CE 103

Surveying

Introduction of Surveying

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❑Definition

- **Surveying :** Surveying is the art of determining the relative positions of different objects on the surface of the earth by measuring the horizontal distances between them, and by preparing a map to any suitable scale.

- **Levelling :** Levelling is the art of determining the relative vertical distances of different point on the surface of the earth.

❖History of surveying :

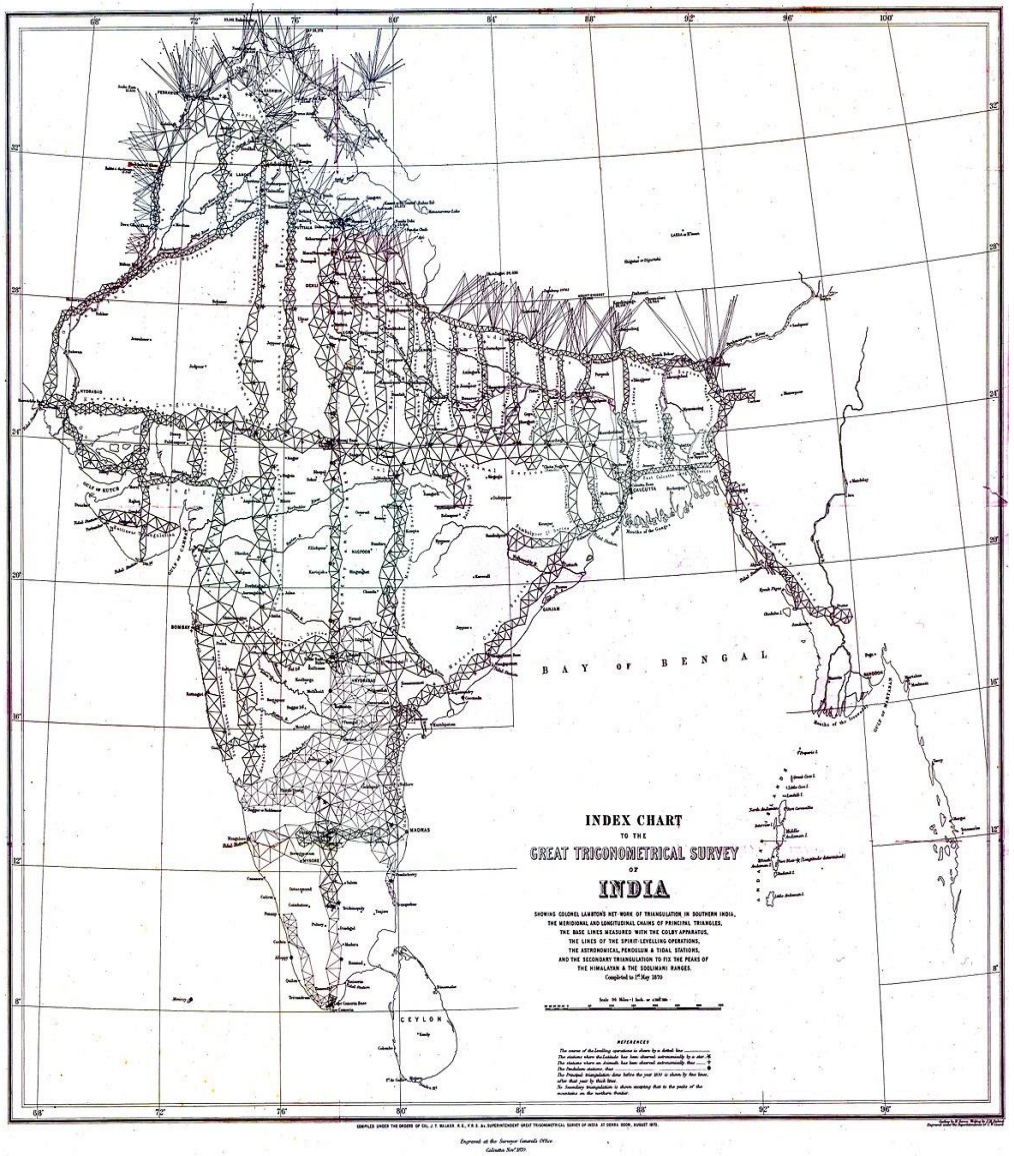
- **Ancient history -**

A rope stretcher would use simple geometry to re-establish boundaries after the annual floods of the Nile River.

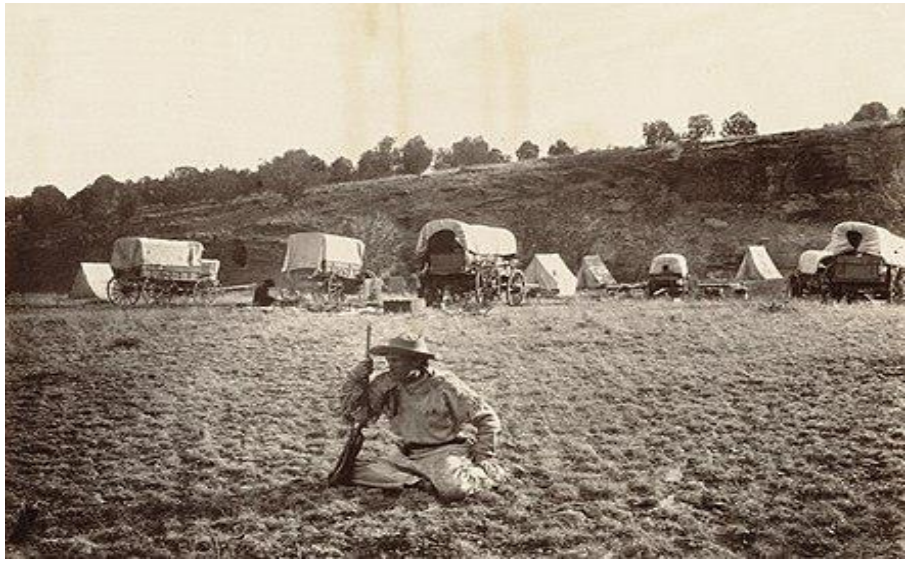
Ancient Egypt

Nile River

Rope stretcher



A map showing the Great Trigonometrical Survey, produced in 1870



A railroad surveying party at Russel's Tank, Arizona in the 1860s

A German engineer surveying during the First World War, 1918

❑ Object of surveying

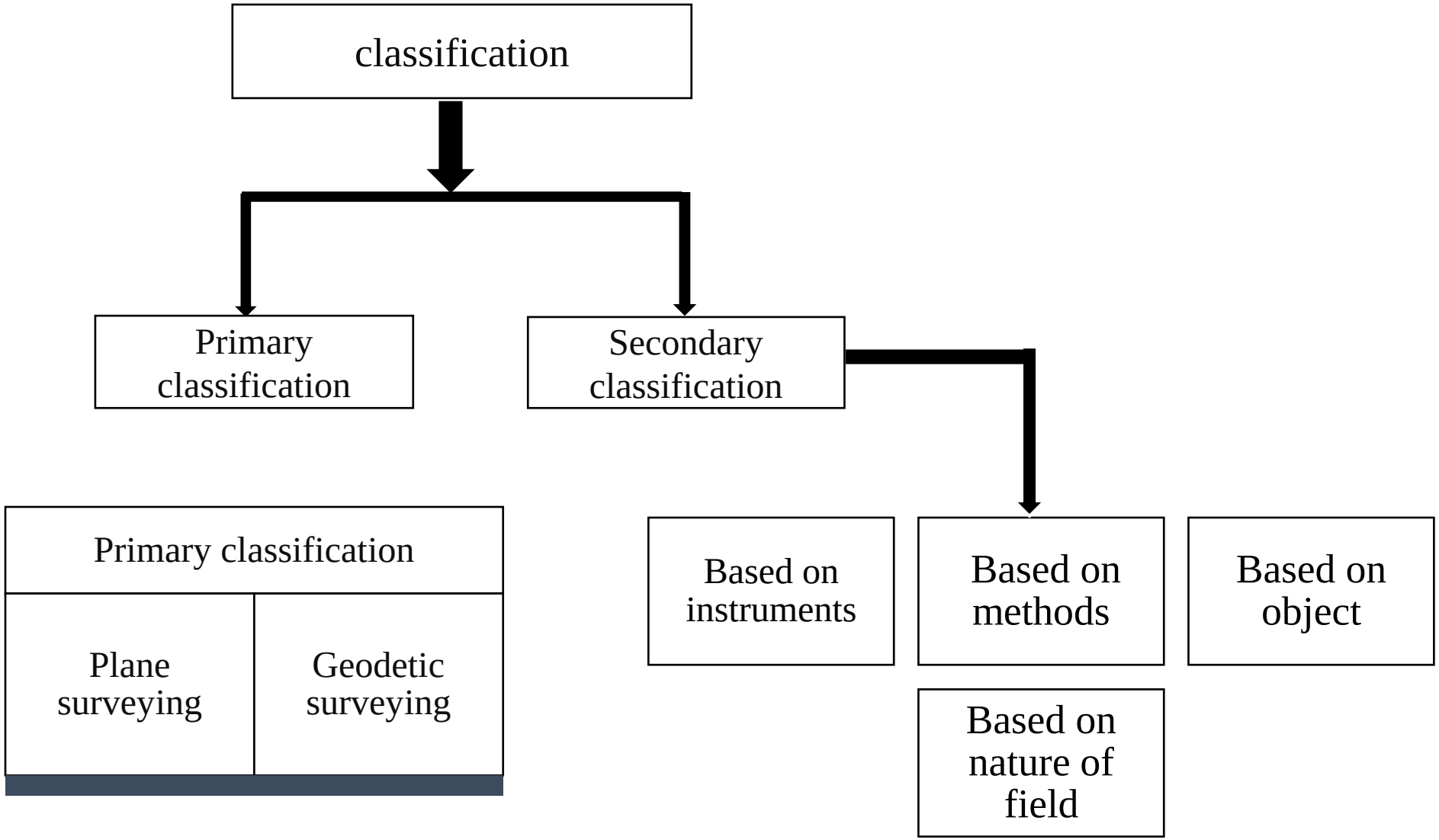
- To prepare a map to show the relative positions of the objects on the surface of the earth.

- To draw the objects to some suitable scale.

❑ Uses of surveying

- To prepare a topographical map which shows the hills, valleys, rivers, villages, towns, forests, etc. Of a country.
- To prepare a cadastral map showing the boundaries of fields, houses, and other properties.
- To prepare an engineering map which shows the details of engineering works such as road, railways, reservoirs, etc.
- To prepare a military map showing the road and railway communications with different part of a country. Such a map also shows the different strategic points import for the defense of a country.
- To prepare a contour map to determine the capacity of a reservoir and to find the best possible route for roads, railways, etc.
- To prepare a geological map showing arcos including underground resources.
- To prepare an archeological map including places where ancient relics exist.

❑ Classification of surveying



❖**Plane surveying :**

- Plane surveying is carried out over a small area.
- The surface of the earth is considered as plane.
- Plane surveying is done on an area of less than 250 km^2.

❖**Geodetic surveying :**

- Geodetic surveying the curvature of the earth is taken into consideration.
- Its extended over a large area.
- Geodetic surveying is carried out over an area exceeding 250 km^2.

❖ Based on instruments :-

- Chain surveying
- Compass surveying
- Plane surveying
- Theodolite surveying
- Tachometric surveying
- Photographic surveying

❖ Based on methods :-

- Triangulation surveying, and
- Traverse surveying

❖ Based on object :-

- Geological surveying
- Mine surveying
- Archaeological surveying, and
- Military surveying

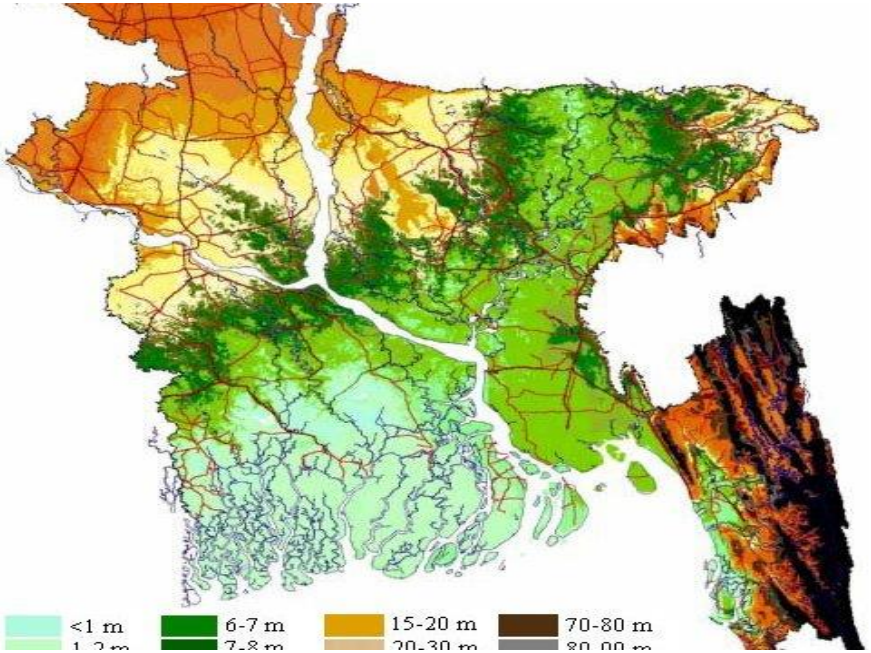
❖ Based on natural of field :-

- Land surveying
- Marine surveying, and
- Astronomical surveying

- **Land surveying :-**

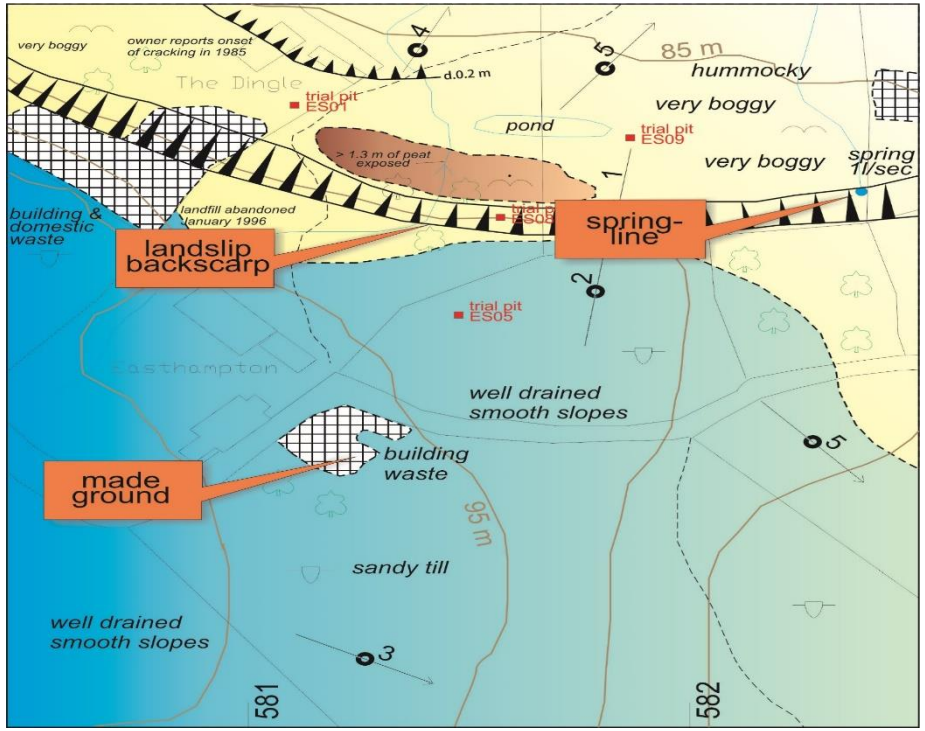
- Topographical surveying, which is done to determine the nature features of a country.
- Cadastral surveying, which is conducted in order to determine the boundaries of fields, estates, houses, etc.
- City surveying, which is carried out to locate the premises, streets, water supply and sanitary systems, etc.
- Engineering surveying, which is done to prepare detailed drawings of projects involving roads, railways, etc.

❖ **Different types of maps :**

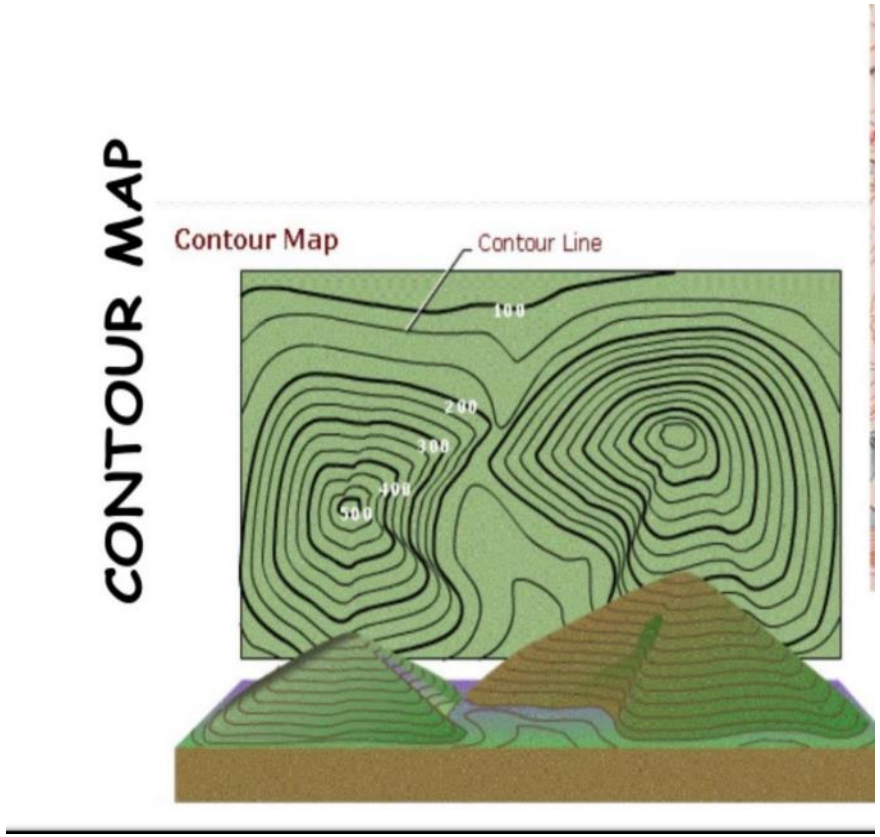


Topographical map

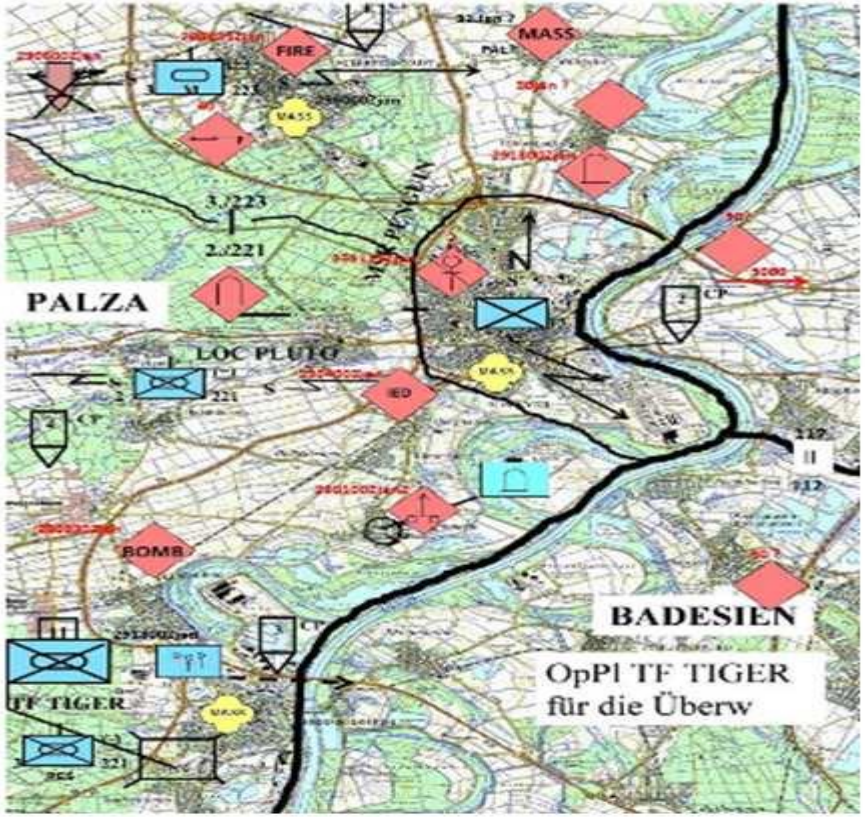
Cadastral map



Engineering map



Contour map



Military map

❑ Different types of chains :-

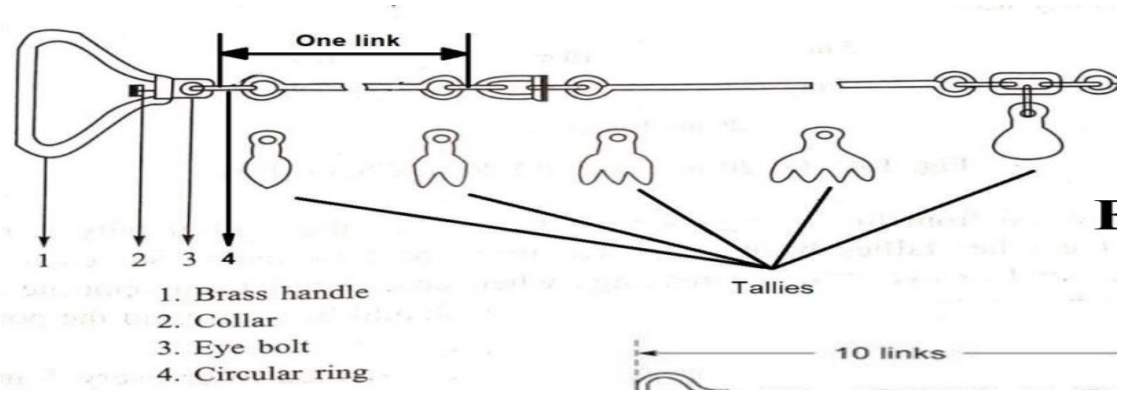
❑ Chains –

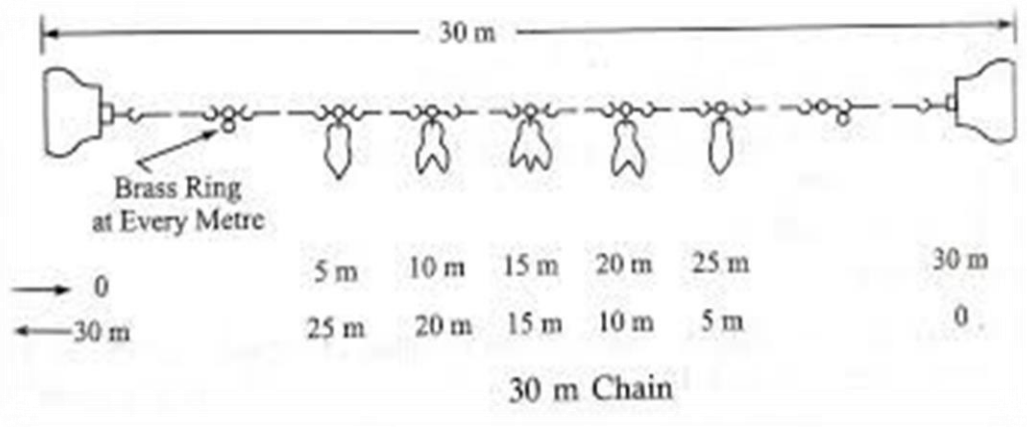
- Metric chain
- Steel chain
- Engineering chain
- Gunter’s Chain, and
- Revenue Chain

- **Metric chain -** Metric chains are available in lengths of 20 m and 30 m. the 20 m chain is divided into 100 links, each of 0.2 m. Tallies are provided at every 10 links (2 m). This chain is suitable for measuring distances along fairly level ground.

- **Engineers Chain -** The engineers chain is 100 ft long and is divided into 100 links. So, each link is of 1 ft. Tallies are provided at every 10 links the central tally being round. Such chains were previously used for all engineering works.

- **Gunter's Chain –** It is 66 ft long and divided into 100 links. So, each link is of 0.66 ft. It was previously used for measuring distances in miles and furlongs.





❑Details of chains –

Adjustment of chains:

- When the chain is too long, it is adjusted by-
  - ➢ Closing up the joints of the rings,
  - ➢ Hammering the elongated rings,
  - ➢ Replacing some old rings by new rings, and
  - ➢ Removing some of the rings.

- When the chain is too short, it is adjusted by-
  - ➢ Straightening the bent links,
  - ➢ Opening the joints of the rings,
  - ➢ Replacing the old rings by some larger rings, and
  - ➢ Inserting new rings where necessary.

- Advantages of chain :

➢ They can be read easily and quickly.
➢ They can withstand wear and tear.
➢ They can be easily repaired or rectified in the field.

- Disadvantages of chain :

➢ They are heavy and take too much time to open or fold.
➢ They become longer or shorter due to continuous use.
➢ When the measurement is taken in suspension, the chain sags excessively.

- **Degree of accuracy in chaining :**

The degree of accuracy in chaining is expressed as a ratio called the chaining ratio. The chaining ratio may be 1/1000, 1/1200, etc.

For example, If there is an error of 0.25 m during the measurement of a total length of 500 m,

$$\text{Chaining ratio} = \frac{0.25}{500} = \frac{25}{500\times100} = \frac{1}{2000}$$

Some permissible limits of error :

I. For measurement with steel band - $\frac{1}{2000}$

II. For measurement with tested chain - $\frac{1}{1000}$

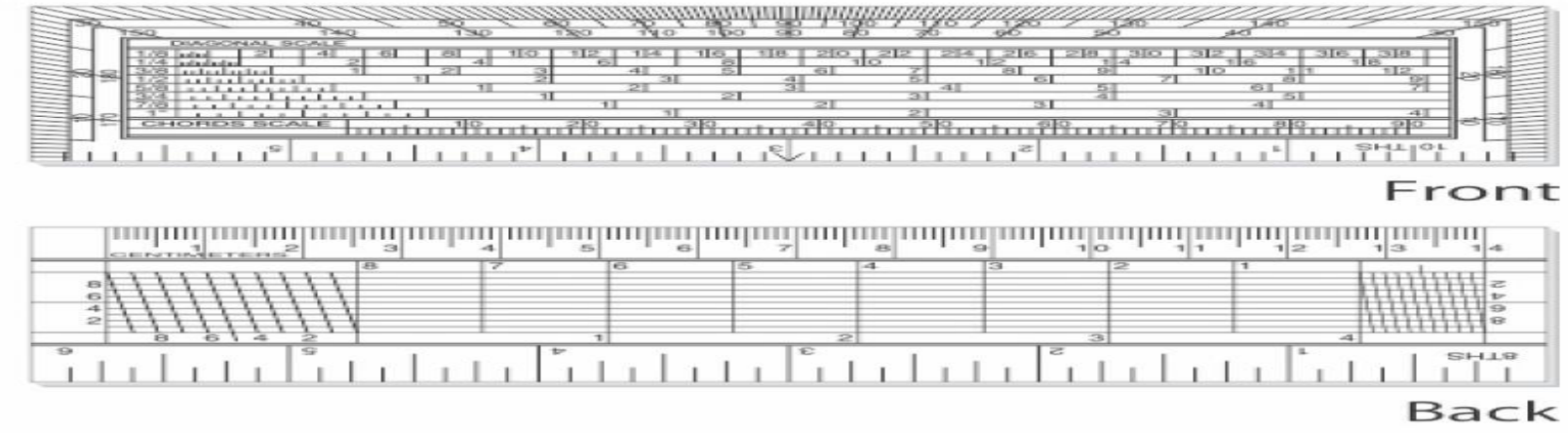
III. In normal conditions - $\frac{1}{500}$

IV. For rough work - $\frac{1}{250}$

❑Different types of scale :

- ➢ Plain
- ➢ Diagonal
- ➢ Comparative, and
- ➢ Vernier

- **Diagonal scale** : This is a scale used to represent three successive units or one unit and its fraction up to the second place of decimals, such as ‘kilometers, hectometres, decametres,’ ‘metres, decimetres, centimetres,’ and ‘metres, 1/100th of a metres,’ and so on.



- **Problems on scale :**

- Representative fraction (RF) : The ratio of the distance on the drawing to the corresponding actual length of the object is known as the representative fraction, i.e.

$$\text{RF} = \frac{Distance\ on\ drawing\ of\ object}{corresponding\ actual\ distance\ of\ object}$$

(both distance in same units) i.e. in cm

For example,

If a scale is 1cm = 10 m, then

$$\text{RF} = \frac{1}{10\times100} = \frac{1}{1000}$$

❑ Different types of tape -

- Cloth or linen tape
- Metallic tape
- Steel tape, and
- Invar tape

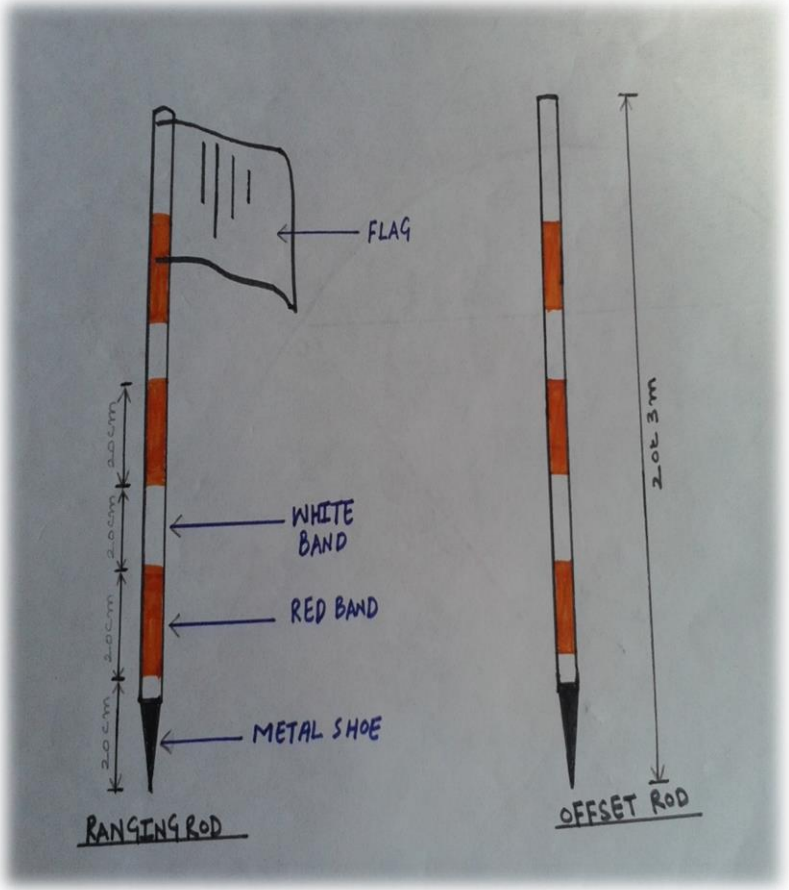
- **Metallic tape –** When linen tape is reinforced with brass or copper wires to make it durable, then its called a metallic tape. This tape is available in lengths of 15, 20 and 30 m. Its wourid on a leather case with a brass handle at the end. Its commonly used for all survey work.

- **Steel tape –** The steel tape is made of steel ribbon of width varying from 6 to 16 mm. The commonly available lengths are 10, 15, 20, 30 and 50 m. Its graduated in meters, decimeters and centimeters . Its not used in the filed, but chiefly for standardizing chains and for measurements in constructional works.

❑ Different types of equipment :-

- Ranging rods –

- ➢ The process of making a straight line.
- ➢ Sometimes we are using GI pipes of 25 mm as a ranging rods.
- ➢ Generally circular in section, of diameter 25 mm and length 2m.
- ➢ The rod is divided into equal parts of 20cm.
- ➢ This rod painted black and white or red and white.
- ➢ The lower end of the rod is pointed or provided with an iron shoe.



Arrows -

- Arrows are made of them pared steel wire of diameter 4 mm.
- One end of the arrow is bent into a ring of diameter 50 m and the other end is pointed.
- It's overall length is 400 mm.

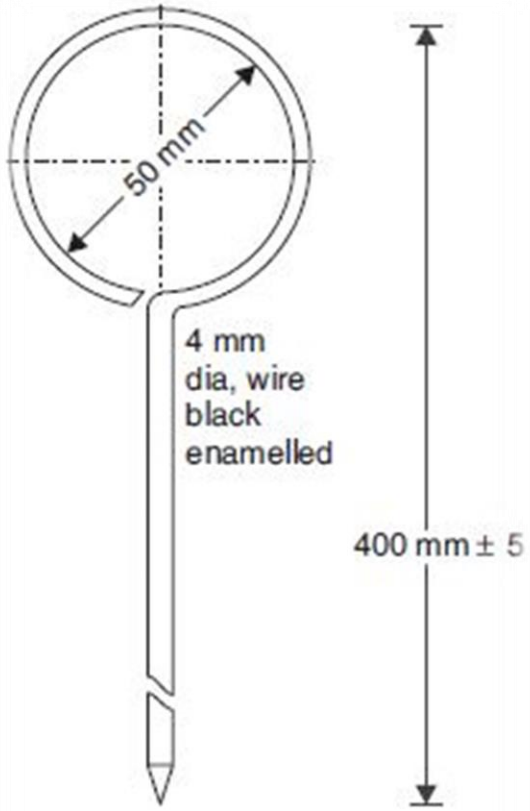
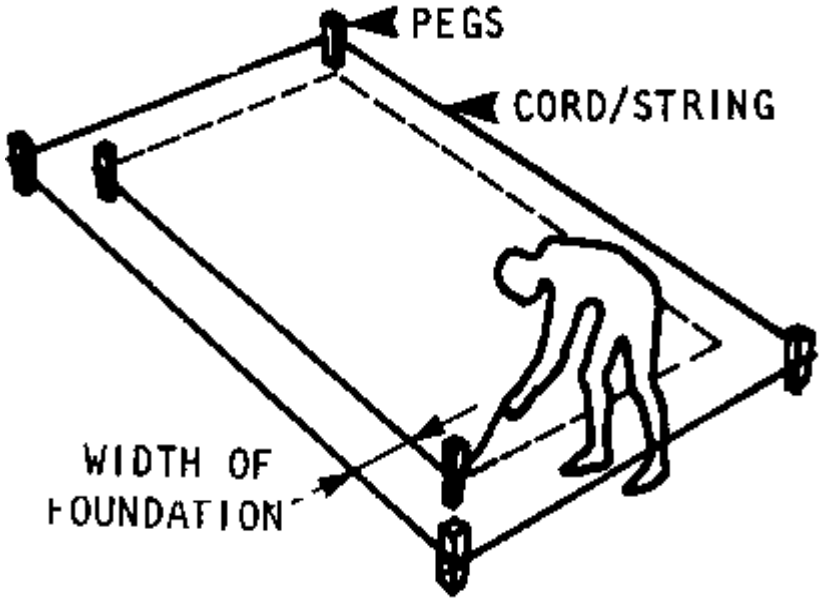


Fig. 12.5. Arrows

- **Pegs:**

➢ used to mark out residential boundaries and indicate points and positions of a site.

➢ They are usually made of wood (although some are made of metal or plastic) and come in different sizes and colored tops.

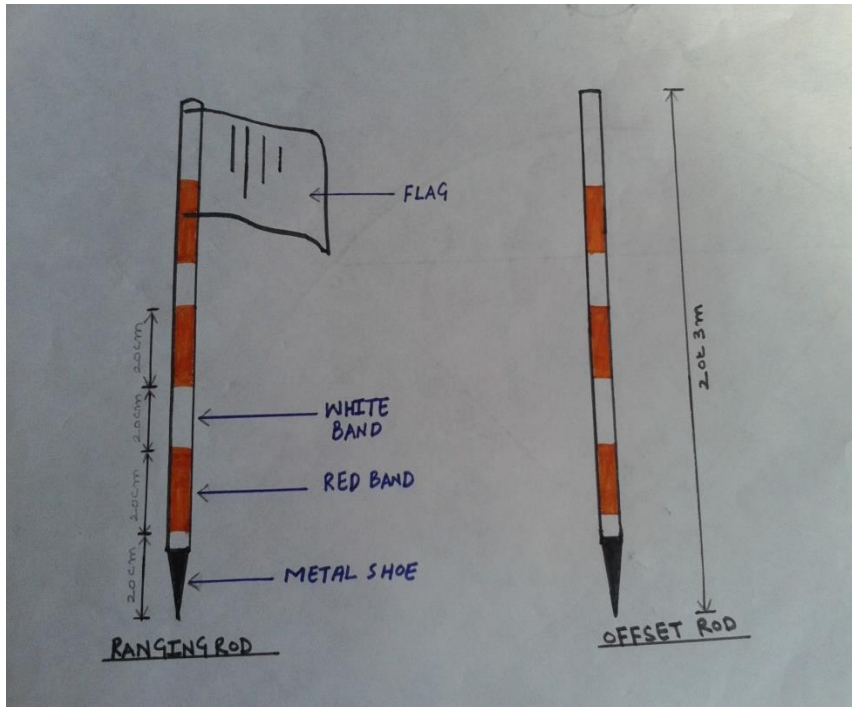


- **Offset Staff :**

➢ Another type of ranging rod is known as an offset rod, which has no flag at the top.

➢ It is used for measuring small offsets from the survey line when the work is of an ordinary nature.

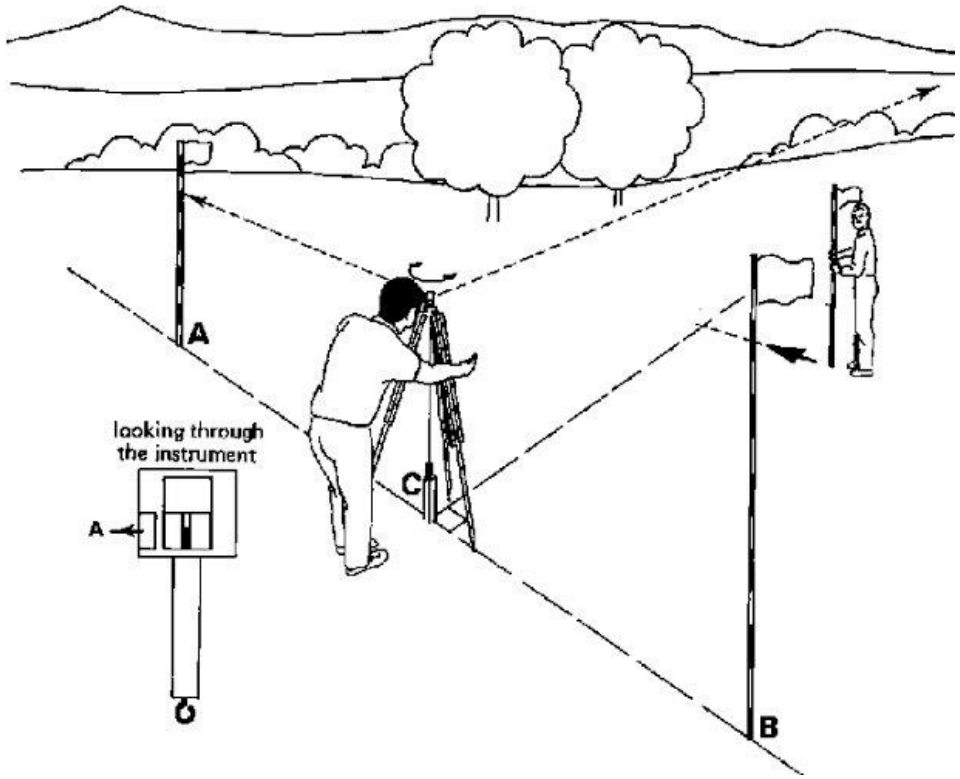
➢ They are about 10 ft long, 1.5 inch diameter round or hexagonal wooden poles painted black/red and white alternate band.

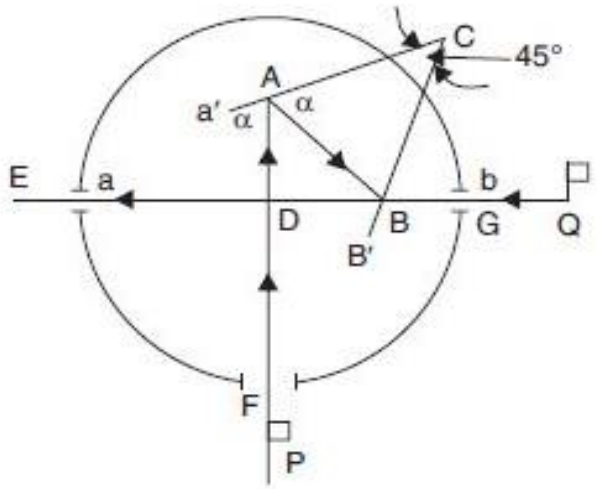


- **Optical Square :**

➢ An optical square is a hand instrument used by surveyor’s.

➢ Used for placing points on a line, offset measurements, setting our curves or determining horizontal plans.





- Proof that optical square 2 mirror incline at 45° Angle.

$$from\ figure, \angle DAB = 180° - 2\alpha$$

$$and\ \angle DBA = 180° - 2\beta$$

According to Triangular law,

$\angle ADB + \angle DBA + \angle DAB = 180°$

$\Rightarrow 90° + 180° - 2\beta + 180° - 2\alpha = 180° \therefore \alpha + \beta = 135°$

Now ΔACB, $\alpha + \beta + \angle C = 180°$

$\Rightarrow 135° + \angle C = 180° \therefore \angle C = 45°$

- **Some types of equipment -**

Optical Theodolite

RTK GPS Base Station

Geo Compass

3D scanners

❑Details of ranging :

- **Ranging :** The process of establishing intermediate points on a straight line between two end points is known as ringing. Ringing must be done before a survey line is chained. Ranging may be done by direct observation by the naked eye or by line theodolite, generally, ranging is done by the naked eye with the help of three ranging rods.

Ranging may be of two kinds :

- Direct, and
- Indirect or reciprocal.

- **Direct ranging :**

➢ When intermediate ranging rods are fixed on a straight line by direct observation from end stations, the process is known as direct ranging.

➢ Direct ranging is possible when the end station are indivisible.

➢ The surveyor stands about 2 m behind the ranging rod at A by looking towards the line AB.

➢ The rod should be held lightly by the thumb and forefinger.

➢ The ringing will be perfect, when the three ranging rods coincide and appear as a single rod.

➢ The ranging rod on the ground by waving both his hands up and down.

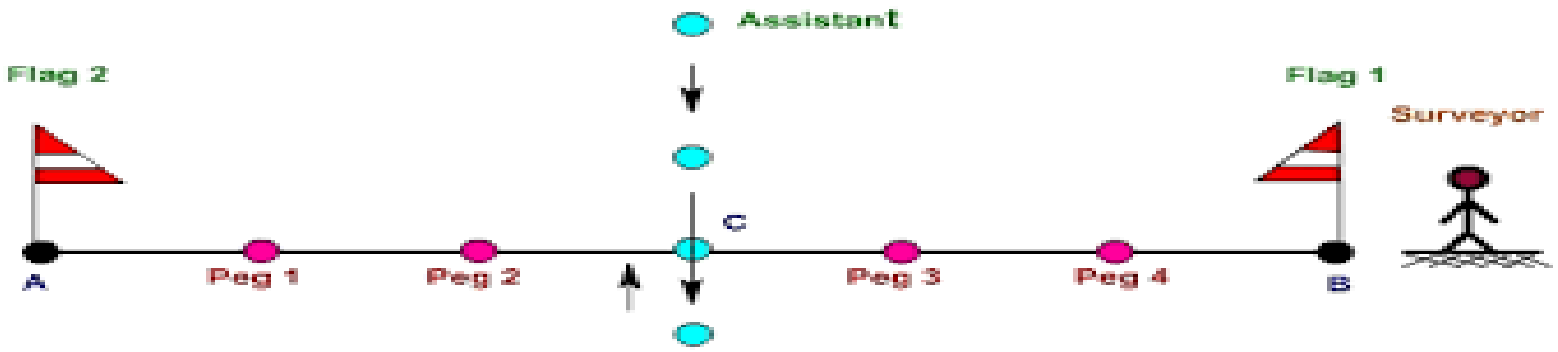


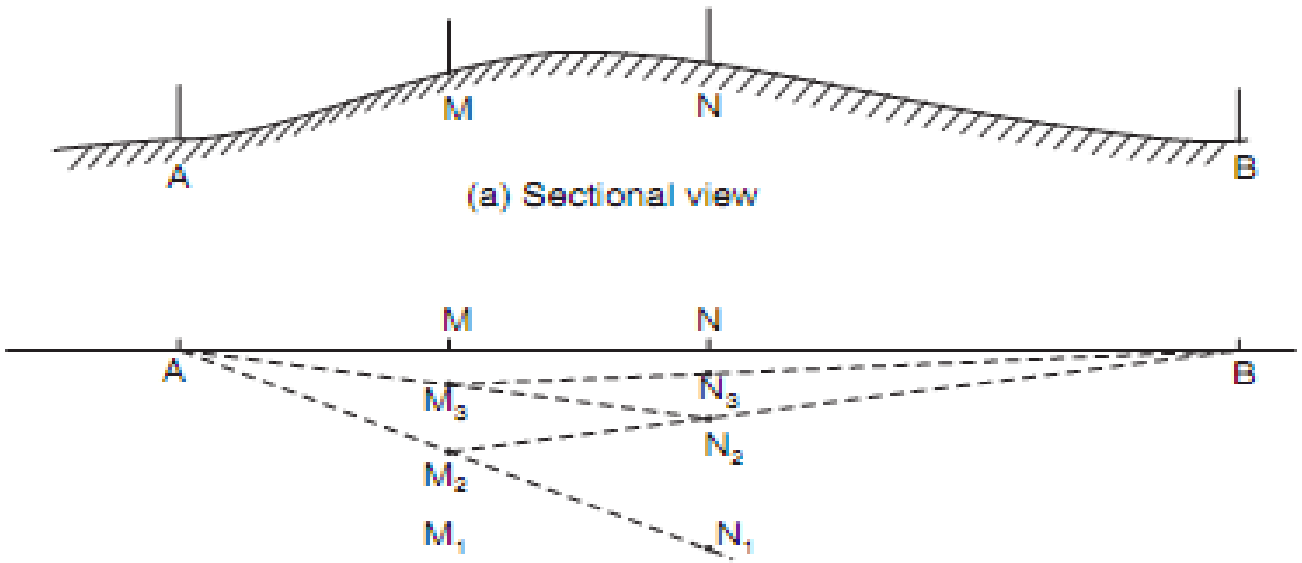
Figure 8.1 Direct Ranging

- **Indirect or reciprocal ranging :**

➢ When the end stations are not intervisible due to there being high ground between them, intermediate ranging rods are fixed on the line in an indirect way.

➢ Suppose it is required to fixed intervisible point between A and B.

➢ The chainman proceed to range the line by the directing each other alternately.



❑Leader and followers :

The chainman at the forward end of the chain who drags the chain forward is known as the leader. The duties of the leader are as follows.

- To drag the chain forward with some arrows and a ranging rod,
- To fix arrows on the ground at the end of every chain, and
- To obey the instruction of the follower.

The chainman at the rear end of the chain, who holds the zero end of the chain at the station is known as the follower. The duties of the follower are :

- To direct the leader at the time of ranging,
- To carry the rear handle of the chain, and
- To pick up the arrows inserted by the leader.

❑**Errors and mistakes in chaining :** Errors in chaining may be caused due to variation in temperature and pull, defects in instruments, etc. They may be either:

- Compensating, and
- Cumulative

- **Compensating errors :**

- Incorrect holding of the chain,
- Horizontality and verticality of steps not being properly maintained during the stepping operation,
- Fractional parts of the chain or tape not being uniform throughout its length, and
- Inaccurate measurement of right angles with chain and tape.

- **Cumulative errors :**

- The length of the chain or tape being shorter than the standard length,
- Slope correction not being applied,
- Correction for sag not being made,
- Measurement being taken with faulty alignment, and
- Measurement begin taken in high winds with the tape in suspension.

- **Negative errors :**

  - The opening of ring joints,
  - The applied pull being much greater than the standard pull,
  - Wearing of connecting rings, and
  - Elongation of the links due heavy pull.

- **Mistakes :**

  - A full chain length may be omitted or added. This happens when arrows are lost or wrongly counted.
  - The numbers maybe read from the wrong direction for instance, a ‘6’ maybe read as a ‘9’.
  - Some numbers may be called wrongly. For example 50.2 may be called as “fifty-two” without the decimal point being mentioned.
  - While making entries in the field books, the figures may be interchanged due to carelessness for instant 245 maybe entered of 254.

❑Chain and tape correction :

- ➢ Temperature correction
- ➢ Pull correction
- ➢ Slope correction

- **Chain correction** –
- Correction applied to incorrect length : Its given by the expression

True length of the (TL) =$(\frac{L`}{L}) \times measured\ legnth\ (ML)$

Where L = Standard or true length of chain

L`= True length ± error

= L ± e (e = error in chain or tape, i.e. Where it is too long or too short)

Use the positive sign when the chain or tape is too long, the negative sign when it is too short.

- Correction of incorrect area : The correction to be applied in the case is given by the expression

$$\text{True area} = \left(\frac{L`}{L}\right)^2 \times measured\ area$$

❑Worked out problems on chain and tape corrections

Problem no 1 : The distance between two points, measured with a 20 m chain, was recorded as 327 m. It was afterwards found that chain was 3 cm too long. What was the true distance between the points?

Solution : Given data,

True length of chain, L= 20 m

Errors in chain, e = 3 cm = 0.03 m, too long

L` = L + e = 20 + 0.03 = 20.03 m

Measured length = 327 m

True length of line = $\frac{L`}{L} \times ML$

$= \frac{20.03}{20} \times 327 = 327.49\ m$

Problem no 2 : The distance between two stations was 1200 m when measured with a 20 m chain. The same distance when measured with 30m chain was found to be 1195 m. If the 20 m chain was 0.05 m too long, what was the error in the 30 m chain?

Solution : Let us consider the 20 m chain.

L = 20 m L` = 20+ 0.05 = 20.05 m

Measured length = 1200 m

True length of line = $\frac{20.05}{20} \times 1200 = 1203\ m$

Let us now consider the 30 m chain.

L = 30 m L` = ?

True length of line 1203 m (as obtained from 20 m chain)

Measured length = 1195 m.

From the relation

$$TL = \frac{L`}{L} \times ML$$

$$1200 = \frac{L`}{L} \times 1195$$

$L` = \frac{1230 \times 30}{1195} = 30.20$ m

Now, L` is greater than L. So, the chain is too long.

Amount of errors, e = 30.20 – 30 = + 0.20 m.

Problem no 3 : A line was me measured by a 20 m chain which accurate before starting the day's work. After chaining 900 m, the chain was found to be 6 cm too long. After chaining a total distance of 1575 m, the chain was found to be 14 cm too long. Find the true distance of the line.

Solution : First part,

L= 20 m

L= 20 + $\frac{0+0.06}{2}$ (considering mean elongation)

= 20.03 m

ML= 900 m

TL= ?

$$TL = \frac{L`}{L} \times ML$$

$$= \frac{20.03}{20} \times 900 = 901.35\ m$$

Second part,

L= 20 m

$$L` = 20 + \frac{0.06+0.14}{2} = 20.1\ m$$

ML= 1575 – 900 = 675 m

$$TL = \frac{20.1}{20} \times 675 = 678.375\ m$$

True distance = 901.350 + 678.375 = 1579.725 m

Problem no 4 : On a map drawn to a scale of 50 m to 1 cm, a surveyor measured the distance between two stations as 3500 m. But it was found that by mistake he had used a scale of 100 m to 1 cm. Find the true distance between the stations.

Solution : First method,

As the surveyor used the scale of 100 m to 1 cm,

Distance between stations on map = $\frac{3500}{100} = 35\ cm$

As the actual scale of map is 50 m to 1 cm,

True distance on the ground = 35 × 50 = 1750 m

Second method,

True distance = $\frac{RF\ of\ wrong\ scale}{RF\ of\ correct\ scale} \times measured\ length$

$= \frac{50 \times 100}{100 \times 100} \times 3500$

True distance = 50 × 35 = 1750 m

❑ Practice problems :

From your text book page number 24 to 32 (NN Basak)


Thank you!