GEE 4812: Principles of Geomatics

Multiple Point Positioning

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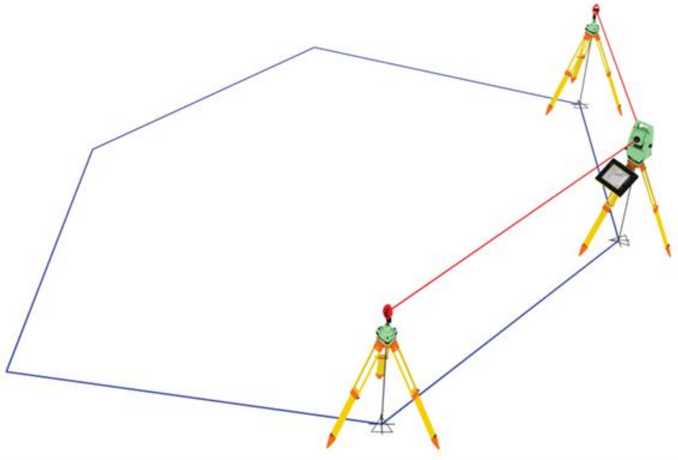
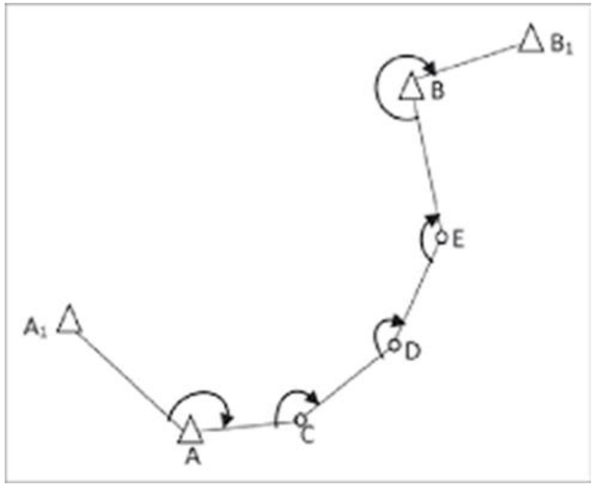
Traversing





Introduction

- Traversing is one of many multiple point positioning methods.
- Traversing is used to establish a network of control points (Reference marks).
- Traverse computations are cumulative in nature, starting from a fixed point or known line, and all of the other directions or positions determined from this reference.

Introduction

- Generally, traversing involves the measurement of the following parameters:

  1. The length of each survey line.
  2. The angle between the successive survey lines or the bearings of the lines.

- The measurement of the directions of the lines is usually done by means of an angle measuring device such as theodolite and the length is measured with the help of tape.
- The co-ordinates of the first established station, as well as the bearing of the first line, are determined, then, the co-ordinates of all the successive stations are computed.

Types of Traverses

- There are two categories of traverses.

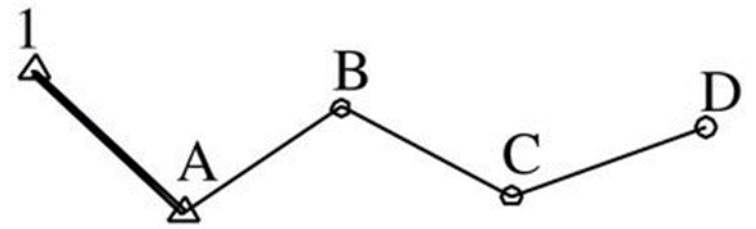
- Depending on the way the network starts and ends, it can be either:

1. open

2. closed

Open Traverse

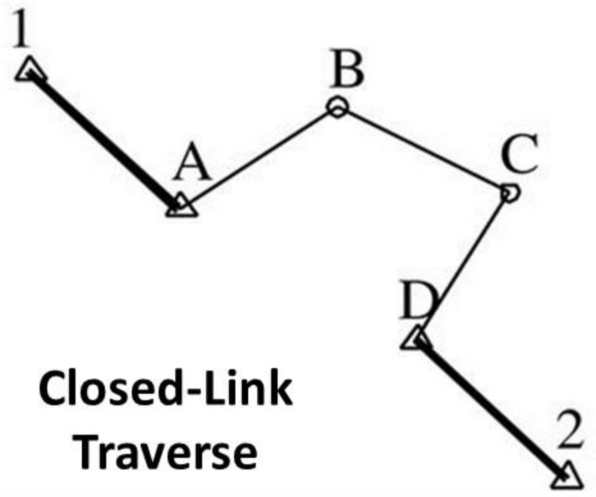
- This type of traverse network starts at known points and ends on unknown point.
- These type of traverses are used in exceptional circumstances since there is no external check on the measurements.
- However, open traverses are used mainly in tunneling work where the physical situation prevents closure on known points

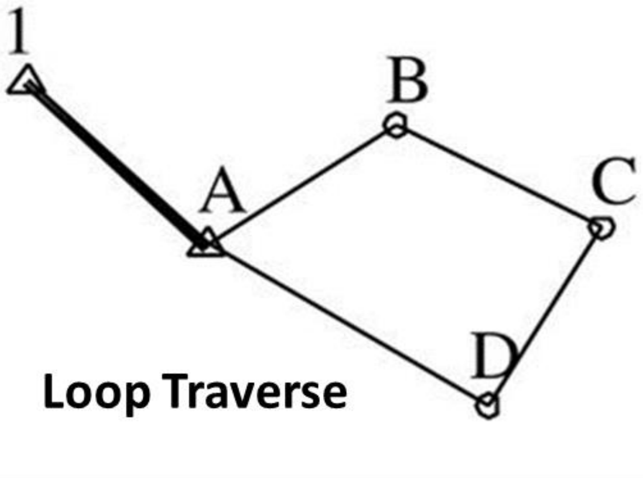


Open-Link Traverse

Closed Traverse

- A closed traverse network is one, which starts and ends on the known points.
- There are two types of closed traverses: a closed link traverse and a loop traverse.





Angular Computations

- If angles are measured within a traverse, they need to be converted to bearings in order to be used in the traverse computation.
- Before the bearings are computed, the measured angles are checked for consistency and to detect any blunders.

Angular Computations

- For a loop before any coordinate calculations can commence, the angles or bearings measured have to be adjusted.
- This is done by comparing the sum of the measured angles to the expected value (computed) or the measured final bearing to the expected (computed from coordinates).

Angular Computations

- For closed loop traverses, a check can be applied to ensure that the measured angles can meet the required specifications.
- For a closed loop traverse with n internal angles, the check that is used is:

90° (2 n – 4) for internal angles
90° (2 n + 4) for external angles, where n = number of the sides of the polygon.

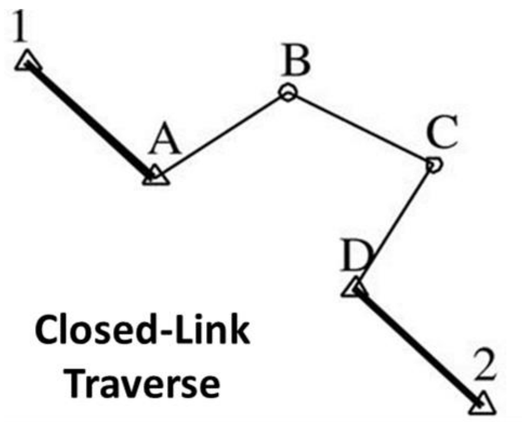
- The difference from between the two i.e. the summed up angles and the computed from the formula above is the **angular misclosure**.

Angular Computations

- In angular measurements, the allowable misclosure = $\pm\ \varepsilon''(\mathbf{n})^{1/2}$ where ε is the estimated standard deviation of observing the angles and n is the number of instrument set ups (stations).
- If the angular misclosure is higher than the allowable misclosure then the traverse has to be repeated.
- For a closed link traverse, the measured angles or bearings are also prone to measurement errors and thus have to be checked.

Angular Computations

- In the case of bearing, the forward bearing of end points (A and D) is compared with the measured bearing of the same points (A and D).
- For angle measurements, the starting bearing of the control points (1 and A) is added to the measured angles and the resulting end bearing is compared as explained earlier.



Sum of measured angles = (final forward bearing – initial back bearing) ± (n-1) 180°

Where n is the number of the measured angles *and n is +ve if the n is even and –ve if n is odd.*

Angular Adjustment

- The distribution or adjustment of the angular misclosure is done equally since each angle is measured in the same manner and there is an equal chance of the misclosure having occurred in any of the angles.

$$\text{Correction per station} = -(\text{angular misclosure}/\ n)$$

Errors in Angular Measurements

- There are various sources of errors that are common in angular measurements:

1. Inaccurate centering of the theodolites or targets
2. Non verticality of targets (Hint: sight the bottom part of the target if you can)
3. Inaccurate bisection of the target
4. Lateral refraction, wind and atmospheric effects
5. Theodolite not level and not in adjustment when measuring angles
6. Incorrect use of the theodolite
7. Mistakes in reading and booking

Computation of the Coordinate differences (Partials)

$$\Delta Y_{i,i+1} = d_{i,i+1} Sin\,\theta_{i,i+1}$$

$$\Delta X_{i,i+1} = d_{i,i+1} Cos\,\theta_{i,i+1}$$

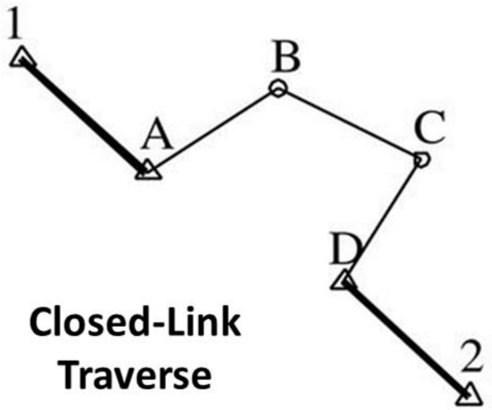
- Having adjusted and computed the bearings, then the partials for each individual legs can be computed in combination with projected horizontal distances.

Where i = 1, 2 …n, instrument station points

Computation of the Coordinate differences (Partials)

- In an ideal situation, the sum of the shifts (partials) in Y and X coordinates should equal to zero in the case of a closed loop traverse since you are coming back to the same point.

- And in the case of a closed link traverse the sum of the partials in both Y and X should equal the difference in coordinates between the start and the end points, i.e for closed link traverses.



$$\sum \Delta Y = Y_D - Y_A$$
$$\sum \Delta X = X_D - X_A$$

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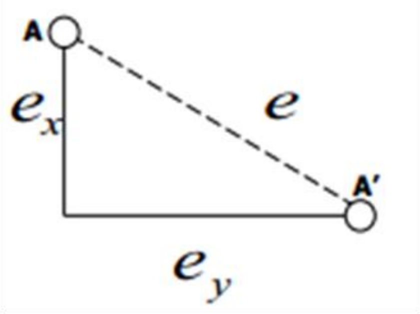
Linear Misclosure

- However, due to the errors in the measured distances of the traverse and angles, there will always be a disparity on arrival at the closing point.



- The resultant displacement AA’ (e) is known as the linear misclosure and it is given by

$$e = \left(e_y^2 + e_x^2\right)^{1/2}$$

Linear Adjustments

- During the computation of the traverse, it becomes necessary to balance the traverse because of the different errors that may persist during the field measurement.
- Thus, there are a number of methods that can be used for adjusting such traverse.
- We shall focus on Bowditch Method

Linear Adjustments (Bowditch Method)

- Traverse adjustments are based on the assumptions that the errors in the linear measurements are directly proportional to the length of the traverse leg.
- In this method of balancing, the total error in latitude (ΔX) and in the departure (ΔY) is distributed in proportion to the length of the sides.

Linear Adjustments (Bowditch Method)

- In this method, the values of the adjustment are directly proportional to the length of the individual traverse lines (legs).

Correction (δY_i) $= \dfrac{-e_y}{\sum_{i=1}^{n} d_i} * d_i = K_y d_i$

Correction (δX_i) $= \dfrac{-e_x}{\sum_{i=1}^{n} d_i} * d_i = K_x d_i$

Where $\delta X_i, \delta X_i$ the coordinate (partial) correction in Y and X

e_y, e_x the partial misclosure in Y and X coordinates - constant

d_i the horizontal distance of the ith traverse leg

$\sum_{i=1}^{n} d_i$ sum of the distances (total length of the traverse) - constant

K_y, K_X the resulting constants.

Traverse specifications and Accuracy

- The standard of accuracy should, according to the Zambian Regulations, be

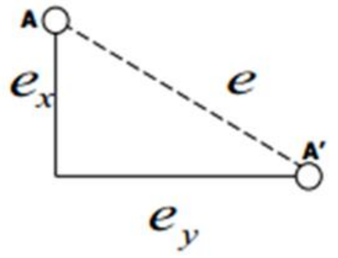
Class	Relative Accuracy	Specifications
Class A	1/12,000	Reference marks, township control
Class B	1/8,000	Township surveys
Class C	1/4, 000	Surveys not included in A and B (Farm surveys, etc.)

- Generally, the accuracy of the traverse is judged on basis of the resultant closure of the traverse.
- This resultant closure is a function of the accuracies in the measurement of angles and distances and hence varies with the length of the traverse.

Traverse specifications and Accuracy

$$\textbf{RELATIVE ACURACY} = \frac{1}{\sum d / e}$$

$$\frac{\left(e_y^2 + e_x^2\right)^{\frac{1}{2}}}{\sum d} = \frac{e}{\sum d}$$



Where e_y is the misclosure in the Y partial between end control points.

e_x is the misclosure in the X partial between end control points.

d_i is the distances of the individual traverse legs.

Traverse Computation

- The final coordinates of the traverse points are obtained by adding or subtracting the adjusted partials, working round the traverse.
- For the polygon (closed loop) traverse, the final and the initial coordinates should be the same as these represent the same point and for the closed link traverse, the final coordinates should equal those of the last known station in the traverse.
- If in both cases the expected in not achieved, it should be due to arithmetic errors or rounding off errors.

Traverse Computation Steps

1. Obtain the angular misclosure, by comparing the sum of the observed angles with the sum of error-free angles in a geometrically correct figure.
2. Assess the acceptability or otherwise of the angular misclosure.
3. If the angular misclosure is acceptable, distribute it throughout the traverse in equal amounts to each angle.
4. From the corrected angles compute the whole circle bearing of the traverse lines relative to AB.

Traverse Computation Steps

5. Compute the partials (ΔY, ΔX) of each traverse line.

6. Assess the coordinate misclosure (e_y, e_x) i.e linear misclosure.

7. Balance the traverse by distributing the linear misclosure throughout the traverse lines. (Bowditch method)

8. Compute the final coordinates (Y, X) of each point in the traverse relative to A, using the adjusted values of ΔY and ΔX per line.

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