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Surveying

SIERRA INNOVATIONS

SURVEYING PRINCIPLE'S

THEORY

1.1 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:

1.2 TYPES OF SURVEYING

Primarily Surveying can be divide into two classes

(1) Plane Surveying

(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 extend over small area.

(2) Geodetic Surveying : This method of survey is adopted when large distances and areas are to be covered. In this survey curvature of the earth is considered 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

(a) very large distances and areas.

(b) use of very precise instruments.

(c) use of refined method of observation.

(d) high degree of precision.

1.3 CLASSIFICATION OF SURVEYS

1. Based upon the nature of field of survey

(i) **Land survey :** This survey work is done on the land only. It can be divided into following types.

(a) Topographical surveys

(b) City surveys

(c) 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.

(ii) Astronomical Survey

(iii) Marine or Navigational Surveys

2. Based on the Object of Surveying

(i) Engineering surveys
(ii) Military surveys
(iii) Geological surveys
(iv) Archaeological surveys

3. Based upon the Instruments used

(i) Chain survey
(ii) Compass survey
(iii) Theodolite survey
(iv) Tacheometric survey
(v) Photographic survey
(vi) Aerial survey
(vii) Levelling

4. Based upon the method employed in survey

(i) Triangulation survey
(ii) Traverse survey

1.4 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 localize the minor errors.

1.5 SCALE

(1) **Engineer's scale :** In this method of representation of scale 1 cm on the plane represents some whole number of meters on the ground.

(2) **Representative Fraction (RF) method :** According to this type of scale 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 can be very easily found for any given Engineers 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 clearly visible.

1.5.1 Types of Scales

The scales may be classified under following five heads

(1) Plain Scale : A plain scale consist of a line divided into suitable number of equal parts or unit. The first part is undivided into smaller part. Plain scales represent either two units or a unit and it sub-division such as meters and decimeters miles and furlongs, units and tenths etc.

(2) Diagonal Scale : Diagonal scale is used to read three dimensions such as meters, decimeters and centimeters.

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

(3) Comparative Scales : Scales having same representative fraction but graduated to read different units are called comparative series. Comparative scales may be plain scales or diagonal scales.

(4) 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

(a) 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.

Since n divisions of vernier are equal to (n – 1) divisions of the main scale

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

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

$$\text{Least count (LC)} = s - v = s - \left(\frac{n-1}{n}\right)s = \frac{s}{n}$$

s = value of smallest divisions of main scale.

v = value of smallest divisions on the vernier

n = number of divisions on vernier.

Least count of the vernier is the difference between the smallest division on the main scale and smallest division on the vernier.

(b) Retrograde vernier : In retrograde vernier the length of smallest division on the vernier is longer than the smallest division on the main scale. In 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

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

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

(5) Shrunk Scale : If a graphical scale is not constructed on an old map and map has shrunk, it becomes necessary to refine the shrunk scale of the plane so that plane could be correctly interpreted. Representative fraction 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 representative fraction. The ratio of the shrunk length to the true length is known as the shrinkage factors which is obviously less than unity. The shrunk scale is then obtained as follows

Shrunk scale = shrinkage factor × original scale of the map

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

1.6 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.

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

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

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

1.7 SOME IMPORTANT DEFINITIONS

(1) Accuracy : The degree of perfection obtained in observations, instruments used, and the methods employed, is known as the accuracy. Accuracy depends on the :

(a) Precision of the instruments used

(b) Precision of the methods used

(c) Perfectness of the planning

(d) Perfectness of the observations

(2) Error : The difference between the true value and the measured value of anything 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.

1.8 SOURCES OF ERRORS

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

1.9 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.

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

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

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

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

Solution :

$$\text{Least Count} = \frac{s}{n}$$

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

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

Example 2 : A surveyor measured the distance between two points marked on the plan drawn to a scale of 1 cm = 1m (RF = 1 : 100) and found it to be 50m. Later he detected that he used a wrong scale of 1 cm = 50 cm (RF = 1 : 50) for the measurement.

(a) Determine the correct length.

(b) What would be the correct area if the measured area is 60 m^2 ?

Solution :

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

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

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

Example 3 : 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").

Solution :

$$\text{Least Count} = \frac{s}{n}$$

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.

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