Online Surveying FE 208

Lectures 15
Leveling Loop Adjustments

Learning Objectives for this Lecture

1. **Understand the different vertical accuracy standards**
2. **Be able to determine the number of setups in a level loop survey**
3. **Be able to determine the setup number at any station along a level loop survey**
4. **Be able to correctly calculate leveling error in a level loop**
5. **Be able to perform the leveling elevation adjustments for any station in a level loop survey**

LEVEL LOOP ADJUSTMENTS

We can define the permissible amount of misclosure according to control standards. Although we haven't discussed control standards yet, let's just say that there are horizontal and vertical accuracy standards that guide the permissible amount of error from a survey process. The level of accuracy depends on the survey purposes. For leveling, we must have the length of the level loop before we can determine whether our closure error meets one of the standards. If it does, we can adjust the survey, rather than re-run the survey. Here are the Federal Geodetic Control Subcommittee (FGCS) vertical accuracy standards for level loops:

Federal Geodetic Control Subcommittee (FGCS) Vertical Accuracy Standards

Order and Class	Accuracy Required
First Order	
Class 1	4 mm * √K
Class II	5 mm * √K
Second Order	
Class I	6 mm * √K
Class II	8 mm * √K
Third Order	12 mm * √K

Where K = loop distance expressed in km and the sum = acceptable misclosure.

Working these calculations will give you the allowable closure for your level loop. As you can see, the First Order Standards are much tighter than the Third Order. From your text on page 8 (Kiser), there are descriptions of when these standards are applied.

We can examine the accuracy standards as they relate to a level loop that contains four stations A-D. The length of the level loop is three miles or 4.83 km (3 miles). Let's take a look at the acceptable vertical accuracy levels for our closure:

Applying Accuracy Standards to a 3.0 mile Course

First Order

Class 1 4 mm * 2.20 = 8.79 mm = 0.03'

Class II 5 mm * 2.20 = 10.10 mm = 0.12'

Second Order

Class I 6 mm * 2.20 = 13.18 mm = 0.14'

Class II 8 mm * 2.20 = 17.58 mm = 0.19'

Third Order 12 mm * 2.20 = 26.37 mm = 0.28'

Level Loop Adjustments with Unknown Horizontal Distance

Errors in leveling tend to cumulate- they build up over a course. In a level loop where we haven't measured distances, we can assign corrections with larger weights given to elevations toward the end of the course. This can include a level loop section of a survey where we have distances in a one-way direction but not for the closure back. This is a typical case.
Procedures:

We calculate the number of setups (number of back-sights or fore-sight), and divide this figure into the misclosure error. For each setup, we then multiply this sum by the set-up# and apply the correction to the elevation, rounding to the nearest hundredth.

If our misclosure is positive, we're going to subtract the correction. If it's negative, we'll add the correction.

1. Sum up number of set-ups
2. Calculate closure error, the divide closure error / by # of set-ups
3. For each station, multiply the set-up number * correction factor to get correction
4. For each station, apply correction to each elevation to get adjusted elevation

Example:

For the following survey notes, you should be able to complete the notes and then perform the adjustments at each station

Station	BS	HI	IFS	FS	Elev
BM	7.35				836.50
TP1	16.42			12.14	
TBM1			9.73		
TP2	4.88			11.96	
TBM2			17.11		
TBM3	7.36			16.81	
TP3	14.38			4.54	
TP4	9.74			9.21	
BM				5.35	

Complete the field notes showing the final level check

Station	BS	HI	IFS	FS	Elev
BM	7.35	**843.85**			836.50
TP1	16.42	**848.13**		12.14	**831.71**
TBM1			9.73		**838.40**
TP2	4.88	**841.05**		11.96	**836.17**
TBM2			17.11		**823.94**
TBM3	7.36	**831.60**		16.81	**824.24**
TP3	14.38	**841.44**		4.54	**827.06**
TP4	9.74	**841.97**		9.21	**832.23**
BM				5.35	**836.62**
Sum BS – Sum FS = 60.13 - 60.01 = +0.12					
836.62 – 836.50 = +0.12 Check					

What is the adjusted elevation at TBM 3?

Solution:

The total number of setups is 6. We can see this from the total number of backsights. The error is +0.12. The number of setups at TBM3 is 3. We can see this from the number backsights previous to TBM3.
So, the adjustment at TBM3 is –(+0.12/6) * 3 = -0.06.
The elevation adjusted at TBM3 is 824.24 – 0.06 = 824.18

The full adjustment for the survey is:

Station	BS	HI	IFS	FS	Elev	# Setups	Adjustment	Adj. Elev
BM	7.35	**843.85**			836.50	0	0	836.50
TP1	16.42	**848.13**		12.14	**831.71**	**1**	**-0.02**	**831.69**
TBM1			9.73		**838.40**	**2**	**-0.04**	**838.36**

TP2	4.88	**841.05**		11.96	**836.17**	**2**	**-0.04**	**836.13**
TBM2			17.11		**823.94**	**3**	**-0.06**	**823.88**
TBM3	7.36	**831.60**		16.81	**824.24**	**3**	**-0.06**	**824.18**
TP3	14.38	**841.44**		4.54	**827.06**	**4**	**-0.08**	**826.98**
TP4	9.74	**841.97**		9.21	**832.23**	**5**	**-0.10**	**832.13**
BM				5.35	**836.62**	**6**	**-0.12**	**836.50**

Level Loop Adjustments with Known Horizontal Distance

We can also adjust elevations in a level loop based on the horizontal distance between benchmarks and/or turning points and on the elevation differences between our benchmarks and/or turning points.

Procedures:

We first sum the length of the level loop. We take our measured elevations, calculate a misclosure, and calculate the difference in elevation between elevation benchmarks. We then divide the misclosure by the total traverse length to get a correction factor. Again, our correction factor will be positive for a negative closure. We then multiply the correction factor by corresponding line lengths to get a correction. This correction is applied to the measured elevation differences to get an adjusted elevation difference. We can now use the adjusted differences to start from our initial benchmark and calculate new elevations.

1. Sum traverse perimeter
2. Calculate closure error (apply positive or negative sign)
3. Divide closure error by traverse perimeter to get correction factor (carry sign)

FOR EACH STATION

4. Calc difference in elevation between stations
5. Multiply correction factor by each traverse side distance to get correction
6. Apply correction to each elevation difference

7. Calc new elevations based on corrected elevation differences

Assumptions: we have HDs and measured elevations for our stations. Adding the length of the sights gives us 3.0 miles. A misclosure of +0.24 ft is calculated with four set-ups. Since the difference in elevations is positive, our correction will be negative. We divide the misclosure by the traverse perimeter to get a correction factor (-0.24 / 3.0 = -0.08). For each station, we calculate measured elevation differences. We then multiply the correction factor by corresponding line lengths to get a correction. We apply the correction to our elevation differences to get an adjusted elevation difference. The adjusted differences are used to get the final adjusted elevations.

	HD	Elev	M El Diff	Correction	Adj Diff	Adj Elev
A		100.00				100.00
	1.0		10.60	-0.08	10.52	
B		110.60				110.52
	0.7		5.42	-0.06	5.36	
C		116.02				115.88
	0.8		-8.47	-0.06	-8.53	
D		107.55				107.35
	0.5		-7.31	-0.04	-7.35	
A		100.24				100.00
	3.0	0.24		-0.08		