NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR
HAZRATBAL, SRINAGAR, J&K - 190006

SURVEYING-I (CIV-303)

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COURSE CONTENTS

S. No.	Contents	Lecture Hours
1	Introduction: Importance, principle of surveying, types of surveying.	4
2	Chain surveying: Field equipment, methods of chaining, offsets, corrections in chaining, obstacles in chain surveying; plotting; degree of accuracy, tape and chain corrections.	7
3	Prismatic compass surveying: Instruments, principle, procedure and precautions. Closed traverse; corrections, local attraction, plotting.	6
4	Plane table surveying: Field equipments, methods of tabling, two-point and three-point problem, precautions and accuracy.	6
5	Levelling: Instruments, field book recording, bench mark and its types, methods of reductions of levels, various types of field works; contouring, plotting. Testing and permanent adjustments. Sensitivity of bubble tube.	9
6	Areas and volumes: Methods of determining areas and volumes viz; borrow pits.	4
Total		**36**

REFERENCES

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Surveying Vol I and II by Dr. K.R. Arora	------
2	Surveying Vol I and II by B.C. Punmia	------
3	Surveying Vol I and II by S.K. Duggal	------

LECTURE 1
Introduction to Surveying

Introduction

Surveying is the art of making measurements of objects on, above or beneath the ground to show their relative positions on paper. The relative position required is either horizontal, or vertical, or both. Less precisely, the term Surveying is used for the measurement of objects in their horizontal positions. Measurements to determine their relative vertical positions is known as levelling.

1.1 Importance of Surveying

As stated in the definition, object of surveying is to show relative positions of various objects of an area on paper and produce plan or map of that area. Various uses of surveying are listed below:

(*i*) Plans prepared to record property lines of private, public and government lands help in avoiding unnecessary controversies.

(*ii*) Maps prepared for marking boundaries of countries, states, districts etc., avoid disputes.

(*iii*) Locality plans help in identifying location of houses and offices in the area.

(*iv*) Road maps are helpful for travelers and tourists.

(*v*) Topographic maps showing natural features like rivers, streams, hills, forests help in planning irrigation projects and flood control measures.

(*vi*) For planning and estimating project works like roads, bridges, railways, airports, water supply and waste water disposal surveying is required.

(*vii*) Marine and hydrographic surveys help in planning navigation routes and harbors.

(*viii*) Military survey is required for strategic planning.

(*ix*) Mine surveys are required for exploring mineral wealth.

(*x*) Geological surveys are necessary for determining different strata in the earth's crust so that proper location is found for reservoirs.

(*xi*) Archeological surveys are useful for unearthing relics of antiquity.

(*xii*) Astronomical survey helps in the study of movements of planets and for calculating local and standard times.

1.2 Primary Divisions in Surveying

The earth is an oblate spheroid, length of equatorial axis being 12756.75 km and polar axis being 12713.80 km. Since the difference between these two axes and irregularities on the earth surface are very small (Note. Height of Mount Everest is 8.79 km) compared to these two axes, the earth may be treated as a sphere, Figure 1.1 shows a circular plane passing through a point A on the earth surface. The gravitational force is always directed towards the center of the earth. Hence, the plumb-line shown in Fig. 1.1 is a vertical line. Line perpendicular to vertical line (tangential to earth's surface) is known as horizontal line. In surveying all measurement at any point are in the direction of these two lines.

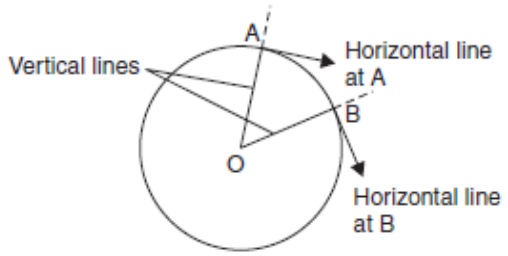

Fig. 1.1 Vertical and horizontal lines

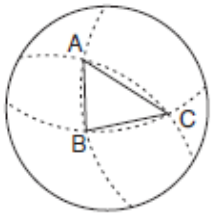

Fig. 1.2 Plane and spherical triangles

Obviously, the vertical and horizontal lines at another point B are not parallel to the respective lines at A. It should be noted that all lines lying on the earth's surface are curved lines and all triangles are spherical triangles as shown in Fig. 1.2. Hence, surveying involves spherical trigonometry.

If the area to be surveyed is small, the curvature of the earth may be neglected and all plumb lines are treated as the same vertical. Hence, the lines normal to plumb line at any point in the area are treated as the same horizontal. All triangles in the area may be treated as plane triangles. The survey in which earths curvature is neglected is called Plane Surveying and the survey in which earth's curvature is considered is known as Geodetic Surveying. No definite value can be assigned to the area up to which a survey may be treated as plane, since the degree of accuracy required forms the controlling factor. However, the following points should be noted:

(i) The length of an arc of 1.2 km on earth's mean surface is only 1 mm more than the straight line connecting those two points.

(*ii*) The sum of the interior angles of a geometrical figure laid on the surface of the earth differs from that of the corresponding spherical figure only to the extent of one second for about 200 square kilometers of area. Hence, in most of engineering projects plane surveying is used. The geodetic surveying is used to determine the precise positions of control stations on the surface of the earth to which plane survey details are connected in works of larger magnitude like preparing maps of countries. Thus, in surveying there are two primary divisions viz; Geodetic Surveying and Plane Surveying.

1.3 Fundamental Principles of Surveying

To get accurate results in surveying one should follow the following fundamental principles:

(*i*) Work from whole to part

(*ii*) Extra care in fixing new control points.

Work from Whole to Part

In surveying large areas, a system of control points are identified and they are located with high precision. Then secondary control points are located using lesser precise methods. The details of the localized areas are measured and plotted with respect to the secondary control points. This is called working from whole to part. This principle in surveying helps in localizing the errors. If the surveying is carried out by adding localized areas, errors get accumulated and may become unacceptable when large area is covered.

Extra Care in Fixing New Control Points

Figure 1.3 shows the various methods of fixing point *C* with respect to already fixed points *A* and *B* by measuring sides, angles or setting perpendiculars. For fixing new control points (stations) with respect to already fixed points at least two independent process should be followed. If *A* and *B* are already located control points and with respect to them new control point *C* is to be located, apart from the minimum measurements required as shown in Fig. 1.3, one more measurement should be taken. Measuring the lengths of check lines and tie lines will also serve this purpose (Ref. Fig. 1.4).

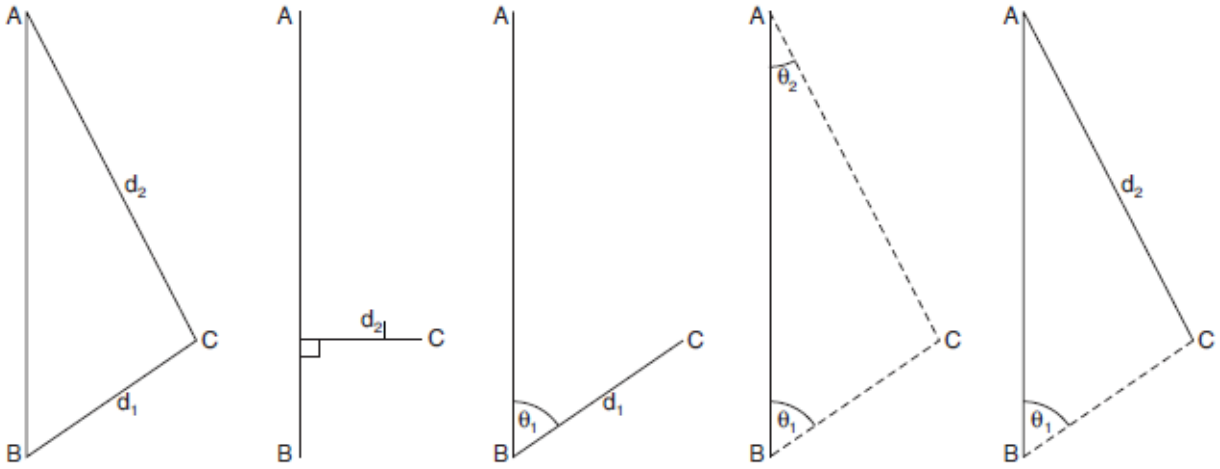

Fig. 1.3 Locating point C w.r.t. points A and B

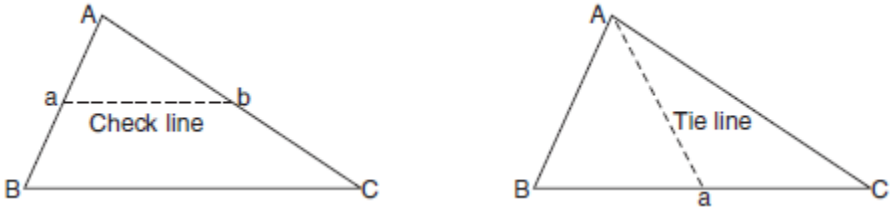

Fig. 1.4 Check line and tie line

1.4 Classification of Surveying

Surveying may be classified on the following basis:

(*i*) Nature of the survey field

(*ii*) Object of survey

(*iii*) Instruments used and

(*iv*) The methods employed.

1.4.1 Classification Based on Nature of Survey Field

On this basis survey may be classified as land survey, marine or hydraulic survey and astronomical survey.

Land Survey

It involves measurement of various objects on land. This type of survey may be further classified as given below:

(*a*) *Topographic Survey:* It is meant for plotting natural features like rivers, lakes, forests and hills as well as man-made features like roads, railways, towns, villages and canals.

(*b*) *Cadastral Survey:* It is for marking the boundaries of municipalities, villages, districts, states etc. The survey made to mark properties of individuals also come under this category.

(*c*) *City Survey:* The survey made in connection with the construction of streets, water supply and sewage lines fall under this category.

Marine or Hydrographic Survey

Survey conducted to find depth of water at various points in bodies of water like sea, river and lakes fall under this category. Finding depth of water at specified points is known as sounding.

Astronomical Survey

Observations made to heavenly bodies like sun, stars etc., to locate absolute positions of points on the earth and for the purpose of calculating local time is known as astronomical survey.

1.4.2 Classification Based on Object of Survey

On the basis of object of survey the classification can be engineering survey, military survey, mine survey, geological survey or archeological survey.

(*a*) *Engineering Survey:* The objective of this type of survey is to collect data for designing civil engineering projects like roads, railways, irrigation, water supply and sewage disposals. These surveys are further sub-divided into:

Reconnaissance Survey for determining feasibility and estimation of the scheme.

Preliminary Survey for collecting more information to estimate the cost of the project, and

Location Survey to set the work on the ground.

(*b*) *Military Survey:* This survey is meant for working out plans of strategic importance.

(*c*) *Mine Survey:* This is used for exploring mineral wealth.

(*d*) *Geological Survey:* This survey is used for finding different strata in the earth's crust.

(*e*) *Archeological Survey:* This survey is for unearthing relics of antiquity.

1.4.3 Classification Based on Instruments Used

Based on the instruments used, surveying may be classified as:

(*i*) Chain survey

(*ii*) Compass survey

(*iii*) Plane table survey

(*iv*) Theodolite survey

(*v)* Tacheometric survey

(*vi*) Triangulation survey

(*vii*) Photographic and Aerial survey

The survey is taught to students mainly based on this classification.

1.4.4 Classification Based on Methods Employed

On this basis surveying is classified as triangulation and traversing.

(*i*) *Triangulation:* In this method control points are established through a network of triangles.

(*ii*) *Traversing:* In this type, control points consist of a series of connected points established through linear and angular measurements. If the last line meets the starting point it is called as closed traverse. If it does not meet, it is known as open traverse.

LECTURE 2
Scales and Measurements

2.1 Plans and Maps

As stated in the definition of surveying, the objective of measurements is to show relative positions of various objects on paper. Such representation on paper is called plan or map. *A plan may be defined as the graphical representation of the features on, near or below the surface of the earth as projected on a horizontal plane to a suitable scale.* However, since the surface of the earth is curved and that of the paper is plane, no part of the earth can be represented on such maps without distortion. If the area to be represented is small, the distortion is less and large scale can be used. Such representations are called plans. If the area to be represented is large, distortion is large and small scales have to be used. Representation of larger areas are called maps. Representation of a particular locality in a municipal area is a plan while representation of a state/country is a map. There is no exact demarcation between a plan and map.

2.2 Scales

It is not possible and also not desirable to make maps to one to one scale. While making maps all distances are reduced by a fixed proportion. That fixed proportion is called scale of the map. Thus, if 1 mm on the paper represents 1 metre on the ground, then the scale of the map is 1 mm = 1 m or 1 mm = 1000 mm or 1 : 1000. To make scale independent of the units it is preferable to use representative fraction which may be defined as the ratio of one unit on paper to the number of units it represents on the ground.

Thus 1 mm = 1 m is equivalent to

$$RF = 1/1000$$

Apart from writing scale on map, it is desirable to show it graphically on it. The reason is, over the time, the paper may shrink and the scaling down the distances from map may mislead. The graphical scale should be sufficiently long (180 mm to 270 mm) and the main scale divisions should represent one, ten or hundred units so that it can be easily read.

The scale of a map is considered as

(*i*) large if it is greater than 1 cm = 10 m *i.e.*,

RF >1/1000

(*ii*) intermediate if it is between

RF =1/1000 and 1/10,000

(*iii*) small if

RF <1/10,000

In general, scale selected should be as large as possible, since it is not possible for human eye to distinguish between two points if distance between them is less than 0.25 mm.

2.3 Types of Graphical Scales

The following two types of scales are used in surveying:

(*i*) Plain Scale

(*ii*) Diagonal Scale.

2.3.1 Plain Scale

On a plain scale it is possible to read two dimensions directly such as unit and tenths. This scale is not drawn like ordinary foot rule (30 cm scale). If a scale of 1:40 is to be drawn, the markings are not like 4 m, 8 m, 12 m etc. at every 1 cm distance. Construction of such a scale is illustrated with the example given below:

Example 2.1: *Construct a plain scale of RF =1/500 and indicate 66 m on it.*

Solution. If the total length of the scale is selected as 20 cm, it represents a total length of 500 × 20 =10000 cm = 100 m. Hence, draw a line of 20 cm and divide it into 10 equal parts. Hence, each part corresponds to 10 m on the ground. First part on extreme left is subdivided into 10 parts, each subdivision representing 1 m on the field. Then they are numbered as 1 to 10 from right to left as shown in Fig. 2.1. If a distance on the ground is between 60 and 70 m, it is picked up with a divider by placing one leg on 60 m marking and the other leg on subdivision in the first part. Thus, field distance is easily converted to map distance.

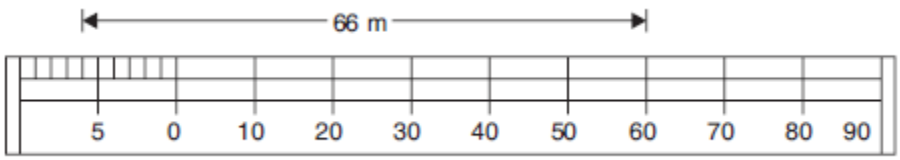

Fig. 2.1

2.3.2 Diagonal Scale

In plain scale, only unit and tenths can be shown whereas in diagonal scales it is possible to show units, tenths and hundredths. Units and tenths are shown in the same manner as in plain scale. To show hundredths, principle of similar triangles is used. If *AB* is a small length and its tenths are to be shown, it can be shown as explained below.

Draw the line *AC* of convenient length at right angles to plain scale *AB*. Divide it into 10 equal parts. Join *BC.* From each tenth point on line *AC* draw lines parallel to *AB* till they meet line *BC*. Then line 1–1 represent 1/10th of *AB*, 6–6 represent 6/10th of *AB* and so on.

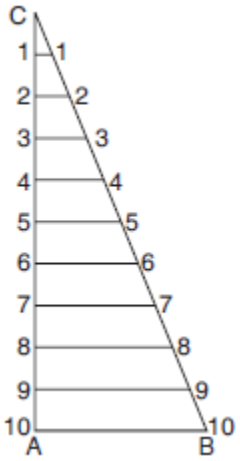

Fig. 2.2

2.4 Units of Measurements

According to Standards of Weights and Measurements Act, India decided to give up FPS system used earlier and switched over to MKS in 1956. In 1960, International system of units (SI units) was approved by the conference of weights and measures. It is an international organization of which most of the countries are the members. In this system also, unit of linear measurement is metre. However, in this system use of centimeters and decameters are discouraged. Of course, major difference between MKS and SI is in the use of unit of force. In MKS, unit of force is kg-wt (which is commonly called as kg only) while in SI it is newton.

The recommended multipliers in SI units are given below

Giga unit = 1×10^9 units

Mega unit = 1×10^6 units

Kilo unit = 1×10^3 units

unit = 1×10^0 units

Milli unit = 1×10^{-3} units

Micro unit = 1×10^{-6} units

Commonly used linear units in surveying are kilometre, metre and millimetres. However centimetre is not yet fully given up.

For measuring angles sexagesimal (base 60) system is used. In this system:

1 circumference = 360°

1 degree = 60′ (minutes of arc)

1 minute = 60″ (seconds of arc)

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