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BPSC - AE

ASSISTANT ENGINEER

Civil Engineering

Bihar Public Service Commission

Volume - 3

Surveying

SIERRA INNOVATIONS

Table of Content

1 CHAPTER

Surveying Principle's

THEORY

Definition of Surveying

- Suveying is the science or art of miking the measurements necessary to determine or establish the relative positions of points. The points may be on, above or below the urface 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 Suveying

- 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 negected. 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 trigonmetrical 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. boundries of districts, States, Municipalities and even countries are fixed by this survey.

(2) Astronomical Survey.

(3) Marine or Navlgation 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 aiready fixed. The two measurements from reference points may e (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 accumu-lation of error and to control and localise the minor errors.

(1) Engineer's scale :

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

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

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

(3) Graphical scale :

❖ The scale may be represented on the plane graphically. It should e repreented 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 consist of a line divided into suitable number of equal parts or unit. The firt part is ubdivided into smaller part. Plain cales represent either two units or a unit and it sub-division such as metres and decimetres miles and furlongs, units and tenths etc.

Diagonal Scale :

❖ Diagonal scale is ued to read three dimensions such as metres, decimetres and centimetres, units tenths and hundredths, yard, fect and inches, etc.

❖ The principle of construction of a diagonal scale is based upon the fact that similar triangles have their like sides proportional.

Compartive Scales

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

Vernier Scale

❖ Vernier scales are used to reade very small units with great accuracy. Vernier scale consists of two parts– a primary scale and a verniter. The primary scale is nothing but plain scale fully divided into minot divisions.

Types of Verniers

❖ Veriner may be divide into two classes

1. Direct and
2. Retorgrade.

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 o (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.) = $s - v = s - \left(\frac{n-1}{n}\right)s = \frac{8}{n}$. Thus L C. division by total number of divisions on the vernier. Least count of the vernier i 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 reain scale. I it 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 fine the shrunk scale of the plane so that plane 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 corrsponding distance on the map as calculated from the given scale or R.F. The ratio of the shrunk length to the true length is knwon as the shrinkage factors which is obviously les than unity. The shrun scale is then obtaines as follows.
- Shrunk scale=shrinkage factor × 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 observa-tions, 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 plan-ning 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 dis-crepancy may be small, yet the error may be large. Diserepancy 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 ERTORS :

1. Natural errors.
2. Instrnmental 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 venier 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 m^2?

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

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

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

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 he 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.

□□□

OBJECTIVE QUESTIONS

1. The required slope correction for a length of 60m, along a gradient of 1 in 20 is: **[GATE-1990]**

(a) 7.50 cm (b) 0.750 cm

(c) 75.0 cm (d) 5.50 cm

2. Systematic errors are those errors **[GATE-1990]**

(a) whose effects are cumulative and can be determined

(b) on circumference of circumscribing circle

(c) outside the great triangle

(d) in the centre of the circumscribing circle

3. The length of a base line measured on ground at an elevation of 300metres above mean sea level is 2250 meters. The required correction to reduce to sea level length, (given the radius of earth is 6370 km) is _____ **[GATE-1991]**

4. It is required to produce a small-scale map of an area in magnetic zone by directly plotting and checking the work in the field itself. Which one of the following surveys will be most appropriate for purpose? **[IES-1995]**

(a) Chain (b) Theodolite

(c) Plane table (d) Compass

5. The sensitieness of a bubble tube in a level would decrease if **[IES-2001]**

(a) the radius of curvature of the internal surface of the tube is increased

(b) the diameter of the tube is incerased

(c) the length of the vapour bubble is increased

(d) the viscosity of the liquid is increasesd

6. Which one of the following surveys is employed for collecting sufficinet data in connection with sewage disposal and water supply works? **[IES-2002]**

(a) Topographic survey

(b) Cadastral survey

(c) Geodetic survey

(d) Cross-sectioning and profile levelling

7. Match List-I (Type of survey) with List-II (Purpose) and select the correct answer using the codes given below the lists: **[IES-2004]**

List-I

A. Topographical survey

B. Reconaissance survey

C. Cadastral survey

D. Archaeological survey

List-II

1. To determine boundaries of fields, houses, etc.

2. To fine relics of antiquity

3. To determine natural features of a country

4. To determine possibility and rough cost of the surveying system to be adopted

Codes:	**A**	**B**	**C**	**D**
(a)	3	4	1	2
(b)	3	1	4	2
(c)	2	4	1	3
(d)	2	1	4	3

8. The plan of a map was photo copied to a reduced size such that a line originally 100 mm, measures 90 mm. The original scale of the plan was 1 : 1000. The revised scale is **[GATE-2007]**

(a) 1 : 900 (b) 1 : 1111

(c) 1 : 1121 (d) 1 : 1221

9. The plan of a survey plotted to a scale of 10m to 1 cm is reduced in such a way that a line originally 10cm long now measures 9 cm. the area of the reduced plan is measured as 81 cm^2. The actual area (m^2) of the survey is **[GATE-2008]**

(a) 10000 (b) 6561
(c) 1000 (d) 656

10. The survey in which the earth curvature is also considered is called **[GATE-2008]**

(a) Geodetic survey
(b) plane survey
(c) preliminary survey
(d) topographical survey

11. Which one of the following conditions requires geodetic surveying? **[IES-2009]**

(a) Horizontal curve ranging
(b) Vertical curve ranging
(c) Survey of a country
(d) Reconnaissance survey

12. The subtense tacheometry method is adopted when the ground is **[IES-2012]**

(a) Flat (b) Inclined
(c) Undulating (d) A waterbody

13. Which one of the following statements is correct? **[IES-2013]**

(a) In a retrograde vernier, (n –1) divisions on the primary scale are divided into n divisions on the vernier scale
(b) A double vernier consists of two simple verniers placed end-to-end forming one scale with the zero in the centre
(c) In an extended vernier, (2n +1) primary divisions are divided into n divisions on the verner
(d) In a direct vernier, (n+1) primary divisions are divided into n equal divisions on the vernier scale.

14. The survey carried out to delineate natural features, such as hills, rivers, forests and man-made features, such as towns, villages, buildings, roads, transmission lines and canals is classified as **[GATE-2014]**

(a) engineering survey
(b) geological survey
(c) land survey
(d) topographic survey

15. ***Assertion (A) :*** Multistage imaging refers to viewing a given area in several narrow bands.

Reason (R) : Multistage imaging is also called spatial resoultion. **[IES-2014]**

(a) both A and R are individually true and R is the correct explanation of A
(b) both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

16. Which of the following scales is the largest one

(a) 1 cm = 50 m (b) 1 : 42 000
(c) RF = 1/300 000 (d) 1 cm = 50 km

17. The shrinkage factor of an old map is 24/25 and the RF of original map is 1/2400, then the corrected scale for the map is

(a) 1/2400 (b) 1/2500
(c) 1/600 (d) 1/60000

18. The RF of scale 1 cm = 1 km is

(a) 1/100000 (b) 1/10000
(c) 1/100 (d) 1/10

19. The smallest length that can be drawn on a map is

(a) 0.25 mm (b) 0.5 mm
(c) 10 mm (d) 15 mm

20. The main plate of a transit is divided into 1080 equal divisions. 60 divisions of the vernier coincide exactly with 59 divisions of the main plate. The least count (in seconds) of the transit is

(a) 5 (b) 10
(c) 15 (d) 20

21. The difference in the length of an arc and its subtended chord on earth's surface for a distance of 18.5 km is about

(a) 0.1 cm (b) 1.52 cm
(c) 10 cm (d) 100 cm

22. Surveys which are carried out to provide a national grid of control for preparation of accurate maps of large areas are known as

(a) Plane surveys
(b) Geodetic surveys
(c) Geographical surveys
(d) Topographical surveys

23. Surveys which are carried out to depict mountains, water bodies, woods and other details are known as

(a) Cadastral surveys

(b) City surveys

(c) Toporaphical surveys

(d) Hydrographic surveys

24. The effect of the curvature of the earth's surface is taken into account only if the extent of surveys is more than

(a) 100 km^2 (b) 260 cm^2

(c) 195.5 km^2 (d) 300 km^2

25. Match the following:

Section-I

(I) Topographical survey

(II) Cadastral surveys

(III) City survey

(IV) Engineering surveys

Section-II

(A) To determine the natural features of a country such as hills, valley, rivers, nuallas, lakes, woods, etc.

(B) To survey for the features such as roads, railways, cannals, buildings, towns, villages, etc.

(C) To locate the boundaries of fields, houses, etc

(D) To determine quantities and for collection of data for road, railways, reservoirs, sewerage, water supply scheme, etc.

(E) For laying out plots and construction streets, water supply systems and sewers.

(a) I–A and B, II–C, III–E, IV–D

(b) I–C, II–A and B, III–C, IV–E

(c) I–D, II–A and B, III–C, IV–E

(d) I–B, II–C, III–A, IV–D and E

26. Surveying is the art of determining the relative positions of points on, above or beneath the surface of the earth, with respect to each other, by the measurement of

(i) distance

(ii) directions

(iii) elevations

(a) (i), (ii), (iii) are required

(b) only (i) is required

(c) only (ii) required

(d) only (iii) is required

27. The main principle of surveying is to work from

(a) higher level to the lower level

(b) lower level to the higher level

(c) part to whole

(d) whole to part

28. The error which occurs while conducting the survey from whole to part and part to whole is

(a) same

(b) in whole to part, it is localized and in part to whole it is expanded

(c) in whole to part it is expanded and in part to whole it is localized

(d) in both the methods error is localized

29. A point R can be located by the two control points P and Q by

(i) measuring PR and QR from P and Q, measure distance of R and plot

(ii) dropping a perpendicular from R on PQ, meeting the line in S, measure PS, SQ and plot

(iii) distance QR and angle a between QR and QP

(a) only (i) is correct

(b) by (i) and (ii) both

(c) by (i), (ii) and (iii)

(d) by none of them

30. The objective of a survey is to

(i) prepare a plan or map

(ii) determine the relative position of points

(iii) determine position of points in a horizontal plane

(iv) determine position of points in a vertical plane

(a) only (i) is correct

(b) only (i) and (ii) are correct

(c) (i), (ii), (iii), (iv) all are correct

(d) none of them are correct

❍❍❍

ANSWERS EXPLANATIONS

1. ***Ans. (a)***

Angle of sloping ground is $= \tan^{-1}(0/20) = 2.86°$

Horizontal distance $= 60 \times \cos 2.86$

slope correction is $= 60 - (60 \times \cos 2.86)$

$= 0.075\text{m} = 7.5\text{cm}$

2. ***Ans. (a)***

Systematic errors are positive or negative whose effect can be determined.

3. ***Ans. 0.1 m***

msl correction $= Lh/R$

$= (300 \times 2250) / (6370 \times 1000) = 0.1\text{m}$

4. ***Ans. (c)***

5. ***Ans. (d)***

6. ***Ans. (d)***

7. ***Ans. (a)***

8. ***Ans. (b)***

Original length of a line, L = 100 mm Shrunk length,

$$L^1 = 90 \text{ mm}$$

$$\text{Shrinkage ratio} = \frac{L^1}{L} = \frac{9}{10}$$

Shrunk scale = original scale × Shrunk ratio

$$= \frac{1}{1000} \times \frac{9}{10} = \frac{1}{1111}$$

9. ***Ans. (a)***

Shrinkage ratio,

$$SR = \frac{9\text{cm}}{10\text{cm}} = 0.9$$

reduced area $= 81 \text{ cm}^2$

$$\text{Actual area} = \frac{81}{(0.9)^2} = 100\text{cm}^2$$

Actual area in the field

$= 100 \times 10 = 10000 \text{ m}^2$

10. ***Ans. (a)***

In geodetic survey earth curvature is also considered.

11. ***Ans. (c)***

Geodetic surveying is the type of surveying in which the curvature of the earth is taken into consideration and a very high standard of accuracy is maintained. It is used for large areas like survey of a country.

12. ***Ans. (a)***

13. ***Ans. (b)***

14. ***Ans. (d)***

15. ***Ans. (c)***

Multistage imaging is composed of more than one spectral band and each band represents specific wavelength. Multistage imaging is also called temporal resolution.

16. ***Ans. (a)***

17. ***Ans. (b)***

18. ***Ans. (a)***

19. ***Ans. (a)***

20. ***Ans. (d)***

21. ***Ans. (b)***

22. ***Ans. (d)***

23. ***Ans. (c)***

24. ***Ans. (c)***

25. ***Ans. (a)***

26. ***Ans. (a)***

27. ***Ans. (d)***

28. ***Ans. (b)***

29. ***Ans. (c)***

30. ***Ans. (c)***

❍❍❍

2 CHAPTER Distance Measuring Instruments

THEORY

Measurement of Distance :

- The verious methods of measuring the distances are listed as folows.
  1. Packing
  2. Passometer
  3. Pedometer
  4. Odometer
  5. Speedometer
  6. Perambulator
  7. Chaining.

Measureing 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 atached 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 :

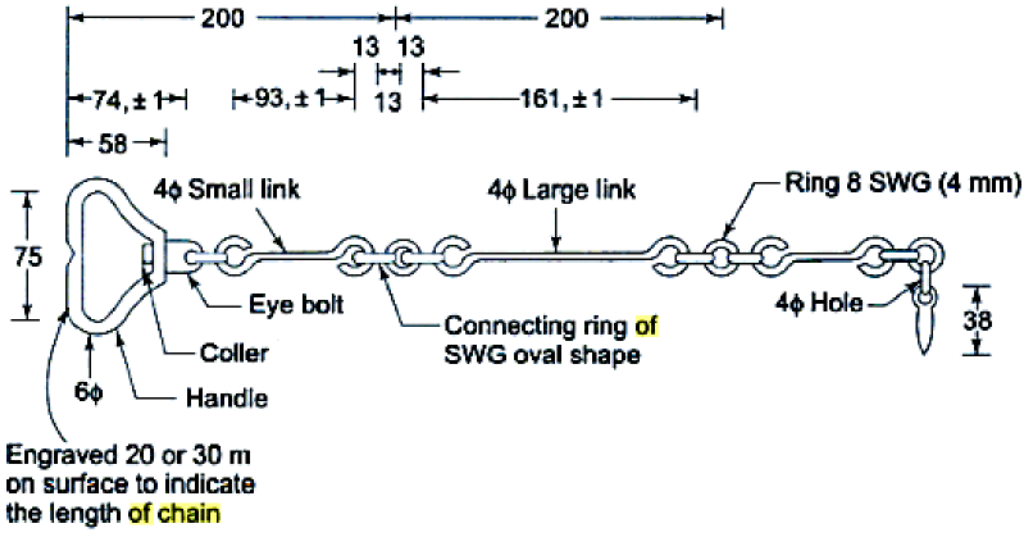
- It is also sometimes referred as surveyor's chain. It is 66 ft. long and is divided into 100 links each link being 0.66 ft. It is very convenient for measuring the distances in miles and furlonges. It is equally convenient where area to be measured is in acres. System of tags is similar to that explained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

3. Revenue chain :

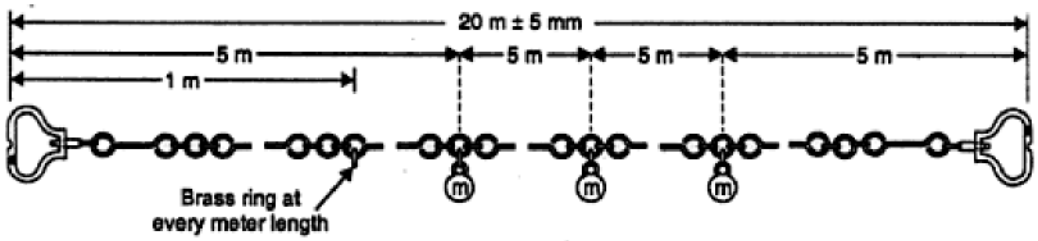
❖ This chain is 33 ft long and has 16 links. It is used for measuring fields in cadastral survey.

4. Metric chain :

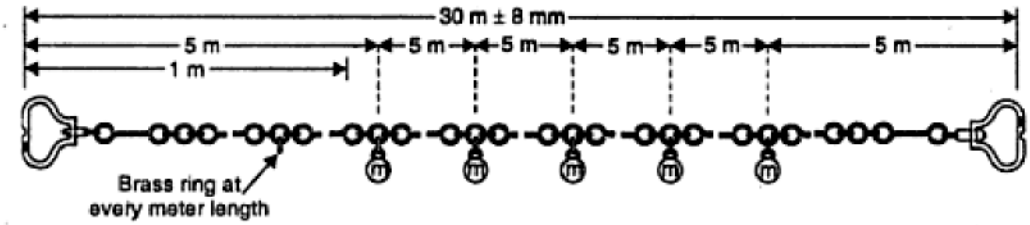
❖ Metric chains are used for survey work in India. The metric chains are available in lengths of 5,10, 20 and



Details of a metricchain.



20 m chain.



30 cm 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. Howver, it may be used for taking subsidiary measure-ments lise ofsets. 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 conductd with a very high degree of precision as in measure-ment of base lines in triangulation. Invar is an alloy of steel and nickel and has very low coefficient of thermal expansion (0.0000005 per °F) Because of low coefficient of the thermal expansion, effect of temperature chage on the length of the rape is almost negllgible.

ARROWS :

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

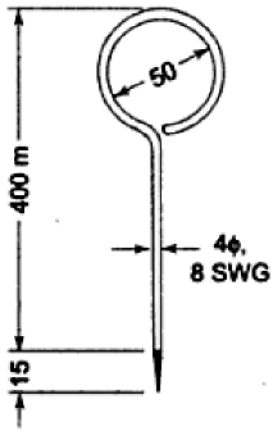


Fig. : Arrows.

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

PEGS :

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

RANGING RODS :

❖ Ranging rods are used for marking the positions of inter-mediate 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 willl 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 errorneous 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 ditance 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 chage 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 nega-tive. Correction for temperature is computed from following formula

$$C_i = a\ (T_m - T_0)L$$

where C_t = Correction for temperature

a = Coefficient of thermal expansion

T_m = Mean temperature during measurements

T_b = Standard temperature for the tape or chain

L = Measured length in metres.

C_t will be + ve if $T_m > T_b$ 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. Rverse 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 21×10^6 kg/cm^2

L = Measured length in inetres.

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 strtched 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 puoposes. the distance measured along the catenary curve will be more than the horizontal distance between support points. The difference between hoirziontal distance and the distance measured along the catenary is known as 'sag correction'. This correction is computed from formula

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

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