Vertical Elevations - Differential Leveling and Trigonometric Methods

Monday, March 2, 2020 9:39 AM

Learning Objectives

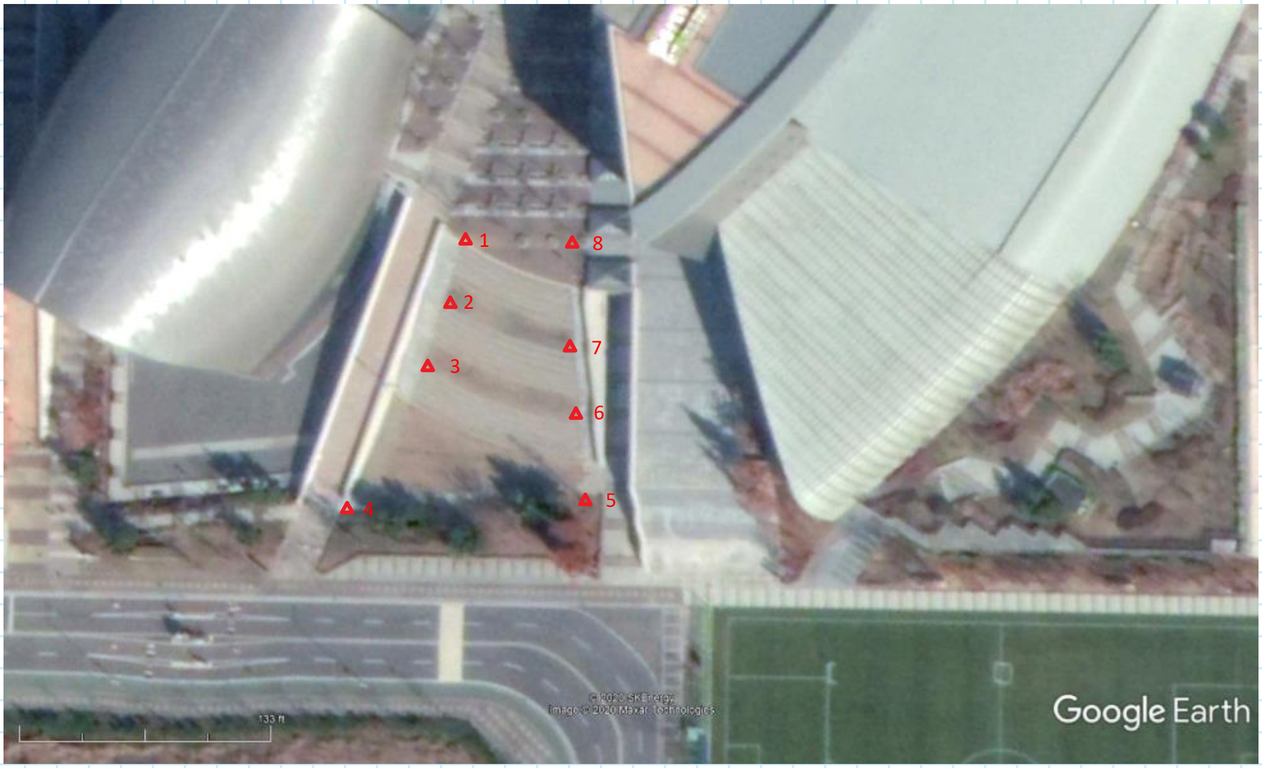
1. Demonstrate how to determine elevations for a closed traverse using a digital level.
2. Demonstrate how to adjust the elevations a closed digital level traverse for survey error.
3. Demonstrate how to determine elevations using trigonometric techniques and a total station theodolite
4. Make a comparison of the elevations determined from both techniques.
5. Know how to calculate the precision of the closed traverse (i.e., 1st order, 2nd order, etc.)
6. Demonstrate good practices and neatness in developing field book records

Group Assignment

1. Complete a digital level elevation survey on the IGC campus.
2. Complete a total station trigonometric elevation survey on the IGC campus
3. Prepare field notes from each survey
4. Adjust the digital level elevation survey from any error (i.e., calculate the adjusted survey elevation for each survey point
5. Compare the elevations obtained from the trigonometric survey with those obtained from digital level
6. Calculate the precision of the digital level closed traverse

Survey Point Locations on IGC Campus

Monday, March 2, 2020 9:39 AM



Survey point

Differential Level Survey

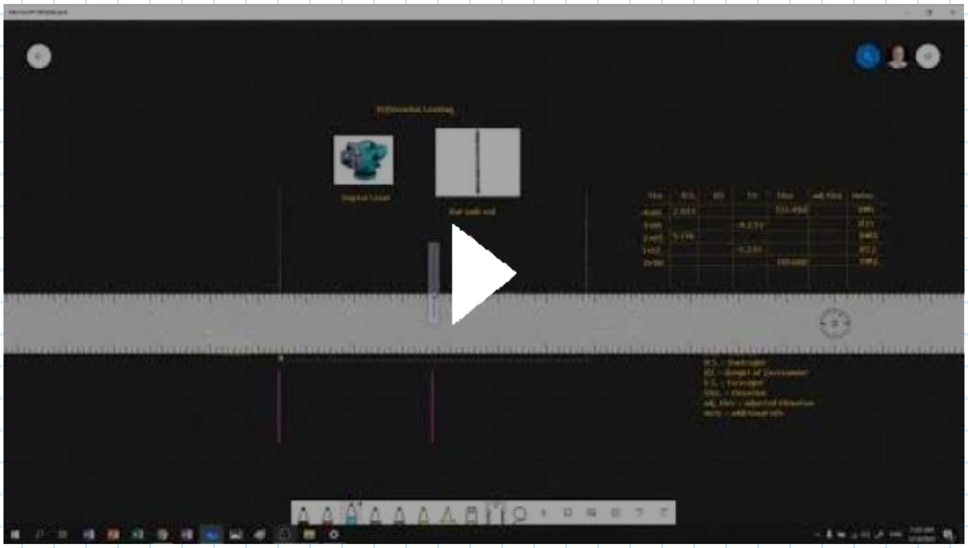
Monday, March 2, 2020 9:39 AM

Equipment Setup (12:45 min)

[CVEEN 2410 Ch 4 Level Set up]

Differential Level - Example

[CVEEN 2410 Ch 4 Differential Leveling]



Survey Notebook Preparation

Monday, March 2, 2020 9:39 AM

DIFFERENTIAL LEVELS

HD	+ B.S.	H.I.	− F.S.	Elev.	Adj. Elev.
5.3	1.33			2053.18	
		2054.51			
4.8	0.22		8.37	2046.14	
		2046.36			
5.6	0.96		7.91 ~~8.91~~	2038.45	
		2039.41			
15.2	0.46		11.72	2027.69	
		2028.15			
3.5	11.95		8.71	2019.44	
		2031.39			
4.2	12.55		2.61	2028.78	
		2041.33			
3.8	12.77		0.68	2040.65	
		2053.42			
10.9			0.21	2053.21	
	Σ = +40.24		Σ = −40.21		
		Page Check:			
		2053.18			
		+ 40.24			
		2093.42			
		− 40.21			
		2053.21	Check		

DIFFERENTIAL LEVELS

BM Mil.					
TP1					
TP2					
TP3					
BM Oak					
TP4					
TP5					
BM Mil.					

- Remember to include all classmates names on the above sheet so all can receive a score for your group work.

Adjustment of Elevation (Adj. Elev.) - Calculations

Monday, March 2, 2020 9:39 AM

1. Calculate the error of the survey.
   +40.24-40.21=0.03 (Positive error needs to be subtracted)

2. Calculate the total length of the survey circuit
   5.3+4.8+5.6+15.2+3.5+4.2+3.8+10.9=53.3

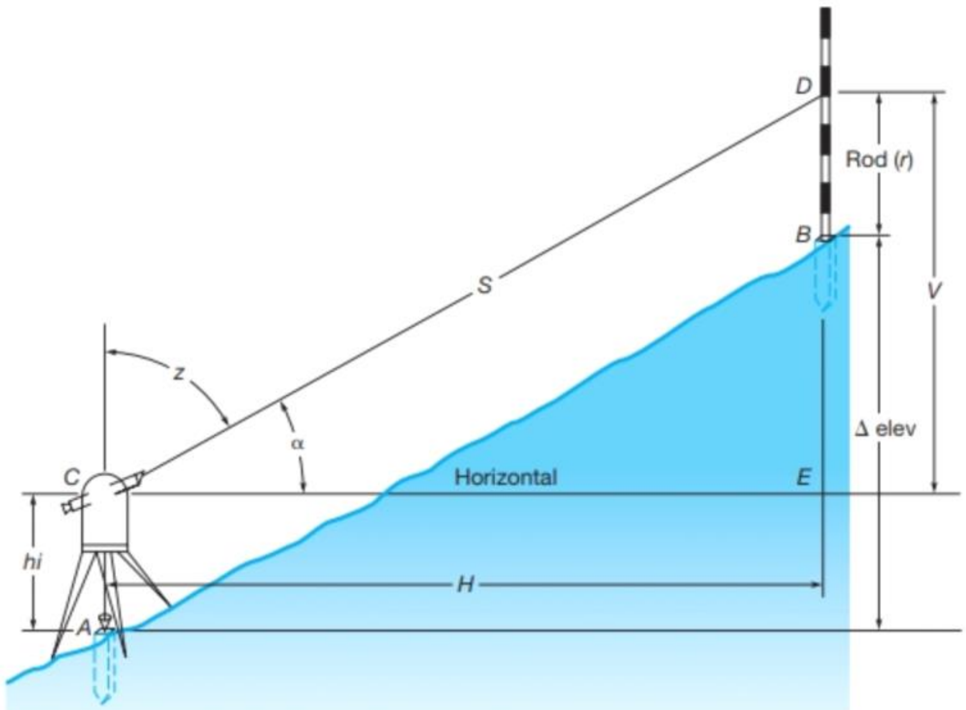
3. Calculate the error per unit length (i.e., error per meter)
   -0.03/53.3=-0.0006

4. Calculate the error adjustment for each point
   a. BM Mil = 0.0006x0=0
   b. TP1 = -0.0006x5.3=-0.0032
   c. TP1 adjusted elevation = 2053.18-0.0032=2053.1768
   d. Repeat this for all points.
   e. For the last point
   f. BM Mil = -0.0006x53.3=-0.032
   g. BM Mil adjusted elevation = 2053.21-0.032=2053.178=2053.18

Total Station Trigonometric Leveling

Monday, March 2, 2020 9:39 AM

The difference in elevation between two points can be determined by measuring (1) the inclined or horizontal distance between them and (2) the zenith angle or the altitude angle to one point from the other. (Zenith and altitude angles, described in more detail in Section 8.13, are measured in vertical planes. **Zenith angles are observed downward from vertical**, and altitude angles are observed up or down from horizontal.)



$$V = S \cos z \tag{4.6}$$

or

$$V = S \sin \alpha \tag{4.7}$$

Alternatively, if horizontal distance H between C and D is measured, then V is

$$V = H \cot z \tag{4.8}$$

or

$$V = H \tan \alpha \tag{4.9}$$

The difference in elevation (Δelev) between points A and B in Figure 4.7 is given by

$$\Delta\text{elev} = hi + V - r \tag{4.10}$$

Total Station Trigonometric Leveling - Example Calculation

Monday, March 2, 2020 9:39 AM

Given

- hi = 2.300 m (height of instrument)
- α = 95.0312 deg. (angle from vertical)
- S = 102.230 m (slope distance)
- r = 1.342 m (rod height)

Find:

- Δ elevation

Solution:

$\cos\alpha = H / S$

H = cos α*S

H = cos(5.0312)*102.230=101.8361170484325 m

V = sin α*S

V = sin(5.0312)*102.230=8.96538702443731 m

Δ elevation = hi + V - r

Δ elevation = 2.300+8.96538702443731-1.342=9.92338702443731 m

Δ elevation = 9.923 m

Precision in Leveling

Monday, March 2, 2020 9:39 AM

Precision in leveling is increased by repeating observations, making frequent ties to established benchmarks, using high-quality equipment, keeping it in good adjustment, and performing the measurement process carefully. However, no matter how carefully the work is executed, errors will exist and will be evident in the form of misclosures, as discussed in Section 5.4. To determine whether or not work is acceptable, misclosures are compared with permissible values on the basis of either number of setups or distance covered. Various organizations set precision standards based on their project requirements. For example, on a simple construction survey, an allowable misclosure of $C = 0.02\ \text{ft}\sqrt{n}$ might be used, where n is the number of setups. Note that this criterion was applied for the level circuit in the field notes of Figure 5.5.

The Federal Geodetic Control Subcommittee (FGCS) recommends the following formula to compute allowable misclosures:[1]

$$C = m\sqrt{K} \qquad (5.3)$$

where C is the allowable loop or section[2] misclosure, in millimeters; m is a constant; and K the total length leveled, in kilometers. For "loops" (circuits that begin and end on the same benchmark), K is the total perimeter distance, and the FGCS specifies constants of 4, 5, 6, 8, and 12 mm for the five classes of leveling, designated, respectively, as (1) first-order class I, (2) first-order class II, (3) second-order class I, (4) second-order class II, and (5) third order. For "sections" the constants are the same, except that 3 mm applies for first-order class I and 4 mm applies to first-order class II. The particular order of accuracy recommended for a given type of project is discussed in Section 19.8.

Example:

A differential leveling loop is run from an established BM A to a point 2 mi away and back, with a misclosure of 0.056 ft. What order leveling does this satisfy?

Solution

$$C = \frac{0.056\ \text{ft}}{0.00328\ \text{ft/mm}} = 17\ \text{mm}$$

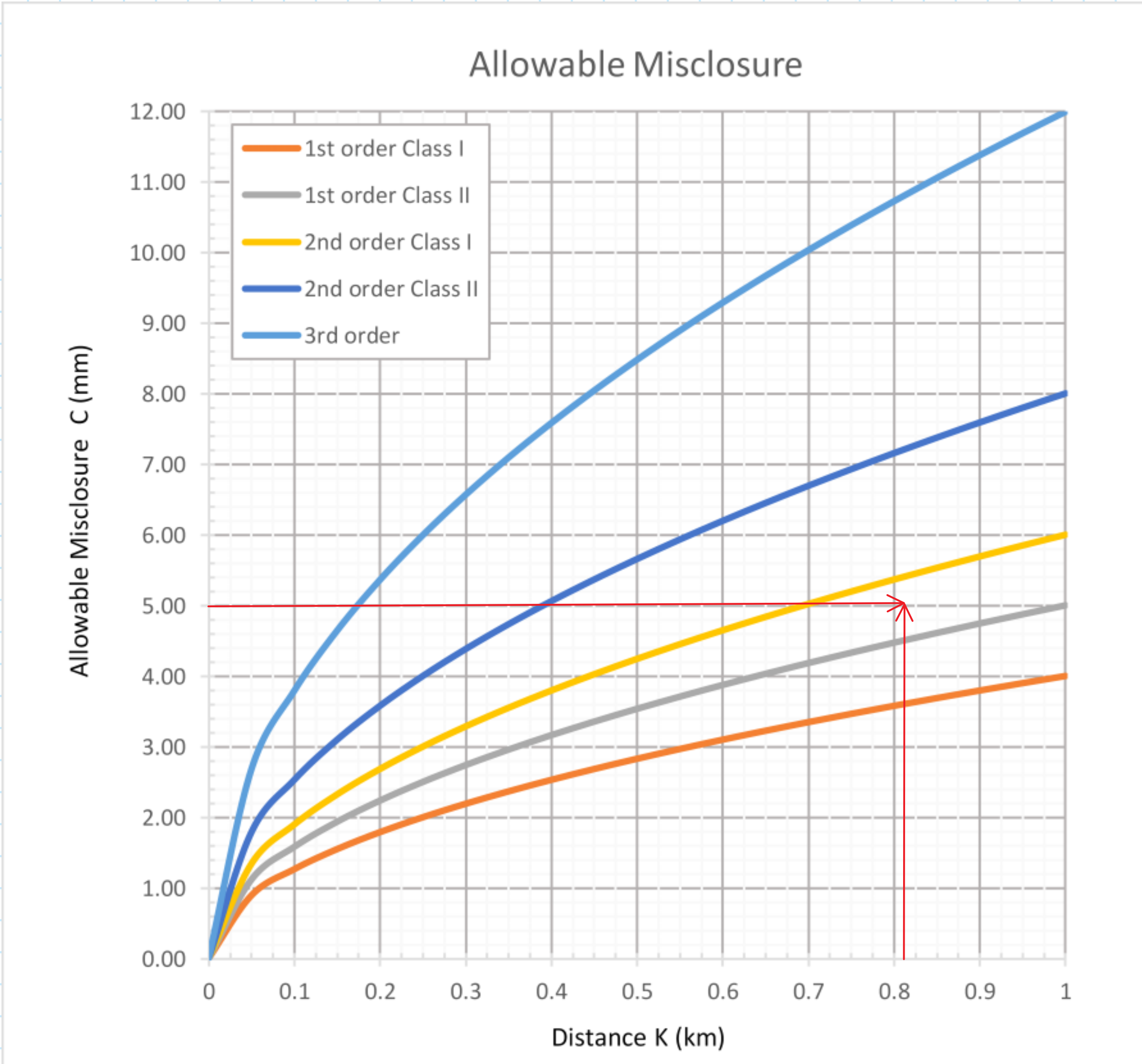
$$K = (2\ \text{mi} + 2\ \text{mi}) \times 1.61\ \text{km/mi} = 6.4\ \text{km}$$

By a rearranged form of Equation (5.3), $m = \dfrac{C}{\sqrt{K}} = \dfrac{17}{\sqrt{6.4}} = 6.7$

This leveling meets the allowable 8-mm tolerance level for second-order class II work, but does not quite meet the 6-mm level for second-order class I, and if that

Precision in Leveling (cont.)

Monday, March 2, 2020 9:39 AM



Example 3

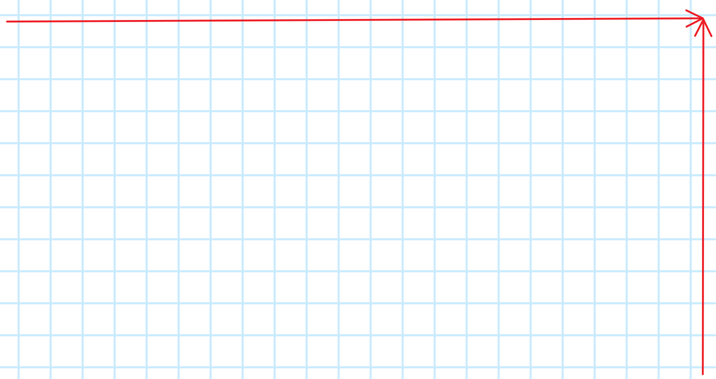
Given the chart above, what is the "order" of survey given the amount of misclosure from Example 1.

Closure error = 5 mm
Length of survey, K = 405*2/1000=0.81 Km

Answer (2nd Order, Class I)

Blank

Monday, March 2, 2020 9:39 AM



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