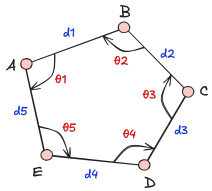
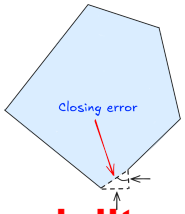




CE331 Lab 5 : Traverse by Digital Theodolite

Aman Kumar Singh
Teaching Assistant
Department of Civil Engineering
Indian Institute of Technology Kanpur

Objective

Lab Exercise 5 : Traverse using Digital Theodolite

- Establish a closed traverse using a digital theodolite
- Adjust closing error using Bowditch's rule

Equipment

- Total Station as Digital Theodolite
- Leveling Staff
- Pegs
- Tape
- Compass

Traversing: Why?

- Map Making

Courtesy: SimDaaS Autonomy



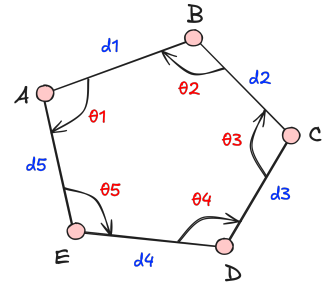

Traversing: What and How?

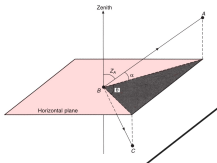
Traverse

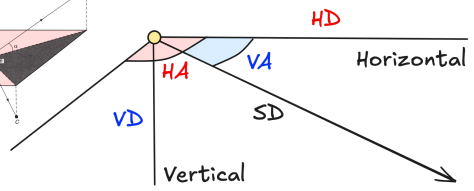
- Control established using measured distances and angles
- Framework of connected lines
- Traverse Measurements
  - Angles
  - Distance
- Theodolite: Measures horizontal and vertical angles
- EDMI: Measures distances

Types of Traversing

- Open Traverse : can't apply checks
- Closed Traverse : can apply checks

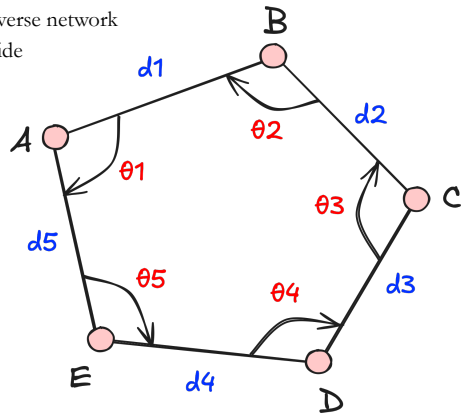






Basic Measurements for Traversing

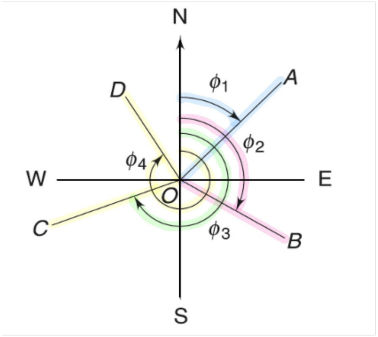
- **Angles**
  - Measure internal or external angles of a polygon traverse network
  - Measure WCB from North using compass for one side
- Distances
  - Measure sides of polygon



Bearing Systems

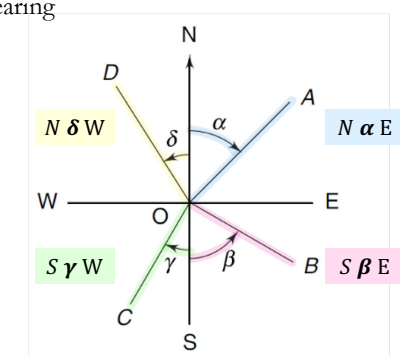
Whole Circle Bearing (WCB)

- Measurement from North in a clockwise direction (0° to 360°)
- Azimuth



Reduced/Quadrantal Bearing (RB/QB)

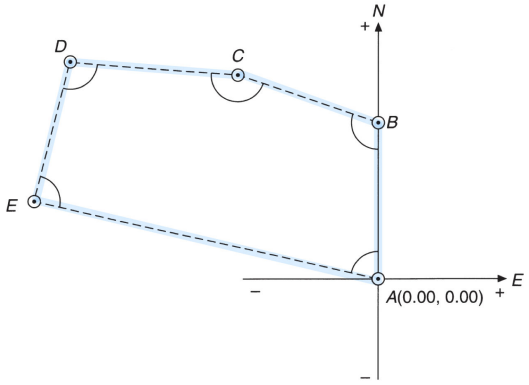
- Measurement from North or South, in either direction (0° to 90°).
- Bearing

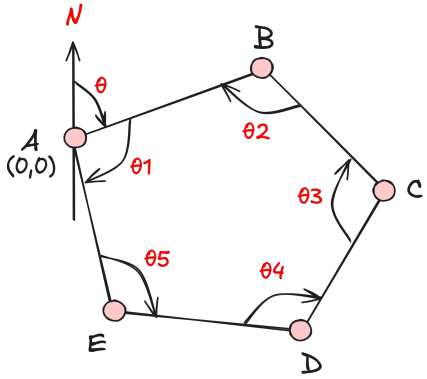


WCB Calculation

Whole Circle Bearing (WCB)

- Use Compass to measure Northing.





Face Left (FL) and Face Right (FR) Observations

Face Left (FL) Observation

- Vertical circle is on the left side of the observer.
- Total Station's "+" sign faces right during observation.

Face Right (FR) Observation

- Vertical circle is on the right side of the observer.
- Total Station's "+" sign faces left during observation.

Switching between FL and FR

- Rotate the theodolite telescope 180° in azimuth.

Observation Table for Recording Angles

I.S	Station Observed	Face (L/R)	Horizontal Angle		
			Reading	Corrected Angle	Mean
A	B	L	0° 0′ 0″		
	E		θ_1		
	B'				
	Error				
	B	R	180° 0′ 0″		
	E		θ_1		
	B'				
	Error				
B	C	L	0° 0′ 0″		
	A		θ_2		
	C'				
	Error				
	C	R	180° 0′ 0″		
	A		θ_2		
	C'				
	Error				

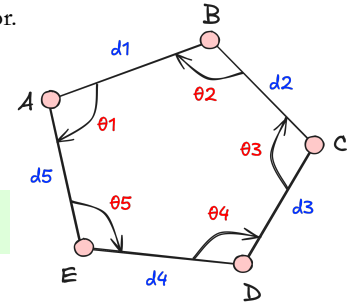
and so on …

Angle Misclosure and Adjustment

Angle Misclosure

- Sum of interior angles of a closed polygon should ideally be $\sum = (n-2)180°$
- It will deviate from the theoretical sum due to random error.

$$Angle\ Misclosure = \sum\theta_i - (n-2)180°$$



Bowditch's Rule for Angle Adjustment

- Correction to internal angle i

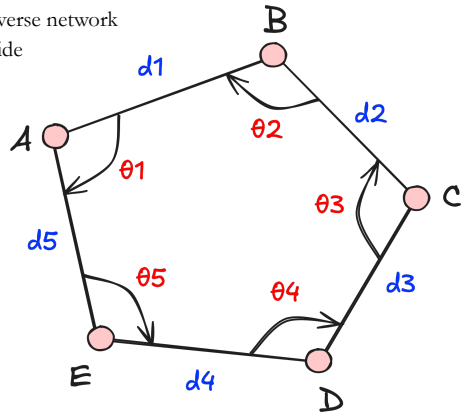
$$Correction\ (C_i) = \frac{\theta_i}{\sum\theta_i} \cdot M = \frac{Internal\ angle\ of\ station\ i}{Sum\ of\ internal\ angles} \cdot \text{Misclosure}$$

$$Corrected\ Angle = Measured\ Angle\ - Correction$$

We can also measure external angles instead of internal, with their sum ideally being $\sum = (n+2)180°$

Basic Measurements for Traversing

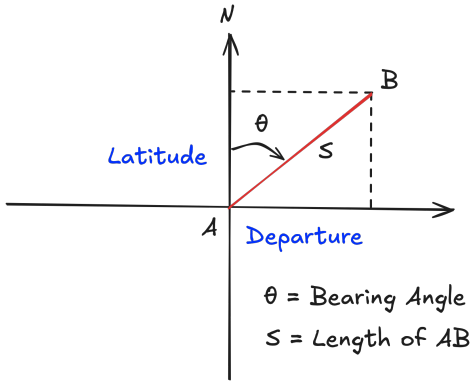
- Angles
  - Measure internal or external angles of a polygon traverse network
  - Measure WCB from North using compass for one side
- **Distances**
  - Measure sides of polygon

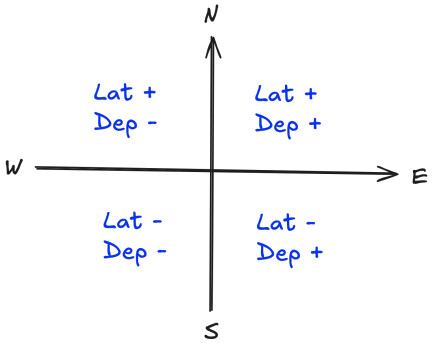


Latitude and Departure

$$Latitude\ (L)\ or\ Northing\ (N)\ = S\cos\theta$$

$$Departure\ (D)\ or\ Easting\ (E) = S\sin\theta$$





Gales Traverse Table

- All traverse computations are tabulated in **Gale's Traverse Table**.

Line	WCB	RB	Length (m)	Latitude			Departure		
				Calculated	Correction	Corrected	Calculated	Correction	Corrected
AB	296° 00' 00"	N 64° 00' 00" W	40	17.53	-1.73	19.26	-35.95	0.23	19.26
BC	321° 45' 32"	N 38° 14' 28" W	32	25.13	-1.39	26.52	-19.81	0.18	26.52
CD	66° 32' 19"	N 66° 32' 19" E	35.05	13.95	-1.52	15.47	32.15	0.20	15.47
DE	120° 43' 42"	S 59° 16' 18" E	30.8	-15.74	-1.34	-14.40	26.48	0.18	-14.40
EA	182° 05' 31"	S 2° 05' 31" W	49	-48.97	-2.12	-46.85	-1.79	0.28	-46.85
Σ			186.85	-8.1	-8.1	0	1.08	1.08	0

Distance Misclosure

- Total Latitude and Departure Misclosure

$$Total\ Latitude\ Misclosure = \sum L$$

$$Total\ Departure\ Misclosure = \sum D$$

- Linear Misclosure or Closing Error

$$Closing\ Error = \sqrt{\sum L^2 + \sum D^2}$$

- Direction of Closing Error

$$tan\theta = \frac{\sum D}{\sum L}$$

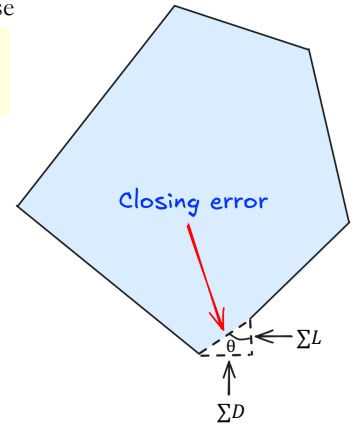
- Relative Precision

$$Relative\ Precision = \frac{Closing\ Error}{Traverse\ Perimeter}$$

- Ideal Case

$$\sum L = 0$$

$$\sum D = 0$$



Traverse Adjustment

Bowditch's Rule

- Correction to Latitude of side i

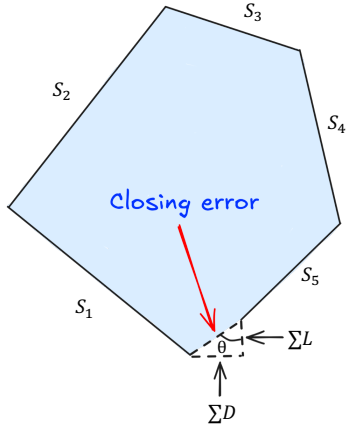
$$C_{L_i} = \frac{S_i}{\sum S_i} \cdot \sum L = \frac{Length\ of\ that\ side}{Traverse\ Perimeter} \cdot (\text{Total latitude misclosure})$$

$$Corrected\ Latitude = Measured\ Latitude\ - Correction$$

- Correction to Departure of side i

$$C_{D_i} = \frac{S_i}{\sum S_i} \cdot \sum D = \frac{Length\ of\ that\ side}{Traverse\ Perimeter} \cdot (\text{Total departure misclosure})$$

$$Corrected\ Departure = Measured\ Departure\ - Correction$$



This method is suitable where linear and angular measurements are done with equal precision.

Quality of Traverse

Quality of Traverse for Angles

- Tolerance for Angle Misclosure

$$Tolerance\ ('') = c\sqrt{n}$$

Quality of Work	Permissible limit of closing error
First Order	$6\sqrt{n}$ "
Second Order	$15\sqrt{n}$ "
Third Order	$30\sqrt{n}$ "

$n = no.\ of\ stations$

Quality of Traverse for Distances

- Tolerance for Relative Precision

$$Tolerance\ (e/p) = 1:X$$

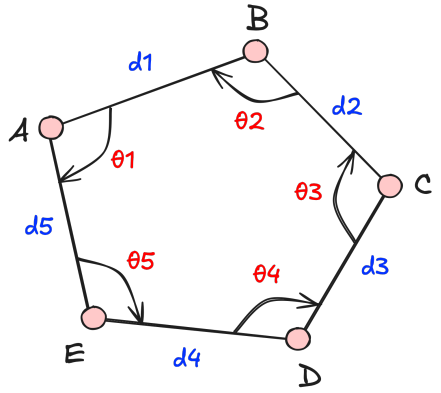
Quality of Work	Permissible limit of relative precision
First Order	1:25000
Second Order	1:10000
Third Order	1:5000

Procedure

- Initial Settings:
  - Perform initial settings as per the instrument manual for the digital theodolite with a plumb bob.
- Station Setup:
  - Select 5 stations forming a braced quadrilateral with sides 40-50m long.
  - Each group sets up the instrument at one station only.
- Measure Distances:
  - Determine the length of each side using tape and tacheometry before instrument setup.
- Equipment Adjustment:
  - Carry out temporary adjustments: centering and leveling.
- Record Angles:
  - At each station, record all angles (horizontal and vertical).
  - Each group records both face right and face left observations.
  - Close the horizon and apply station adjustments.
  - Each group should use different "ZERO" or initial readings.

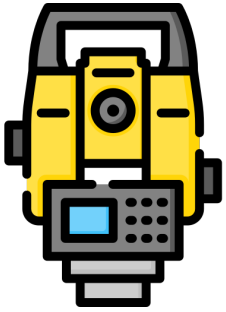
Procedure

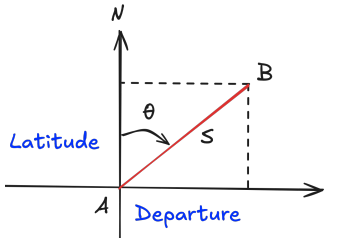
- Move to Next Station:
  - After recording, move to the next station.
  - **Do not move the instrument**.
  - Use the instrument setup by the previous group; repeat angle measurements.
- Error Adjustment:
  - Adjust closing errors using Bowditch's rule. Refer to Gales Traverse Table.

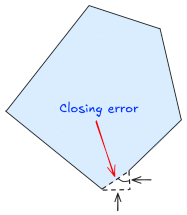


Deliverables

- Detailed Report with figures and equations
- Observation Table for angles and distances
- Traverse Adjustments for angles and distances
- Closing Error calculations for angles and distances
- Quality of Traverse for angles and distances







Courtesy: Schofield & Breach; Ghilani & Wolf.

Thank you

Comments and Questions?
Email: amanks20@iitk.ac.in