

## Sheet (7): Leveling

### 1. Terms used in Leveling

The following terms are used in leveling:

- 1) **Station:** It is the point, the elevation of which is to be determined or the point to be established at a given elevation. In other words, station is the point where leveling staff is held and not the point where level is kept.
- 2) **Height of Instrument:** for any set-up of the level, the height of the instrument is the elevation of the plane of sight with respect to the assumed datum.
- 3) **Back Sight (BS):** *it is the sight taken on a level staff held at a point of known elevation with an intention of determining the plane of collimation (height of instrument). It is always the first reading after setting the instrument.*
- 4) **Intermediate Sight (IS):** *Sights taken on points after taking back sight and before taking last sight from an instrument station are known as intermediate sights. The intention is to get reduced levels of the points where staff is held.*
- 5) **Fore Sight (FS):** *This is the last reading taken from an instrument station just before shifting the instrument.*
- 6) **Change Point (CP) or Turning Point (TP):** *This is a point on which both fore sight and back sights are taken. Staff held at this point first fore sight is taken, then instrument is shifted to a new point and back sight is taken on the same point.*
- 7) **Reduced Levels (RL):** Reduced level of a point is the level of a point with respect to assumed datum.

## 2. Types of Levelling

The following types of leveling are required in surveying:

- 1) Simple Leveling
- 2) Differential Leveling
- 3) Fly Leveling
- 4) Profile Leveling
- 5) Cross Sectioning, and
- 6) Reciprocal Leveling

### 2.1 Simple Leveling

When difference in levels of two nearby points is required it is obtained by simple leveling. The two points are so near that with one setting of the level the readings on the two points can be obtained, Figure (1) shows one such case. The reduced level of A is 100.00 m and RL of B is required.

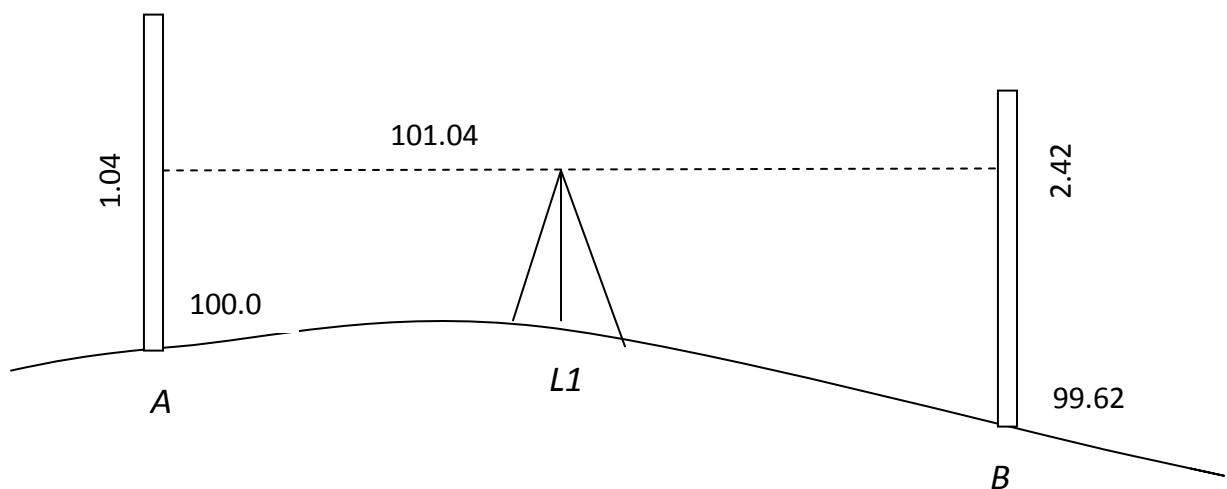


Figure (1): Simple Leveling

RL of A = 100.00 m and back sight is 1.04 m

∴ Height of Instrument (HI) = RL of A + BS

$$= 100.00 + 1.04 = 101.04 \text{ m}$$

Fore Sight on B = 2.42 m

$$\text{RL of B} = \text{HI} - 2.42 = 101.04 - 2.42 = \underline{\underline{99.62 \text{ m}}}$$

**2.2 Differential Levelling**

If the distance between the two points A and B is too large, it may not be possible to take the readings from a single settings of the instrument. The elevation of B w.r.t. A can be found by differential levelling. In such cases instrument is set at more than one point, each shifting facilitated by taking a change point. Figure (2) shows a scheme of such levelling.

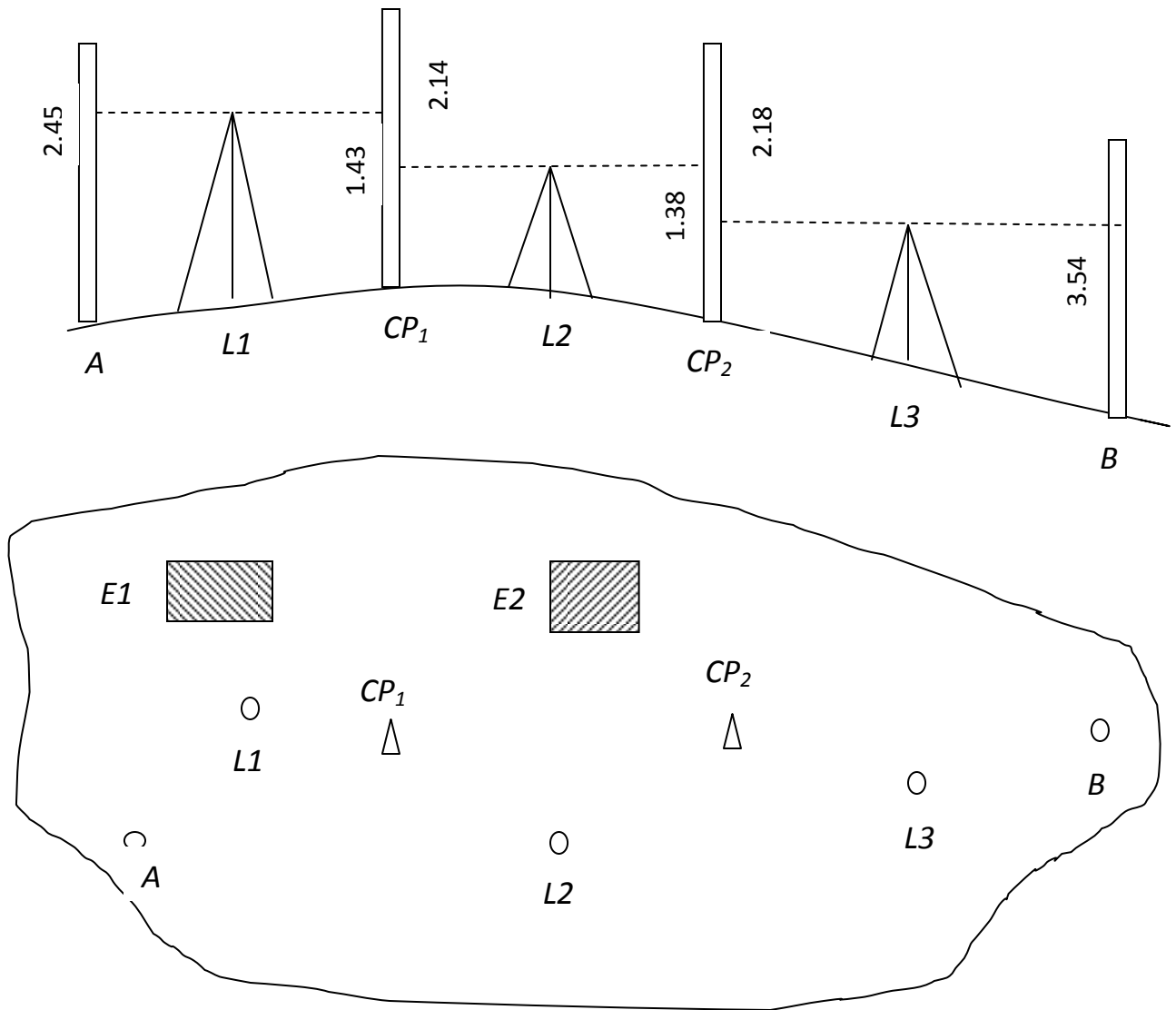


Figure (2): Differential leveling

Note) assume that E1 (0.86 m) and E2 (0.76 m) .. intermediate points.

Booking and Reducing the Levels

The booking of readings and reducing of levels can be carried out systematically in the tabular form. There are two such methods:

- (i) **Height of Instruments** (Plane of Collimation) Method
- (ii) **Rise and Fall** Method

**(i) Height of Instruments Method**

Solution

Station	BS	IS	FS	HI	R.L	Remark
A	2.45			102.45	100.00	BM
E1		0.86			101.59	
CP <sub>1</sub>	1.43		2.14	101.74	100.31	C.P
E2		0.76			100.98	
CP <sub>2</sub>	1.38		2.18	100.94	99.56	C.P
B			3.54		97.40	
Check	Sum = 5.26		Sum = 7.86			
Diff. = -2.60 (fall)						

- a) Height of instrument for first setting = RL of BM + BS
- b) Subtract intermediate and fore sights to get RL of intermediate stations and change points.
- c) Add back sights to RL of change points to get new height of the instrument.
- d) Subtract last fore sight from last height of instrument to get RL of last point.

**Check:**

- 1) No. of Bs = No. of FS
- 2)  $\sum BS - \sum FS = \text{RL of last point} - \text{RL of the first point}$

Difference in last and first RL is –ve if fall and +ve if it is rise.

**(ii) Rise and Fall Method**

In this method, difference in staff reading at a point with previous reading is found. If the present reading is less than the previous it indicates rise and if it is more it is the fall in the level of present point.

If the reduced level of first point is known, using rise and fall values for the consecutive readings, the reduced levels of all points can be calculated one after the other.

Station	BS	IS	FS	Rise	Fall	R.L	Remark
A	2.45					100.00	BM
E1		0.86		1.59		101.59	
CP <sub>1</sub>	1.43		2.14		1.28	100.31	C.P
E2		0.76		0.67		100.98	
CP <sub>2</sub>	1.38		2.18		1.42	99.56	C.P
B			3.54		2.16	97.40	
Check	Sum = 5.26		Sum = 7.86				
sum Rise – sum fall = -2.60				Last RL – First RL = -2.60		Diff. = -2.60 (fall)	

Note:

1. Previous reading - present reading is +ve, if is rise
2. Previous reading – present reading is –ve, if is fall

The arithmetic checks for the calculations are

$$\sum BS - \sum FS = \sum Rise - \sum Fall = Last RL - First RL$$

**Comparison of the two methods**

The **height of instrument** methods is *simple and rapid*. However, in this method there is **no check on the calculation for intermediate sights**.

The **rise and fall method** is more tedious and takes more time. But in this method **there is check on all calculations**.

### **2.3 Fly Leveling**

If the work site is away from the bench mark, the surveyor starts levelling work with a back sight on the bench mark from a convenient instrument point. He proceeds towards work site taking fore sight and back sight to change points along with convenient directions, till he finds a suitable point for temporary bench mark. Rest of leveling work he carries out with respect to the temporary bench mark. At the end of work or day, he comes back to the bench mark in any convenient direction taking a number of change points. This way of leveling is known as fly leveling.

#### **Example**

The following readings were observed successively with a levelling instrument. The instrument was shifted after 5<sup>th</sup> and 11<sup>th</sup> readings.

- (1) 0.585   (2) 1.010   (3) 1.735   (4) 3.295   (5) 3.775   (6) 0.350  
 (7) 1.300   (8) 1.795   (9) 2.575   (10) 3.375   (11) 3.895   (12) 1.735  
 (13) 0.635   (14) 1.605 m

Draw up a page of level back and determine the RL of various points, if RL of first point is 136.440m. Use the rise and fall method.

Station	BS	IS	FS	Rise	Fall	R.L	Remark
A	0.585					136.440	Given
		1.010			0.425	136.015	
		1.735			0.725	135.290	
		3.295			1.560	133.730	
	0.350		3.775		0.480	133.250	Change point
		1.300			0.950	132.300	
		1.795			0.495	131.805	
		2.575			0.780	131.025	
		3.375			0.800	130.225	
	1.735		3.895		0.520	129.705	Change point
		0.635		1.100		130.805	
B			1.605		0.970	129.835	Last point
Check	Sum = <b>2.670</b>		Sum = <b>9.275</b>	<b>1.100</b>	<b>7.705</b>		
Check: $\sum BS - \sum FS = \sum Rise - \sum Fall = Last\ RL - First\ RL = -6.605$							

**2.4 Profile Leveling**

This type of leveling is known as longitudinal sectioning. The reduced levels of various points at regular intervals are found along a line or along a set of lines. Then the engineers draw the sectional view of the ground to get the profile. This type of leveling is commonly employed in deciding railway, highway, canal and sewage line routes. Figure (3) shows a scheme of such leveling along line AB.

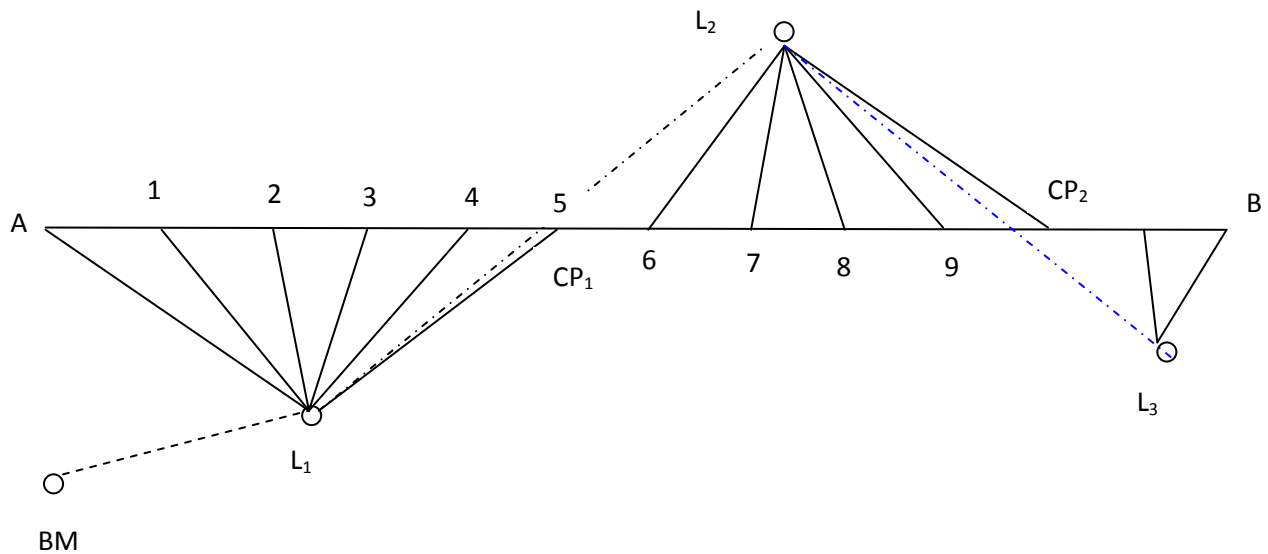
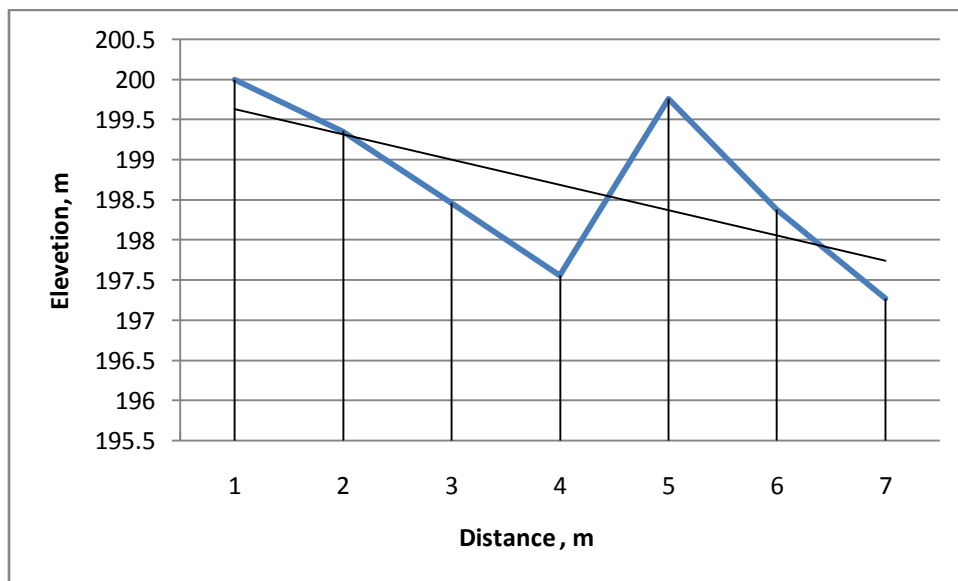


Figure (3): scheme for profile leveling (Plan view)



After getting reduced level of various points along the line, profile of the ground is plotted on a drawing sheet. Normally, vertical scale is much larger than horizontal scale to clearly view the profile.

Then the engineers decide the formation level of the proposed project. The decision is mainly based on balancing, cutting and embanking so that the transport of earth is minimum. However, the proposed gradient of formation level should not be more than as permitted, after deciding the formation level and the gradient, the difference between two consecutive points is known. If LR of first point is known, RL of other points are calculated. During the execution of the work, it is the duty of site-engineer to ensure the required RL of various points so that the formation level is obtained.

**Example: Solve this problem and submit the solution next week**

**The following consecutive readings are taken with a level and a 4 m levelling staff along continuously sloping line AB at a common interval of 20m; 0.385, 1.030, 1.925, 2.825, 0.625, 2.005, 3.110. The RL of the first point was 200 m. Enter the readings in a level book and calculate the RLs of each point by rise and fall method and calculate the gradient of the line joining first and the last points. Draw the profile of the ground.**