SHREE

CHAPTER 2

ENGINEERING SURVEY

Surveying is a process of determining the actual existing points from earth surface to a map.

It is done by measuring the horizontal and vertical distances, angles, and taking the details of these points and by preparing a map or plan to any suitable scale.

Main Objectives of Surveying

The map or plan is drawn to some suitable scale. The object of surveying is to prepare a map or plan to show the relative positions of the objects on the surface of the earth.

Fundamental Principles of Surveying

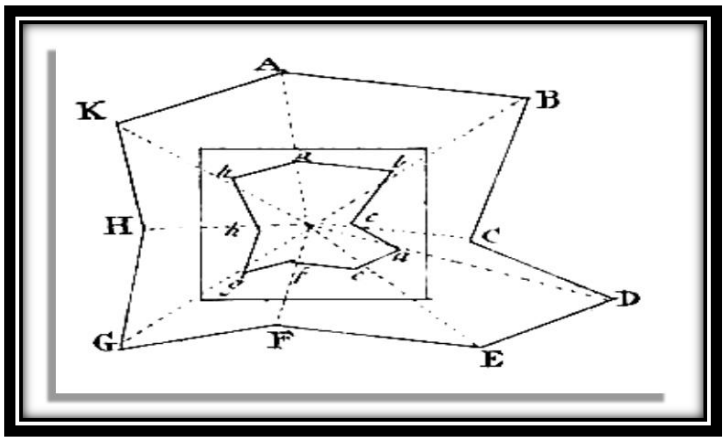
Two basic principles of surveying are:

1. **Always work from whole to the part**
2. **To locate a new station by at least two measurements (Linear or angular) from fixed reference points.**

1. **Always work from whole to the part**

   According to the first principle, the whole survey area is first enclosed by main stations.

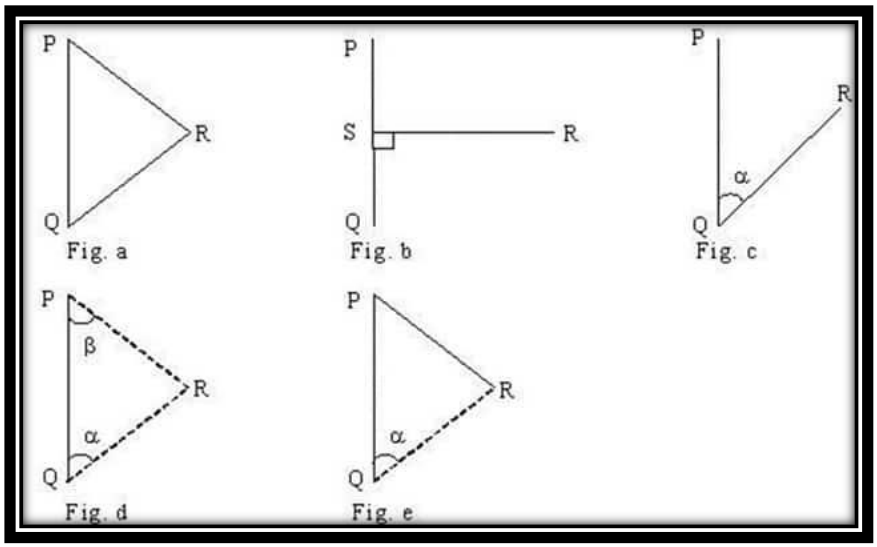
   The line joining these stations are known as Main Survey Lines.



1. **The area is divided into number of divisions by forming well-conditioned triangles.**
2. **The main survey lines are measured very accurately with precise survey instruments.3**
3. **Then the remaining sides of triangle are measured.**
4. **The main benefit and advantage of this method of working is to control accumulation of errors.**
5. **This small error will not affect the complete work report.**

2. **<u>To locate a new station by at least two measurements (Linear or angular) from fixed reference points.</u>**

According to the second principle the points are located by linear or angular measurement or by both in surveying. If two control points are established first, then a new station can be located by linear measurement. Let A & B are control points, a new point C can be established.



Let R be the point whose location is to be fixed and P and Q be the two reference points whose positions have already been fixed. The position of the point R can be determined by any one of the above-shown methods in the figure.

Objectives of Surveying

1. To determine the relative position of various points above, on, or beneath the surface of the earth.

2. To take the linear measurements and angular measurements between various points.

3. To prepare the plans and maps i.e. for the representation of a measured plot of the area on a horizontal plane.

4. To provide a basis for civil engineering construction works and activities.

Surveying is divided into two basic types

1. **Plane Surveying**
2. **Geodetic surveying**

Primary Classification

A] Plane Surveying

The plain surveying is that type of surveying in which earth surface is considered as a plane.

Curvature of earth is ignored i.e., it is not considered. In plain surveying a line joining any two stations is considered to be straight. The triangle formed by any three points is considered as a plane triangle. The angles of the triangle are considered as plain angles.

Surveying is carried out for a small area of less than 250 km^2.

B] Geodetic Surveying

The geodetic Surveying is that type of surveying in which the curvature of the earth is taken into consideration. The line joining any two stations is considered as curved line. The triangle formed by any three points is considered to be spherical and the angles of the triangle are considered to be spherical angles. It is generally extended over larger areas.

Geodetic surveying is conducted by the survey of India Department and is carried out for a larger area exceeding 250 km^2.

Classification based upon following nature of field of survey:

A. **Land Survey**
B. **Object of survey**
C. **Methods of survey**
D. **Instrument**

A. Land Survey

1. **Topographical survey: This consists of horizontal and vertical location of certain points by linear and angular measurements and is made to determine the natural features of a country such as rivers, streams, lakes, woods, hills, etc., and such artificial features as roads, railways, towns and villages.**

2. **Cadastral survey: Cadastral surveys are made incident to the fixing of property lines, the calculation of land area, or the transfer of land property from one owner** to another. **They are also made to fix the boundaries of municipalities and of state and federal jurisdictions.**

3. **City Survey: They are made in connection with the construction of streets, water supply systems, sewers and other works.**

4. **Astronomical survey: The astronomical survey offers the surveyor means of determining the absolute location of any point or the absolute location and direction of any line on the surface of the earth.**

B. Object of survey

1. **Engineering survey: This is undertaken for the determination of quantities or to afford sufficient data for the designing of engineering works such buildings, roads and reservoirs, or those connected with sewage disposal or water supply.**

2. **Military survey: This is used for determining points of strategic importance.**

3. **Mine survey: This is used for exploring mineral wealth.**

4. **Geological survey: This is used for determining different strata in the earth's crust.**

5. **Archaeological survey: This is used for finding rests of antiquity.**

C. Methods of survey

1. **Triangulation survey: In this type of surveying, a network of well defined triangles is formed on the plot land to be surveyed.**

2. **Traverse survey: It is a type of surveying, in which the plot of land to be surveyed is enclosed by a series of straight lines making angles with one another.**

D. Instrument

1. Chain survey 2. Theodolite survey 3. Tacheometric survey

4. Compass survey 5. Plane table survey 6. Photographic survey 7. Aerial survey

Applications of Surveying

1. **To prepare a topographical map which shows the hills, valley, rivers, villages, towns, forests, etc. of a country.**

2. **To prepare a cadastral map showing the boundaries of fields, houses and other properties.**

3. **To prepare an engineering map which shows the details of engineering works such as buildings, roads, railways, reservoirs, irrigation canals, etc.**

4. **To prepare a military map showing the road and railway communications with different parts of a country. Such a map also shows the different strategic points important for the defence of a country.**

5. **To prepare a contour map to determine the capacity of a reservoir and to find the best possible options for building, roads, railways, etc.**

6. **To prepare a geological map showing areas including underground resources.**

7. **To prepare an archaeological map including places where ancient relics exist.**

Levelling

Levelling is a branch of surveying to find the elevations of given points with respect to a given or assumed datum.

Levelling is the general term applied to any of the various processes by which elevations of points or differences in elevation are determined.

Following are the important terms used in levelling

1. **Vertical line- A line that follows the local direction of gravity as indicated by a plumb line.**
2. **Level surface - A curved surface that, at every point is perpendicular to the local plumb line (the direction in which gravity acts).**
3. **Level line - A line lying in a level surface is a level line. It is thus a curved line normal to the plumb at all points. In field surveying, it is defined by the direction of a freely suspended plumb-bob.**
4. **Horizontal plane - A plane perpendicular to the local direction of gravity. In plane surveying, it is a plane perpendicular to the local vertical line.**
5. **Horizontal line - A line in a horizontal plane. In plane surveying, it is a line • perpendicular to the local vertical.**
6. **Vertical datum - Any level surface to which elevations are referenced. This is the surface that is arbitrarily assigned an elevation of zero.**
7. **Elevation - The distance measured along a vertical line from a verticaldatum to a point or object.**

Following terms are used in calculation and noting down the readings.

1. **Benchmark (BM) - A relatively permanent object, natural or artificial, having a marked point whose elevation above or below a reference datum is known or assumed. Station- A point where the leveling staff is kept.**

2. **Height of instrument: It is the elevation of the plane of sight with respect to assumed datum. It is also known as plane of collimation.**

3. **Back sight(BS): It is the sight taken on the level staff, of a known elevation with the intention to obtain the elevation of plane of collimation. It is called PLUS sight because it is added to elevation of that point to get height of instrument or plane of collimation.**

4. **Intermediate sights(IS): These are the sight taken after back sight and before sighting the final point. These are called MINUS sights. These are subtracted from plane of collimation to find the reduced level of different points.**

5. **Fore sight(FS): The last reading taken from the instrument before shifting the instrument.**

6. **Change point(CP) or turning point(TP): The point at which both BS and FS are taken.**

7. **Reduced level(RL): The elevations of the points with respect to assumed datum**

Calculation of Reduced Level by RISE AND FALL METHOD AND HI METHOD.

[SOLVE THE NUMERICAL GIVEN IN ASSIGNMENT]

Modern Equipment's used in Surveying

1. **EDM**
2. **TOTAL STATION**
3. **GIS**
4. **GPS**
5. **REMOTE SENSING**

1. EDM

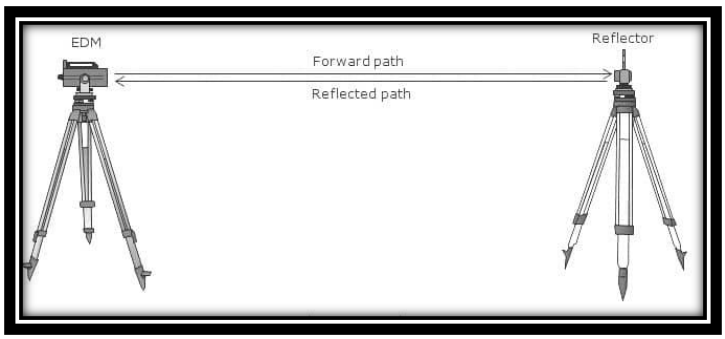
Electronic distance measurement (EDM) is a method of determining the length between two points using electromagnetic waves. EDM instruments are highly reliable and convenient pieces of surveying equipment and can be used to measure distances of up to 100 kilometers. Devices known as total stations share similarities with theodolites and can be used to measure distances as well as angles.

Electronic distance measurement (EDM) is a method of determining the length between two points, using phase changes, that occur as electromagnetic energy waves travels from one end of

the line to the other end. In this method instruments are used to measure distance that rely on propagation, reflection and reception of electromagnetic waves like radio, visible light or infrared waves.

It works on following principles

1. **Propogation**
2. **Reflection**
3. **Receptition**



2. **TOTAL STATION**

Total station is a surveying equipment combination of Electromagnetic Distance Measuring Instrument and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping distance of object to the instrument.

Important Operations of Total Station

Distance Measurement

Electronic distance measuring (EDM) instrument is a major part of total station. Its range varies from 2.8 km to 4.2 km. The accuracy of measurement varies from 5 mm to 10 mm per km measurement. They are used with automatic target recognizer.

Angle Measurements

The electronic theodolite part of total station is used for measuring vertical and horizontal angle. For measurement of horizontal angles any convenient direction may be taken as reference direction. For vertical angle measurement vertical upward (zenith) direction is taken as reference direction. The accuracy of angle measurement varies from 2 to 6 seconds.

Data Processing

This instrument is provided with an inbuilt microprocessor. The microprocessor averages multiple observations. With the help of slope distance and vertical and horizontal angles

measured, when height of axis of instrument and targets are supplied, the microprocessor computes the horizontal distance and X, Y, Z coordinates.

Display

Electronic display unit is capable of displaying various values when respective keys are pressed. The system is capable of displaying horizontal distance, vertical distance, horizontal and vertical angles, difference in elevations of two observed points and all the three coordinates of the observed points.

Electronic Book

Each point data can be stored in an electronic note book (like compact disc). The capacity of electronic note book varies from 2000 points to 4000 points data. Surveyor can unload the data stored in note book to computer and reuse the note book.

Uses of Total Station

The total station instrument is mounted on a tripod and is levelled by operating levelling screws. Within a small range instrument is capable of adjusting itself to the level position. Then vertical and horizontal reference directions are indexed using onboard keys. It is possible to set required units for distance, temperature and pressure (FPS or SI). Surveyor can select measurement mode like fine, coarse, single or repeated. When target is sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriate keys they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information about the point and displays on screen. This information is also stored in the electronic notebook. At the end of the day or whenever electronic note book is full, the information stored is downloaded to computers. The point data downloaded to the computer can be used for further processing. There are software like auto civil and auto plotter clubbed with AutoCad which can be used for plotting contours at any specified interval and for plotting cross-section along any specified line.

Advantages of Using Total Stations

The following are some of the major advantages of using total station over the conventional surveying instruments:

1. **Field work is carried out very fast.**
2. **Accuracy of measurement is high.**
3. **Manual errors involved in reading and recording are eliminated.**
4. **Calculation of coordinates is very fast and accurate. Even corrections for temperature and pressure are automatically made.**
5. **Computers can be employed for map making and plotting contour and cross-sections. Contour intervals and scales can be changed in no time.**

G I S

GIS is Geographic Information System. It is a collection of computer software and information which is used for viewing, analysing, managing and displaying geographical data.

In general, it allows users to search for information about specific geographical areas, analyse spatial information, edit the data and create maps, charts and reports that show users the results in visual forms.

ADVANTAGES OF GIS

1. **Improved decision making – decisions are made easier because specific and detailed information is presented about one or more locations.**
2. **Reduce costs and increase efficiency – especially regarding maintenance schedules, fleet movements or scheduling timetables.**
3. **Improved communication between any involved organisations or departments as the visual format is easily understood by all.**
4. **Easy recordkeeping – geographical changes are easily recorded by GIS for those responsible of recording the changes.**
5. **Managing geographically – knowing what is and will be occurring in a geographic space in order to plan a course of action.**

HOW IS GIS USED

It allows people to see the world in a different way by mapping the position and quantity of things, mapping the density of people and objects and mapping any changes that occur. GIS also allows us to find out what is happening inside a specific area or nearby to a specific area.

1. **Environmental Geography – to analyse the impact people have on the environment.**
2. **Physical Geography – to study the elements of atmosphere, biosphere and geosphere.**
3. **Emergency Management Information System – to give real time data to emergency responders about the geographical layout.**
4. **Health Geography – to use geographical information to study health related issues such as disease and illness.**
5. **Economic Geography – to study economic activities across the earth.**
6. **Transportation Geography – to investigate the spatial interactions of people or things.**

GPS

GPS stands for Global Positioning System. It is a highly accurate navigation system using signals from satellites to determine a location on the Earth's surface, irrespective of weather conditions.

It is dependent on satellites high above the Earth which transmit signals containing the time and location of the satellite. Any ground-based receiver which receives signals from four or more GPS satellites can use navigation equations to calculate its location on the Earth's surface. Constant signaling can then update speed and direction information for moving receivers.

GPS was originally developed for military use but since the 1990s has been open for civilian use and is now used in such common applications as mobile phones, car navigation systems, and of course surveying and mapping.

USE OF GPS IN SURVEYING

Surveying and mapping was one of the first commercial adaptations of GPS, as it provides a latitude and longitude position directly without the need to measure angles and distances between points.

In practice, GPS technology is often incorporated into a Total Station to produce complete survey data. Receivers used for base line measurements are generally more complex and expensive than those in common use, requiring a high quality antenna.

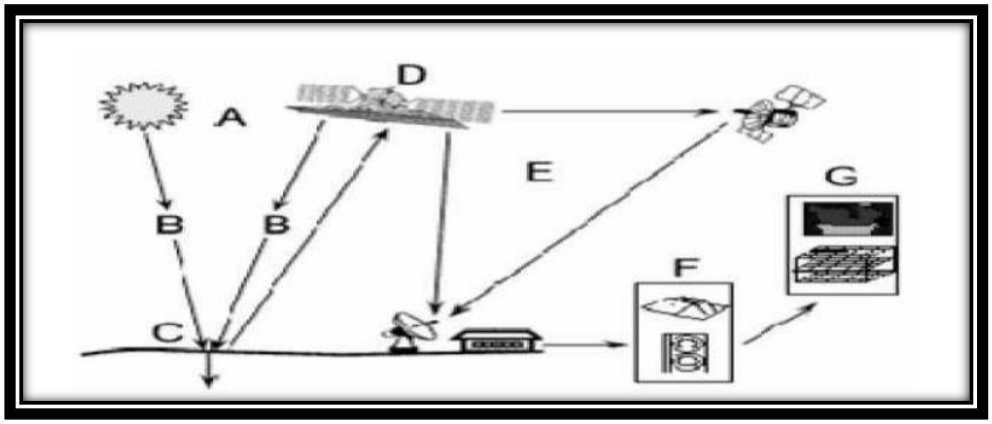
Advantages of GPS in Surveying

1. **It allows working in a longer distance thereby enabling covering a larger area in a shorter time.**
2. **It requires fewer people to use it unlike a Total Station where there is the need for a prism man**
3. **It offers a higher level of accuracy than conventional surveying methods Calculations are made very quickly and with a high degree of accuracy.**
4. **GPS technology is not bound by constraints such as visibility between stations.**
5. **Land surveyors can carry GPS components easily for fast, accurate data collection.**
6. **Some GPS systems can communicate wireless for real-time data delivery.**
7. **A more reliable data as human error from setting up are reduced when using a permanent reference station.**
8. **Aid in the Machine Control technology development for heavy construction control and time management.**

Remote Sensing

Remote sensing is the science of acquiring information about the Earth's surface by being at far distance from it.

This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest.



Components of Remote Sensing

1. **Energy Source or Illumination (A) – the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.**
2. **Radiation and the Atmosphere (B) – as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.**
3. **Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.**
4. **Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.**
5. **Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).**
6. **Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.**
7. **Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it.**

   It helps in reveal or getting some new information, or assist in solving a particular problem.

Passive and Active Sensors

Remote sensors can be classified in different ways as follows.

On the Basis of Source of Energy Used: On the basis of source of energy used by the sensors, they can be classified into two types – Active sensors and Passive sensors.

Active Sensors

Active sensors use their own source of energy and earth surface is illuminated by this energy. Then a part of this energy is reflected back which is received by the sensor.
Radar and laser al time rare active sensors. Radar is composed of a transmitter and a receiver.
The transmitter emits a wave, which strikes objects and is then reflected or echoed back to the receiver.

The properties of an active sensor are:

1. **It uses both transmitter and receiver units to produce imagery, hence it requires high energy levels.**
2. **It mostly works in microwave regions of EMR spectrum, which can penetrate clouds and is not affected by rain.**
3. **It is an all-weather, day-night system and independent of solar radiation.**
4. **The RADAR signal does not detect colour information or temperature information, but it can detect the roughness, slope and electrical conductivity of the objects under study.**

Passive Sensors

Passive sensors do not have their own source of energy. The earth surface is illuminated by sun/solar energy. The reflected solar energy from the earth surface or the emitted electromagnetic energy by the earth surface itself is received by the sensor.

The properties of a passive sensor are:

1. **It is relatively simple both mechanically and electrically and it does not have high power requirement.**
2. **The wavebands, where natural remittance or reflected levels are low, high detector sensitivities and wide radiation collection apertures are necessary to obtain a reasonable signal level. Therefore, most passive sensors are relatively wide band systems.**
3. **It depends upon good weather conditions.**

Contours

Contours are imaginary lines. These lines connect points of the same value. A contour map generally shows different contours such as the elevation or even the temperature contours.

Contours are the lines on a map that join the same height. The Contour interval refers to the variation in height, example the contours are drawn at every meter.

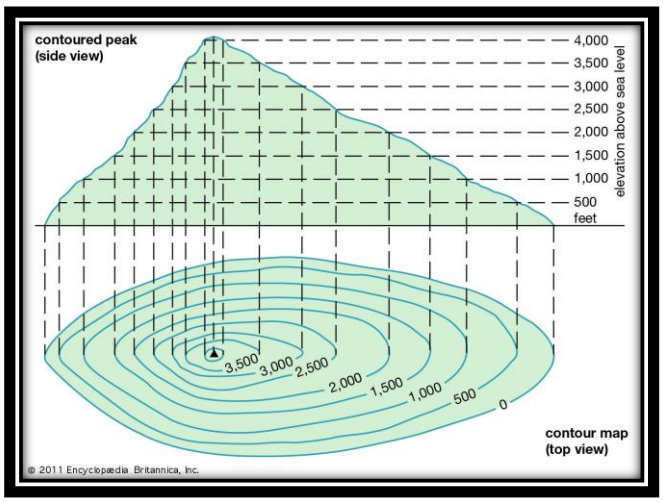
Contour lines on a map basically illustrate the height of a distinct place. This also helps us to obtain information regarding the steepness of the slopes, which is along the direction of the land that is sloping.

The contours here form patterns representing how steep the slopes actually are. The closer the contour lines are stuck together; the steeper is the slope.

With the use of contour, we can analysis the nature of the land. Whether this is a valley, a mountain, a valley which has a flat floor, also if the valley has a stream, or not, or is it around the cone-shaped hill or a hilltop.

Applications of Contour Map / Mapping

1. **The Contours provide important information which can help us to study the nature of the terrain. This proves to be useful for the selection of sites, to determine the catchment area of a drainage basin, or to find indivisibility between two or more stations**
2. **To study the nature of the ground which we want to study or for further construction.**
3. **To identify the route, a contour map provides worthy information on how to locate a route.**
4. **Contour Map is useful for getting the precise indivisibility between the two points cannot be easily ascertained by inspecting the area.**
5. **The catchment area of a particular river can be well determined by using the contour map. The watershed line very well indicates the drainage basin of the river which passes through the ridges and then saddles of the terrain that turns around the river.**



Contour Map