RPSC 2024

Rajasthan Public Service Commission

Assistant Engineer

CIVIL ENGINEERING

Surveying and Field Engineering

MADE EASY PUBLICATIONS

CONTENTS

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FUNDAMENTAL CONCEPTS OF SURVEYING

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Surveying is the art of determining the relative positions of points on, above or beneath the surface of the earth by means of direct or indirect measurements of distance, direction and elevation. It also includes the art of establishing points by predetermined angular and linear measurements.

Surveying can be divided into two classes:

1. Plane surveying
2. Geodetic surveying

PLANE SURVEYING

- Plane surveying is that type of surveying in which the mean surface of the earth is considered as a plane and the spheroidal shape is neglected.
- All triangles formed by survey lines are considered as plane triangles.

Do you know?

The length of an arc 12 kilometers long lying in the earth's surface is only 1 cm greater than the subtended chord and further that the difference between the sum of the angles in a plane triangle and the sum of those in a spherical triangle is only one second for a triangle at the earth's surface having an area of 195 sq. km.

GEODETIC SURVEYING

- Geodetic surveying is that type of surveying in which the shape of the earth is taken into account. All lines lying in the surface are curved lines and the triangles are spherical triangles.

Do you know?

All geodetic surveys include work of larger magnitude and high degree of precision. The object of geodetic survey is to determine the precise position on the surface of the earth, of a system of widely distance points which form control stations to which surveys of less precision may be referred.

CLASSIFICATION

- Surveys may be classified under headings which define the uses of purpose of the resulting maps.

Classification Based Upon the Nature of the Field Survey

1. Land Surveying
   - (i) Topographical surveys
   - (ii) Cadastral surveys
   - (iii) City surveying
2. Marine or Hydrographic Survey
3. Astronomical Survey

Classification Based on the Object of Survey

1. Engineering Survey
2. Military Survey
3. Mine Survey
4. Geological Survey
5. Archaeological Survey

Classification Based on Instruments Used

An alternative classification may be based upon the instruments or methods employed, the chief types being:

1. Chain survey
2. Theodolite survey
3. Traverse survey
4. Triangulation survey
5. Tacheometric survey
6. Plane table survey

7. Photogrammetric survey
8. Aerial survey

Units of Measurements

There are four kinds of measurements used in plane surveying:

1. Horizontal distance
2. Vertical distance
3. Horizontal angle, and
4. Vertical angle

Linear Measures

- According to the standards of weights and measures act (India), 1956 the unit of measurement of distance is meters and centimeters. Prior to the introduction of metric units in India, feet, tenths and hundredths of a foot were used.

Do you know?

*(i) Earth is an **Oblate spheroid***

*(ii) Polar axis of earths is shorter than Equatorial axis by **42.95 kilometers.***

*(iii) **Level line:** Line curved like earth surface obtained from joining points perpendicular to plumb line.*

Basic Units of Angular Measure

- An angle is the difference in directions of two intersecting lines. The radian is the unit of plane angle. The radian is the angle between two radii of a circle which are cut-off on the circumference of an arc equal in length to the radius. There are three popular systems of angular measurements:
  1. Sexagesimal system
     - 1 circumference = 360° (degree of arc)
     - 1 degree = 60' (minutes of arc)
     - 1 minute = 60'' (seconds of arc)
  2. Centesimal system
     - 1 circumference = 400^g (grades)
     - 1 grade = 100^c (centrigrades)
     - 1 centrigrade = 100^{cc} (centi-centegrades)
  3. Hours system
     - 1 circumference = 24^h (hours)
     - 1 hour = 60^m (minutes of time)
     - 1 minute = 60^s (seconds of time)

Do you know?

- *The hours system is mostly used in astronomy and navigation.*
- *The representation is called a map if the scale is small while it is called a plan if the scale is large.*

Scales

- The area that is surveyed is vast and, therefore, plans are made to some scale. Scale is the fixed ratio that every distance on the plan bears with corresponding distance on the ground.

Do you know?

This ratio of map distance to the corresponding ground distance is independent of units of measurement and is called representative fraction. The representative fraction (abbreviated as R.F.) can be very easily found for a given engineer's scale. For example, if the scale is 1 cm = 50 m

$$\text{R.F.} = \frac{1}{50 \times 100} = \frac{1}{5000}$$

Scales Used in Survey

Purpose of survey	Scale Adopted
(a) Topographic Survey	
1. Building sites	$\frac{1}{1000}$ or less
2. Town planning schemes, reservoirs etc.	$\frac{1}{5000}$ to $\frac{1}{10000}$
(b) Cadastral maps	$\frac{1}{500}$ to $\frac{1}{5000}$
(c) Geographical maps	$\frac{1}{5,00,000}$ to $\frac{1}{160,00,000}$
(d) Longitudinal sections	
1. Horizontal scale	$\frac{1}{1000}$ to $\frac{1}{20,000}$
2. Vertical scale	$\frac{1}{100}$ to $\frac{1}{200}$
(e) Cross-sections	$\frac{1}{100}$ to $\frac{1}{200}$

Types of Scales

Scales may be classified as follows:

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

Plane Scale

- A plain scale is one on which it is possible to measure two dimensions only, such as units and lengths, metres and decimeters, miles and furlongs, etc.

Diagonal Scale

- On a diagonal scale, it is possible to measure three dimensions such as meters, decimeters and centimeters; units, tenths and hundredths; yards, feet and inches etc.

The Vernier

- The principle of vernier is based on the fact that the eye can perceive without strain and with considerable precision when two graduations coincide to form one continuous straight line. The vernier carries an index mark which forms the zero of the vernier.

Do you know?

The fineness of reading or least count of the vernier is equal to the difference between the smallest division on the main scale and smallest division on the vernier.

Types

(a) Direct Vernier

- A direct vernier is the one which extends or increases in the same direction as that of the main scale and in which the smallest division on the vernier is shorter than the smaller division on the main scale. It is so constructed that (n – 1) divisions of the main scale are equal in length to *n* divisions of the vernier.

Let, s = Value of one smallest division on main scale.

v = Value of one smallest division on the vernier.

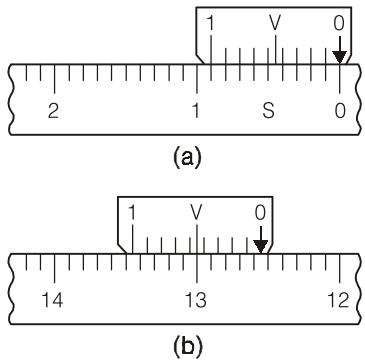
n = Number of divisions on the vernier.

Since a length of (n – 1) divisions of main scale is equal to n divisions of vernier, we have

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

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

$$\text{Least count} = s - v = s - \frac{n-1}{n}s = \frac{s}{n}$$



Direct vernier reading to 0.01

(b) Retrograde Vernier

- A retrograde vernier is the one which extends or increases in opposite direction as that of the main scale and in which the smallest division of the vernier is longer than the smallest division on the main scale. It is so constructed that (n + 1) divisions of the main scale are equal in length to n divisions of the vernier

$$nv = (n+1)\,s;$$

$$\text{or} \qquad v = \frac{n+1}{n}s$$

$$\text{The least count} = v - s$$

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

Do you know?

In the case of astronomical sextant, the vernier generally provided is of extended type having 60 spaces equal to 119 spaces of the main scale, each of 10°, the least count being 10/60 minutes or 10 seconds.

Error Due to Use of Wrong Scale

Correct length,

$$= \frac{\text{R.F. of Wrong scale}}{\text{R.F. of Correct Scale}} \times \text{measured length}$$

Correct area,

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

Shrunk Scale = Shrinkage factor × original Scale.

Theory of Probability

- Investigations of observations of various types show that accidental errors follows a definite law, the law of probability.
- The most important features of accidental errors which usually occur are:

(i) Small errors tend to be more frequent than the large ones; that is, they are more probable.

(ii) Large errors occur infrequently and are improbable.

Probability Curve

- The theory of probability describes these features by saying that the relative frequencies of errors of different extents can be represented by a curve. This curve, called the curve of error or probability curve, forms the basis for the mathematical derivation of theory of errors.

Principal of Least Square

- The most probable value of an observed quantity available from a given set of observations is the one for which the sum of the square of errors (residuals) is a minimum.

Most Probable Value

- The most probable value of a quantity is the one which has more chances of being correct than has any other. The most probable error is defined as that quantity which when added to and subtracted from, the most probable value fixes the limits within which it is an even chance the true value of the measured quantity must lie.
- The probable error of a single observation is calculated from the formula

$$E_s = \pm 0.6745\sqrt{\frac{\Sigma v^2}{n-1}}$$

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

$$E_m = \pm 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}} = \frac{Es}{\sqrt{n}}$$

where,

E_s = Probable error of single observation

V_s = Difference between any single observation and mean of the values.

n = Number of observations of the mean.

Errors in Computed Results

Errors in Addition

Let $s = x + y$

where, x and y are measured quantities.

Probable error $\pm e_s = \sqrt{e_x^2 + e_y^2}$

Errors in Subtraction

Let $s = x - y$

Probable error $\pm e_s = \sqrt{e_x^2 + e_y^2}$

Error in Multiplication

Let $s = x \times y$

error ratio $\frac{\pm e_s}{s} = \sqrt{\left(\frac{e_x}{x}\right)^2 + \left(\frac{e_y}{y}\right)^2}$

Error in Division

Let $s = x/y$

error ratio $\frac{\pm e_s}{s} = \sqrt{\left(\frac{e_x}{x}\right)^2 + \left(\frac{e_y}{y}\right)^2}$

Error in Powers

Let $s = x^n$

Error ratio $\frac{\delta s}{s} = \frac{n\delta x}{x}$

Example:

If $S = 4.88 + 5.367$

Then maximum errors $\delta x = 0.005$

and $\delta y = 0.0005$

and probable error = + 0.0025 and + 0.00025

Hence $\pm e_s = \sqrt{\delta x^2 + \delta y^2}$

Practice Questions : Level-1

Q.1 The smallest scale adopted for topographical surveys is

(a) 1 : 25,000 (b) 1 : 50,000
(c) 1: 2,50,000 (d) 1: 5,00,000

Q.2 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists :

List-I	List-II
A. Geographical map	1. 1 cm = 2.5 km
B. Topographical map	2. 1 cm = 0.25 km
C. Location map	3. 1 cm = 160 km
D. Forest map	4. 1 cm = 5 m to 25 m

Codes:

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

Q.3 Which one of the following is a conventional sign for North Line surveying?

(a)  (b) 
(c)  (d) 

Q.4 Which of the following scales is largest one?

(a) 1 cm = 50 m (b) 1 : 42000
(c) R.F. $= \frac{1}{300000}$ (d) 1 cm = 50 km

Q.5 If the probable error in single observation is ±0.04 m and that of the mean is ±0.01 m, then the number of observations are

(a) 4 (b) 10
(c) 16 (d) 64

Q.6 During the measurement of a line by chain or tape in slopes, if the length of the line is 'l' and the height difference between the ends of the line is 'h', then the correction to the measured length is more than $\frac{h^2}{2l}$ by

(a) zero (b) $+\frac{h^2}{8l^3}$
(c) $+\frac{h^2}{4l^2}$ (d) $-\frac{h^3}{2l^2}$

Practice Questions : Level-2

Q.7 A circle of radius 7 m has a standard error of 0.02 m on the radius. The standard error of its area is

(a) 0.04 m^2 (b) 0.14 m^2
(c) 0.28 m^2 (d) 0.88 m^2

Q.8 The sides of a rectangle are (120 ± 0.05) and (180 ± 0.06) m. The probable error in the area will be

(a) ± 16.8 sq m (b) ± 12.35 sq m
(c) ± 16.2 sq m (d) ± 11.53 sq m

Q.9 Mean sea level at any place is the average datum of the hourly tide heights observed over a period of nearly

(a) 5 years (b) 10 years
(c) 20 years (d) 50 years

Q.10 A survey is conducted with a view to prepare map of an area to a scale of 1 : 1000. If a scale with least count of 0.1 mm is used for plotting, what would be the accuracy in length measurement in the field?

(a) 0.325 m (b) 0.01 m
(c) 0.1 m (d) 1 m

Q.11 The representative friction 1/2500 means that the scale 1 cm is equal to

(a) 0.25 m (b) 2.5 m
(c) 25 m (d) 2.5 km

ANSWERS

1. (c)	2. (b)	3. (d)	4. (a)	5. (c)
6. (b)	7. (d)	8. (d)	9. (c)	10. (c)

Hint & Solution

7. (d)

Area of circle A = πr^2

$\therefore \quad \frac{dA}{dr} = 2\pi r$

If standard error in radius is e_r, then standard error in area,

$e_A = e_r \frac{dA}{dr} = 0.02 \times 2 \times \pi \times 7 = 0.88\ m^2$

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