2nd nov,
SUNDAY

LEVELLING

→ Principle.

Measurements in vertical plane.

→ Objectives

- To find RL of different objects lying on (or) below (or) above the Earth's surface.
- To establish points at a given elevation wrt datum.

→ Uses

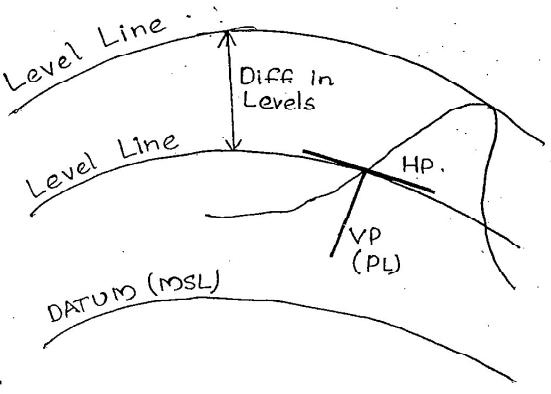
- to prepare the contour map.
- altitudes of different points in a hill.
- to prepare layout of water distribution system, drainage system etc.
- to prepare longitudinal sectioning and cross sectioning of a project.

→ Terms.

1. Level Surface:

Curved surface perpendicular to direction of gravity.

Eg: still water in a lake., pond.



2. Horizontal Plane:

Tangential to lvd surface and ⊥r to plumb line.

3. Vertical Plane.

It is normal to horizontal plane and shown by plumb bob.

4. Datum.

Any surface to which elevations are referred done it

5. Mean Sea Level :

Average height of sea for all the stages of tides considered for 19 years period.

6. Bench Mark :

It is a permanent point of reference whose elevation wrt datum is known.

(i) Permanent BM
(ii) Temporary BM
(iii) GTS BM.
(iv) Arbitary BM

7. Reduced Level :

Elevation of a point above or below datum

4th NOV, TUESDAY

→ Methods of Levelling

1. Barometric Levelling.

RL difference b/w any two points can be measured by taking the pr. difference b/w them. Pressure can be measured with the help of barometer, hypsometer, altimeter also.

2. Indirect Leveling / Trigonometrical Levelling.

Heights and distances of various points can be calculated by taking the vertical angles.

3. Spirit Levelling / Direct Levelling.

Concept of telescope and spirit level is coupled.

→ Levelling Instruments.

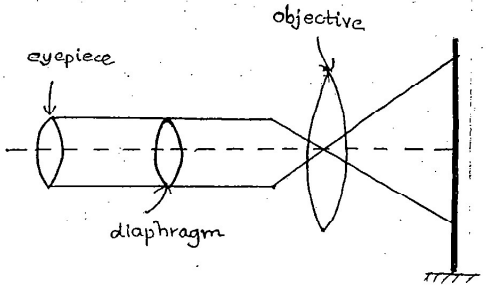
1. Level.
   a) Dumpy Level.
   b) Auto level.
   c) Reversible level.
   d) Tilting level.
   e) Wye Level.

2. Levelling Staff.
   (i) Self Reading
      a) Solid – 3m
      b) Folded. – 4m
      c) Telescopic – 4m, 5m
   (ii) Target Levelling staff.

* Level.

It consists of :

- Telescope
- Levelling head.
- Level tube.
- Tripod.



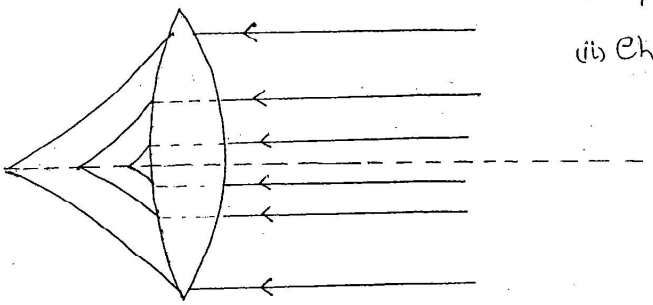
* Telescope is adoption of Kepler, eyepiece is of Ramsdon's type.

⊙ Optical Defects of Lenses.

a) Abberation – It is the deviation of rays of light when unequally refracted By a lens so that they do not converge and meet at a focus, but seperate forming an indistinct image of the object.

(i) Spherical Aberattion.

(ii) Chromatic Aberration.



Optical defects of lens can be avoided by providing compound lens.

Definition:

It is the capability of producing the sharp image.

Magnification:

It is the ratio b/w focal length of objective to the eyepiece.

$$\text{Magnification} \propto \frac{1}{\text{Illumination of lenses.}}$$

Illumination depends on the quality of lens, magnification power of lens and no. of lenses used.

External Focusing Telescope:

It is the one in which focusing is done by the external movement of either objective or eyepiece.

Internal Focussing Telescope:

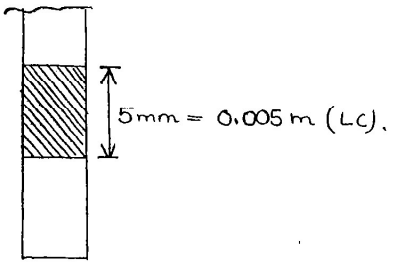
It is the one in which focussing is done internal by negative lenses.

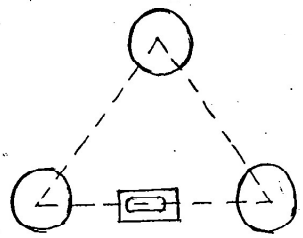
NOTE:

Internal focussing telescope is advantageous than external focussing telescope.

(ii) Rising Gradient

* Levelling Staff.





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→ Types of Levelling

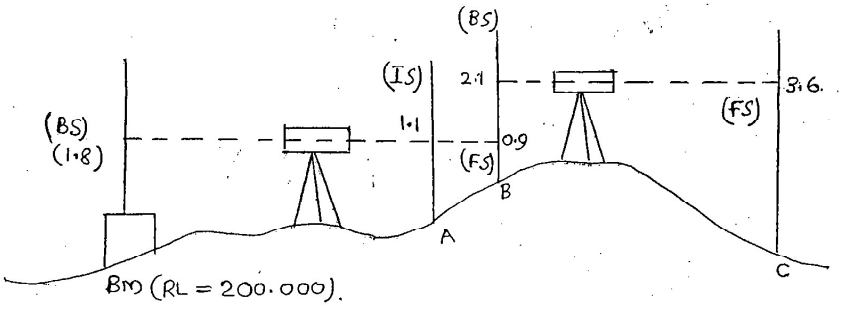
(i) Differential Levelling / Fly levelling / Check levelling.

(ii) Profile Levelling.

(iii) Longitudinal sectioning & Cross sectioning.

(iv) Precise levelling

(v) Reciprocal levelling



* Terms :-

1. Station – location of levelling staff.

2. Height of instrument – it is the reduced level of LOS.

3. Backsight – It is the sight taken on a point of known elevation. It is called as a plus sight because HI can be calculated by adding BS to the known RL.

$$HI = RL + BS.$$

4. Foresight – it is the sight taken on a point of unknown elevation. It is called as minus sight because RL of any point can be calculated by deducting FS from HI.

$$RL \text{ of any point} = HI - FS$$

5. Intermediate sight – it is the sight taken b/w FS & BS.

$$RL \text{ of any point} = HI - IS$$

6. Line of sight – it is an imaginary line passing through the optical centres of objective and intersection of cross hairs.

→ Methods of Reduction of Levels.

(i) HI method (or) Collimation method.

– It is not suitable for intermediate sights because there is no check for it.

Stn	BS	IS	FS	HI	RL	Remarks
BM	1.8			201.800	200.000	RL of B.
A		1.1			200.700	
B	2.1		0.9	203.00.	200.900.	CP
C			3.6		199.400	

Check:

$\Sigma BS - \Sigma FS$ = Last RL − First RL.

= 0.6

Stn.	BS	IS	FS	Rise (+)	Fall (−)	RL	Remarks
BM	1.8					200.00	
A		1.1		0.7		200.7	
B	2.1		0.9	0.2		200.9	
C			3.6		1.5	199.4	

If succeeding reading < preceding reading ⇒ RISE

If succeeding reading > preceding reading ⇒ FALL

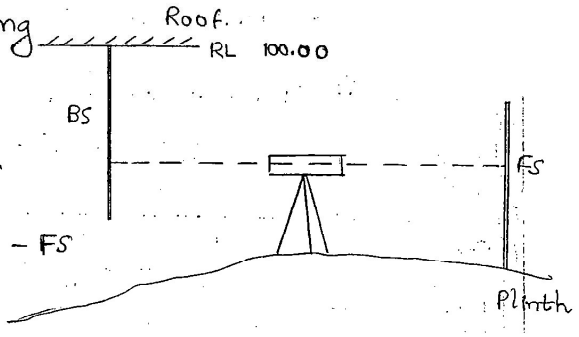
Check:

$\Sigma BS - \Sigma FS = \Sigma Rise - \Sigma Fall = L RL - FRL = -0.6$

NOTE:

⊙ Rise & Fall Method is superior than HI method; as IS one verified. Rise and fall method is used for small areas, preparation of contour maps and LS and CS.

→ Inverted Staff Reading



⊙ Difference in height of roof and plinth = BS + FS

⊙ RL of plinth = $(RL)_{roof}$ − BS − FS

Eg: 0.71, 0.85, 2.2, 0.9, 2.4, 3.6, 0.2
(FS) (FS) (BS)

⇒ instrument is shifted after 3rd & 5th readings

→ Levelling on Slopes

(i) Falling Gradient.

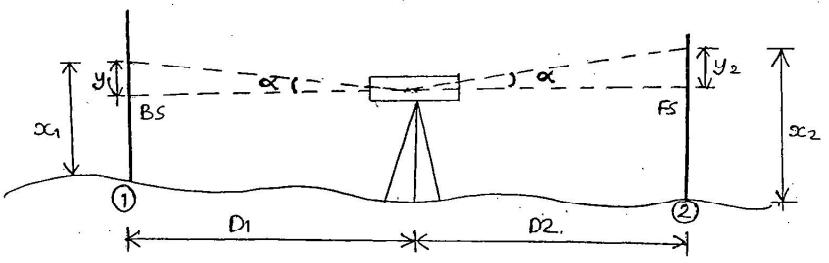
0.7 (BS), 1.4, 2.6, 3.7 (FS), 1.2 (BS), 1.9, 3.4 (FS)

(ii) Rising Gradient.

3.9 (BS), 2.4, 1.6 (FS), 0.2 (BS), 3.6, 2.9, 1.7 (FS)

→ Balancing Backsight & Foresight.

When it is required to evaluate the RL difference b/w any two points taking BS on point 1 and FS on point 2 it is necessary to make the distance equal from instrument to each of the stations to eliminate the error due to line of collimation and its adjustment, error due to curvature and refraction.



Correct staff reading on ① = $(x_1 - y_1)$.

Correct staff reading on ② = $(x_2 - y_2)$.

True difference in levels b/w point ① & ②

$= (x_1 - y_1) - (x_2 - y_2)$.

$= x_1 - x_2$; if $y_1 = y_2$

$y_1 = y_2$

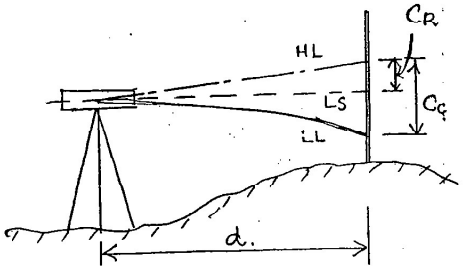
$D_1 \tan\alpha = D_2 \tan\alpha$

$\Rightarrow D_1 = D_2$; instrument must be centrally located b/w stations.

→ Correction for Curvature.

It is the difference b/w horizontal line and level line.

The apparent reading is more and the object appears to be lower than it really is.



Hence correction for curvature is negative.

$$C_c = \frac{d^2}{2R} \quad (-)$$

where $R = 6370$ km.

$$C_c = -0.07857\, d^2$$

C_c obtained in m when d = km

→ Correction for Refraction.

The LOS is deviated from horizontal line, hence the effect of refraction is to make the object appear higher than it really is. ∴ C_R is positive.

$$C_R = \frac{1}{7} C_c = \frac{d^2}{14R}$$

$$C_R = 0.01122\, d^2 \quad \text{(when } d \text{ in km)}$$
(m)

* Combined Correction, $C = C_c + C_R = -0.07857\, d^2 + 0.01122\, d^2$

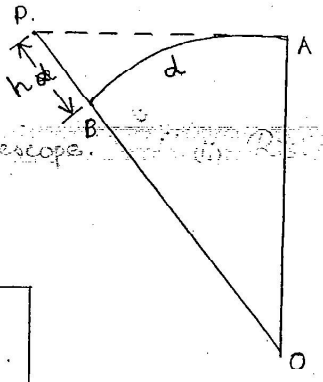
$$\Rightarrow C = -0.06735\, d^2$$

→ Distance to Visible Horizon.

P → point of observation.

A → horizon

d → distance blw P & A.



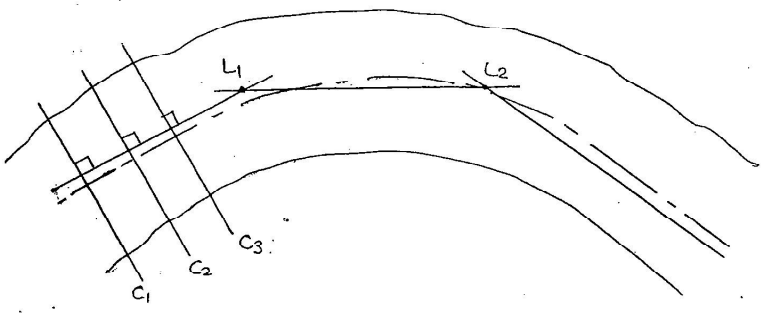
h = combined correction

$= 0.06735 d^2$

$$\therefore d_{(km)} = \sqrt{\frac{h}{0.06735}} \quad (h \text{ in m}).$$

→ Profile Levelling.

- Profile levelling is used to locate the centre line of path. Centre line can be straight or curved.
- LS & CS can give you an idea of cross sections from which volumes can be calculated.

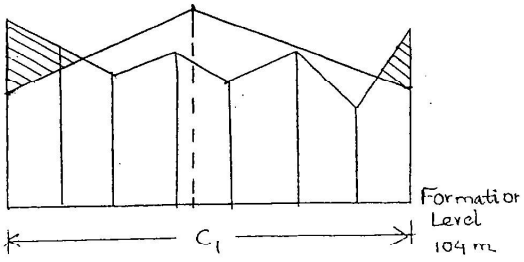


LS : Interval 5m to 10m

CS : Interval 1m to 2m.


cutting

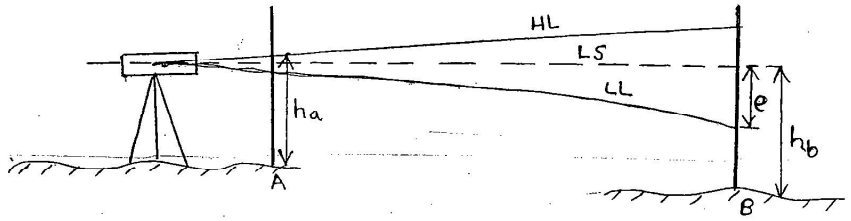

filling.



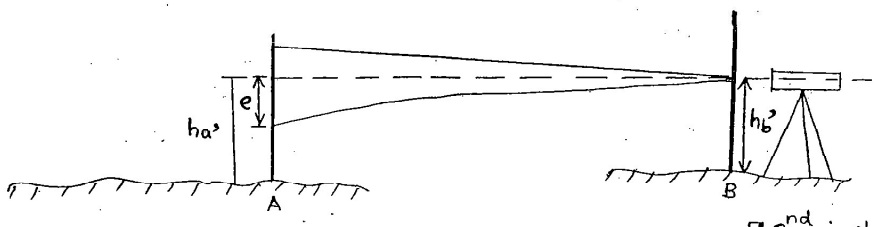
→ Reciprocal Levelling

When it is necessary to carry the levelling across a river or ravine or any obstacle requiring long sight between two points so situated that no place for the level can be found from which the length of FS & BS will be even approximately equal, the special method, ie, reciprocal levelling must be opted to obtain the accuracy and to eliminate the following errors:-

(i) Error in line of collimation and instrument adjustment.
(ii) Error due to curvature.
(iii) Error due to refraction. (partly eliminated).



■ 1st instrument set up



■ 2nd instrument set up.

A → A : h_a B → A : h_a'

A → B : h_b B → B : h_b'

(i) True difference in levels b/w A & B :

$$H = \frac{1}{2}\left[(h_a - h_b) + (h_a' - h_b')\right]$$

It is average of difference of apparent readings from both stations

(ii) RL of B = RL of A $\pm$ H.

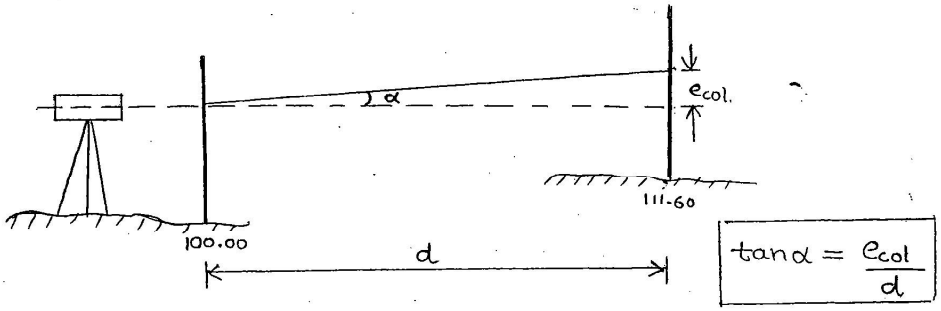
(iii) Total error, $e = \frac{-1}{2}\left[(h_a - h_b) - (h_a' - h_b')\right]$

$$e = e_{col} + e_{cur} + e_{ref}$$

e_{col} → collimation error ($= 0.07857\, d^2$; d in km)

e_{cur} → curvature error →

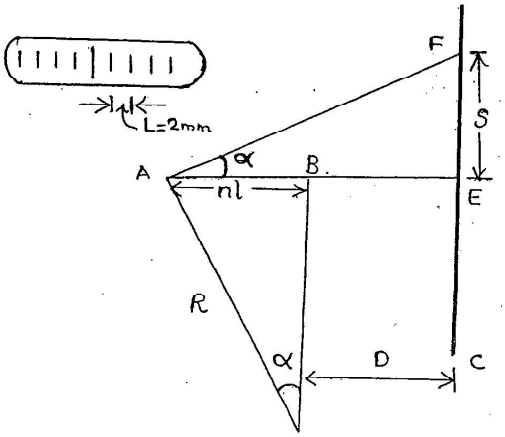
e_{ref} → refraction error. ($= -0.01122\, d^2$; d in km).



$$\tan\alpha = \frac{e_{col}}{d}$$

→ Sensitivity of Bubble tube

It is an angular value of one division marked on the level tube. It is an amount the horizontal axis has to be tilted to cause the bubble to move from one graduation to other.



n → no. of divisions disturb.

S → diff. in staff readings before and after disturbi the level.

$S = CF - CE$; $l = 2$ mm.

In Δ FAE,

$$\tan\alpha = \frac{S}{D}$$

$$\Rightarrow \boxed{\alpha = \frac{S}{D}}$$

Arc of AOB:

$$nl = R\alpha$$

$$\therefore \alpha = \frac{nl}{R}$$

$\Rightarrow$ Radius of curvature of level tube, $R = \frac{nlD}{S}$

$$\alpha' = \frac{L}{R} \text{ rad}$$

$$= 206265 \frac{L}{R} \text{ sec.}$$

$$\therefore \alpha' = \frac{l}{R} = \frac{l}{\frac{nlD}{S}} = 206265 \frac{S}{nD} \text{ seconds.}$$

Unit : seconds/2 mm.

Sensitivity, $\alpha' = 206265 \frac{S}{nD}$

Sensitivity depends on:

(i) increasing the radius of level tube.
(ii) increasing the diameter of the tube.
(iii) increasing the length of level tube
(iv) decreasing the roughness of wall.
(v) decreasing the viscosity of liquid in level tube.

P-52

04. $(BS)_A = 1.535$ m. (normal staff)

$(FS)_B = -1.837$ m (inverted staff.)

Difference in elevation blw A & B $= 1.535 + 1.837$

$= 3.37$ m

06. RL of forward station = 200 + 1.525 + 3.175

= 204.7 m

07. $\Sigma BS - \Sigma FS$ = LRL − FRL → (Correction for Curvature)

$6.475 - 8.565 = (RL)_2 - 560.5$

$\Rightarrow (RL)_2 = 558.41$ m

10. Distance AB = 1 km.

$$e = -\frac{1}{2}\left[(h_a - h_b) - h_a' - h_b'\right]$$

$$= -\frac{1}{2}\left((1.625 - 2.545) - (0.725 - 1.405)\right)$$

$$= +0.12$$

$$e = e_{col} + e_c + e_R$$

$$e_c = 0.07857 \times 1^2$$

$$e_R = -0.01122 \times 1^2$$

$$0.12 = e_{col} + 0.07857 - 0.01122.$$

$$\Rightarrow e_{col} = 0.0527$$

20. $$d = \sqrt{\frac{h}{0.06735}} = \sqrt{\frac{120}{0.06735}} = 42.226 \text{ km}$$

23. HI = RL + IS.

= 79.1 + 2.885 = 81.985.

RL = HI − FS = 81.985 − 0.68

= 81.305 m

25. $D = 200\ m,\ n = 2.5,\ \alpha'' = 206265\,\frac{S}{nD} = 30''$

$\Rightarrow S = \underline{0.073\ m}.$

26. $H = \frac{1}{2}\left[(h_a - h_b) + (h_a' - h_b')\right]$

$= \frac{1}{2}\left[(1.485 - 1.725) + (1.190 - 1.415)\right]$

$= -0.2325$

RL of A = RL of B + H.

$= 55.18 + 0.2325 = \underline{55.4125\ m}$

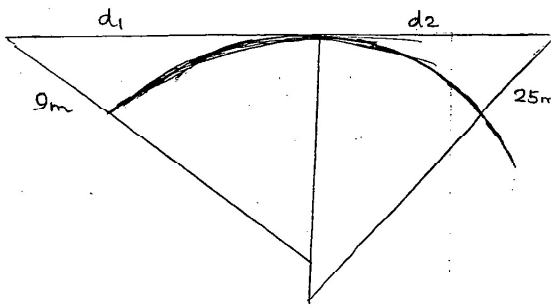
27. $e = -\frac{1}{2}\left((1.485 - 1.725) - (1.190 - 1.415)\right)$

$= 0.0075\ m.$

$e = e_{col} = 0.0075\ m \quad (\because e_c = e_R = 0)$.

28. $d_1 = \sqrt{\frac{9}{0.06735}}$

$d_2 = \sqrt{\frac{25}{0.06735}}$



$d = d_1 + d_2 = \underline{30.84\ km}.$

32. $h = 0.06735 \times D^2$

$= 0.06735 \times 60^2 = \underline{242.46\ m}$

34 RL of plinth = 100 − 2.105 − 1.105

= 96.79 m

35. $H = \frac{1}{2}\left[(1.03 - 1.630) + (0.950 - 2.711)\right]$

$= -1.195$ m

RL of Q = RL of P + H

= 450 − 1.195 = 448.805 m