7th Oct,
TUESDAY

2. LINEAR MEASUREMENTS

1. Direct Method : Chain or tape.
2. Optical Method : EDM

EDMs are classified as:

(i) Light Waves – Geodimeter, Mekametor & Range Finder

(ii) Microwaves – Distomat, Decca navigator, Lambda Omega, Telurometer etc.

3. Approximate Methods:
   a) Pacing : 75 cm to 95 cm
   b) Pasometer : gives the no. of foot steps covered.
   c) Pedometer
   d) Perambulator / Odometer
   e) Speedometer

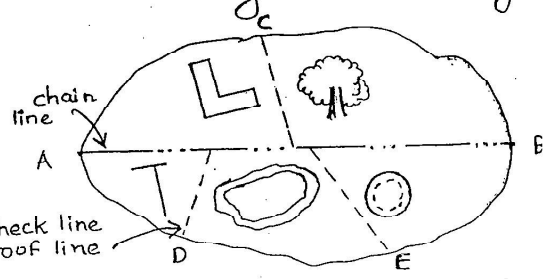
→ Chain Survey

→ Principle

(i) Triangulation.

Baseline : Longest line laid approximately through middle of field. It is a chain connecting main survey stations.

Offsets : lateral distances measured from chain line (base line) to objects.



Offsets are of two types:

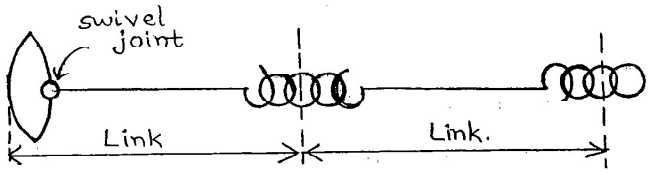
(i) $\perp^{r}$ offset.

(ii) Oblique offset.

→ Instruments for Chain Surveying

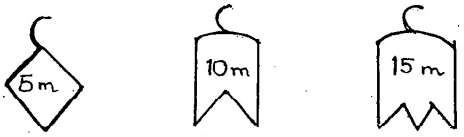
(i) Chains
(ii) Tape
(iii) Ranging rods.
(iv) Arrows.
(v) Offset Rod.
(vi) Cross Staff
(vii) Plumb bob
(viii) Wooden Peg
(ix) Plasterers, laths & whites.

→ Chain (metric)

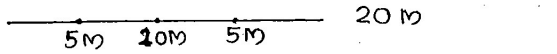


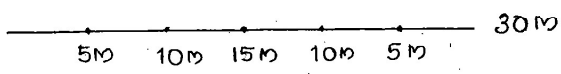
In metric chain, link = 0.2 m
= 20 cm

- Brass rings are provided every 1 m
- Tallies are provided for every 5 m.



Tallies	5 M	10 M	15 M
20 M	2	1	0
30 M	2	2	1





- Standard temp : 20°C
  Allowable pull : 8 kg
- 20 m ⟹ ±5mm
  30 m ⟹ ±8mm

→ Types of Chains

(i) Metric Chain : 20 M, 30 M

(ii) Gunter's chain : 66 ft, 100 links (Surveyor's chain)

(iii) Revenue Chain : 33 ft, 16 links

(iv) Engineer's chain : 100 ft, 100 links.

→ Sources of Errors

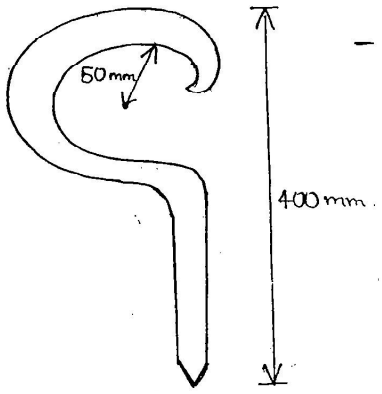
→ Tapes :

- Least count : 1 mm.
- Types of tapes :-
  - (i) Cloth or linen tape :- 10 m, 15 m, 20 m, 30 m
  - (ii) Metallic tape : Survey works, construction works
  - (iii) Steel tape : 2 m, 5 m, 10 m, 15 m, 20 m, 30 m, 50 m)
  - (iv) Invar tape : steel (64%) & nickel (36%)

Invar tape is used for baseline measurements.

$$\alpha = 1.2 \times 10^{-6}/^{\circ}C \implies \alpha = \frac{1}{10}\alpha_s$$

→ Arrows :



- At the end of every chain length, an arrow is fixed.

→ Ranging Rods :

- purpose of ranging rods is to range a line.
- they are available at 2m & 3m length

→ Offset Rod :

- maximum length is 5m.

→ Cross Staff:

(i) Open Type – 90°

(ii) French type – 45° & 90°

(iii) Adjustable ± @ 15° interval

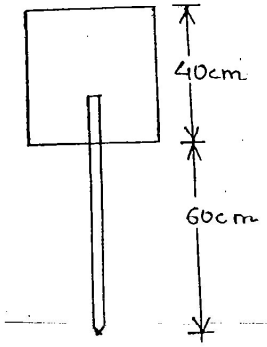
→ Plumb bob:

To check the verticality of ranging rods, cross staff e

→ Wooden Pegs:

To mark the terminal stations

→ Plasterers Lath's & whites



– used to mark the intermediate station in an open level ground online with a base line.

→ Ranging out Survey Lines:

– Ranging is required when the length of a line to be measured is greater than the chain length

– methods of ranging:

(i) Direct Ranging: It is possible when two stations are intervisible.

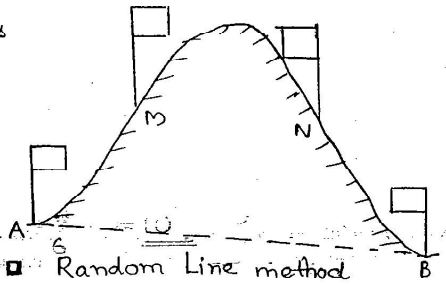
a) By eye judgement

b) By using Line Ranger

(ii) Indirect Ranging / Reciprocal Ranging:

– when stations are not intervisible.

Random Line method is used to establish intermediate stations by reciprocal ranging.



Random Line method

→ Error due to Incorrect Chain

– When chain is too long, measured distance is less, error is -ve correction is +ve.

– If chain is too short, measured distance is more, error is +ve correction is -ve.

⊙ Correction to length / Corrected length } , $l = l'\left(\frac{L'}{L}\right)$

where l' → measured length
L' → incorrect length of a chain
L → true / designated length of a chain.

$$L' = L + \Delta L$$

$$\frac{L'}{L} = \frac{L+\Delta L}{L} = 1 + \frac{\Delta L}{L}$$

$$\Rightarrow 1 + \frac{\Delta L}{L} = e \quad ; \; e \rightarrow \text{error}$$

$$\boxed{l = l'(1+e)}$$

Corrected area, $A = A'\left(\frac{L'}{L}\right)^2$

$$\boxed{A = A'(1+2e)}$$

Corrected volume, $V = V'\left(\frac{L'}{L}\right)^3$

$$\boxed{V = V'(1+3e)}$$

Case (i): zero at begin & 'e' at end.

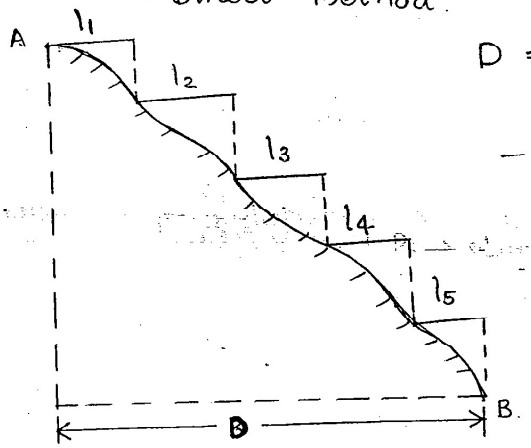
$$e_{avg} = \frac{0+e}{2} = \frac{e}{2}$$

Case (ii): e_1 at beginning & e_2 at end.

$$e_{avg} = \frac{e_1 + e_2}{2}$$

→ Chaining on Uneven / Sloping Ground:

(i) Direct Method.

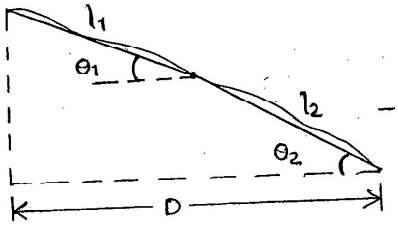


$$D = \sum_{i=1}^{n} l_i$$

– measuring down the hill is easier than up the hill.

(ii) Indirect Method.

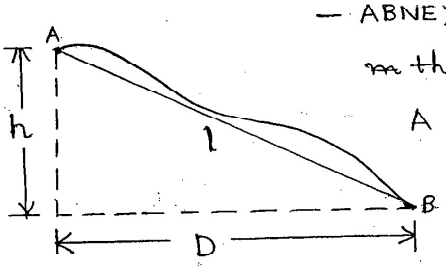
a)



– Clinometer is used to measure the angles.

– $D = \sum_{i=1}^{n} l\cos\theta$

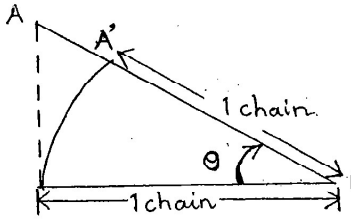
b)



– ABNEY level is used to measure the level difference b/w A & B.

$$D = \sqrt{l^2 - h^2}$$

c) Hypotenusal Allowance



It is the correction to be applied in the field at every chain length and every point, where the slope changes

This facilitates in locating & surveying the intermedia points.

Hypotenusal Allowance, $AA' = AB - BA'$

$$\cos\theta = \frac{BC}{AB} = \frac{100 \text{ links}}{AB}.$$

$$\therefore AB = 100 \sec\theta \text{ link}.$$

$$\therefore AA' = (100 \sec\theta - 100) \text{ links} = 100 (\sec\theta - 1) \text{ links}.$$

AA' is the correction for 1 chain ($= 20m = 100$ links).
This can be extended to any length.

$$\Rightarrow AA' = 100 \left(1 + \frac{\theta^2}{2} + \cdots - 1\right)$$

$$\therefore AA' = 50\,\theta^2 \text{ links.} \quad (\theta \text{ radians})$$
$$= 0.015\,\theta^2 \text{ links} \quad (\theta \text{ degrees})$$

⊙ When slope is given as 1 in n ($\theta \approx \tan\theta \approx \frac{1}{n}$)

$$AA' = \frac{50}{n^2} \text{ links.} = \frac{50}{n^2} \times 0.02 \text{ m}.$$

NOTE:

For 30 m chain, $AA' = 150 (\sec\theta - 1)$ links.
$= 75\,\theta^2$ links; (θ radians)

→ Errors in Chaining:

(i) Cumulative Errors

Cumulative error is the one which occurs in the same direction and get accumulate.

(ii) Compensating Errors

Compensating error may occur in either direction and tends to compensate.

1. Erraneous Length of a Chain/tape: cumulative '±'
2. Bad Ranging cumulative '+'
3. Careless holding & marking compensating '±'

4. Bad straightening. Non horizantality & Sag in Chains. } Cumulative '+'

5. Variation in temp : cumulative '±'

6. Variation in pull : Cumulative '±'

1st Nov, SATURDAY

TAPE CORRECTIONS

1. Correction for Standardisation

$$C_a = \frac{L \cdot C}{l}$$

$L \rightarrow$ measured length of a line.

$C \rightarrow$ correction for tape length.

$l \rightarrow$ designated length of a tape.

$C_a \rightarrow$ +ve if tape or chain is too long

$C_a \rightarrow$ −ve if tape or chain is too short.

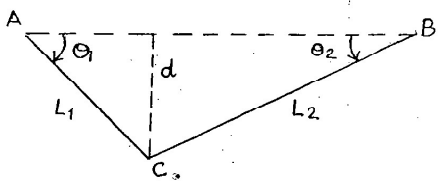
2. Correction for Slope

$$C_{SL} = L - \sqrt{L^2 - h^2} = \frac{h^2}{2L}$$

$$C_{SL} = L - L\cos\theta = L(1-\cos\theta) = 2L' \sin^2\left(\frac{\theta}{2}\right)$$

C_{SL} is always −ve.

3. Correction for misalignment.



$$C_{MA} = \frac{d^2}{2L_1} + \frac{d^2}{2L_2}$$

$$C_{MA} = L_1(1-\cos\theta_1) + L_2(1-\cos\theta_2) \quad \{C_{MA} \text{ is always } -ve\}$$

4. Correction for temperature

$$C_t = L \alpha (T_m - T_0)$$

where $T_m \rightarrow$ temperature during measurement.

$T_o \rightarrow$ standard temperature.

C_t is +ve $(T_m > T_o)$ & C_t is −ve $(T_m < T_o)$

5. Correction for Pull.

$$C_p = \frac{(P - P_o) * L}{AE}$$

C_p is +ve $(P > P_o)$

C_p is −ve $(P < P_o)$

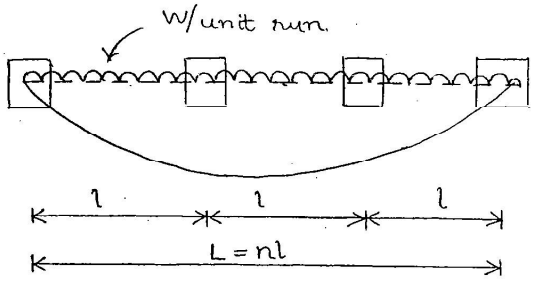
$P_o \rightarrow$ standard pull.

$E \rightarrow$ Young's modulus of tape ($= 2 \times 10^5$ MPa if not given)

$A \rightarrow$ c/s area of tape

$P \rightarrow$ pull applied during measurement.

6. Correction for Sag.



n = no. of bays.

(i) If both the supports are at same level.

$$C_{sag} = \frac{(wl)^2 l}{24 P^2} \quad ; \text{ for length 'l'}$$

$$= \left(\frac{(wl)^2 l}{24 P^2}\right) * n \quad ; \text{ for 'n' no. of bays.}$$

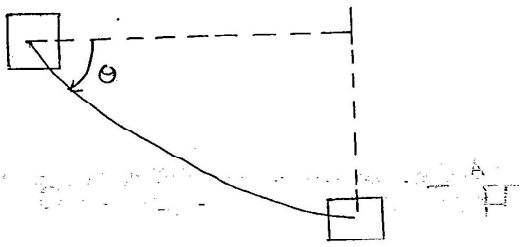
$$= \frac{w^2 \left(\frac{L}{n}\right)^2 L}{24 P^2} = \frac{(wL)^2 L}{24 n^2 P^2} \quad ; \text{ for length 'L'}$$

$$= \frac{W^2 L}{24 n^2 P^2}$$

$W = wL$ = weight of tape

Correction for sag is always −ve

(ii) If ends are at different level.



$$C'_{sag} = C_{sag} * \cos^2\theta.$$

7. Correction for normal tension.

$$P_n = \frac{0.204 \, w \sqrt{AE}}{\sqrt{P_n - P_o}}$$

where $P_n \rightarrow$ normal tension.

$P_o \rightarrow$ standard pull.

$w \rightarrow$ total weight of tape

$A \rightarrow$ c/s area of tape

$E \rightarrow$ young's modulus of material of tape.

8. Correction for Mean Sea Level.

$$C_{MSL} = \frac{Lh}{R}$$

where $L \rightarrow$ length of a tape.

$h \rightarrow$ height of object above or below MSL

$R \rightarrow$ radius of curvature of earth. (= 6370 km).

$C_{MSL} \rightarrow +ve$; if object lies above MSL

$C_{MSL} \rightarrow -ve$; if object lies below MSL

→ Limiting Length of Offset

The min. length of an offset in plotting is 0.25 mm

The length of offset on ground depends on scale value that we are using.

1 mm → 100 mm

0.25 mm → 25 mm.

Eg: 1) Scale 1 : 100.

Length of offset on ground = 25 mm

2) Scale 1 : 500

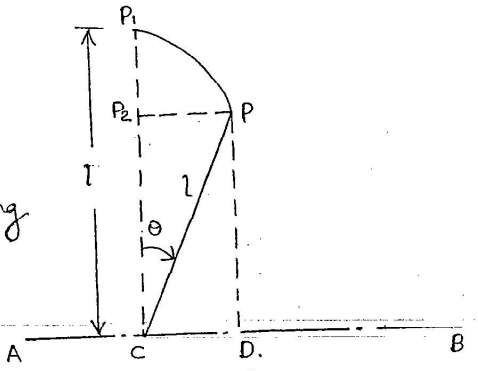
Length of offset on ground = 125 mm.

Let the scale of a map be

1 cm = 'S' m.

Degree of accuracy in limiting the length of an offset

= 1 in r



- Displacement of point P parallel to the chain line = PP_2

$$PP_2 = l \sin\theta.$$

$$= \frac{l \sin\theta}{S} \text{ cm}$$

$$\frac{l \sin\theta}{S} = 0.025$$

ie limiting length of an offset, $l = 0.025\, S\, \text{cosec}\,\theta$.

$$\boxed{l = 0.025 * S * \text{cosec}\,\theta}$$

- Displacement of point P perpendicular to chain line

$= P_1P_2$

$$P_1P_2 = l - l\cos\theta$$

$$= \frac{l(1-\cos\theta)}{S}$$

$$\therefore \boxed{P_1P_2 = \frac{l(1-\cos\theta)}{S}}$$

Degree of accuracy can be calculated from,

$$\boxed{r = \text{cosec}\,\theta.}$$

Limiting length of an offset by considering both linear and angular displacements,

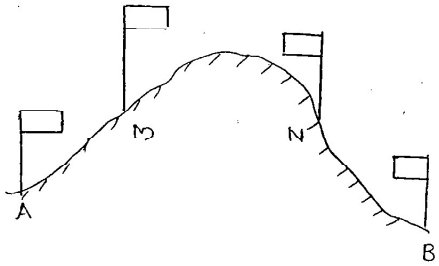
$$\boxed{l = \frac{S.r}{40\sqrt{2}}}$$

→ Instruments for setting Perpendicular Offsets.

1. Cross-staff : 90° only.
2. Optical square : 90° only.
3. Prism square : 45° & 90° only
4. Side square : 90° only.

→ Obstacles in Chain Surveying

1. Obstacle to Ranging but not chaining

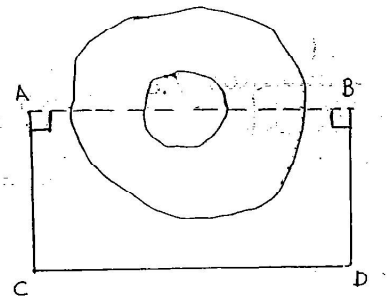


Eg: Hill.

2. Obstacle to Chaining but not Ranging

Eg: Pond, river.

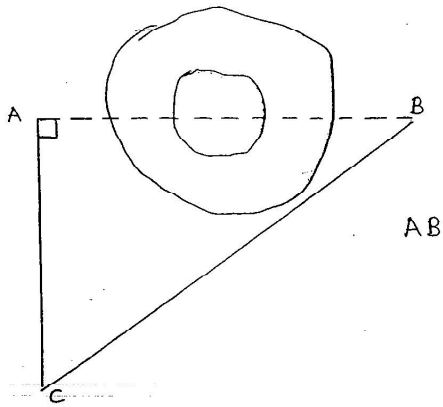
(i)



$BD = AC$

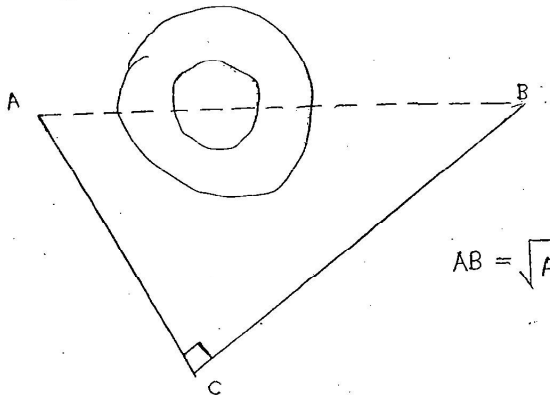
$\therefore AB = CD.$

(ii)



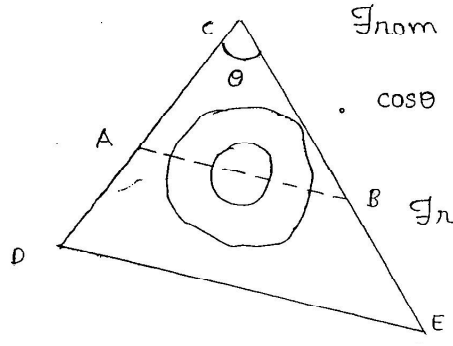
$$AB = \sqrt{BC^2 - AC^2}$$

(iii)



$$AB = \sqrt{AC^2 + BC^2}$$

(iv)



From triangle DCE,

$$\cos\theta = \frac{CD^2 + CE^2 - DE^2}{2 * CD * CE} \rightarrow (1)$$

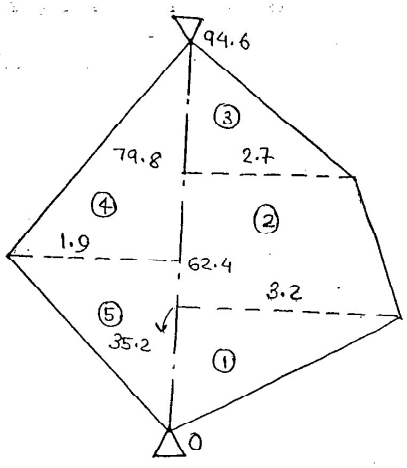
From triangle ACB,

$$\cos\theta = \frac{CA^2 + CB^2 - AB^2}{2 * CA * CB} \rightarrow (2)$$

Equating ① & ②, find AB.

→ Cross - staff Survey

It is done to locate the boundaries of field and also to be calculate the area.



$A_1 = \frac{1}{2} \times 35.2 \times 3.2 = 56.32\ m^2$

$A_2 = \frac{1}{2}(79.8 - 35.2)(3.2 + 2.7) = 131.57\ m^2$

$A_3 = \frac{1}{2}(94.6 - 79.8)(2.7) = 19.98\ m^2$

$A_4 = \frac{1}{2}(94.6 - 62.4)(1.9) = 30.59\ m^2$

$A_5 = \frac{1}{2}(62.4)(1.9) = 59.28\ m^2$

Total area, $A = A_1 + A_2 + A_3 + A_4 + A_5$

$= 297.74\ m^2$

07. Correction for temperature, $C_t = L\alpha(T_m - T_o)$

$= 20 \times (6 \times 10^{-6}) \times (30 - 55)$.

$= -0.003\ m$

11. $L' = \frac{20.10 + 20.30}{2} = 20.2\ m$

$A = A'\left(\frac{L'}{L}\right)^2 = 32.56\left(\frac{20.2}{20}\right)^2 = 33.21\ cm^2$

$10\ cm = 8\ m \Rightarrow 1\ cm = 0.8\ m.$

$33.21\ cm^2 = 33.21 \times 0.8 \times 0.8$

$= 21.256\ m^2$

12 With 20m chain :

$$\text{Corrected distance} = 1200 \times \frac{20.1}{20} = 1206 \text{ m}$$

With 25 m chain :

$$1206 = 1212 \times \frac{L'}{25}$$

$$\Rightarrow L' = \underline{24.88 \text{ m}}$$

13. $W = \gamma V = (7.86 \times 0.08 \times 3000) \times 10^{-3}$.

$= 1.8864$ kg.

Correction for sag, $C_{sag} = \frac{W^2 L}{24 n^2 P^2} = \frac{1.886^2 \times 30}{24 \times 3^2 \times 10^2}$

$= 0.0049$ m.

C_{sag} is always negative.

$\therefore C_{sag} = -0.0049$ m

15. Degree of accuracy, $r = \text{cosec}\,\theta$

$= \text{cosec}\ 1°30'$

$= 38.25$.

DA = 1 in r

= 1 in 38.25 ($\simeq$ 1 in 39).

16. $l = \frac{S.r}{40\sqrt{2}} = \frac{20 \times 40}{40\sqrt{2}} = \underline{14.14 \text{ m}}$

S : 1 cm = 20 m

r : 1 in 40.

20 $1\,mm = 1000\,mm$

$0.1\,mm = 100\,mm$

$\therefore 0.1\,mm = 0.1\,m$

P-8

19 $\tan\theta = \frac{1}{20}$

$\therefore \theta = 2.86^{\circ}$

$\cos\theta = 0.998$

Correction for slope, $C_{SL} = L(1-\cos\theta)$

$= 60(1-0.998) = 0.075\,m$

$= 7.5\,cm$