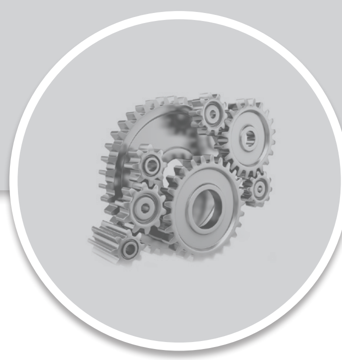
CIVIL ENGINEERING

Surveying and Geology



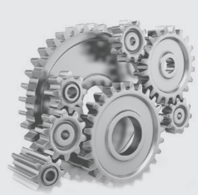
Comprehensive Theory
with Solved Examples *and* Practice Questions

MADE EASY Publications

www.madeeasypublications.org

MADE EASY Publications Pvt. Ltd.
Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016 | **Ph. :** 9021300500
Email : infomep@madeeasy.in | **Web :** www.madeeasypublications.org

Surveying and Geology



EDITIONS

First Edition: 2015
Second Edition: 2016
Third Edition: 2017
Fourth Edition: 2018
Fifth Edition: 2019
Sixth Edition: 2020
Seventh Edition: 2021
Eighth Edition: 2022

Ninth Edition: 2023

CONTENTS

Surveying and Geology

CHAPTER 1

CHAPTER 2

CHAPTER 3

CHAPTER 11

CHAPTER 12

CHAPTER 13

CHAPTER 14

CHAPTER 15

CHAPTER 16

CHAPTER 17

CHAPTER

1

Fundamentals of Surveying

1.1 INTRODUCTION

- Surveying is the science of determining the relative positions of different features on ground, along with their elevations.
- The relative positions are determined by measuring the horizontal distances, horizontal angles, vertical distances and the vertical angles.
- After taking observations in the field, computations are done in office to prepare topographic map or plan of the area.
- These maps or plans are needed for various purposes like computing the volume of earth work, volume of reservoir, finalizing the alignment of canal, railway line or highway and for this, sufficient number of points and lines have to be located on the plan.
- The new developments that would be impossible without accurate surveys include testing equipment like rocket tracks, accelerators for atomic research, as well as control for both position and direction of rockets, intercontinental missiles and space craft.

1.2 OBJECTIVE OF SURVEYING

The objectives of surveying can be stated as follows:

(a) Collect and record data of the relative positions of points on the surface of the earth.

(b) Compute areas and volumes using data collected from survey, required for various purposes.

(c) Prepare the plans and maps required for various activities.

(d) Layout the various engineering works in correct positions.

(e) Check the accuracy of built up structures.

1.3 TYPE OF SURVEY

1.3.1 Classification of Survey Based on Accuracy Desired

(a) Plane Survey: In this type of survey, the mean surface of earth is assumed to be flat and not the curved one. Here, the level lines are regarded as straight lines and the angle between any two such lines is taken as the plane angle and not the spherical angle.

This type of survey is used when the area under consideration is of small extent. (less than 250 km^2).

Almost all surveys for various engineering projects like construction of dams, highways, railway lines, canals etc. use plane survey.

(b) **Geodetic Survey:** In this type of survey, the shape or the curvature of earth is taken into account in order to have a higher degree of precision. Such surveys are required for surveying large areas (more than 250 km^2) and measurements are required to be made with the highest possible order of precision. Here, a line connecting the two points is an arc and not the straight line. This distance between the two points is corrected for curvature and then plotted on the plan. The angle between the two lines is the spherical angle. Thus all this requires a high level of computation work.

Geodetic survey is needed to fix the widely spaced control points that are later on used as necessary control points for fixing the minor control points.

1.3.2 Classification of Survey Based on Place of Survey

(a) **Land Survey:** It is the survey which is being done on land to prepare plans and maps of a given area. It involves running of survey lines and determining their length and directions thereby sub dividing the area into definite shapes and sizes and calculating their areas etc. in order to set up a structure.

(b) **Hydrographic Survey:** It involves survey of water bodies like streams, sea, ponds etc. The basic purpose of this survey is to design water navigation system by determining the shore line. Apart from this, this survey is done to determine the amount of water stored by a water body, water supply, under water construction etc.

(c) **Underground Survey:** This survey is required for construction of tunnels for highways, railways, water transport, mines etc. Here in this survey, transfer of surface line coordinates to the underground line etc. are done.

(d) **Aerial Survey:** This survey is carried out above ground by taking the aerial photographs with cameras fitted to airplanes, helicopters etc. This survey is particularly required for preparing large scale maps of an area, for development of projects in areas where ground survey is difficult or too much time consuming.

1.3.3 Classification of Survey Based on Instrument Used

(a) **Chain Survey:** Here, only the linear measurements are made with a chain (or a tape) and no angular measurements are made. This survey is of limited use, since it requires clear ground without any obstruction like intervening trees, buildings, rivers etc. This survey is particularly useful for laying of sewer lines, water supply lines, construction of roads etc.

(b) **Compass Surveying** : In this survey, horizontal angles are measured with the help of a magnetic compass. Magnetic compass works on the principle that a freely suspended magnetic needle points in the magnetic north-south direction. A compass together with a chain or tape, can be used to survey a given area by many methods such as traversing.

(c) **Leveling:** Here, relative, elevations of different points are determined. A graduated staff and a level are used for this purpose. Almost all projects require determination of the elevation of the different points and this is achieved by leveling.

(d) **Plane Table survey:** In this, survey, observations and plotting are done simultaneously in the field. The advantage of this method is that there is least possibility of omitting any important measurement since the actual field being surveyed is in view on the plot in the field itself. The drawbacks of this method are that it cannot be done in humid or rainy weather and the carrying of plane table apparatus is cumbersome.

(e) **Theodolite Survey:** In this type of survey horizontal and vertical angles are measured with the help of theodolite. A theodolite is a very precise instrument used for measuring horizontal and vertical angles. Theodolite survey can be broadly classified into two types:

(i) Traverse survey

(ii) Triangulation survey

(f) **Triangulation:** This method of survey is used for large areas. The entire area is divided into a network of triangles and any one side of any of the triangles so formed is measured very precisely. This line is referred to as **baseline.** All the angles of the network are measured. The lengths of the sides of the triangles are then computed using the laws of triangles.

(g) **Tacheometry:** Here, in this type of survey, both the horizontal distance and the vertical distance are measured by sighting a graduated staff with a transit telescope fitted with an analytic lens. It is particularly useful when direct measurement of horizontal distances are not possible.

(h) **EDM Survey:** EDM refers to Electronic Distance Measurement and in this method of survey, distances are measured electronically using wave propagation, reflection and subsequent reception of the reflected wave. Some of the examples of EDM instruments are tellurometer, distomat, geodiameter etc.

(i) **Total Station Survey:** Total station is the combination of conventional transit theodolite with EDM instrument. It reads and records the horizontal and vertical distances together with slope distances. This instrument also computes the Cartesian coordinates of the observed points, slope corrections, elevation of remote objects etc. Survey carried out using total station is referred to as total station survey.

(j) **Satellite Survey:** In this method of survey, information about the land or space is determined using satellite based navigation system like the GPS (Global Positioning System). Another method is the Remote Sensing wherein the data about an object is acquired using the sensors placed on satellite.

NOTE Trilateration is the type of triangulation in which all the three sides of each triangle are measured accurately with the help of EDM instrument. Then angles are computed indirectly from the known sides of the triangles.

1.3.4 Classification of Survey based on Purpose

(a) **Geological Survey:** In this type of survey, information about both the surface and sub-surface is acquired for assessing the extent of different reserves like the minerals, rocks etc. It is also used for locating the faults, folds and other unconformities in the ground. This survey helps in determining the type of foundation, soil treatment required etc.

(b) **Geographical Survey:** This survey is done for preparation of geographical maps depicting the land use efficiency, irrigation intensity, surface drainage, slope profile, contours, national boundaries etc.

(c) **Engineering Survey:** This survey is required to be done for acquiring information for the planning and design of engineering projects like the highways, dams, railway line, water supply design, reservoirs, bridges etc. It involves topographic survey of the area, earthwork measurement etc.

(d) **Cadastral Survey:** These are done to establish boundary of properties for legal purposes. These are also called public land survey.

(e) **Defence Survey:** Such surveys are done for military purpose. They provide strategic information for deciding the future course of action. Aerial and topographical maps of the area are prepared which gives crucial information about the existing roads, airports, ordnance depots etc.

(f) **Mine Survey:** This requires both the surface and the underground surveys. It involves making the surface map and doing the underground survey for locating the reserves of minerals.

(g) **Route Survey:** It is a sort of linear survey for deciding the alignment of a highway or a railway.

(h) **Archaeological Survey:** This is done to gather information about the ancient monuments, towns, villages, kingdoms, past civilizations, temples, forts etc. buried underground due to natural forces like earthquakes, landslides, floods etc. It gives an idea about the past history, culture and development of the civilization that existed in the past. These provide vital links on understanding the evolution of the present civilisation as well as human beings.

1.4 PRINCIPLES OF SURVEYING

The two basic principles of surveying are as follows:

(a) Work from whole to part

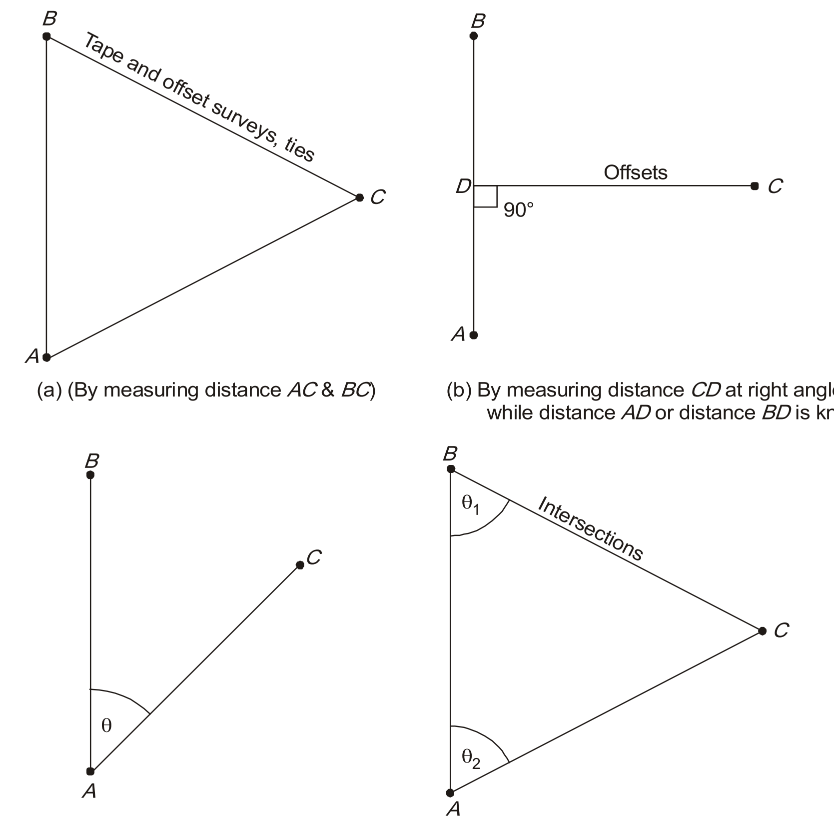
(b) Locate a point by at least two measurements (linear or angular).

1.4.1 Work from Whole to Part

- It is the first principle of surveying.
- By this principle, it means that the surveyor should first establish the large frame work consisting of main control points, accurately.
- In between the large frame work so established, subsidiary small frame works can be established by a relatively less accurate survey. By doing so, the errors in small frame work get localized and are not magnified and thus the accumulation of errors gets confined.
- In the reverse process of working from part to whole, small errors get magnified due to accumulation of errors from small frame work to large frame work.

1.4.2 Locate a point by atleast two measurements

- According to this principle, the new point (station) should always be fixed by atleast two measurements (linear or angular) from a fixed reference point.
- Take two control points A and B and the distance between them is accurately measured. By using A and B, two control points whose positions are already known on the plan, the position of C can be plotted by any of the following methods:



(a) (By measuring distance *AC* & *BC*)

(b) By measuring distance *CD* at right angles to *AB*, while distance *AD* or distance *BD* is known

(c) By measuring distance *AC* and angles θ

(d) By measuring angle θ_1,& angle θ_2

Fig. Location of unknown point from two known points

1.5 UNITS OF MEASUREMENT

- There are many units of measurement that are prevalent worldwide like the CGS System, FPS System, MKS System but the standard one is the **SI System**.
- Past records of all survey works are usually in FPS System. Thus to use those records and any other records that are in different units, those have to be converted into SI unit or other unit that is in use.

Length Unit Conversion

Unit	Conversion factor for m
1 astronomical unit	149597870691
1 angstrom	1×10^{-10}
1 chain	20.1168
1 fathom	1.8288
1 foot	0.3048
1 furlong	201.168
1 inch	0.0254
1 light year	9460730472581000
1 mile	1609.344
1 nautical mile	1852
1 yard	0.9144

Area Unit Conversion

Unit	Conversion factor for m^2
1 acre	4046.85
1 are	100
1 hectare	10^4
1 ft^2	0.0929
1 $inch^2$	6.4516×10^4
1 $mile^2$	2589988.11
1 $yard^2$	0.8361

OBJECTIVE BRAIN TEASERS

Q.1 Which of the following scale in the longest?
(a) 1 : 50000 (b) 1 cm = 50 m
(c) 1 cm = 500 km (d) R.F. = 1/500000

Q.2 The R.F. of scale 1 cm = 5 km is
(a) 1/5 (b) 1/50
(c) 1/500000 (d) 1/50000

Q.3 The main principal of survey is
(a) to work from left to right
(b) to work from top to bottom
(c) to work from to left to bottom right
(d) to work from whole to part

Q.4 Shrinkage ratio is expressed as
(a) shrunk length/original length
(b) shrunk length + original length
(c) shrunk length × original length
(d) None of these

Q.5 The type of surveying wherein curvature of earth is also accounted for is known as
(a) plain surveying
(b) hydrographic surveying
(c) aerial surveying
(d) geodetic surveying

Q.6 A survey plan was plotted to a scale of 20 m to 1 cm. This scale was reduced in such a way that originally 20 cm line now measures 19 cm. If area of reduced plan is 100 cm^2, then actual area of survey was
(a) 44320 m^2 (b) 110.8 cm^2
(c) 36100 m^2 (d) Data insufficient

Q.7 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
A. Stream gauging
B. Station pointer
C. Tide gauge
D. Sounding

List-II
1. Solving three point problem
2. To determine water level and its variation
3. The process of determining the river bed depth
4. To measure turbidity
5. Measuring the discharge of a stream

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	1	2
(c)	5	1	2	3
(d)	3	1	2	5

Q.8 The map projection in which the angle between any pair of short lines represented correctly is called
(a) conformal projection
(b) equidistant projection
(c) azimuthal projection
(d) equal area projection

Q.9 The type of surveying in which the curvature of the earth is taken into account is called
(a) Geodetic surveying
(b) Plane surveying
(c) Preliminary surveying
(d) Topographical surveying

Q.10 **Assertion (A) :** Nautical sextant is used in hydrographic surveying.
Reason (R) : This instrument helps in determining the depth of water.
(a) Both Assertion (A) and Reason (R) are individually true and Reason (R) is the correct explanation of Assertion (A).
(b) Both Assertion (A) and Reason (R) are individually true but Reason (R) is NOT the correct explanation of Assertion (A).
(c) Assertion (A) is true but Reason (R) is false.
(d) Assertion (A) is false but Reason (R) is true.

Q.11 A rectangular plot of 50 km^2 in area is shown on a map by a similar rectangular area of 2 cm^2. RF of the scale to measure a distance of 50 km will be
(a) $\frac{1}{1600}$ (b) $\frac{1}{500000}$
(c) $\frac{1}{400}$ (d) $\frac{1}{16000}$

Q.12 Match **List-I** (Type of survey) with **List-II** (Purpose) and select the correct answer using the codes given below the lists:

List-I

A. Topographical survey

B. Reconnaissance survey

C. Cadastral survey

D. Archaeological survey

List-II

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

2. To find 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)	4	3	1	2

Q.13 The type of surveying in which the curvature of the earth is taken into account is called

(a) Geodetic surveying

(b) Plane surveying

(c) Preliminary surveying

(d) Topographical surveying

ANSWER KEY

1. (b)	**2.** (c)	**3.** (d)	**4.** (a)	**5.** (d)
6. (a)	**7.** (c)	**8.** (a)	**9.** (a)	**10.** (a)
11. (b)	**12.** (a)	**13.** (a)		

HINTS & EXPLANATIONS

6. (a)

Shrinkage factor $= \frac{19}{20}$

Reduced plan area

= Original plan area × (shrinkage factor)^2

$$\Rightarrow \quad 100 = \text{original plan area} \times \left(\frac{19}{20}\right)^2$$

⇒ Original plan area

$= 110.8 \text{ cm}^2$

∴ Actual survey area

$= 110.8 \times (20)^2 = 44320 \text{ m}^2$

7. (c)

All these terms are related to hydrographic surveying.

8. (a)

The map projections are divided into four categories viz.

(i) **Conformal projections:** In this type of map projections, the angle between any pair of short lines is represented correctly. These are also called orthomorphic projections.

(ii) **Equal area projections:** In this type of projections, the areas are represented correctly and the relative areas remain same. However, the shapes may not remain same.

(iii) **Equidistant projections:** In this type of projections, distances are represented correctly from one central point to other points on the map

(iv) **Azimuthal projections:** In this type of projections, the azimuth or direction of any point relative to one central point is represented correctly.

11. (b)

$$\text{Scale} = \sqrt{\frac{\text{Map area}}{\text{Ground Area}}}$$

$$= \sqrt{\frac{2 \text{ cm}^2}{50 \times 10^{10} \text{ cm}^2}}$$

$$\text{Scale} = \frac{1 \text{ cm}}{500000 \text{ cm}}$$

$$\text{Scale} = \frac{1}{500000}$$

CONVENTIONAL BRAIN TEASERS

Q.1 The dimensions i.e. length, breadth and height of an embankment were measured with a 20 m chain and volume of embankment came out to be 550.77 cu.m. Later on, it was found that the chain used for measurement was 15 cm too short. What is the actual volume of embankment?

Solution:

$$\text{True volume} = \left(\frac{l'}{l}\right)^3 \times \text{measured volume}$$

$$= \left(\frac{20-0.15}{20}\right)^3 \times 550.77 = 538.47 \text{ m}^3$$

Q.2 The length of a line measured from a chain was found to be 280 m. Calculate the true length of the line if:

(a) The length was measured with a 30 m chain and chain was found to be 12 cm too long.

(b) The length was measured with a 30 m chain in the beginning and 30.2 m at the end of the work.

Solution:

Measured length (L) = 280 m

True chain length (l) = 30 m

(a) Actual chain length used for measurement (l') = 30.12 m

$$\therefore \quad \text{True length of line} = \left(\frac{l'}{l}\right)L = \left(\frac{30.12}{30}\right)280 = 281.12 \text{ m}$$

(b) Average length of chain during measurement $= \frac{30+30.2}{2} = 30.1$ m

$$\text{True length of line} = \frac{30.1}{30} \times 280 = 280.93 \text{ m}$$

Q.3 A 30 m tape was found 0.20 m too short. If the computed volume of concrete is 1600 m^3 then what is the correct volume of concrete?

Solution:

$$\text{Correct volume} = \left(\frac{l'}{l}\right)^3 \times \text{computed volume} = \left(\frac{30-0.2}{30}\right)^3 \times 1600 = 1568.21 \text{ m}^3$$

■■■■