DEPARTMENT OF CIVIL ENGINEERING

LABORATORY MANUAL

SURVEYING

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113 → 01/feb – 22feb

List of the Experiments

EXPERIMENT NO - 1

Aim of the experiment : To measure correct distance between two points by Ranging and Chaining.

Instruments required : Chain (20m /30m) - 1 No., Tape– 1, Arrows- 5No. Ranging Rods - 4 No.

Theory:

Description of Instruments

a) Chain:

The chain is composed of 100 or 150 pieces of galvanized mild steel wire, 4mm in diameter called links .The ends of each link are bent into a loop and connected together by means of three oval rings. The ends of the chain are provided with handles for dragging the chain on the ground, each wire with a swivel joint so that the chain can be turned without twisting. The length of the chain is measured from the outside of one handle to the outside of another handle.

Following are the various types of chain in common use:

1) Metric chains
2) Gunter's chain or surveyor's chain
3) Engineers chain
4) Revenue chain
5) Steel band or Band chain

Metric chain: Metric chains are made in lengths 20m and 30m. Tallies are fixed at every five-meter length and brass rings are provided at every meter length except where tallies are attached.

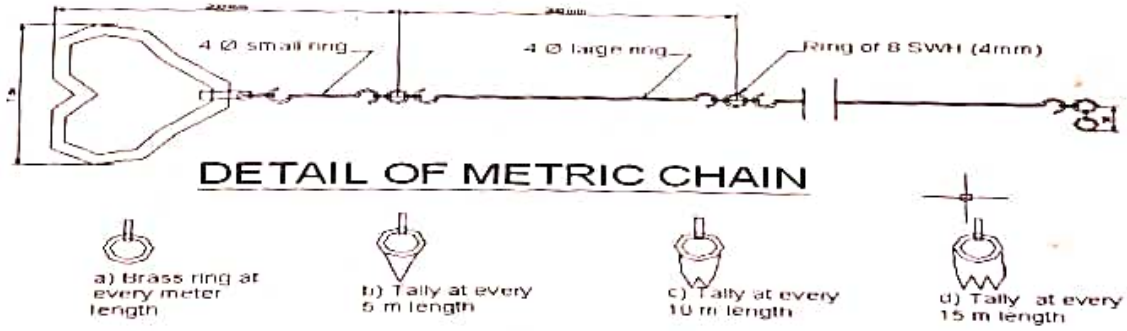


FIG. Details of matric chain

b) Tape:

The following are the various types of tapes:

i) Cloth tape
ii) Metallic tape
iii) Steel tape
iv) Invar tape

Among the above, metallic tapes are widely used in surveying. A metallic tape is made of varnished strip of waterproof line interwoven with small brass, copper orbronze wires. These are light in weight and flexible and are made 2m, 5m 10m, 20m,30m, and 50m.

c) Ranging rods:

The ranging rods are used for marking the positions of Stations conspicuously and for ranging the lines. In order to make these visible at a distance, they are painted alternately black and white, or red and white or red White and black successively. The adjustment of the chain should as far as possible be affected symmetrically on either side of the middle so as that the position of central tag remains unaltered.

In measuring the length of survey line also called as chain line. It is necessary that the chain should be laid out on the ground in a straight line between the end stations.

d) Arrows:

Arrows are made of good quality hardened steel wire of 4 mm diameter. These are 400 mm in length, pointed at one end and the other end is bent into a loop or circle.

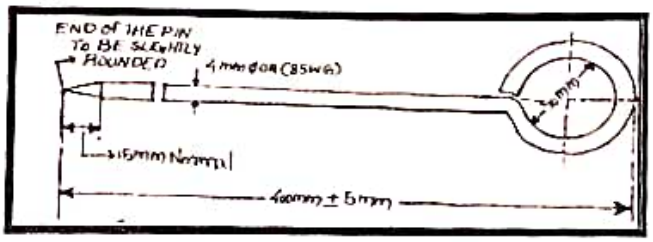


FIG. Details of Arrow

FIG. Details of Ranging rod

Ranging:

Ranging is a process of fixing intermediate points in line between two end points, while distance between to end points is more than one chain length. There are two types of ranging

1. Direct ranging
2. Indirect ranging

Procedure:

- Cross check the length of chain and record it as L_1
- Fix the ranging rods at the two given end stations (let A & B), where pegs are already driven into the ground.
- Stand behind station A (Follower should be at 1st station) and direct the leader, with ranging rod to come in line with AB by using signals of ranging.
- After coming into line follower directs the leader to insert an arrow into ground at that particular position.
- Let the intermediate point be C which should be less than 20m / 30 m(Depends on length of chain).
- Leader has to move in forward direction toward station B (End station).
- With respect to movement of leader the follower has to move in forward direction upto position of 1st arrow.
- Repeat the steps till leader will reach at end station (B).
- Measure the length of line by consider no of chains and links between A & B and record it as l_1.

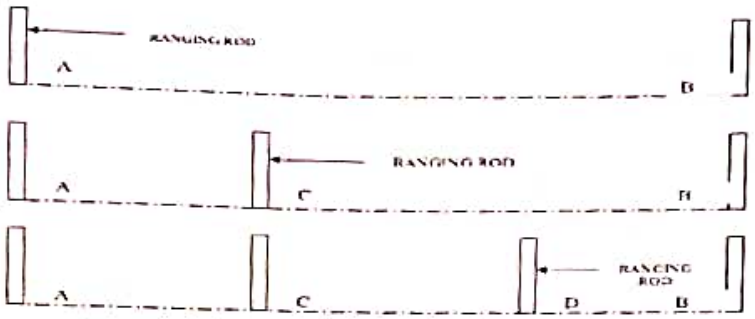


FIG. Details of Ranging process

The code of signals shown in the Table below should be followed by the surveyors while ranging a survey line using chain, to direct or convey message to the other surveyors or assistants in order to bring all the intermediate points in alignment with the end points in a chain line.

Signal given by the Surveyor	Meaning of the signal to the Assistant
1. Rapid sweep with right hand 2. Slow sweep with right hand 3. Right arm extended 4. Right arm up and moved to the rig	Move considerably to the right Move slowly to the right Continue to move to the right Plumb the rod to the right
5. Rapid sweep with left hand 6. Slow sweep with left hand 7. Left arm extended 8. Left arm up and moved to the left	Move considerably to the left Move slowly to the left Continue to move to the left Plumb the rod to the left
9. Both hands above head and brought down 10. Both arms extended forward horizontally and the hands brought down quickly	Ranging is correct Fix the ranging rod

Calculation:

Chain or Tape long or short Correction = $(L_1/L) \times$ measured length

Where L is true length of chain or tape

L_1 is faulty length of chain or tape

l_1 is measured length of line

Result:

The correct distance between AB = _____ meter.

EXPERIMENT NO - 2

Aim of the experiment: To traverse around a building by Chaining.

Instruments Required: Chain (20m /30m) - 1 No., Tape – 1, Arrows - 5 No., Ranging Rods - 4 No.

Theory :

Principle of chain survey

1. Whole to part:

The main purpose of surveying from the whole to the part is to localize the errors as working the other way round would magnify the errors and introduce distortions in the survey. If survey is carried out from part to whole then the errors would expand to greater magnitude. In partial terms, this principle involve covering the area to be surveyed with large triangles. These are further divided into smaller triangles and their vertices are surveyed with instruments. The process continues until the area has been sufficiently covered with small triangles to a level that allows detailed surveys to be made in a local level.

2. Location of a point by measurement from two control points:

The control points are selected in an area band distances between them is measured. The line is plotted to a convenient scale of drawing sheet. Then location of required point may be plotted by any one of the following methods:

For an example, if A and B are the control points, the following operations can be performed to fix other points.

i) by measuring the distance AC & BC.

ii) by dropping perpendicular CD

iii) by measuring BC & <ABC

iv) by measuring interior angles of triangle (< ABC & < BAC)

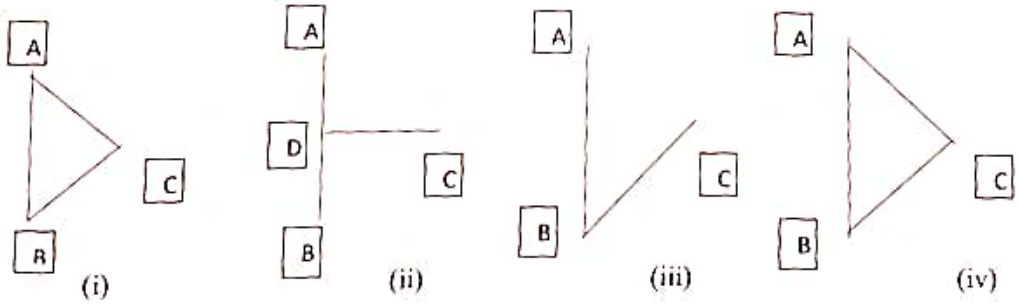


FIG. Location of a point by measurement from two control points

Main stations: Main station is a prominent point on the chain line and can be either at the beginning of the chain line or at the end or along the boundary.

Subsidiary stations: The stations located on the main survey lines are known as Subsidiary stations.

Tie stations: These are also subsidiary stations taken on the main survey lines to locate the details of the object.

Check line:

Check lines or Proof lines are the line which are run in the field to is to take the details of the objects.

Tie line:

The main object of running a tie line is to take the details of the objects. Tie line is a line which joints subsidiary stations or tie stations on the main line.

Offsets:

An offset is the lateral distance of an object or ground feature measured from a survey line.
The two types of offsets are,
(i) Perpendicular offset: The angle of offset from a point on a chain line is 90°
(ii) Oblique offset: When the angle of offset is other than 90°.

Rope Method

This method is used when a line has to be set out perpendicular to the base line from a point outside from base line. A long rope with a loop at both ends and a measuring tape are used for this method. The rope should be a few meters longer than the distance from the outer point to the base line. One loop of the rope is placed around the peg at outer point. Put a peg through the other loop of the rope and make a circle on the ground keeping the rope straight. This circle crosses the base line twice. Find the midpoint between two points where the rope crossed the base line. Now by joining the outer point and the mid-point on base line one can get perpendicular line.

Instruments used for setting right angles:

1) Optical square
2) Prism square
3) Site square
4) Cross staff
   a. Open cross staff
   b. French cross staff
   c. Adjustable cross staff

Procedure :

- Select minimum no. of main survey stations such that the entire area is controlled from the main survey lines which run near to the boundaries.
- Fix the ranging rods at the main survey stations.
- Select the base line and fix the intermediate stations by ranging.
- Take the offsets (perpendicular or oblique) wherever there is a bend or any special feature in the boundary.
- Take as many no. of short offsets for important details.
- After knowing the length and positions of the offsets the boundaries and the other details can be plotted to their shapes with a scale.

Result: With the chainage and offset draw the layout of the survey on a drawing sheet and record the data in a field book.

EXPERIMENT NO – 3

Aim of the experiment: To conduct compass survey along the closed traverse.

Instruments Required: Prismatic compass, chain, ranging rods.

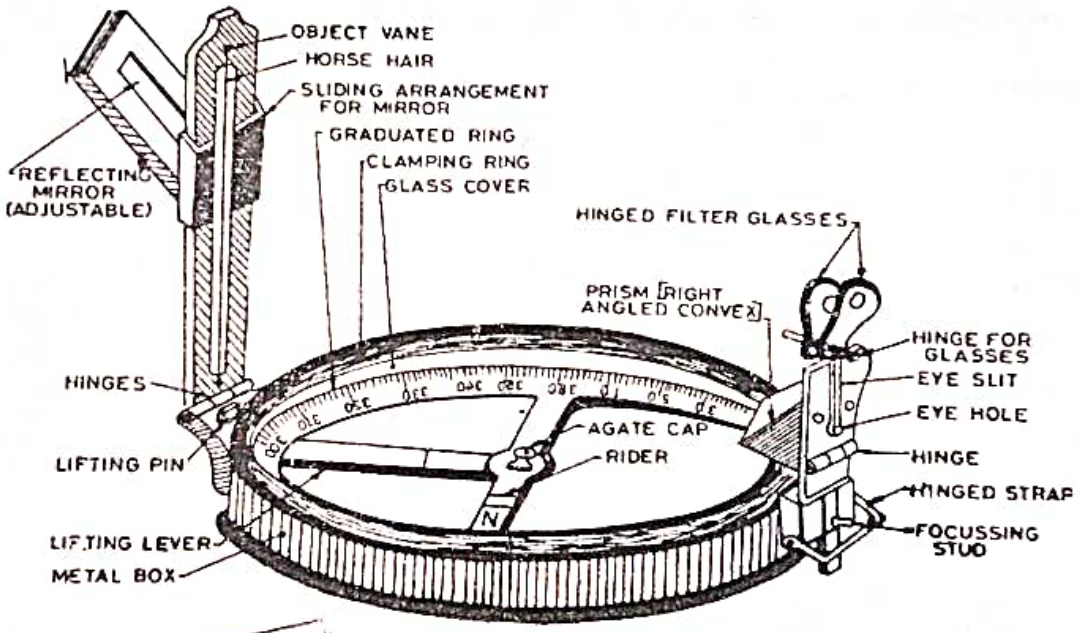
Theory :

There are two types of compasses:-

1) Prismatic compass
2) Surveyor's compass.

Different parts of prismatic compass

1. Compass Box 2. Magnetic Needle 3. Graduated Ring
4. Pivot5. Objective Vane 6. Eye Vane
7. Adjustable Mirror 8. Spring Brake 9. Brake Pin
10. Lifting Lever 11. Lifting Pin 12. Prism
13. Focusing Stud 14. Glass Cover 15. Prism Dust Cap
16. Sun Glasses



THE PRISMATIC COMPASS SHOWING ITS VARIOUS PARTS

Fig. 3.1 (a)

FIG. Details of prismatic compass

The least count of prismatic compass is 30 min. It consists of circular box of 10cm-12 cm dia. of non-magnetic material. Pivot is fixed at the center of box and is made up of hard steel with a Sharp pivot. Graduated aluminum is attached to the needle. It is graduated in clockwise direction from 0^0 to360^0.The figures are written in inverted. Zero is written at south end and 180 at north end and 270 at the east. Diametrically opposite are

fixed to the box. The sighting vane consists of a hinged metal frame in the center of which is stretched a vertical Horsehair fine silk thread of which is stretched a vertical hair. It presses against a lifting pin which lift the needle of the pivot and holds it against the glass lid. Thus preventing the wear of the pivot point to damp the oscillations of the needle when about to take reading and to bring to rest quickly, a light spring is brought lifted inside the box. The face of the prism can be folded out the edge of the box when North end is used. Sometime the sighting vanes are provided with a hinge mirror which can be placed upward or downwards on the frame and can be also slided along it is required. The mirror can be made inclined at any angle so that Objects which are too high or too low can be sighted directly by reflecting.

Adjustment of the Prismatic Compass:

The compass may be held in hand but for better results it should be fitted at the top of tripod having ball and socket arrangement. The adjustment of a compass is done in the following three steps.

1) Centering: The compass fitted over the tripod Is lifted bodily and placed approximately on the station peg by spreading the leg of a tripod equally, The centre of the compass is checked by dropping a small piece of stone from the centre of the bottom of the compass so that it falls on the top of the station peg. A plumb bob may be used to judge the centering either attaching it with a hook providing at the bottom or otherwise by holding it by hand.

2) Levelling: After the compass is centered, it is leveled by means of ball and socket arrangement so that the graduated circle may swing freely. It can be checked roughly by placing a round pencil on the top of the compass, when the pencil does not move, that is roughly the horizontal position.

3) Focusing the prism: The prism attached is moved up and down so that graduation on the graduated circle should become sharp and clear.

Bearing of Lines: A bearing of a line is a horizontal angle made by the survey line with some reference direction or meridian. Meridian may be

1) ***True meridian:*** The true geographical meridian passing through a point is a line of intersection of earth's surface by a plane containing north south pole and given point. They are not parallel to each other at different places.
2) ***Magnetic meridian:*** The direction indicates by a free suspended and a properly balanced magnetic needle free from all other attractive forces. The direction of magnetic meridian can be established with the help of Magnetic compass.
3) ***Arbitrary meridian:*** Any direction is assumed to be the Reference meridian to carry out small survey.

Designation of bearing:

Whole Circle Bearing: In whole circle bearing system, the bearing of a line is always measured clockwise from the north point of the reference meridian towards the line right round the circle. The angle thus measured between the reference meridian and the line is called Whole circle bearing of the line. Angles measured will have value between 0 to 360 degrees.

Reduced bearing (R.B): In this system of bearing of a line is measured clockwise or anti-clockwise from north or south direction whichever is nearer to the line towards east or west. The concept of reduced bearing facilitates computations in traverse surveying.

Conversion of W.C.B. to R.B:

Cases	WCB between	Rule for Reduced Bearing	Quadrant
1	0^0 to 90^0	RB = WCB	N-E
2	90^0 to 180^0	RB = 180^0 - WCB	S-E
3	180^0 to 270^0	RB = WCB -180^0	N-W
4	270^0 to 360^0	RB = 360^0 – WCB	S-W

Conversion of R.B. to W.C.B:

Cases	Quadrant of R.B	Rule for W.C.B	WCB between
1	N-E	W.C.B = RB	0^0 to 90^0
2	S-E	W.C.B = 180^0 - RB	90^0 to 180^0
3	N-W	W.C.B = 180^0 + RB	180^0 to 270^0
4	S-W	W.C.B = 360^0 – RB	270^0 to 360^0

Local Attraction:

Sometimes the magnetic needle does not point towards magnetic North or South. The reason being that the needle may be under the influence of external attractive forces which are produced due to magnetic substances like magnetic rock, iron ores, cables carrying current or electric poles etc. Thus the deflection of the needle from its original position, due to the presence of some magnetic substances is known as local attraction. To detect local attraction at a particular place, fore and back bearing of each line are taken. Then difference comes out to be 180° there is no local attraction at either station. On the other hand of the difference is other than 180°, the bearing may be rechecked to find out the discrepancy may not be due to the presence of iron substance near to the compass. If the difference still remains the local attraction exists at on or both the stations.

Elimination of Local attraction:

1st method:

In this method, the bearing of the other lines are corrected and calculated on the basis of the a line which has the difference between its fore bearing and back bearing equal to 180°.The magnetic of the error is formed due to local attraction by drawing a sketch of observed and correct bearing of the line at each station. The error will be negative when the observed bearing is less than the corrected one and the correction will be positive and vice versa. If however, there is no such line in which the difference of fore bearing and back bearing is equal to 180°, the correction should be made from the mean value of the bearing of that line in which the difference between the fore and the back bearing is the least. If the bearings are observed in quadrantal system, the correction should be applied in proper direction by drawing a neat sketch roughly.

2nd Method:

This method is more general as the bearing at a station locally affected may be incorrect but include angles calculated from these bearing will be correct since the amount of the error will be the same for all the bearing observed from that station. Thus starting from the unaffected line and using these included angles the correct bearing of all other lines can be calculated.

Note: The sum of the internal included angles must be equal to (2n-4) right angles where n=number of sides of a closed traverse.

Procedure:

Closed traverse is generally run around a structure .It is defined as a series of connected lines whose directions and lengths are determined precisely. Following procedure is adopted to run a closed compass traverse.

- Let us say we have to run a closed compass traverse ABCDA.
- Set the prismatic compass at point A. center it and level it.
- Take bearings of traverse lines AB and AD.
- Shift the compass to point B center it and level it. Take the bearings BC and BA.
- Link-wise complete the traverse as shown in fig below.
- Measure the length of traverse line AB, BC, CD, and DA.
- Record the observation in tabular columns.
- Care must be taken to see that the stations are not affected by local attractions. If they are affected corrections to local attractions should be applied first and then the traverse should be plotted with corrected bearings.
- Simplest method of plotting is angle and distance method with a protractor. If Last point is falling short by some distance in meeting the first point then it means that there is a closing error.

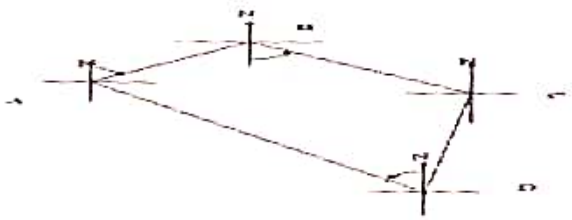


FIG. Closed traverse ABCDA

Calculation:

Line	Length	Observed bearing		Difference	Included Angles		Corrected Bearing		Remarks
		FB	BB		Observed	Corrected	FB	BB	
AB									
BC									
CD									
DA									

Check that summation of all the included angles = (2n-4) x 90

Result:

The adjusted traverse with bearings and length is to be shown on a Drawing sheet.

EXPERIMENT NO - 4

Aim of the experiment: To study different components of dumpy level and to find out reduced level of different point.

Instruments Required: Dumpy level, levelling staff , tripod

Theory:

Components of levelling instruments:

A levelling instrument essential consist of the following
a. A levelling head with three foot screws which enables to bring the bubble center
b. A telescope that provides line of sight to bisect the distant object
c. A bubble tube to make line of sight horizontal
d. A tripod for supporting the levelling instrument

The telescope of levelling instrument consist of the following
1. A body of the telescope with focusing arrangement

2. Object lens or objective: A combination of double convex lens at the front face and a concave lens at the back face is used. The image formed by the above compound lens is an inverted image

3. Eye piece: The main purpose of eyepiece is to effect the magnification of cross hair of the diaphragm, and the image is formed by the object lens

4. Diaphragm: It consists of very fine cross hairs bounded in a braising fitted inside the body of the telescope .The cross hairs are made of line platinum wires or line attached on glass plate

5. The line of sight: The line of sight is maintained perpendicular to the direction of gravity through a system of prisms called a compensator. This compensator maintains a horizontal line of sight when the instrument is approximately levelled.

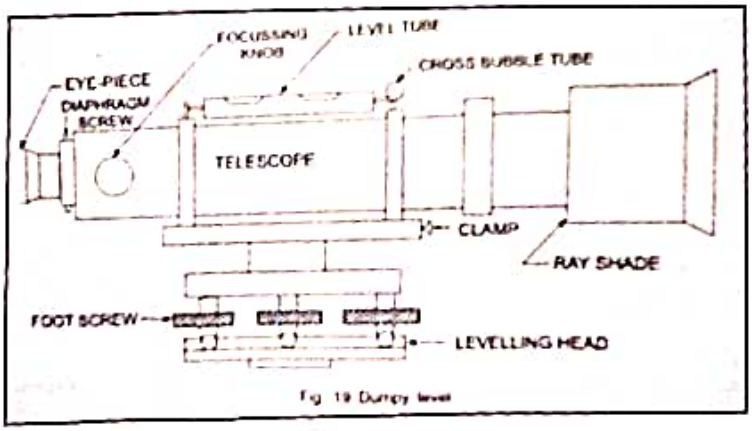


FIG. Details of Dumpy level

Temporary adjustments :

The following are the temporary adjustments to be made.

1. Setting up of the level
2. Leveling up
3. Elimination of parallax.

1. Setting up of the level

- Release the clamp screw of the instrument
- Hold the instrument in the right hand and fix it on the tripod by turning round only the lower part with the left hand.
- Screw the instrument firmly.
- Bring all the foot screws to the center of its run.
- Spread the tripod legs well apart.
- Fix any two legs firmly into the ground by pressing them with the hand.
- Move the third leg to the right or left until the main bubble is approximately in the center.
- Then move the third leg in or out until the bubbles of the cross-level is Approximately in the center.
- Fix the third leg firmly when the bubbles are approximately in the centers of their run.

2. Levelling up

- Place the telescope parallel to a pair of foot screws.
- Bring the bubble to the center of its run by turning the foot screws equally either both inwards and both outwards.
- Turn the telescope through 90° so that it lies over the third foot screw.
- Turn this third foot screw so that the bubble comers to the center of its run.
- Bring the telescope back to the original position without reversing the eye-piece and object glass.
- Repeat the above operations until the bubble remains in the center of its run in both the positions.
- Turn the telescope through 180° and check whether the bubble remains central.

3. Elimination of parallox:

- Remove the lid from the object glass.
- Hold a sheet of white paper in front of the object glass.
- Move the eyepiece in or out until the cross hairs are distinctly visible.
- Direct the telescope towards the staff.
- Turn the focusing screw until a clear and sharp image in formed in the plane of the cross hairs.

Fly-Levelling

Differential levelling is the method of direct levelling the object of which is To determine Difference in elevations of two points regardless of horizontal position of point with respect to each Other, when points are apart it may be necessary to setup the instrument several times. This type of Levelling is also known as "FLY-LEVELLING". Fly levelling is a very approximate form of levelling in which sights are taken as large as possible. There are two methods to book and reduce the levels.

1. Rise and fall method
2. Height of instrument method

Difference between height of instrument & rise and fall method:

Sl.No	Height of collimation system	Rise and fall system
1	It is rapid as it involves few calculation	It is laborious involving several calcuation
2	There is no check on the RL of the intermediate sight	There is a check on the RL of the intermediate points
3	Errors in the intermediate RLs cannot be detected.	Errors in the intermediate 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 leveling where there are a number of intermediate sights	This system is suitable for fly leveling where there are no intermediate sights

Procedure:

- Set the instrument at convenient positions near first point (say A).
- Do required temporary adjustments (setting up, levelling up, elimination of parallax).
- Take first sight on B.M (point of known elevation) and enter the reading in back Sight column and enter all other sights in intermediate sight column except fore sight.
- If distance between two points is large enough then shifting of instrument is required. Mark the change point.
- After setting the instrument at new position and performing temporary adjustment, take back sight on the last point of previous setting.
- It means change point will have both back sight and fore sight readings.
- Repeat the process link wise till last point (say B) is reached.
- After entering the readings in a tabular form calculate reduced levels either by height of instrument method (or) is and fall method.
- Apply the arithmetical check.

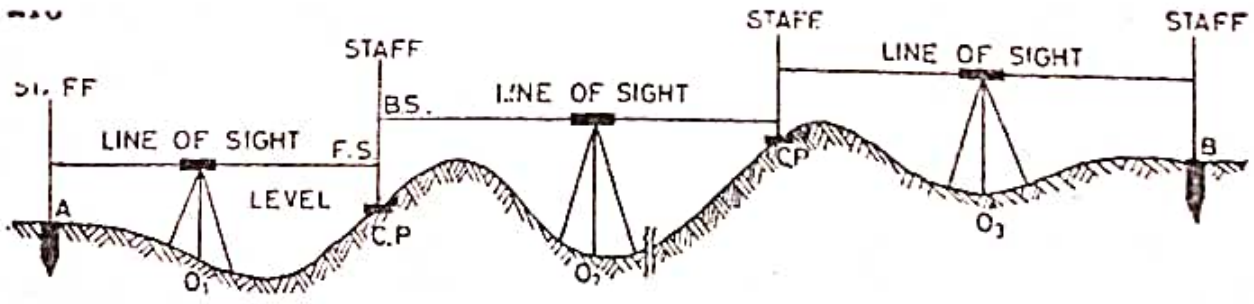


FIG. Details of fly levelling process

Calculation

TABULAR FORM FOR HEIGHT OF INSTRUMENT (H.I) METHOD

Station	Readings			Height of Instrument	Reduced Level	Remarks
	Back sight	Inter Sight	Fore Sight			

H.I = R.L of B.M – B.S

R.L of other station points = H.I – I.S or F.S

ARITHMATICAL CHECK:

Σ B.S – Σ F.S = Last R.L – First R.L

FOR RISE AND FALL METHOD

Station	Readings			Rise	Fall	R.L.	Remarks
	Back sight	Inter Sight	Fore Sight				

ARITHMATICAL CHECK:

Σ B.S – Σ F.S = Σ Rise – Σ Fall = Last R.L. – First R.L

Result: The results are to be represented in level book.

Difference of elevation between first and last given points is _____ M.

EXPERIMENT NO –5

Aim of the experiment: To determine the elevation at various points on ground at regular interval

Instruments Required: Dumpy level, levelling staff, , and peg

Theory:

Levelling is a process of determining the height of one level relative to another. It is used in surveying to establish the elevation of a point relative to a datum, or to establish a point at a given elevation relative to a datum.

Profile levelling: The process of determining elevations at points at short measured intervals along a fixed line is called Longitudinal or profile levelling.

Cross sectioning: It is a method of levelling to know the nature of Ground on either side of the centreline of the proposed route. Levels are taken at right angles to the proposed Direction of the road end at suitable distances and levelling is carried out along this cross Section.

Procedure:

There are two methods to determine level of a road surface:

1. Profile levelling(longitudinal levelling)
2. Cross sectioning

1. ***Profile levelling***

It is the process of determining elevation of points at short measured intervals along a fixed line such as the centre line of highway, canal, or sewer.

- First set dumpy level at a point outside the centre line of a section and back sight is taken towards the benchmark.
- Then take intermediate sights from the same instrument station towards the points at regular interval.
- The point where instrument is shifted is known as turning point and at this point both FS and BS taken.
- From the above staff reading reduced level of different points can be determined by using H.I or rise and fall method and plotted in the graph.

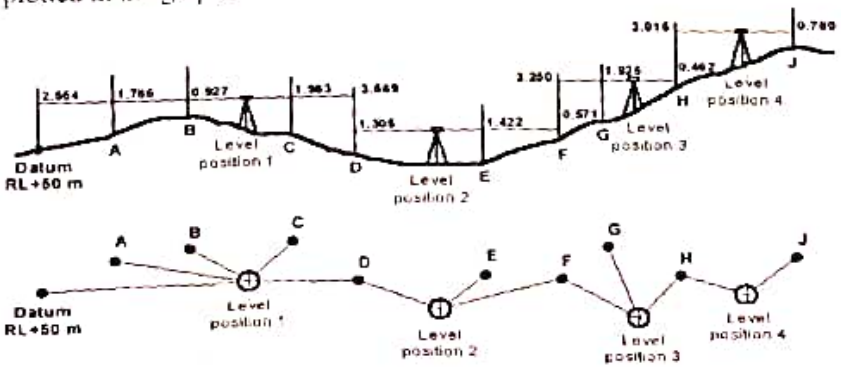


FIG. Details of profile levelling process

2. *Cross sectioning*

In this method the centre line of area of interest is divided into a number of cross section and staff reading is taken along these cross sections.

- First divide the section into a number of cross sections by using 3-4-5 method or draw perpendicular lines by using cross staff.
- Then measure the left and right distance from the centre peg using a tape.
- Set the dumpy level at a point outside the central line of a section and take back sight towards the bench mark.
- Take intermediate sights from the same instrument station towards the points at regular interval.
- From the above staff readings determine reduced levels of different points by using H.I method or rise and fall method and the same can be plotted in graph.

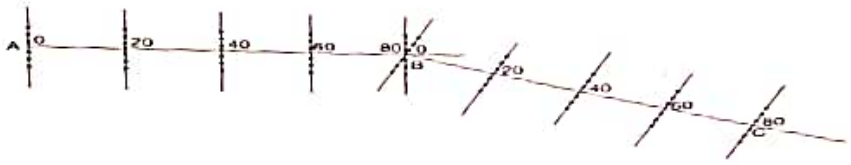


FIG. Details of cross sectioning process

Calculation

TABULAR FORM FOR HEIGHT OF INSTRUMENT (H.I) METHOD

Station	Readings			Height of Instrument	Reduced Level	Remarks
	Back sight	Inter Sight	Fore Sight			

H.I = R.L of B.M + B.S

R.L of other station points = H.I – I.S or F.S

ARITHMATICAL CHECK:

Σ B.S – Σ F.S = Last R.L – First R.L

FOR RISE AND FALL METHOD

Station	Readings			Rise	Fall	R.L	Remarks
	Back sight	Inter Sight	Fore Sight				

ARITHMATICAL CHECK:

Σ B.S – Σ F.S = Σ Rise – Σ Fall = Last R.L. – First R.L

Result: the results are to be plotted in the graph.

EXPERIMENT NO-6

Aim of the experiment: To plot contour map of a given area

Instruments Required: Dumpy level, levelling staff, tripod, peg, and chain 20m or 30m, tape.

Theory:

Contours: Contours are imaginary lines joining points of equal altitudes upon the earth's surface with reference to a fixed datum.

Contouring: The process by which a contour map is prepared is known as contouring.

Contour map/topographic map: The map showing the altitudes of all these points is called contour map or topographic map.

Contour Interval: The difference in elevation between successive contour lines.

Contour Spacing: The horizontal gap between successive contour lines.

There are two methods of contour surveying.

1. Direct method
2. Indirect method

Direct methods

It consists in finding vertical and horizontal controls of the points which lie on the selected contour line.

For vertical control leveling instrument is commonly used. A level is set on a commanding position in the area after taking fly levels from the nearby bench marks. The plane of collimation is found and the required staff reading for a contour line is calculated. The instrument men ask staff man to move up and down in the area till the required staff reading is found. A surveyor establishes a horizontal control of that point using this instrument. After that instrument man directs the staff man to other points where the same staff reading can be found. It is followed by establishing horizontal control. Thus several points are established on a contour line on one or two contour lines and noted down.

Indirect method

In this method levels are taken at some selected points and their levels are reduced. Thus in this method horizontal control is established first and then the levels of those points found. After locating the points on the plan, reduced levels are marked and contour lines are interpreted between the selected points.

For selecting points anyone of the following methods may be used:

1. Method of square
2. Method of cross section
3. Radial line method

Procedure

Method of square:

- Divide the total area into a number of squares and mark all grid points (Sizes of square vary from 5m*5m to 20m *20m).
- Establish levels of all grid points by leveling.
- Then plot grid square on the drawing sheet.
- Mark the reduced levels of grid points.
- Draw the contour lines by interpolation.

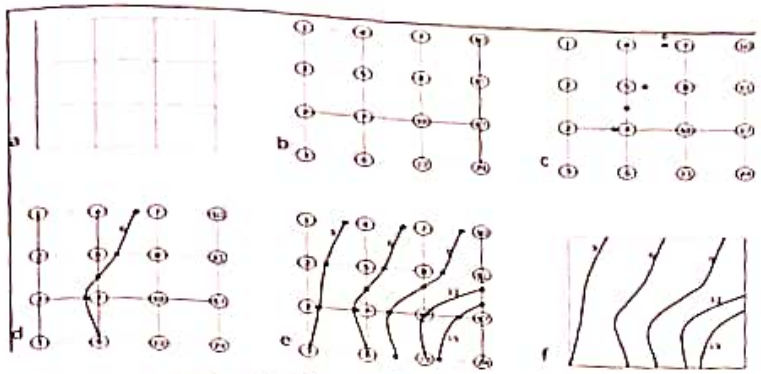


FIG. Details of contouring by method of square

Result: the contour map are plotted to be scale.

EXPERIMENT NO-7

Aim of the experiment: To measure horizontal and vertical angle between two points using theodolite.

Instruments Required: Transit theodolite, Tripod, ranging rod, pegs

Theory: Theodolite is an instrument designed for the measurement of horizontal and vertical angle. It is most precise method it is also used for laying of horizontal angles Locating points on line prolonging the survey line establishing the gradient, determination of difference in the elevation setting out curve .Theodolite are of two types transit and non transit. Transit theodolite is commonly used now a days .in transit theodolite telescope can be revolved a complete revolution about its horizontal axis in a vertical plane. A transit theodolite consists of essential part.

Various parts of transit theodolite:

1) ***Telescope:*** It is an integral part and is mounted on the spindle known as horizontal axis or turn on axis. Telescope is either internal or external focusing type.

2) ***The leveling head:*** It may consists of circular plates called as upper and lower Parallel plates. The lower parallel plate has a central aperture through which a plumb bob may be suspended. The upper parallel plate or tribranch is supported by means of four or three leveling screws by which the instrument may be leveled.

3) ***To lower plate or screw plate:*** It carries horizontal circle at its leveled screw. It carries a lower clamp screw and tangent screw with the help of which it can be fixed accurately in any desired position.

4) ***The upper plate or vernier plate:*** It is attached to inner axis and carries two vernier and at two extremities diametrically opposite.

5) ***Compass:*** The compass box may be either of circular form or of a rough type. The former is mounted on the vernier plate between the standards while the latter is attached to the underside of the scale or lower plate or screwed to one of the standards. Modern theodolite is fitted with a compass of the tubular type and it is screwed to one of the standards.

6) ***Vertical circle:*** The vertical circle is rigidly attached to the telescope and moves with it. It is silvered and it is usually divided into four quadrants.

7) ***Index bar or T-frame:*** The index bar is T shaped and centered on horizontal axis of the telescope in front of the vertical axis. It carries two vernier of the extremities of its horizontal arms or limbs called the index arm. The vertical leg called the clip or clipping screws at its lower extremity. The index arm and the clipping arm are together known as T-frame.

8) ***Clamps and tangent screws*** There are two clamps and associated tangent screws with the plate. These screws facilitate the motion of the instruments in horizontal plane. Lower clamp screw locks or releases the lower plate. When this screw is unlocked both upper and lower plates move together. The associated lower tangent screw allows small motion of the plate in locked position. The upper clamp screw locks or releases the upper vernier plate. When this clamp is released the lower plate does not move but the upper vernier plate moves with the instrument. This causes the change in the reading. The upper tangent screw allows the fine adjustment

9) ***Vertical circle clamp and tangent screw (11):*** Clamping the vertical circle restrict the movement of telescope in vertical plane.

10) Altitude level (2): A highly sensitive bubble is used for levelling particularly when taking the vertical angle observations.

11) ***Plumb bob:*** To center the instrument exactly over a station mark, a plumb bob is suspended from the hook fitted to the bottom of the central vertical axis.

Temporary adjustments of theodolite:

The temporary adjustments are steps that must be carried out every time at theodolite is used. It is a procedure of setting up a theodolite that involves the following process:

A) Centering

The operation of setting includes:

1. Centring of instrument over the station mark by plumb Bob.
2. Approximate levelling with the help of Tripod legs.

B) Leveling

After the centring and approximate levelling , The accurate levelling is done with the help of foot screws and with reference to the plate levels.The levelling of instrument by the plate levels depend upon whether the instrument has three levelling screws or four levelling screws.

C)Elimination of parallax

It is arised when the image formed by the objective is not in the plane of the cross-hairs . Parallax is eliminated in two steps :

1. By focusing the eye-piece .
2. By focusing the objective.

Focusing the eye-piece : To focus the eye-piece for distinct visions of the cross-hairs, hold a sheet of white paper in front of objective and move eyepiece in and out till the cross hairs are seen sharp and distinct. *Focusing the objective :* The Telescope is now directed towards the object to be sighted and the focusing screw is turned till the image appears clear and sharp.

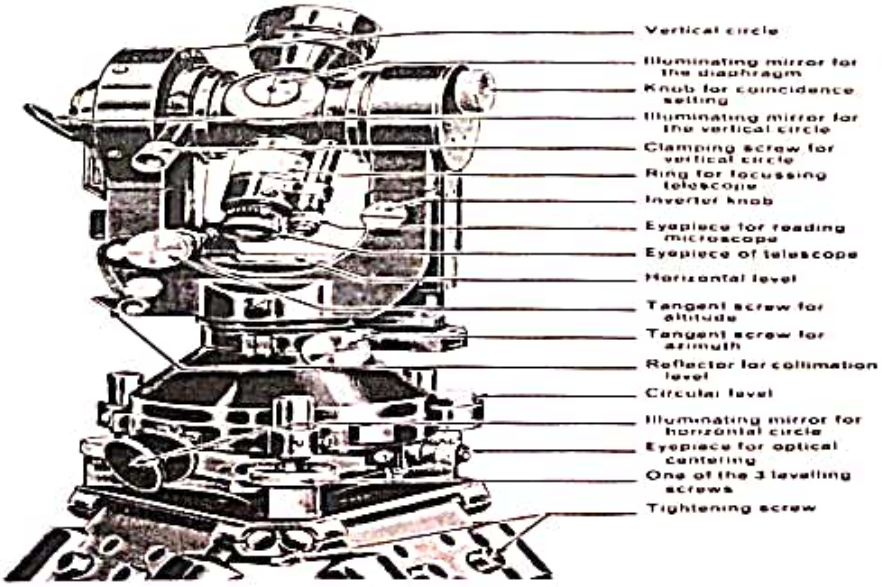


FIG. Details of transit theodolite

Procedure:

Measurement of horizontal angles:-

- Set the theodolite over '0'. Take make the vernier at 0°0'0".
- To set the reading at 0°0'0" loose the upper plate till zero of vernier plate coincide with lower horizontal circle at 0°.
- Turn the telescope to bisect ranging rod at P using clamp screw to exact bisect P point.
- Now unclamp the upper plate and turn the telescope in clockwise direction to bisect ranging rod at R is bisected, clamp upper plate.
- Read both reading.
- Change the face to repeat the process, mean of the face reading gives <POR.

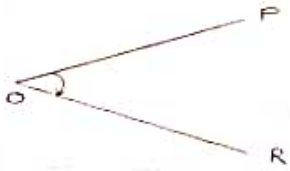


FIG. Measurement of horizontal angle by theodolite

Measurement of vertical angle:

To measure the vertical angle of an object P

- Set up the instrument over station O and level it carefully with respect to altitude bubble.
- By means of vertical circle clamp and tangent screw, set 0 of the vertical circle exactly to 0 of the circle.
- Bring the bubble of the altitude level to the centre of its run by means of foot &clip screw. The line of sight is thus made horizontal.
- Loose the vertical circle clamp and direct the telescope in vertical plane towards the object P, and bisect exactly using vertical tangent screw.
- Read both the verniers
- The mean of two readings gives angle for that face.
- Change the face and repeat the above process, and get the face reading.
- The average of two face values gives exact value of required vertical angle.

FIG. Measurement of vertical angle by theodolite

Calculation

Horizontal angles

Station	Object	Face	Reading		Reading		Mean Vernier A	Mean Vernier B	Mean Face angle
			Vernier A		Vernier B				
			Initial	Final	Initial	Final			

Vertical angle

Station	Object	Face	Reading		Reading		Mean Vernier A	Mean Vernier B	Mean Face angle
			Vernier A		Vernier B				
			Initial	Final	Initial	Final			

Result: The horizontal and vertical angle is found as _____ & _____.

EXPERIMENT NO-8

Aim of the experiment: To determine the lengths and included angles between the lines of an open traverse with the use of Theodolite by following included angle method.

Instruments Required: 1.Theodolite, 2.Ranging rods, 3. Pegs or Arrows, 4. Chain/Tape

Theory:

"The traversing, in which the traverse legs are measured by direct chaining on ground and the traverse angle at every traverse station is measured with a theodolite, is known as theodolite traversing."
There are different methods of theodolite traversing as follows:

1. Included angle method
2. Deflection angle method

The included angle method consists simply in measuring each angle directly from a back sight on the preceding station. The angled may also be measured by repetition. The angles measured from the back station may be interior or exterior depending on the direction of progress.

Procedure:

- Set the instrument over the station "P" and make all the temporary adjustments. Orient the telescope along the magnetic meridian and the magnetic meridian of PQ is measured.
- Set reading 0°0'0" at vernier A by using upper clamp and tangent screw and keep the face of Theodolite as left.
- Bring the telescope back in the line of PT with the help of lower clamp and tangent screw, keep the reading in vernier A as 0°0'0" and the reading in vernier B as 180°0'0".
- Loosen the Upper clamp and turn the telescope clockwise and bisect "Q". Clamp the Upper clamp and bisect "Q" is exactly using tangent screws.
- Read and note Both the verniers of A and B. Determine Mean of the two verniers as an included angle QPT.
- Change the face and repeat all the above steps to determine one more included angle QPT.
- Shifted the theodolite to second station Q. Bisect the station P and repeat whole process to get an included angle of RQP.
- Similarly measure angles at R,S and T.
- measure lengths of traverse lines PQ,QR,RS,ST and TP by using a tape or chain.

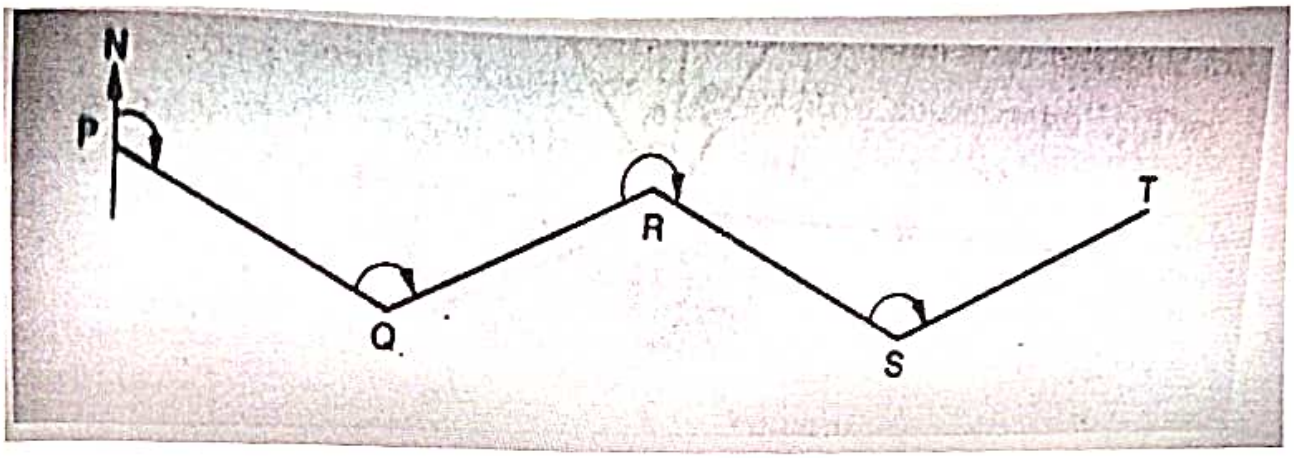


FIG. Open traverse PQRST

Calculation:

Inst stn	Sight to	Face:- A					Swing:- Mean			Horizontal angle			Face:- A					Swing:- Mean			Horizontal angle			Avg. Hori. angle		
		°	'	"	°	'	°	'	"	°	'	"	°	'	"	°	'	°	'	"	°	'	"	°	'	"

Result: Calculate all the angles and length of sides.

1. **The included angle between the lines**

I) Face Left	II) Face Right
∠QPT =	∠ QPT =
∠ RQP =	∠ RQP =
∠ SRQ =	∠ SRQ =
∠TSR =	∠ TSR =
∠PTS =	∠ PTS =

2. Length of lines
   - i) PT =
   - ii) TS =
   - iii) SR =
   - iv) RQ =
   - v) QP =

EXPERIMENT NO-9

Aim of the experiment: To study working principle of digital theodolite & measure horizontal & vertical angle between two points.

Instruments Required: 1. Digital theodolite 2. Tripods 3. Batteries and Chargers 4.Data and Power cables

Theory: Digital theodolite is a modern engineering instrument for measuring both horizontal and vertical angles. It is a key tool in surveying and engineering work. The theodolite consists of a telescope movable within two perpendicular axes- the horizontal axis, and the vertical axis. When the telescope is pointed at a desired object, the angle of each of these axes can be measured with great precision. The following preparation must be done before staring survey work.

a. Setting up the instrument

1. Setting up the tripod 2. Setting up instrument on the tripod

b. Levelling the instrument

1. Levelling with the bubble 2. Levelling precisely by the Plate level

c. Centring

1. Centering with laser plummet 2. Centring with the optical plummet

d. Focusing and Sighting

1. Reticle Cross Hairs 2. Target Image Focusing

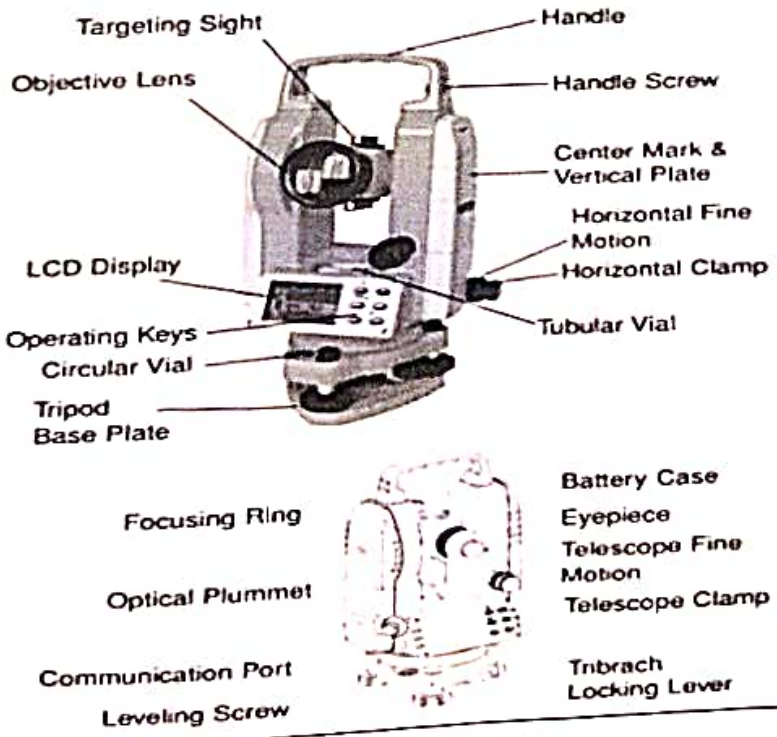


FIG. Details of digital theodolite

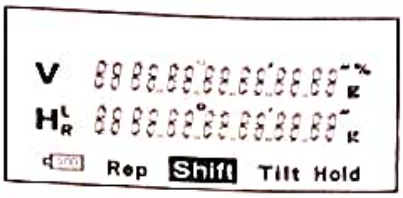


Fig.4

Display	Description	Display	Description
	Battery indicator		
Rep	Repeat angle measurement	Tilt	Tilt sensor work mode
Shift	The second function key mode	Hold	Horizontal angle is holding
%	Percent grade	HL	Horizontal angle left
V	Zenith angle	HR	Horizontal angle right
g	Unit display GON	° ' "	Unit display DEG

FIG. Description of display unit

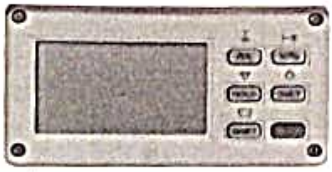


Fig.5

First function of key board

Key	Short press(<2s)	Long press (≥2s)
⏻	Power on or off	
SHIFT	Active the second function of keys	Send data to other equipment through RS-232C
HOLD	Holding measured horizontal angle	No response
0SET	Set horizontal angle to 0° 00' 00"	No response
V/%	Select the zenith angle or grade angle	No response
R/L	Select the right or left horizontal angle	No response

Second function of key board

Key	Short press(<2s)	Long press (≥2s)
⏻	Power on or off	
SHIFT	Active the second function of keys	Send data to other equipment through RS-232C
HOLD	Enter repeat angle measurement mode	No response
0SET	LCD and telescope reticle lamp on/off	Compensator on/off
V/%	Turn on/off telescope laser point	Adjust intensity of laser point
R/L	Turn on/off laser plummet	No response

FIG. Description of function of operational keys

Procedure:

Horizontal angle measurement

- Switch on.
- Check battery indicator.
- Check LCD illumination is ON or OFF.
- Select direction of angle measurement (H_R or H_L).
- Set unit of angle (360°or 400gon).
- Set horizontal angle to 0°or set to arbitrary value.(0SET or HOLD)
- Aim target.
- Read the displayed value.
- Go on next measurement item.
- Complete measurement and turn off.

Vertical angle measurement

- Switch on.
- Check battery indicator.
- Check LCD illumination is ON or OFF.
- Set unit of angle (360°or 400gon).
- Select vertical angle measurement mode (zenith V, grade %).
- Aim target.
- Read the displayed value.
- Go on next measurement item.
- Complete measurement and turn off.

Note: Both of horizontal and vertical angle can be measured at the same time.

Result: The horizontal & vertical angle is found as _____ & _____ .

EXPERIMENT NO-10

Aim of the experiment: To find horizontal & vertical angle between two points and to plot contour map a small area by using Total Station.

Instruments Required: 1. Total Station, 2. Tripods 3. Batteries and Chargers 4.Data and Power cables

5.Prisms 6.Prism Poles 7.Tribraches

Theory:

Total station is a surveying equipment combination of Electromagnetic Distance Measuring Instrument and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping distance of object to the instrument.

Total stations with different accuracy, in angle measurement and different range of measurements are available in the market. Figure 1 & 2 represents one such instrument & all the accessories associated with it.

Important Operations of Total Station:

1 Distance Measurement: Electronic distance measuring (EDM) instrument is a major part of total station. Its range varies from 2.8 km to 4.2 km. The accuracy of measurement varies from 5 mm to 10 mm per km measurement. They are used with automatic target recognizer. The distance measured is always sloping distance from instrument to the object.

2.Angle Measurements: The electronic theodolite part of total station is used for measuring vertical and horizontal angle. For measurement of horizontal angles any convenient direction may be taken as reference direction. For vertical angle measurement vertical upward (zenith) direction is taken as reference direction. The accuracy of angle measurement varies from 2 to 6 seconds.

3.Data Processing: The instrument is provided with an inbuilt microprocessor. The microprocessor averages multiple observations. With the help of slope distance and vertical and horizontal angles measured, when height of axis of instrument and targets are supplied, the microprocessor computes the horizontal distance and X, Y, Z coordinates. The processor is capable of applying temperature and pressure corrections to the measurements, if atmospheric temperature and pressures are supplied.

Advantages of Using Total Stations

The following are some of the major advantages of using total station over the conventional surveying instruments:

1. Field work is carried out very fast.

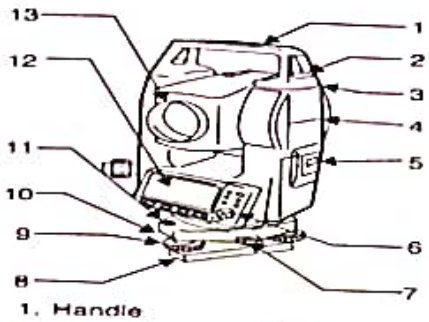
2. Accuracy of measurement is high.

3. Manual errors involved in reading and recording are eliminated.

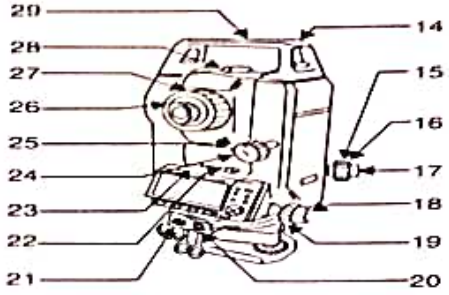
4. Calculation of coordinates is very fast and accurate. Even corrections for temperature and pressure are automatically made.

5. Computers can be employed for map making and plotting contour and cross-sections. Contour intervals and scales can be changed in no time.

However, surveyor should check the working condition of the instruments before using. For this standard points may be located near survey office and before taking out instrument for field work, its working is checked by observing those standard points from the specified instrument station.



1. Handle
2. Handle securing screw
3. Data input/output terminal (Remove handle to view)
4. Instrument height mark
5. Battery cover
6. Operation panel
7. Tribrach clamp (SET300S/500S/600S: Shifting clamp)
8. Base plate
9. Levelling foot screw
10. Circular level adjusting screws
11. Circular level
12. Display
13. Objective lens
14. Tubular compass slot
15. Optical plummet focussing ring



16. Optical plummet reticle cover
17. Optical plummet eyepiece
18. Horizontal clamp
19. Horizontal fine motion screw
20. Data input/output connector (Besides the operation panel on SET600/600S)
21. External power source connector (Not included on SET600/600S)
22. Plate level
23. Plate level adjusting screw
24. Vertical clamp
25. Vertical fine motion screw
26. Telescope eyepiece
27. Telescope focussing ring
28. Peep sight
29. Instrument center mark

FIG : Details of Total Station

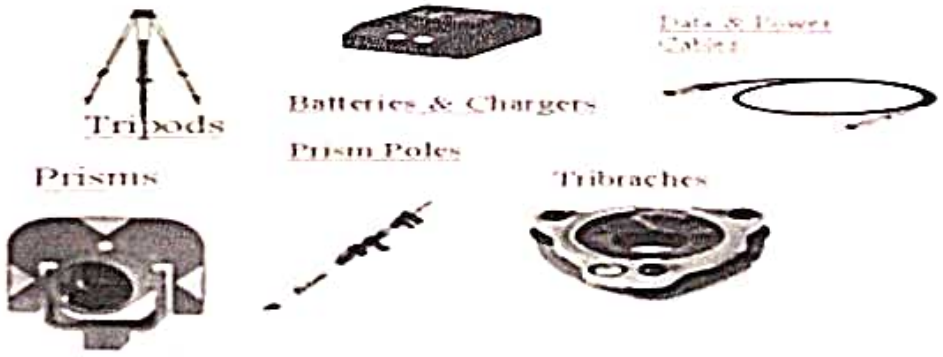


FIG : Accessories Used with Total Station

Procedure:

- Mount the total station instrument on a tripod and level it by operating levelling screws (Within a small range instrument is capable of adjusting itself to the level position).
- Then book vertical and horizontal reference directions by using onboard keys.
- Set required units for distance, temperature and pressure (FPS or SI).
- By sighting the target, measure horizontal and vertical angles as well as sloping distances and by pressing appropriate keys record data along with point number.
- Record heights of instrument and targets after measuring them with tapes. Then processor computes various information about the point and displays on screen.

- This information is also stored in the electronic notebook. Download the stored informations to computer at the end of the day or whenever electronic note book is full.
- There are software like auto civil and auto plotter clubbed with AutoCad which can be used for plotting contours at any specified interval and for plotting cross-section along any specified line.

Result : The horizontal & vertical angle is found as _____ & _____.

Plot the contour map by using the data stored by total station on sheet.

Rules & Guidelines for conducting Lab-Work

- Students are not allowed to touch any equipment, chemicals or other materials in the laboratory area until you are instructed by Teacher or Technician.
- Before starting Laboratory work follow all written and verbal instructions carefully. If you do not understand a direction or part of a procedure, ask your concern teacher before proceeding with the activity.
- Before use equipment must be read carefully Labels and instructions.
- Set up and use the equipment as directed by your teacher. If you do not understand how to use a piece of equipment, ask the teacher for help!
- Perform only those experiments authorized by your teacher.
- Carefully follow all instructions, both written and oral.
- Unauthorized experiments are not allowed in the Laboratory.
- Students are not allowed to work in Laboratory alone or without presence of the teacher.
- Any failure / break-down of equipment must be reported to the teacher.
- Protect yourself from getting electric shock.

Dos and Don'ts

Dos:

- Center and level the base of Auto Level accurately.
- Crosshairs must be focused sharply.
- Keep the Back sight and Foresight distances nearly equal to compensate for collimation error, if any.
- Always take 3 or more observations of each point to take the average.
- Take sufficient number of observations at regular interval along and across the direction of survey, so as to represent the ground profile (Longitudinal and Cross-sectional) accurately.
- In Profile Levelling, use Height of Instrument Method for computation of RL's.
- Apply checks after computing RL's.
- Find closing error and distribute it.

Don'ts:

- Handle the Auto Level with utmost care. If dropped accidently, it may damage compensator and digital display.
- If using aluminum staff, be away from electric poles, transformers and wires.
- While shifting the instrument from one station to another station, always keep it in box for transport.
- Protect the instrument from heavy rains.