‘Plane Surveying’

Lecture-1

Curvature and Refraction, Collimation Error, Reciprocal Leveling and Inverted Staff Readings

By

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Outline

- ✓ Curvature and Refraction
- ✓ Collimation Error
- ✓ Reciprocal Leveling
- ✓ Inverted Staff Readings

Curvature and Refraction Correction

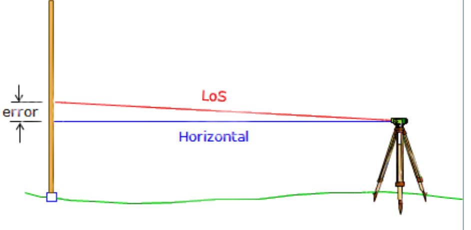
- c: it is the error due to the curvature that may be computed.
- r: it is the error due to the refraction of the line of sight.
- Note: the refraction reduced the effect of the curvature.
- Combined error is the final error due to curvature and refraction $(c + r)$.
- It is proved that the value of (r) is about (1/7) of (c).
- Ignoring (Ht) height of instrument due to smallness with respect to R.

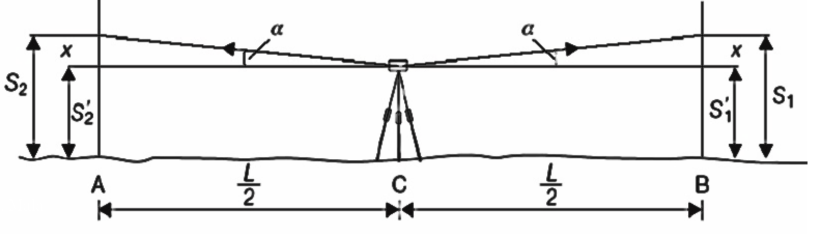
- $(R + c)^2 = R^2 + K^2$
- $R^2 + 2Rc + c^2 = R^2 + K^2$
- $c(2R + c) = K^2$
- $c = \frac{K^2}{2R+c} = \frac{K^2}{2R}$
- We can ignore (c) because it's value is too small according to R.
- $\frac{K^2}{2*6370} = 0.0000785\ K^2 \rightarrow (K\ distance\ in\ km)$
- $[multiply\ by\ 1000\ to\ obtain\ units\ in\ m]$
- C = 0.0785 K^2 (K is in km).

- Since **r** is about (1/7) of **c**
- r = 0.14 c
- $(c + r) = 0.0785K^2 - (0.14 * 0.0785K^2)$
- $(c + r) = 0.0675K^2$
- $(c + r)$ are subtracted from staff readings to obtain corrected staff readings.
- **Example**: for k = 100 m
- $(c + r) = 0.0675K^2 = 0.0675(0.1)\ ^2 \backsimeq 1mm$
- Thus, keep the distance from level to staff less than 100m, typically maximum 75 m.

Collimation Error

- Error (x) due to collimation error are equal, because the distance from the level to the staff at A and B are equal.
- $\Delta H_{AB} = R'_A - R'_B\ (visible\ \Delta H)$
- $\Delta H_{True} = R_A - R_B$
- $(R_A + x) - (R_B + x) = \Delta H_T$
- $R_A + x - R_B - x = \Delta H_T$
- $\Delta H_{AB} = \Delta H_T$





Two peg test

- This method is a simple method for test the collimation line of sight that if it is truly horizontal or not, and also improves the accuracy of its vertical angle readings.
- The two-peg test is very simple, but provides a way to test the accuracy of a level.

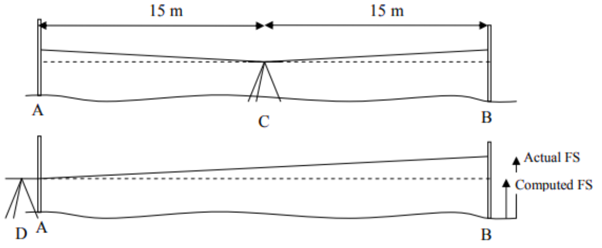
In case one; when the instrument at C (center of stations A and B)

$$\Delta H_{AB\,(1)} = R_A - R_B \ \rightarrow (true \Delta H)$$

In second case; when the instrument at D (beside A)

$$\Delta H_{AB\,(2)} = R'_A - R'_B$$

If $\Delta H_{AB\,(1)} = \Delta H_{AB\,(2)}$ the instrument is ok, if not; there is a collimation error.



- If $\Delta H_{AB\,(2)}$ is larger than $\Delta H_{AB\,(1)}$, the line of sight is inclined upward.
- If $\Delta H_{AB\,(2)}$ is less than $\Delta H_{AB\,(1)}$, the line of sight is inclined downward.

In the first case; if the readings are $R_A = 1.150 \; and \; R_B = 1.322$

$$\Delta H_{AB\,(1)} = 1.322 - 1.150 = 0.172\text{m}$$

In the second case; if the readings are $R_A = 1.818 \; and \; R_B = 2.000$

$$\Delta H_{AB\,(2)} = 2.000 - 1.818 = 0.182\text{m}$$

$\Delta H_{AB\,(1)} \neq \Delta H_{AB\,(2)}$, there is a collimation error.

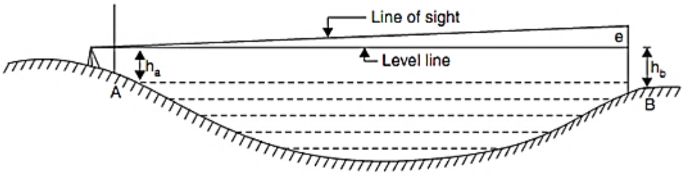
Collimation error = 0.182 – 0.172 = +10mm

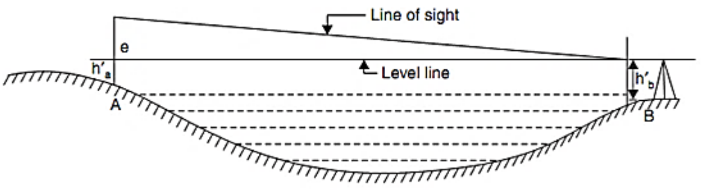
10 mm collimation error per 30 m

Error of collimation = 0. 333 mm/m

Reciprocal leveling

It is a leveling between two widely separated points in which observations are made in both directions to eliminate the effects of atmospheric refraction and the curvature of the earth.





$$\Delta H_1 = R_A - R^*_B \rightarrow \Delta H_1 = R_A - (R_B + e)$$

$$\Delta H_2 = R'^*_A - R'_B \rightarrow \Delta H_2 = (R'_A + e) - R'_B$$

True $\Delta H_{AB} = average\ of\ \Delta H_1\ and\ \Delta H_2$

$$true\Delta H_{AB} = \frac{\Delta H_1 + \Delta H_2}{2}$$

$$\Delta H_1 = 2.112 - 1.336 = 0.776$$

$$\Delta H_2 = 1.582 - 0.792 = 0.790$$

$$\Delta H_{True} = \frac{0.776 + 0.790}{2} = 0.783$$

$$0.783 = R_A - (R_B + e)$$

$$0.783 = 2.112 - (1.336 + e) \rightarrow e = 0.007$$

Inverted Staff Reading

Generally points to be measured lie below line of sight, but often it is required to determine points above the line of sight such roofs, at this case the staff is held inverted at the point then the readings are made with (*) or (-) in the leveling table.

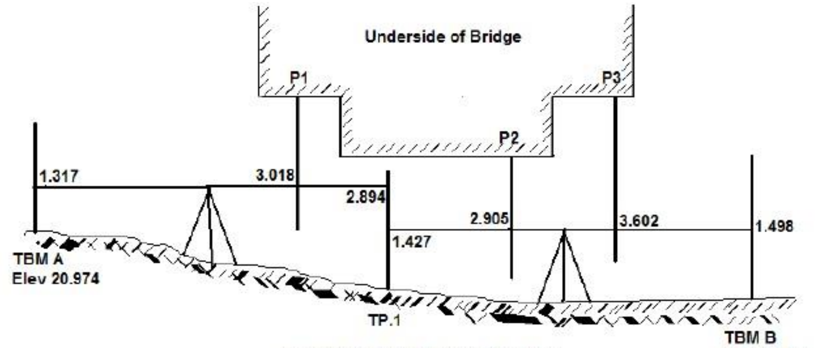


Diagram to show Inverted Levelling

Example -14

Station	BS	IS	FS	HI	Elevation
TBM (A)	1.317			22.291	20.974
P1		-3.018			25.309
TP1	1.427		2.894	20.824	19.397
P2		-2.905			23.729
P3		-3.602			24.426
TBM (B)			1.498		19.326

ΣBS = 2.744 ΣFs = 4.392

-1.648 -1.648

Example -15

Station	BS	IS	FS	Rise	Fall	Elevation
TBM (A)	1.630					40.000
P1		*3.070		4.700		44.700
P2		1.758			4.828	39.872
TP1	*4.275		*2.725	4.483		44.355
P3		*1.340			2.935	41.420
TBM (B)			2.187		3.527	37.893

∑BS=-2.645 ∑FS= -0.538 9.183 11.290

-2.107 -2.107 -2.107

Source of errors in leveling

1- **Instrument**:

Any level does not obey the conditions must not be used.

If not → adjust the level.

2- staff:

- Make sure that the section of the staff are exactly extended.
- Hold the staff vertically with the help of the bubble.
- Focus the staff image exactly to be seen properly.
- Choose rigid points for turning points (change points).

Rule: any leveling must start and close on a point of known elevation.

3- Personal:

Depends on the person (mistake) (set up, reading, and booking).

4- Environment:

Avoid high temperature, windy.