UNIT-4

"LINEAR MEASURMENT"

Grounds पर दो point के मध्य Horizontal distance measure करने कि Process linear measurment कहलाता है, इसके लिए निम्न method उपयोग मे लाये जाते है।

1. Direct Mearsurment (chain tape)
2. Measurment by optical measurment(Techeometer survey, Triangulation survey)
3. Electromagnatic Waves (Radio waves, light waves, infrared waves)

1. **Direct Measurment -** Following methods are used in direct measurment-
   (i) Pacing
   (ii) Passometer
   (iii) Padometer
   (iv) Odometer
   (v) Speedometr
   (vi) Chain & Tape

(i) **Pacing -** इस method में दो points मे मध्य चले गए कदमों कि संख्या ज्ञात कर ली जाती है, उसके बाद एक कदम मे चली गई दूरी के Average से Multiply करके Total distance ज्ञात कर ली जाती है।

(ii) **Passometer**- यह instrument घडी कि size के जैसा होता है, जिसे पैर पर बांध दिया जाता है, और इस पर चले गये कदमों की संख्या अंकित हो जाती है।

(iii) **Padometer** - यह instrument भी passometer कि तरह होता है, लेकिन इस instrument पर कदमों के द्वारा चली गई दूरी सीधे ही अंकित हो जाती है।

(iv) **Odometer** - इस instrument को Adjustment vehical के पहियों के साथ attach कर दिया जाता है और पहियों के द्वारा चले गए चक्रों की संख्या इस पर अंकित हो जाती है।

(v) **Speedometer**- आजकल सभी Automobile vehical में speedometer use किया जाता है, और इसके उपर पहियों के द्वारा सीधे ही चली गई दूरी Mention हो जाती है।

(vi) **Chain/Tape** - Chain/Tape का use भी Linear measurment के लिए किए जाता है-
Chain - it is classified in different types-
   (a) Meter chain
   (b) Engineering Chain
   (c) Gunter chain and surveyer chain
   (d) Revenue chain

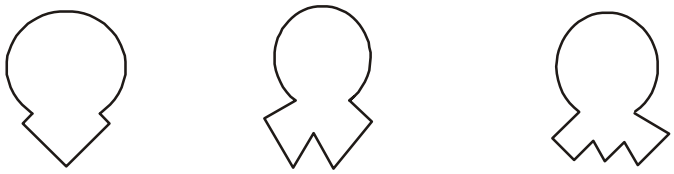
(a) **Meter chain** - Meter chain 5, 10, 20, 30 mtr. length में उपलब्ध होती है, normally 20 and 30 mtr. वाली chain उपयोग मे लायी जाती है।

	20 mtr. chain	30 mtr. chain
1.	No. of link = 100	No. of link = 150

2. length of one link = $\frac{20}{100}$ = 0.2 mtr = 20 cm

   length of one link = $\frac{20}{150}$ = 0.20 mtr. = 20 cm

3. No. of link in one (every) mtr. chain = 5



5m 10 m 15m

→ 5 मीटर और 10 मीटर चैन में Permeter length पर (every meter length of chain) talles लगा दी जाती है।

→ 20 m or 30 m chain मे every 5m length पर tallies provide कर दी जाती है।

→ 20 m or 30 m chain में permeter length पर small brass rings are provided.

	5m & 10m chain	20m & 30m chain
Tallies	Permtr. Length of chain	Per 5mtr. Length of chain
Small Brass ring	-	Permtr. Length of chain

(b) **Engineering chain -**
Length of chain = 100 feet
Nos of Link = 100 Link

Length of one link = $\frac{100}{100}$ = 1 feet

Engineering chain में every 10 link पर brass tag are provided.

(c) **Gunter chain** - It is also knwon as surveyer chain.
Length of chain = 66 feet
No.s of link = 100 link

Length of one link = $\frac{66}{100}$ = 0.66 feet (7.92 inch)

Linear Measurment

- 10 Gunter chain = 1 Furlongs
  10 X 66 = 660 Feet = 1 Furlongs

- 80 Gunter chain = 1 Mile
  80 X 66 = 5280 Feet = 1 Mile

$\frac{5280}{3.28}$ = 1609.75 1610 mtr. = 1 Mile

- 10 X square of Gunter chain = 1 Acre
  $10X(66)^2$ = 1 Acre
  43560 sq. feet = 1 Acre

(d) **Revenue chain -**

Length of chain = 33 Feet

No.s of link = 16 link

Length of one link = $\frac{33}{16} = 2\frac{1}{16}$

This chain is used in cadestral survey.

(अर्थात् भूमि सर्वेक्षण के लिए किया जाता है।)

Tape - It is classified in different types

(a) Cloth Tape

(b) Metallic Tape

(c) Steel Tape

(d) Invar Tape

(a) **Cloth Tape** - यह Tape made by cloth है, इसके द्वारा मापी गयी दूरियॉ बहुत ज्यादा शुद्ध नही होती है, इसलिए इनका उपयोग rough measurment कार्यो के लिए किया जाता है।

(b) Metallic Tape - This tape are made with cloth and thin wire. इस Tape में Thin wire के रूप में Brass, copper, Bronze का उपयोग किया जाता है। इस Tape के द्वारा measure कि गई distance cloth tape के compare में Accurate होती है।

(c) Steel Tape - This tape is made with steel. इसके द्वारा मापी गई दूरियॉ cloth tape or matallic tape के compare में ज्यादा accurate होती है, और survey works में ज्यादातर इसी tape का उपयोग किया जाता है।

(d) Invar Tape- This Tape is made of Mixture of (Nickel + steel)

Nickel $\rightarrow$ 36% + steel $\rightarrow$ 64%

- इस Tape के द्वारा मापी गई दूरी Highly Accurate होती है, इसलिए इस Tape का use survey Field में Base line measurment के लिए किया जाता है।
- Survey Field में सबसे लम्बी line Base line कहलाती है।

Invar Tape का Thermal coefficient steel tape के compare में 30 times कम होता है।

Thermal Coefficient $= \frac{1}{30} X$ *thermal coefficient of steel tape*

$= 0.0000005$

TESTING AND ADJUSTMENT OF CHAIN

Chain का Field में continuesly use करने से link में bend होने के कारण या ring के Flat होने के कारण chain कि लम्बाई standard से कम या ज्यादा हो जाती है, जिसको दोबारा से standard length की करने के लिए Adjustment किए जाते है।

chain कि standard length 8kg pull and 20^0 c temperture पर measured कि जाती है।

Tolerance of chain

Length of Chain	Tolerance
10 m chain	±3 mm
20m chain	±5 mm
30 m chain	±8 mm

CASE-I Adjustment of chain if it is Found longer than the standard length-
1. Closing the joints of ring
2. Re-shaping the elonginated rings.
3. Removing one or more circular ring

CASE-II Adjustment of chain if it is found shorter than the standard length-
1. Straightning (elongnated, flatness) of the ring.
2. Open the ends of link or ring
3. Adding one or more rings.

ERROR IN CHAINING

Chain survey करते समय errors को निम्न प्रकार से classified किया जाता है-
1. Accidential error (compansating error)
2. Systematic error (cumulative error)
3. Mistake error

1. **Accidental error**- ऐसी error जो survey field में एक ही direction में same sign में नही बडती हो अर्थात् इनका effect कभी positive कभी negative आता है is called compansating error. और यह error survey के लिए बहुत ज्यादा harmful नही होती है।
2. **Systematic error**- ऐसी error जो survey field में continuesly एक ही direction में same sign में बडती जाती है is called cumulative errror और यह errors survey के लिए बहुत ज्यादा Harmful होती है।
3. **Mistake error**- इस प्रकार की error confusion of mind, inexperience person, care-less, poor judgement etc. के कारण उत्पन्न होती है।

Example of Accidential/compansating error-
1. Variation in pull
2. Error in marking tape length

Example of systematic/cumulative error-
It is classified in 2 type-
1. Cummulative (+ve) error
2. Cummulative ($\pm$ ve) error

Example of cummulative (+ve) error-
(i) Bad Ranging
(ii) Error due to sag
(iii) Tape or chain are not streched tightly.

Note: इन errors के कारण correction always (-ve) होता है।

Example of cummulative ($\pm$ ve) error
(i) Incorrect length of Tape/Chain
(ii) Error due to temperature

Example of Mistake Error
Error in reading the tape due to confusion of surveyer

ERROR DUE TO INCORRECT CHAIN

Survey करते समय जब chain कि length standard से बडी या छोटी हो, तो मापी गयी दूरी सही नही आती है जिसे सही measure करने के लिए निम्नप्रकार से measure किया जाता है।

$$Actual\ distance = Measured\ distance\ X \frac{Incorrect\ length\ of\ tape/chain}{Standard\ length\ of\ tape/chain}$$

Q. The length of a line measured with a 20m chain was found to be 250m. Calculate the true lenghth of the line if the chain was 10cm too short and 10cm too long.

Sol. True length = $250\ X \frac{19.90}{20}$

True length = 248.75m

(ii) **If chain was 10 cm too long:-**

True length = $250\ X\ \frac{20.10}{20}$

True length = 251.25m

Q. The length of a survey line was measured with a 20m chain and was found to be equal to 1200m as a check the length was given measured with a 25m chain and was found to be 1212m on comparing the 20m chain with the test it was found to be 1 decimeter (10cm) too long. Find the actual length of 25 m chain.

Sol. For 20m chain True length

True length = $1200X \frac{20.10}{20}$

True length = 1206m

For 25cm chain incorrect length.

$1206 = 1212X \frac{Incorrect\ length\ of\ chain}{25}$

$\frac{1206X25}{1212}$ = Incorrect length of chain

Incorrect length of chain = 24.87m

Q. A 20m chain was found to be 10cm too long after chaining a distance of 1500m it was found to be 18 cm too long at the end of day work after chaining a total distance of 2900m. Find the true distance of a chain if the chain was correct before the commencement of work.

Sol. standard length of chain = 20m

Average error = $\frac{0+10}{2}$ = 5cm = 0.05

Incorrect length = 20+0.05 = 20.05m

For 1500m distance

True length = $1500\ X \frac{20.05}{20}$

True length = 1503.75m

For another 1400 m distance

Average error = $\frac{10+18}{2} = \frac{28}{2}$ = 14cm = 0.14m

True length = $1400\ X\ \frac{20.14}{20}$

True length = 1409.8m

Total true distance = 1503.75 + 1409.8
= 2913.55m

TAPE/CHAIN CORRECTION

जब दो Points में मध्य distance measured करते है बहुत types के error कि वजह से मापी गयी दूरियॉ सही नही आती है, जिसे correct करने के लिए निम्नलिखित correction किए जाते है-

(i) Correction For Absolute Length
(ii) Correction For temperature
(iii) Correction For Pull or tension
(iv) Correction For slope
(v) Correction For sag

(i) **Correction For Absolute length -**

$$C_a = \pm \frac{L.C}{l}$$

where

L = measured length
l = standard length of chain/tape
c = correction pertape length

Q. The Length of a line measured with a 20m chain was found to be 250m. Calculate the true length of the line if the chain was 10cm too short.

$\Rightarrow$ $C_a = \pm \frac{L.C}{l}$

L = 250m l = 20m c = 0.10m

$$C_a = \frac{250X0.10}{20}$$

C_a = -1.25m

(ii) **Correction For temperature**

$$C_t = \alpha\,(T_m - T_o)L$$

where,

α = Thermal co-effecient of expansion

T_m = Average temperature in field during measurment

T_o = Standard temperature during standerisation of chain/tape.

L = measured length

Case-I

If $T_m > T_o$ average field temperature is more than the standard temperature.

Correction $C_t = +ve$

effect or error = cummulative (-ve)

case-II

If averge field temperature is less than standared temperature

if $T_m < T_o$

correction $C_t = -ve$

effect or error = Cummulative(+ve)

(iii) **Correction For pull or tension:-**

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

where,

P = Applied pull in field

P_o = Standard pull

L= measured length

A = Cross-section Area fo tape

E = Young-modulus of tape

Case-I

If $P > P_o$

Applied pull > Standard pull

$C_p = +ve$

Case-II

If $P < P_o$

Applied pull < standard pull

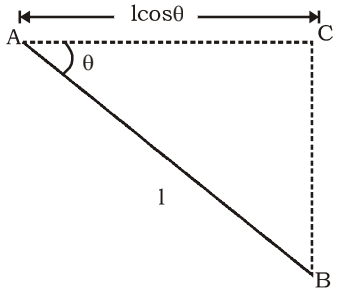
$C_p = -ve$

(iv) Correction For Slope :-

When the distance are measured on sloping ground.

Case-I

If length & angle with Horizontal are given



ΔABC

$$\cos\theta = \frac{AC}{AB}$$

$AC = AB\cos\theta$

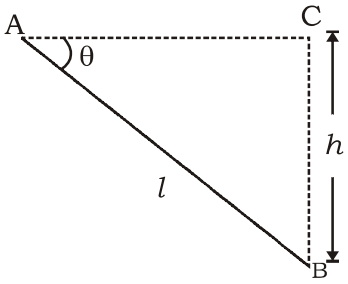
$AC = l\cos\theta$

Slope correction = l-$l\cos\theta$

$C_s = l(1-\cos\theta)$

Case-II If length and difference in elevation are given between end points

$B = \sqrt{(H)^2-(P)^2} = \sqrt{l^2-h^2}$



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

$= l - l\left(1-\frac{h^2}{l^2}\right)^{\frac{1}{2}}$

$= l - l\left[1-\frac{h^2}{2l^2}-\frac{h^4}{8l^4}.....hn^4\right]$

$= l - l + \frac{lh^2}{2l^2}$

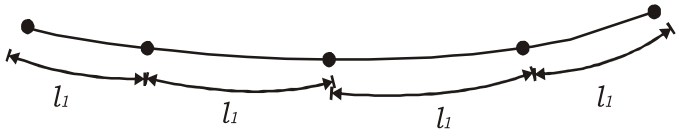
$= \frac{h^2}{2l}$

Correction = $\frac{h^2}{2l}$

(v) **Correction For Sag:-**

Chain survey करते समय जब दो points के मध्य कोई depress area हो तो दूरी मापते समय मापी गई दूरी हमेशा Actual से ज्यादा आती है। अर्थात् effect हमेशा positive होता है Correction हमेशा negative होता है।

Sag correction $C_s = \frac{(-)w^2l^3_1}{24p^2}$



where,

C_s = Sag correction

w = weight of tape per unit length(N/M)

l_1 = length of tape b/w two support

p = Applied pull

if w = wl_1

$$C_s = \frac{(-)w^2 \times l^2{}_1 l_1}{24p^2} = \frac{(wl_1)^2 l_1}{24p^2} = \frac{w^2 l_1}{24p^2}$$

$$= \frac{l_1 w^2}{24p^2}$$

Total sag correction = $\frac{n\, w^2 l^3{}_1}{24p^2}$

or

$$= \frac{n\ X\ l_1 w^2}{24p^2}$$

Total length l = nl_1

$$l_1 = \frac{l}{n}$$

$$= \frac{n\ X\ w^2\ X \left(\frac{l}{n}\right)^3}{24p^2}$$

$$C_s = \frac{(-)w^2 l^3}{24n^2 p^2}$$

NORMAL TENSION

जब दो points में मध्य difference area हो, तो applied किया गया वह pull जिस पर sag correction or pull correction दोनों का effect neutral हो जाए is called Normal Tension

Pull Tension = Sag Correction

$$\frac{(P_n - P_0)}{AE} l_1 = \frac{l_1 \omega^2}{24p^2 n}$$

$$24P^2 n(P_n - P_0) = \omega^2 AE$$

$$Pn^2 = \frac{\omega^2 AE}{24(Pn - P_0)}$$

$$Pn = \frac{W\sqrt{AE}}{\sqrt{24(P_n - P_0)}}$$

$$P_n = 0.204w\sqrt{\frac{AE}{(P_n - P_0)}}$$

Ranging out of A Survey Line

Chain survey करते समय जब दो points के मध्य measured कि जाने वाली distance chain length से ज्यादा हो, तो उस condition में changing किए जाने वाले दोनों extream point (First and last) के मध्य intermidiate points स्थापित करने कि process is called Ranging.

Ranging करने के लिए दो विधियों को उपयोग में लाया जाता है–

1. Direct Ranging 2. Indirect Ranging

1. **Direct Ranging** : जब survey field में दोनों extreme points एक दूसरे से intervisible हो, तो उस condition में direct ranging adopt कि जाती है, और direct ranging में intermidiate points स्थापित करने के लिए theodolite या line ranger instrument उपयोग में लाये जाते है।
   Direct ranging में ranging rod Nos. 3 से कम नही होनी चाहिए।

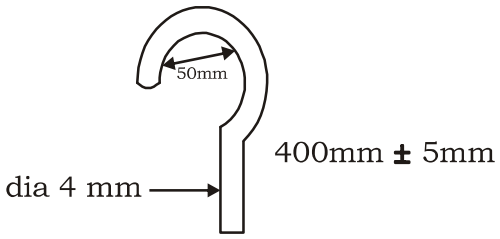
2. **Indirect Ranging** : इसे reciprocal raning के नाम से भी जाना जाता है।
   यह Method survey field में उस condition में उपयोग लाया जाता है, जब दोनों extreme points एक दूसरे से intervisible नहीं हो लेकिन बीच के किसी points से दिखाई देते हो, यह method area or Hilly area में use किया जाता है।
   Indirect ranging में ranging करने के लिए minimum No.s of Rs 4 से कम नही होनी चाहिए।

Degree of Accuracy In chaging:

(i) For measurement with chain on rough or hilly ground 1 in 250.
(ii) For measurement with chain under average condition 1 in 500.
(iii) For measurement with tested chain 1 in 1000.
(iv) For ordinary measurement with steel tap 1 in 1000.
(v) For measurement with invar tap 1 in 10,000.

Some other instrument use in chaining:

1. **Ranging Rod** : Survery में काम आने वाली ranging road कि Height 2 to 3 mtr. के मध्य होती है, लेकिन normally 2m height वाली ranging rod उपयोग में लाई जाती है। Ranging road कि shape circular or octagonal होती है और इसका dia 3 cm होता है।
   Ranging rod almost 200 m length तक easily intervisible रहती है।
2. **Ranging pole** : Ranging pole बिल्कुल ranging rod कि तरह होता हे, लेकिन Basic difference यह होता है, इसकी height or dia दोनों ही ज्यादा होते है।
   Ranging pole कि height 4 to 8 mtr. होती हे, तथा dia 6 to 10 cm होता है।
3. **Offset Rod:** यह बिल्कुल ranging road कि तरह होती है, और इसका उपयोग field में rough off set measured करने के लिए किया जाता है, और इसकी height 3m होती है।
4. **Arrow** : Arrows stout steel wire के बने होते है, और इसका dia 4mm or (8 wire 9 gage) का होता है। Arrows कि length 25-50 cm के मध्य होती है, लेकिन normally 40 cm height वाला Arrow use में लाया जाता है।



Shape of Tallies:

Provide in every meter or length In 5m and 10 m chain.

5m Chain

1 Mtr 

2 Mtr 

10m Chain

1 Mtr 

2 Mtr. 

3 Mtr 

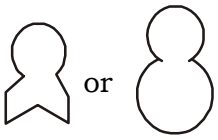
4 Mtr 

5 Mtr  or

Provide every 5m length in 20 & 30 chain.

20 m Chain

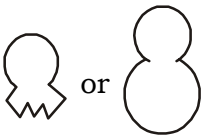
5 Mtr 

10 Mtr 

30 m Chain

5 Mtr 

10 Mtr 

15 Mtr 

Chain 8 wire guage (4 mm dia) कि बनी होती है।

Chain कि length एक Handle से दूसरे handle के बाहर तक (outer to outer) measure कि जाती है।

UNIT- V

Chain Surveying

Survey Station : In a chain survey the beginning and ending point is called survey station. This is also known as Main Station.

Tie Station and Subsidiary Station:
Chain survey field में किसी भी line पर main survey station (beginning & ending) को छोडकर बाकी सभी fix किये गये station is called tie & subsidiary station.

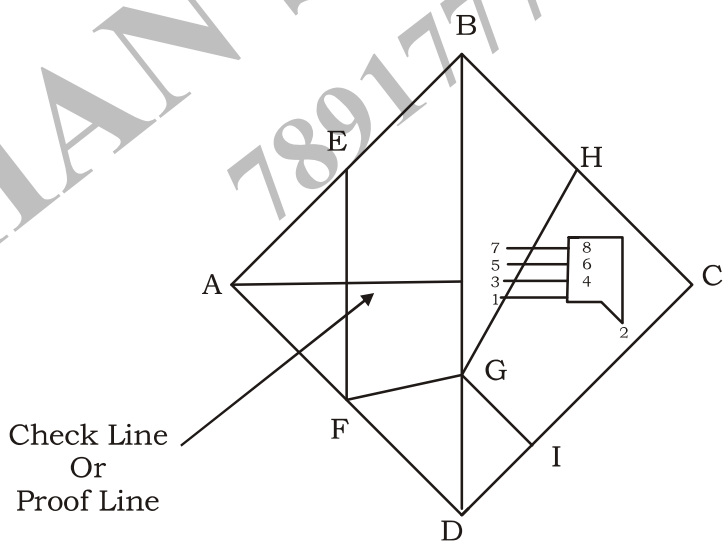
Main Survey Line:

Chain survey field में main stations को मिलाने वाली line is called main survey lines.

Tie Line and Subsidiary Line: Chain survey field में tie statioin or subsidiary statioin को मिलाने वाली line is called tie and subsidiary line.

Base Line: Longest line in survey field is called base line.
Invare tape are used for measurement of base line.

Offset: An off set is the lateral distance of an object or any ground feature measured from a survey line.



Main survey station
A, B, C, D
Base line = BD
Main line = AB, BC, CD, DA
Tie station & subsidiary station = E, F, G, H, I
Tie line & subsidiary line = EF, FG, GH, GI
Offset = 1-2, 3-4, 5-6, 7-8

Offset are classified mainly two types-
1. Perpendicular offset
2. Oblique offset

1. **Perpendicular offset**- किसी भी survey line से 90^0 पर लिया गया offset is called perpendicular offset or offset.
2. **Oblique offset**- किसी line से 90^0 के अलावा किसी भी Angle पर लिया गया offset is called oblique offset.

Classification of offset According to length:-

According to length offset are classified in two types:-

1. Short offset
2. Long offset

1. **Short offset**:- If the length of offset are less than or equal to ($\leq$) 16m is called short offset.
2. Long offset:- If the length of offset are exceed (>16m) 16m is called long offset.

Limiting length of offset

The limiting length or allowble length of offset are depended following:-

1. Degree of accuracy required
2. Scale of map
3. Nature of Ground
4. Method of setting out offset

Check line or Proof line

Check line or proof line are the line which are run in the field to check the accuracy of work

Well condition Triangle

Survey field मे ऐसा Trinagle जिसका कोई भी angle 30^0 से कम नही हो और कोई भी एक angle 120^0 से अधिक नही हो is called well condition triangle.

Best well condition Triangle

Survey field में कोई भी ऐसा triangle जिसकी side base के साथ 56^014^0 का angle बनाती हो is called best well condition triangle.

Ill well condition triangle

suvey field मे किसी भी triangle का angle 30^0 से कम रह जाए तथा 120^0 से अधिक बड जाए is called ill well condition triangle.

OBSTACAL IN RANGING AND CHAINING-

1. Obstacal in ranging not in chaining- Hill
2. Obstacal in chaining not in ranging - River

3. Obstacal in both chaining and ranging- Building

INSTRUMENT USE FOR SETTING OUT THE RIGHT ANGLE

During the survey for setting out right angle (90^0) following instrument are used.

1. Cross-staff
2. Optical Square
3. Prism square
4. Site square

1. **Cross staff** - It is classified in 3 types-
   A. Open cross staff (O.C.S)
   B. French cross staff(F.C.S)
   C. Adjustable cross staff (A.C.S)

A. **Open cross staff -** It's only measured 90^0 Angle
B. **French cross staff** - It's measured 45^0, 90^0 and 135^0 angle
C. **Adjustable cross staff** - It measured 0^0 to 360^0 all anlge
2. **Optical Square**- It measured only right anle (90^0) or in optical square their are two prism those are at horizontal and they both are at 45^0 Angle.
3. **Prism square** - It's working principle is same as optical square but the basic difference is its reflecting angle is not adjustable.
   (The prism square has same principle as that of optical square but it is more modern or accurate instrument. It has the merit that no adjustable or adjustment is required since the angle between reflecting surface.)
4. **Site square**- Site square is the type of instrument that connect 2 telescope those are in horizontal and are in the angle of 90^0.