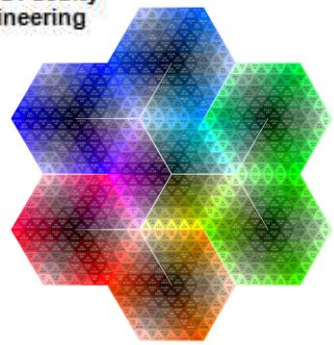
Benha University

Shoubra Faculty of Engineering



Surveying Engineering
Lecture 7: Levelling

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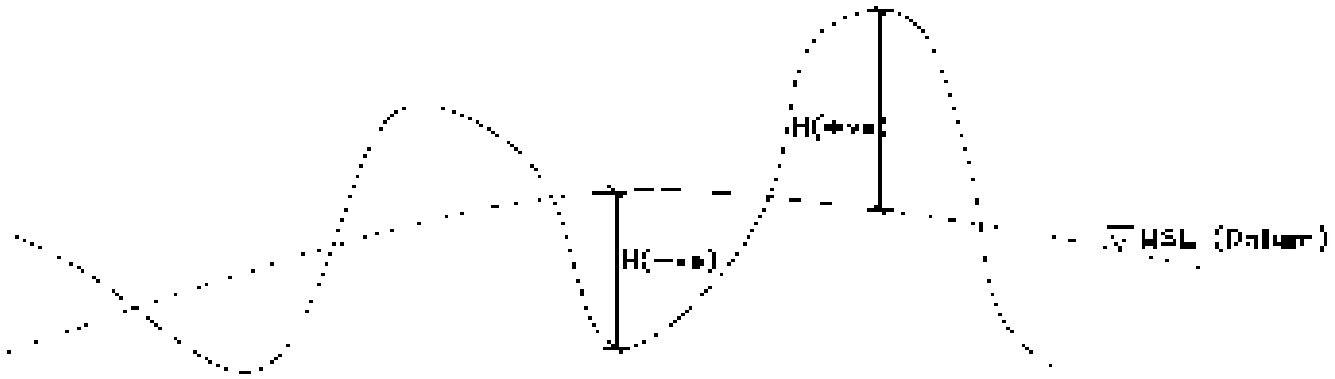
Geomatics Department

Levelling

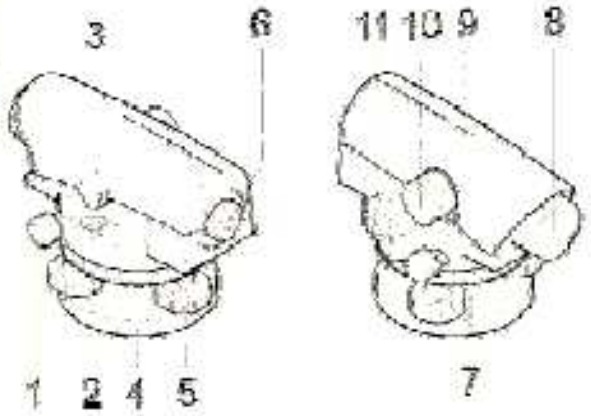


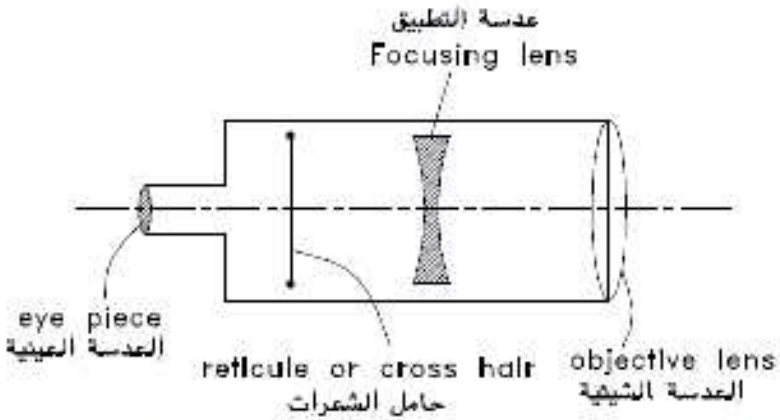
1. Leveling is the operation in surveying performed to determine the elevation of points.
2. 2- The elevation of a point is defined as its vertical distance above (+) or below (-) a given reference surface (datum).

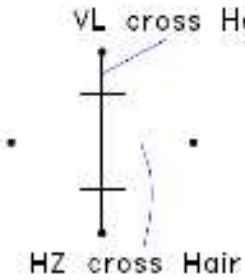
Levelling

3. Reference Datum surface: the imaginary level surface with reference to which vertical distances of the points (above or below) are measured.
4. It could be Global: relative to MSL (mean Sea Level) or Local assumed at any elevation.
5. Mean Sea Level (MSL): the datum adopted for determining the elevations of different points (in Egypt in Alexandria).
6. Bench mark: a relatively permanent and fixed reference point of known elevation above Mean Sea Level (MSL). (Egypt: ESA)

Levelling Instrument







1. Horizontal rotation screw
2. Circular bubble tube (to form Hz plane)
3. Mirror to view circular bubble tube
4. Base plate (sits on tripod)
5. Leveling screw (to adjust the Hz plane)
6. Eyepiece
7. Horizontal circle (for Hz angles)
8. Objective lens
9. Pointing
10. Focusing knob (for clear visibility)
11. Window for digital angle reading

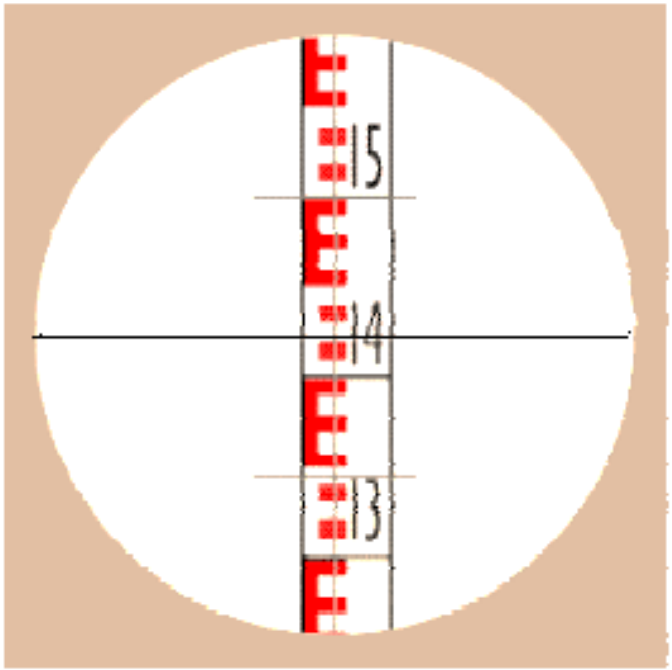
Levelling Instrument

1. Line of sight: the line passing through the optical center of the objective traversing the eye-piece and entering the eye.

2. Line of collimation: the line passing through the optical center of the objective and the point of intersection of the cross hairs and the eye-piece.

Levelling staff

- Usually 3m or 4m in height
- 4m Divided into 40 parts → each part 10cm Divided into 10parts → 1cm
- Zero end of staff located on point required to obtain its elevation
- Direction of increase upwards or downwards (How?)



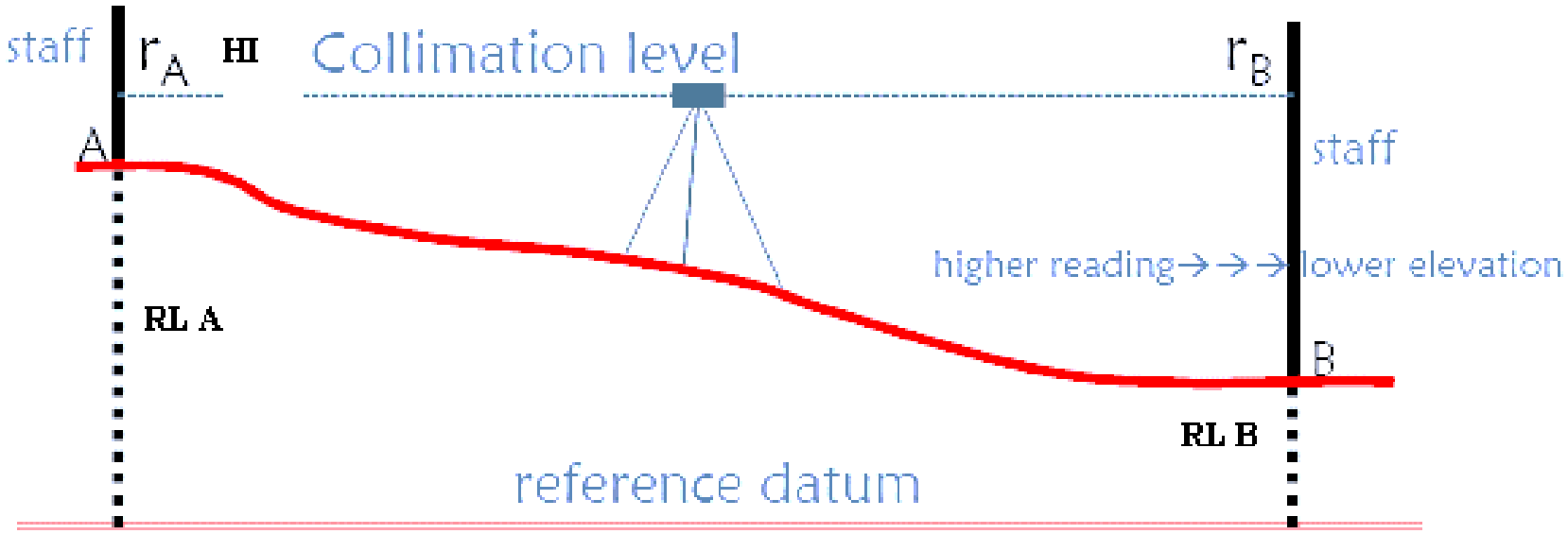
0 ⇨ 13 = 14 parts = 1.4m

2 whole centimeters = 0.02m

Estimate the remaining part = 0.002m

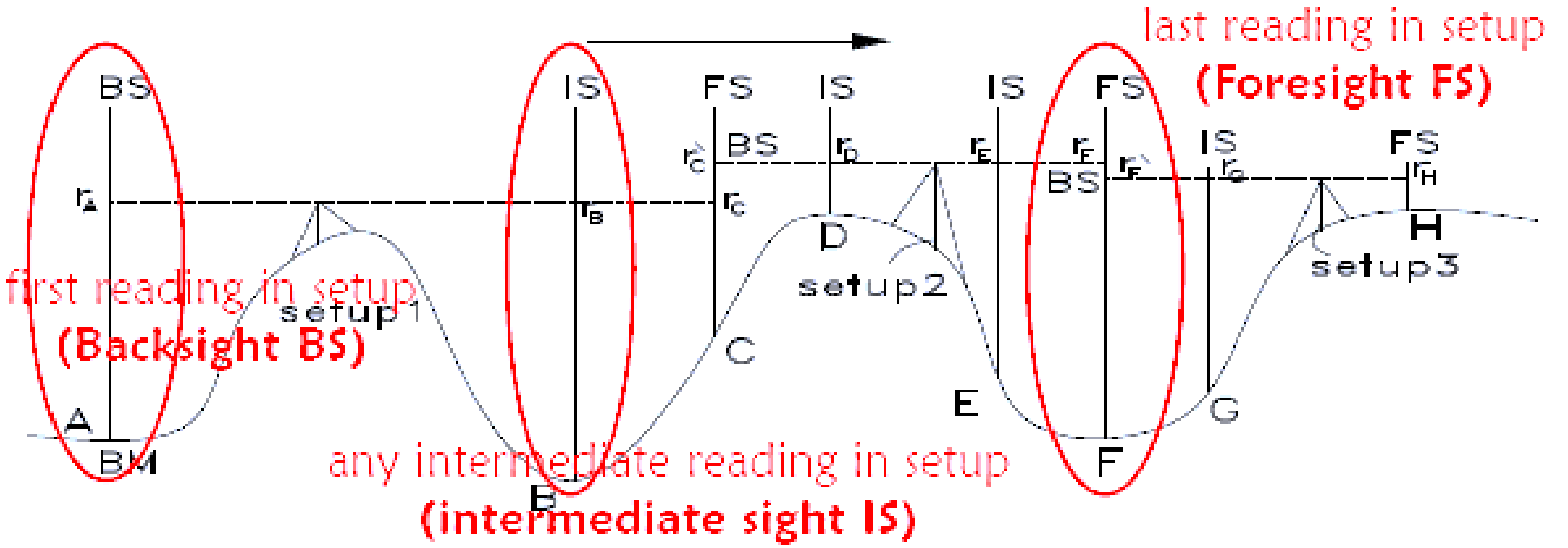
R=1.422m

Levelling Procedure



1. HI = RL A (BM) + r A (BS)
2. RL B = HI – r B (IS OR FS)

Levelling Procedure



1. HI = RL A (BM) + r A (BS)
2. RL B = HI – r B (IS OR FS)

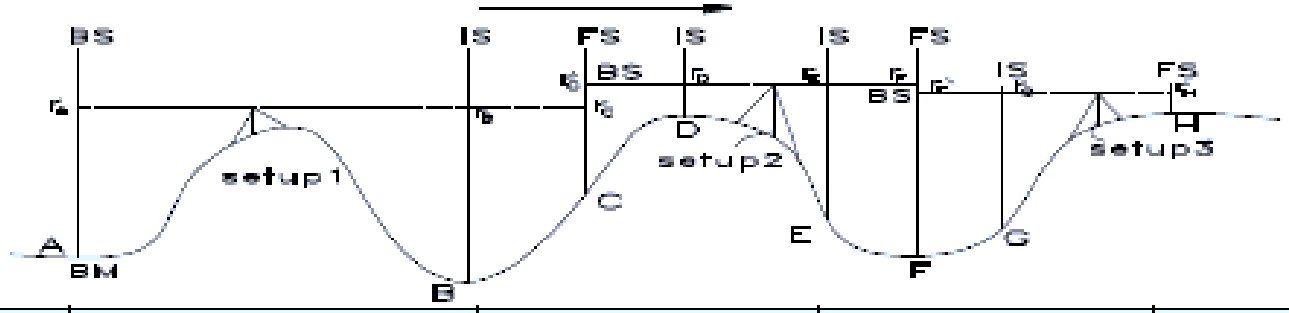
Levelling Procedure

1. Height of instrument (HI): the elevation of the line of sight with respect to the reference datum (MSL).
2. Back sight (BS): the first sight taken on a leveling staff held at a point of known elevation (BM)
3. Intermediate sight (IS): the sight taken on staff at a point between two turning points to determine the elevation of that point.
4. Fore sight (FS): the sight taken on the last point of the position of the level before moving the level.

Levelling Procedure

1. Form a leveling table for ease of calculations
2. To connect the whole job together in order to calculate all elevations, last observed point in setup (i) (FS) must be first observed point in setup (i+1) (BS) and called turning point (TP)

Line of collimation method (HI)



Point	Staff Readings			HI	Elevation RL	Remarks
	BS	IS	FS			
A	r_A			HI = RL A + r A	RL A	BM
B		r_B	Setup 1		RL B = HI - r B	
C	r'_C		r_C	HI = RL C + r' C	RL C = HI - r C	TP
D		r_D			RL D = HI - r D	
E		r_E	Setup 2		RL E = HI - r E	
F	r'_F		r_F	HI = RL F + r' F	RL F = HI - r F	TP
G		r_G			RL G = HI - r G	
H			r_H	Setup 3	RL H = HI - r H	
	$\sum BS$		$\sum FS$			

Rise and Fall method

If $r_B > r_A$ ⟹ B lower than A ⟹ ΔH_{AB} = -ve **FALL**

If $r_B < r_A$ ⟹ B higher than A ⟹ ΔH_{AB} = +ve **RISE**

$H_B = H_A + \Delta H_{AB}$

Point	Staff Readings			RISE OR FALL	Elevation (m)	Remarks
	BS	IS	FS			
A	r_A				**RL A**	BM
B		r_B		$\Delta H_{AB} = r_A - r_B$	$H_B = H_A + \Delta H_{AB}$	
C	r'_C		r_C	$\Delta H_{BC} = r_B - r_C$	$H_C = H_B + \Delta H_{BC}$	TP
D		r_D		$\Delta H_{CD} = r'_C - r_D$	$H_D = H_C + \Delta H_{CD}$	
E		r_E		$\Delta H_{DE} = r_D - r_E$	$H_E = H_D + \Delta H_{DE}$	
F	r'_F		r_F	$\Delta H_{EF} = r_E - r_F$	$H_F = H_E + \Delta H_{EF}$	TP
G		r_G		$\Delta H_{FG} = r'_F - r_G$	$H_G = H_F + \Delta H_{FG}$	
H			r_H	$\Delta H_{GH} = r_G - r_H$	$H_H = H_G + \Delta H_{GH}$	
	ΣBS		ΣFS	$\Sigma\Delta H$		

Levelling Checks

- $\sum$BS - $\sum$FS = elevation of last point (RL) – elevation of first point (RL)
- $\sum$BS - $\sum$FS = elevation of last point (RL) – elevation of first point (RL)= $\sum$ RISE - $\sum$ FALL
- Leveling checks: allowable (mm) = $12\sqrt{}$ k (km) K is the length of leveling route (km)
- IF Error (Δ) < allowable (mm) : leveling procedure accepted (ok)
- IF Error (Δ) > allowable (mm) : leveling procedure rejected. STOP. repeat observations.

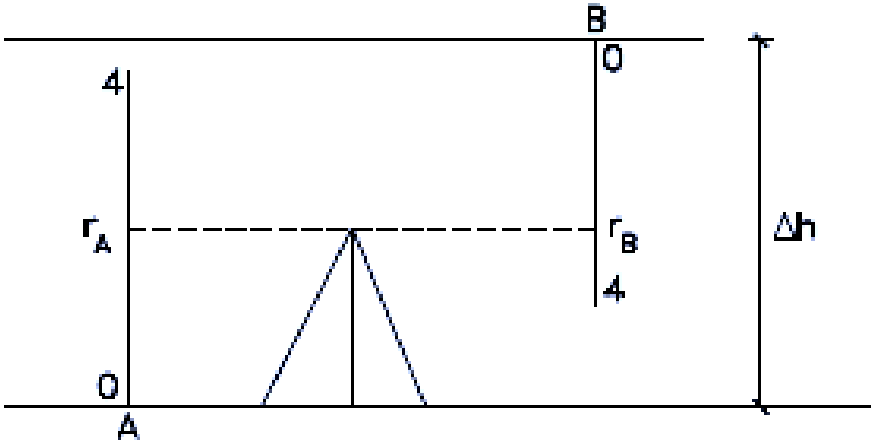
Leveling methods

- **Closed Leveling: Starts from a known BM and ends at the same BM**
- **Error (Δ) = calc. elev. of BM – known elev. of BM**
- **Connected Leveling: Starts from a known BM1 and ends at another BM2**
- **Error (Δ) = calc. elev. of BM2 – known elev. of BM2**

Levelling Applications

1- Inverted Staff:

$$\Delta H_{AB} = r_A - r_B$$
$$\Delta H_{AB} = r_A - (-r_B)$$
$$\Delta H_{AB} = r_A + r_B$$

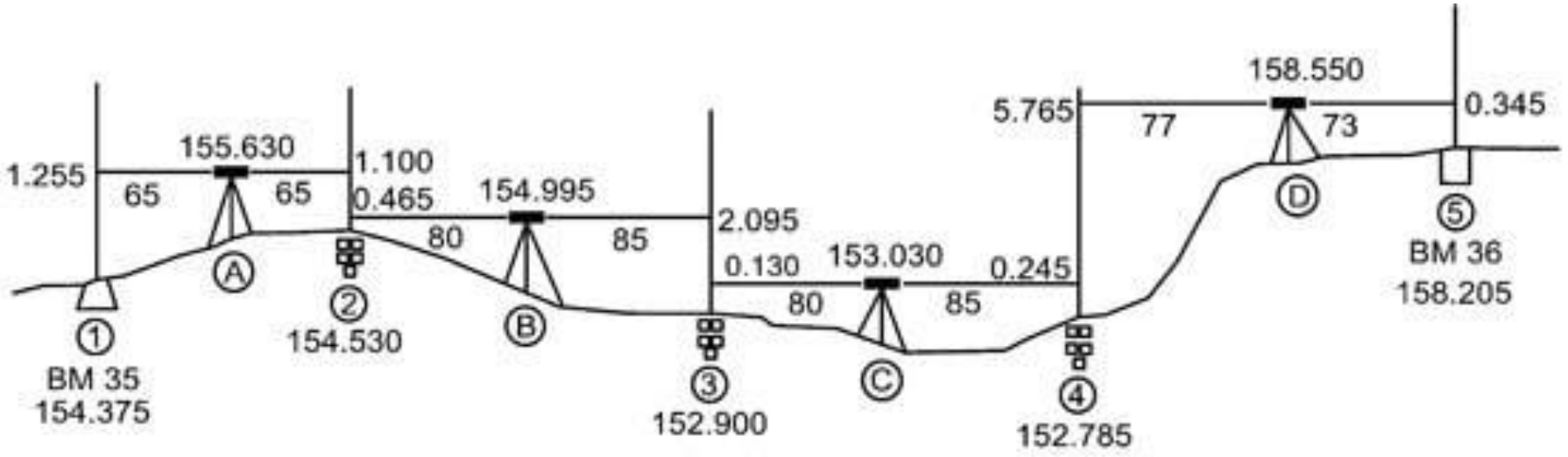


- ∑BS - ∑FS = elevation of last point (RL) – elevation of first point (RL)
- If staff inverted with zero end touching roof
- Substitute with -r instead of r in leveling table

Levelling Applications

2- Flying Leveling:

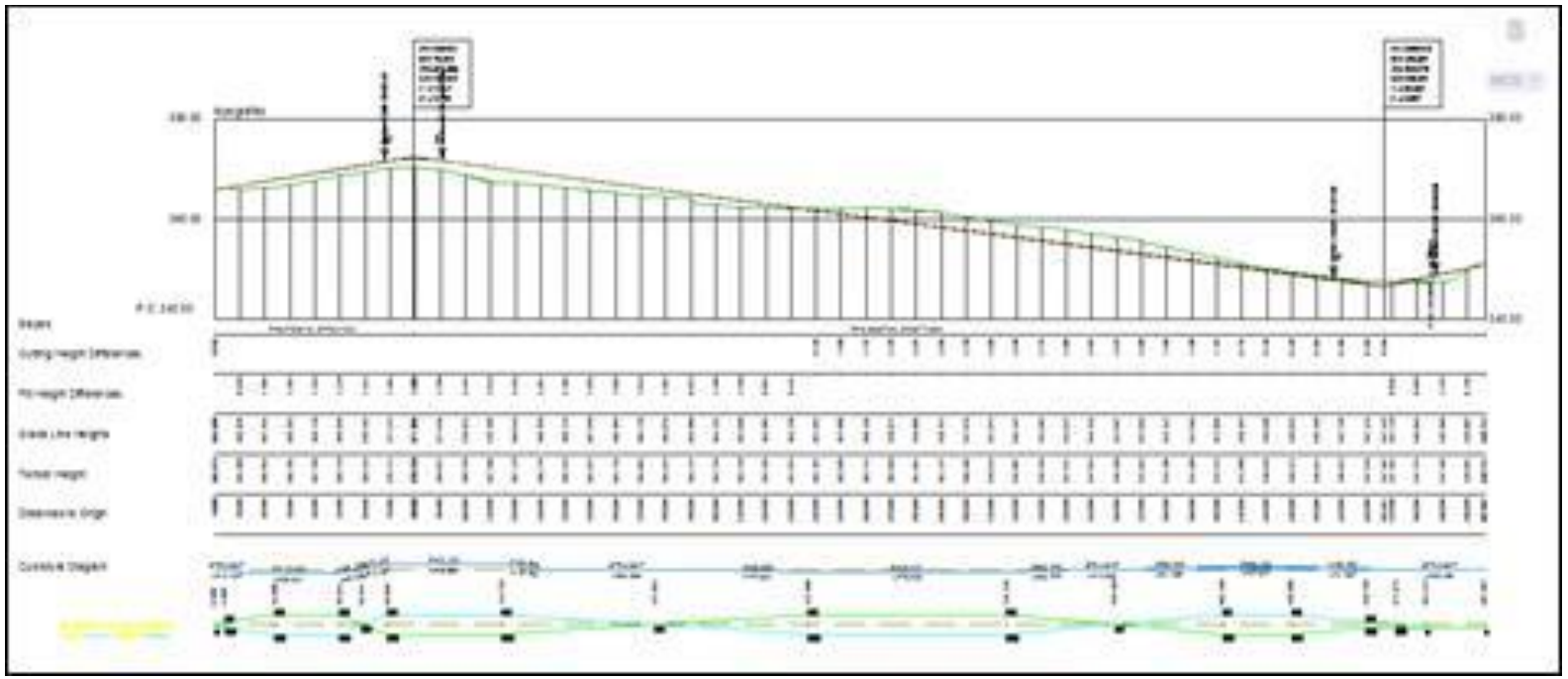
A procedure used to get the level of point (B) at a far distance from known a Benchmark (A) without the need to measure intermediate sights for quickness and easiness



Levelling Applications

3- Longitudinal Profile:

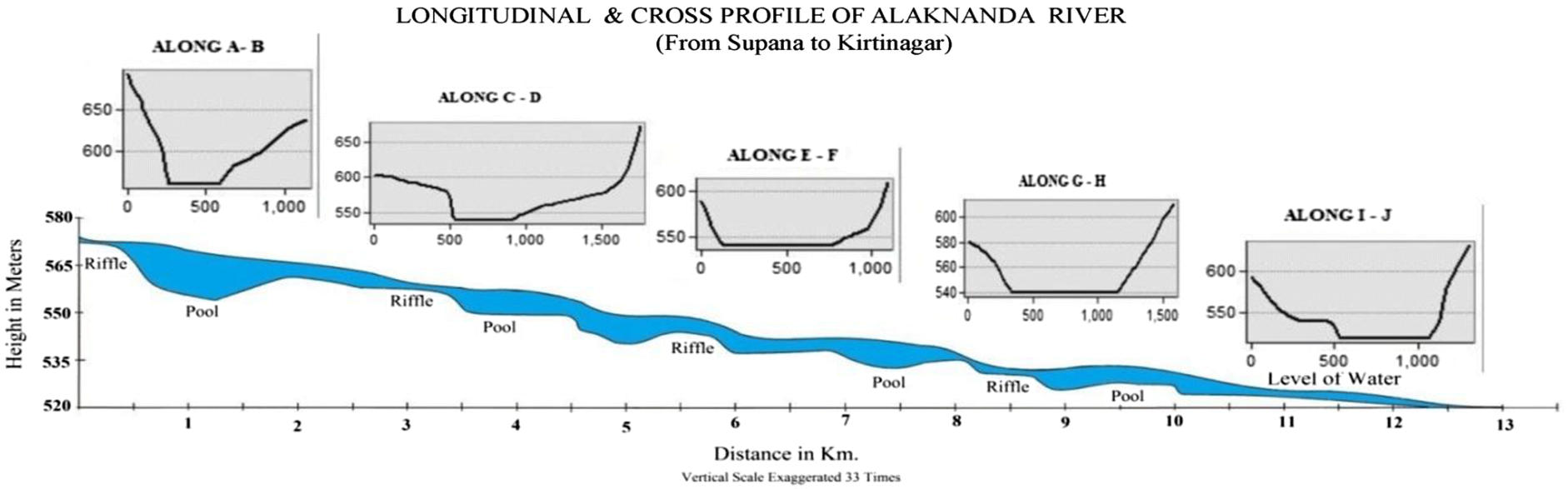
Showing the ground elevations in a certain long direction (road design)



Levelling Applications

4- Cross Sections:

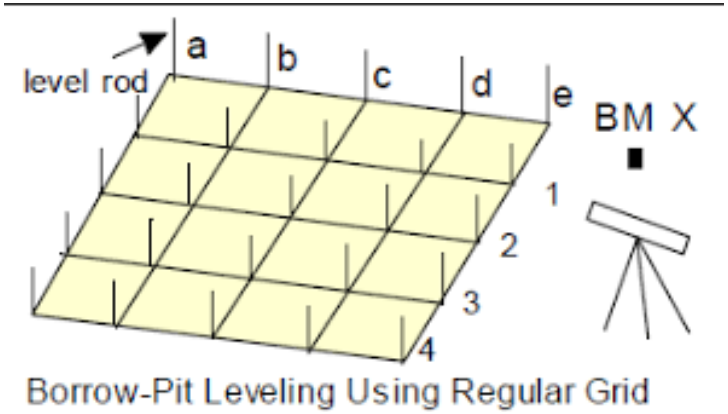
Showing the ground elevations in certain sections of the longitudinal profile



Levelling Applications

5- Grid Leveling:

Transformation of network (Grid) of elevations into continuous lines (contour lines) each having a constant elevation (3D information on a 2D map)



Borrow-Pit Leveling Using Regular Grid

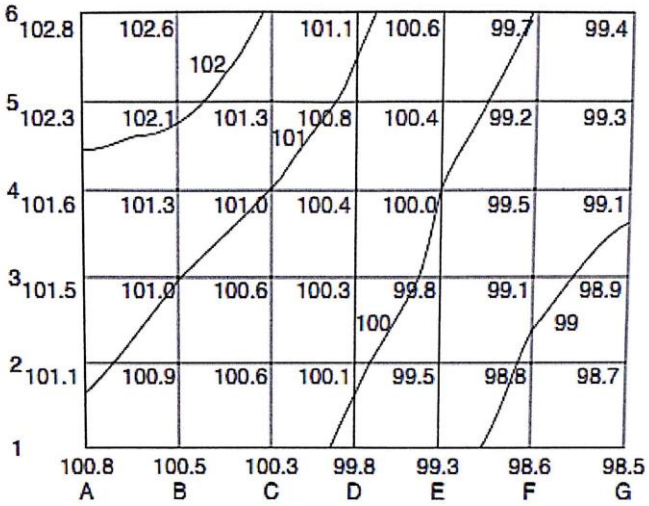


Fig. Con. 10

Supplementary files:

- https://www.youtube.com/watch?v=v1jKEfcbp8o
- https://www.youtube.com/watch?v=NmYBsmwcP1c
- https://www.youtube.com/watch?v=fEmI2P9MBPw
- https://senyashah.co.in/2020/10/21/rise-fall-method-and-h-i-method-example-part-1/
- https://senyashah.co.in/2020/10/21/rise-amp-fall-method-and-h-i-method-example-part-2/

Thanks

Dr.Eng. Hassan Mohamed