubble tube which is called the altitude bubble tube.

6) Plate levels: - The upper plate carries two plate levels placed at right angles to each other. One of the plate bubbles is kept parallel to the trunnion axis. The plate levels can be centered with the help of the foot screws. In some theodolites only one plate level is provided.

7) Telescope: - The telescopes may be classified as

(i) The external focusing telescope

(ii) The internal focusing telescope

DEFINATIONS AND OTHER TECHNOICAL TERMS

Following terms are used while making observations with a theodolite.

1. Vertical axis:- The axis about which the theodolite, may be rotated in a horizontal plane, is called vertical axis. Both upper and lower plates may be rotated about vertical axis.

2. Horizontal axis:- The axis about which the telescope along with the vertical circle of a theodolite, may be rotated in vertical plane, is called horizontal axis. It is also sometimes called trunnion axis or traverse axis.

3. Line of collimation: - The line which passes through the intersection of the cross hair of the eye piece and optical center of the objective and its continuation is called line of collimation. The angle between the line of collimation and the line perpendicular to the horizontal axis is called error of collimation. The line passing through the eye piece and any point on the objective is called line of sight.

4. Axis of telescope: - The axis about which the telescope may be rotated is called axis of telescope.

5. Axis of the level tube: - The straight line which the tangential to longitudinal curve of the level tube at its center is called the axis of the level tube. When the bubble 0f the level tube is central, the axis of the level tube becomes horizontal..

6. Centering: - The process of setting up a theodolite exactly over the ground station mark, is known as centering. It is achieved when the vertical axis of the theodolite is made to pass through the ground station mark.

7. Transiting: - The process of turning the telescope in vertical plane through 180˚ about its horizontal axis is known as transiting. The process is also sometimes known as reversing or plunging.

8. Swing: - A continuous motion of the telescope about the vertical axis in horizontal plane is called swing. The swing may be in either direction i.e. left or right. When the telescope is rotate in the clockwise right direction, it is known as right swing. If it is rotated in the anticlockwise left direction it is known as left swing.

9. Face left observations: - When the vertical circle is on the left. of the telescope at the time of observations, the observations of the angles are known as face left observations.

10. Face right observations: - When the vertical circle is on the right of the telescope at the time of observations, the observations of the angles are known as face right observations.

11. Changing face:- It is the operation of changing the face of the telescope from left tom right and vice-versa.

12. Telescope normal: - Telescope is said to be normal when its vertical circle is to its left and the bubble of the telescope is up.

13. Telescope inverted: - A telescope is said to be inverted or reversed when its vertical circle is to its right and the bubble of the telescope is down.

The temporary adjustments of a theodolite include the following:

i. Setting up the theodolite over the station.

ii. Leveling of the theodolite

iii. Elimination of the parallax.

1) Setting up: - The operation of setting up a theodolite includes the centering of the theodolite over the ground mark and also approximate leveling with the help of tripod legs.

2) Centering: - The operation with which vertical axis of the theodolite represented by a plumb line, is made to pass through the ground station mark is called centering.

The operation of centering is carried out in following steps:

i) Suspend the plumb bob with a string attached to the hook fitted to the bottom of the instrument to define the vertical axis.

ii) Place the theodolite over the station mark by spreading the legs well apart so that telescope is at a convenient height.
iii) The centering may be done by moving the legs radially and circumferentially till the plumb bob hangs within 1cm horizontally of the station mark.
iv) By unclamping the center shifting arrangement, the finer centering may now be made.

Levelling of a theodolite: The operation of the making the vertical axis of a theodolite truly vertical is known as leveling of the theodolite.

After having leveled approximately and centered accurately, accurate leveling is done with the help of plate levels. Two methods of leveling are adopted to the theodolites, depending upon the number of leveling screws.

Levelling with three screw head: - The following steps are involved

1) Turn the horizontal plate until the longitudinal axis of the plate level is approximately parallel to line joining any two leveling screws.
2) Bring the bubble to the center of its run by turning both foot screws simultaneously in opposite directions either inwards or outwards. The movement of the left thumb indicates the direction of movement of the bubble.
3) Turn the instrument through 180˚ in azimuth.
4) Note the position of the bubble. If it occupies a different position, move it by means of the same foot screws to the approximate mean of the two positions.
5) Turn the theodolite through 90˚ in a azimuth so that the plate level becomes perpendicular to the previous position [
6) With the help of the third foot screw move the bubble to the approximate mean position already indicated.
7) Repeat the process until the bubble retains the same position for every setting of the instrument in azimuth.

ELEMATION OF PARALLAX: - An apparent change in the position of the object caused by change in position of the surveyor's eye is known as parallax.

In a telescope parallax is caused when the image formed by the objective is not situated in the plane of the cross hairs. Unless parallax is removed accurate bisections and sighting of objects become difficult.

Elimination of parallax may be done by focusing the eye piece for distinct vision of cross hairs and focusing the objective to bring the image of the object in the plane of the cross-hairs as discussed below.

Focusing the eye piece: To focus the eye-piece for distinct vision of cross hairs, either holds a white paper in front of the objective or sight the telescope towards the sky. Move the eye piece in or out till the cross hairs are seen sharp and distinct.

Focusing the objective: After cross hairs have been properly focused, direct the telescope on a well defined distant object and intersect it with vertical wire. Focus the objective till a sharp image is seen. Removal of the parallax may be checked by moving the eye slowly to one side. If the object still appears intersected, there is no parallax.

Theodolites are commonly used for the following operations.

i. Measurements of horizontal angles.
ii. Measurements of vertical angles.
iii. Measurements of magnetic bearing of lines.
iv. Measurements of direct angles.
v. Measurements of deflection angels.
vi. Prolongation of straight lines.
vii. Running a straight line between two points.
viii. Laying off an angle by repetition method.

1**. Measurement of horizontal angles**

i. To measure the angle by method of repetition: -

Let ABC be the required angle between sides BA and BC to be measured by repetitio0n method When the measure of an angle is small, slight error in its sine value introduce a considerable error in the computed sides as the sine value of the angle changes rapidly. Therefore, for accurate and precise work, the method of repetition is generally used. In this method, The value of the angle is added several times mechanically and the accurate value of the angular measure is determined by dividing the accumulated reading by the number of repetition.

Method of repetition

ii. **To measure the angle by reiteration method: When** several angles having a common vertex, are to be measured the reiteration method is generally adopted. In this method angles are measured successively starting from a reference station and finally closing on the same station. The operation of making last observation on the starting station is known as closing horizon. Making observations on the starting station twice provides a check on the sum of all angles around a station. The sum should invariably be equal to 360˚, provided the instrument is not disturbed during observations. As the angles are measured by sighting the stations in turn, this method is sometimes known as direction method of observation of the horizontal angles.

2. Measurement of vertical angles: A vertical angle may be defined as the angle subtended by the inclined line of sight and the horizontal line of sight at the station in vertical plane. If the point sighted is above the horizontal axis of the theodolite, the vertical angle is known as angle of elevation and if it is below, it is known as angle of depression. Procedure: To measure a vertical angle subtended by the station B at the instrument station A, The following steps are involved:

i. Set up the theodolite over the ground station mark A. Level it accurately by using the altitude bubble.
ii. Set the zero of the vertical vernier exactly in coincidence with zero of the vertical scale using vertical clamp and vertical tangent screw. Check up whether the bubble of the altitude level is central of its run. If not, bring it to the centre of its run by means of the clip screw. In this position, the line of collimation of the telescope is horizontal and the verniers read to zero.
iii. Loosen the vertical circle clamp and move the telescope in vertical plane until the station B is brought in field of view. Use vertical circle tangent screw for accurate bisection.
iv. Read both the verniers of the vertical circle. The mean of two vernier readings gives the value of the vertical angle.
v. Change the face of the instrument and make the observations exactly in similar way as on the face left.
vi. The average of two values of the vertical angle is the required value of the vertical angle.