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Surveying



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1 CHAPTER

Surveying Principle's

THEORY

Definition of Surveying

- ❖ Surveying is the science or art of making the measurements necessary to determine or establish the relative positions of points. The points may be on, above or below the surface of the earth. Surveying is done to ascertain and delineate on map or plan the shape and extent of any portion of the earth's surface:

Divisions of Surveying

- ❖ Primarily Surveying can be divide into two classes
 1. Plane Surveying and
 2. Geodetic surveying.
- 1. **Plane Surveying :**
- ❖ In plane surveying the curvature of the earth' surface is neglected. the earth's surface is considered plane. The line connecting any two points on the surface of the earth is considered straight line and the angles of polygons as plane angles. This type of survey is adopted when surveys exted over small area.
- 2. **Geodetic Surveying :**
- ❖ This method of survey is adopted when large distances and areas are to be covered. In it the curvature of the earth is considred in all the measurement taken on the surface of the earth. All the lines in the surface of the earth are curved lines and all the polygons formed on the surface are spherical polygons. This survey is also called trigonometrical survey.
- ❖ The main characteristics of Geodetic survey
 - (1) very large distances and areas.
 - (2) use of very precise instruments
 - (3) use of refined method of obervation
 - (4) high degree of precision.

Classification of Surveys

1. *Based upon the nature of field of survey :*

(1) Land survey :

- ❖ This survey work is doen on the land only. it can be divided into following types.
 - (i) Topographical surveys.
 - (ii) City surveys.

(iii) Cadastral surveys. they are also conducted for fixing the position of pathways, properties; transfer of land from one owner to another. boundaries of districts, States, Municipalities and even countries are fixed by this survey.

(2) Astronomical Survey.

(3) Marine or Navigation Surveys.

2. Based on the Object of Surveying

(1) Engineering surveys.

(2) Military surveys.

(3) Geological surveys.

(4) Archaeological surveys.

3. Based upon the Instruments used

(1) Chain survey.

(2) Compass survey.

(4) Theodolite survey.

(5) Tacheometric survey.

(6) Photographic survey.

(7) Aerial survey.

(8) Levelling

4. Based upon the method employed in survey.

(1) Triangulation survey.

(2) Traverse survey.

PRINCIPLES OF SURVEYING :

1. In order to fix the location of any point measurements from two reference points whose position are known have to be taken :

- ❖ According to this fundamental, for the location of the relative position, of any point at least two measurements are required from reference points the positions of reference points being already fixed. The two measurements from reference points may be (i) linear measurements (ii) angular measurements (iii) linear and angular measurements.

2. To work from whole to part

- ❖ According to this principle of surveying first of all a system of control points is fixed covering whole of area to be surveyed with very high degree of precision.
- ❖ The object of this system of working is to prevent the accumulation of error and to control and localise the minor errors.

(1) Engineer's scale :

- ❖ In this method of representation of scale 1 cm on the plane represents some whole number of metres on the ground.

(2) Representative Fraction (R.F.) method :

- ❖ According to this method one unit length on the plane represents so many units of length on the ground. The ratio of plane distance to the corresponding ground distance is independent of units and is called representative fraction (R.F.) R.F. can be very easily found for any given Engineer's scale.

(3) Graphical scale :

- ❖ The scale may be represented on the plane graphically. It should be represented near the title of the map so that it is readily visible.

Types of Scales :

- ❖ The scales may be classified under following four heads.

- (1) Plain scale.
- (2) Diagonal scale.
- (3) Vernier scale.
- (4) Scale of chords.

PLAIN SCALE :

- ❖ A plain scale consists of a line divided into suitable number of equal parts or unit. The first part is subdivided into smaller part. Plain scales represent either two units or a unit and its sub-division such as metres and decimetres, miles and furlongs, units and tenths etc.

Diagonal Scale :

- ❖ Diagonal scale is used to read three dimensions such as metres, decimetres and centimetres, units, tenths and hundredths, yard, feet and inches, etc.
- ❖ The principle of construction of a diagonal scale is based upon the fact that similar triangles have their like sides proportional.

Comparative Scales

- ❖ Scales having same R.F. but graduated to read different units are called comparative scales. Comparative scales may be plain scales or diagonal scales.

Vernier Scale

- ❖ Vernier scales are used to read very small units with great accuracy. Vernier scale consists of two parts—a primary scale and a vernier. The primary scale is nothing but plain scale fully divided into minor divisions.

Types of Verniers

- ❖ Vernier may be divided into two classes

1. Direct and
2. Retrograde.

1. Direct vernier :

- ❖ In direct vernier the smallest division on the vernier is shorter than the smallest division on the main scale. In it n divisions of vernier are equal in length to $(n - 1)$ divisions of the primary or main scale.

8 = value of smallest divisions of main scale.

v = value of smallest divisions on the vernier

n = number of divisions on vernier.

Since n divisions of vernier are equal to n – divisions of the main scale

$$nv = (n - 1) s$$

$$v = \left(\frac{n-1}{n} \right) s = \left(1 - \frac{1}{n} \right) s$$

- ❖ Least count (L.C.) = $s - v = s - \left(\frac{n-1}{n} \right) s = \frac{s}{n}$. Thus L.C. division by total number of divisions on the vernier. Least count of the vernier is the difference between the smallest division on the main scale and smallest division on the vernier.

2. Retrograde vernier :

- ❖ In this case the length of smallest division on the vernier is longer than the smallest division on the main scale. If n divisions of the vernier are equal in length to n + 1 divisions of the main scale.

In this case also $nv = (n + 1) s$

$$v = \left(\frac{n+1}{n} \right) s$$

$$\text{L.C.} = v - s = \left(\frac{n+1}{n} \right) s - s = \frac{s}{n}$$

SHRUNK SCALE :

- ❖ If a graphical scale is not constructed on an old map and map has shrunk, it becomes necessary to find the shrunk scale of the map so that map could be correctly interpreted. R.F. of the original scale is known. The distance between two points on the map is measured and then compared with the corresponding distance on the map as calculated from the given scale or R.F. The ratio of the shrunk length to the true length is known as the shrinkage factor which is obviously less than unity. The shrunk scale is then obtained as follows.
- ❖ Shrunken scale = shrinkage factor \times original scale of the map.

- ❖ If R.F. of the original scale is $\frac{1}{1000}$ and shrinkage factor is $\frac{10}{11}$. The R.F. of shrunk scale shall be $\frac{10}{11} \times \frac{1}{1000} = \frac{1}{1100}$ i.e. 1 cm, = 11 m.

MEASUREMENT WITH WRONG SCALE :

- ❖ If any measurement on the map has been taken with a wrong scale the distance so measured will be wrong. The true distance and areas can be found by using following relations.

$$\text{True length} = \left(\frac{\text{Wrong scale}}{\text{Correct scale}} \right) \times \text{Measured length.}$$

$$= \left(\frac{\text{R.F. wrong scale}}{\text{R.F. of correct scale}} \right) \times \text{Measured length.}$$

$$\text{True area} = \left(\frac{\text{R.F. wrong scale}}{\text{R.F. of correct scale}} \right)^2 \times \text{Calculated area.}$$

SOME IMPORTANT DEFINITIONS :

1. Accuracy.

- ❖ The degree of perfection obtained in observations, instruments use, and the methods employed, is known as the accuracy.
- ❖ Accuracy depends on the :
 - (1) precision of the instruments used
 - (2) precision of the methods used
 - (3) perfectness of the planning and
 - (4) perfectness of the observations.

2. Error :

- ❖ The difference between the true value and the measured value of any thing is known as the error.

3. Discrepancy :

- ❖ It is the difference between the two measured value of the same quantity. It is not an error. A discrepancy may be small, yet the error may be large. Discrepancy does not reveal the magnitude of systematic errors.

4. Precision :

- ❖ It denotes relative or apparent nearness to the truth and is based upon the refinement of the measurements and the size of the discrepancies.

SOURCES OF ERRORS :

1. Natural errors.
2. Instrumental errors.
3. Personal errors.

PROBABILITY :

Most probable value :

- ❖ It is that value of a quantity which has more chances of being correct than any other quantity. The most probable error is that quantity which when added to and subtracted from the most probable value fixed the limits within which the true value of measured quantity must lie.

THEORY OF ERRORS :

- ❖ The probable error of a single measurement is obtained from the equation.

$$PE = \pm 0.6745 \sqrt{\frac{\sum d^2}{n-1}}$$

- ❖ The probable error of the mean of a number of observations of the same quantity is calculated from the equation.

$$PE_m = \pm 0.6745 \sqrt{\frac{\sum d^2}{n(n-1)}}$$

Principle of least squares :

- ❖ The principle of least squares which is developed from the law of probability, requires adjusting the observed values so as to produce a minimum sum of the squares of the errors (residuals)

Example: A Philadelphia rod has the main scale graduations in centimetres. Design a suitable retrograde vernier to read upto 1 mm.

Sol. Least Count = $\frac{s}{n}$,

$$\text{Here, } 1 = \frac{10}{n} \text{ or } n = 10$$

Ten divisions of the vernier should be equal to 11 divisions of the main scale.

Example: A surveyor measured the distance between two points marked on the plan drawn to a scale of 1 cm = 1m (R.F. = 1 : 100) and found it to be 50m. Later he detected that he used a wrong scale of 1 cm = 50 cm (R.F. = 1 : 50) for the measurement. Determine the correct length.

(b) What would be the correct area if the measured area is 60 m²?

Sol. Correct length = $\frac{\text{R.F. of the wrong scale}}{\text{R.F. of the correct scale}} \times \text{measured length}$

$$= \frac{1/50}{1/100} \times 50 = 100\text{m}$$

$$\text{correct area} = \left(\frac{1/50}{1/100} \right)^2 \times 60 = 240 \text{ m}^2$$

Example : Design a direct vernier for a theodolite circle having main scale graduations upto 20 minutes (20') if the least count required is 20 seconds (20").

Sol. Least Count = $\frac{s}{n}$,

$$\text{Here, } 20'' = \frac{20 \times 60}{n}, n = 60$$

As in the case of a direct vernier, n divisions of the vernier are equal to (n-1) divisions of the main scale, 60 divisions of the vernier scale should be equal to 59 divisions of the main scale. A length of 59 divisions of the main scale should be taken and divided into 60 divisions to form the vernier scale.



2 CHAPTER

Distance Measuring Instruments

THEORY

Measurement of Distance :

❖ The various methods of measuring the distances are listed as follows.

1. Pacing
2. Passometer
3. Pedometer
4. Odometer
5. Speedometer
6. Perambulator
7. Chaining.

Measuring Distance :

❖ Following are the instruments used for measuring the distances :

- (1) Chains
- (2) Tape
- (3) Arrows
- (4) Pegs
- (5) Ranging rods
- (6) Offset rods
- (7) Plasterer's laths and whites
- (8) Plumb bob.

CHAIN :

❖ It is made of galvanized mild steel wire 8 SWG or 4 mm diameter. It consists of links. the ends of the links are bent into loops. The links are connected together by means of three oval or circular rings. The rings afford flexibility to the chain and make it less itable to become kinked.

1. Engineer's Chain
2. Gunter's Chain
3. Revenue Chain
4. Metric Chain.

1. Enginner's Chain :

❖ This chain is 100 ft long and has 100 links each one foot in length it is used mostly for Engineer survey and thus namd. Engineer's chain. Brass tags are attached at every 10 links. Reckoning from one end of the chain, tags with one notch is attachd at 10 links, with two notches at 20 links, with three notches at 30 links. with four notches at 40 links.

2. Gunter's chain :

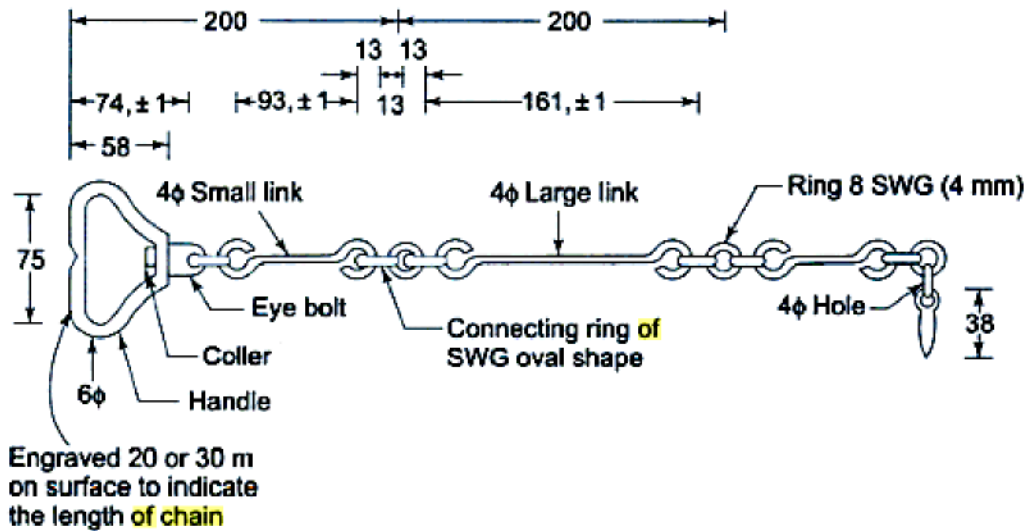
❖ It is also sometimes referred as surveyor's chain. It is 66 ft. long and is divided into 100 links each link being 0.66 ft. It is very convenient for measuring the distances in miles and furlonges. It is equally convenient where area to be measured is in acres. System of tags is similar to that explained for engineer's chain.

3. Revenue chain :

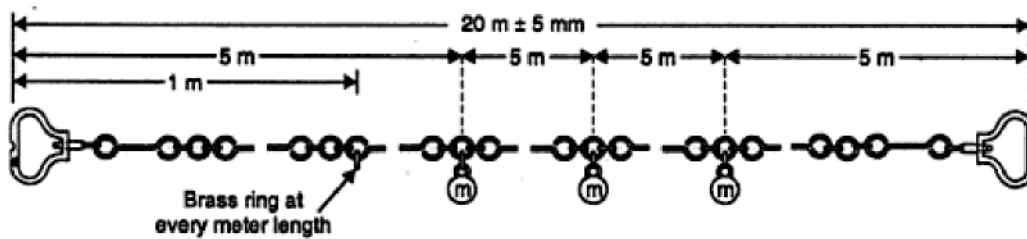
❖ This chain is 33 ft long and has 16 links. It is used for measuring fields in cadastral survey.

4. Metric chain :

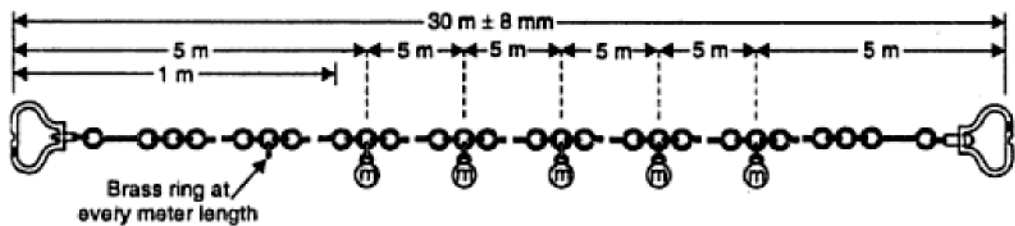
❖ Metric chains are used for survey work in India. The metric chains are available in lengths of 5,10, 20 and



Details of a metric chain.



20 m chain.



30 m chain

TAPES :

❖ Tapes are used for the same purpose as the chains. But they are more accurate and easy to handle. the tape is a graduated strip and enclosed in a case of leather or metal. The tapes are classified according to the material they are made of.

- (1) Cloth or linen tape.
- (2) Metallic tape.
- (3) Steel rape and

(4) Invar tape.

(1) Cloth or linen tape :

- ❖ This tape is not used for engineering surveys. However, it may be used for taking subsidiary measurements like offsets. It consists of 12 to 15 mm wide strip of closely woven cloth, varnished to make it stiff and moisture resistant. It is available in 10 m, 20 m, 25 m and 30 m lengths.

(2) Metallic tape :

- ❖ Like linen tape, this tape is also made from varnished strip of water proof cloth. But in this case in order to strengthen the tape, thin brass, copper or bronze wires are interwoven in the strip.

(3) Steel tapes :

- ❖ Steel tapes are available in lengths of 1, 2, 10, 20, 30 and 50 m. The tapes of 10, 20, 30 and 50 m lengths are provided with a brass ring at the free end with the help of a metal strip of the same width as the tape. The length of the tape includes the length of the ring also.

(4) Invar Tape :

- ❖ This tape is used when survey work has to be conducted with a very high degree of precision as in measurement of base lines in triangulation. Invar is an alloy of steel and nickel and has very low coefficient of thermal expansion (0.000005 per °F). Because of low coefficient of the thermal expansion, effect of temperature change on the length of the tape is almost negligible.

ARROWS :

- ❖ A bundle of 10 arrows is always issued along with the chain, whenever survey is to be conducted with the help of chain. They are also, sometimes, referred as marking pins or chaining pins. They

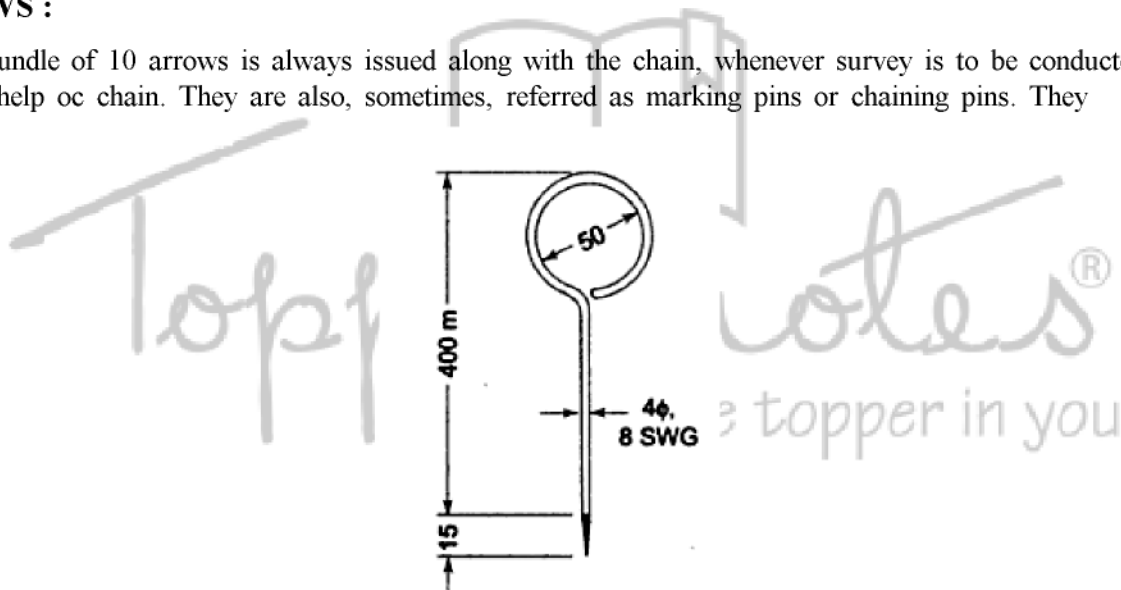


Fig. : Arrows.

are used to mark the end of each chain during the process of chaining.

PEGS :

- ❖ Pegs are generally made of timber but they can be made from angle irons also, if situation demands. Pegs are used to mark the positions of survey stations. Wooden pegs are usually 25 cm square 15 cm long. For soft ground.

RANGING RODS :

- ❖ Ranging rods are used for marking the positions of intermediate points while ranging a survey line. They are circular or octagonal in cross-section and have 3 cm nominal diameter. They are made of well

seasoned straight grained timber of teak, deodar, sisso, or blue plane.

PLASTERER'S LATHS AND WHITE :

➤ Plasteror's laths :

- ❖ They are useful for ranging long lines on very undulating ground an also when forward ranging rod is not visible due to obstructions. Gross-ing of a depression may also require use of laths.

PLUMB BOB :

- ❖ Plumb bob is made of brass, or coper. It is used for trans-ferring points vertically from space to the ground or from ground to space. It is used by suspending in space by means of a thread. It is used for centring most of the survey instruments like, theodolite, plane table, compass etc. It is also used for making ranging poles vertical and transferring points to ground vertically while measuring distances on stopes. It works on the fundamental that any thing supended freely, in space represents a plumb line or vertical line at that place.



Fig. : Plumb-bob.

1. Correction to measured length :

- ❖ If the chain is too short, the distance measured by it will be more than the true dis-tance. Similarlkky if the chain is too long, the distance measured by it will be less than the true distance.

Let L = True or standard length of the chain.

L' = Actual length of the chain or of the tape.

l' = Measured length of the line with wrong chain.

l = True length of the line.

the measured length with the help of wrong chain cna be corrected by using formula.

$$\text{True or actual length} = \frac{L'}{L} \times \text{measured wrong length of the line.}$$

$$\text{or } l = \frac{L'}{L} \times l'.$$

2. Correction to the measured area :

- ❖ If some area is measured byk an incorrect chain, it can be corrected as follows.

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

where A = True area

A' = Measured area.

L and L' carry same meaning as before.

3. Correction to the measured volume :

- ❖ If erroneous chain has been used to measure volume; it can be corrected as follows,

$$\text{Ture volume} = \left(\frac{L'}{L} \right)^a \times \text{Measured volume.}$$

(1) Cumulative errors and

(2) Compenasting errors. time mistakes are also classified as third category or errors.

- ❖ The cumulative errors are those which occur in the same direction and tend to add up. The compensating errors those which are liable to occur in either and hence tend to compensate. Cumulative errors are serious as they make the apparent measurements too long short. Compensating errors do not affect the measurements that much.
- ❖ *The causes of errors may be the following :*

1. Wrong length of the chain or tape
2. Defective ranging.
3. Careless holding and marking.
4. Not straightening the chain.
5. Undulating and sloping ground.
6. Sag in the chain or Tape.
7. Variation in pull.
8. Variation in pull.
9. Personel mistakes.

Type correction :

1. Correction for absolute length or standardization.
2. Correction for temperature.
3. Correction for pull or tension.
4. Correction for sag.
5. Correction for slope.

1. Correction for absolute length or standardization :

- ❖ If the actual length of tape or chain is not equal to its nominal length, the correction will have to be applied to the length of the line. When chain is too short the measured dittance of the line is too long and correction to be applied will be minus or negative. Reverse is the case when chain is too long. The correction for he measured lnegth is as follows

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

where C_a = Correction for absolute length

L = Measured length of the line

l = Nominal length of the tape or chain

C = Correction to the tape or chain.

- ❖ The sign of C_a will be same as that of C . L and l must be xpressed in same units. Similarly C_a and C

must also carry the same unit.

2. Correction for temperature :

- ❖ Since temperature change causes change in the length of the tape, correction have to be applied to the distance measured. Rise in temperature causes increase in length of the tape and consequently, measured distances are too small and correction becomes positive. Similarly fall in temperature cause decrease in length and consequently, measured distance become too longer. In this case correction will be negative. Correction for temperature is computed from following formula

$$C_t = a (T_m - T_0)L$$

where C_t = Correction for temperature

a = Coefficient of thermal expansion

T_m = Mean temperature during measurements

T_0 = Standard temperature for the tape or chain

L = Measured length in metres.

C_t will be + ve if $T_m > T_0$ and - ve if $T_m < T_0$. Units of C_t and L are the same.

3. Correction for pull or tension :

- ❖ The correction to the measured length of a line has to be applied when the pull used during measurements is different from that at which tape is standardized. When less than standard pull in applied length of tape will be too short and measured length with it will be too long and correction to be applied will be - ve. Reverse is the case when applied pull during measurements is more than the standard pull. Correction for the pull is computed as follows

$$C_p = \left(\frac{P - P_0}{AE} \right) \times L$$

where P = Pull applied during measurement (kg)

P_0 = Standard pull (kg)

A = Cross-sectional area of tape in cm^2

E = Modulus of elasticity of the steel (kg/cm^2)

The value of E for steel may be taken $21 \times 10^6 \text{ kg}/\text{cm}^2$

L = Measured length in metres.

C_p will be + ve if $P > P_0$ and - ve if $P < P_0$.

C_p will have the same unit as that of L .

4. Correction for sag :

- ❖ When a tape or chain is stretched in air and supported on two points, the unsupported length of the tape takes the form of a catenary. Catenary curve is assumed parabolic for all purposes. the distance measured along the catenary curve will be more than the horizontal distance between support points. The difference between horizontal distance and the distance measured along the catenary is known as 'sag correction'. This correction is computed from formula

$$C_a = \frac{l_1^2 (wl_1)^2}{24P^2}$$

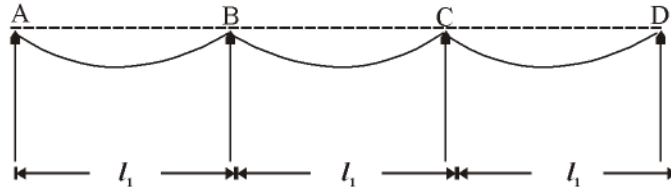
where l_1 = the distance between supports in metres

w = Weight of the tape in kg per metre

P = Applied pull in kg

C_s = Sag correction for single span in metres

wl_1 = Weight of the tape suspended between the supports



- ❖ If there are n equal spans per tape length, the sag correction per tape length is given by

$$C_s = \frac{nl_1(wl_1)s}{24P^s}$$

$$= \frac{l(wl_1)^2}{24P^s} = \frac{l(wl)^s}{24n^2P^s}$$

l is the length of the full tape = $n l_1$, or $l_1 = \frac{l}{n}$.

- ❖ The above said formulae for sag are applicable where both the supports are at the one level. The correction for sag is always of negative sign.

NORMAL TENSION :

- ❖ We have discussed both correction for pull and correction for sag. Both the corrections are opposite in sign to each other. Extra pull tends to increase the length of the tape and decreases the measured length than the actual length of the line. On the contrary extra sag shortens the length of the tape, and increases the measured length. The normal tension is the pull which when applied to the tape equalizes the correction due to sag and correction due to pull. Both corrections being opposite in sign cancel each other and the net effect on chain length becomes zero. Normal tension can be obtained by equating the correction for pull and correction for sag

Corrections for pull = $\frac{(P_a - P_0)}{AE}$ (additive)

Correction for sag = $\frac{l_1(wl_1)^2}{24P_n^2}$ (subtractive)

P_n is the normal tension in kg. $\frac{(P_a - P_0)}{AE} = \frac{l_1(wl_1)^2}{24P_n^2}$

or $(P_n - P_0)P_n^2 = \frac{l_1(wl_1)^2 AE}{24l_s} = \frac{W^2 AE}{24}$

$$P_n = \frac{0.204W\sqrt{AE}}{\sqrt{P_n - P_0}} \quad \dots(1)$$

W = Weight of the tape or chain supported between the two supports.

Value of P_n can be computed by trial and error from (1) above.

5. Correction for slope :

- ❖ The distance measured along the slope is always more than the horizontal distance. Hence correction for slope is always subtractive i.e. - ve.
- ❖ If L is the inclined measured distance and h the difference in elevation of the ends of the line, the slope correction C_l is given as follows

$$C_l = L - \sqrt{L^2 - h^2} = L - L \left(1 - \frac{h^2}{2L^2} - \frac{h^4}{8L^4} \dots \right)$$

$\frac{h^4}{8L^4}$ is neglected being very small.

$$\text{Hence } C_1 = \frac{h^2}{2L}$$

- ❖ If instead of difference in elevation of end points, the slope is given in terms of vertical angle, the correction for the slope is found as follows

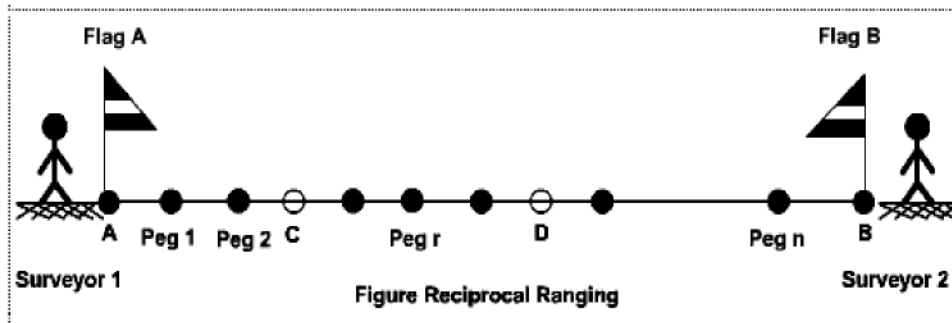
$$\begin{aligned} C_1 &= L - L \cos \theta = L (1 - \cos \theta) \\ &= 2L \sin^2 \frac{\theta}{2} \quad ; = L \text{ versing } \theta. \end{aligned}$$

MEASUREMENT OF HORIZONTAL DISTANCE :

- ❖ In surveying there are several methods for measurement of distance. These are
 1. Direct methods :
 2. Optical methods; and
 3. Electronic method.
- ❖ In any work, the choice of a method depends on many factors like field condition, accuracy required, availability of resources (instruments, time, skill, fund etc). Table summarizes the principal methods, instrument required, precision, use, errors of measurement of distance.
- ❖ **Direct methods** : When the distance between points / stations are measured directly, usually by using tape, is known as direct method.
- ➔ **Ranging** :
 - ❖ When the distance to be measured is more than a tape length, a straight line is required to be laid between the points/ stations along which measurements are to be carried out. The process of laying out a straight line between points is known as ranging.
 - ⊛ Direct Ranging
 - ⊛ Indirect Ranging
- ➔ **Direct Ranging** :
 - ❖ When the end stations are inter visible, ranging is being carried out directly. The intermediate points are placed at distances having interval less than one tape length. The intermediate points are found by moving a ranging pole in transverse direction and thus, points are selected in such a way that the end points and the intermediate points lie in a straight line. In this method, two flags, one ranging pole and a bunch of pegs are required in a team of at least one surveyor and one assistant.
- ➔ **Indirect Ranging** :
 - ❖ When the end stations between which a straight line is to be laid, are not inter visible, indirect method of ranging is being adopted. It is being carried out either by reciprocal method or by random line method.
 1. Reciprocal Ranging
 2. Random Line Method

Reciprocal Ranging :

- Given Figure shows the field operations involved in reciprocal ranging. Let A and B are the two end points whose distance is required to be found and are not inter visible. To fix the intermediate points in a straight line between these points, two more points say C and D are chosen in such a way that D & B are visible from C and C & A from D. Then, direct ranging is being carried out alternatively along DCA and CDB for a number of times so that ACDB lie in a straight line.



Ranging by Random Line Method :

$$BR = \sqrt{BQ^2 + QR^2}$$

$$XX_1 = \frac{QR}{BQ} \times BX$$

$$YY_1 = \frac{QR}{BQ} \times BY$$

- In this method, (Figure) a random line such as BQ is being laid such that R is visible from Q. A perpendicular QR is being erected at Q and measure its distance. Then the desired distance BR is being calculated using distance formula.
- In laying the line BR, intermediate points are established first. These are laid by taking offset from the random line at distances calculated by using the method of similar triangle such as
- After locating the intermediate points on the line BR, the obstructions get cleared to make the end points intervisible. Then, direct ranging is being carried out to obtain an extended continuous straight line.

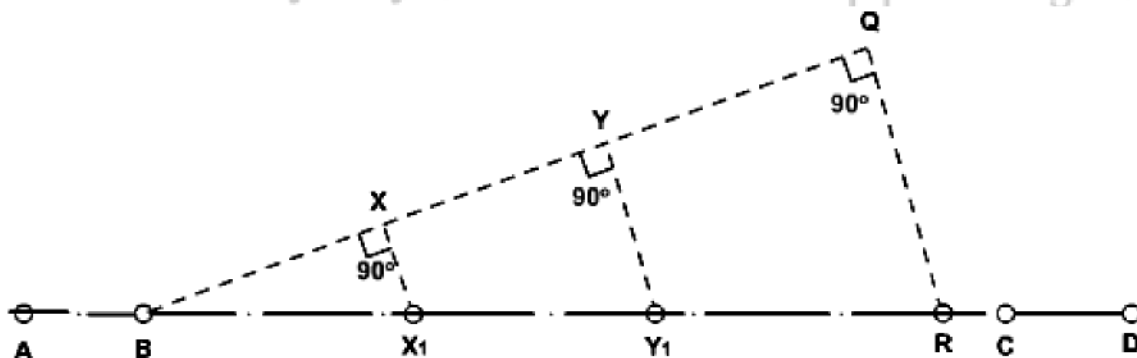


Figure Ranging by Random Line Method

TAPING :

- Taping involves measurement of the distance with tapes (steel/linen), either by placing it on the ground or sometimes by getting it suspended between points. Additional equipments employed during taping are plumb bob, the hand level, pegs/ pins and range pole (or flag or ranging rod) etc. The precision of distance measured with tapes depends upon the degree of refinement with which measurements are taken.

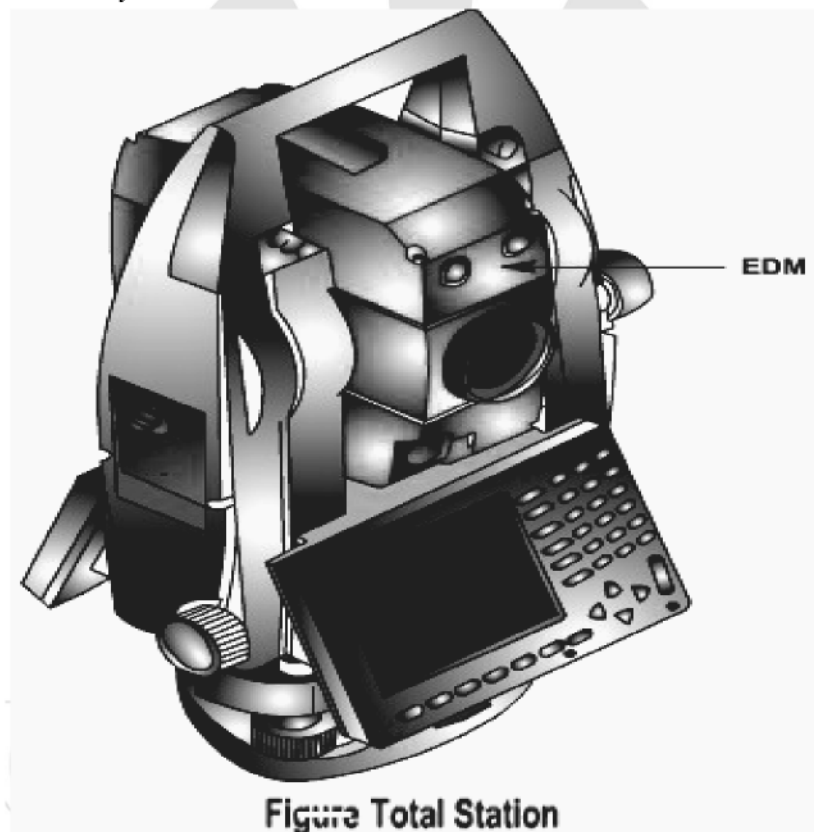
Mistakes in Taping :

- ❖ During taping, mistakes generally made by individuals (usually inexperienced) are:
 1. Adding or dropping a full length of tape
 2. Adding or dropping a part of the length of tape
 3. Other points incorrectly taken as 0 or 30 meter marks on tape
 4. Reading numbers incorrectly
 5. Calling numbers incorrectly or not clearly

USING ELECTRONIC INSTRUMENTS :

1. EDM Instrument :

- ❖ It is usually an integrated unit called EDM (Electronic distance - measuring instrument) consisting of an electro-wave generator, an oscillator, a modulator, a transmitter, and a receiver etc. The type, range and accuracy of an EDM instrument depend on the type of carrier waves it can generate and subsequently can transmit, receive and analyze



- ❖ An EDM instrument generally gets mounted in the framework of an electronic theodolite. The net result is a single instrument termed as total station which can be used to measure all the fundamental measurements involved in surveying.
 - ❖ The basic principle of EDM instrument is the determination of time required for electro-magnetic waves to travel between two stations. Here the velocity of electro-magnetic wave is the basis for computations of the distance.
- #### **2. Reflector :**
- ❖ It consists of one or more corner cube prisms in which the sides are perpendicular to each other in order to get back incident light reflected parallel to it self.

EXAMPLES AND EXPLANATIONS

Example: Using Prismoidal Rule calculate the volume of a 5 m deep pit whose top and bottom dimensions are respectively 10 m × 20 m and 20 m × 40 m.

Sol. Since in Prismoidal Rule ordinates required should be even but here ordinates provide are even so take the average of the sides and then calculate the area.

$$A_1 = 10 \times 20 = 200 \text{ m}^2$$

$$A_2 = 20 \times 40 = 800 \text{ m}^2$$

$$A_m = \left(\frac{10+20}{2} \right) \left(\frac{20+40}{2} \right) = 450 \text{ m}^2$$

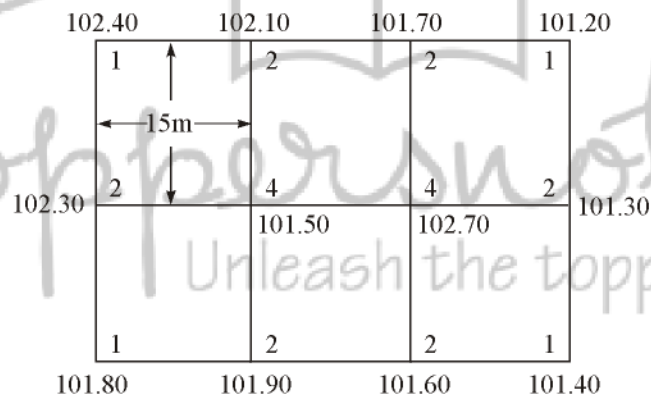
$$V = \frac{h}{3} [A_1 + 4A_m + A_2]$$

$$V = \frac{2.5}{3} [200 + 4 \times 450 + 800]$$

$$V = \frac{2.5}{3} \times 2800$$

$$V = 2333.33 \text{ m}^3$$

Example: Figure shows the existing ground levels on a 15 m square grid for a plot of land which is to be excavated to a uniform formation level of 100.00. Calculate the volume of earth required to be excavated.



Sol. Number of times a particular corner height is used in various squares is marked in the circles.

$$\Sigma h_1 = 2.40 + 1.20 + 1.80 + 1.40 = 6.80$$

$$\Sigma h_2 = 2.10 + 1.70 + 2.30 + 1.30 + 1.90 + 1.60 = 10.90$$

$$\Sigma h_3 = 0$$

$$\Sigma h_4 = 1.50 + 2.70 = 4.20$$

$$V = \frac{A}{4} (\Sigma h_1 + 2\Sigma h_2 + 3\Sigma h_3 + 4\Sigma h_4)$$

$$= \frac{(15 \times 15)}{4} (6.80 + 2 \times 10.90 + 0 + 4 \times 4.20)$$

$$= 2553.75 \text{ m}^3$$

Example: A plan of an old survey plotted to a scale of 10m to 1 cm carried a note stating that, the chain (20m) used was 0.8 links (16 cm) too short. It was also found the the plan had shrunk so that a line originally 10 cm long was 9.77 cm. The area of a plot on the available plan was found to be 58.2 cm². What is the correct area of the plan in hectares.

Sol. Scale of plan = 1 cm : 10 m

$$\therefore \text{R.F.} = 1 : 1000$$

The chain was 0.8 links or 16 cm short in 20m so actual length of chain was 19.84m.

Plan has shrunk into a ratio of 10 cm \Rightarrow 9.77 cm

Available area is \Rightarrow 58.2 cm² which is shrunk area

$$\text{So actual area before shrunk} = 58.2 \times \left(\frac{10}{9.77}\right)^2 = 58.2 \times 1.04 = 60.99 \text{ cm}^2$$

But the chain was 16 cm short as its length was 19.84 m instead of 20 m and the scale is 1: 1000

$$\text{So actual area measured on ground is} = 60.99 \times (1000)^2 = 60.99 \times 10^6 \text{ cm}^2$$

$$1\text{m} = 100 \text{ cm}$$

$$1\text{m}^2 = 10^4 \text{ cm}^2$$

$$\text{Hence } 60.99 \times 10^6 \text{ cm}^2 = 6099 \text{ m}^2$$

But as the chain was 16 cm short which was used

\therefore Its length was 19.84 m instead of 20 m.

$$\text{Corrected area} = 6099 \times \left(\frac{19.84}{20}\right)^2 = 6001.8 \text{ m}^2$$

$$1 \text{ hectare} = 10^4 \text{ m}^2$$

Corrected area of plan = 0.60018 hectare

Alternately

$$\text{Correct area on map} = \left[\frac{\text{measured area}}{(\text{SF})^2} \right] \times \left(\frac{l'}{l} \right)^2$$

$$\text{SF} = \frac{9.77}{10} = 0.977$$

$$l' = (2000 - 16)\text{cm} = 19.84\text{m}$$

$$l = 20\text{m}$$

$$\Rightarrow \text{Correct area on map} = \frac{58.2}{(0.977)^2} \times \left(\frac{19.84}{20}\right)^2$$

$$\text{Correct area on ground} = \text{correct area on map} \times \frac{1}{(\text{scale})^2} = \frac{58.2}{(0.977)^2} \times \left(\frac{19.84}{20}\right)^2 \times (1000)^2 \text{ cm}^2$$

$$= 0.600 \text{ hec}$$