INSITUTE OF ENGINEERING & MANAGEMENT, JEYPORE (K)

Laboratory Manual

SURVEY PRACTICE-II

DEPARTMENT OF CIVIL ENGINEEERING

LIST OF EXPERIMENTS

EXPERIMENT NO-1

AIM OF THE EXPERIMENT: - To study of essential features and parts of different types of levels.

THEORY:-

Differential levelling is the term applied to any method of measuring directly with a graduated staff the difference in elevation between two or more points.

Precise levelling is a particularly accurate method of differential levelling which uses highly accurate levels and with a more rigorous observing procedure than general engineering levelling. It aims to achieve high orders of accuracy such as 1 mm per 1 km traverse.

A level surface is a surface which is everywhere perpendicular to the direction of the force of gravity. An example is the surface of a completely still lake. For ordinary levelling, level surfaces at different elevations can be considered to be parallel.

A level datum is an arbitrary level surface to which elevations are referred. The most common surveying datum is mean sea-level (MSL), but as hydrological work is usually just concerned with levels in a local area, we often use:

An assumed datum which is established by giving a benchmark an assumed value (e.g. 100.000 m) to which all levels in the local area will be reduced. It is not good practice to assume a level which is close to the actual MSL value, as it creates potential for confusion.

A reduced level is the vertical distance between a survey point and the adopted level datum.

A bench mark (BM) is the term given to a definite, permanent accessible point of known height above a datum to which the height of other points can be referred.

EQUIPMENTS:-

The level, its tripod, the staff and the staff bubble are all precision items of equipment upon which the accuracy of the work is highly dependent. They shall be kept correctly calibrated, and be used and stored with care.

Levels

A level is basically a telescope attached to an accurate levelling device, set upon a tripod so that it can rotate horizontally through 360°. Normally the levelling device is a bubble, but modern ones incorporate a pendulum. There are three basic types of level and described below:

(a) Dumpy levels

These are more basic levels often used in construction work. The telescope is rigidly attached to a single bubble and the assembly is adjusted either by means of a screwed ball-joint or by footscrews which are adjusted first in one direction, then at 90°.

(b) Tilting levels

This type of level is fitted with a circular bubble for preliminary approximate levelling and a main bubble which is attached to the telescope. For each observation (not setup) the main bubble is viewed through an eyepiece and the telescope tilted by a fine screw to bring the two ends of the bubble into coincidence.

(c) Automatic levels

This more modern type of level is now in general use. It has a compensator which consists of an arrangement of three prisms. The two outer ones are attached to the barrel of the telescope. The middle prism is suspended by fine wiring and reacts to gravity. The instrument is first levelled approximately with a circular bubble; the compensator will then deviate the line of sight by the amount that the telescope is out of level.

Levelling procedures

Setting up

(a) Backsight and foresight distances should be approximately equal to avoid any errors due to collimation, refraction or earth curvature.
(b) Distances must not be so great as to not be able to read the graduations accurately.
(c) The points to be observed must be below the level of the instrument, but not lower than the height of the staff.

Elimination of parallax

Parallax is the apparent movement of the image produced by movement of the observer's eye at the eyepiece. It is eliminated by focusing the telescope on infinity and then adjusting the eyepiece until the cross-hairs appear in sharp focus. The setting will remain constant for a particular observer's eye.

PROCEDURE:-

Two methods are in general use; the "rise and fall" method and the "height of collimation" method. The latter reduces levels relative to the instrument height. As it has inferior in-built checks it should not be used and will not be covered here.

The "rise and fall" methods shall be used for reduction of all site levelling. Reduction shall be carried out on site before packing up to ensure that the levelling has been done correctly.

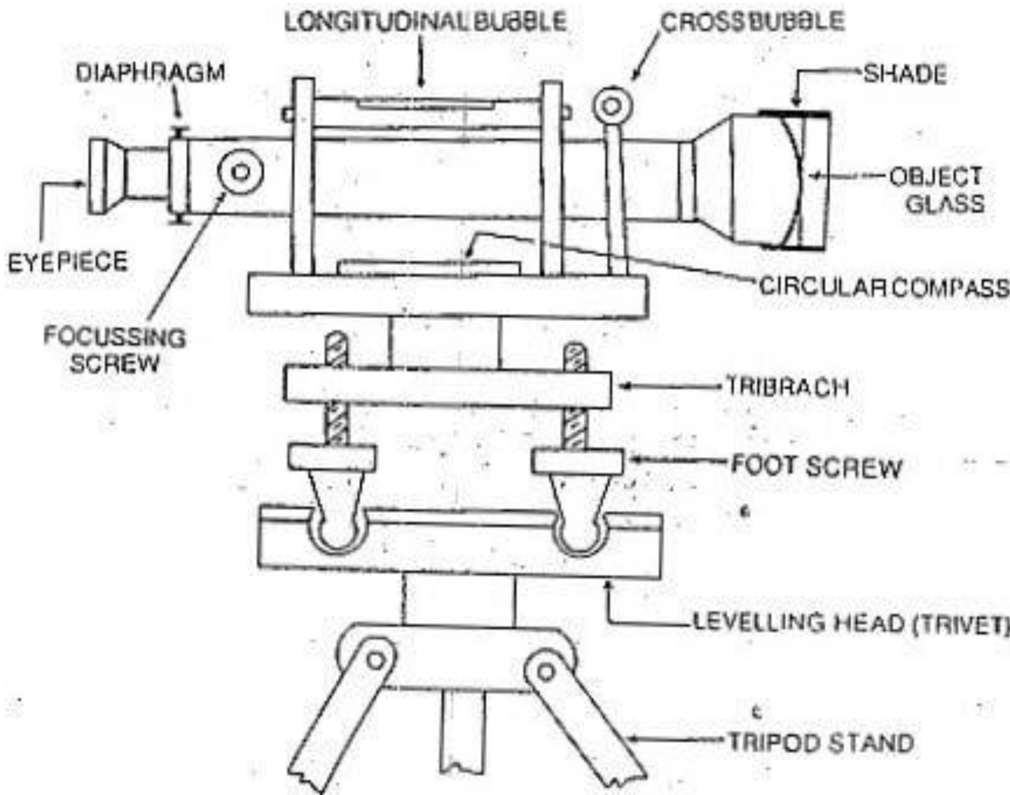
• calculate the rises and fall between successive points and book them in the appropriate column (one can determine whether each shot is a rise or fall by the following rule of thumb: a higher value on top denotes a rise; a higher value on the bottom denotes a fall)

• add up the back sight and foresight columns for the entire traverse and note the difference between them; this is the close

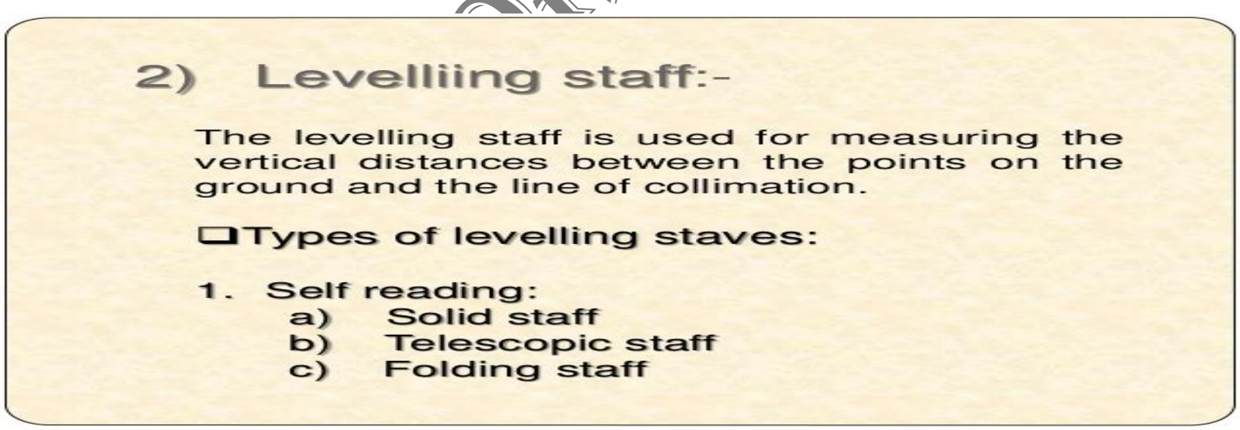
• add up the rises and falls for the entire traverse, and compare the difference between them with the difference between the back sights and foresights; they should be the same.

• carry the reduced levels in the R.L. column down the page by adding or subtracting the appropriate rise and fall values to the successive values of R.L. The final value of the original starting point will differ from the original value by the amount of the close.

DIFFERENT PARTS OF A DUMPY LEVEL



Levelling staff



Along with a level, a levelling staff is also required for levelling. The levelling staff is a rectangular rod having graduations. The staff is provided with metal shoes at its bottom to resist wear and tear. The foot of the shoe represents zero reading. Levelling staff may be divided into two groups:

i)Self reading staff (ii) Target staff.

(i) Self reading staff: This staff reading is directly read by the instrument man through telescope.
In a metric system staff, one meter length is divided into 200 subdivisions, each of uniform thickness of 5 mm. All divisions are marked with black in a white background. Metres and decimeters are written in red colour

The following three types of self reading staffs are available:
(a) Solid staff: It is a single piece of 3 m.
(b) Folding staff: A staff of two pieces each of 2 m which can be folded one over the other.
(c) Telescopic staff: A staff of 3 pieces with upper one solid and lower two hollow. The upper part can slide into the central one and the central part can go into the lower part. Each length can be pulled up and held in position by means of brass spring. The total length may be 4 m or 5 m

(ii) Target staff: If the sighting distance is more, instrument man finds it difficult to read self reading staff. In such case a target staff shown in may be used. Target staff is similar to self reading staff, but provided with a movable target. Target is a circular or oval shape, painted red and white in alternate quadrant. It is fitted with a vernier at the centre. The instrument man directs the person holding target staff to move the target, till its centre is in the horizontal line of sight. Then target man reads the target and is recorded.

<u>Temporary adjustment of levelling</u>

The adjustments to be made at every setting of the instrument are called temporary adjustments. The following three adjustments are required for the instrument whenever set over a new point before taking a reading:

(i) Setting (ii) Levelling and
(iii) Focussing.

Setting
Tripod stand is set on the ground firmly so that its top is at a convenient height. Then the level is fixed on its top. By turning tripod legs radially or circumferentially, the instrument is approximately levelled.
Some instruments are provided with a less sensitive circular bubble on tribrach for this purpose.
Levelling The procedure of accurate levelling with three levelling screw is as given below:
(i) Loosen the clamp and turn the telescope until the bubble axis is parallel to the line joining any two screws [Ref. Fig. 15.5 (a)].

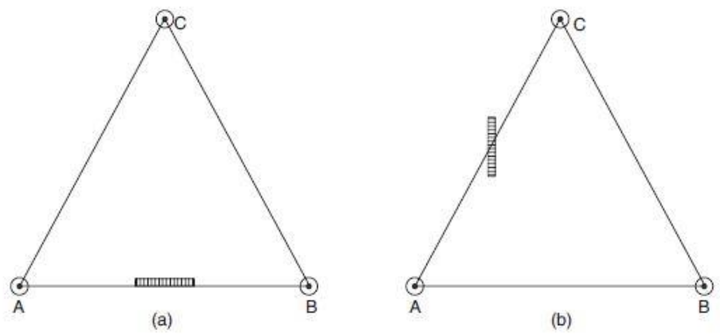


Fig. 15.5

(ii) Turn the two screws inward or outward equally and simultaneously till bubble is centred.
(iii) Turn the telescope by 90° so that it lies over the third screw [Fig. 15.4 (b)] and level the instrument by operating the third screw.
(iv) Turn back the telescope to its original position [Fig. 15.5 (a)] and check the bubble. Repeat steps (ii) to (iv) till bubble is centred for both positions of the telescope.
(v) Rotate the instrument by 180°. Check the levelling.

Focussing

Focussing is necessary to eliminate parallax while taking reading on the staff. The following two steps are required in focussing:
(i) Focussing the eyepiece: For this, hold a sheet of white paper in front of telescope and rotate eyepiece in or out till the cross hairs are seen sharp and distinct.
(ii) Focussing the objective: For this telescope is directed towards the staff and the focussing screw is turned till the reading appears clear and sharp.

CONCLUSION:

From the above experiment we study about the theory of levelling and temporary adjustment of level.

<u>EXPERIMENT NO- 2</u>

AIM OF THE EXPERIMENT: - To Determine the difference of levels between two points by taking staff readings from single set up of levels.

EQUIPMENTS/APPARATUS REQUIRED:

- Dumpy Level
- Levelling Staff
- Ranging rod
- Chain

THEORY:-

Carrying out a level traverse

To determine the difference in level between points on the surface of the ground a 'series' of levels will need to be carried out; this is called a *level traverse* or *level run*.

Leveling or Field Procedures

The leveling or field procedure that should be followed is shown in Figure 1 below..

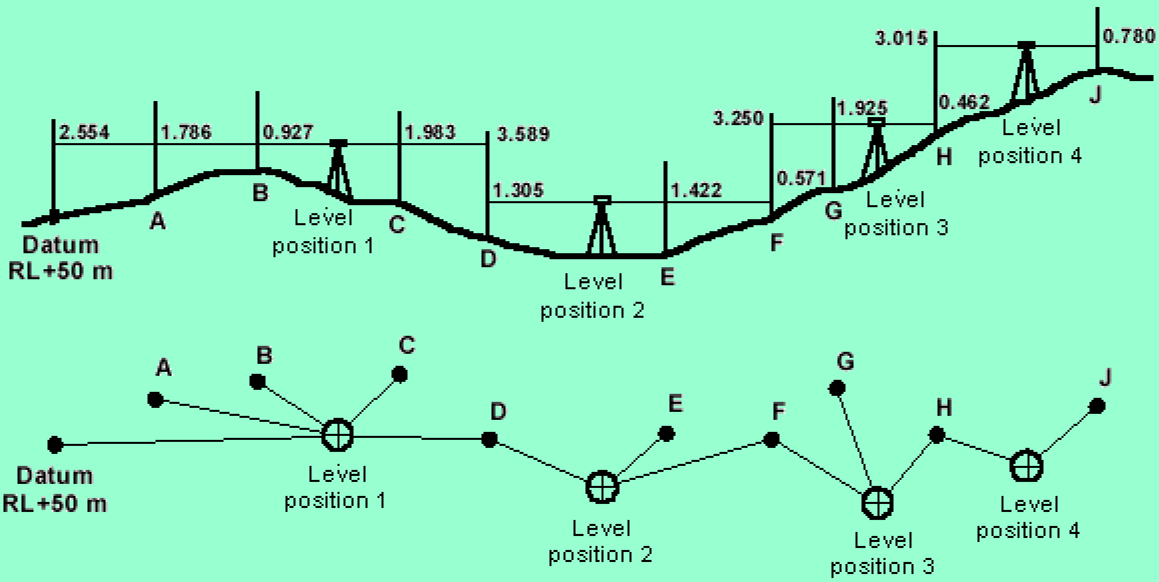


Figure 1

Procedure:

1. Set up the leveling instrument at Level position 1.
2. Hold the staff on the Datum (RL+50 m) and take a reading. This will be a backsight, because it is the first staff reading after the leveling instrument has been set up.
3. Move the staff to **A** and take a reading. This will be an intermediate sight.
4. Move the staff to **B** and take a reading. This also will be an intermediate sight.
5. Move the staff to **C** and take a reading. This will be another intermediate sight.
6. Move the staff to **D** and take a reading. This will be a foresight; because after this reading the level will be moved. (A changeplate should be placed on the ground to maintain the same level.)
7. The distance between the stations should be measured and recorded in the fieldbook (see Table 1)
8. Set up the level at Level position 2 and leave the staff at **D** on the changeplate. Turn the staff so that it faces the level and take a reading. This will be a backsight.
9. Move the staff to **E** and take a reading. This will be an intermediate sight.

10. Move the staff to **F** and take a reading. This will be a foresight; because after taking this reading the level will be moved.
11. Now move the level to Leveling position 3 and leave the staff at **F** on the changeplate. Now repeat the steps describe 8 to 10 until you finished at point **J**.

Field procedures for leveling

All staff readings should be recorded in the fieldbook. To eliminate errors resulting from any line of sight (or collimation) backsights and foresights should be equal in distance. Length of sight should be kept less than 100 metres. Always commence and finish a level run on a known datum or benchmark and close the level traverse; this enables the level run to be checked.

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Booking levels

There are two main methods of booking levels:

- rise and fall method
- height of collimation method

Table 1 Rise & Fall Method

Back-sight	Inter-mediate	Fore-sight	Rise	Fall	Reduced level	Distance	Remarks
2.554					50.00	0	**Datum** RL+50 m
	1.783		0.771		50.771	14.990	**A**
	0.926		0.857		51.628	29.105	**B**
	1.963			1.037	50591	48.490	**C**
1.305		3.587		1.624	48.967	63.540	**D** / change point **1**
	1.432			0.127	48.840	87.665	**E**
3.250		0.573	0.859		49.699	102.050	**F / change point 2**
	1.925		1.325		51.024	113.285	**G**
3.015		0.496	1.429		52.453	128.345	**H** / change point **3**
		0.780	2.235		54.688	150.460	**J**
10.124		**5.436**	**7.476**	**2.788**	**54.688**		Sum of B-sight & F-sight, Sum of Rise & Fall
-5.436			-2.788		-50.000		Take smaller from greater

4.688			**4.688**		**4.688**		Difference should be equal

The millimeter reading may be taken by estimation to an accuracy of 0.005 metres or even less.

1. Backsight, intermediate sight and forsight readings are entered in the appropriate columns on different lines. However, as shown in the table above backsights and foresights are place on the same line if you change the level instrument.
2. The first reduced level is the height of the datum, benchmark or R.L.
3. If an intermediate sight or foresight is **smaller** than the immediately preceding staff reading then the difference between the two readings is place in the **rise** column.
4. If an intermediate sight or foresight is **larger** than the immediately preceding staff reading then the difference between the two readings is place in the **fall** column.
5. A rise is added to the preceding reduced level (RL) and a fall is subtracted from the preceding RL

Arithmetic checks

While all arithmetic calculations can be checked there is no assurance that errors in the field procedure will be picked up. The arithmetic check poves only that the rise and fall is correctly recorded in the approriate rise & fall columns. To check the field procedure for errors the level traverse **<u>must</u>** be closed. It is prudent to let another student check your reading to avoid a repetition of the level run

If the arithmetic calculation are correct, the the difference between the sum of the backsights and the sum of the foresights will equal:

- the difference between the sum of the rises and the sum of the falls, and

- the difference between the first and the final R.L. or vice versa.
  (there are no arithmetic checks made on the intermediate sight calculations. Make sure you read them carefully)

Table 2 Height of collimation method (height of instrument)

Back-sight	**Inter-mediate**	**Fore-sight**	**Height of collimation**	**Reduced level**	**Distance**	**Remarks**
2.554			52.554	50.00	0	**Datum** RL+50 m
	1.783			50.771	14.990	**A**
	0.926			51.628	29.105	**B**
	1.963			50591	48.490	**C**
1.305		3.587	50.272	48.967	63.540	**D** / change point **1**

	1.432			48.840	87.665	**E**
3.250		0.573	52.949	49.699	102.050	**F / change point 2**
	1.925			51.024	113.285	**G**
3.015		0.496	55.468	52.453	128.345	**H** / change point **3**
		0.780		54.688	150.460	**J**
10.124		**5.436**		**54.688**		Sum of B-sight & F-sight, Difference between RL's
-5.436				-50.000		Take smaller from greater
4.688				**4.688**		Difference should be equal

1. Booking is the same as the rise and fall method for back-, intermediate- and foresights. There are no rise or fall columns, but instead a height of collimation column.
2. The first backsight reading (staff on datum, benchmark or RL) is added to the first RL giving the height of collimation.
3. The next staff reading is entered in the appropriate column but on a new line. The RL for the station is found by subtracting the staff reading from the height of collimation
4. The height of collimation changes only when the level is moved to a new position. The new height of collimation is found by adding the backsight to the RL at the change point.
5. Please note there is no check on the accuracy of intermediate RL's and errors could go undetected.

CONCLUSION:- From the above experiment we have calculated the difference in level by different method of levelling.

EXPERIMENT NO- 3

AIM OF THE EXPERIMENT: To locate contour points in the given area by direct method

THEORY

Contouring in surveying is the determination of elevation of various points on the ground and fixing these points of same horizontal positions in the contour map.

To exercise vertical control leveling work is carried out and simultaneously to exercise horizontal control chain survey or compass survey or plane table survey is to be carried out.

If the theodolite is used, both horizontal and vertical controls can be achieved from the same instrument. Based on the instruments used one can classify the contouring in different groups.

Contour Maps and Its Uses

A contour maps consists of contour lines which are imaginary lines connecting points of equal elevation. Such lines are drawn on the plan of an area after establishing reduced levels of several points in the area.

The contour lines in an area are drawn keeping difference in elevation of between two consecutive lines constant. For example, the contour map in fig. 1 shows contours in an area with contour interval of 1 m. On contour lines the level of lines is also written.

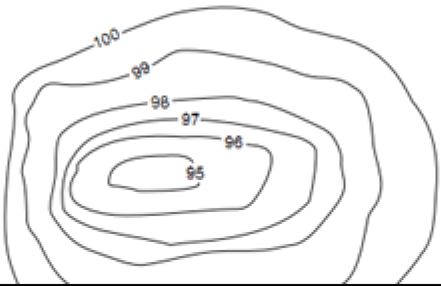

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Fig. 1: Contours

Characteristics of Contour Maps

The contours maps have the following characteristics:

1. Contour lines must close, not necessarily in the limits of the plan.
2. Widely spaced contour indicates flat surface.
3. Closely spaced contour indicates steep ground.
4. Equally spaced contour indicates uniform slope.
5. Irregular contours indicate uneven surface.
6. Approximately concentric closed contours with decreasing values towards centre (Fig. 1) indicate a pond.
7. Approximately concentric closed contours with increasing values towards centre indicate hills.
8. Contour lines with U-shape with convexity towards lower ground indicate ridge

Methods of Contour Surveying

There are two methods of contour surveying:

1. Direct method
2. Indirect method

Direct Method of Contouring

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

For vertical control levelling instrument is commonly used. A level is set on a commanding position in the area after taking fly levels from the nearby bench mark. The plane of collimation/height of instrument is found and the required staff reading for a contour line is calculated.

The instrument man asks staff man to move up and down in the area till the required staff reading is found. A surveyor establishes the horizontal control of that point using his instruments.

After that instrument man directs the staff man to another point 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 suitably noted down. Plane table survey is ideally suited for this work.

After required points are established from the instrument setting, the instrument is shifted to another point to cover more area. The level and survey instrument need not be shifted at the same time. It is better if both are nearby to communicate easily.

For getting speed in levelling sometimes hand level and Abney levels are also used. This method is slow, tedious but accurate. It is suitable for small areas.

Radial Line Method

[Fig. 3]. In this method several radial lines are taken from a point in the area. The direction of each line is noted. On these lines at selected distances points are marked and levels determined. This method is ideally suited for hilly areas. In this survey theodolite with tacheometry facility is commonly used.

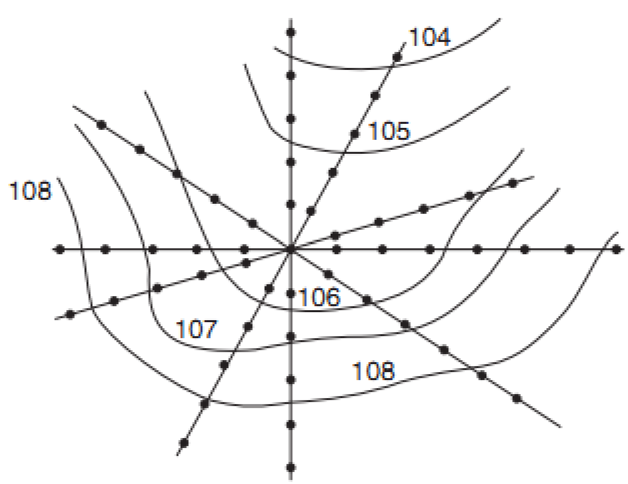


Fig. 3

For **interpolating contour points** between the two points any one of the following method may be used:

(a) Estimation

(b) Arithmetic calculation

(c) Mechanical or graphical method.

Mechanical or graphical method of interpolation

Consist in linearly interpolating contour points using tracing sheet:

On a tracing sheet several parallel lines are drawn at regular interval. Every 10th or 5th line is made darker for easy counting. If RL of A is 97.4 and that of B is 99.2 m. Assume the bottom most dark line represents 97 m RL and every parallel line is at 0.2 m intervals. Then hold the second parallel line on A.

Rotate the tracing sheet so that 100.2 the parallel line passes through point B. Then the intersection of dark lines on AB represents the points on 98 m and 99 m contours .

Similarly the contour points along any line connecting two neighbouring points may be obtained and the points pricked. This method maintains the accuracy of arithmetic calculations at the same time it is fast.

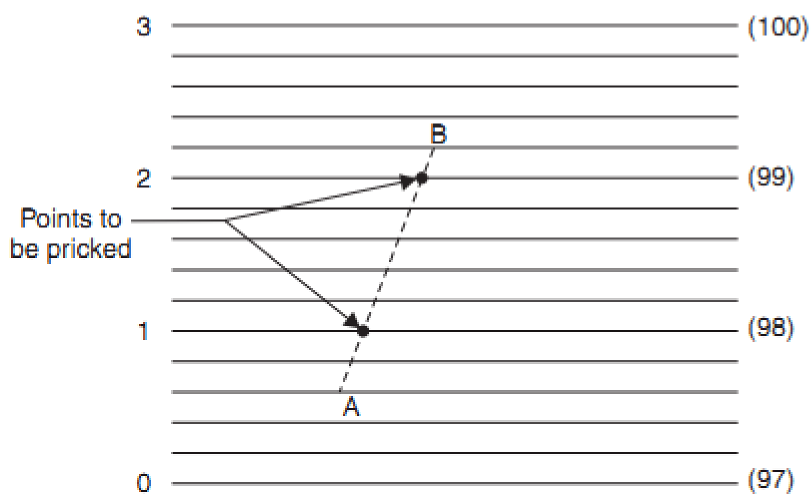


Fig. 4

Drawing Contours

After locating contour points smooth contour lines are drawn connecting corresponding points on a contour line. French curves may be used for drawing smooth lines. A surveyor should not lose the sight of the characteristic feature on the ground. Every fifth contour line is made thicker for easy readability. On every contour line its elevation is written. If the map size is large, it is written at the ends also.

Uses of Contour Maps

Contour maps are extremely useful for various engineering works:A civil engineer studies the contours and finds out the nature of the ground to identify. Suitable site for the project works to be taken up.

1. By drawing the section in the plan, it is possible to find out profile of the ground along that line. It helps in finding out depth of cutting and filling, if formation level of road/railway is decided.
2. Intervisibility of any two points can be found by drawing profile of the ground along that line.
3. The routes of the railway, road, canal or sewer lines can be decided so as to minimize and balance earthworks.
4. Catchment area and hence quantity of water flow at any point of nalla or river can be found. This study is very important in locating bunds, dams and also to find out flood levels.From the contours; it is possible to determine the capacity of a reservoir.

CONCLUSION:

From the above experiment we studied about method of the contour.

<u>EXPERIMENT NO- 4</u>

AIM OF THE EXPERIMENT: To study the essential features and parts of transit Theodolite and to describe the Theodolite with neat sketches.

THEORY:

Theodolite has many parts which needs to be adjusted every time while surveying. It is important to know about theodolite parts and their functions before using it to minimize errors during theodolite surveying.

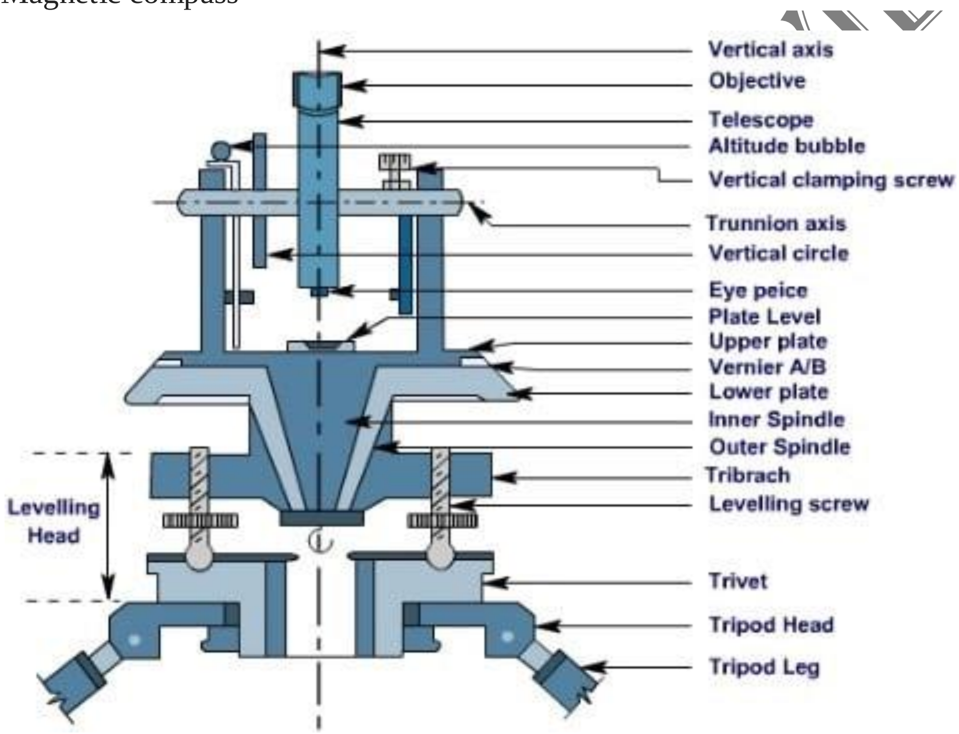
Theodolite is an instrument used in surveying to measure horizontal and vertical angles. It is also used for leveling, indirect measure of distances and prolonging a line etc. The line of sight of theodolite can be rotated through 180^{o} in vertical plane about its horizontal axis.

Parts of Theodolite and their Functions

Following are the parts of a theodolite:

- Telescope
- Vertical circle
- Index frame

- The standards
- The upper plate
- The lower plate
- The leveling head
- The shifting head
- Plate level
- Tripod
- Plumb bob
- Magnetic compass



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

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

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

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

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

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

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

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

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

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

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

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

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

Plumb Bob

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

Magnetic Compass

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

CONCLUSION:

From the above experiment we studied about transit Theodolite

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EXPERIMENT NO- 5

AIM OF THE EXPERIMENT: - To setting out a closed traverse with six sides.

THEORY:-

Introduction

Traverse Surveying is a popular method of surveying. This method used in the field of surveying to establish control networks. It is also used in geodesy. Traverse networks involve placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point.

There are two types of Traverse Surveying; closed traverse and open traverse, the closed traverse starts at a point and ends at the same point or at a point whose relative position is known. The surveyor adjusts the measurements by computations to minimize the effect of accidental errors made in the measurements. Large errors are corrected. This type of traverse is suitable for locating the boundaries of lakes, woods, etc and for survey of large areas. the open traverse is suitable for surveying a long narrow strip of land as required for a road of canal or the coast line.

Equipments

List of equipments and tools need to completing the test:

- Auto Level
- Staff
- Tripod
- Pen, Paper, and Calculator

Procedure

Steps of the test:

2

PROCEDURE:-

1. Select a place (point) as benchmark, and take the reading of the point as the first station.
2. Move the staff to another points around benchmark and take readings of some points.
3. After taking some points move the level to the new position, in this time the staff should not be moved.
4. During the test move the level to some different places, and taking readings, finally reading the benchmark again.

Calculation

Station	BS	IS	FS	HI	RL
1 (BM)	143.9			101.439	100
2		181.2			99.627
3 (TP1)	121.5		231.1	100.343	99.128
4		146.1			98.882
5		161.9			98.724
6		134			99.003
7		116.6			99.177
8		109.1			99.252
9 (TP2)	108		107.1	101.052	99.272
10		83.2			92.732
11			36.1		97.442

Σ BS = 3.734

Σ FS = 6.992

3

$\sum BS - \sum FS = -3.258$

Diff in RL of 1 and 11 = 97.442 – 100 = – 2.558

Result and Conclusion

In this fieldwork, we were required to carry out a closed traverse survey .Closed loop traverse is a traverse starts and ends at the same point, forming a closed geometric figure called a polygon which is the boundary lines of a tract land.

Overall, this fieldwork has taught us a lot of hands-on knowledge about the surveying. We are more understand that a land surveyor required to measure distances in order to build level, sound buildings or determine the boundaries of a piece of land. This profession, typically held by individuals with a degree in civil engineering, is a very important one that has existed for all of recorded human history.

EXPERIMENT NO- 6

AIM OF THE EXPERIMENT: - To setting out a simple circular curve by offsets from long chord

INSTRUMENTS REQUIRED:-

- Theodolite
- Chain
- Ranging rods
- Arrows and hammer

THEORY:-

Curve is defined as an arc provided between intersecting straight to negotiate a change in direction, the provision of a curve makes the change of direction not only easy and smooth, but also safe and comfortable, the straight or the tangent are the lines connected by the curve and they are tangential to the curve, the curvature is usually provided by simple curve.

Simple curve:

Simple curve is defined as a circular curve of single radius connecting two straight.

Back tangent:

The tangent AT_1 previous to the curve is called as the back tangent. It is also known as the forward tangent or rear tangent.

Forward tangent:

The tangent BT_2 following the curve is called as the forward tangent. It is also known as the second tangent.

Intersection and deflection angles:

The angle AVB between the tangent lines AV and BV is called the angle of intersection and the angle V'VB by which forward tangent deflects from the rear tangent is called the deflection angle of the curve.

Length of the curve:

The arc T_1DT_2 is called the length of the curve.

Long chord:

The line T_1T_2 joining two tangent points is called as the long chord.

Mid Ordinate:

The intercept DC on the line VO between the midpoint of the long chord and the midpoint of the curve is known as mid ordinate or the versed sin of the curve.

Point of curvature:

The point T from which the curve begins is called the point of curvature P.C.

Point of intersection:

The tangent lines AT_1 and BT_2 when produced, meet at point V which is called the vertex or point of intersection P.I.

Point of tangency:

The point T_2 where the curve ends is called point of tangency P.T.

Tangent distance:

The distance from the point of intersection to the tangent point i.e., VT_1 or VT_2 is called the tangent distance or tangent length.

Tangent:

The straight line VA and BV which are connected by the curve are known as the tangents or straight of the curve.

Principle:

The angle between the target and the chord is equal to the angle which that chord subtends in opposite segment.

Given data:

Chainage of curve, angle of intersection (Θ) and radius of curve (R)

PROCEDURE:-

1. First extent the center line of the cross roads i.e., extend the two straight, fix the point of intersection V.
2. Measure the intersection angle (Θ) with the help of theodolite. Then deflection angle is calculated by Ø = 180 - Θ
3. Choose the suitable radius of curvature R.
4. Then fix the points, point of curve T on back tangent and point tangency T on forward tangent by fixing the distance R tan $\Theta/2$
5. Then directly measure the distance between the two tangent points T_1 and T_2 to get the length of the long chord (L)
6. To calculate the length of the long chord from the formula $L = 2R \sin \Theta/2$
7. Then the length of the curve is equal to R Ø/2
8. To get the change point T_1, deduct the length of tangent distance of back tangent from the chainage of intersection point V.
9. To get the chainage of point T_2, add the length of curve to chainage of point T_1.

10. Find the mid point of the long chord “C”. Then from this mid point of long chord, fix the mid point of curve “D” , by fixing the mid ordinate length $R - \quad R^2 - L^2/4$ towards the point V.
11. Fix the other points on the curve on either side of the mid ordinate by fixing the corresponding length $R^2 - X^2 - (R - O_0)$ from the long chord. Where x is the distance of corresponding ordinates from the mid ordinate. O_0 is the length of the mid ordinate.

CALCULATION:-

Chainage at V =

Radius of curve (R) =

Deflection angle (Ø) =

Formula:

Length of tangent = $VT_1 = BT_2 = R \tan \Theta/2$
Length of Chord = $T_1T_2 = L = 2R \sin \Theta/2$
Length of Curve = $T_1T_2 = RØ/180$
Chainage at T_1 = Chainage at V – VT_1
Chainage at T_1 = Chainage at T_1 + T_1T_2
Mid ordinate = $R - \quad R^2 - L^2/4$

The ordinates are fixed on either side of mid ordinate, at x m interval, i.e., the distance between the successive ordinate is equal to x m.
The length of the ordinate $R^2 - X^2 - (R - O_0)$

CONCLUSION:-

The given simple curve is set out by the method of ordinates from long chord.

EXPERIMENT NO- 7

AIM OF THE EXPERIMENT: - To measure the distance between two points with Electronic Distance Meter

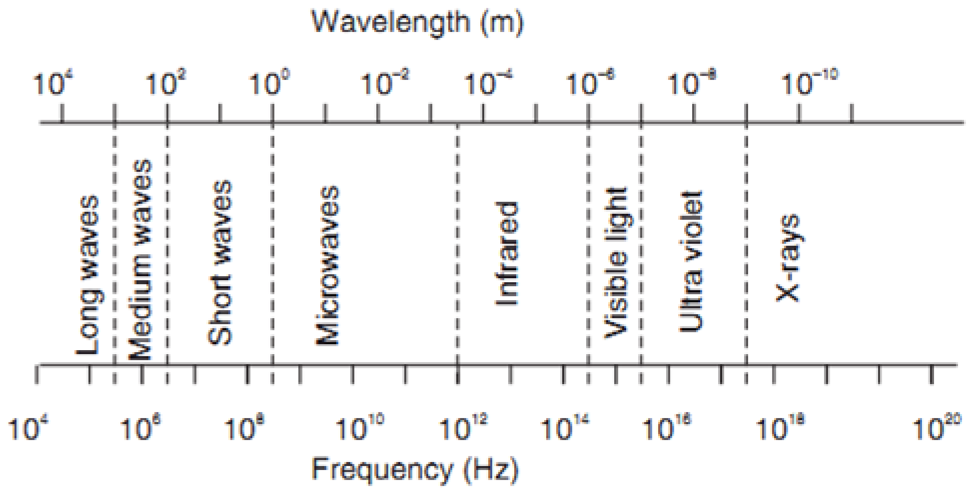
THEORY:-

Electronic distance measuring instrument is a surveying instrument for measuring distance electronically between two points through electromagnetic waves.

Electronic distance measurement (EDM) is a method of determining the length between two points, using phase changes, that occur as electromagnetic energy waves travels from one end of the line to the other end. As a background, there are three methods of measuring distance between two points.

DDM or Direct distance measurement – This is mainly done by chaining or taping.
ODM or Optical distance measurement – This measurement is conducted by tacheometry, horizontal subtense method or telemetric method. These are carried out with the help of optical wedge attachments.
EDM or Electromagnetic distance measurement – The method of direct distance measurement cannot be implemented in difficult terrains. When large amount of inconsistency in the terrain or large obstructions exist, this method is avoided.
As an alternative to this optical distance measurement method was developed. Still it gained a disadvantage of limited range of measurement. It is limited to 15 to 150m with an accuracy of 1 in 1000 to 1 in 10000. Above all we have EDM with an accuracy of 1 in 10^5, having a distance range of 100km.
Electronic distance measurement in general is a term used as a method for distance measurement by electronic means. In this method instruments are used to measure distance that rely on propagation, reflection and reception of electromagnetic waves like radio, visible light or infrared waves.

Sun light or artificially generated electromagnetic wave consists of waves of different lengths. The spectrum of an electromagnetic wave is as shown below:



Among these waves microwaves, infrared waves and visible light waves are useful for the distance measurement. In EDM instruments these waves are generated, modulated and then propagated. They are reflected at the point up to which distance is to be measured from the instrument station and again received by the instrument.

The time taken by the wave to travel this 2x distance may be measured and knowing the velocity of wave, the distance may be calculated. However time is too short, measuring the time taken is difficult.

The improved techniques use phase difference method in which the number of completed wave and incomplete wave is measured. Knowing the length of wave, distances are calculated.

Error in Electronic Distance Measurement Instruments

Personal Errors

- Inaccuracy in initial setups of EDMs and the reflectors over the preferred stations
- Instrument and reflector measurements going wrong
- Atmospheric pressures and temperature determination errors

Instrumental Errors

- Calibration errors
- Chances of getting maladjusted time to time generating frequent errors
- Errors shown by the reflectors

Natural Errors

- Atmospheric variations in temperature, pressure as well as humidity. Micro wave EDM instruments are more susceptible to these.
- Multiple refraction of the signals.

The advantage of using EDM instruments is the speed and accuracy in measurement. Several obstacles to chaining are automatically overcome when these instruments are used.

Measurement of distance with EDM and a Reflector

As explained let the waves get transmitted from A and reflected from B. If the received signal is out of phase by a measure of $\Delta\emptyset$, then equivalent distance is

$$d = \Delta\emptyset \frac{\lambda}{360}$$

Thus, the distance

$$D = \frac{1}{2}\left[n\lambda + \left(\frac{\Delta\emptyset}{360}\right) \lambda\right]$$

Where n is the integral number of wavelength, λ in the double path operations of Electronic Distance Measurement instruments.
It is essential to know the fundamental principle behind EDM to work with it. The electromagnetic waves propagate through the atmosphere based on the equation

$$V = f.\lambda = (\frac{1}{T}\lambda)$$

$$f = 1/T; \text{ (T=Time in seconds)}$$

Where ‘v’ is the velocity of electromagnetic energy in meters per second(m/sec); f is the modulated frequency in hertz (Hz) and λ is, the wavelength measured in meters. Mainly the waves that are propagated can be represented like a sine wave as shown in figure below.

Another property of wave called as phase of wave $\varnothing$, is a very convenient method of small fraction of wavelength during measurement in EDM. The points A, B, C etc. represents various phase points

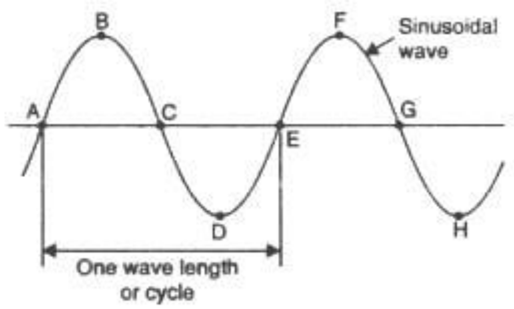


Fig. Sinusoidal Waves

Point →	A	B	C	D	E	F	G	H
Phase $\phi°$	0	90	180	270	360 (or 0)	90	180	270

Fig. Corresponding phase values

Say AB is the survey line to me measured, having a length of D. The EDM equipment is placed at ends A and B. A transmitter is placed at A and a receiver is placed at B. the transmitter lets propagation of electromagnetic waves towards B. A timer is also placed. At the instant of transmission of wave from A the timer at B starts and stops at the instant of reception of incoming wave at B. This enable us to know the transit time for the wave from the point A to B.

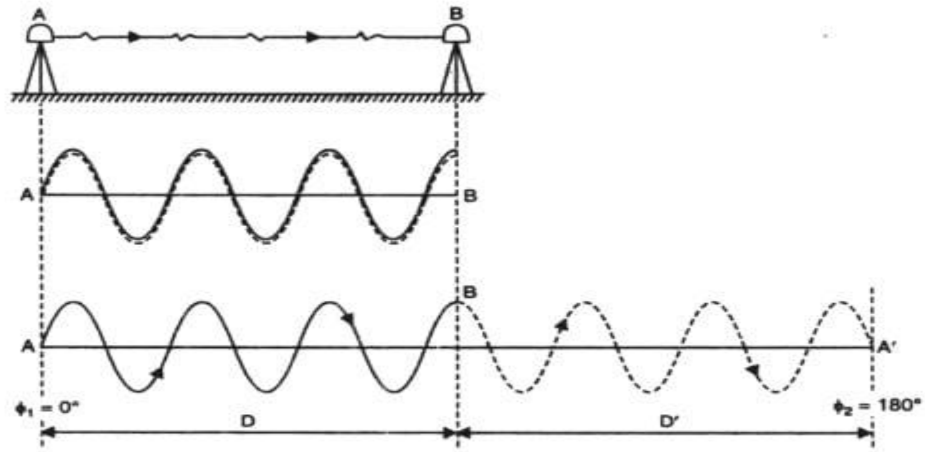


Fig. Transit Time Measurement Demonstration

From the transit time and known velocity, the distance can be easily measured. Now to solve the problem arise due to difficulty in starting the timer at B, a reflector can be placed as shown below instead of a receiver at B.

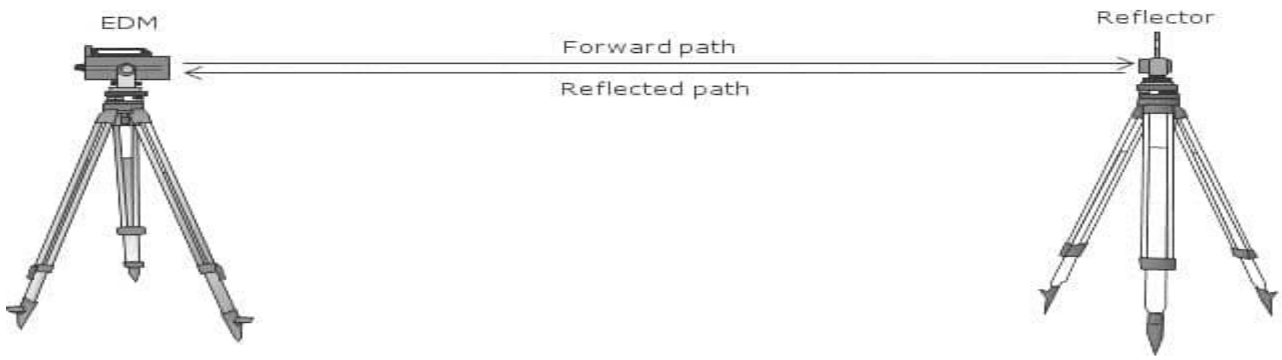


Fig. Transit measurement arrangement with the help of a EDM and a reflector

CONCLUSION:-

From the above experiment we study the distance measurement by EDM.