CVG 2171 – Surveying and Measurements

Assignment # 5 – Traverse Computations

SOLUTION

Problem 1

Balance the following interior angles (angles-to-the-right) of a five sided closed polygon traverse given the following information. Calculate the azimuths of the remaining sides. Note that line BC bears SE.

Point	Angle	Adjusted Angle
A	132°47′06"	132°47'07"
B	108°46′18"	108°46'19"
C	107°19′37"	107°19'38"
D	81°50′36"	81°50'37"
E	109°16′18"	109°16'19"
Σ	539°59'55"	540°00'00" ✓

Course	Azimuth
AB	218°59′30"
BC	147°45'49"
CD	75°05'27"
DE	336°56'04"
EA	266°12'23"
-	-

Balance Interior Angles

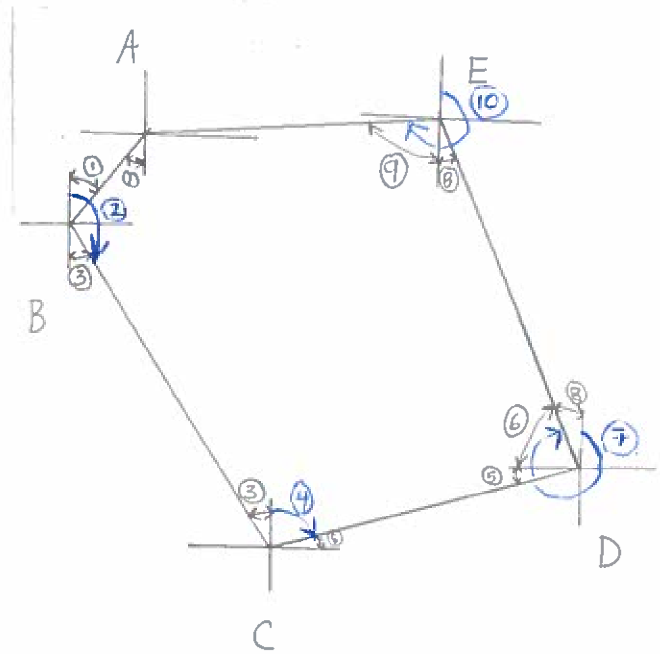
1. Σangles $= (n-2)\,180° = (5-2)\,180° = 540°$

2. misclosure $= \Sigma$measured $- \Sigma$angles $= 539°59'55" - 540°00'00" = -5"$

3. Correction per angle $= \left|\dfrac{\text{misclosure}}{n}\right| = \left|\dfrac{-5"}{5}\right| = -1"$

$\therefore$ Since Σmeasured $< \Sigma$angles ADD correction

Compute Azimuths



① $218°59'30'' - 180° = 38°59'30''$

② $38°59'30'' + 108°46'19'' = 147°45'49''$

③ $180° - 147°45'49'' = 32°14'11''$

④ $107°19'38'' - 32°14'11'' = 75°05'27''$

⑤ $90° - 75°05'27'' = 14°54'33''$

⑥ $81°50'37'' - 14°54'33'' = 66°56'04''$

⑦ $270° + 66°56'04'' = 336°56'04''$

⑧ $90° - 66°56'04'' = 23°03'56''$

⑨ $109°16'19'' - 23°03'56'' = 86°12'23''$

⑩ $180° + 86°12'23'' = 266°12'23''$

Problem 2

Compute departures and latitudes, linear misclosure, and relative precision for the traverse problem above if lengths of the sides (in feet) are as follows:

Course	Azimuth	Length (ft.)	Departure (ft.)	Latitude (ft.)
AB	218°59′30"	202.74	-127.565	-157.577
BC	147°45′49"	283.87	151.420	-240.113
CD	75°05′27"	498.37	481.592	128.224
DE	336°56′04"	320.33	-125.500	294.722
EA	266°12′23"	380.78	-379.946	-25.193
Σ	-	1,686.09	0.001	0.063

Departure and Latitude

Sample Calculation for Course AB:

$$dep = L\sin\alpha = (202.74)\sin(218°59'30'') = -127.565 \text{ ft}$$

$$lat = L\cos\alpha = (202.74)\cos(218°59'30'') = -157.577 \text{ ft}$$

Linear Misclosure (LEC)

$$LEC = \sqrt{(\Sigma dep)^2 + (\Sigma lat)^2} = \sqrt{(0.001)^2 + (0.063)^2} = 0.063 \text{ ft.}$$

Relative Precision

$$\text{Precision} = \frac{LEC}{\text{Perimeter}} = \frac{0.063}{1686.09} = \frac{0.063/0.063}{1686.09/0.063} = \frac{1}{26,527.53}$$

∴ Precision ≈ 1 : 27,000

Problem 3

Using the compass (Bowditch) rule adjust the departures and latitudes of the traverse given in the previous problem. Given the coordinates at A, calculate (a) coordinates for the other stations (b) the lengths and bearings of lines BC and CD, and (c) the final adjusted angles at B and C.

Course	Length (ft.)	Corrected Departure (ft.)	Corrected Latitude (ft.)
AB	202.74	-127.566	-157.585
BC	283.87	151.420	-240.123
CD	498.37	481.592	128.206
DE	320.33	-125.500	294.710
EA	380.78	-379.946	-25.208
Σ		Ø ✓ OK	Ø ✓ OK

Adjust the Departures and Latitudes

Sample Calculation for Course AB:

→ $\text{Correction in dep AB} = -\dfrac{\text{dep misclosure}}{\text{perimeter}} \times \text{length AB}$

$$= -\frac{0.001}{1689.09} \times (202.74)$$

$$= -0.000120029$$

$$\text{adjusted dep AB} = \text{dep.} + \text{correction in dep AB}$$

$$= -127.565 + (-0.000120029)$$

$$= -127.566 \text{ ft.}$$

→ $\text{Correction in lat AB} = -\dfrac{\text{lat misclosure}}{\text{Perimeter}} \times \text{length AB}$

$$= -\frac{0.063}{1689.09} \times (202.74)$$

$$= -0.007561835$$

$$\text{adjusted lat AB} = \text{lat.} + \text{correction in lat. AB}$$

$$= -157.577 + (-0.007561835)$$

$$= -157.585 \text{ ft.}$$

Coordinates of Stations

Point	X (ft.)	Y (ft.)
A	20,000.00	15,000.00
B	19,872.43	14,842.42
C	20,023.85	14,602.29
D	20,505.45	14,730.50
E	20,379.95	15,025.21

$X_B = X_A + \text{dep } AB = 20{,}000 + (-127.566) = 19{,}872.43 \text{ ft}$

$Y_B = Y_A + \text{lat } AB = 15{,}000 + (-157.585) = 14{,}842.42 \text{ ft}$

$X_C = X_B + \text{dep } BC = 19{,}872.43 + (151.420) = 20{,}023.85 \text{ ft.}$

$Y_C = Y_B + \text{lat } BC = 14{,}842.42 + (-240.123) = 14{,}602.29 \text{ ft.}$

$X_D = X_C + \text{dep } CD = 20{,}023.85 + (481.592) = 20{,}505.45 \text{ ft.}$

$Y_D = Y_C + \text{lat } CD = 14{,}602.29 + (128.206) = 14{,}730.50 \text{ ft.}$

$X_E = X_D + \text{dep } DE = 20{,}505.45 + (-125.500) = 20{,}379.95 \text{ ft}$

$Y_E = Y_D + \text{lat } DE = 14{,}730.50 + (294.710) = 15{,}025.21 \text{ ft}$

Lengths and Azimuths

→ BC:

$$\text{Length } BC = \sqrt{(X_C - X_B)^2 + (Y_C - Y_B)^2}$$

$$= \sqrt{(20023.85 - 19872.43)^2 + (14602.29 - 14842.42)^2}$$

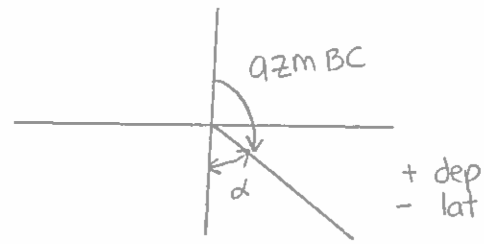
$$= \underline{\underline{283.88 \text{ ft}}}$$

$$\tan\alpha = \frac{X_C - X_B}{Y_C - Y_B} = \frac{20023.85 - 19872.43}{14602.29 - 14842.42} = -0.630575105$$

$$\alpha = \tan^{-1}(-0.630575105)$$

$$\alpha = 32°14'4.24''$$

$$\therefore \text{azm } BC = 180° - 32°14'4.24'' = \underline{\underline{147°45'56''}}$$



→ CD:

$$\text{Length } CD = \sqrt{(X_D - X_C)^2 + (Y_D - Y_C)^2}$$

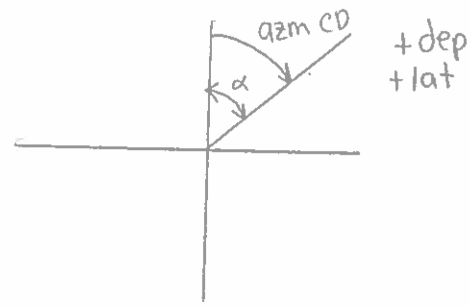
$$= \sqrt{(2050545 - 20023.85)^2 + (14730.50 - 14602.29)^2}$$

$$= \underline{\underline{498.37 \text{ ft}}}$$

$$\tan\alpha = \frac{X_D - X_C}{Y_D - Y_C} = \frac{20505.45 - 20023.85}{14730.50 - 14602.29} = 3.756337259$$

$$\alpha = \tan^{-1}(3.756337259)$$

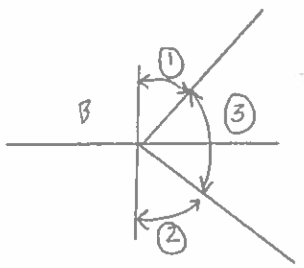
$$\alpha = 75°05'33.54''$$



$$\therefore \text{azm } CD = \underline{\underline{75°05'34''}}$$

Final Adjusted Angles

→ B:

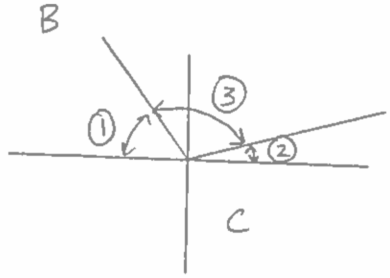


① $\sin\alpha = \frac{X_A - X_B}{L_{AB}} = \frac{20{,}000 - 19{,}872.43}{202.74} \rightarrow \alpha = 38°59'36''$

② $\sin\alpha = \frac{X_C - X_B}{L_{CB}} = \frac{20{,}023.85 - 19{,}872.43}{283.87} \rightarrow \alpha = 32°14'11''$

③ $180° - 38°59'36'' - 32°14'11'' = \underline{\underline{108°46'13''}}$

→ C:



① $\sin\alpha = \frac{Y_B - Y_C}{L_{CB}} = \frac{14{,}842.42 - 14{,}602.29}{283.87} \rightarrow \alpha = 57°46'13''$

② $\sin\alpha = \frac{Y_D - Y_C}{L_{CD}} = \frac{14{,}730.50 - 14{,}602.29}{498.37} \rightarrow \alpha = 14°54'27''$

③ $180° - 57°46'13'' - 14°54'27'' = \underline{\underline{107°19'20''}}$

Problem 4

Compute the linear misclosure, relative precision, and adjusted lengths and azimuths for the sides after the departures and latitudes are balanced by the compass rule in the following closed-polygon traverse:

Course	*Length (m)*	*Departure (m)*	*Latitude (m)*
AB	412.516	−216.2394	−351.2975
BC	513.185	+512.9654	+15.0112
CA	448.495	−296.7364	+336.2964
Σ	1,374.196	−0.0104	0.0101

Course	*Adj. Departure (m)*	*Adj. Latitude (m)*	*Adj. Length (m)*	*Azimuth*
AB	−216.236	−351.301	412.517	211°36'49"
BC	512.969	15.008	513.189	88° 19'27"
CA	−296.733	336.293	448.490	318° 34'33"
Σ	∅ ✓ OK	∅ ✓ OK		

Linear Misclosure (LEC)

$$LEC = \sqrt{(\Sigma dep)^2 + (\Sigma lat)^2}$$

$$= \sqrt{(-0.0104)^2 + (0.0101)^2}$$

$$= 0.0145$$

Relative Precision

$$\text{Precision} = \frac{LEC}{\text{Perimeter}}$$

$$= \frac{0.0145/0.0145}{1374.196/0.0145}$$

$$= \frac{1}{94,772.14}$$

$\therefore$ Precision $\approx$ 1 : 95,000

Adjust the Departures and Latitudes

Sample Calculation for course AB:

→ $$\text{correction in dep } AB = -\frac{\text{dep misclosure}}{\text{Perimeter}} \times \text{length } AB$$

$$= -\frac{(-0.0104)}{1374.196} \times 412.516$$

$$= 0.003121947$$

$$\text{adjusted dep } AB = \text{dep} + \text{correction in dep } AB$$

$$= -216.2394 + (0.003121947)$$

$$= -216.236 \text{ m}$$

→ $$\text{correction in lat } AB = -\frac{\text{lat misclosure}}{\text{perimeter}} \times \text{length } AB$$

$$= -\frac{(0.0101)}{1374.196} \times 412.516$$

$$= -0.00303189$$

$$\text{adjusted lat } AB = \text{lat} + \text{correction in lat } AB$$

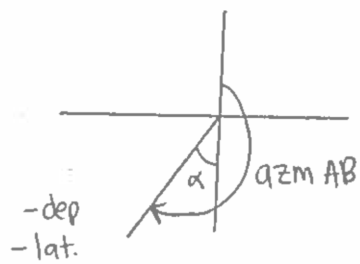
$$= -351.2975 + (-0.00303189)$$

$$= -351.301 \text{ m}$$

Lengths and Azimuths

→ Course AB:

$$\text{length} = \sqrt{(\text{dep}\,AB)^2 + (\text{lat}\,AB)^2}$$
$$= \sqrt{(-216.236)^2 + (-351.301)^2}$$
$$= 412.517\text{m}$$

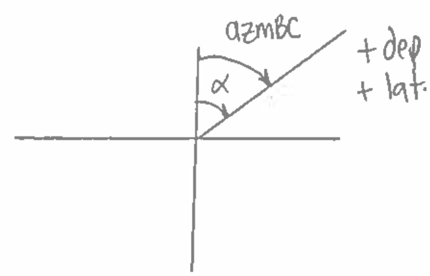


$$\tan\alpha = \frac{\text{dep}\,AB}{\text{lat}\,AB}$$
$$= \frac{-216.236}{-351.301} \longrightarrow \alpha = 31^\circ 36' 49''$$

$\therefore$ Azm AB $= 180^\circ + 31^\circ 36' 49'' = 211^\circ 36' 49''$

→ Course BC:

$$\text{length} = \sqrt{(\text{dep}\,BC)^2 + (\text{lat}\,BC)^2}$$
$$= \sqrt{(512.969)^2 + (15.008)^2}$$
$$= 513.189\text{m}$$

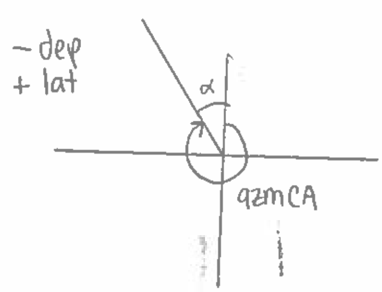


$$\tan\alpha = \frac{\text{dep}\,BC}{\text{lat}\,BC}$$
$$= \frac{512.969}{15.008} \longrightarrow \alpha = 88^\circ 19' 27''$$

$\therefore$ azm BC $= 88^\circ 19' 27''$

→ Course CA:

$$\text{length} = \sqrt{(\text{dep}\,CA)^2 + (\text{lat}\,CA)^2}$$
$$= \sqrt{(-296.733)^2 + (336.293)^2}$$
$$= 448.490\text{m}$$



$$\tan\alpha = \frac{\text{dep}\,CA}{\text{lat}\,CA}$$
$$= \frac{-296.733}{336.293} \longrightarrow \alpha = 41^\circ 25' 27''$$

$\therefore$ azm CA $= 360^\circ - 41^\circ 25' 27'' = 318^\circ 34' 33''$