

1 Introduction to Surveying

What is Surveying?

Surveying is the art and science of determining the relative position of points on, above or below the surface of the earth and representing them on a map or plan.



Measure Today
Plan Tomorrow

Objectives

- To prepare plans and maps
- To provide data for design and construction
- To set out works on ground
- To determine areas and volumes
- To monitor deformations

Classification

By extent : Plane / Geodetic

By purpose : Topographic / Cadastral Engineering

By method : Chain, Compass, Theodolite, Plane Table, Photogrammetry, GPS

"Good surveying is the foundation of good engineering"

2 Basic Terms & Units

Important Terms

- Station : A point on ground
- Survey line : Line joining two stations
- Bearing : Direction of a line w.r.t. meridian
- Level : A horizontal line
- Datum : Reference level
- Reduced Level (RL) : Elevation of a point
- Contour : Line joining points of equal RL
- Bench Mark (BM) : Fixed point with known RL

Units of Measurement

Quantity	Unit	Symbol	Conversion
Length	metre	m	1 m = 100 cm
	Kilometre	km	1 km = 1000 m
Area	hectare	ha	1 ha = 10,000 m ²
Angle	degree	°	1° = 60'
Time	second	s	1° = 3600°

Scales

Representative Fraction (RF) = $\frac{\text{Drawing distance}}{\text{Ground distance}}$

- Common scales:
- 1:500, 1:1000, 1:2000, 1:5000

Types of Errors

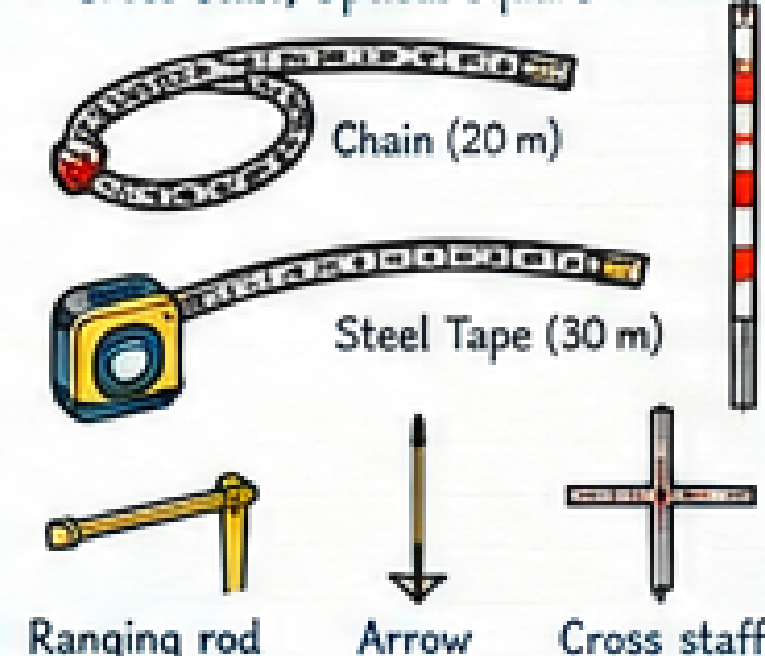
- Gross errors – blunders
- Systematic errors – instrument, environmental
- Random errors – unpredictable

"Accuracy in measurement leads to confidence in design"

3 Chain & Tape Surveying

Instruments

- Chain (20 m, 30 m)
- Steel tape, Linen tape
- Ranging rods
- Arrows, wooden pegs
- Cross staff, Optical square



Ranging

To locate points in a straight line.



Chaining

- Measure horizontal distance between stations
- Keep tape horizontal and taut
- Take care of slope, temperature, pull

Offset types

- Perpendicular, Oblique, Tie line

Obstacles

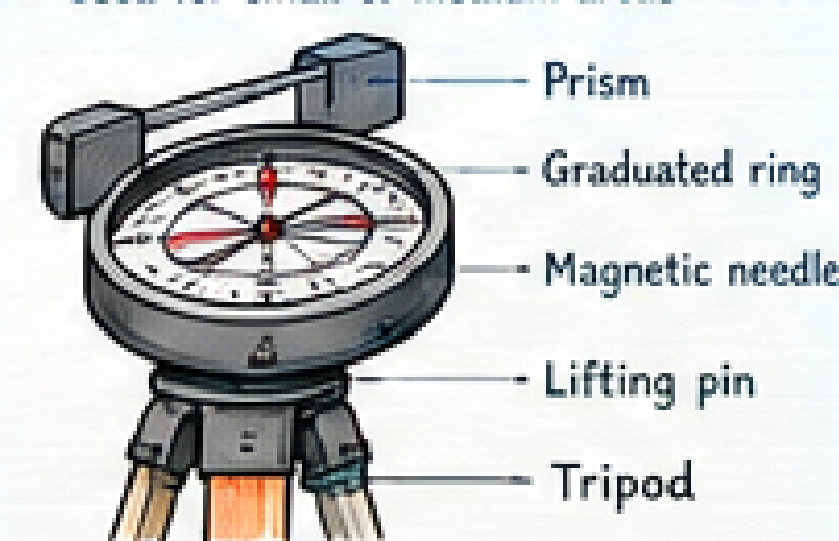
- Across river, hill, building – use indirect methods

"Measure carefully, mark clearly"

4 Compass Surveying

Types of Compass

- Prismatic Compass – graduated ring attached to magnetic needle (whole circle bearing)
- Surveyor's Compass – quadrantal bearing
- Used for small to medium areas



Prismatic Compass

Bearings

- Whole Circle Bearing (WCB) : 0° – 360°
- Quadrantal Bearing (QB) : 0° – 90° (N, S, E, W)
- Conversion :

QB	WCB
N θ E	θ
S θ E	180° – θ
S θ W	180° + θ
N θ W	360° – θ

Local Attraction

- Causes error in bearing
- Check by FB and BB
- Apply corrections

"Magnetic directions guide the way"

5 Levelling

What is Levelling?

Levelling is the process of determining the relative elevation of points with respect to a datum.

Instruments

- Dumpy level, Auto level, Tilting level
- Levelling staff
- Tripod



Methods of Levelling

- Height of Instrument (HI) method
- Rise and Fall method
- Profile levelling
- Cross-section levelling
- Reciprocal levelling

Important Formulae

- HI = RL + BS
- RL = HI – FS
- Rise = Next RL – Current RL (if +ve)
- Fall = Current RL – Next RL (if +ve)

Terms

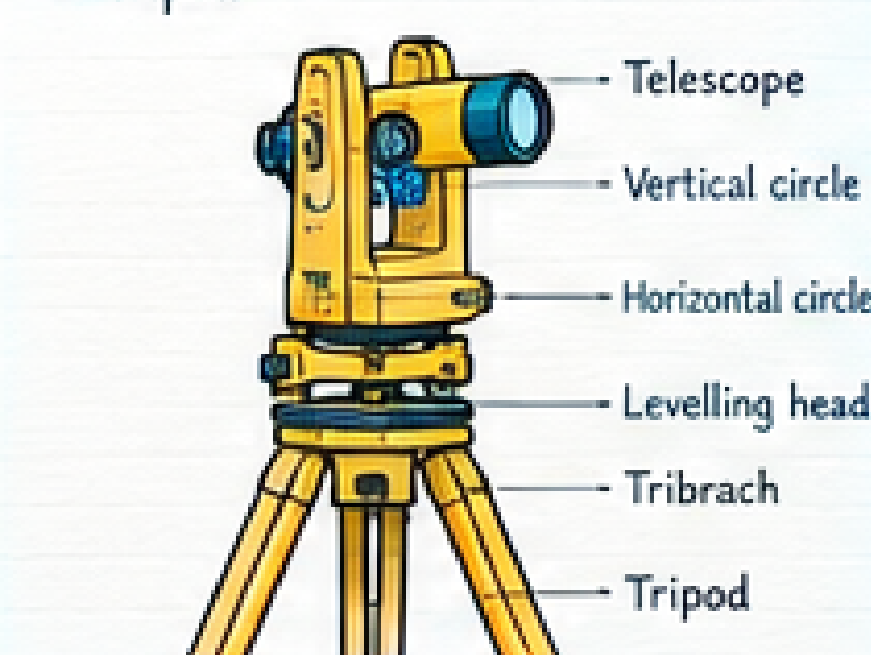
- Back Sight (BS)
- Fore Sight (FS)
- Intermediate Sight (IS)
- Change Point (BM)
- Reduced Level (RL)

"Find the level, build the future"

6 Theodolite Surveying

Parts of Theodolite

- Telescope
- Horizontal circle
- Vertical circle
- Upper & lower plates
- Levelling head
- Tripod



Important Adjustments

- Setting up
- Levelling
- Focusing
- Elimination of parallax
- Collimation
- Trunnion axis horizontal
- Vertical circle index

Measurements

- Horizontal angles – by repetition/reiteration method
- Vertical angles – for tacheometry and trigonometric levelling

"Precision angles for accurate positions"

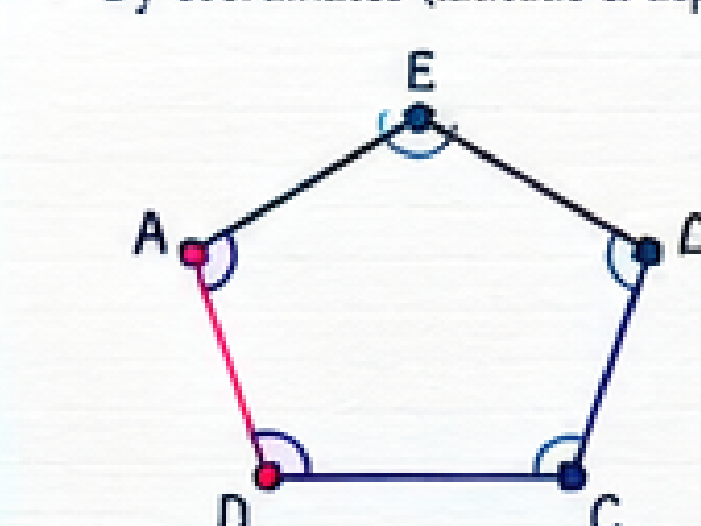
7 Traversing

Types

- Open traverse – does not return to start
- Closed traverse – returns to start
- Link traverse – connects two fixed points

Methods of Traversing

- By included angles
- By bearings (WCB or QB)
- By coordinates (latitude & departure)



Latitude & Departure

- Latitude = L cos θ (N +ve, S -ve)
- Departure = L sin θ (E +ve, W -ve)

Closing Error

$$\text{Linear error} = \sqrt{(\sum \text{Lat})^2 + (\sum \text{Dep})^2}$$

$$\text{Relative error} = \frac{\text{Linear error}}{\text{Perimeter}}$$

Adjustment Methods

- Bowditch (Compass) rule
- Transit rule

"A closed traverse builds confidence"

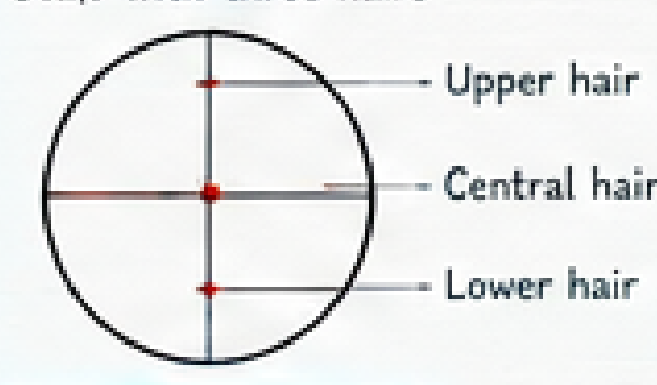
8 Tacheometry

What is Tacheometry?

A rapid method of surveying in which distances and elevations are determined indirectly by angular measurements using a theodolite and stadia staff.

Stadia System

Staff with three hairs



Stadia Constants

Multiplying constant (K) = 100
Additive constant (C) = 0 (for anallactic lens)

Distance Formula

D = K s + C = 100 s (horizontal sight)

For inclined sight

Horizontal distance, H = K s cos² θ + C cos θ
Vertical difference, V = H tan θ

"Distance without chaining – speed with accuracy"

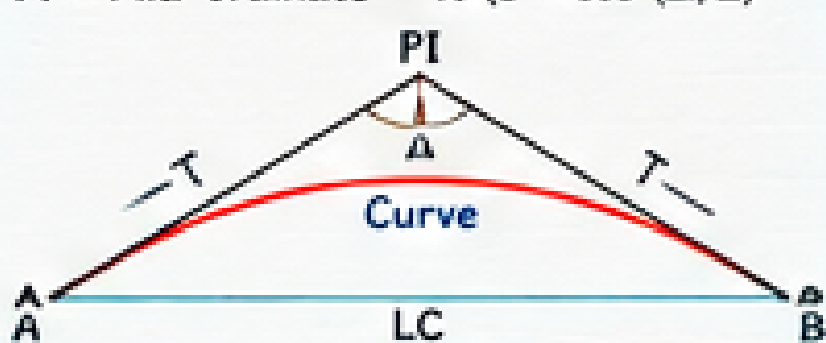
9 Curves

Types of Curves

- Simple circular curve
- Compound curve
- Reverse curve
- Transition curve

Elements of a Simple Circular Curve

R = Radius of curve
Δ = Deflection angle
T = Tangent length = R tan (Δ/2)
L = Length of curve = π R Δ / 180
LC = Long chord = 2 R sin (Δ/2)
E = External distance = R (sec (Δ/2) – 1)
M = Mid-ordinate = R (1 – cos (Δ/2))



Setting Out Methods

- Offsets from chord
- Deflection angle method

"Curves connect destinations"

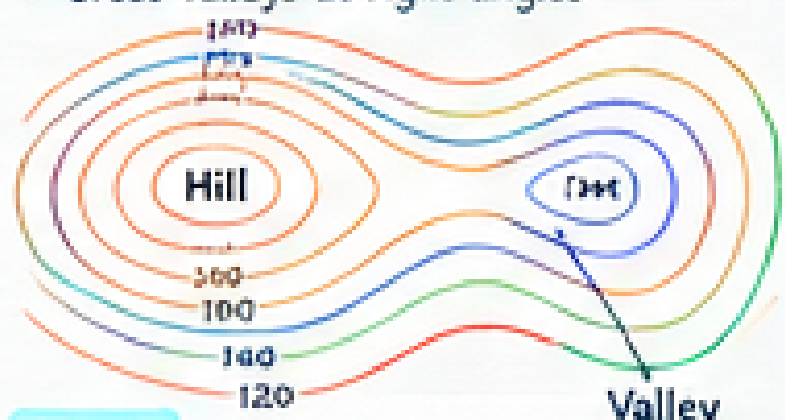
10 Contouring

What is a Contour?

A contour is a line joining points of equal elevation on the ground surface.

Characteristics

- Closed lines
- Do not intersect
- Equal vertical interval
- Spacing indicates slope
- Perpendicular to direction of steepest slope
- Cross valleys at right angles



Uses

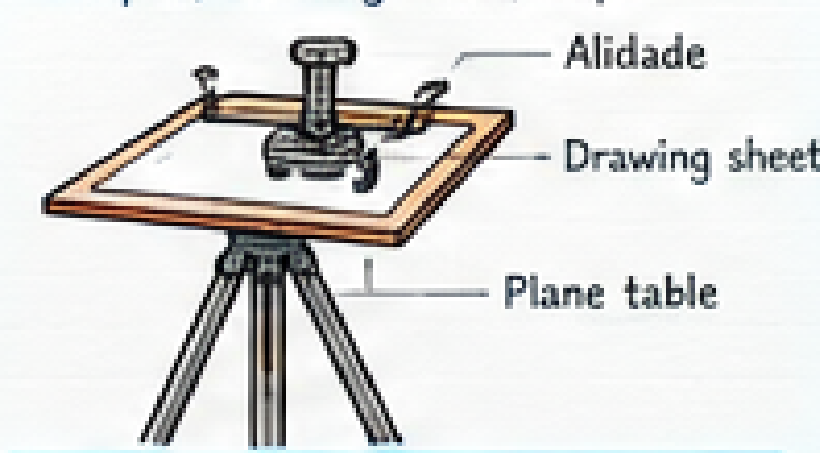
- To show relief and shape of ground
- In planning and design of roads, dams
- To estimate earthwork
- In site selection and drainage design

"Contours show the shape of the land"

11 Plane Table Surveying

Instruments

- Plane table, Alidade, Spirit level
- Tripod, Drawing sheet, Clips



Methods of Plane Table Surveying

- Radiation – points from single station
- Intersection – fix a point by two stations
- Traversing – combination of above
- Resection – fix station by known points

Advantages

- Simple and inexpensive
- Field work and plotting done together
- Useful for small and medium areas

Limitations

- Less accurate
- Affected by weather
- Not suitable for large areas

"See it on the ground, draw it on the table"

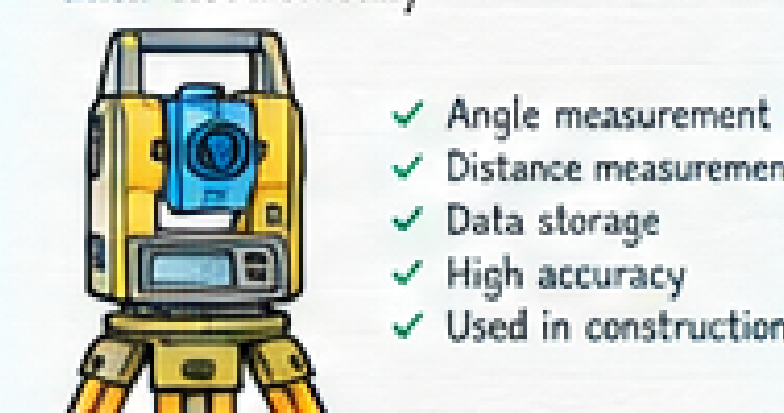
12 Modern Surveying

Electronic Distance Measurement (EDM)

- Uses electromagnetic waves (IR, laser)
- Measures distance quickly and accurately
- Examples: Total Station, Distomat

Total Station

- Combines theodolite and EDM
- Measures angles, distances and records data electronically



GPS / GNSS

- Satellite based positioning
- Used for large scale and control surveys
- Types: GPS, GLONASS, Galileo, BeiDou
- Provides 3D coordinates (X, Y, Z)

Applications

- Topographic mapping
- GIS and remote sensing
- Construction layout
- Monitoring of structures and deformations

"Modern technology, greater possibilities"

13 Area & Volume Computation

Area Computation Methods

- From chain survey (trapezoidal rule)
- From coordinates (shoelace formula)
- From planimeter
- From GIS / CAD data

Trapezoidal Rule

$$A = d \left(\frac{y_0 + y_n}{2} + \sum y \right)$$

d = spacing of ordinates
y = offsets

Volume of Earthwork

- Average end area method
- Trapezoidal formula

$$V = \frac{L}{6} (A_1 + 4A_m + A_2)$$

$$V = \frac{L}{3} (A_1 + 4A_2 + A_3)$$

where, A = cross-sectional area,
L = interval length

"Calculate today, construct tomorrow"

14 Applications & Conclusion

Applications in Civil Engineering

- Site selection and feasibility studies
- Planning and design of roads, railways
- Layout of buildings, bridges and dams
- Estimation of earthwork quantities
- Inspection and monitoring of structures
- Urban planning and GIS
- Resource management and environmental studies

Career Opportunities

- Government (PWD, Survey of India, etc.)
- Private construction companies
- Mining and hydro projects
- GIS and remote sensing sector
- Research and academia



"Surveying shapes a better, brighter future"