Unit-C: LEVELLING AND CONTOURING:

Topic 1: Definitions, Methods of determining elevation, Classification and salient parts of levels.

Definitions of Technical Terms Used in Levelling and Contouring:
LEVELLING

•***Datum***- it is the level surface whose elevation is known or assumed. In levelling operations, to get level points height are taken from the datum surfaces in vertical plane.

•***Elevation***- The height of point from a datum and are represented by ***Reduced levels***.

•The instrument used to measure the elevations is known as a ***level*** and the process of determining elevation is called as ***levelling.***

•***Benchmark***- The fixed reference point through a level surface of known elevation.

The GTS benchmark refers to the mean sea level at a point by collecting data of sea level elevations over long periods of time. Such benchmarks are available in many places in India for reference purposes.

Some important terms used

•Reduced Level- It is the height of the point obtained by adding the known or assumed datum surfaces elevation and the elevation of the point from the datum surface.

•Level surface- the surface parallel to the mean spheroidal surface of the earth at every point.

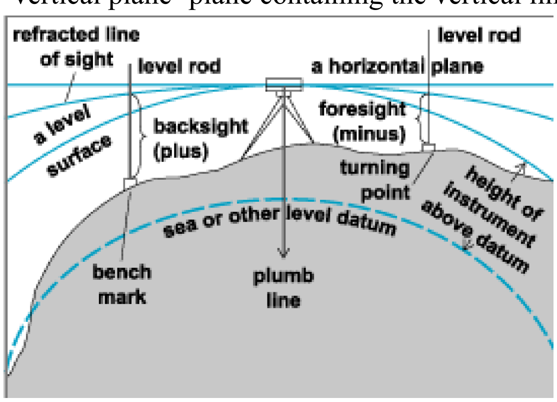
•Level line- It is the line lying on the level surface

•Horizontal plane- the plane tangential to the level surface passing through that point, perpendicular to the plumb line.

•Horizontal line- line lying in the horizontal plane, tangential to the level surface and perpendicular to the plumb line.

•Vertical line- line perpendicular to the level surface and lies along the plumb line through that point.

•Vertical plane- plane containing the vertical line



Methods of finding Elevations

•Direct method- also known as ***spirit levelling***

•Barometric leveling- works on the principle, atmospheric pressure (measured by Barometer) decreases as we go higher in altitude, so based on pressure reading the height of the place from the surface of the earth can be calculated.

•Hypsometry- principles based on atmospheric pressure but relates the pressure to the boilling point of the liquid

Direct levelling or spirit levelling:

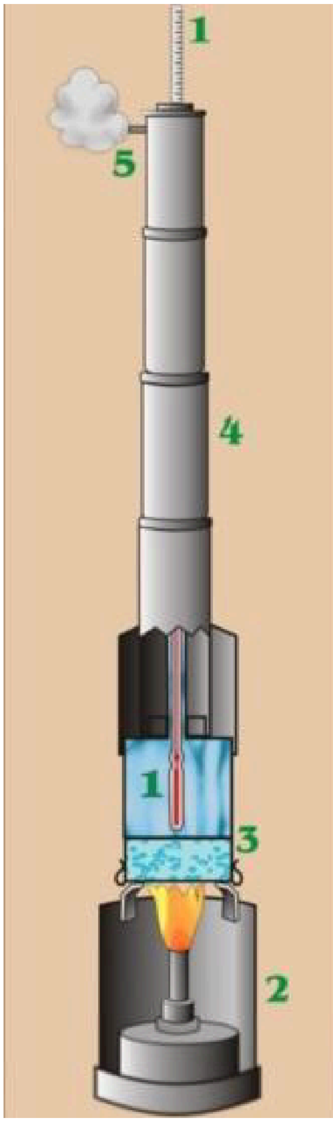


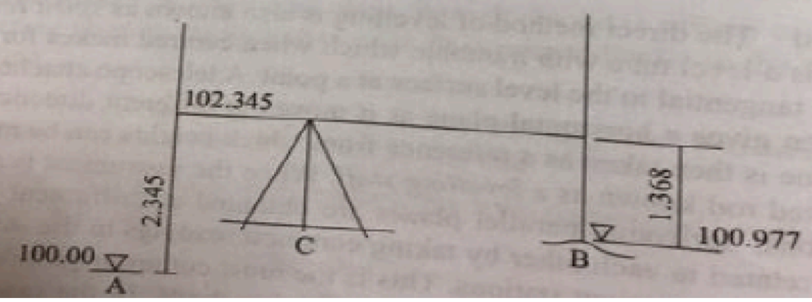
Fig. 14 (a) An Old Aneroid Barometer

Fig. 14 (b) A modern Aneroid Barometer

Direct levelling or spirit levelling:

Direct levelling or spirit levelling is the most accurate method of finding elevations of points. The principle of direct levelling can be explained with reference to Fig. 4.2. The elevation of point B is to be determined with reference to the datum surface through point A, whose elevation is known or assumed. Often we will be interested only in the difference in elevations between points and not in their absolute elevation with reference to the nationally accepted mean sea level. The following procedure is adopted.

1. Set up a levelling instrument (essentially consisting of a spirit level and a telescope) at point C. It must be clearly understood that *the instrument station, or where the instrument is set up, is not the point whose elevation is determined.* Set up the instrument at a station for convenience of observation to the points whose elevations are to be determined.
2. Centre the spirit level so that the bubble traverses (remains at the centre). In this position, the telescope, when rotated horizontally, traces a horizontal plane and the line of sight remains in that plane in all directions.
3. Keep a measuring rod at A and take a reading on the measuring rod with the horizontal hair of the telescope.
4. Now turn the telescope to sight point B. Keep the measuring rod vertically at B and take a reading corresponding to the horizontal hair of the telescope.
5. Knowing the two readings, determine the elevation of point B with respect to point A.



LEVELLING INSTRUMENTS

Various types of Levelling Instruments

•Dumpy level

•Wye level

•Modern Tilting level

•Automatic level

The levelling instruments essentially consist of the following:

•A ***levelling head*** with three ***foot screws*** which enables to bring the ***bubble*** at its centre.

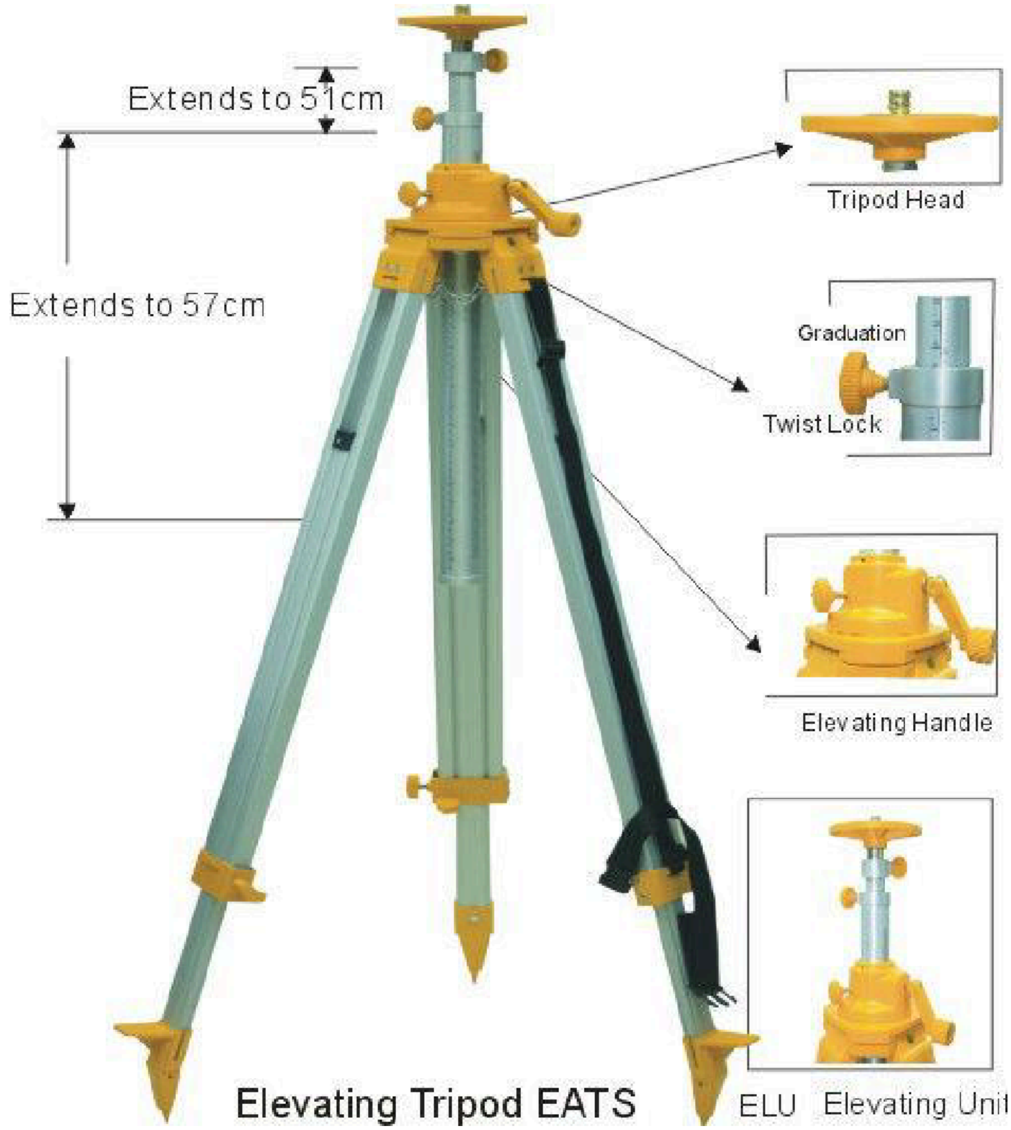
•***Telescope*** that provides line of sight to bisect distinct objects.

•A ***bubble tube*** to make the line of sight horizontal either mounted on top or side of the telescope.

•A ***tripod*** for supporting the levelling instrument.


Automatic level
Gun sight
PENTAX
Spherical level
with mirror
Eye piece
Tangent
Screws
Levelling
head
Object focus screw
AP-020
Horizontal
circle
Tribrach
Foot screws
Levelling
head
Trivet


Prism & Accessories
Staffs
GPS
Royal Auto Level
Automatic Level
Stand (Tripod)


Extends to 51cm
Extends to 57cm
Tripod Head
Graduation
Twist Lock
Elevating Handle
Elevating Tripod EATS
ELU Elevating Unit

) A dumpy level used on Construction Site

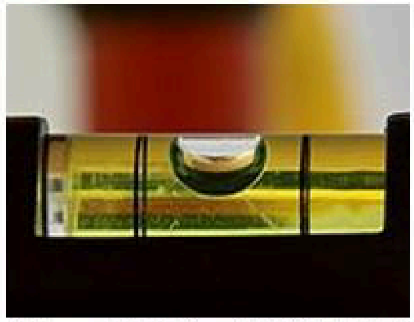
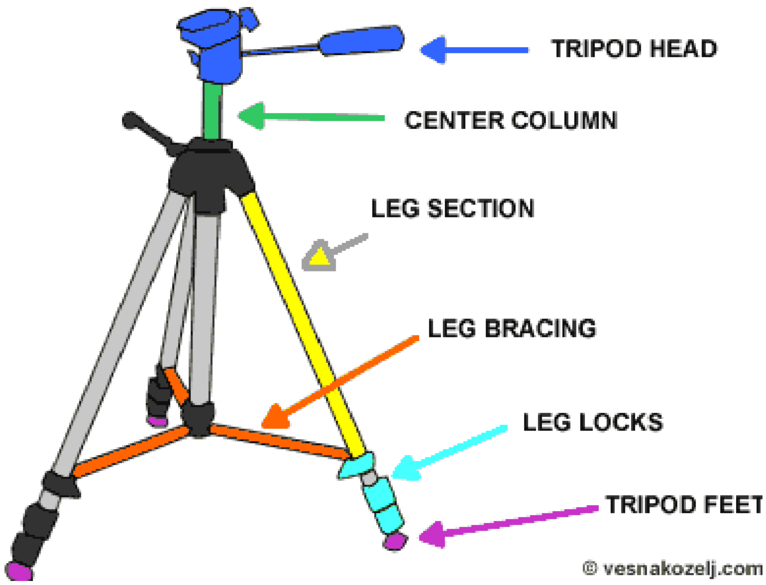


Fig. 11. A spirit level



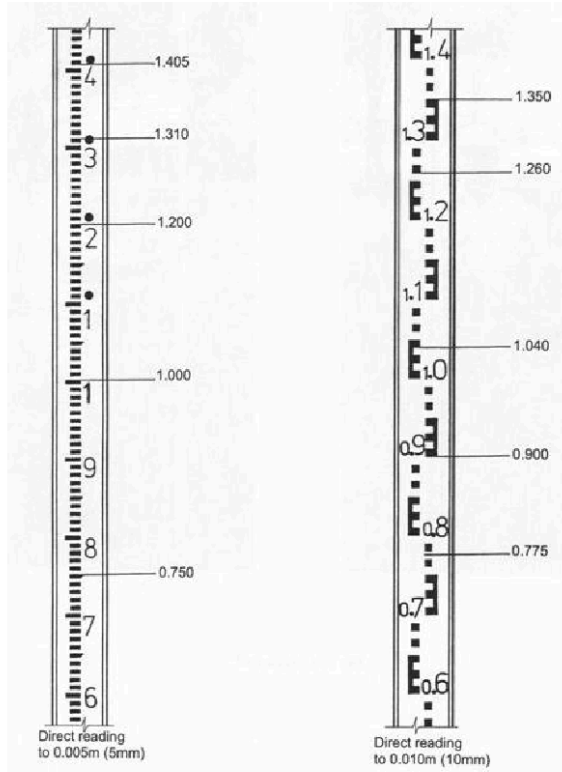
A level staff, also called leveling rod, is a graduated wooden or aluminum rod, the use of which permits the determination of differences in metric graduation as the left and imperial on the right leveling rods can be one piece, but many are sectional and can be shortened for storage and transport or lengthened for use. There are many types of rods, with names that identify the form of the graduations and other characteristics. Marking can be in imperial or metric units. Some rods are graduated on only one side while others are marked on both sides. If marked on both sides, the markings can be identical or, in some cases, can have imperial units on one side and metric on the other side.

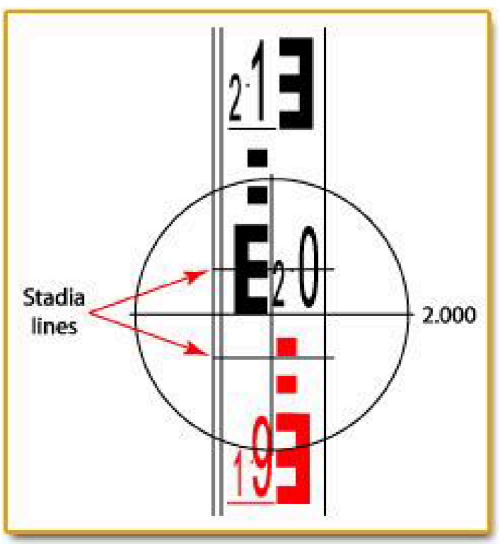
Reading Staffs

•It is important to hold staff plumb

•Use slow rocking technique

•Use vertical line in level to keep plumb





LECTURE-12

Adjustments of Levels

•Temporary adjustments are done whenever the instrument is set up to take readings.

•Permanent adjustments are done to adjust the fundamental line once in a while.

Temporary Adjustments of Levels
The temporary adjustments required for a levelling instrument are as follows:
•Setting up- on the tripod, firmly fixed on the ground and well apart for stability

•Levelling the bubble- using spirit level

•Focusing the eye piece- adjust to see the sharp and clear view of cross hair

•Focusing the objective- adjusted according to the distance between the between the instrument and the object using the help of focusing screws.

Three screw and four screw levelling head- screws are adjusted to bring the bubble parallel to any two of the foot screws.

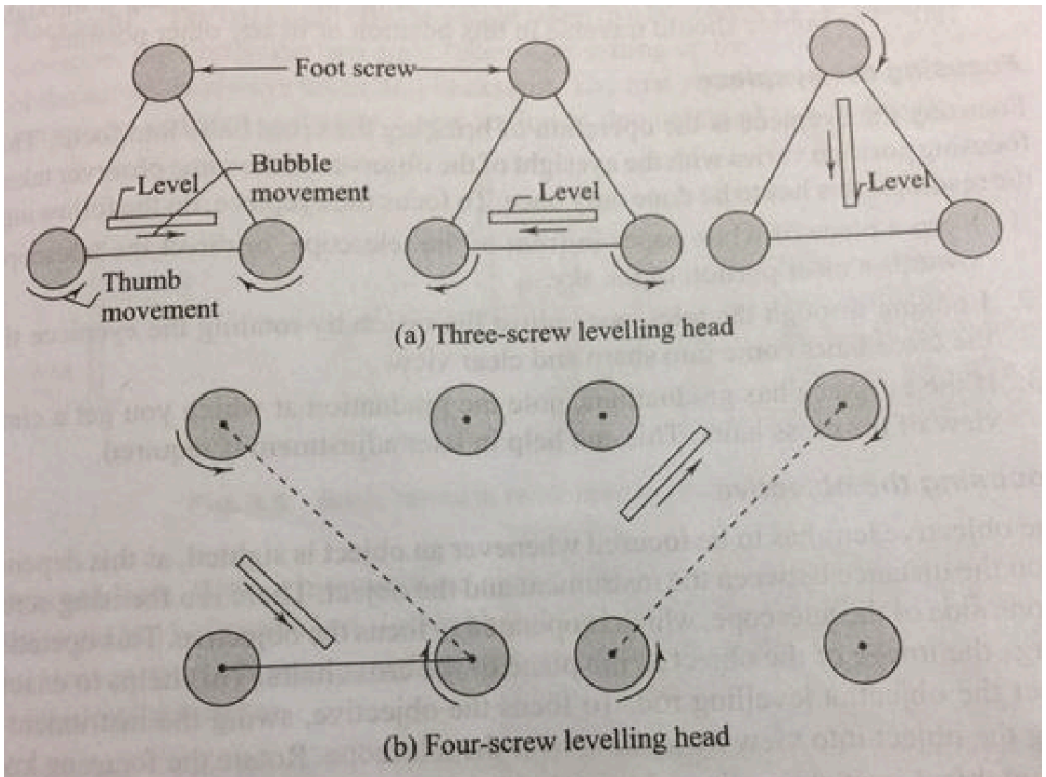


Fig. 4.8 Levelling operation

Permanent Adjustments of Levels:

The establishment of a desired relationship between the fundamental lines of a levelling instrument is termed permanent adjustment. So, permanent adjustment indicates the rectification of instrumental errors.

The fundamental lines are as follows:

1. The line of collimation,
2. The axis of the bubble tube,
3. The vertical axis
4. The axis of the telescope.

The following relationships between the lines are desirable:

1. The line of collimation should be parallel to the axis of the bubble.
2. The line of collimation should coincide with the axis of the telescope.
3. The axis of the bubble should be perpendicular to the vertical axis. That is, the bubble should remain in the central position for all directions of the telescope.

Principle of reversal The principle of reversal states that if there is any error in a certain part of the instrument, then it will be doubled by reversing, i.e. by revolving the telescope through 180°. Thus the apparent error becomes twice the actual error on reversal.

Suppose, for example, that in a right-angled triangle ABC (Fig. 5.38), the angle ACB is not exactly 90° but less by $\theta°$. If this triangle is reverses as A_1B_1C, then the angle between the faces BC and B_1C becomes $2\theta°$. This is the underlying principle of reversal.

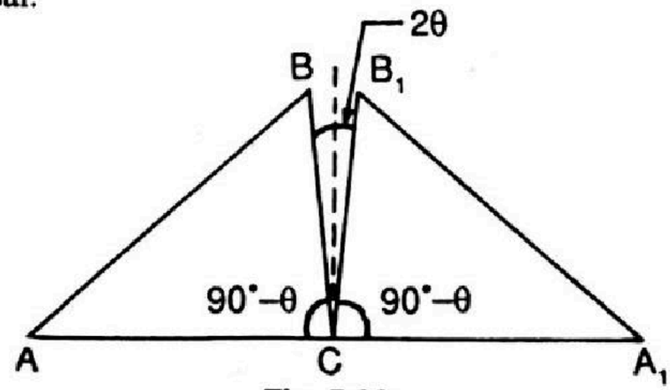


Fig. 5.38

This principle is followed in levelling instruments and theodolite. By the principle of reversal, the relationship between the fundamental lines can be determined and hence the necessary correction can be applied.

1. First adjustment The following procedure is adopted to make the line of collimation parallel to the axis of the bubble tube:

(a) The level is set up on fairly level and firm ground, with its legs well apart. It is firmly fixed to the ground.

(b) The telescope is placed parallel to any pair of foot screws and, by turning the foot screws either both inward or both outward, the bubble is brought to the centre.

(c) The telescope is then turned through 90°, so that it lies over the third foot screw. Then by turning the third foot screw the bubble is brought to the centre.

(d) The process is repeated several times until the bubble is in the central position in both the directions.

(e) Now the telescope is turned through 180° and the position of the bubble is noted.

If the bubble still remains in the central position, the desired relationship is perfect. If not, the amount of deviation of the bubble is noted.

(f) Suppose, the deviation is of $2n$ divisions. Now by turning the capstan headed nut (which is at one end of the tube), the bubble is brought half-way back (i.e. n divisions). The remaining half-deviation (i.e. n divisions) is adjusted by the foot screw or screws just below the telescope.

(g) The procedure of adjustment is continued till the bubble remains in the central position at any position of the telescope.

2. Second adjustment The second adjustment is done by two-peg method, which is described below.

(a) Two pegs A and B are driven at a known distance apart (say D) on level and firm ground. The level is set up at P, just mid-way between A and B. After bringing the bubble to the centre of its run (usual), the staff readings on A and B are taken. Suppose the readings are a and b.

Now the difference of level between A and B is calculated, this difference is the true difference, as the level is set up just mid-way between BS and FS (Fig. 5.39(a)).

Then the rise or fall is determined by comparing the staff readings.

(b) The level is shifted and set up at P_1 (very near A), say at a distance d from A. Then after proper levelling (following the usual method), staff readings at A and B are taken. Suppose the readings are a_1 and b_1.

Then the apparent difference of level is calculated (Fig. 5.39(b)).

(c) If the true difference and apparent difference are equal, the line of collimation is in adjustment. If not, the line of collimation is inclined.

(d) In the second set up, let e be the staff reading on B at the same level of the staff reading a_1.

Then

$$e = a_1 \pm \text{true difference}$$

(Use the positive sign in the case of a fall and the negative sign when there is a rise.)

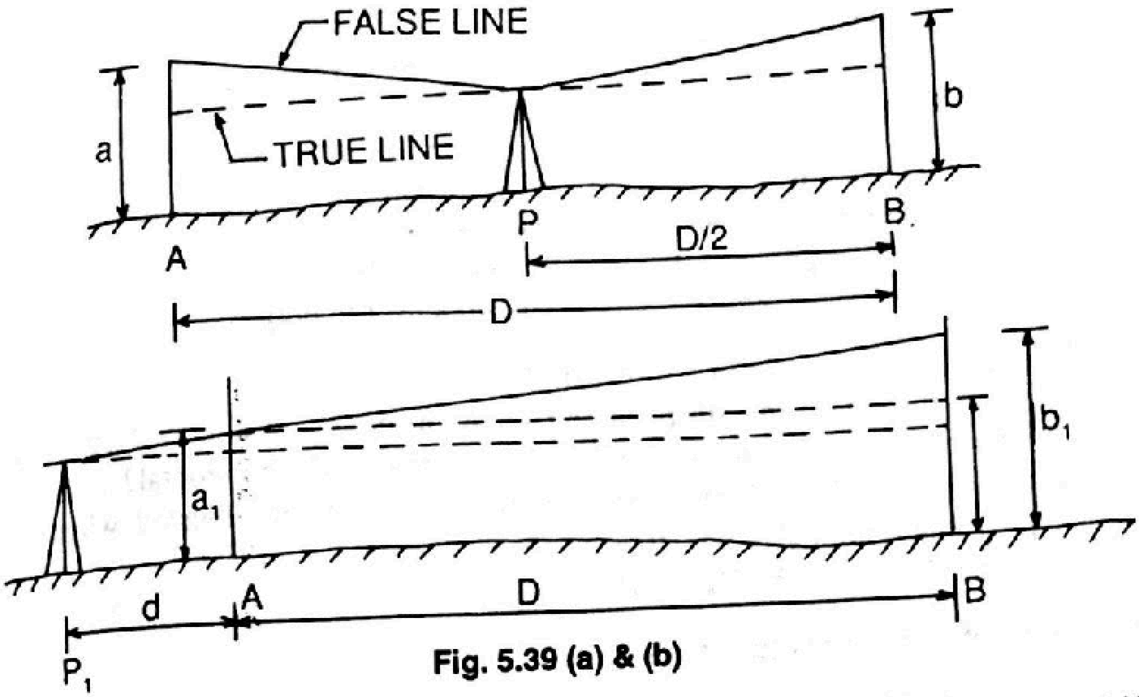


Fig. 5.39 (a) & (b)

(e) If b_1 is greater than e, the line of collimation is inclined upwards and if b_1 is less than e, it is inclined downwards.

$\therefore$ Collimation error $= b_1 \sim e$ (in distance D)

(f) By applying the principle of similar triangle

Correction to near peg, $C_1 = \dfrac{d}{D} \quad (b_1 \sim e)$

Correction to far peg, $C_2 = \dfrac{D+d}{D} \quad (b_1 \sim e)$

Correct staff reading on A $= a_1 \pm C_1$
Correct staff reading on B $= b_1 \pm C_2$

(Use the positive sign when the line of collimation is inclined downwards, and the negative sign when it is inclined upwards.)

(g) Then the cross-hair is brought to the calculated correct reading by raising or lowering the diaphragm by means of the diaphragm screw.

B. Field Instructions

1. If the correct reading is seen below the collimation hair on looking through the telescope, the cross-hair is to be lowered. This is done by loosening the upper screw and tightening the lower screw of the diaphragm.
2. If the correct reading is seen above the collimation hair, on looking through the telescope, the cross-hair should be raised. This is done by loosening the lower screw and tightening the upper screw of the diaphragm.

Basic Terminology in levelling Staff station- point where the levelling staff is kept for determining the elevation **Instrument station-** point where the level is kept. **Height of instrument or height of line of collimation**- It is the reduced level of the line of collimation with reference to the datum. **Rise**- When a point (let A) is above another point (let B) then A has a rise over B. **Fall-** The reverse of rise.

Back sight reading- The reading taken by levelling instrument on a levelling staff held on a point whose elevation is known. It is very first reading taken on the benchmark after setting up the instrument.
Fore sight reading- The reading taken on the point whose elevation is to be found out.
It is the last reading before shifting the instrument.
Intermediate sight- Any other staff reading taken on a point of unknown elevation from the same setup of the instrument. All sights which are taken between back-sight or fore-sight or intermediate sight.
Change point- It is a point on which fore-sights and back-sight are taken.

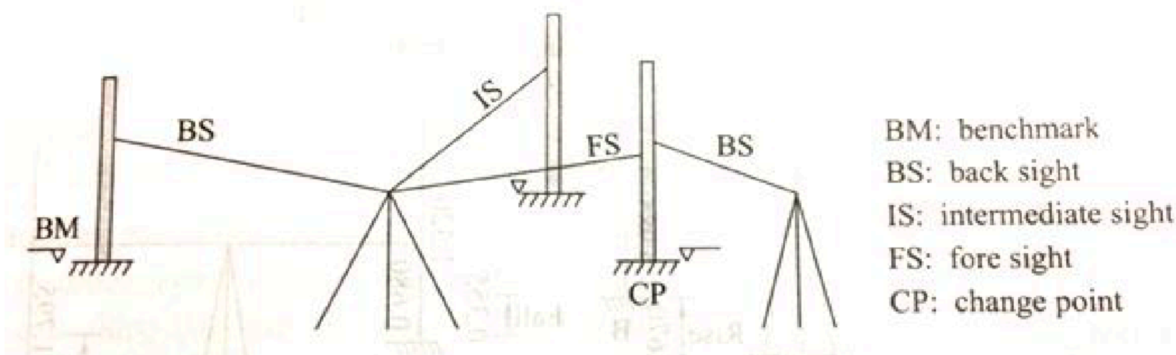


Fig. 4.9 Basic terms in recording and reducing levels

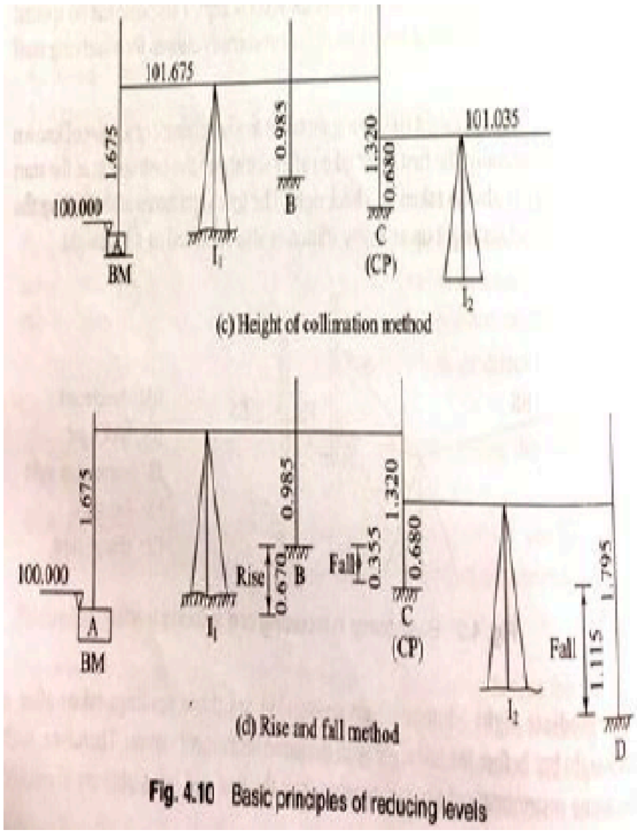
Levelling Operations
•Setting up and levelling the instrument

•Holding the staff

•Taking the readings

Methods of Reduction of levels
•Height of collimation method

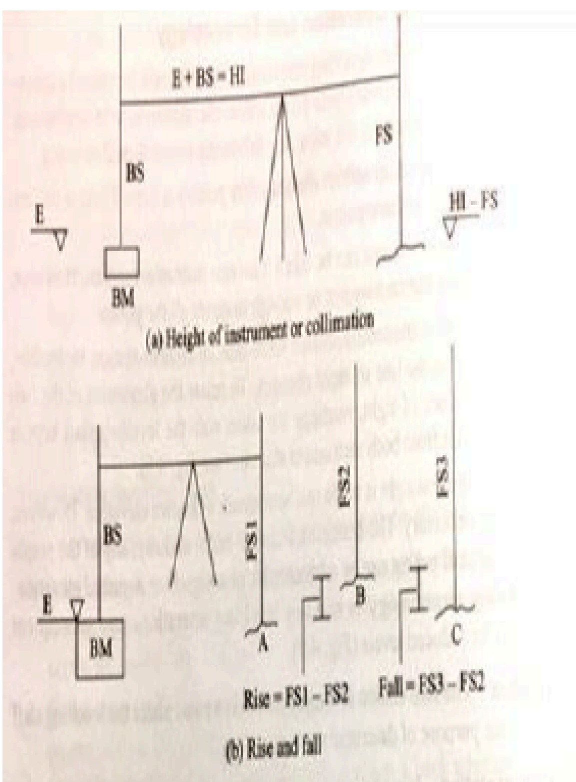
•Rise and fall method



(c) Height of collimation method

(d) Rise and fall method

Fig. 4.10 Basic principles of reducing levels



(a) Height of instrument or collimation

(b) Rise and fall

HEIGHT OF COLLIMATION METHOD (HI):

•It consist of finding the elevation of the plane of collimation (H.I.) for every set up of the instrument, and then obtaining the reduced level of point with reference to the respective plane of collimation.

1.Elevation of plane of collimation for the first set of the level determined by adding back side to R.L. of B.M.

2.The R.L. of intermediate point and first change point are then obtained by starching the staff reading taken on respective point (IS & FS) from the elevation of the plane collimation. [H.I.]

3.When the instrument is shifted to the second position a new plane collimation s set up. The elevation of this plane is obtained by adding B.S. taken on the C.P. From the second position of the level to the R.L. C.P. The R.L. of successive point and second C.P. are found by subtract these staff reading from the elevation of second plane of collimation

Arithmetical check= **Sum of B.S. – sum of F.S. = last R.L. – First R.L.**

•This method is simple and easy.

•Reduction of levels is easy.

•Visualization is not necessary regarding the nature of the ground.

•There is no check for intermediate sight readings

•This method is generally used where more number of readings can be taken with less number of change points for constructional work and profile leveling.

RISE AND FALL METHOD:

•It consists of determining the difference of elevation between consecutive points by comparing each point after the first that immediately preceding it.

•The difference between there staff reading indicates a rise fall according to the staff reading at the point. The R.L is then found adding the rise to, or subtracting the fall from the reduced level of preceding point.

Arithmetic check= **Sum of B.S. – sum of F. S. = sum of rise – sum of fall = last R. L. – first R.L.**

•Reduction of levels takes more time.

•Visualization is necessary regarding the nature of the ground.

•Complete check is there for all readings.

•This method is preferable for check levelling where number of change points are more.

Numerical

The following staff readings were recorded in a levelling operation:
1.185, 2.604, 1.925, 2.305, 1.155, 0.864, 1.105, 1.685, 1.215, 1.545 and 0.605.

Staff station	Backsight	Intermediate sight	Foresight	Height of collimation	Reduced levels	Remarks
A	1.185			186.870	185.685	BM
B	1.925		2.604	186.191	184.266	CP
C		2.305			183.886	
D		1.155			185.036	
E	1.105		0.864	186.432	185.327	CP
F		1.685			184.747	
G	1.545		1.215	186.762	185.217	CP
H			0.605		186.157	

Solution by Height of collimation (HI) method

1. The instrument was shifted after the readings 2.604, 0.864, and 1.215. All these are foresight readings. The readings following these, 1.925, 1.105, and 1.545, are backsights. The first reading is a backsight and the last reading is a foresight. The remaining are intermediate sights.
2. Enter the readings as shown in Table 4.5 (columns 1 to 4).
3. The height of collimation for the first set-up is 185.685 + 1.185 = 186.870. RL of B = 186.870 – 2.604 = 184.266.
4. Now the instrument has been shifted; the new height of collimation = 184.266 + 1.925 = 186.191. Calculate the reduced levels of C, D, and E by subtracting 2.305, 1.155, and 0.864 from this height of collimation.
5. The instrument was shifted after the foresight at E. The new height of collimation = 185.327 + 1.105 = 186.432. Find the RLs of F and G by subtracting 1.685 and 1.215 from this height of collimation.
6. Now the instrument has been shifted; the new height of collimation = 185.217 + 1.545 = 186.762. RL of H = 186.762 – 0.605 = 186.157.
7. Arithmetic check: Sum of backsights = 5.760, sum of foresights = 5.288, difference = 0.472. Last RL – first RL = 186.157 – 185.685 = 0.472.

Solution by Rise and Fall method:

1.185, 2.604, 1.925, 2.305, 1.155, 0.864, 1.105, 1.685, 1.215, 1.545 and 0.605.

Staff station	Backsight	Intermediate sight	Foresight	Rise	Fall	Reduced level	Remarks
A	1.185					185.685	BM
B	1.925		2.604		1.419	184.266	CP
C		2.305			0.380	183.886	
D		1.155		1.150		185.036	
E	1.105		0.864	0.291		185.327	CP
F		1.685			0.580	184.747	
G	1.545		1.215	0.470		185.217	CP
H			0.605	0.940		186.157	

ΣBS=5.760 ΣSF=5.288 ΣR=2.851 ΣF=2.379 Last RL-1st RL= 186.157-185.685 =0.472

Difference of Σ BS and FS= 0.472 Difference= 0.472

Solution by Rise and Fall method:

Rise and fall method The solution by the rise and fall method is shown in Table 4.6. Columns 1 to 4 are filled as before.

1. Calculate the rises and falls from the readings. The rises are 2.305 – 1.155 = 1.150, 1.155 – 0.864 = 0.291, 1.685 – 1.215 = 0.470, and 1.545 – 0.605 = 0.940. The falls are 2.604 – 1.185 = 1.419, 2.305 – 1.925 = 0.380, and 1.685 – 1.105 = 0.580.

2. The reduced levels are obtained by adding the rises to and deducting the falls from the RL of the preceding point: 185.685 – 1.419 = 184.266, 184.266 – 0.380 = 183.886, 183.886 + 1.150 = 185.036, and so on.
3. Arithmetic check: Sum of backsights = 5.760, sum of foresights = 5.288, difference = 0.472. Sum of rises = 2.851, sum of falls = 2.379, difference = 0.472. Last RL – first RL = 186.157 – 185.685 = 0.472.

Other Methods of Levelling

•**Differential levelling**- to determine the elevations of points some distance apart or to establish benchmarks.

•**Check levelling**- operation of running levels for the purpose of checking a series of levels that has been previously fixed

•**Profile levelling-** objective is to determine the elevation of the points at known distances apart along a given line to obtain the accurate outline of the surface of the ground.

•**Cross sectioning-** operation of levelling to determine the surface undulations or the outline of the ground traverse to the given line on either side of it.

•**Reciprocal levelling-** method of levelling in which the difference in elevations between two points is accurately determined by two sets of observations when it is possible to set up the level midway between the two points.

•Barometric levelling

•Hypsometry

RECIPROCAL LEVELLING
•Error due to curvature- due to curvature of earth

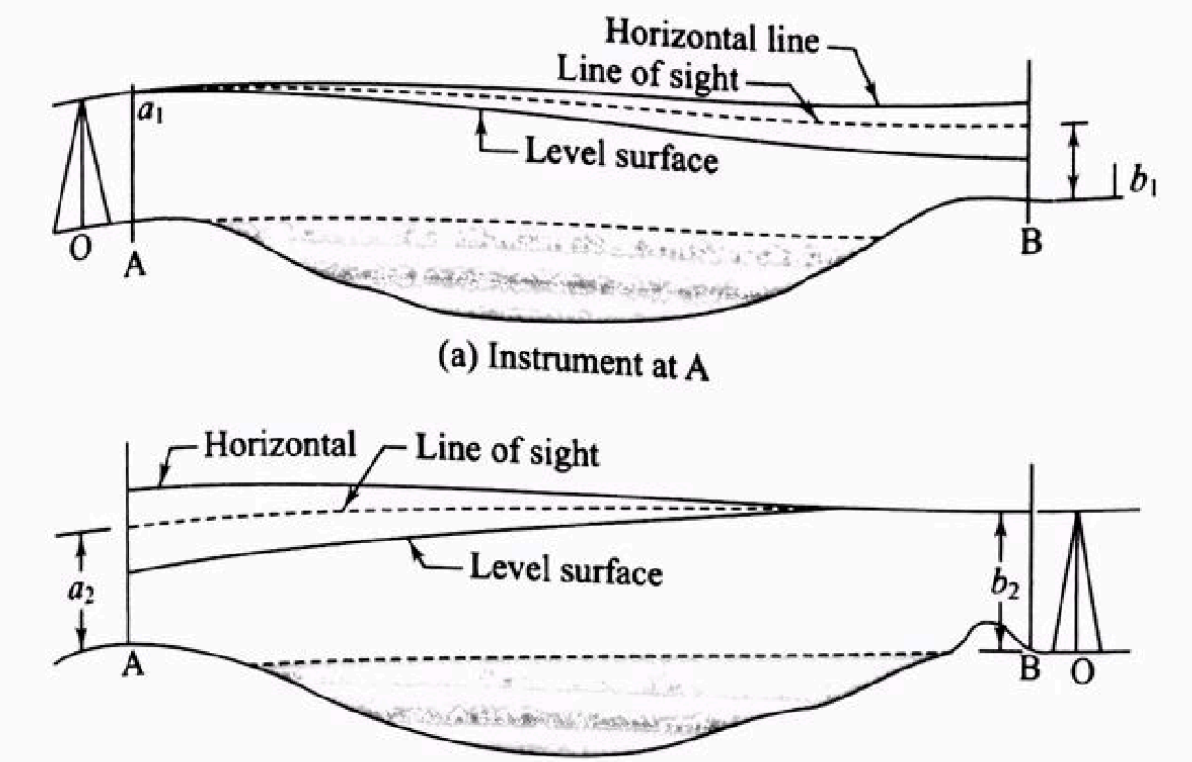
Correction of curvature = 0.0785D2, D= distance between the staff and level in km.
True staff reading= observed staff reading – 0.0785D2
•Error due to refraction = (1/7) x(0.0785D2)= 0.0112D2

•Combined error = (Error due to curvature - Error due to refraction)

= 0.0785D2 - 0112D2 = 0.0673D2
•To find accurate relative elevations of two widely separated points (between which levels cannot be set), reciprocal levelling is being used.

•Examples- in case of deep valley, or a river

• Advantages- reduces error due to curvature and refraction and also the line of collimation error.



(a) Instrument at A

(b) Reciprocal levelling

Instrument at A

On staff held at A = a_1. On staff held at B = $b_1 - e$, where e = curvature correction − refraction correction ± correction due to inclined line of collimation.

$$\text{True difference in elevation} = (b_1 - e) - a_1 = (b_1 - a_1) - e$$

assuming a fall from A to B or

$$\text{True difference in elevation} = a_1 - (b_1 - e) = (a_1 - b_1) + e$$

if A is lower than B.

Instrument at B

On staff held at B = b_2. On staff held at A = $a_2 - e$.

$$\text{True difference in elevation} = b_2 - (a_2 - e) = (b_2 - a_2) + e$$

assuming a fall from A to B or

$$\text{True difference in elevation} = (a_2 - e) - b_2 = (a_2 - b_2) - e$$

Adding the two corresponding equations in either case = 2 x true difference in elevation = (b1-a1)+(b2-a2) or (a1-b1)+(a2-b2)

Sources of errors and precision:

4.13 Precision of Levelling

The precision required, or the degree of precision that can be achieved, of a levelling work depends upon the nature of the survey, the terrain, environmental conditions, skill of personnel, importance of the survey, and the instruments used. The precision required of a levelling job, more accurately the permissible error, is given by the general formula $E = C\sqrt{K}$. Here, K is the distance in kilometres and C is a constant. The values generally recommended are as follows.

(a) Rough levelling work: $\pm 100\sqrt{K}$

(b) Ordinary levelling, construction surveys: $\pm 24\sqrt{K}$

(c) Accurate levelling for establishing benchmarks, etc: $\pm 12\sqrt{K}$

(d) Precise levelling: $\pm\sqrt{K}$ to $\pm 4\sqrt{K}$

4.14 Errors in Levelling

Errors in levelling can be classified into instrumental errors, personal errors, and errors due to natural causes.

4.14.1 Instrumental Errors

Instrumental errors arise from maladjustments of the level. These can be of the following types.

Line of collimation not parallel to the bubble axis When the bubble is in the centre, the bubble tube axis is horizontal. The line of collimation, if parallel to the bubble tube axis, traverses a horizontal plane when moved around to sight objects. The basic principle of levelling is based on this parallelism of the two lines. This can be adjusted to be so by permanent adjustment. The line of collimation if inclined upwards or downwards introduces a collimation error which depends upon the length of sight. Adjusting the backsight and foresight lengths is one way to minimize the error.

Sources of errors and precision:

Sensitivity of bubble The bubble is sometimes sluggish and may be apparently centred even though the bubble axis is not horizontal. This will cause errors in the readings. If the bubble is oversensitive, levelling the bubble tube may take a long time.

Faulty levelling staff The graduations on the levelling may be faulty but this is not a serious problem in ordinary surveys. In the case of a folding or telescopic staff, the moving parts may wear out and cause errors in readings.

Other mistakes

Many other small errors or mistakes can take place due to carelessness. These include (i) reading the staff in the wrong direction, upwards instead of downwards or vice versa, (ii) reading the stadia hair instead of the central horizontal hair if there are three cross hairs, (iii) reading the staff wrongly, (iv) not taking the foresight and backsight at the same point, (v) entering the readings wrongly, (vi) not extending a telescopic staff fully before taking the reading, (vii) missing some readings or recording digits wrongly, etc.

Sources of errors and precision:

4.14.2 Operational Errors

Carelessness in operating the equipment can cause errors in levelling work.

Careless levelling of bubble tube Levelling of the bubble tube is a basic operation to make the bubble traverse and is a fundamental requirement of levelling. This should be done carefully at every setting of the level. Except in the case of tilting level, all other levels need careful levelling of the bubble tube.

Bubble not at centre while sighting After the bubble tube has been levelled, it must be ensured that the bubble is in the centre while sighting. If not, the bubble can be centred before taking the reading.

Staff not held plumb The levelling staff has to be vertical while taking readings. Whether the staff is out of plumb sideways or along the line of sight, the effect is to make the reading larger. One method is to swing the staff to and fro and note the minimum reading which will be in the plumb position.

Parallax This is a temporary adjustment and if not done properly will result in a hazy view of the staff. Eye lens adjustment has to be done once for the eye of the observer. The object lens has to be adjusted to the length of sight. The staff must be in sharp and clear view before taking the reading.

Settlement of level and staff The level should be set up on firm ground so that the legs are stable. The tripod legs should not be touched while taking readings. The staff should be held on firm ground or can be provided with some support for taking readings. The staff is likely to settle between backsight and foresight readings or its position may change.

4.14.3 Errors Due to Natural Causes

Curvature As explained earlier, a level surface is parallel to the mean spheroidal surface of the earth. The line of sight is horizontal and hence the effect of curvature is to make the readings appear large. This is apparent, or needs to be taken into account, only in the case of long sights. This can also be eliminated by reciprocal levelling.

Refraction It is a phenomenon whereby light rays bend while travelling through different media or the same medium with different densities. It is highly variable, as the atmospheric conditions change with time. The effect of refraction is opposite to that of curvature and is generally taken to be one-seventh of the effect of curvature.

Effect of temperature High temperature does not have any perceptible effect on levelling in ordinary work. In precise levelling work, these effects are reduced by shielding the level and staff. An invar staff with a low coefficient of thermal expansion is used in precise levelling. The level may get heated up and the bubble may go off-centre due to differential heating. Most of these effects are random and tend to cancel over a number of readings.

Effect of wind In windy conditions the stability of the instrument may be affected. It also becomes difficult to keep the levelling staff plumb and stable and to sight and read.

A is the benchmark of reduced level with RL 185.685 m.
Find the RLs in both methods.
The first reading was at point A and the instrument was shifted after the readings 2.604, 0.864 and 1.215.

Solution by Height of collimation (HI) method ΣBS=5.760 **ΣFS=5.288**
Difference of Σ BS and FS= 0.472

Last RL-1st RL=186.157-185.686
= 0.472

Topic 2: Temporary and Permanent Adjustments of Levels, method of reduction of levels, Sources of errors and precision, Methods of representation.

LECTURE-21

Topic 3: Definition and characteristics of contours, Methods of contouring and its usage:

DEFINITIONS:

CONTOURS AND CONTOUR LINES: Contour is an imaginary line joining points of the same elevation on the ground surface. More precisely, it may be thought of as the trace formed by the intersection of a level surface with the ground surface, e.g. shoreline of a still body of water. If the locations of several closely spaced ground points of equal elevation are plotted on a drawing, a line joining these points is called a **contour line**. There are infinite numbers of points on the line. Obviously, the elevation of all the points cannot be actually measured. Some points may be obtained by direct measurements and some may be obtained by interpolation. Thus contours on the ground may be represented by contour lines on the map. However, the terms contour and contour line, often, are used interchangeably. A contour line should always be marked with its elevation from the datum

CONTOURING: Contouring is a method, essentially of levelling, of locating contour lines. In order to plot contour lines, we need both vertical and horizontal distances. The method, thus involves locating points on the ground by distance measurement and finding their elevations using level.

CONTOUR MAP: A contour map is a map showing contour lines of different elevations at some selected contour interval. It provides considerable information about the topography of the terrain, as it indicates both horizontal and vertical distances.

CONTOUR INTERVAL: It is the difference in elevation between successive contour lines. It is the vertical distance between two successive contour lines.

HORIZONTAL EQUIVALENT: It is the horizontal distance between two successive contour lines. It depends upon the slope of the ground.

CHARACTERISTICS OF CONTOURS: (i) All points on a contour line have the same elevation, (ii) Two contour lines cannot intersect, as this would mean that the point of intersection has two elevations as mentioned against the contour lines, (iii) The horizontal distance between contour lines is inversely proportional to slope. Hence on steep slopes, the contour lines are spaced closely. (iv) On uniform slopes, the contour lines are spaced uniformly, (v) Along plane surfaces, the contour lines are straight and parallel to one another, (vi) As contour lines represent level lines, they are perpendicular to the lines of steepest slope. They are perpendicular to ridge and valley lines, (vii) As all the land areas may be regarded as summits or islands above sea level; evidently all contour lines must close on themselves either within or outside the borders of the map. It follows that a closed contour line on a map always indicates either a local summit or local depression, (viii) A single contour line cannot lie between two contour lines of higher or lower elevation, (ix) Contour lines cannot merge or cross one another on the map, except in rare cases of vertical cliff or overhanging cliff, (x) A series of closed contour lines on the map represent a hill, if the higher values are inside, however they represent a depression, if the higher values are outside. (xi) Contour lines across ridge or valley lines are at right angles. If the higher values are inside the bend or loop, it indicates ridge. Here the contour lines are so curved to have the concave side towards higher ground. However if the higher values are outside the bend, it represents a valley and the V-shaped curves across the valley line will have their convex side towards higher ground. (xii) A contour line passing through a point is at right angles to the line of maximum slope at that point. (xii) Depression between summits is called a saddle. It is represented by four sets of contours of the lowest range. It represents a dip in a ridge or the junction of two ridges. And in case of mountain range, it takes the form of a pass. Line passing through the saddles and summits gives watershed line.

LECTURE-22

METHODS OF CONTOURING:

1. Direct Method:

(i)Trial and Error method: (a) Locate nearby appropriate BM and connect site by fly levelling, (b) Set up Level Instrument at suitable position covering large area to be surveyed, (c) Take a back sight on TBM and calculate height of collimation of instrument (HI),(d) Calculate the instrument reading to get a point on desired contour, based on HI, (e) Hold the level staff at various points on the slope till the desired reading is obtained, (f) Mark the point suitably for a theodolite or compass survey to locate it horizontally. The point is marked with the elevation of the point written on it, (g) Obtain a number of such points by similar trials on the desired contour, (h) Repeat this method for other desired contour lines, and (i) locate all the points marked in the plan by distances from the chain lines of a traverse, (j) Plot all the points on the plan, join them by curve.

(ii)Radial Line method: (a) Locate a TBM near centre of the area, (b) Lay out radial lines from the centre point conveniently to cover the area suitably, (c) Locate points on these radial lines having the required elevation after calculating the staff reading required for that elevation. This can be done conveniently by moving inwards or outwards with the staff, (d) Mark the point with an arrow tagged with its elevation, (e) Repeat the process with all the radial lines and for all the desired contours, (f) Locate the points by a chain or tape by measuring distances from the centre point already marked, and (i) Plot all the points on the plan, join them by curve for each value of contour.

2. Indirect Method:

(i) By Spot Levels: (a) Divide the area into squares of reasonable dimensions (5 sq.m to 20 sq.m), (b) Take levels at the corners of the squares only, (c) Depending upon undulations of the ground, levels may be taken at intermediate points on the sides of the squares, (d) Once these levels are available, determine the contours of required elevation by interpolation, (e) Dimensions of the squares should be large enough to have the survey done rapidly, but small enough to locate the points of desired elevations and take care of the undulations of the ground.

(ii) By cross sections: (a)Take sections at right angles to the centre line of the road, (b) Distance between sections depends on the terrain. They should not be less than 20m in hilly terrain, but can be 50 to 100m in plane country, (c) Take levels at a number of points along the section line, (d) Locate the points horizontally by a chain or tape, (e) Obtain contours of required elevation by interpolation, (f) Join such lines to get contour lines.

(iii) By Tacheometry: (a)Set up the instrument at a suitable place having commanding view of the area. Carry out the temporary adjustments as required, (b) Hold the staff on a BM of known elevation to get the elevation of the line of sight, (c) Hold the staff in positions marked either on the vertices of squares or otherwise, (e) At each position of the staff, read the vertical angle from the vertical circle and the stadia intercept. Record identification mark of the staff station, the vertical angle, and the intercept, (f) To facilitate the work for a given small area, keep the theodolite at a central position, from where radial lines can be laid out. The staff can be kept at points along the radial lines and the readings taken. The radial lines are identified by the horizontal angles measured, (g) Once all the readings are taken, interpolate to get the contours of desired elevation.

INTERPOLATION OF CONTOURS:

(i) By estimation: The positions of the required contour points between the known elevations are roughly estimated and marked. The points are thereafter joined by smooth curves to obtain required contour lines.

(ii) By calculation: Required points are obtained by linear interpolation from elevations of the guide points.

(iii) By graphical methods using tracing paper or cloth:(a) Prepare the tracing paper as per requirement. On the vertical axis, mark the lines suitably with a constant interval depending upon the contour interval desired. Draw horizontal lines to the required length. (b) Keep the tracing paper on the grid points of known elevations. (c) On any line AB, the elevations of the end points A and B are known. Keep the tracing paper such that the points A and B lie on the lines marking their elevations. To get such a placement, keep line A on the horizontal line of its elevation. Turn the tracing paper such that point B also lies on the horizontal line showing its elevation. (d) Mark the intersection points of AB and the horizontal lines of required elevation on paper with pin. (e) Designate the points so marked with their elevations. (f) Repeat this procedure with all the lines of the grid. (g) Draw contour lines that join lines of equal elevation on the map.

Alternate

(a) Draw a line QR conveniently on the tracing paper. Choose a pole P such that it lies on the perpendicular bisector of line QR. Choose the distance of P from QR conveniently. (b) Mark points on the line QR as per the required elevations and contour interval.(c) Join pole P to elevation of equal interval marked on QR. Choose the length of QR and the contour intervals such that the lines joining P to points on QR are clearly spaced at or near the line QR. (d) In order to interpolate contours between two points, place the tracing paper such that A and B lie simultaneously on the lines corresponding to their elevations. (e) Now mark points of required elevation on the contours with a pin on the line AB at the intersection with the line from P corresponding to that elevation. (f) Repeat this procedure with other lines on the grid to get contour points of desired elevation.

USAGE OF CONTOUR MAPS:

(i) Developing cross sections: From a contour map sections may be easily drawn in any direction, from which the general shape of the terrain can be determined. This can be used to determine the earthwork required to lay engineering works.

(ii) Setting contour gradients: A contour gradient is a line in a plan having a constant slope. This line will pass through the different contour lines at different points but is assumed to be a straight line between contour lines. Knowing the contour interval and the horizontal equivalent, the contour gradient can be worked out on the plan. Thus route alignment for road, rail, canal, can be firmed up.

(iii) Determining intervisibility between stations: In case of undulating ground, this map can be used to ascertain the intervisibility between stations which is important in case of a triangulation survey, where the distance between stations can be considerably large.

(iv) Locating watershed line at a point: The watershed line for a point encloses the area from which water will flow through that point. A watershed has following characteristics: (a) It passes through the ridge lines (points of high elevation with respect to the ground on either side), (b) It is perpendicular to the contour lines, and (c) In general it follows the ridge lines.

(v) Determining features of the terrain: A contour map furnishes information regarding the features of the ground, whether it is flat, undulating or mountainous, etc.

(vi) Estimating Reservoir capacity: The calculation of reservoir surface area (submergence area) and capacity of a reservoir is possible using a contour plan.