Online Surveying FE 208
Lectures 8 and 9

Traverse Adjustments

Learning Objectives for this Lecture

1. **Know the process for traverse computations and adjustment**
2. **Know the computations for departure and latitude**
3. **Know the quadrant signs for departure and latitude**
4. **Be able to compute coordinates from unadjusted departures and latitudes**
5. **Be able to compute traverse closure**
6. **Be able to compute linear error**
7. **Be able to compute relative error**
8. **Be able to compute relative error on an equivalent scale basis**
9. **Know the 4 methods of adjusting traverses**
10. **Be able to adjust traverses by the compass rule**
11. **Be able to compute latitude and departure corrections**
12. **Be able to compute adjusted latitude and departure**
13. **Be able to compute adjusted coordinates**

We have already established that all measurements have error. The next step in the traverse is to identify and adjust errors in distance and direction.

IMPORTANT! WE ARE *NOT* ADJUSTING MISTAKES, ONLY ERRORS

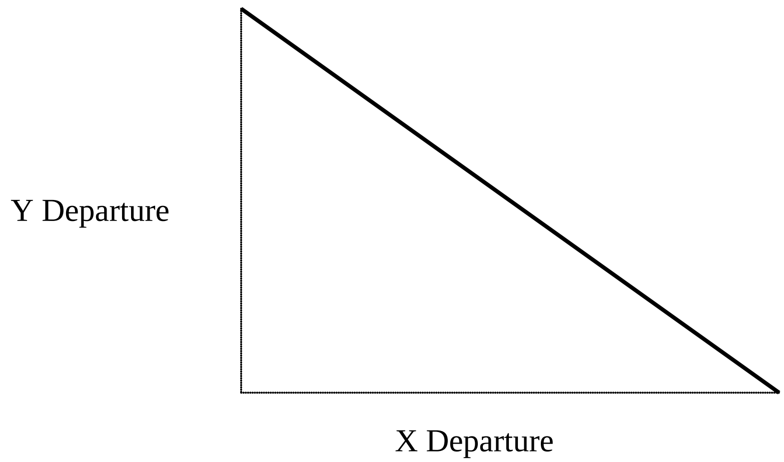
The steps in the traverse adjustment process for a closed traverse are:

1. **Compute the departures and latitudes of each line segment (course)**
2. **Compute unadjusted coordinates for each survey position (station)**
3. **Compute the sums of departure and sums of latitude**
4. **Compute the adjustment for each station by the appropriate rule**
5. **Compute the adjusted departure and adjusted latitude**
6. **Compute the adjusted coordinates**

Departures and Latitudes

Defined as the X and Y components of a survey line, superimposed onto a horizontal plane with a directional reference system.

Mathematically they are the legs of a right triangle, the hypotenuse being the survey line itself.



Departure = ΔX

Latitude = ΔY

$\Delta X = L \sin Z$

$\Delta Y = L \cos Z$

Where: L = the length of the line
Z = the azimuth or bearing of the line

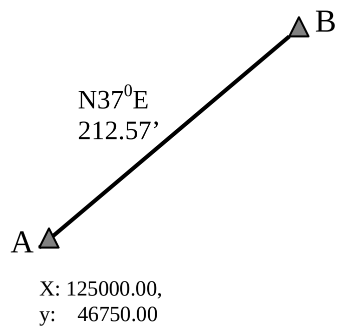
Coordinates of X and Y at any station are calculated from the previous station coordinates plus the departure and latitude to the current station

(WATCH SIGNS!)

Rules on the signs in the four quadrants:

Latitude:	Positive in the northerly direction Negative in the southerly direction
Departure:	Positive in the easterly direction Negative in the westerly direction

Example:



Coordinates of B =

$$\alpha = 37^0$$

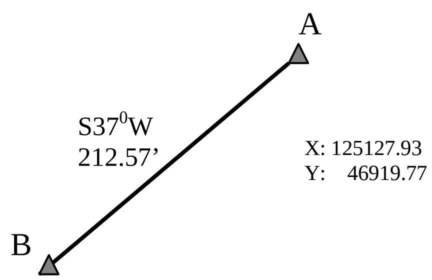
$$\Delta X = L \sin Z \qquad \Delta Y = L \cos Z$$

$$\Delta X = 212.57' \sin 37^0 \qquad \Delta Y = 212.57' \cos 37^0$$

$$\Delta X = (212.57')0.601815 \qquad \Delta Y = (212.57')0.798636$$

$$\Delta X = 127.93' \qquad \Delta Y = 169.77'$$

X_B = 125000.00 + 127.93 = 125127.93
Y_B = 46750.00 + 169.77 = 46919.77



Angle = 217º

$\Delta X = L \sin Z$ $\quad$ $\Delta Y = L \cos Z$

$\Delta X = 212.57' \sin 217$ $\quad$ $\Delta Y = 212.57 \cos 217$

$\Delta X = 212.57' (-.6018\ldots)$ $\quad$ $\Delta Y = 212.57 (-.7986\ldots)$

$\Delta X = -127.93$ $\quad$ $\Delta Y = -169.77$

$X_B = 125127.93 - 127.93 \quad = 125000.00$

$Y_B = 46919.77 - 169.77 \quad = 46750.00$

Traverse Closure

In a closed-loop survey the sums of the departures and latitudes should equal zero.

The total or linear error of closure = the hypotenuse of the triangle formed by the errors in latitude and departure.

$$E_T = \sqrt{\left(E_d^2 + E_l^2\right)}$$

The relative error of closure (or precision of the traverse) = the total error divided by the perimeter. Usually expressed as a ratio.

Example:

The error in departure on a traverse = 0.13'
The error in latitude on a traverse = 0.09'
The total length of the traverse is 1950.23'

$$\boxed{E_T = \sqrt{\left(0.13_d^2 + 0.09_l^2\right)}}$$

$$\boxed{E_T = \sqrt{(0.250)}}$$

$$\boxed{E_T = 0.158}$$

$$\boxed{E_R = \frac{(0.158)}{1950.23}}$$

$$\boxed{E_R = 0.000081}$$

$$\boxed{E_R = 1:12300}$$

Example:

Sta	SD	%	HD	AHD	LAT	DEP
A						
	422.73	+6	421.97	S80^0 21'E	-70.73	+416.00
F						
	280.01	+7	279.33	N39^0 18'W	+216.16	-176.92
E						
	455.91	-12	452.66	N26^0 17'E	+405.86	+200.44
D						
	886.70	+1	886.04	S56^0 27'W	-489.68	-738.43
C						
	392.59	+4	392.28	S8^0 27'W	-388.02	-57.64
B						
	483.74	-3	483.52	N47^0 28'E	+326.87	+356.30
A						
			2915.80		+0.46	-0.25

$$Linear\ \ error\ \ of\ \ closure\ \ = \sqrt{(0.46^2) + (0.25^2)} = 0.52'$$

$$\mathrm{Re}lative\ \ error\ \ of\ \ closure\ \ = \frac{0.52'}{2915.80}\ \ =\ \ 1:5607$$

Equivalent error can be calculated from the relative error by understanding that the relative error is unitless. For example in the above we can read the relative error of 1:5607 as :

1 foot in 5607 feet or 1 meter in 5607 meters

Typical is to express relative error on a per mile basis, therefore:

$$\frac{1'}{5607'} = \frac{x'}{5280'} = \frac{0.94'}{mile}$$

Traverse Adjustments

Methods of adjusting traverses:

1. Compass (or Bowditch rule)
2. Transit rule
3. Least Squares
4. Crandall method

Assumptions:

Compass rule: Distances and directions are measured with consistent precision
This means there is an equal chance of error from either measurement.

Transit rule: Directions are measured with higher precision than the distances
After adjustments, directions are disrupted less than distances.

Least Square rule: Theoretically results in the least disturbance to the original measurements
This method minimizes the overall adjustments.

Crandall method: A weighted least squares method
Higher weight is given to the directions, similar to the transit rule.

Compass Rule

Departures and latitudes are adjusted in proportion to their lengths.

$$\text{Correction in departure for } XY = \frac{-(\text{total departure misclosure})}{\text{Traverse perimeter}} \times \text{length of } XY$$

$$\text{Correction in latitude for } XY = \frac{-(\text{total latitude misclosure})}{\text{Traverse perimeter}} \times \text{length of } XY$$

<u>NOTE: Pay particular attention to the signs of the correction</u>

Example:

Sta	HD	LAT	DEP	LAT_{corr}	DEP_{corr}	LAT_{adj}	DEP_{adj}
A							
	421.97	-70.73	+416.00	-.07	.04	-70.80	+416.04
F							
	279.33	+216.16	-176.92	-.04	.02	+216.12	-176.90
E							
	452.66	+405.86	+200.44	-.07	.04	+405.79	+200.48
D							
	886.04	-489.68	-738.43	-.14	.08	-489.82	-738.35
C							
	392.28	-388.02	-57.64	-.06	.03	-388.08	-57.61
B							
	483.52	+326.87	+356.30	-.08	.04	+326.79	+356.34
A							
	2915.80	+0.46	-0.25	-0.46	+0.25	0.00	0.00

Coordinate computations

Coordinate computations are made by simply adding the adjusted departures and latitudes to the previous coordinates.

In a closed traverse these coordinates should agree in balance back at the first.

Example:

Coordinates of A

Northing = 10000.00
Easting = 10000.00

Sta	LAT_{adj}	DEP_{adj}	Northing	Easting			
A			10000.00	10000.00			
	-70.80	+416.04					
F			10070.80	9583.96			
	+216.12	-176.90					
E			9854.68	9760.86			
	+405.79	+200.48					
D			9448.89	9560.38			
	-489.82	-738.35					
C			9938.71	10298.73			
	-388.08	-57.61					
B			10326.79	10356.34			
	+326.79	+356.34					
A			10000.00	10000.00			
	0.00	0.00					