



ISTANBUL TECHNICAL UNIVERSITY

DEPARTMENT OF GEOMATICS ENGINEERING

TOPOGRAPHY

WEEK 6

TRAVERSE

A traverse consists of a series of straight lines connected successively at established points, along the route of survey. The points defining the ends of the traverse line are called traverse station or traverse points. Distance (horizontal distance) between traverse stations are known as traverse side which are measured by using a tape or electronic measuring equipment.

Traversing is the traditional surveying method which is used to determine plane coordinates (rectangular coordinates) of established traverse stations.

TRAVERSE

A traverse is currently the most common of several possible methods for establishing a series or network of monuments with known positions on the ground. Such monuments are referred to as horizontal control points and collectively, they comprise the horizontal control for the project.

This method is employed to establish horizontal control, the result is to assign rectangular coordinates to each control point within the survey. This allows each point to be related to every other point with respect to distance and direction, as well as to permit areas to be calculated when needed.

PURPOSE OF TRAVERSE STATIONS

- To determine the horizontal location of natural or artificial objects and topographic detail points on the ground to prepare plans or maps with contour lines.
- To determine the location of points of which horizontal positions are unknown by the help of other points of which positions are known by making necessary observations between traverse stations and traverse sides.
- Some measurements on scaled plans can be applied on the ground.

TRAVERSE SURVEYING

Field Work

- Reconnaissance
- Selection of Station Sites
- Marking of Stations
- Field Measurement
 - Linear Measurement
 - Angular Measurement
- Computations

Office Work

- Computation of traverse and control of computations
- Plotting map or plan

TRAVERSE SURVEYING

Reconnaissance:

Reconnaissance provides opportunity for surveyors to gather information about fieldwork such as terrain information and other potential effects on surveying.

During reconnaissance , the usability of existing stations are examined, suitable location of traverse stations are identified and the method of traversing is decided for the field conditions. Also, types of monuments to be established on the ground are determined.

TRAVERSE SURVEYING

Selection of Station Sites:

- Traverse stations must be established on the firm ground.
- Intervisibility between adjacent stations, forward and back, must be maintained for angle and distance observations.
- The stations should also ideally be established in convenient locations that allow for easy access
- Efficient numbers of topographic detail points can be observed from selected traverse stations. Station locations must be selected to permit complete coverage of the area to be mapped.
- The traverse sides should not be intersected road or similar facilities so long as there is not a necessity.

TRAVERSE SURVEYING

Referencing Traverse Stations:

Referencing is the process of measuring the distances and directions from station points to near fixed points or objects which can be identified easily on the ground.

Traverse stations often must be found and reoccupied months or even years after they are established. They may be destroyed through construction or other activity. Therefore, it is important that they be referenced by creating observational ties to them. Therefore, they can be relocated if obscured or reestablished if destroyed.

TRAVERSE SURVEYING

Referencing Traverse Stations:

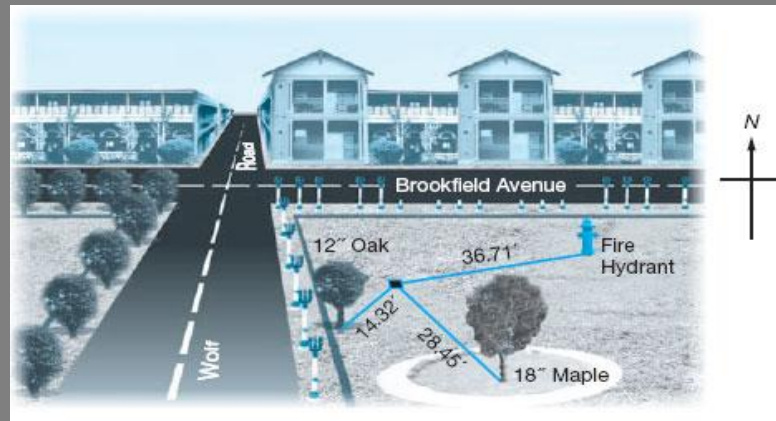


Figure: 1 (C.D. Ghilani, P.R. Wolf, 2008)

This figure represents a typical traverse tie. This tie consist of distance observation made to nearby fixed objects. Short length are convenient, also that length of ties is shorter than a steel tape being used is convenient.

Three ties must be used to allow for the possibility that one reference mark may be destroyed. Also , at least three ties, which are well – distributed around the traverse stations, are used to find where the stations exist clearly.

TRAVERSE SURVEYING

a) Linear Measurements:

Distance (horizontal distance) between traverse stations are known as traverse side which are measured by using a tape, electronic measuring equipment or total stations.

Observation of traverse length with taping:

Averages of distances observed forward and back will provide increased accuracy, and the repeat readings afford a check on the observation.

S_1 = the distance of AB line (forward observation) with taping

S_2 = the distance of AB line (backward observation) with taping

d = tolerance (in respect of Production Regulation of Large Scale Map standards. Item no.27 / b , $d = 3$ cm)

TRAVERSE SURVEYING

Observation of traverse length with taping:

if Absolute value ($S_2 - S_1$) \leq d

distance of AB line = $(S_1 + S_2) / 2$ (mean value of observations)

if not absolute value ($S_2 - S_1$) \leq d observations are dismissed and observations are repeated.

The maximum distance of a traverse length which is measured by using taping method is 150 meters in respect of Production Regulation of Large Scale Map standards.

TRAVERSE SURVEYING

a) Angular Measurements:

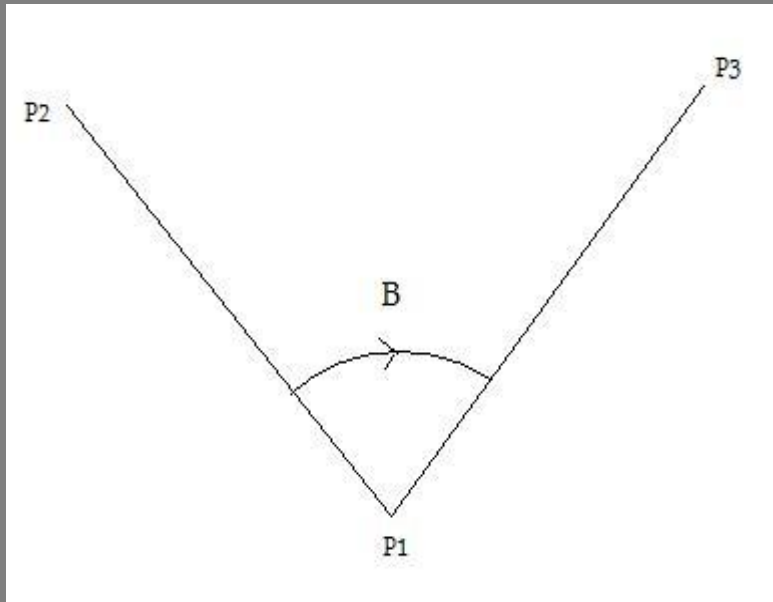


Figure: 2

P1 – station point

P2 – left target (back sight)

P3 – right target (foresight)

B : horizontal angle (clockwise)

Face I = P2 then P3 observations

Face II = P3 then P2 observations

TRAVERSE SURVEYING

a) Angular Measurements:

An *angle* is defined as the difference in direction between two convergent lines. A *horizontal angle* is formed by the directions to two objects in a horizontal plane.

- Interior angles are measured clockwise or counter-clockwise between two adjacent lines on the inside of a closed polygon figure.
- Exterior angles are measured clockwise or counter-clockwise between two adjacent lines on the outside of a closed polygon figure.
- Angles to the right are turned from the *back* line in a clockwise or right hand direction to the ahead line.
- Angles to the left are turned from the back line in a counter-clockwise or left hand direction to the ahead line.

TRAVERSE SURVEYING

a) Angular Measurements:

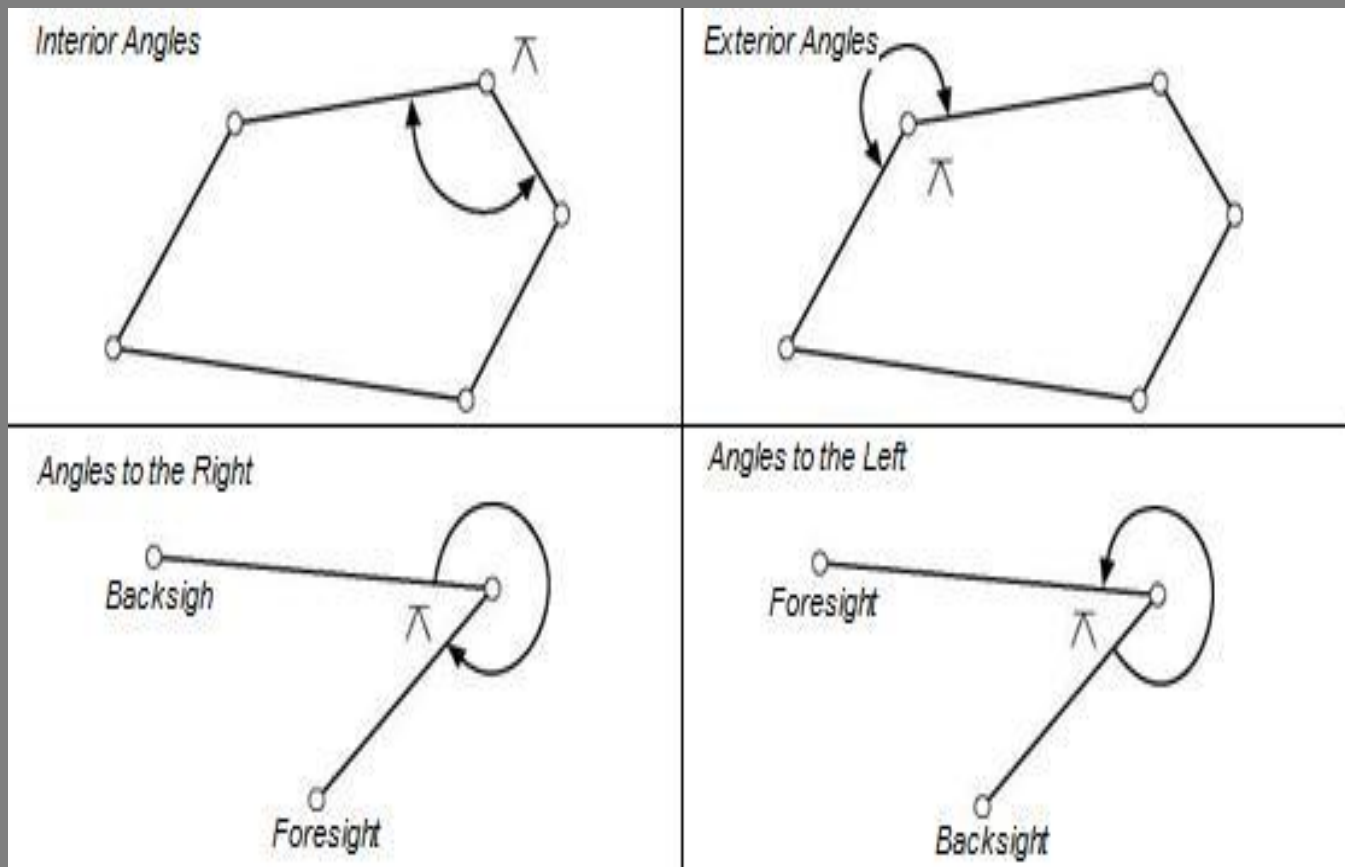


Figure:3

TRAVERSE SURVEYING

a) Angular Measurements:

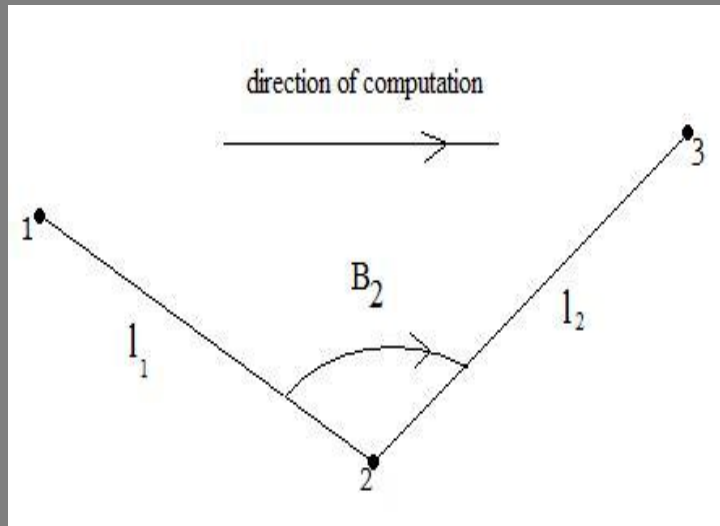


Figure:4

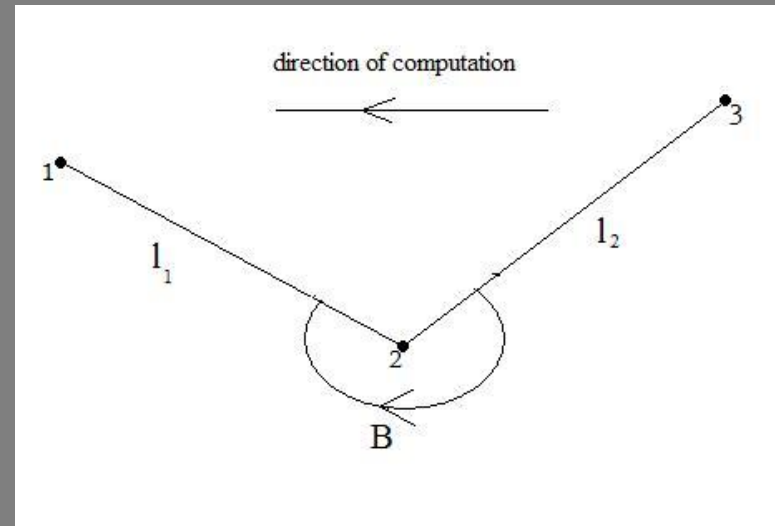


Figure:5

Traverse angle is a horizontal angle which is measured between two adjacent traverse sides. The angles which are left side of the route of survey or direction of computation are used as a traverse angle.

TRAVERSE SURVEYING

a) Angular Measurements:

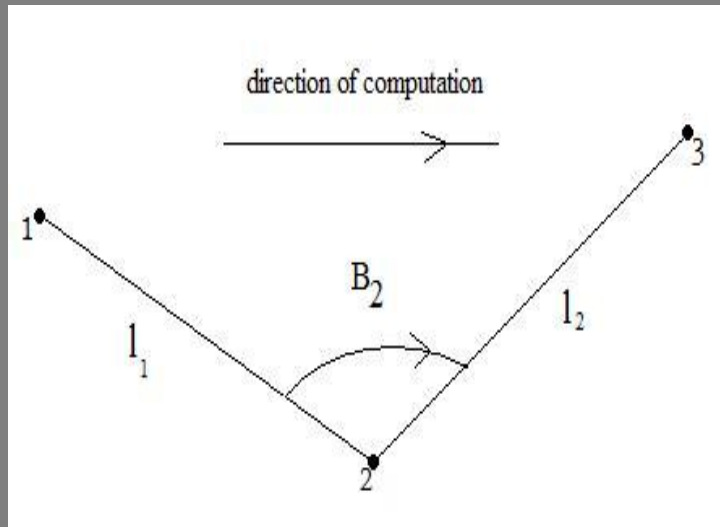


Figure:4

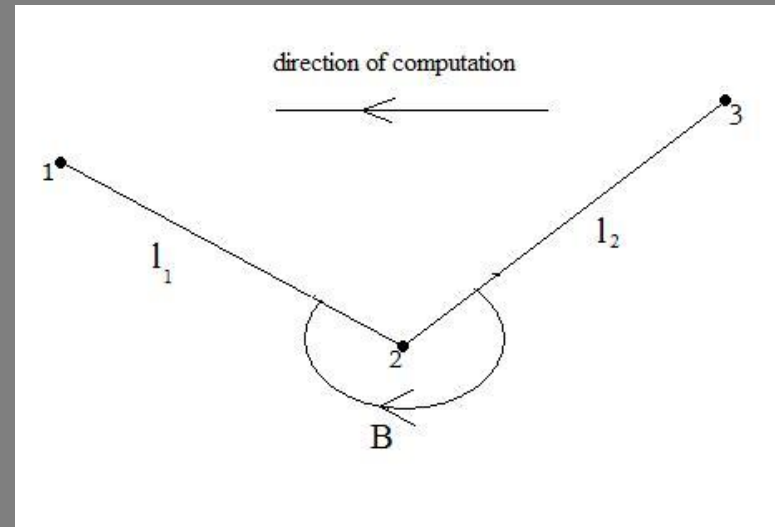


Figure:5

To reduce mistakes in reading, recording, and computing, traverse angles should always be turned clockwise from the backsight station to the foresight station. Also traverse angles are measured by using set method.

TYPES OF TRAVERSE

There are three kinds of traverses with their geometrical properties;

- Open traverse
- Closed-loop traverse
- Closed-link traverse

Open Traverse:

Open Traverse does not create a closed shape and may begin at a point of known position and ends at a point of previously unknown position. Computational check is not possible to detect error or blunder in distance and directions.

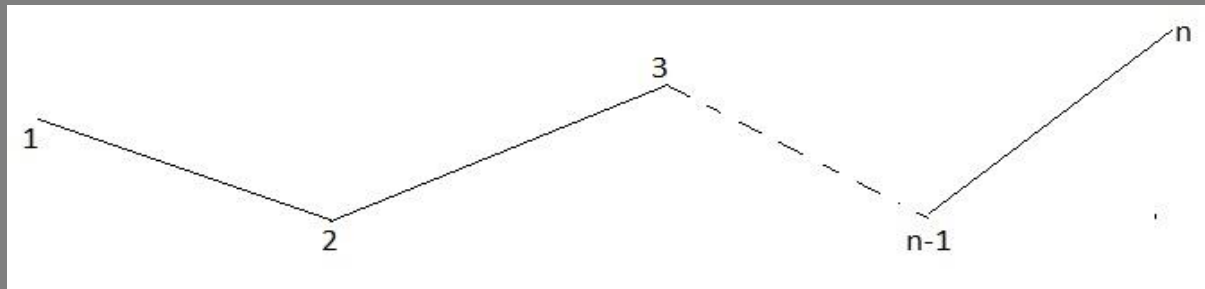


Figure:6

TYPES OF TRAVERSE

Closed-loop Traverse:

Closed Traverse creates a closed geometrical shape (polygon). A closed traverse is one that either begins and ends at the same point. Therefore the angles can be closed geometrically and the position closure can be determined mathematically.

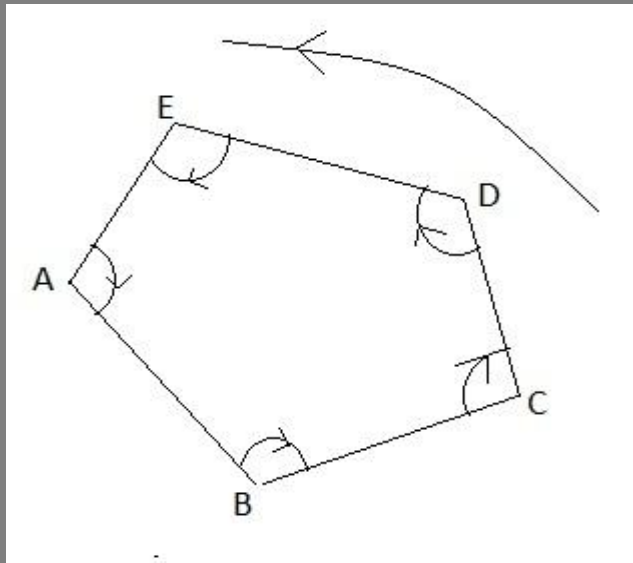


Figure:7

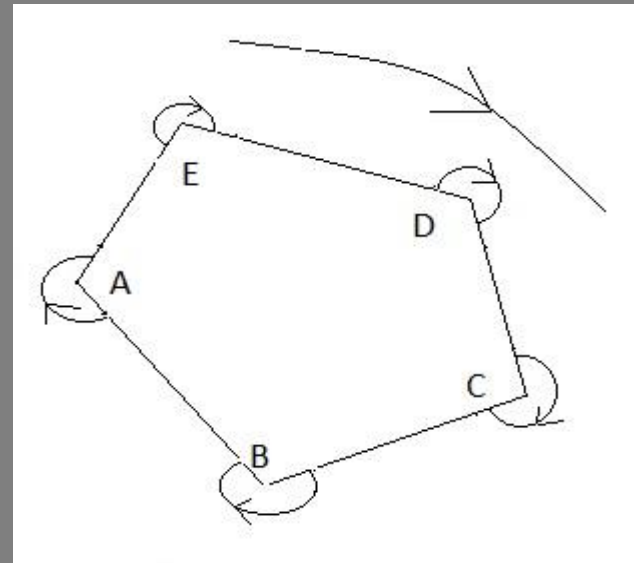


Figure:8

TYPES OF TRAVERSE

Closed-link Traverse:

A link traverse is connected to at least two points, at the beginning and at the end of traverses, whose coordinates have been previously determined. Calculations can be made to check for errors.

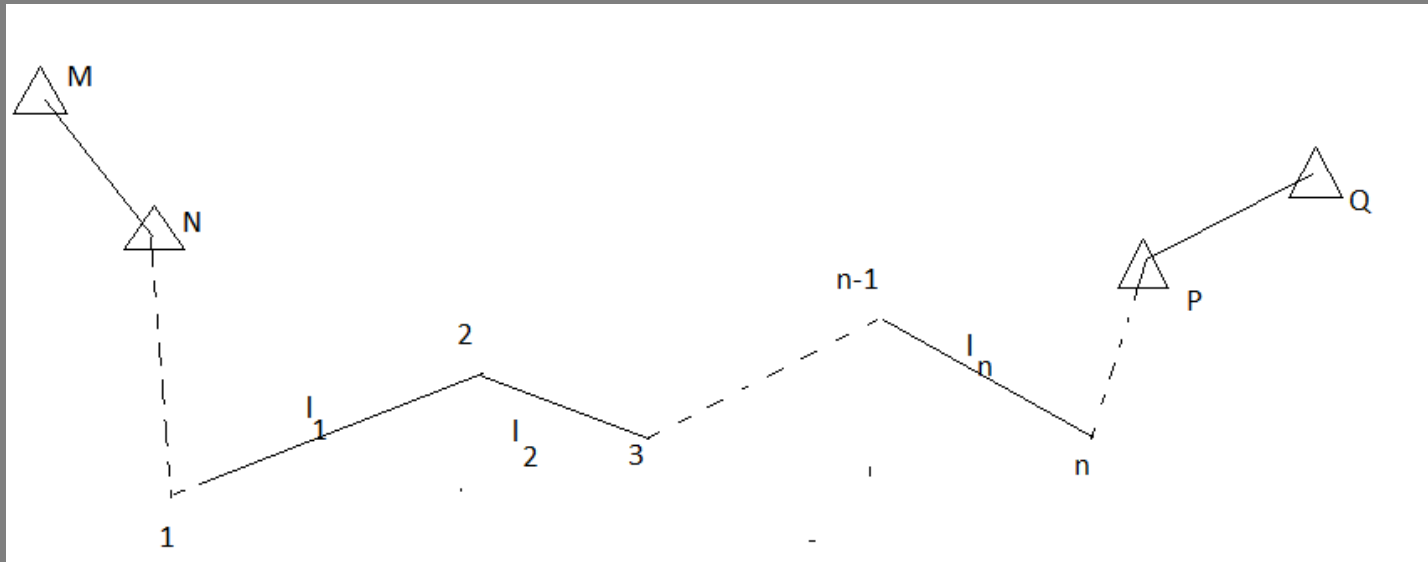


Figure:9

TRAVERSE COMPUTATION

Open Traverse Computation:

Traverse surveying in the field yields observed angles or directions and length of the traverse sides. Thus, these parameters are used in traverse computations which are performed in a plane rectangular coordinate system.

Computation of Azimuths:

Computational check is not possible to detect error or blunder in distance and directions in open traverse computation. Therefore, it is impossible to balance traverse angles .

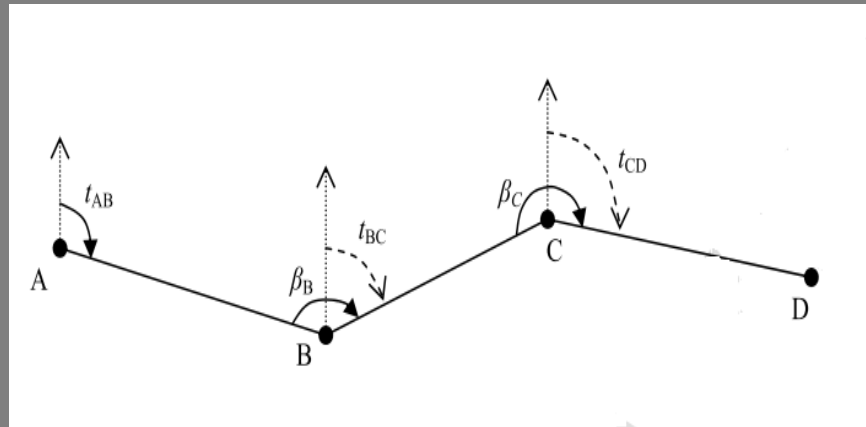
TRAVERSE COMPUTATION

Open Traverse Computation:

Computation of Azimuths:

$$t_{BC} = t_{AB} + \beta_B + n * 200^{grad}$$

$$t_{AB} + \beta_B = K$$



$$K < 200^g ; K + 200^g ; t_{BC} = t_{AB} + \beta_B + 200^g$$

$$200^g < K < 600^g ; K - 200^g ; t_{BC} = t_{AB} + \beta_B - 200^g$$

$$K > 600^g ; K - 600^g ; t_{BC} = t_{AB} + \beta_B - 600^g$$

TRAVERSE COMPUTATION

Open Traverse Computation:

Computation of Azimuths:

$$t_{23} = t_{12} + \beta_2 \pm k.200^g$$

$$t_{34} = t_{23} + \beta_3 \pm k.200^g$$

$$t_{45} = t_{34} + \beta_4 \pm k.200^g$$

.....

$$t_{n(n+1)} = t_{n-1(n)} + \beta_n \pm k.200^g$$

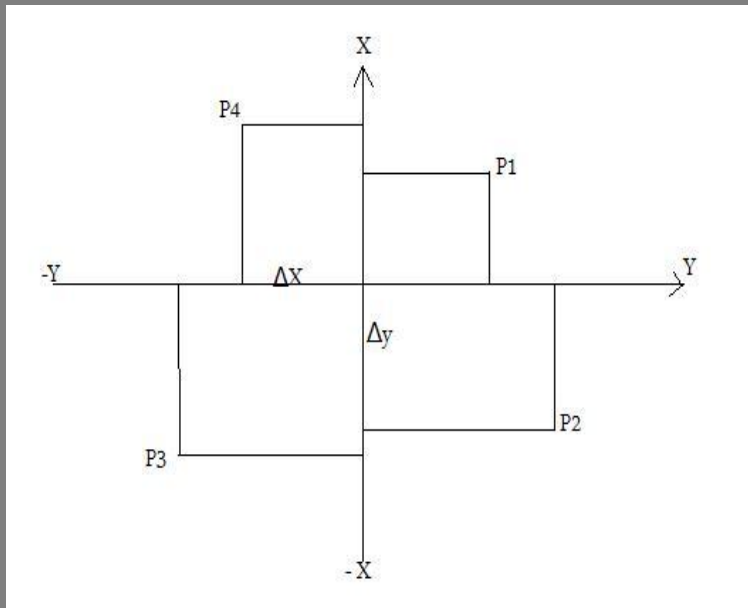
Control of Computation Azimuth:

$$t_{\text{end}} = t_{1,2} + \Sigma\beta \pm k.200^g$$

TRAVERSE COMPUTATION

Open Traverse Computation:

Computation Departure and Latitudes:



RECTANGULAR COORDINATE SYSTEM

Direction of +X refers to north,
Direction of +Y refers to east,

TRAVERSE COMPUTATION

Open Traverse Computation:

Computation Departure and Latitudes:

To calculate the coordinates for each point on a traverse, the direction and distance from a known point must also be known.

Once the distance and direction values are known, the latitude and departure can be calculated. These values will indicate the distances north or south and east or west between the two points. The coordinates of the unknown point can then be determined by algebraically adding the latitude to the northing of the known point and the departure to the easting of the known point.

TRAVERSE COMPUTATION

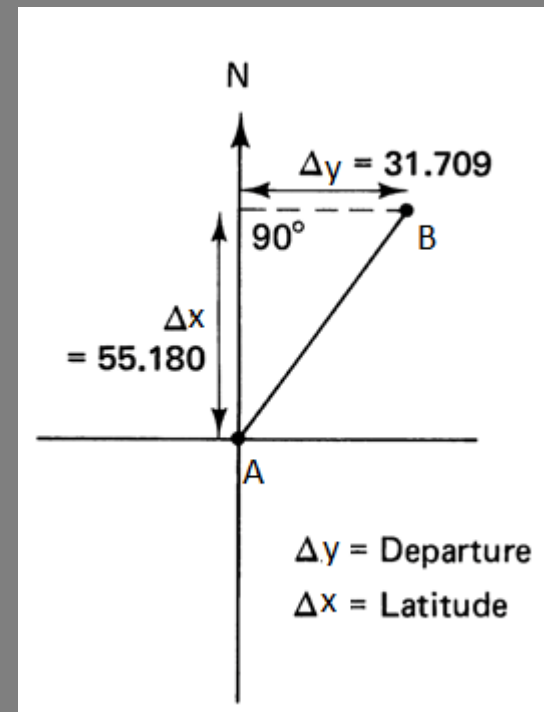
Open Traverse Computation:

Computation Departure and Latitudes:

$$\Delta Y = S_{AB} \cdot \sin t_{AB}$$

$$\Delta X = S_{AB} \cdot \cos t_{AB}$$

- $Y_B = Y_A + \Delta Y = Y_A + S_{AB} \sin t_{AB}$
- $X_B = X_A + \Delta X = X_A + S_{AB} \cos t_{AB}$
- $Y_n = Y_{n-1} + \Delta Y_{n-1}$
- $X_n = X_{n-1} + \Delta X_{n-1}$



TRAVERSE COMPUTATION

Open Traverse Computation:

Computation of Coordinates:

- $Y_B = Y_A + \Delta Y = Y_A + S_{AB} \sin t_{AB}$
- $X_B = X_A + \Delta X = X_A + S_{AB} \cos t_{AB}$
- $Y_n = Y_{n-1} + \Delta Y_{n-1}$
- $X_n = X_{n-1} + \Delta X_{n-1}$

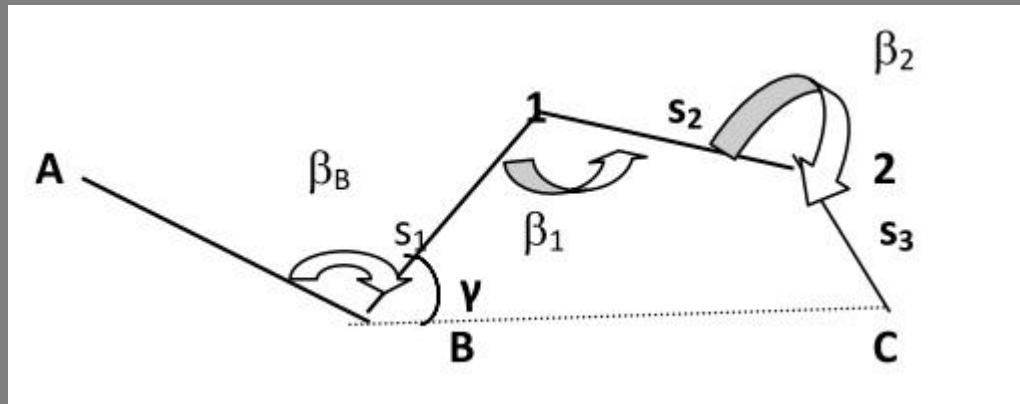
Control of Coordinates Computation:

- $Y_n - Y_1 = \Sigma \Delta Y$
- $X_n - X_1 = \Sigma \Delta X$

TRAVERSE COMPUTATION

Open Traverse Computation:

Question1:



- Calculate the coordinates of 1,2,C ?
- Determine S_{BC} and γ ?

TRAVERSE COMPUTATION

Open Traverse Computation:

Question1:

Known: A ($Y_A = 8450.00\text{m}$; $X_A = 9300.50\text{m}$)

B ($Y_B = 8575.00\text{m}$; $X_B = 9125.75\text{m}$)

Station Point	Target Point	Horizontal Direction (Grad)	
		FACE I	FACE II
B	A	0,1560	200,1600
	1	98,5100	298,5200

$$\beta_1 = 144^{\text{g}} .348 \quad S1 = 175.58 \text{ m}$$

$$\beta_2 = 207^{\text{g}} .893 \quad S2 = 168.75 \text{ m}$$

$$S3 = 184.94 \text{ m}$$

TRAVERSE COMPUTATION

Open Traverse Computation:

Solution1:

Station	Target	Horizontal Direction (Grad)		Mean	Reduced	Mean of Set
Point	Point	FACE I	FACE II	$(F_{II}-200+F_{I})/2$	Directions (grad)	grad
B	A	0,1560	200,1600	0,1580	0,0000	98, 3570
	1	98,5100	298,5200	98,5150	98,3570	

t_{AB} :

$$\Delta Y_{AB} = Y_B - Y_A = 125$$

$$\Delta X_{AB} = X_B - X_A = -174.75$$

$$t'_{AB} = \arctan \frac{|\Delta Y_{AB}|}{|\Delta X_{AB}|}$$

$$t'_{AB} = 125/174.75 \text{ (+/- II. QUAD)}$$

$$t'_{AB} = 39.529$$

$$t_{AB} = 200 - t'_{AB} = \mathbf{160.471 \text{ grad}}$$

TRAVERSE COMPUTATION

Open Traverse Computation:

Solution1:

Station	Measured	Azimuths	Length	ΔY	ΔX	Coordinates (m)	
Point	Traverse Angles (g)	(g)	(m)	(m)	(m)	Y	X
A		160,4710				8450,00	9300,50
B	98,3570	58,8280	175,58	140,12	105,8	8575,00	9125,75
1	255,6520	114,4800	168,75	164,40	-38,05	8715,12	9231,55
2	207,8930	112,3730	184,94	173,64	-63,66	8879,52	9193,5
C						9053,16	9129,84
Σ				478,16	4,09		

Control of Traverse Computation:

$$t_{2C} = t_{AB} + \sum \beta \pm n200 = 122,373 \quad Y_C - Y_B = \sum \Delta Y, \quad X_C - X_B = \sum \Delta X$$

TRAVERSE COMPUTATION

Open Traverse Computation:

Solution1:

$$\gamma = t_{BC} - t_{B1}$$

$$\tan t'_{BC} = \left| \frac{Y_C - Y_B}{X_C - X_B} \right|$$

$$\tan t'_{BC} = 478,16 / 4,09 \quad (+/+ \text{I. quadrant})$$

$$t_{BC} = t'_{BC} = 99.455 \text{ grad}$$

$$t_{B1} = 58,828 \text{ (in table)}.$$

$$\gamma = t_{BC} - t_{B1} = 99.455 - 58.828 = 40.627 \text{ grad}$$

$$S_{BC} = \sqrt{\Delta X^2 + \Delta Y^2} = 478.18 \text{ m}$$

TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

Traverse surveying in the field yields observed angles or directions and length of the traverse sides. Thus, these parameters are used in traverse computations which are performed in a plane rectangular coordinate system.

The usual steps followed in making elementary traverse computations are;

- Adjusting angles or directions to fixed geometric conditions
- Determining azimuths of the traverse lines.
- Calculating departures and latitudes and adjusting them for misclosure
- Computing rectangular coordinates of the traverse stations.

TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

Balancing Traverse Angles:

In elementary methods of closed loop traverse adjustment, the first step is to balance the traverse angles to the proper geometrical total. For closed traverses, angle balancing is done readily since the total error is known. The correction for each angle is found by dividing the total angular misclosure by the number of angles. Also another methods for balancing angles is that making larger corrections to angles where poor observing conditions were present. The first method is almost always applied.

TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

Balancing Traverse Angles:

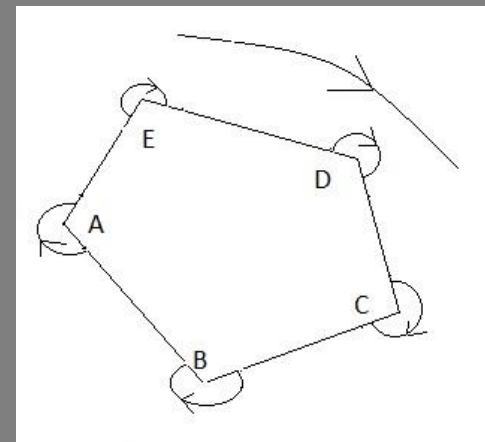
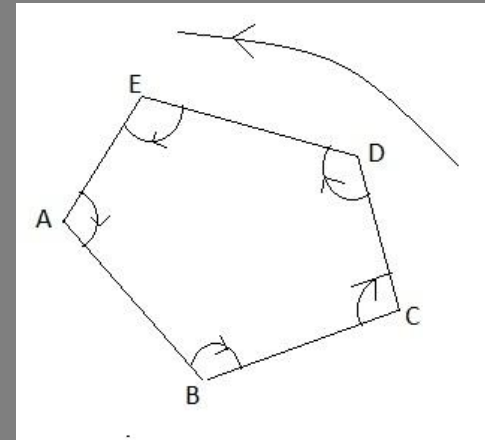
n = number of sides of geometrical shape

- Total interior angles of a closed geometrical shape can be computed by this formula;

$$\Sigma (\text{interior angles}) = (n-2) * 200^g$$

- Total exterior angles of a closed geometrical shape can be computed by this formula;

$$\Sigma (\text{exterior angles}) = (n+2) * 200^g$$



TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

The Angular Misclosure:

The difference between total measured traverse angles and total angles which are computed for geometrical shape is described as the angular misclosure.

$$f_{\beta} = \Sigma (\text{measured traverse angles}) - \Sigma (\text{computed angles geometrically})$$

Maximum Angular Misclosure:

The maximum angular misclosure of a traverse angles is calculated by below formula in respect of Production Regulation of Large Scale Map standards.

$$F_B = 1.5^c \sqrt{n}$$

n = number of traverse angles

TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

Control of angle misclosure error:

If the angle misclosure (f_{β}) < the maximum angle misclosure (F_{β})
It can be accepted and measured traverse angles can be balanced.

The correction for each angle is found by dividing the total angular misclosure by the number of angles in respect of Production Regulation of Large Scale Map standards.

$$v_i = - (f_{\beta}) / n$$

Adjusted traverse angles :

$$\beta'_i = \beta_1 + v_{\beta}$$

TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

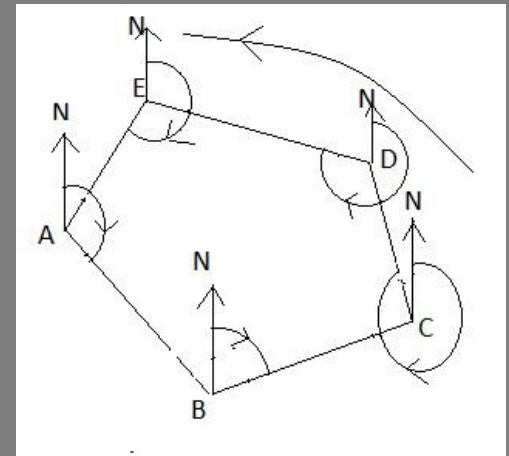
Computation of Azimuths:

After the balancing the traverse angles, the next step in closed-loop traverse computation is calculation of either azimuths.

Azimuths are calculated by using balanced (adjusted) traverse angles.

$$t_{BC} = t_{AB} + \beta_B + n * 200^{grad}$$

$$t_{AB} + \beta_B = K$$



$$K < 200^g ; K + 200^g ; t_{BC} = t_{AB} + \beta_B + 200^g$$

$$200^g < K < 600^g ; K - 200^g ; t_{BC} = t_{AB} + \beta_B - 200^g$$

$$K > 600^g ; K - 600^g ; t_{BC} = t_{AB} + \beta_B - 600^g$$

TRAVERSE COMPUTATION

Closed-Loop Traverse Computation:

Computation of Azimuths:

$$t_{23} = t_{12} + \beta'_2 \pm k.200^g$$

$$t_{34} = t_{23} + \beta'_3 \pm k.200^g$$

$$t_{45} = t_{34} + \beta'_4 \pm k.200^g$$

.....

$$t_{n(n+1)} = t_{n-1(n)} + \beta'_n \pm k.200^g$$

Control of Computation Azimuth:

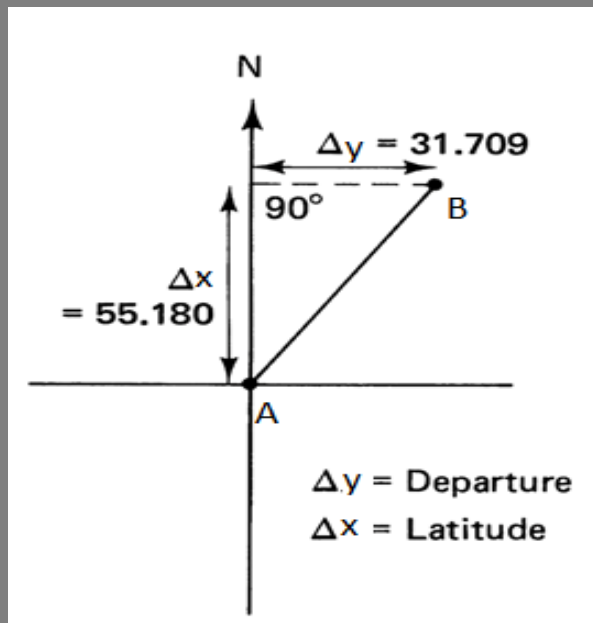
$$t_{12} = t_{n1} + \beta'_1 \pm k.200^g$$

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Computation Departure (ΔY) and Latitudes (ΔX) :

After balancing the angles and calculating azimuths for each line, traverse closure is checked by computing (ΔY), (ΔX) of each lines.



$$\Delta Y = S_{AB} \cdot \sin t_{AB}$$

$$\Delta X = S_{AB} \cdot \cos t_{AB}$$

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

For a closed-polygon traverse, It can be reasoned that if all angles and distances were measured perfectly, the algebraic sum of the departures of all courses in traverse should equal zero. Likewise, the algebraic sum of all latitudes should equal zero. Because starting and ending control points are the same point for closed-polygon traverse.

The observations are not perfect and errors exist in the angles and distances, the conditions just stated rarely occur. The amounts by which they fail to be met are termed departure misclosure and latitude misclosure. Their values are computed by algebraically summing the departures and latitudes and comparing the totals to required conditions.

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

Control of (ΔY) and (ΔX) for Closed-Loop Traverse:

$$\Sigma \Delta Y = 0$$

$$\Sigma \Delta X = 0$$

Computation of Traverse Coordinate Misclosure :

$$f_y = 0 - \Sigma \Delta Y$$

$$f_x = 0 - \Sigma \Delta X$$

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

$$F_{Q[m]} = 0.05 + 0.15\sqrt{S_{[km]}}$$

$$F_{L[m]} = 0.05 + 0.04\sqrt{n - 1}$$

$S_{[km]}$ total length of traverse sides

$$f_Q = \frac{1}{S} (f_y [\Delta X] - f_x [\Delta Y])$$

$$f_L = \frac{1}{S} (f_y [\Delta Y] + f_x [\Delta X])$$

$$S = \sqrt{[\Delta Y]^2 + [\Delta X]^2}$$

n = number of stations

F_Q = limit of latitude error

F_L = limit of departure error

f_Q = error of latitude

f_L = error of departure

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

It should be;

$$F_Q > f_Q$$

$$F_L > f_L$$

it can be accepted and the departures and latitudes of traverse courses can be adjusted in proportion to their lengths.

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Correction in departure for AB:

$$= \frac{-[\Delta Y]}{\text{traverse perimeter}} \times \text{length of AB}$$

Correction in latitude for AB:

$$= \frac{-[\Delta X]}{\text{traverse perimeter}} \times \text{length of AB}$$

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Computation of adjusted ΔY and ΔX :

$$\Delta y'_i = \Delta y_i + V_{y_i}$$

$$\Delta x'_i = \Delta x_i + V_{x_i}$$

$$\Sigma \Delta y'_i = 0$$

$$\Sigma \Delta x'_i = 0$$

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Computation of Coordinates:

- $Y_B = Y_A + \Delta Y' = Y_A + S_{AB} \sin t_{AB}$
- $X_B = X_A + \Delta X' = X_A + S_{AB} \cos t_{AB}$
- $Y_i = Y_{i-1} + \Delta y'_{i-1}$
- $X_i = X_{i-1} + \Delta x'_{i-1}$

Controls of Coordinates:

- $Y_1 = Y_n + \Delta y'_n$
- $X_1 = X_n + \Delta x'_n$

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Question2:

Known:

$$Y_1 = 1020.00\text{m} \quad t_{12} = 304.0000 \text{ grad}$$

$$X_1 = 1020.00\text{m}$$

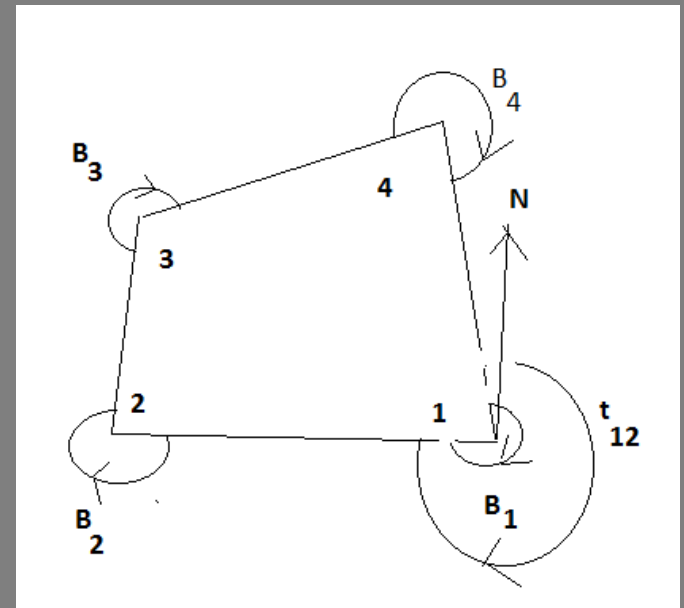
$$\beta_1 = 288.7790 \text{ grad}$$

$$l_{12} = 47.17\text{m} \quad \beta_2 = 286.6910 \text{ grad}$$

$$l_{23} = 58.04\text{m} \quad \beta_3 = 305.0790 \text{ grad}$$

$$l_{34} = 71.63\text{m} \quad \beta_4 = 319.4450 \text{ grad}$$

$$l_{41} = 67.01\text{m}$$



TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Solution2:

STATION	MEASURED TRAVERSE ANGLE	AZIMUTHS	LENGTH	ΔY (m)	Δx (m)	COORDINATES	
	β_n (grad)	V_n^{n+1} (grad)	l_n (m)	$l_n * \sin V_n^{n+1}$	$l_n * \cos V_n^{n+1}$	Y (m)	X(m)
1						1020.00	1020.00
2	$286.691^{+(2)}$	304.000	47.17	$(-)47.08^{-(1)}$	$(+)2.96$	972.91	1022.96
3	$305.079^{+(1)}$	390.693	58.04	$(-)8.45^{-(2)}$	$(+)57.42^{-(1)}$	964.44	1080.37
4	$319.445^{+(1)}$	95.773	71.63	$(+)71.47^{-(2)}$	$(+)4.75^{-(1)}$	1035.89	1085.11
1	$288.779^{+(2)}$	215.219	67.01	$(-)15.87^{-(2)}$	$(-)65.10^{-(1)}$	1020.00	1020.00
2		304.000					
Σ	1199.994		243.85	$(+)0.07$	$(+)0.03$		

TRAVERSE COMPUTATION

Closed Loop Traverse Computation:

Solution2:

for exterior traverse angles:

$$(n+2)*200=(4+2)*200=1200g$$

$$\Sigma\beta = 1199.994$$

$$f\beta = \Sigma\beta - [(n+2)*200] = -0.006 \text{ grad} = -0.6c$$

$$F\beta = 1.5c * \sqrt{n} = 3.0c$$

$$f\beta < F\beta, \text{ therefore ; } v_{\beta i} = -\frac{f\beta}{n}$$

$$s = \sqrt{[\Delta X]^2 + [\Delta Y]^2}$$

$$f_y = 0 - \Sigma\Delta y \quad f_y = -7 \text{ cm}$$

$$f_x = 0 - \Sigma\Delta x \quad f_x = -3 \text{ cm}$$

$$F_Q > f_Q; F_L > f_L$$

$$F_{Q[m]} = 0.05 + 0.15\sqrt{S_{[km]}} = \pm 0.124 \text{ m}$$

$$F_{L[m]} = 0.05 + 0.04\sqrt{n-1} = \pm 0.12 \text{ m}$$

$$f_Q = \frac{1}{S} * (f_y[\Delta X] - f_x[\Delta Y]) = 0$$

$$f_L = \frac{1}{S} * (f_y[\Delta Y] + f_x[\Delta X]) = -7.6 \text{ cm}$$

$$V_{yi} = \frac{-[\Delta Y]}{\Sigma S} * S_{i(m)}; \quad V_{xi} = \frac{-[\Delta X]}{\Sigma S} * S_{i(m)}$$

$$V_{y1} = -0.01 \text{ m}$$

$$V_{y2} = -0.02 \text{ m}$$

$$V_{y3} = -0.02 \text{ m}$$

$$V_{y4} = -0.02 \text{ m}$$

$$V_{x1} = 0.00$$

$$V_{x2} = -0.01 \text{ m}$$

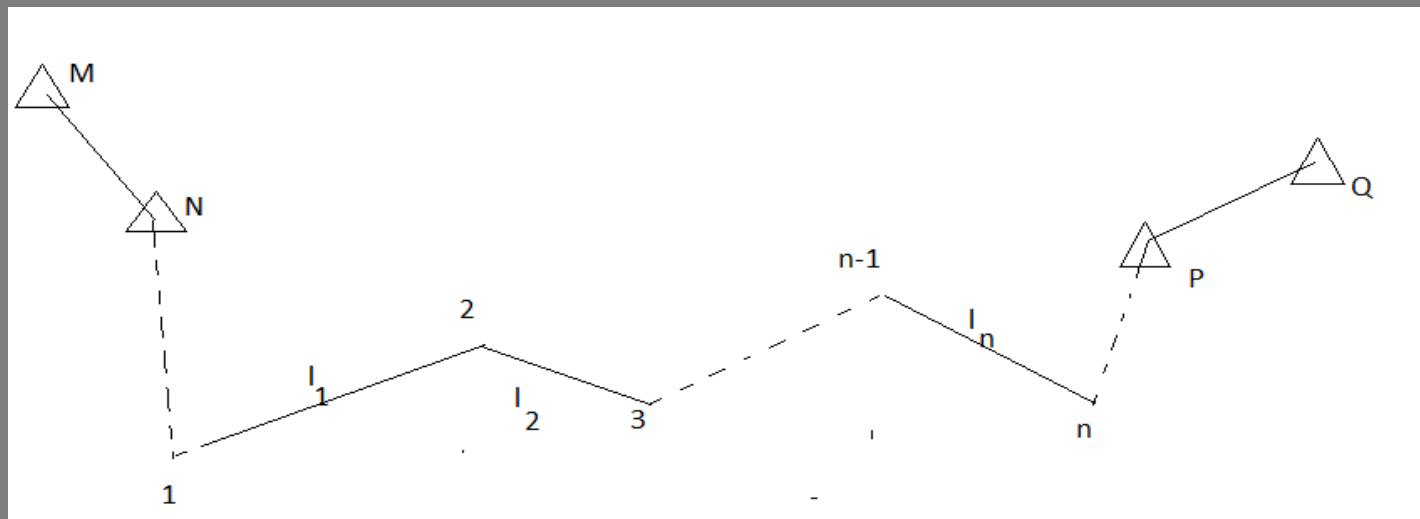
$$V_{x3} = -0.01 \text{ m}$$

$$V_{x4} = -0.01 \text{ m}$$

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Balancing Traverse Angles:



Firstly, azimuth of MN traverse side and azimuth of PQ traverse side must be calculated. Az_{MN} and Az_{PQ} are calculated.

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Balancing Traverse Angles:

Angular condition:

$$t_{PQ} = t_{MN} + \Sigma\beta - m.200^g$$

- m= the number of station with starting and end points.

Angular misclosure:

$$f_{\beta} = (t_{MN} + \Sigma\beta - m.200^g) - t_{PQ}$$

Maximum Angular Misclosure:

The maximum angular misclosure of a traverse angles is calculated by below formula in respect of Production Regulation of Large Scale Map standards.

$$F_B = 1.5^c \sqrt{n}$$

n= number of the traverse angles

TRAVERSE COMPUTATION

Closed-Link Traverse Computation:

Control of angle misclosure error:

If the angle misclosure (f_β) < the maximum angle misclosure (F_β)
It can be accepted and measured traverse angles can be balanced.

The correction for each angle is found by dividing the total angular misclosure by the number of angles in respect of Production Regulation of Large Scale Map standards.

$$v_i = - (f_\beta) / n$$

Adjusted traverse angles :

$$\beta'_i = \beta_1 + v_\beta$$

TRAVERSE COMPUTATION

Closed-Link Traverse Computation:

Computation of Azimuths:

After the balancing the traverse angles, the next step in closed-link traverse computation is calculation of either azimuths.

Azimuths are calculated by using balanced (adjusted) traverse angles.

$$t_{BC} = t_{AB} + \beta_B + n * 200^{grad}$$

$$t_{AB} + \beta_B = K$$

$$K < 200^g ; K + 200^g ; t_{BC} = t_{AB} + \beta_B + 200^g$$

$$200^g < K < 600^g ; K - 200^g ; t_{BC} = t_{AB} + \beta_B - 200^g$$

$$K > 600^g ; K - 600^g ; t_{BC} = t_{AB} + \beta_B - 600^g$$

TRAVERSE COMPUTATION

Closed-Link Traverse Computation:

Computation of Azimuths:

$$t_{23} = t_{12} + \beta'_2 \pm k.200^g$$

$$t_{34} = t_{23} + \beta'_3 \pm k.200^g$$

$$t_{45} = t_{34} + \beta'_4 \pm k.200^g$$

.....

$$t_{n(n+1)} = t_{n-1(n)} + \beta'_n \pm k.200^g$$

Control of Computation Azimuth:

$$t_{PQ} = t_{MN} + \Sigma\beta' - m.200^g$$

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Computation Departure (ΔY) and Latitudes (ΔX) :

After balancing the angles and calculating azimuths for each line, traverse closure is checked by computing (ΔY), (ΔX) of each lines.

$$\Delta Y = S_{AB} \cdot \sin t_{AB}$$

$$\Delta X = S_{AB} \cdot \cos t_{AB}$$

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

$$(Y_P - Y_N) = \Sigma \Delta Y$$

$$(X_P - X_N) = \Sigma \Delta X$$

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Computation of Traverse Coordinate Misclosure :

$$f_y = (Y_P - Y_N) - \sum \Delta Y$$

$$f_x = (X_P - X_N) - \sum \Delta X$$

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

$$F_{Q[m]} = 0.05 + 0.15\sqrt{S_{[km]}}$$

$$F_{L[m]} = 0.05 + 0.04\sqrt{n - 1}$$

F_Q = limit of latitude error

F_L = limit of departure error

f_Q = error of latitude

f_L = error of departure

$S_{[km]}$ = total length of traverse sides

$$f_Q = \frac{1}{S} (f_y [\Delta X] - f_x [\Delta Y])$$

$$f_L = \frac{1}{S} (f_y [\Delta Y] + f_x [\Delta X])$$

$$S = \sqrt{[\Delta Y]^2 + [\Delta X]^2}$$

n = number of stations

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Departure (ΔY) and Latitude (ΔX) Closure Conditions :

It should be;

$$F_Q > f_Q$$

$$F_L > f_L$$

it can be accepted and the departures and latitudes of traverse courses can be adjusted in proportion to their lengths.

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Correction in departure for AB:

$$= \frac{f_y}{\text{traverse perimeter}} \times \text{length of AB}$$

Correction in latitude for AB:

$$= \frac{f_x}{\text{traverse perimeter}} \times \text{length of AB}$$

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Computation of adjusted ΔY and ΔX :

$$\Delta y'_i = \Delta y_i + V_{y_i}$$

$$\Delta x'_i = \Delta x_i + V_{x_i}$$

$$\Sigma \Delta y' = (Y_P - Y_N)$$

$$\Sigma \Delta x' = (X_P - X_N)$$

TRAVERSE COMPUTATION

Closed Link Traverse Computation:

Computation of Coordinates:

- $Y_B = Y_A + \Delta Y' = Y_A + S_{AB} \sin t_{AB}$
- $X_B = X_A + \Delta X' = X_A + S_{AB} \cos t_{AB}$
- $Y_i = Y_{i-1} + \Delta y'_{i-1}$
- $X_i = X_{i-1} + \Delta x'_{i-1}$

Controls of Coordinates:

- $Y_P = Y_N + \Sigma \Delta y'$
- $X_P = X_N + \Sigma \Delta x'$

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