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G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY
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Permanently Affiliated to JNTUA, Anantapuramu
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Department of Civil Engineering

Bridge Course
On
SURVEYING-I

Surveying: Surveying is defined as the science of making measurements of the earth specifically the surface of the earth. This is being carried out by finding the spatial location (relative / absolute) of points on or near the surface of the earth (or)

- Surveying or land surveying is the technique, profession, and science of determining the terrestrial or three-dimensional position of points and the distances and angles between them.
- A land surveying professional is called a land surveyor
- These points are usually on the surface of the Earth, and they are often used to establish maps and boundaries for ownership, locations like building corners or the surface location of subsurface features, or other purposes required by government or civil law, such as property sales.

Surveyors work:

- Surveyors work with elements of geometry, trigonometry, regression analysis, physics, engineering, metrology, programming languages and the law
- They use equipment like total stations, robotic total stations, GPS receivers, retro reflectors, 3D scanners, radios, handheld tablets, digital levels, subsurface locators, drones, GIS and surveying software
- Surveying has been an element in the development of the human environment since the beginning of recorded history
- The planning and execution of most forms of construction require it. It is also used in transport, communications, mapping, and the definition of legal boundaries for land ownership
- It is an important tool for research in many other scientific disciplines

Importance of Surveying to Civil Engineers: The planning and design of all Civil Engineering projects such as construction of highways, bridges, tunnels, dams etc are based upon surveying measurements, Moreover during execution, project of any magnitude is constructed along the lines and points established by surveying.

Thus, surveying is a basic requirement for all Civil Engineering projects and other principal works in which surveying is primarily utilised are:

- To fix the national and state boundaries
- To chart coastlines, navigable streams and lakes
- To establish control points
- To execute hydro graphic and oceanographic charting and mapping
- To prepare topographic map of land surface of the earth

History of surveying instruments and inventors:

- Basic surveyance has occurred since humans built the first large structures. The prehistoric monument at Stonehenge (c. 2500 BC) was set out by prehistoric surveyors using peg and rope geometry.
- In ancient Egypt, a rope stretcher would use simple geometry to re-establish boundaries after the annual floods of the Nile River. The almost perfect squareness and north-south orientation of the Great Pyramid of Giza, built c. 2700 BC, affirm the Egyptians' command of surveying. The Groma instrument originated in Mesopotamia (early 1st millennium BC).[3]
- The mathematician Liu Hui described ways of measuring distant objects in his work Haidao Suanjing or The Sea Island Mathematical Manual, published in 263 AD.
- The Romans recognized land surveyors as a profession. They established the basic measurements under which the Roman Empire was divided, such as a tax register of conquered lands (300 AD), Roman surveyors were known as Grammatical.
- In medieval Europe, beating the bounds maintained the boundaries of a village or parish. This was the practice of gathering a group of residents and walking around the parish or village to establish a communal memory of the boundaries. Young boys were included to ensure the memory lasted as long as possible.
- In England, William the Conqueror commissioned the Domes day Book in 1086. It recorded the names of all the land owners, the area of land they owned, the quality of the land, and specific information of the area's content and inhabitants. It did not include maps showing exact locations.
- Abel Foullon described a plane table in 1551, but it is thought that the instrument was in use earlier as his description is of a developed instrument.
- Gunter's chain was introduced in 1620 by English mathematician Edmund Gunter. It enabled plots of land to be accurately surveyed and plotted for legal and commercial purposes
- In the 18th century, modern techniques and instruments for surveying began to be used. Jesse Rams den introduced the first precision theodolite in 1787. It was an instrument for measuring angles in the horizontal and vertical planes. He created his great theodolite using an accurate dividing engine of his own design.
- At the beginning of the 20th century surveyors had improved the older chains and ropes, but still faced the problem of accurate measurement of long distances.
- Dr Trevor Lloyd Wadley developed the Tellurometer during the 1950s. It measures long distances using two microwave transmitter/receivers
- Advances in electronics allowed miniaturization of EDM. In the 1970s the first instruments combining angle and distance measurement appeared, becoming known as total stations
- In 21st century remote sensing and satellite imagery continue to improve and become cheaper, allowing more commonplace use. Prominent new technologies include three-dimensional (3D) scanning and use of lidar for topographical surveys.

The surveying profession:

- The basic principles of surveying have changed little over the ages, but the tools used by surveyors have evolved. Engineering, especially civil engineering, often needs surveyors.
- Surveyors help determine the placementof roads, railways, reservoirs, dams, pipelines, retaining walls, bridges, and buildings. They establish the boundaries of legal descriptions and political divisions. They also provide advice and data for geographical information systems (GIS) that record land features and boundaries.
- Surveyors must have a thorough knowledge of algebra, basic calculus, geometry, and trigonometry. They must also know the laws that deal with surveys, real property, and contracts.
- Most jurisdictions recognize three different levels of qualification
- Survey assistants or chainmen are usually unskilled workers who help the surveyor. They place target reflectors, find old reference marks, and mark points on the ground. The term 'chainman' derives from past use of measuring chains. An assistant would move the far end of the chain under the surveyor's direction.
- Survey technicians often operate survey instruments, run surveys in the field, do survey calculations, or draft plans. A technician usually has no legal authority and cannot certify his work. Not all technicians are qualified, but qualifications at the certificate or diploma level are available.
- Licensed, registered, or chartered surveyors usually hold a degree or higher qualification. They are often required to pass further exams to join a professional association or to gain certifying status.
- Surveyors are responsible for planning and management of surveys.
- They have to ensure that their surveys, or surveys performed under their supervision, meet the legal standards. Many principals of surveying firms hold this status.

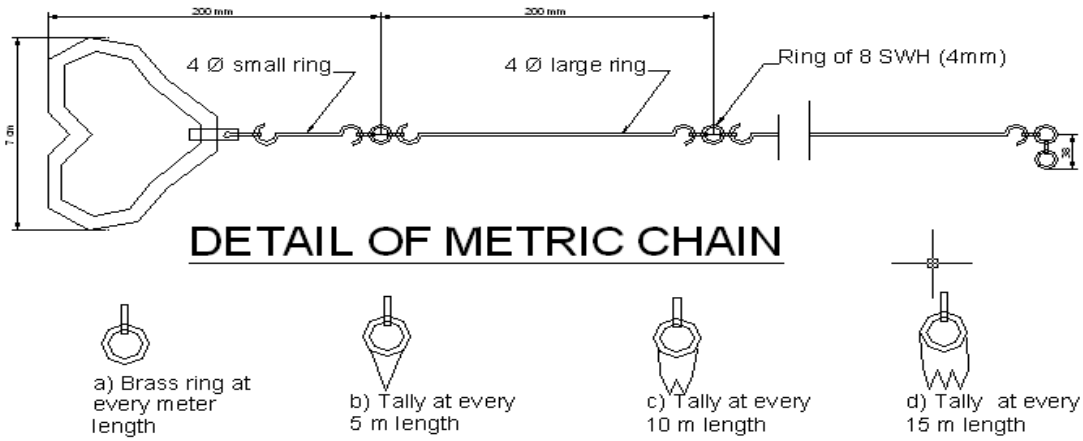
Surveying institutions:

- Most countries' governments regulate at least some forms of surveying.
- Their survey agencies establish regulations and standards. Standards control accuracy, surveying credentials, monumentation of boundaries and maintenance of geodetic networks.
- Many nations devolve this authority to regional entities or states/provinces. Cadastral surveys tend to be the most regulated because of the permanence of the work.
- Lot boundaries established by cadastral surveys may stand for hundreds of years without modification.
- Most jurisdictions also have a form of professional institution representing local surveyors. These institutes often endorse or license potential surveyors, as well as set and enforce ethical standards.
- The largest institution is the International Federation of Surveyors (Abbreviated FIG, for French: Federation Internationale des Geometres).

- They represent the survey industry worldwide.

Basic Concepts of Surveying:

Metric chain:



Chaining:

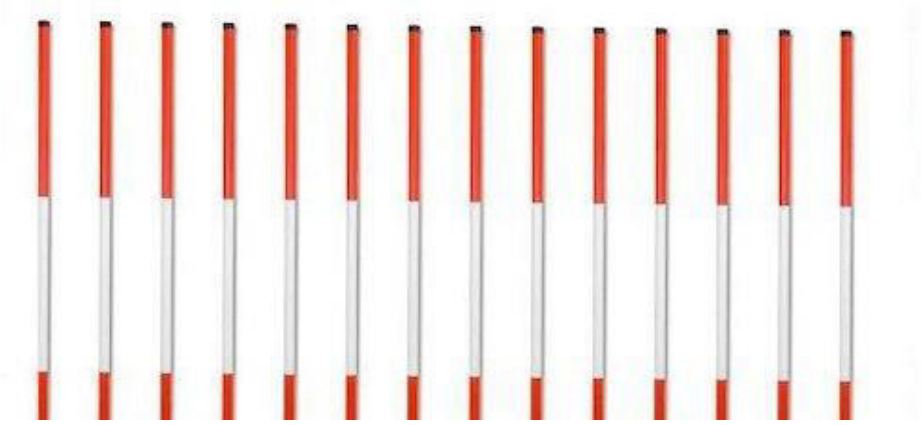
- By the various methods of determining distance the most accurate and common method is the method of measuring distance with a chain or tape is called Chaining.
- For work of ordinary precision a chain is used. The term chaining was originally applied to measure Distance with a chain.
- The term chaining is used to denote measuring distance with either chain or tape, In the process of chaining, The survey party consists of a leader (the surveyor at the forward end of the chain) a follower (the surveyor at the rare end of the chain and an assistant to establish intermediate points)
- The accuracy to which measurement can be made with chain and tape varies with the methods used and precautions exercised. For ordinary work, ranges from 1/1000 to 1/30,000 and precise measurement such as Baseline may be of the order of 1000000.
- The chain is composed of 100 or150 pieces of galvanized mild steel were 4mmin diameter called links.
- The end of each link is bent into a loop and connected together by means of three oval rings which afford flexibility to the chain and make it less liable to become kinked.
- The ends of chain are provided with brass handles for dragging the chain on the ground, each with a swivel Joints so that the chain can be turned round without twisting.

- The length of the A link is the distance between the centers of the two consecutive middle rings.

- The end links include the handles metallic rings indicators of distinctive points of the Chain to facilitate quick reading of fractions of chain in surveying measurements.

Ranging rods:

- The ranging rods are used for marking the positions of Stations conspicuously and for ranging the lines.
- In order to make these visible at a distance, they are painted alternately black and white, or red and white or red White and black successively.
- The adjustment of the chain should as far as possible be affected symmetrically on either side of the middle so as that the position of central tag remains unaltered.
- In measuring the length of survey line also called as chain line. It is necessary that the chain should be laid out on the ground in a straight line between the end stations.

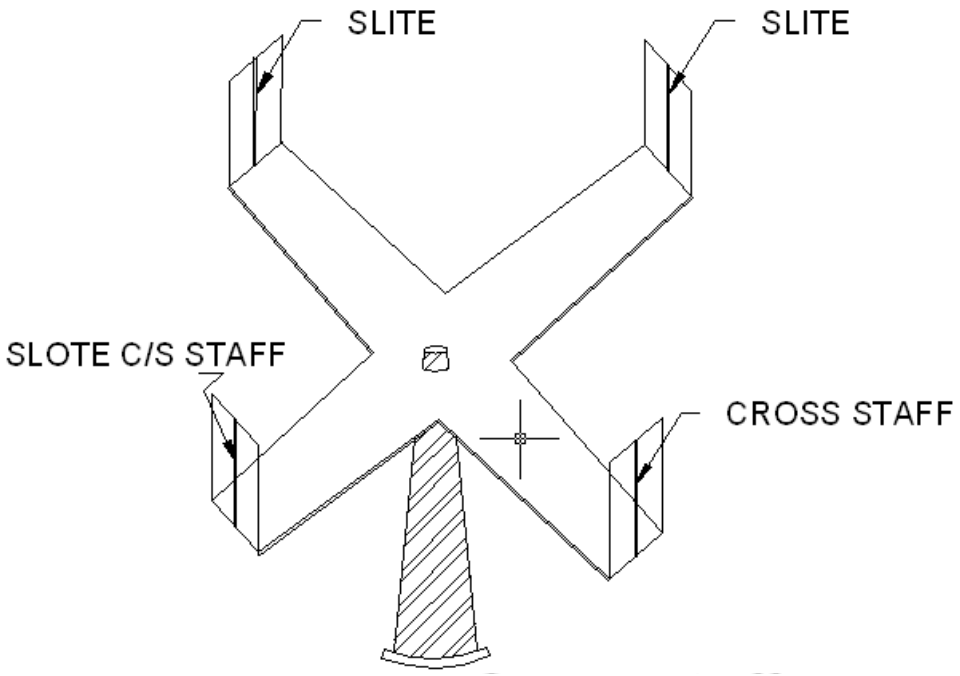


Cross-staff:

- Cross-Staff is the simplest instrument used for setting out perpendicular i.e. taking offsets from a chain line.
- it is easier and quicker method ,but not very accurate,if great accuracy is desired, the work should be carried out by the theodolite.

Open cross staff:-

- The simplest Type consists two parts a) the head b) the leg
- The head is made of wooden block octagonal or round in shape about 15cm side or diameter an 4cm deep on it are scribed two lines at right angles to another.
- At the end of these two lines are fixed two points of metallic strip having slits made in them these slits two lines of sight which are at right angles to one another
- The head is fixed on a wooden staff or pole about 3cm in diameter and 1.2 to 1.5m length .The pole is provided conical metal shoe so that it can be driven into the ground



- The object of cross staff survey is to locate the boundaries of field or plot and to find out its area.
- In this method a base line in the centre of the area is selected.
- Chaining along this line is done and the offsets of the points lying on the boundaries of the plot are taken at different chainages.
- By using a cross staff and tape on either side of the chain line and recorded against the chainages in the field note book as already discussed
- The offsets length is written on the left hand side or right hand side of the line as per position until whole of the area is surveyed.

Instruments are used in Surveying: The common equipment used for measuring angles and elevations in surveying are:

- Hand level
- Abney level
- Dumpy level
- Automatic level
- Prismatic compass
- Plane table
- Laser level
- Transit
- Theodolite
- Total Station

Hand level: The main purpose of hand level is to ensure that the chains are in level when the horizontal distance is measured with the help of plumb bobs. It is also used for the same purpose for slope estimation and change in elevation.

Hand level

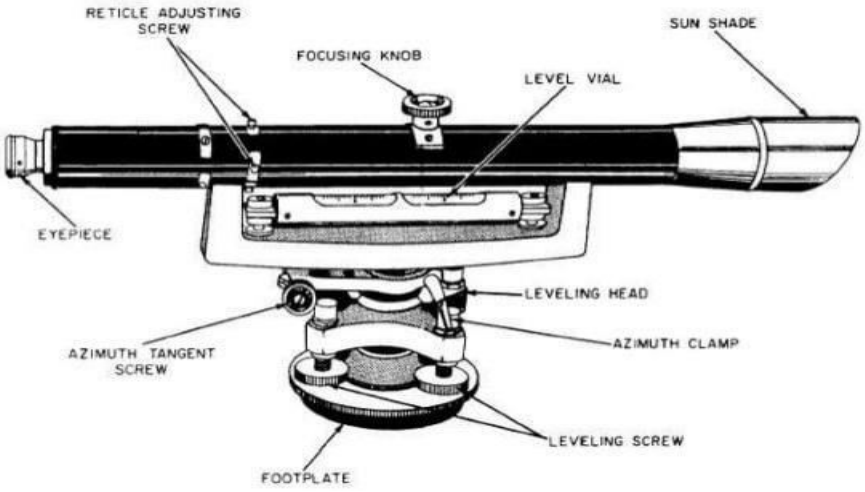
Abney level: Hand levels with more sophistication will form Abney levels. This comprise of a direct reading scale for vertical angles and slope, stadia hairs and better optics and magnification.

Compared to hand level, the precision of slope calculation is better. The measuring distance of the stadia of the Abney level has a precision of 1/10 of a foot. The distance measured using stadia is horizontal Most of the Abney levels have provision for adjustment for both focusing as well as magnification. For preliminary surveying, they give appreciable accuracy if a rod and target are employed

Abney level

Dumpy level:

- The dumpy level is the simplest form of the level that is supported by a tripod.
- The accuracy of the instrument is increased by the use of a tripod. The tripod also helps in providing a reference for the horizontal angles.
- A dumpy level comprises a telescope and a spirit level that is mounted parallel to the line of sight of the telescope.
- The telescope in the dumpy level will have at least one horizontal cross hair that is mounted in line with the line of sight. It also has a vertical cross hair and two stadia cross hairs.



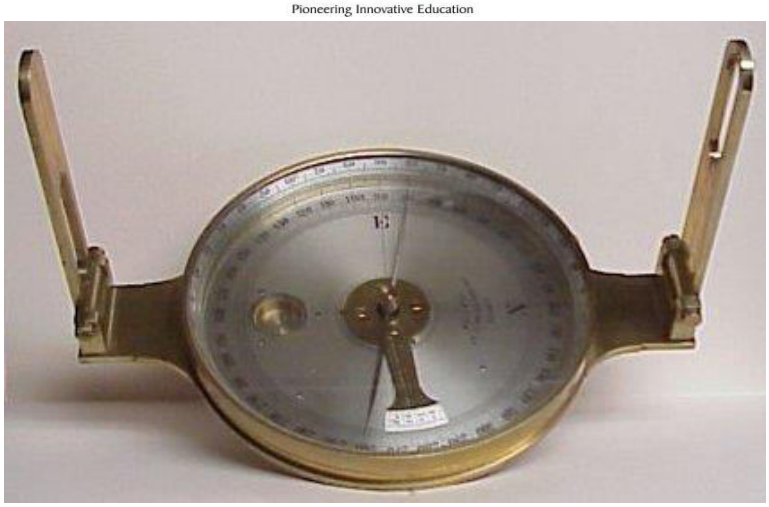
Automatic level:

- The automatic level is designed such a way to automatically compensate for small movements in the instrument and keep the line of sight in level. An internal compensator completes the leveling process once the instrument is nearly level. Later it maintains the line of sight in the horizontal position throughout needed
- The internal compensator does not let the instrument to be knocked out of level by any slight bumps. The movements caused by the wind are also compensated by the internal compensators.
- The instrument is leveled with three leveling screws instead of four. The automatic levels make use of bull's eye spirit level compared to the tube level. The combination of three leveling screws and the bull's eye spirit level helps in faster set up.

- A variety of models is available for automatic levels. Some are more accurate and more precise when compared to the dumpy levels. These are less accurate compared with transits and the total stations.

Automatic level

Prismatic compass: A prismatic compass is navigation and surveying instrument which is extensively used for determining course, waypoints (an endpoint of the course) and direction, and for calculating bearings of survey lines and included angles between them.



Prismatic compass

Plane table: plane Table Surveying is a graphical method of survey in which the field observations and plotting are done simultaneously. It is simple and cheaper than theodolite survey. It is most suitable for small scale maps.

Plane table

Laser level:

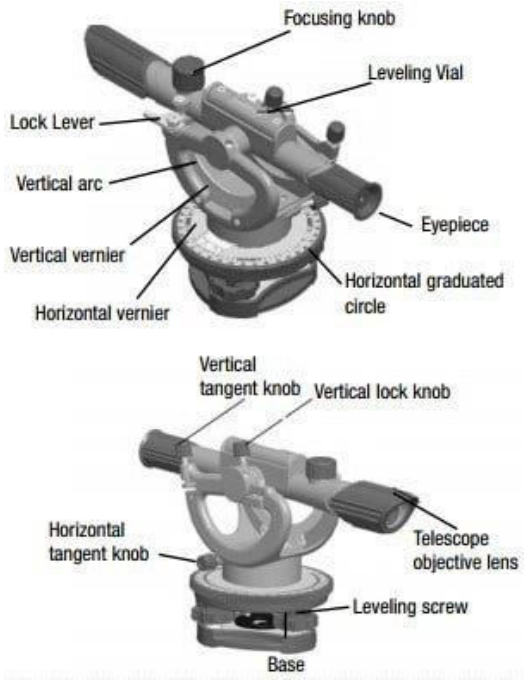
The laser level is a measuring level that makes use of a beam of laser light to establish the line of sight i.e. the reference line. The different types that come under this category are:

- Single beam invisible
- Single beam visible
- Circular beam visible
- Circular beam invisible

The circular beam lasers can be classified into rotating and nonrotating. The single beam laser will make use a single dot or a short line. The circular beam laser will produce a 360-degree beam. The distinct advantage of laser levels is they can be operated by a single person. The laser level is mounted on a tripod and later leveled.

Laser level

Transit level: A transit level is an optical instrument or a telescope that comprises a built-in spirit level that is mounted on the spirit level. They are used to determine the relative position of lines and objects mainly for surveying and building. The transit levels are very precise. The transit level helps in establishing the reference line



Transit level

Theodolite:

- A theodolite is a precision instrument that is used to measure the angle in the horizontal and vertical planes.
- Theodolite is most commonly used in surveying,But they are also used in the areas of metrology and rocket launch technology.
- A modern developed theodolite consists of a movable telescope that is mounted within two perpendicular axes called the horizontal or the trunnion axis and the vertical axis.
- Pointing the telescope on a target object will enable measurement of angle with great precision.
- The theodolite with the help of a forced centering plate is mounted on the tripod head.
- The forced centering plate or the tribrach consist of four thumbscrews, in the case of initial theodolites and three or four rapid leveling in the case of modern theodolites.

- The theodolite must be placed vertically above the point to be measured with the help of a plumb bob or an optical plummet or any laser plummet
- After this, the level is set for the instrument using the leveling foot screws and tubular spirit bubbles.

Theodolite

Total station:

- Total station surveying defined as the use of electronic survey equipment used to perform horizontal and vertical measurements in reference to a grid system (e.g. UTM, mine grid)
- It is an electronic/optical instrument used surveying and building construction. The total station is an electronic theodolite (transit) integrated with an electronic distance measurement (EDM)
- To read slope distances from the instrument to a particular point, and an on-board computer to collect data and perform advanced coordinate based calculations
- Calculations are processed internally so there are no post data collection calculations to process
- Accuracy is much better than alidade, and it is not shot distance dependent

- No plane table for sketching contours and/or contacts on a geologic map
- It may take 30 minutes to an hour to set up (level) the instrument before data can be collected
- Battery life on data collector computer can limit length of daily surveys

Total station