Basic concepts of surveying and survey instrument: Dumpy Level

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- Definition and terms used in levelling.
- Principles of levelling.
- Reduction of levels by Collimation method and Rise and Fall method.
- Levelling difficulties.
- Knowledge about the instrument: Dumpy Level.
- Purpose of levelling.
- Classification of levelling.
- Curvature and Refraction.

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Levelling

An art of determining the relative height of different points on, above or below the surface.

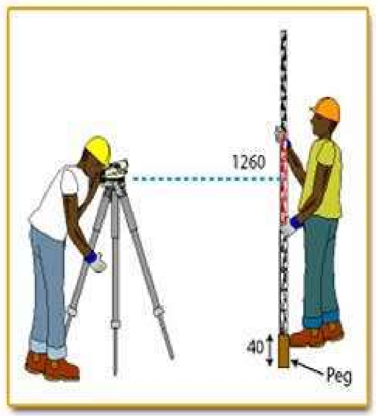
Levelling is of prime importance to an engineer for the purpose of *planning, designing and executing the*

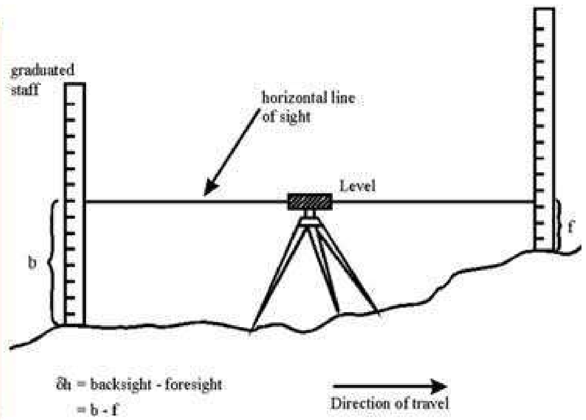
various engineering projects such as roads, railways, canals, dams, water supply and sanitary schemes etc.

The success of any engineering project is based upon the accurate and complete levelling work of the project.

Principle of Levelling

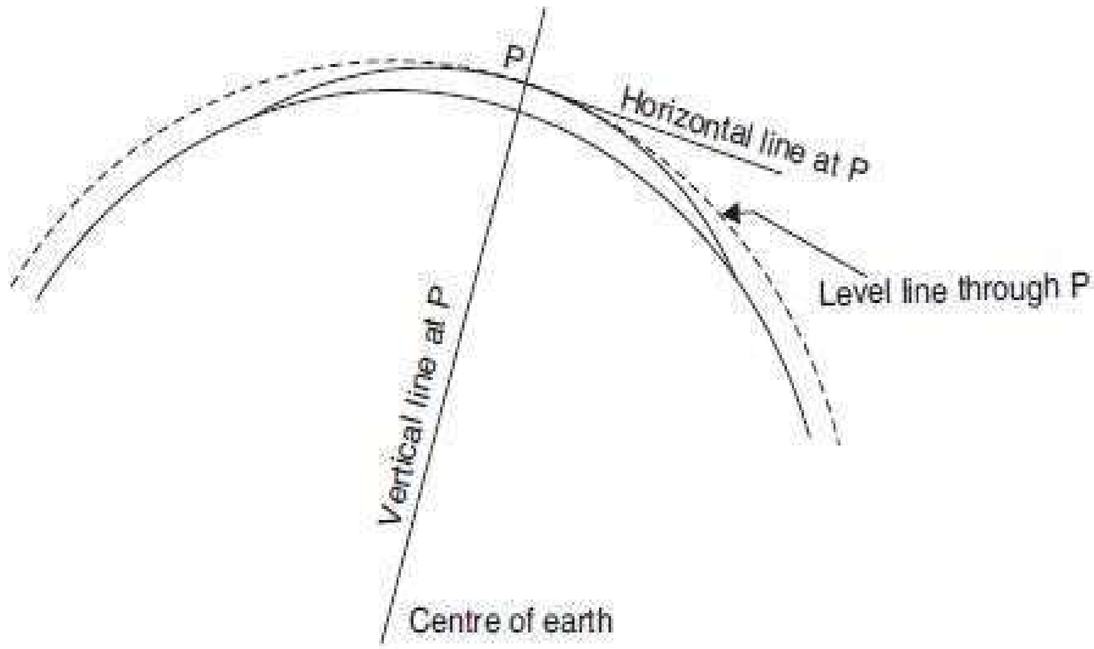
The principle of levelling lies in furnishing a horizontal line of sight and finding the vertical distances of points above or below the line of sight. The line of sight is provided with a level and a graduated levelling staff is used for measuring the height of the line of sight above the staff positions.





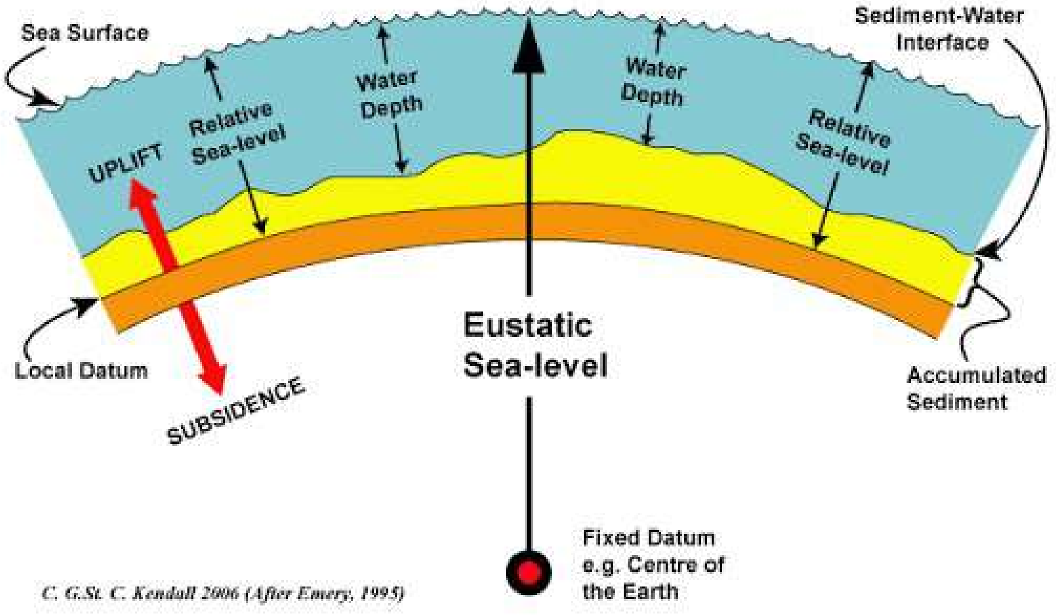
Terms used in Levelling	
Level surface	Surface parallel to the mean spheroidal surface of the earth.
Level Line	Line lying on level surface.
Horizontal plane	Plane tangential to the level surface.
Horizontal line	Straight line tangential to level line. Hence a horizontal line is at right angles to the plumb line at that point.

Vertical Surface	A vertical line at a point is the line connecting the point to the Centre of the earth. It is the plumb line at that point. Vertical and horizontal lines at a point are at right angles to each other.



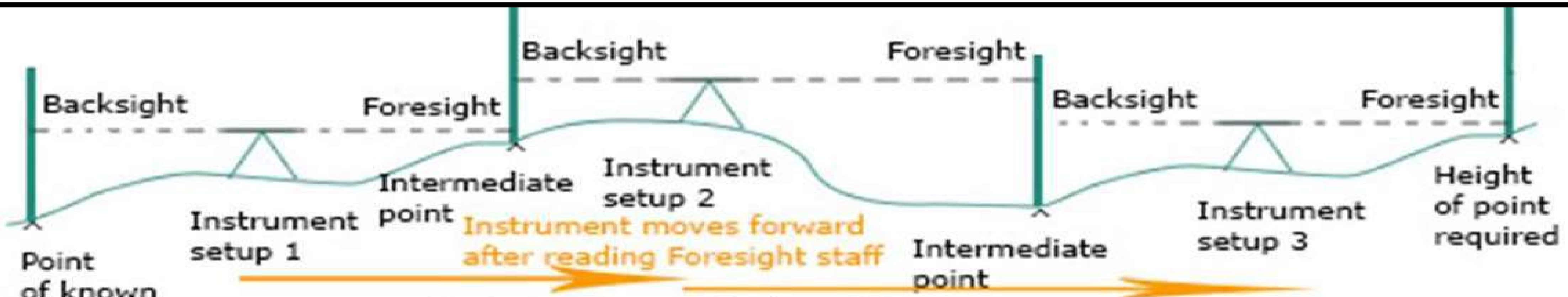
Terms used in Levelling

Mean sea level	Average height of sea for all stages of tides. It is derived by averaging the hourly tide height over a period of 19 years.
Datum	It is an arbitrary level surface from which elevation of points may be referred. In India mean sea level is considered as datum of zero elevation, which is situated at Karachi.
Elevation or Reduced level	It is height or depth of any point above or below any datum. It is denoted as R.L.



Terms used in Levelling

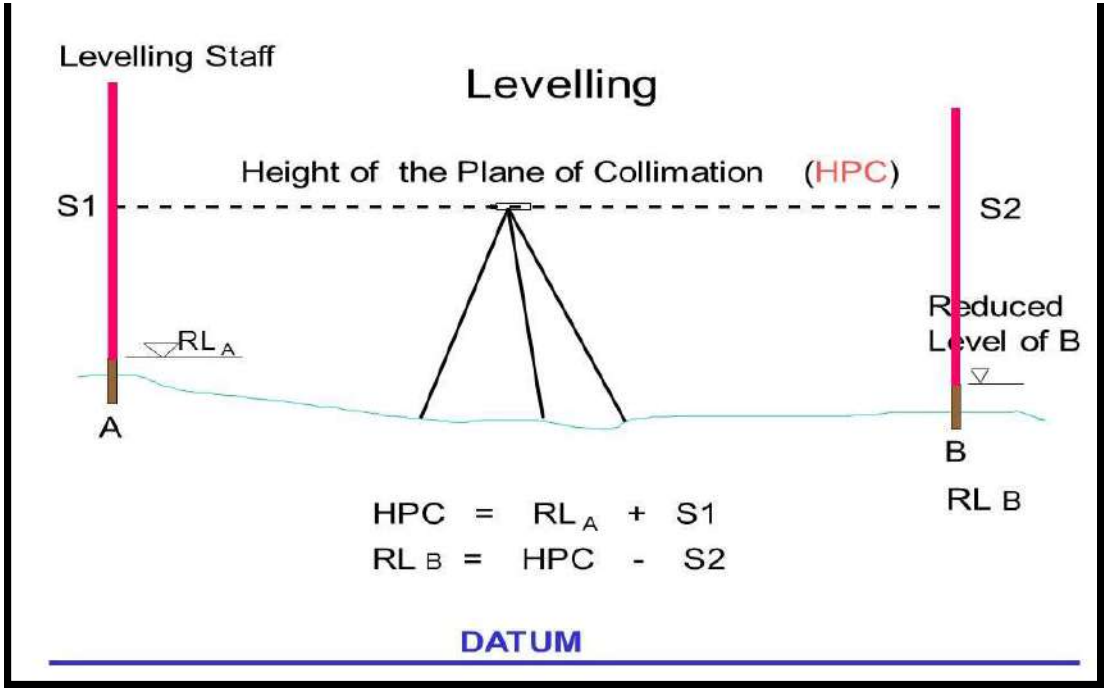
Back sight (B.S.)	It is a staff reading taken at known elevation. It is the *first staff reading* taken after setup of instrument.
Fore sight (F.S.)	It is the last staff reading taken denoting the shifting of the instrument.
Intermediate sight (I.S.)	It is staff reading taken on a point whose elevation is to be determined. *All staff reading between B.S. and F.S. are Intermediate sight*.
Changing point (C.P.)	It is a point on which both fore and back sight are taken.

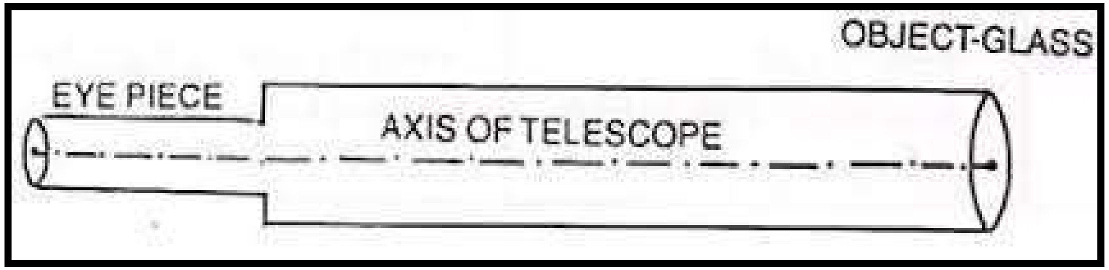


A diagrammatic level traverse

Terms used in Levelling

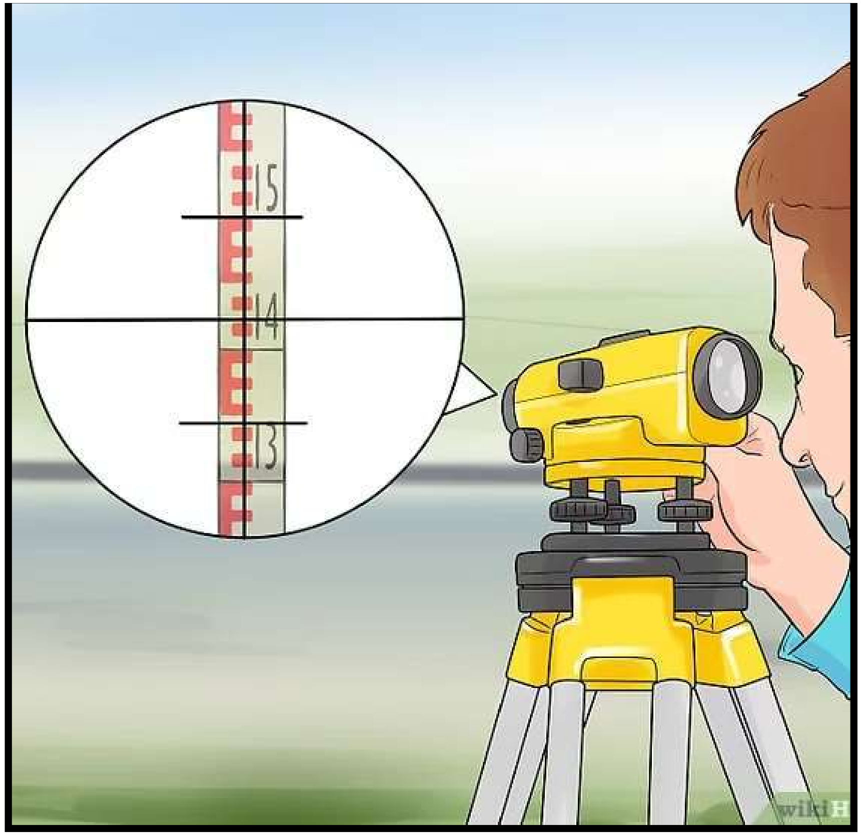
Line of collimation	It is a line joining the *intersection of cross hairs of diaphragm to the optical Centre of object glass and its continuation.* It is also known as line of sight.
Height of instrument	Elevation of the plane of collimation where the instrument is correctly levelled.
Axis of the Telescope	An imaginary line joining the centre of the eye-piece and the optical centre of the object glass.
Station	Any points where the staff is held and the reading taken during the process of levelling is called stations

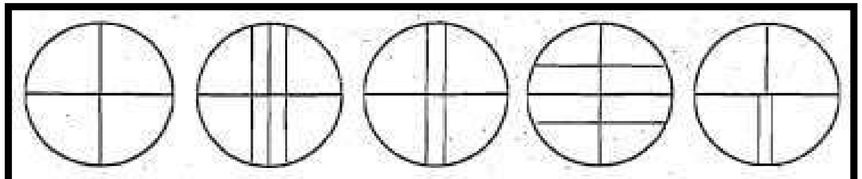




Terms used in Levelling

Focusing:	Focusing means to set the eye-piece and the object – glass at the proper distance apart for the clear vision of the object sighted. The function of the object- glass is to focus the object while that of the eye- piece is to magnify the cross-hairs and the image as projected on the diagram.



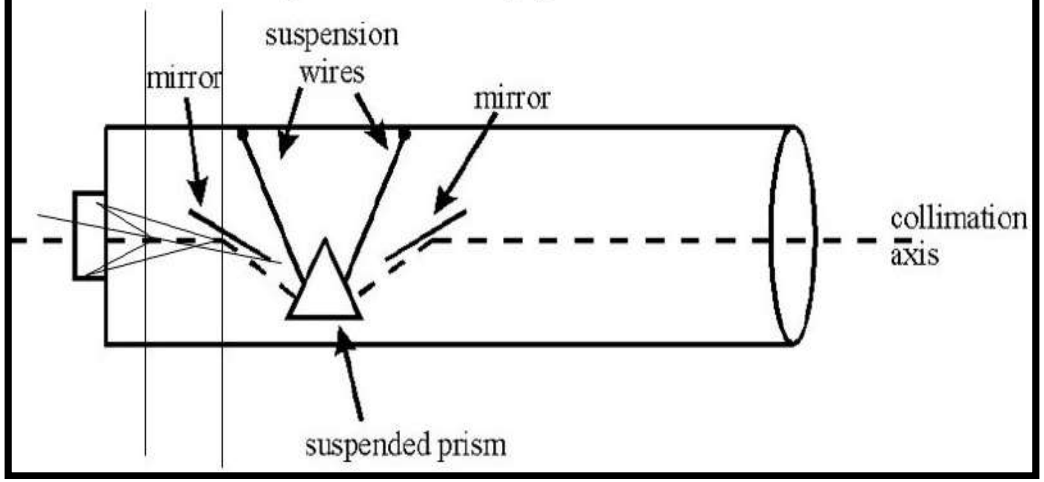


different types of cross-hairs

Terms used in Levelling

Parallax:	*It is the relative motion of the image with respect to the cross hairs* when the image formed by the object- glass does not fall in the plane of the diagram. *It is due to faulty focusing of the object- glass*, it can be tested by moving the eye up or down. *If the focusing is correct, the image seems to be fixed to the cross-hair when the eye is moved up or down.* But if the image appears to move relatively to the cross-hairs when the eye is moved up or down, that means parallax exists. It is a source of error in observations and must, therefore, be eliminated by focusing the objective correctly. This can be done by first focusing the eye- piece for the distinct vision of the cross hairs and then focusing the objective by the focusing screw.

- When using an optical instrument — both the image and cross hairs can be focused- if either is imprecisely focused, the cross hairs will appear to move with respect to the object focused, if one moves one's head horizontally in front of the eyepiece.

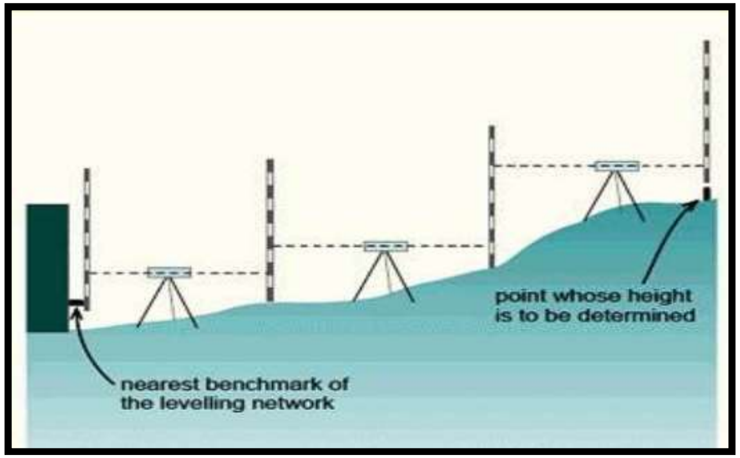


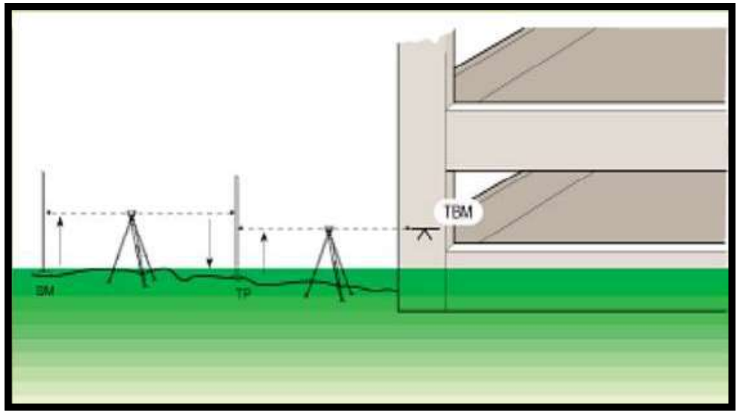
Terms used in Levelling

Bench Mark (B.M.) It is fixed reference point of known elevation with respect to datum	**GTS (Great trigonometrically survey bench mark)**	B.M. established with very high degree of precision at regular intervals by the survey of India Department all over the country. Their position and R.L. s values above M.S.L. which was earlier located at Karachi and now it is taken at Bombay High, Mumbai and is given in catalogue formed by the department.
.	**Permanent bench mark**	It is fixed in between GTS by govt. agencies such as railway, PWD, etc. this B.M.s are written on permanent objects such as milestones, culverts, bridges etc. their value are clearly written and their position are recorded for future reference.

Terms used in Levelling

Bench Mark (B.M.) It is fixed reference point of known elevation with respect to datum	**Arbitrary bench mark**	These are reference points whose R.L.s are arbitrarily assumed. They are used in small works.
	Temporary bench mark	They are reference points established during the levelling operations when there is a break in work, or at the end of day's work the value of R.L>s are marked on some permanent objects such as stones, trees, etc.





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Types of Level

Wye Level

Dumpy Level

Tilting Level

Automatic Level

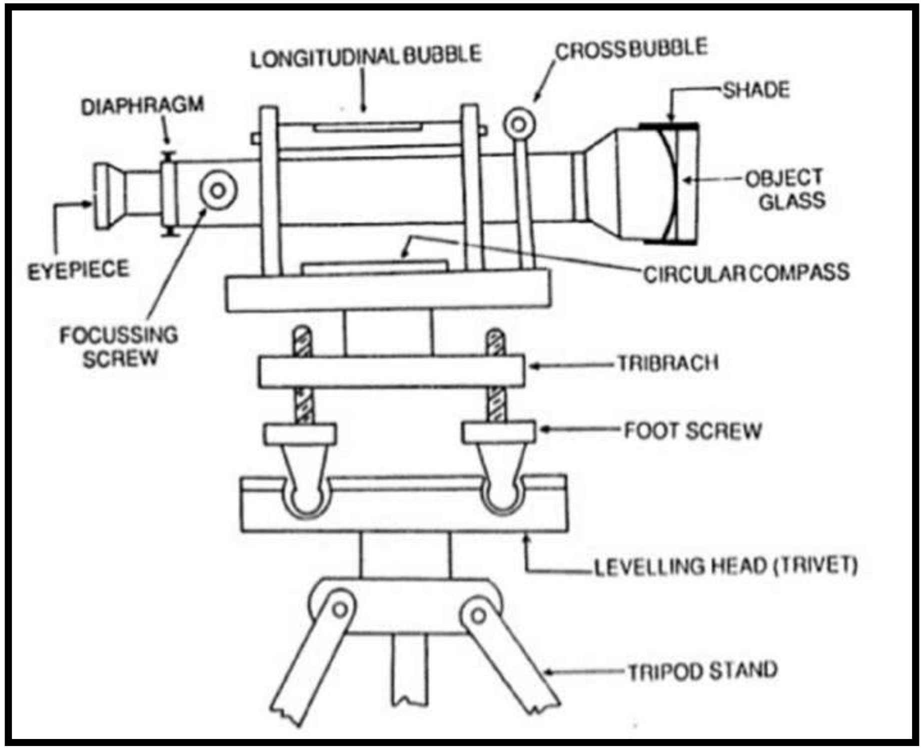
Dumpy Level

What is Dumpy Level?

Dumpy level is commonly used leveling instrument to locate the points in same horizontal plane. It is also called as automatic level or builder's level. Elevations of different points and distance between the points of same elevation can be determined by dumpy level.

The telescope is fixed to its supports in dumpy level and hence it cannot be rotated in vertical axis. English civil engineer William Gravatt is considered as the inventor of the dumpy level. He invented dumpy level in 1832 while using the conventional Y level.

Components of Dumpy Level	
Dumpy level consists the following parts or components	
Telescope	Leveling head
Bubble tubes	Tripod
Compass	Tribrach screws
Foot screws	



Dumpy Level

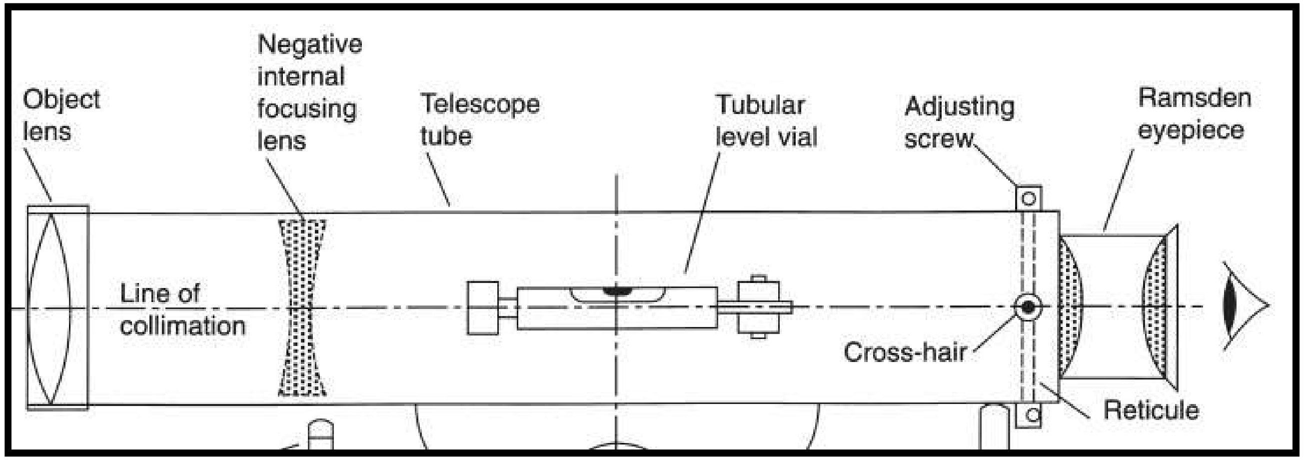
- **Telescope**

Telescope is used to observe the distant object through line of sight provided by its arrangement. In general, the telescope is fixed to the vertical spindle of dumpy level so that it can be rotated along with vertical spindle.

Parts of Telescope in Dumpy Level
The important parts of telescope are as follows:
Eye piece
Objective lens
Diaphragm
Focusing screw
Ray shade

Eye piece

Eye piece is used by the observer's eye to view the distant object. It contains magnifying glass which **magnify** the observing image and also the **cross hairs of diaphragm**. So, accurate reading can be obtained. Erecting eyepiece is used to view the normal image which is generally inverted by objective lens.



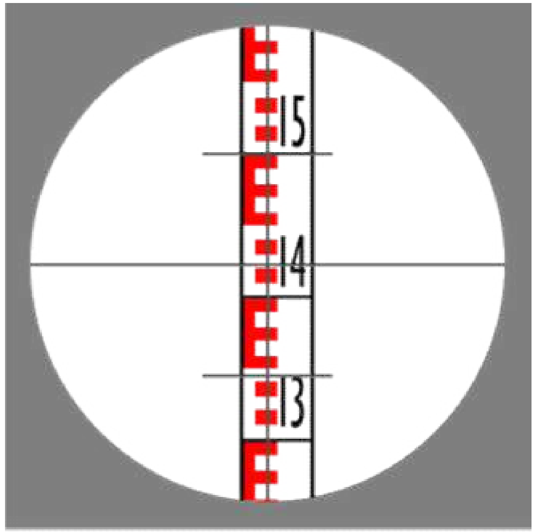
Dumpy Level

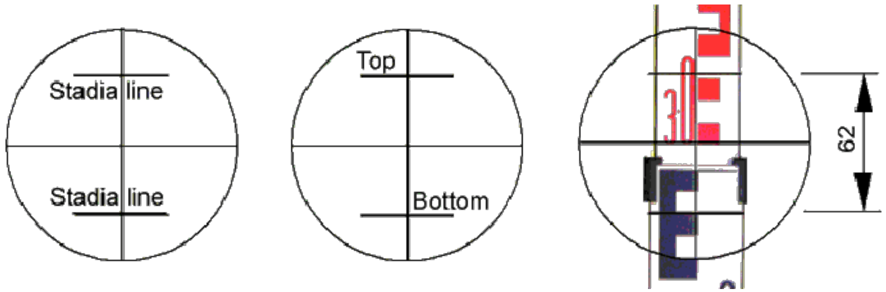
Objective lens

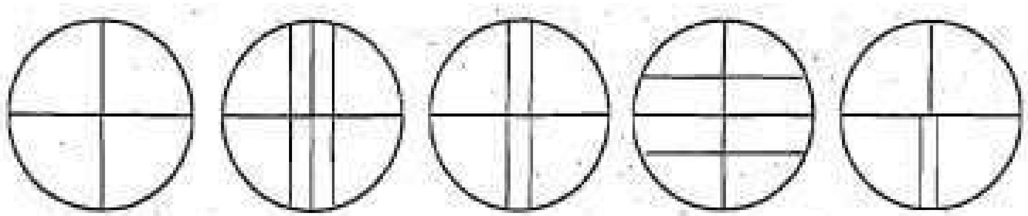
Objective lens are **provided at the other end of the telescope**. The objective lens consists of **two parts, the front part consists convex type lens and the back part consists concave lens**. So, the image obtained from the objective lens is always inverted

Diaphragm

Diaphragm is provided in front of the eye piece. It **contains cross hairs made of dark metal** which are arranged in perfect perpendicular positions. These cross hairs are used by the eye piece to bisect the objective through objective lens.







different types of cross-hairs

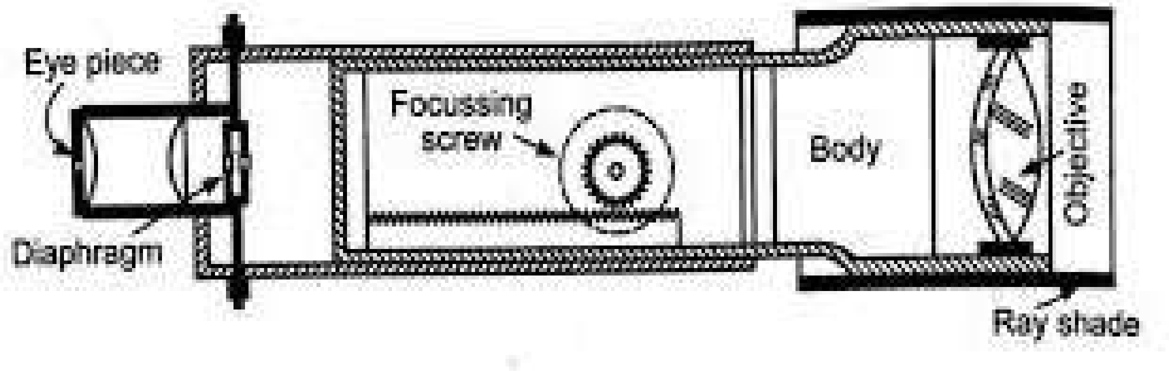
Dumpy Level

Focusing screw

Focusing screw is **used to adjust the focus cross hairs and the image clarity**. The magnification of eye piece is managed by this focusing screw.

Ray shade

Ray shade is used to **prevent the objective lens from sunlight or any other light rays** which may cause disturbance to the line of sight.

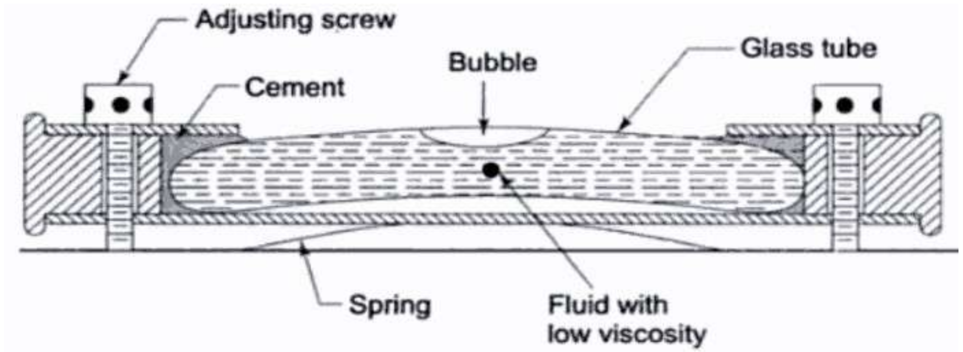


External Focussing Telescope

Dumpy Level

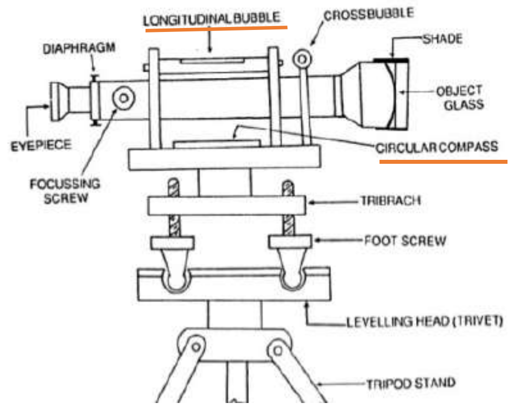
Bubble tubes

Bubble tubes are provided **to check the level of the instrument**. **Two bubble tubes** are provided in a dumpy level which are arranged **perpendicular to each other** on the top of the telescope. **One tube is called as longitudinal bubble tube** and another is called as **cross bubble tube**. The instrument is said to be in perfect position when both the bubbles of the tubes are at center or middle of the tube.



Compass

Compass is used to **determine the magnetic bearing of line**. In case of dumpy level, circular compass is provided just **under the telescope**. The compass contains a pointer in it and readings are marked inside it. The pointer is set to zero when it faces the north line from which the magnetic bearings are measured.



Dumpy Level

Tribrach

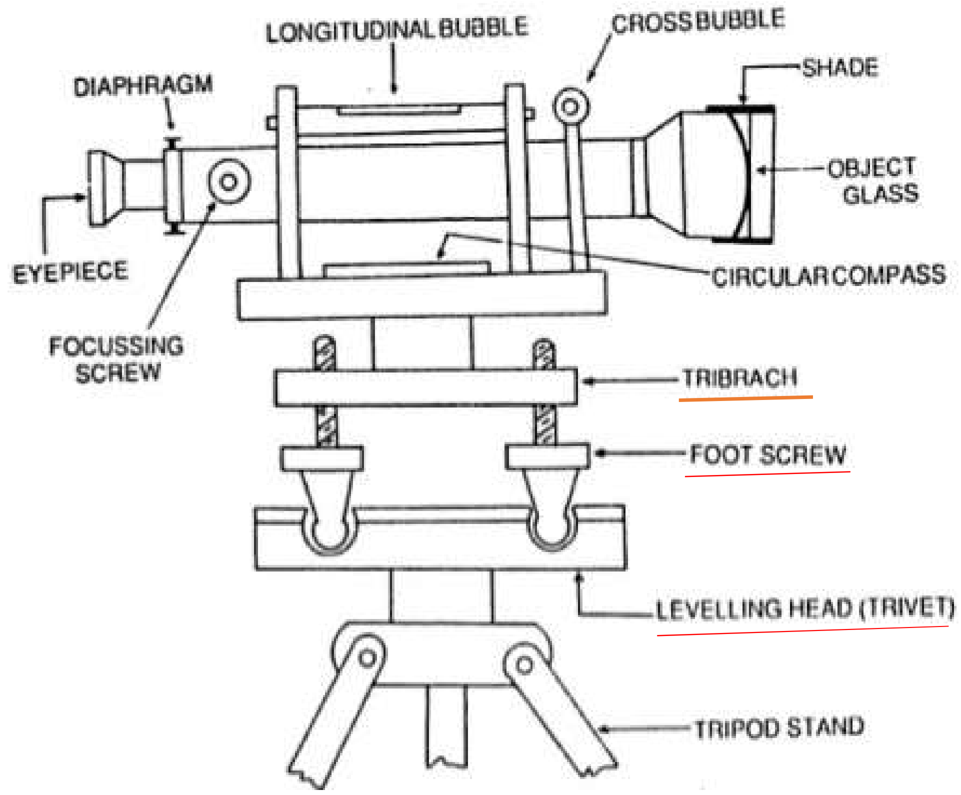
Tribrach plate is **parallel to the leveling head or trivet**. It is connected to trivet by leveling screws or foot screws which can adjust the tribrach plate. The horizontal level of the instrument can be achieved by adjusting this tribrach plate.

Foot screws

Foot screws are provided to **regulate the tribrach position** and hence the instrument can be leveled which is known by observing the bubble tube. The tribrach plates can be lowered or raised using foot screws. The position of tribrach is said to be correct when the bubble in bubble tube is at center.

Leveling head

Leveling head is **also called as trivet**. It contains **two triangular shaped plates which are arranged parallel to each other.** Three groves are provided at the three corners of the plates in which foot screws are supported.



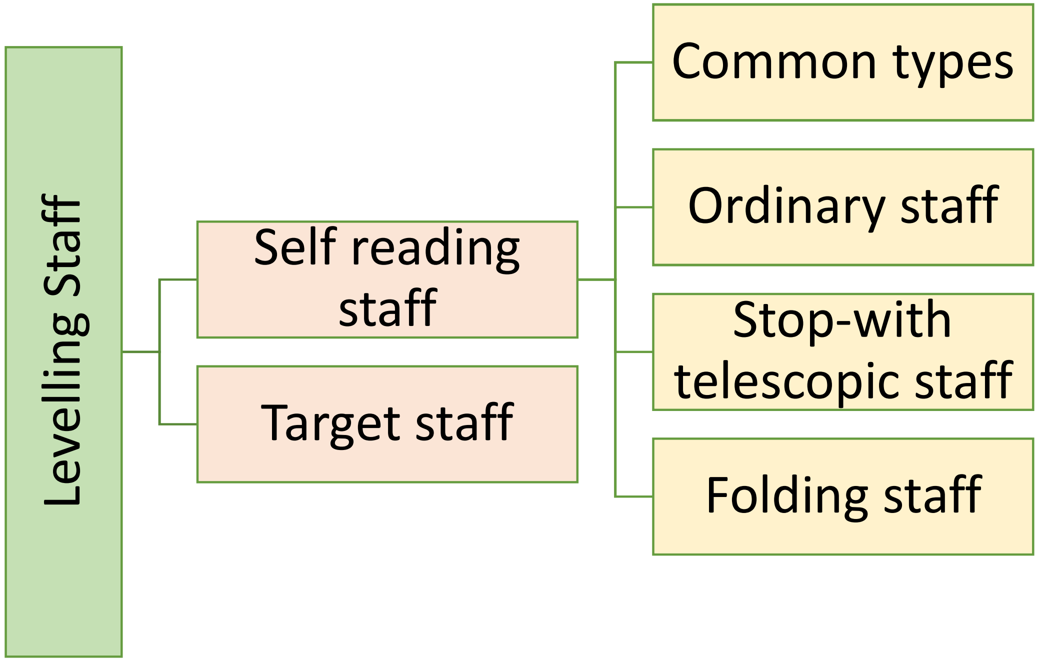
Dumpy Level

Tripod

Tripod is used to **support the whole leveling instrument on its top**. It consists **three legs** which can be adjustable to required position. The legs are of same height and they may be solid or hollow. **Steel shoes are provided** at the bottom of each leg to hold the ground in a fixed position.

Levelling staff

Levelling staffs are scales on which these distances are measured.



Self levelling staffs

The self reading staff can be read directly by the level man looking through the telescope.

Ordinary staff

The one length staff, is solid and made of seasoned wood, it is 3m long and graduated in the same way as the telescopic staff.

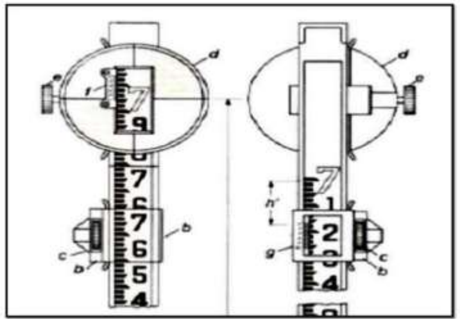
Folding staff

It consists of two 2m wooden pieces with a joint assembly. The folding joint is detachable type with a locking device at the back. The staff has brass cap at the bottom. It has two folding handles, with spring action. It is provided with a circular bubble fitted at the back.

Levelling staff

Levelling staffs are scales on which these distances are measured.

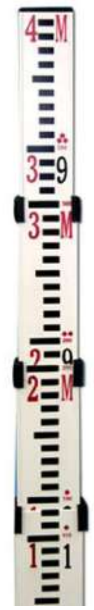
- Levelling Staff
  - Self reading staff
    - Common types
    - Ordinary staff
    - Stop-with telescopic staff
    - Folding staff
  - Target staff



Stop-with Telescopic staff

Staff is arranged in 3 lengths places one into the other. It can be extended to its full length by pulling. The top portion is solid and the external box is hollow the total length of staff is 4m.

Staff is graduated in such a way that smallest division is of 5mm. The value in m are marked in red on the left and those in decimeter are in black on the right.

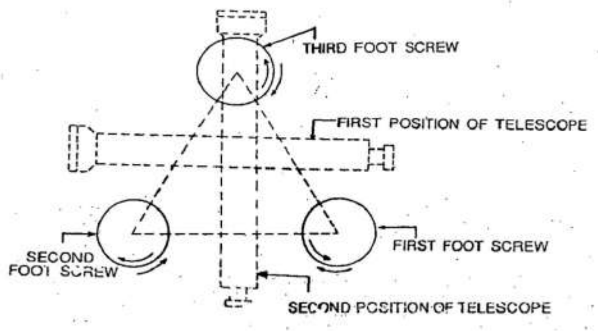


Target staff

For very precise works and sight target staff are used. A movable target is provided in this staff.

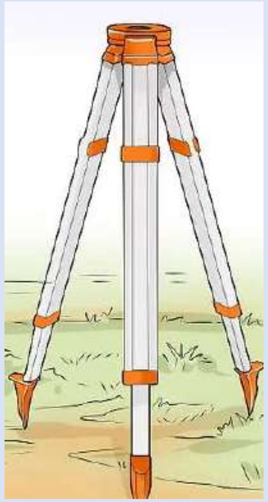
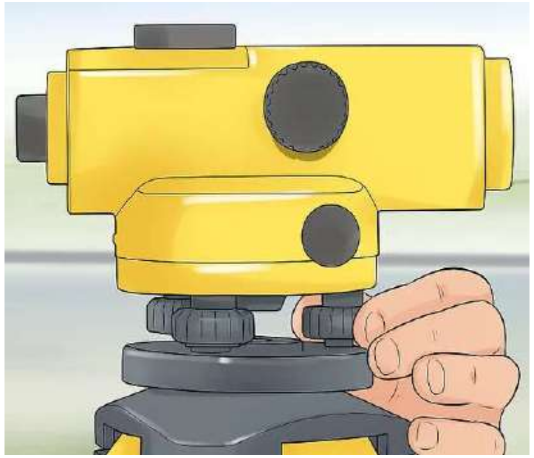
A vernier is provided on target to give precise reading. In target staff level man directs the staff man to move the target up and down until it bisects by the line of sight. The staff man observe the staff reading.

Procedure of Dumpy Level Surveying

The procedure of dumpy level surveying starts with some temporary adjustments which are:		
Setting up of Dumpy Level	The instrument is **fixed to the tripod** stand using clamp screws. Spread the tripod legs and position the instrument at convenient height. Firstly **fix the two legs** in the ground at a point and **centering of bubble in the bubble tubes is done by adjusting third leg.**	
Leveling of telescope	**A.** The leveling up of an instrument is done using **foot screws or leveling screws**. In this case, the telescope is arranged parallel to the any two leveling screws and the bubble in the tube is centered by turning both the screws either inwards or outwards. **B.** When it is centered, then the **telescope is turned 90º and the third screw is turned** until the bubble come to center. Repeat the process until the bubble in the tube always stays at the middle in any position of telescope.	
Focusing- eye piece and object glass	Focusing is done by adjusting **eye piece and focusing screw**. Eye piece is adjusted until the cross hairs of diaphragm are clearly visible. To eliminate the parallax error, a white paper is used to obtain sharp vision of cross hairs. Focusing screw is adjusted to view the clear image of the objective or staff. Focusing is said to be done when the cross hairs bisect the objective or staff with clear vision.	

Procedure of Dumpy Level Surveying

The procedure of dumpy level surveying starts with some temporary adjustments which are:

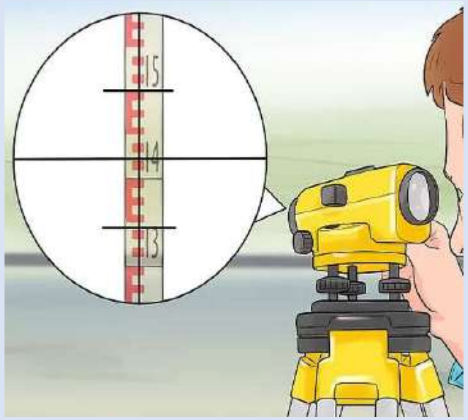
Setting up of Dumpy Level		Set your tripod up near the spot you want to measure.		Connect your device to the tripod and position it over 2 leveling screws.		
Leveling of telescope		Level the device by adjusting the 2 leveling screws.		Turn your telescope 90 degrees and adjust the third leveling screw.		Check your level’s calibration by turning it 180 degrees.

Procedure of Dumpy Level Surveying

The procedure of dumpy level surveying starts with some temporary adjustments which are:

Focusing- eye piece and object glass

Remove your dumpy level's lens cap.

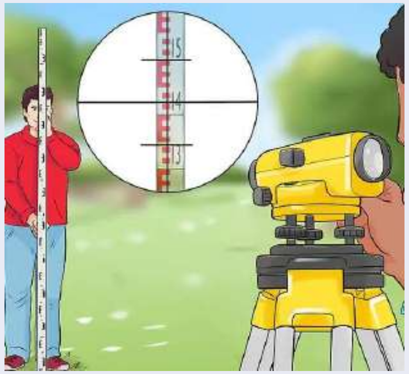


Adjust the eyepiece until you can see the device's crosshairs.

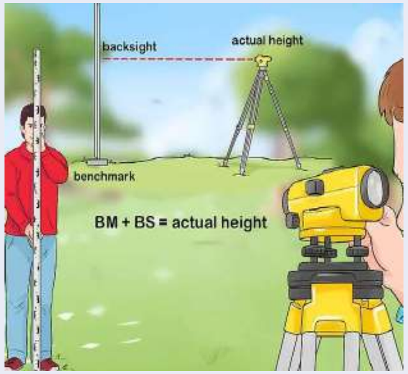
Twist the device's focusing knob until the image is clear.

Taking a Measurement

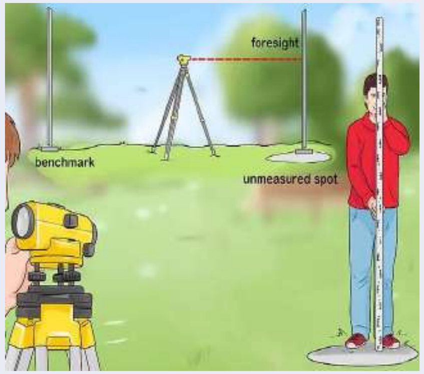
Position an E staff on top of your benchmark spot.



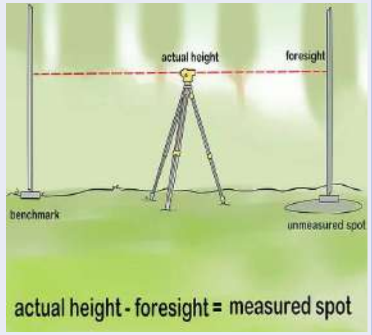
Find the height difference between your level and the benchmark spot.



Calculate your level's actual height using the benchmark height.



Find the height difference between your level and the unmeasured spot.



Calculate the spot's actual height using your level's height.

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Methods of Levelling:

1. Height of Collimation Method **Collimation Method: 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.**	Elevation of plane of collimation for the first set of the level determined by adding back side to R.L. of B.M. 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 elation of the plane collimation. [H.I.] When the instrument is shifted to the second position a new plane collimation is 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.
2. Rise and Fall Method	

Methods of Levelling:

1. Height of Collimation Method

Backsight	Inter Sight	Foresight	Height of Collimation	Reduced Level	Remarks
1.034			87.486	86.452	OBM 86.452
	1.961			85.525	
	0.672			86.814	
2.741		0.488	89.739	86.998	
	2.571			87.168	
	1.991			87.748	
0.512		1.632	88.619	88.107	
	1.773			86.846	
		2.167		86.452	OBM
4.287		**4.287**			

Σ Backsights minus Σ Foresights

= Difference between first and last Reduced Level   86.452 Minus 86.452 = 0

Methods of Levelling:

1. Height of Collimation Method	
2. 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. This method is complicated and is not easy to carry out. 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.

Methods of Levelling:

2. Rise and Fall Method

Rise and fall method

Station	B.S	I.S	F.S	Rise	Fall	RL	REMARKS
1	2.228					432.384M	B.M.
2		1.606		0.622		433.006	
3	2.090		0.988	0.618		433.624	3RD C.P.
4		2.864			0.774	432.850	
5	0.602		1.262	1.602		434.452	6TH C.P
6	1.044		1.982		1.38	433.072	8TH C.P
7			2.684		1.64	431.432	
	5.964		6.916				

CHECK ∑ B.S- ∑ F.S= 5.964-6.916= -0.952 =
LAST R.L- FIRST R.L= 431.432-432.384=-0.952
∑RISE- ∑ FALL= 2.842-3.794=-0.952

Methods of Levelling:

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

Basic concepts of surveying and survey instrument: Dumpy Level

- *Definition and terms used in levelling.*
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- **Levelling difficulties.**
- *Knowledge about the instrument: Dumpy Level.*
- Purpose of levelling.
- Classification of levelling.
- Curvature and Refraction.

Levelling difficulties

Levelling Across a Hill or a Hollow:

In levelling across a hill, the level should not be set up on the top of the hill, but it should be set up on side shown in fig. 7.18. This reduces the number of instrument-settings. Similarly in levelling across a hollow, much time will be saved, if the instrument is set upon one side of the hollow as in fig 7.19 instead of in the bottom of the depression.

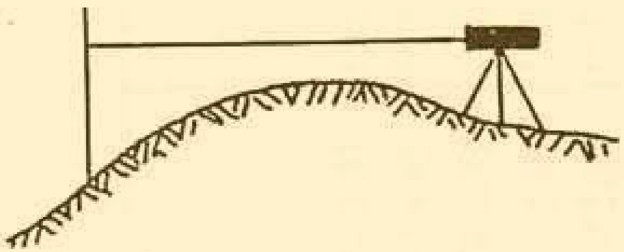

Fig. 7.18.

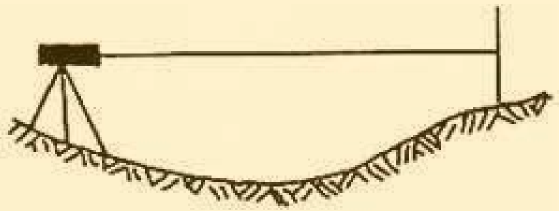

Fig. 7.19

Levelling Up-Hill or Down-Hill:

While levelling up-hill, the fore sight will be near the foot of the staff and the back sight heart the downhill the reverse is the case.

The error due to non verticality of the staff is small when the staff reading is small, but it is serious when the line of sight strikes near the top and the reading is large, in which case the error can be avoided by keeping the staff vertical by using a plumb-bob., or by waving the staff and noting the smallest reading.

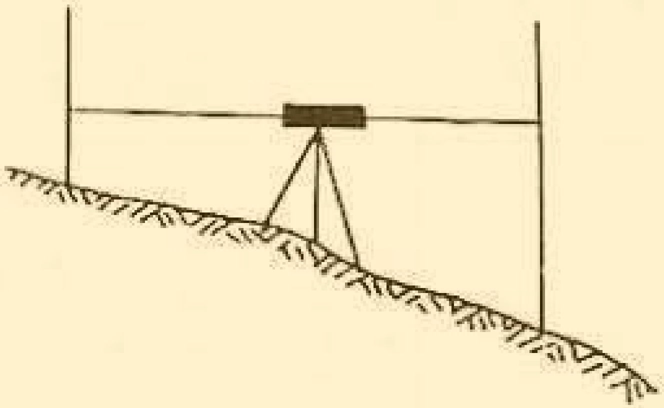

Fig 7.20

Levelling difficulties

Staff Very Near the Instrument:

When the staff is held very near the instrument, the graduations on the staff are not clearly visible. In such a case, a piece of white paper is moved up or down the staff until its edge is bisected by the line of collimation and the corresponding reading is taken. When the level is set up over the staff-station itself the staff reading may be taken by viewing through the object glass or by measuring the height of the centre of the object-glass with the staff.

When the Staff-Station is too Low or too High:

When the staff station is too low i.e., the line of collimation passes above the staff, a peg is driven and staff is held over the peg (fig. 7.21). The staff reading (be) is taken and the height of the top of the peg (ab) above the ground is measured with a tape.
The required staff reading equals (ab + bc).
When the staff-station is too high i.e., above the line of sight as in the case of a the-beam, roof-girder, the stringcourse etc. the staff is held inverted on the point, and the reading is then taken. This reading being negative is entered in the level-book with a negative sign.
Therefore, if the inverted staff reading is back sight it is negative and if the same is fore sight, then it is positive.

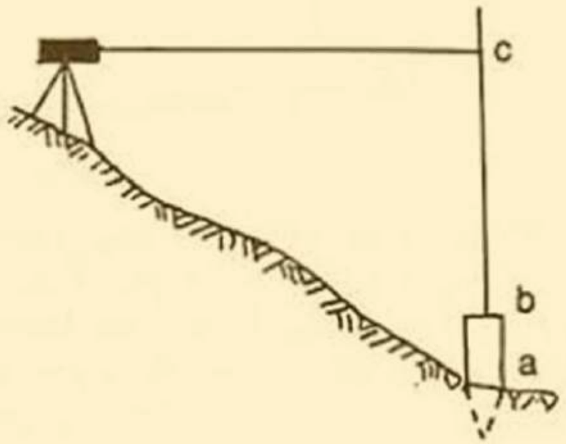

Fig. 7.21.

Levelling difficulties

Levelling across a Pond or a Lake:

This kind of difficulty can be got over by driving two pegs A and B flush with the water surface on opposite sides of a pond or a lake as shown in fig. 7.22.
Evidently the top of the pegs are at the same level. The R.L. of the peg A is determined by taking a fore sight on it. This is also the R.L. of the peg B. The instrument is then shifted and set up on the other side and a back sight is taken on peg B, the two pegs A and B together, being considered as a single change point.

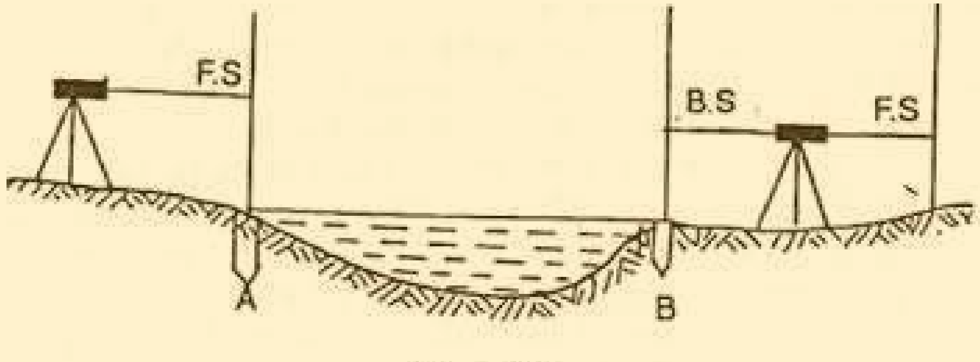

Fig. 7.22.

Levelling across a River:

The above method is not suitable in the case of fast flowing water of a river. In such a case, the method of reciprocal levelling employed to determine the true level between two point on opposite bank and the levelling is continued.

Levelling difficulties

Levelling across Solid Obstruction like a Wall:

The telescope is directed towards the wall where the line of sight cuts it (see fig 7.23).Measure height from this point 'A' to the top of the wall 'B' accurately with a steel tape. Find the R.L. of the top of the wall by adding the distance AB to the Height of Instrument.
Shift the instrument to the other side of the wall and mark a point 'D' where the line of sight strikes it. Measure CD as before. The height of instrument in the second position is then equal to the R.L of the top of the wall minus CD. Then proceed as usual.

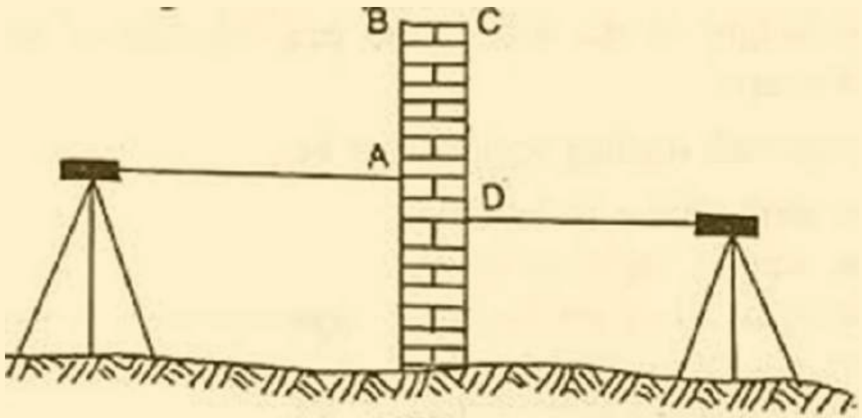

Fig. 7.23

Staff is too low and high:

When the staff is too low (i.e. line of collimation passes above the top of the staff), the staff man should be directed to raise the staff until it can be read, the staff being supported against the pole. The distance from the staff station to the bottom of the staff should be measured and added.

When the staff is too high (i.e. staff station above the line of sight), so that it is impossible to invert the staff.

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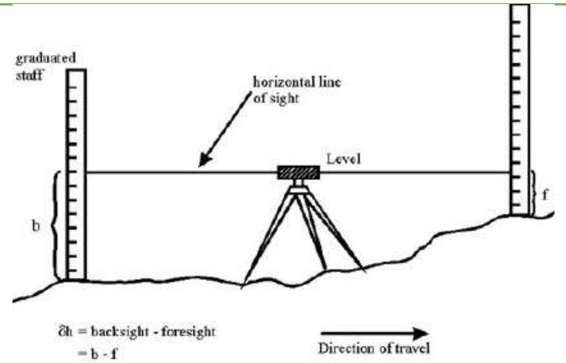
- **Classification of levelling.**
- Curvature and Refraction.

Classification of levelling

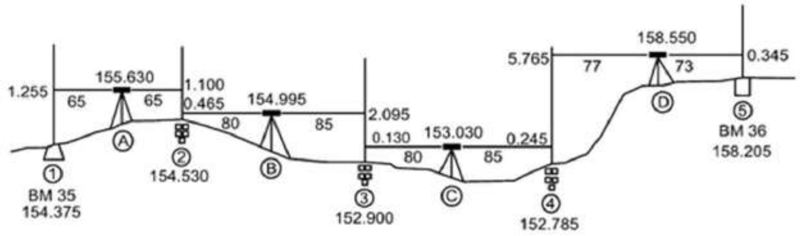
Simple Levelling

It is the simplest method used, when it is required to find the difference in elevation between 2 points.



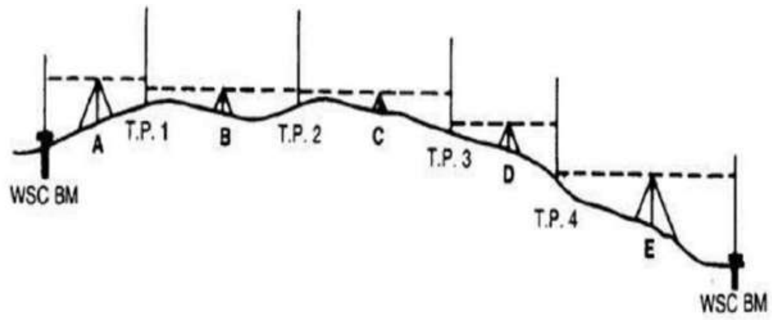
Differential Levelling

This method is used to find the difference in the elevation between points if they are too far apart or the difference in elevation between them is too much.



Check Levelling

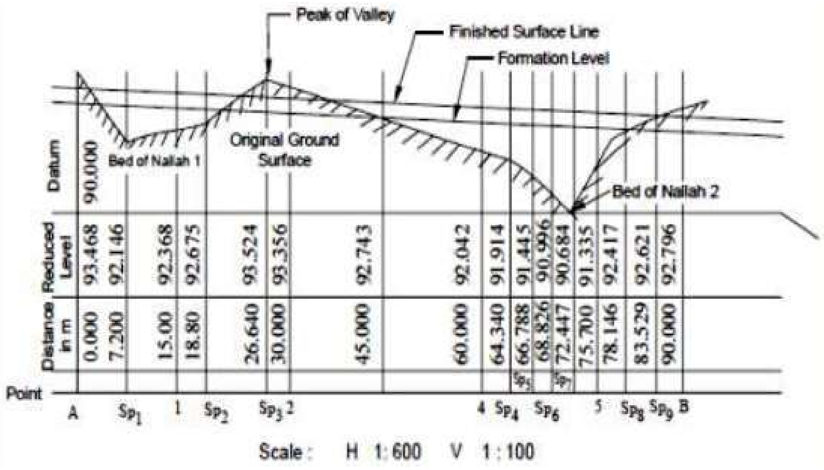
It is carried out to check the accuracy of work. It is done at the end of the days work in the form of fly levelling to connect the finishing point and starting point.



Classification of levelling

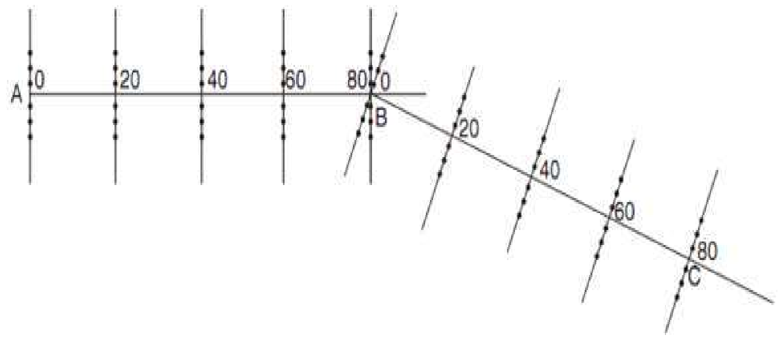
Profile Levelling

Used for taking levels along the center line of any alignment like road, railway, canal etc. the object is to determine the undulation of the ground surface along the alignment.



Cross sectioning

It is to determine the surface undulations or the outline of the ground transverse to the given line and on either side of it.



Classification of levelling

Reciprocal Levelling

This method is adopted to accurately determine the difference of level between two points which are far apart. It is also used when it is not possible to set up level in midway between two points.

Procedure:

1. Suppose A and B are two points on an opposite bank of a river. The level is set up very near A and after proper temporary adjustment staff reading are taken at A and B. suppose reading a1 and b1

2. level is shifted and set up very near B and after proper adjustment, staff reading is taken as A and B. Suppose the reading are a2 and b2

Let,

h= true difference of level between A and B

e= combine error due to curvature, refraction and collimation

(Error is +ve and –ve, here error is assumed +ve)

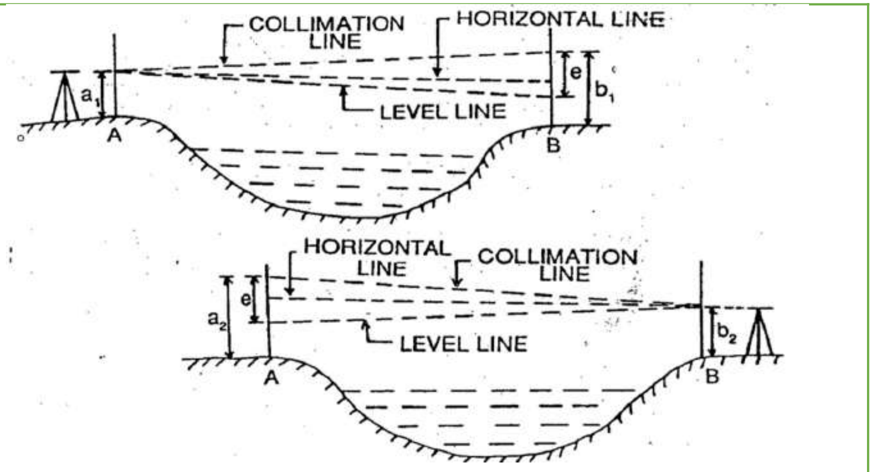
First case:

Correct staff reading A=a1

Correct staff reading B=b1 – e

True difference of level between A and B

h= a1 – (b1-e) ……………………………………………………..eq.1



Procedure:

Second case:

Correct staff reading B=b2

Correct staff reading a=a2 – e

True difference of level between A and B

h= (a2 - e) – b2

……………………………………………………..eq.2

from (1) and (2)

2h= a1 – (b1-e) + (a2 - e) – b2

2h= a1 – b1 + e + a2 – e – b2

2h= (a1 – b1) + (a2 – b2)

h= [(a1 – b1) + (a2 – b2)] / 2

Classification of levelling

Barometric Levelling

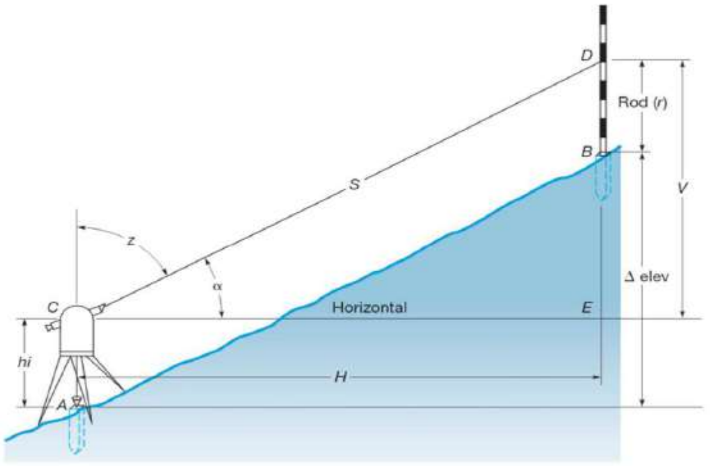
Here, altitude difference is determine by means of a barometer.
It is based on the fact that the atmospheric pressure varies inversely with height. In this method a barometer is used to determine the differences in elevation of points, which differ considerably in heights as in a hilly area or mountainous country.
Mercury and Aneroid Barometers are used for the levelling.

Hypsometric Levelling

Hypsometry is used to determine the elevation depends upon the fact that the temperature at which water boils varies with the atmospheric pressure. The boiling point of water reduces at higher altitude thus knowing the boiling point of water, the atmospheric pressure can be calculated and knowing the atmospheric pressure altitude or elevation can be determined.
The altitude of various points may be determine by using hypsometer, also called as thermo-barometer.

Trigonometric Levelling

Vertical distances between points are computed by observing horizontal distances and vertical angle between points.



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Curvature and Refraction.

In case of long distance sights the effect of curvature and refraction have to be taken into account.

Curvature

The object sighted to appear lower than they really are.

The level line falls away from the horizontal line, and the vertical distance between the horizontal line and the level line represents the effect of the curvature.

Correction of Curvature effect

Formula of correcting curvature effect is:

True staff reading= Observed staff reading – $0.0785D^2$

Correction is subtractive.

Formula may be derived as:

AC = The level line.

B = The horizontal line.

O= The center of earth.

D= Distance between instrument and staff stations.

R= The radius of the earth. (OA)

d = CE, diameter of the earth.

BC= The correction for curvature.

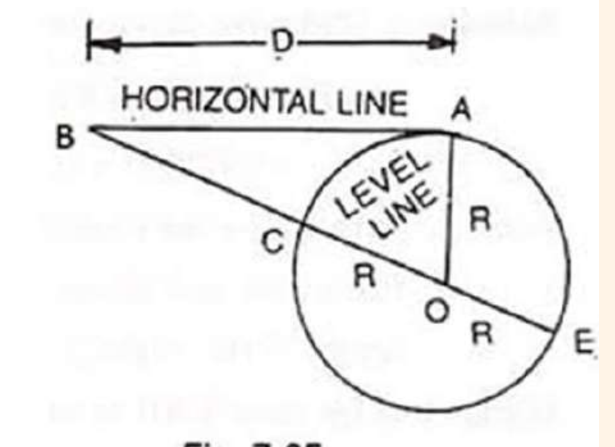
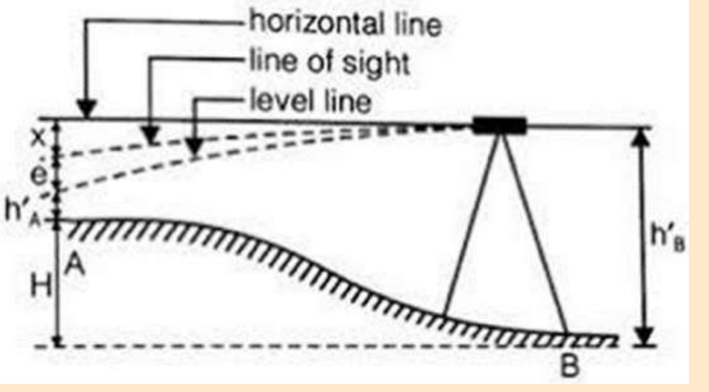


Fig. 7.25



Now, $BC \times BE = BA^2$

Or, $BC (BC + CE) = BA^2$

Or, $BC \times CE = BA^2$

Or, $BC = BA^2/ CE = BA^2/ 2R$ *(let, BC^2 may be neglected as it is very small.)*

Or, BC (km)= $AB^2/ 12742$ *(R = 12742km)*

Or, BC (m) = $(AB^2\ 1000)/12742 = 0.0785\ D^2$

Curvature and Refraction.

In case of long distance sights the effect of curvature and refraction have to be taken into account.

Refraction

It is a well-established law of physics that rays of light passing through layers of different densities do not remain straight but are refracted or bent down towards the denser medium. Consequently, the ray of light from the staff to the instrument is not straight as but it follows a curved path concave towards the earth as the near the surface of the earth is denser than the upper layers of air. Radius of curved path is 7times that of the earth under normal atmospheric condition.

Correction of Refraction effect

Formula of correcting curvature effect is:

true staff reading = observed staff reading -0.0673 D^2

The line of collimation of the level will intersect the staff at D instead of B.

Effect is to diminished the staff reading.

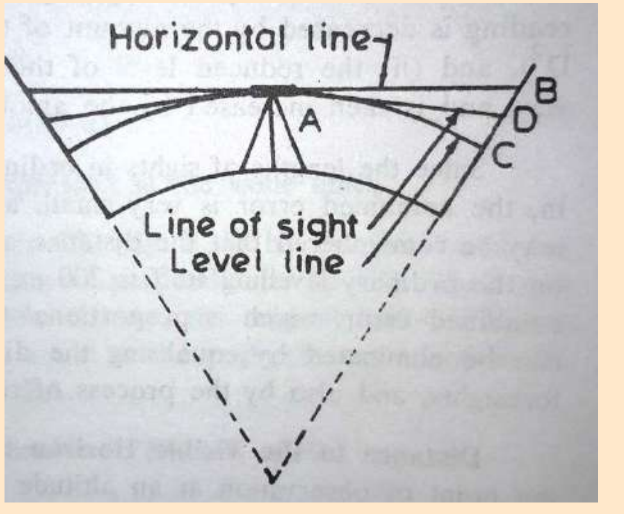
It is not constant.

Correction for refraction is additive to the staff reading.

Correction is BD in m. = 1/7 BC.

= 1/7 (0.0785 D^2)

= 0.0112 D^2



Combined correction

Combine effect is to increase the staff readings, the combined correction is subtractive.

CD is combine error.

CD = BC – BD = BC – 1/7 BC = 6/7 BC = 6/7 × 0.0785D^2

= 0.0673 D^2

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Purpose of levelling.

Benefits of Dumpy Level Surveying	Drawbacks of Dumpy Level Surveying
Dumpy level is easy to use.	It is limited to only horizontal angle measurement.
Adjustments can be made as per the requirement on any type of ground.	The angles obtained by dumpy are not that accurate.
Level readings are very accurate in case of dumpy level.	
Optical power is high for dumpy level.	
Price of dumpy level is cheap when compared to other instruments.	

Common sources of errors in levelling
1. Instrument not correctly levelled. 2. Telescope not correctly focused. 3. The wrong cross-hair reading recorded (e.g. top instead of middle). 4. Staff incorrectly read or not held vertical. 5. Staff incorrectly booked. All the above are mistakes (blunders) and cannot be corrected unless the work is repeated.

Thank You

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