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SUBJECT- LAND SURVEY 1

(4th Semester)

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DEPARTMENT OF CIVIL ENGINEERING

LAND SURVEY 1

INTRODUCTION TO SURVEYING, LINEAR MEASUREMENTS:-

1.1 Surveying: Definition, Aims and objectives;-

Surveying is defined as "taking a general view of, by observation and measurement determining the boundaries, size, position, quantity, condition, value etc. of land, estates, building, farms mines etc. and finally presenting the survey data in a suitable form". This covers the work of the valuation surveyor, the quantity surveyor, the building surveyor, the mining surveyor and so forth, as well as the land surveyor. Another school of thought define surveying "as the act of making measurement of the relative position of natural and manmade features on earth's surface and the presentation of this information either graphically or numerical.

The process of surveying is therefore in three stages namely:

This part of the definition is important as it indicates the need to obtain an overall picture of what is required before any type of survey work is undertaken. In land surveying, this is achieved during the reconnaissance study.

Observation and Measurement:-

This part of the definition denotes the next stage of any survey, which in land surveying constitutes the measurement to determine the relative position and sizes of natural and artificial features on the land.

Presentation of Data:

The data collected in any survey must be presented in a form which allows the information to be clearly interpreted and understood by others. This presentation may take the form of written report, bills of quantities, datasheets, drawings and in land surveying maps and plan showing the features on the land. Types of Surveying On the basis of whether the curvature of the earth is taken into account or not, surveying can be divided into two main categories:

Principles of survey-Plane surveying- Geodetic Surveying- Instrumental surveying:-

Plane surveying:

The type of surveying where the mean surface of the earth is considered as a plane all angles are considered to be plane angles. For small areas less than 250 km2 plane surveying can safely be used. For most engineering projects such as canal, railway, highway, building, pipeline, etc. constructions, this type of surveying is used. It is worth noting that the difference between an arc distance of 18.5 km and the subtended chord lying in the earth's surface is 7mm. Also the sum of the angles of a plane triangle and the sum of the angles in a spherical triangle differ by 1second for a triangle on the earth's surface having an area of 196 km2

Geodetic surveying:-

It is that branch of surveying, which takes into account the true shape of the earth (spheroid). Introduction For easy understanding of surveying and the various components of the subject, we need a deep understanding of the various ways of classifying it. Objective To enable the students have understanding of the various ways of classifying surveying Classification Of Surveying Surveying is classified based on various criteria including the instruments used, purpose, the area surveyed and the method used.

Classification on the Basis of Instruments Used. Based on the instrument used; surveys can be classified into;

i) Chain tape surveys
ii) ii) Compass surveys
iii) iii) Plane table surveys
iv) iv) Theodolite surveys
v) Classification based on the surface and the area surveyed
i) Land survey Land surveys are done for objects on the surface of the earth. It can be subdivided into:

(a) Topographic survey:

This is for depicting the (hills, valleys, mountains, rivers, etc) and manmade features (roads, houses, settlements…) on the surface of the earth

(b) Cadastral survey

It is used to determining property boundaries including those of fields, houses, plots of land, etc.

(c) Engineering survey

It is used to acquire the required data for the planning, design and Execution of engineering projects like roads, bridges, canals, dams, railways, buildings, etc. City surveys: The surveys involving the construction and development of towns including roads, drainage, water supply, sewage street network, etc, are generally referred to as city survey.

(D) Marine or Hydrographic Survey:

Those are surveys of large water bodies for navigation, tidal monitoring, the construction of harbors etc.

(E) Astronomical Survey:

Astronomical survey uses the observations of the heavenly bodies (sun, moon, stars etc) to fix the absolute locations of places on the surface of the earth.

CLASSIFICATION ON THE BASIS OF PURPOSE

i) Engineering survey

Control Survey:

Control survey uses geodetic methods to establish widely spaced vertical and horizontal control points.

ii) Geological Survey

Geological survey is used to determine the structure and arrangement of rock strata. Generally, it enables to know the composition of the earth.

iv) Military or Defense Survey:- It is carried out to map places of military and strategic importance iv) Archeological survey is carried out to discover and map ancient/relies of antiquity. Classification Based On Instrument Used i. Chain/Tape Survey: This is the simple method of taking the linear measurement using a chain or tape with no angular measurements made.

ii. Compass Survey:

Here horizontal angular measurements are made using magnetic compass with the linear measurements made using the chain or tape.

iii. Plane table survey:

This is a quick survey carried out in the field with the measurements and drawings made at the same time using a plane table. iv. Leveling This is the measurement and mapping of the relative heights of points on the earth‟s surface showing them in maps, plane and charts as vertical sections or with conventional symbols.

Vi. Theodolite Survey:-

Theodolite survey takes vertical and horizontal angles in order to establish controls

CLASSIFICATION BASED ON THE METHOD USED 1.

Triangulation Survey:-

In order to make the survey, manageable, the area to be surveyed is first covered with series of triangles. Lines are first run round the perimeter of the plot, then the details fixed in relation to the established lines. This process is called triangulation. The triangle is preferred as it is the only shape that can completely over an irregularly shaped area with minimum space left.

ii. Traverse survey:-

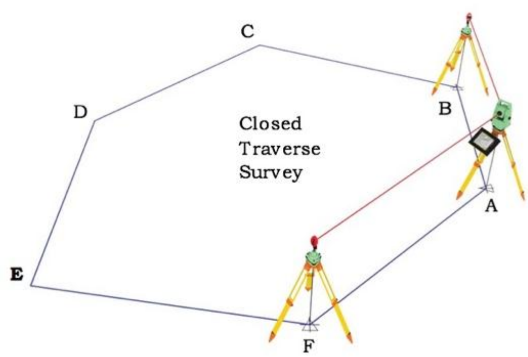
If the bearing and distance of a place of a known point is known it is possible to establish the position of that point on the ground. From this point, the bearing and distances of other surrounding points may be established. In the process, positions of points linked with lines linking them emerge. The traversing is the process of establishing these lines, is called traversing, while the connecting lines joining two points on the ground. Joining two while bearing and distance is known as traverse A traverse station is each of the points of the traverse, while the traverse leg is the straight line between consecutive stations. Traverses may either be open or closed

1. Closed Traverse:-

When a series of connected lines forms a closed circuit, i.e. when the finishing point coincides with the starting point of a survey, it is called as a „closed traverse‟, here ABCDEA represents a closed traverse.

LAND SURVEY

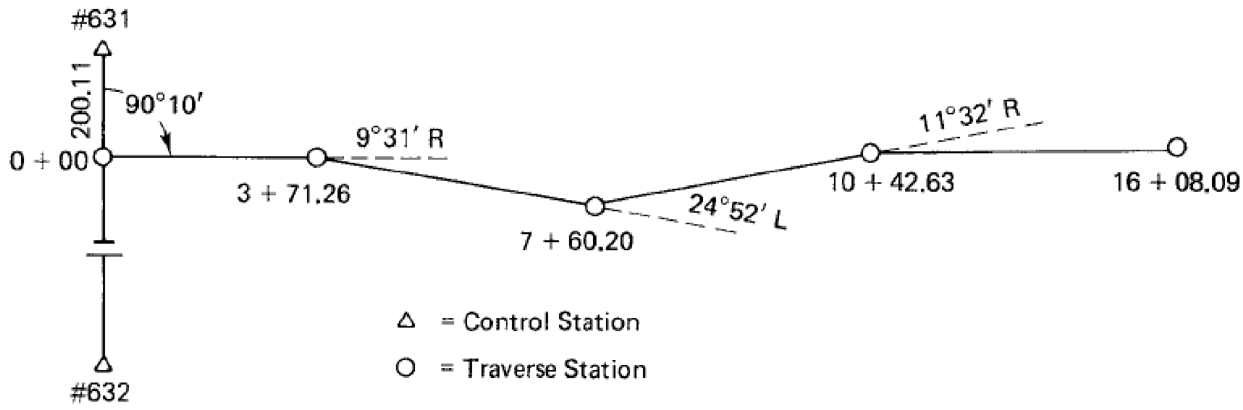
THEORY:



PROCEDURE

1. A rough sketch of the area including station locations
2. Name the stations in alphabetical orders
3. Setup a total station at station A and setup two reflectors at station B and the last station.
4. Target the previous station and consider as north (Please remember this is not a true north, just to measure the horizontal angle between stations) and measure internal horizontal angles (hr), vertical angle (v) and slope distance (SD) to station B.
5. Repeat the steps 3 and 4 from station B.

Open Traverse:-



When a sequence of connected lines extends along a general direction and does not return to the starting point, it is known as „open traverse‟ or (unclosed traverse). Here ABCDE represents an open traverse.

Precision and accuracy of measurements, instruments used for measurement of distance:-

Accuracy:-

The ability of an instrument to measure the accurate value is known as accuracy. In other words, it is the *the closeness of the measured value to a standard or true value*. Accuracy is obtained by taking small readings. The small reading reduces the error of the calculation. The accuracy of the system is classified into three types as follows:

-
    -
        - Point Accuracy

The accuracy of the instrument only at a particular point on its scale is known as point accuracy. It is important to note that this accuracy does not give any information about the general accuracy of the instrument.

-
    -
        - Accuracy as Percentage of Scale Range

The uniform scale range determines the accuracy of a measurement. This can be better understood with the help of the following example: *Consider a thermometer having the scale range up to 500ºC. The thermometer has an accuracy of ±0.5 percent of scale range i.e. 0.005 x 500 = ± 2.5 ºC. Therefore, the reading will have a maximum error of ± 2.5 ºC.*

- Accuracy as Percentage of True Value

Such type of accuracy of the instruments is determined by identifying the measured value regarding their true value. The accuracy of the instruments is neglected up to ±0.5 percent from the true value.

Precision:-

The closeness of two or more measurements to each other is known as the precision of a substance. If you weigh a given substance five times and get 3.2 kg each time, then your measurement is very precise but not necessarily accurate. Precision is independent of accuracy. The below examples will tell you about how you can be precise but not accurate and vice versa. Precision is sometimes separated into:

- Repeatability

The variation arising when the conditions are kept identical and repeated measurements are taken during a short time period.

- ACCURACY AND PRECISION:-

These terms are used frequently in engineering surveying both by manufacturers when quoting specifications for their equipments and on site by surveyors to describe results obtained from field work.

• Accuracy allows a certain amount of tolerance (either plus or minus) in a measurement, while;

• Precision demands exact measurement. Since there is no such things as an absolutely exact measurement, a set of observations that are closely grouped together having small deviations from the sample mean will have a small standard error and are said to be precise.

Instruments used for measurement of distance:-

Both direct and indirect methods are used for distance measurement in surveying. Instruments and equipment are correspondingly divided into two main groups: instruments for direct measurement (or length measurement) and instruments and devices for indirect measurement (or distance measurement). The basic principle of measurement by length measuring devices is that a basic length from a zero mark to an end mark is directly compared with the distance to be measured. The basic length marked on the measuring device is usually an integral multiple of the measuring unit of length measurement. Instruments for distance measurement can be again divided into two groups: distance meters operating on geometrical (optical) pricniples and those operating on the principle of wave-physics (electronic or physical distance meters). In the case of the geometrical distance meter the determination of the distance is generally reduced to the solution of a triangle. Electronic distance meters use either the phenomenon of light interference or electromagnetic waves; they are described in the second part of the book. In a wider sense one can speak of distance measurement in the case of an indirect distance determination, when the distance is computed from the measured data of an established geometric framework in the field. In this case instruments for measuring angles are also used as tools for distance determination. The internationally accepted unit of length is the metre. The reference standard of the metre used to be an iridium-platinum bar at Sevres near Paris. The metre is defined as the distance between the centre marks of the groups of marks at the two ends of the bar, with the bar in a horizontal position and at a temperature of 0 °C. Copies of the original reference standard metre are in the possession of the member-countries of the metre convention. The length of a metre bar, however, changes with time to a degree that cannot be predicted — presumably due to the slow change in the position of the atoms as a result of internal contraction. Therefore, the metre was defined at the 11th International Conference on Weights and Measures as a multiple of the constant wavelength of an exactly defined radiation. According to the definition:

Types of tapes and chains:-

Surveying Measurements:-

Measuring distances and angles from a known reference are fundamental surveying operations. Through the use of trigonometric calculations, the distance and angle measurements are used to establish three dimensional (3-D) coordinates for each surveyed point. The coordinates are then plotted to create planimetric maps and digital terrain models (DTM's). The five common types of survey measurements are horizontal distances and angles, vertical distances and angles, and slope distances.

Horizontal and Vertical Planes:-

Angles and distances are measured relative to either a horizontal or vertical plane. The horizontal plane is a level surface radiating outward from the point of observation and is perpendicular to the vertical axis. The vertical axis (or plumb line) is always parallel to the direction of gravity. The vertical plane runs in a direction parallel to the vertical axis and perpendicular to the horizontal plane. A vertical plane is established whenever the instrument rotates along the horizontal plane to face a new direction.

Horizontal Distances and Angles

A linear measurement on the horizontal plane determines the horizontal distance between two points. However, the true horizontal distance is actually curved like the Earth's surface. Due to this curvature, the direction of gravity is different at each point. Subsequently, vertical axes are not parallel to each other. Figure III-2 shows a representation of the curved surface and the parallel horizontal distance. Horizontal angles are measured on the horizontal plane and establish the azimuth of each survey measurement. An azimuth is a horizontal angle measured clockwise from a defined reference (typically geodetic north). Horizontal distance and angle measurements are then used to calculate the position of a point on the horizontal plane.

Vertical Distances and Angles:-

Vertical distances are measured along the vertical axis to determine the difference in height (or elevation) between points. Vertical angles are measured in the vertical plane either above or below the horizontal plane of the instrument. Zenith angles, used as a reference for measuring vertical angles, are defined as 0° directly overhead and 90° at the horizontal plane.

c. Slope Distance:-

The slope distance is the shortest distance from the instrument to the target. This distance is the hypotenuse of the horizontal and vertical distances. The horizontal and vertical distances can be calculated if the slope distance and vertical angle is known.

Errors:-

A discrepancy is defined as the difference between two or more measured values of the same quantity. However, measurements are never exact and there will always be a degree of variance regardless of the survey instrument or method used. These variances are known as errors and will need to be reduced or eliminated to maintain specific survey standards. Even when carefully following established surveying procedures, observations may still contain errors. Errors, by definition, are the difference between a measured value and its true value. The true value of a measurement is determined by taking the mean value of a series of repeated measurements. Surveyors must possess skill in instrument operation and knowledge of surveying methods to minimize the amount of error in each measurement.

1. Blunders

A blunder (or gross error) is a significant, unpredictable mistake caused by human error that often leads to large discrepancies. Blunders are typically the result of carelessness, miscommunication, fatigue, or poor judgment. Examples of common blunders are:

Improperly leveling the surveying instrument.

Setting up the instrument or target over the wrong control point.

incorrectly entering a control point number in the data collector.

Transposing numbers or misplacing the decimal point.

All blunders must be found and eliminated prior to submitting a survey for inclusion in the project mapping. The surveyor must remain alert and constantly examine measurements to eliminate these mistakes. Blunders can be detected and eliminated by reacting to "out-oftolerance" messages by the data collector when they occur. They can also be detected by carefully examining a plot of the collected survey points while in the office.

2. Types of Errors :-

There are two types of errors, systematic and random. It is important for the surveyor to understand the difference between the two errors in order to minimize them.

a. SystematicErrors:-

   Systematic errors are caused by the surveying equipment, observation methods, and certain environmental factors. Under the same measurement conditions, these errors will have the same magnitude and direction (positive or negative). Because systematic errors are repetitive and tend to accumulate in a series of measurements, they are also referred to as cumulative errors. Although some systematic errors are difficult to detect, the surveyor must recognize the conditions that cause such errors. The following list includes several examples of systematic errors:

   - Using incorrect temperature and /or pressure observations .
   - Not applying curvature and refraction constants.
   - Using incorrect instrument heights and/or target heights.
   - Using an incorrect prism offset.
   - Using an imperfectly adjusted instrument .

   The effect of these errors can be minimized by:

   - Properly leveling the survey instrument and targets .

- Balancing foresight and backsight observations .
- Entering the appropriate environmental correction factors in the data collector .
- Entering the correct instrument heights, targets heights, and prism offset in the data collector.
- Periodically calibrating the surveying equipment.

If appropriate corrections are not made, these errors can accumulate and cause significant discrepancies between measured values. By keeping equipment in proper working order and following established surveying procedures, many of the systematic errors can be eliminated. Section III Revised May, 2013 III-7

b. Random Errors :-

Random (or accidental) errors are not directly related to the conditions or circumstances of the observation. For a single measurement or a series of measurements, it is the error remaining after all possible systematic errors and blunders have been eliminated. As the name implies, random errors are unpredictable and are often caused by factors beyond the control of the surveyor. Their occurrence, magnitude, and direction (positive or negative) cannot be predicted. Errors of this type are compensating and tend to at least partially cancel themselves mathematically. Because the magnitude is also a matter of chance they will remain, to some degree, in every measurement. Disclosures (or residuals) are the difference in a measurement or a series of measurements from an established value. Random errors account for the disclosure when systematic errors have been corrected and blunders have been removed. Disclosures are computed when adjusting level loops, traverses, and GPS networks. Random errors conform to the laws of probability and are therefore equally distributed throughout the survey. Because of their random nature, correction factors cannot be computed and applied as they are with some systematic errors. However, they can be estimated using a procedure based on the laws of probability known as the least-squares method of adjustment. This method computes the most probable adjusted values and the precision of the survey. The least-squares method may also reveal the presence of large blunders.

3. Error Sources

There are a variety of factors that can lead to measurement errors. Errors typically arise from three sources; natural errors, instrument errors, and human errors.

a. Natural Errors:-

Natural errors are caused by environmental conditions or significant changes in environmental conditions. Wind speed, air temperature, atmospheric pressure, humidity, gravity, earth curvature, and atmospheric refraction are examples of natural error sources. Many of these environmental conditions can be compensated for by applying a correction factor to each measurement. Commonly used correction factors are the parts per million (ppm) and curvature and refraction constants. The ppm correction factor is applied to slope distances to minimize the effects of atmospheric changes. The correction is determined using observed temperature and pressure readings. With each instrument setup, new temperature and pressure readings should be taken and the ppm constant revised, if necessary. The curvature and refraction constant is applied to the vertical distance measurement. The constant corrects for the Earth's curvature and atmospheric refraction and should be applied to the survey by the data collector. There are other natural phenomena that can lead to measurement errors. Intense, direct sunlight may cause differential expansion of the components of the instrument, resulting in minor errors. This effect can be minimized by operating on cloudy days, times of low Measurements and Errors III-8 Revised May, 2013 sun angles, or using a parasol to shade the instrument. Heat waves can cause distortion in lines of sight near reflective surfaces. The effects of heat waves can be minimized by surveying in cooler, cloudy periods, taking shorter measurements, or avoiding measurements taken over asphalt or concrete in excessively hot weather.

b. Instrument Errors:-

Instrument errors are caused by imperfectly constructed, adjusted, or calibrated surveying equipment. Most of these errors can be reduced by properly leveling the instrument, balancing backsight/foresight shots, reducing measurement distances, and observing direct and reverse positions (double centering). Prolonged storage, exposure to rapid changes in temperature, and jarring during transportation may lead to instrument maladjustments. Collimation and other sighting errors can be determined and compensated for by specific instrument adjustments. Before making instrument adjustments or beginning surveying operations, allow the instrument to adapt to the ambient temperature before proceeding. Instrument errors can be further minimized by periodically calibrating surveying instruments, prisms, rods, and tribrachs. Yearly maintenance agreements are purchased to ensure that WYDOT surveying instruments are regularly cleaned, calibrated, and adjusted by an authorized technician. Occasionally during these services visits, the data collector's operating system (firmware) will be replaced with a more current version. It is equally important that equipment suspected of being out of tolerance is sent to the appropriate service center. The Photogrammetry & Surveys Section should be notified prior to sending equipment for unscheduled adjustment, calibration and/or repairs.

c. Human Errors:-

Human errors are caused by physical limitations and inconsistent setup and observation habits of the surveyor. For example, minor errors result from misaligning the telescope crosshairs on the target or not holding the target rod perfectly plumb. These errors will always be present to some degree in every observation. However, by following established setup and collection procedures, many potential errors can be minimized. Because any survey is only as accurate as the instrument/target setup; a secure, level tripod is paramount. A tripod should always be used to stabilize the backsight target when placing it over a control point. When positioning the tripod, firmly press the tripod feet into the ground. Place the tripod legs in a position that will reduce the amount of walking near the instrument. Minimizing movement around the tripod will reduce the chances of bumping it. In windy conditions, it may be necessary to place sandbags on the feet of the tripod to ensure stability. When setting up on steep slopes, position two tripod legs on the downhill side. Periodically check the optical plummet to verify that the instrument is still centered over the point. Periodically check the level bubble to ensure that the instrument is still on a horizontal plane. The level bubble should hold one position when the instrument is smoothly rotated through a complete revolution. Section III Revised May, 2013 III-9 When taking an observation with an optical instrument, the center of the target should coincide with the center of the reticle (or crosshair). To obtain accurate results, consistently sight the telescope to the same part of the target. Turn the ocular (or eye piece) until the reticle is clearly focused. Then adjust the focusing knob until the target is clearly defined within the field of view. When the observer's eye moves behind the ocular, the target and reticle should not be displaced with respect to one another.

Corrections to measured lengths due to-incorrect length:-

Tape Corrections

The corrections performed for seven common errors in linear measurements by tape are:

1. Correction for absolute length
2. Correction for pull or tension
3. Correction for temperature
4. Correction for Sag
5. Correction for Slope
6. Correction for Alignment
7. Reduction for the sea level

1. Correction for Absolute Length

If Ca is the correction for absolute length or the actual length, then it is given by:

Ca = Lc/l

Where, L = Measured length of the line; c = Correction per tape length; l= designated length of the tape or the nominal length.

Different cases are:

1. Absolute length > Designated length means Measured distance is short, hence the correction is additive.
2. Absolute length < Designated length means, Measured distance is long, hence the correction is subtractive.

The sign of correction Ca is the same as that of 'c'.

Temperature variation, pull, sag, numerical problem applying corrections:-

2. Correction for Temperature

The correction for temperature Ct is given by the formula:

Tm is the mean temperature in the field during measurement; To is the temperature during the standardization of the tape; L = Measured length

There are two cases possible:

1. The temperature of the field is greater than the temperature at which the tape is standardised; Tm > To. This results in an increase in the tape length, making the measured length shorter. Hence the correction is additive.

2. The temperature of the field is lesser than the standardised temperature, i.e. Tm<To, then the tape length decreases. This results in an increase the measured length than the original. Hence the correction is subtractive.

3. Correction for Pull or Tension

The correction for pull or tension is given by the formula:

Where, P = Pull applied during the measurement; Po= Standard Pull; Both P and Po are measured in Newtons;L = measured length;A =Area of cross-section in cm^2; E = Young's modulus in N/cm^2.

Two cases are possible.

1. Pull applied during the measurement is greater than pull at which the tape is standardized i.e. P > Po. This results in an increase in the length of tape which makes the measured length shorter. Hence the correction is additive.

2. Pull applied during the measurement is lesser than pull at which the tape is standardized i.e. P < Po. This results in a decrease in length of tape which makes the measured length longer. Hence the correction is subtractive.

The pull applied in the field must be less than 20 times the weight of the tape used for measurement.

4. Correction for Sag

Stretching the tape between two supports make the tape to form a horizontal catenary. Hence, the horizontal distance becomes greater than the distance along the curve. Hence,

Sag Correction = Horizontal distance – length along the horizontal catenary. As shown in the figure below, the curve is assumed as a parabola to facilitate the calculation of correction for sag.

Sag Correction

Steel Tape Sag Corrections

Section 2.14.3 of Textbook

$$C_s = \frac{-w^2 L^3}{24 P^2}$$

Metric Units:

- C_s is the correction in meters due to tape sag
- **w** is the weight of the tape per unit length (N/m)
- **P** is the tension (N) of the tape during measurement.
- L is the distance measured, in meters.

Imperial Units:

- C_s is the correction in feet due to tape sag
- **w** is the weight of the tape per unit length (lb/ft)
- **P** is the tension (lb) of the tape during measurement.
- L is the distance measured, in feet.

Steel Tape Sag Corrections

Example 2.13 of Textbook

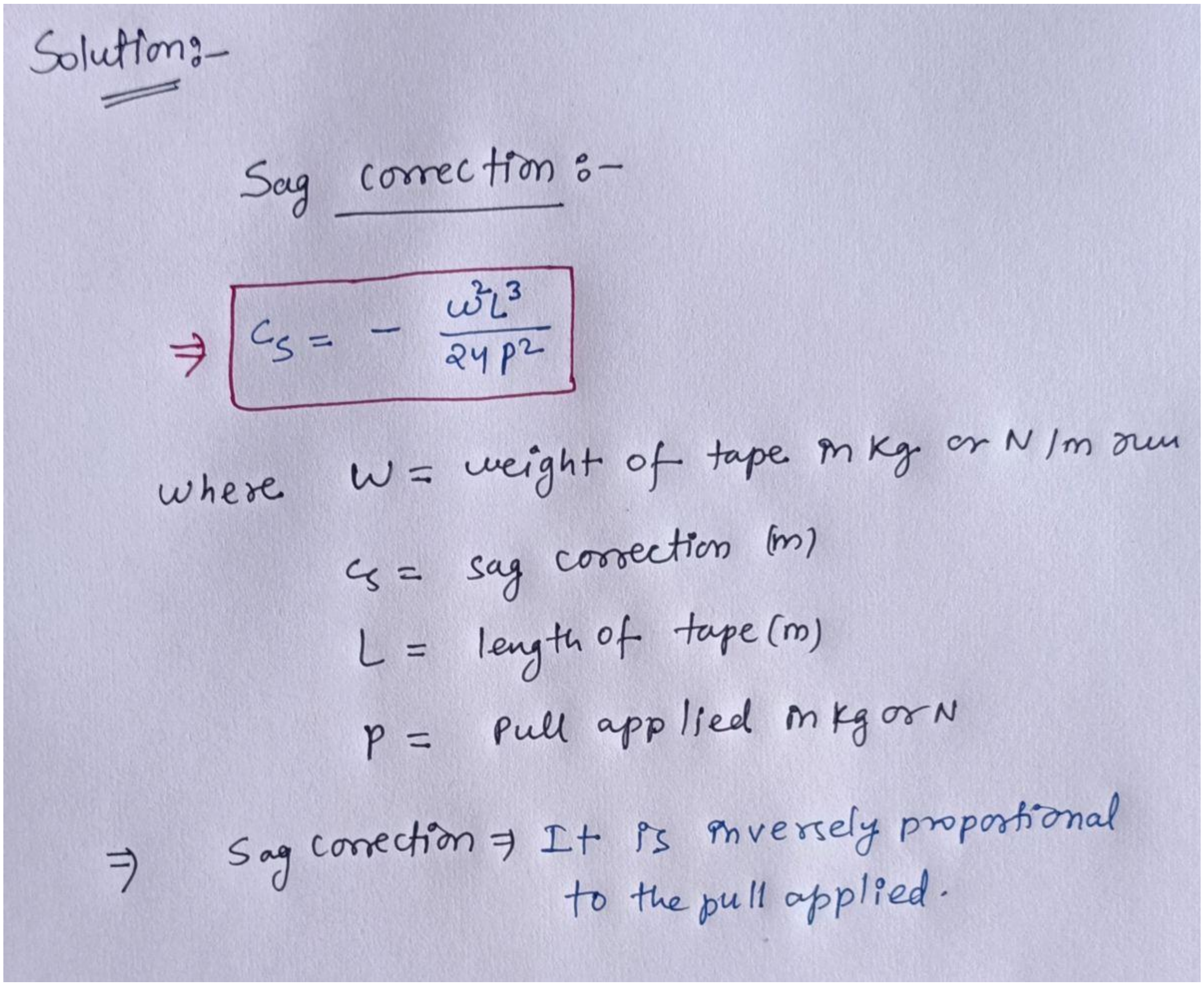
$$C_s = \frac{-w^2 L^3}{24 P^2}$$

A 100-ft steel tape weighs 1.6 lb and is supported only at the ends with a force of 10 lbs. What is the sag correction?

$$C_s = -[(0.016\ lb/ft)^2 \times (100\ ft)^3] \div [24 \times (10\ lb)^2] = -0.11\ ft$$

If the pull force were increases to 20 lbs, what would the sag correction be?

$$C_s = -[(0.016\ lb/ft)^2 \times (100\ ft)^3] \div [24 \times (20\ lb)^2] = -0.03\ ft$$


Solution:-

Sag correction :-

$$\Rightarrow C_s = -\frac{w^2 L^3}{24 P^2}$$

where W = weight of tape in kg or N/m run

C_s = sag correction (m)

L = length of tape (m)

P = Pull applied in kg or N

⇒ Sag correction ⇒ It is inversely proportional to the pull applied.

Tape correction per length is given by,

$Cs = lW^2 / 24n^2P^2$

Where, Cs = Tape Correction per Tape length; l=Total length of the tape; W= total weight of the tape; n= number of equal spans; P= Pull applied;

5. Correction for Slope or Vertical Alignment

The slope correction or correction due to vertical alignment is given by the relation:

$Cv = 2L \sin^2(x/2)$

Or

Where, h = The difference in elevation between the ends; x = slope measured;

The distance that is measured along the slope is always greater than the horizontal distance. This makes the correction to be subtractive.

6. Correction for Horizontal Alignment
There are three possibilities under this:

a. Bad Ranging or Misalignment Error

Stretching the tape out of line results in greater distance value. The correction is therefore negative. As shown in figure below, AB is the measured length and AC is the correct alignment. Hence, the correction is given by:

$Ch = d^2/2L$

b. Deformation of the Tape in Horizontal Plane

When the tape is not pulled straight, the length L1 of the tape stands out of the line by an amount 'd'. Then the correction is given by,

$Ch = (d^2/2L_2) + (d^2/2L_2)$

c. Broken Base

Due to some obstructions, it won't be possible to set out the base in a single continuous line. Such a base is called a broken base.

If the two sections of the broken base are AB and BC, with an exterior angle beta, then the correction is given by:

Ch = (a +c)-b which is subtractive

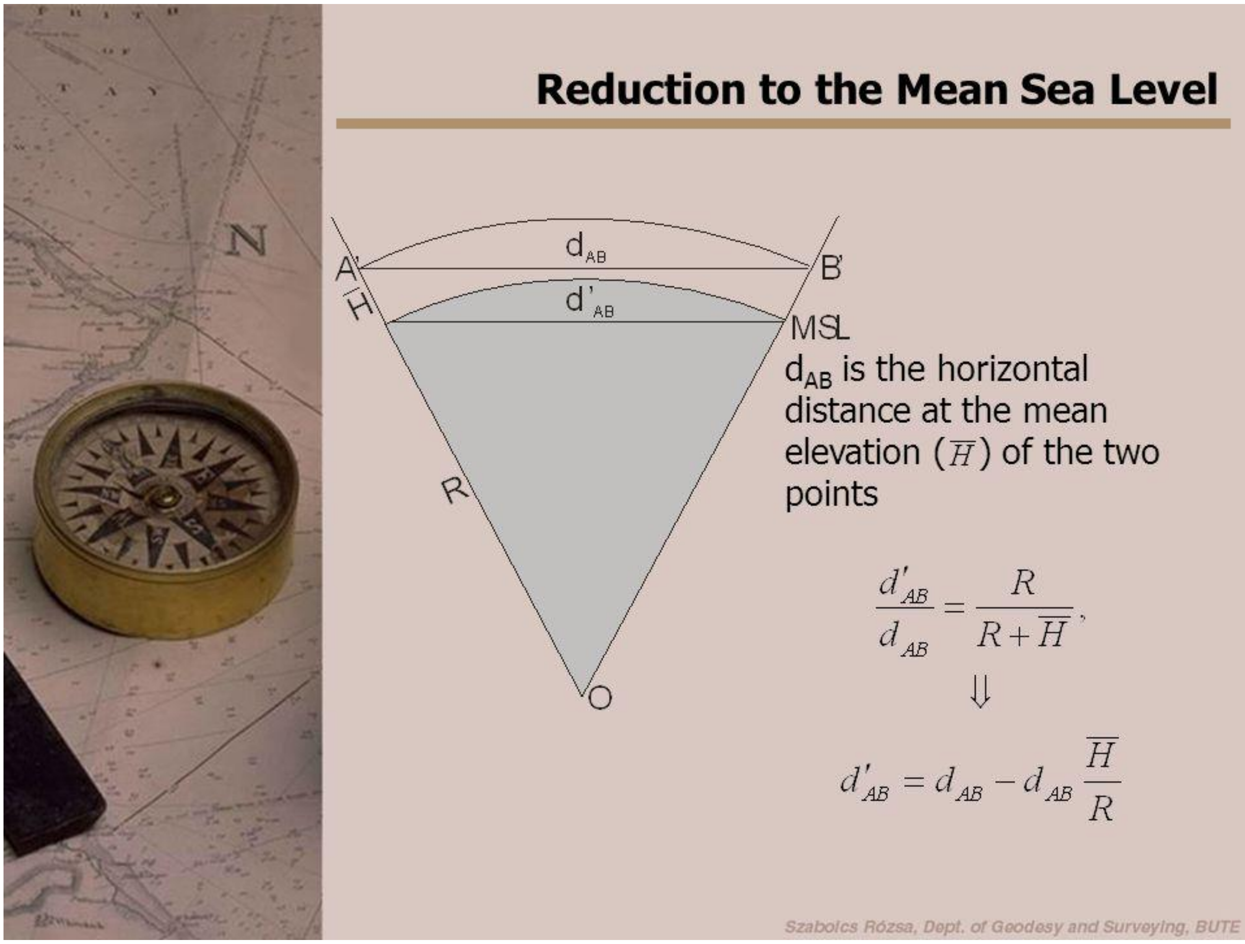
Which is given by,

7. Reduction to Mean Sea Level

The horizontal distance measured must be reduced to the distance at sea level. This distance is called as geodetic distance.

Given, L = Measured Horizontal Distance; D = Geodetic MSL; h= mean the equivalent of the baseline above the mean sea level. R = Radius of the earth; An angle is subtended at the center of the earth.

Then the correction is given by:-



CHAINING AND CHAIN SURVEYING :-

Equipment and accessories for chaining:-

Equipment Used In Chain Surveying

In chain or tape surveying, obviously a tape or a chain is required. But in addition to that, the following instruments and accessories are also required:

(a) Pegs (b) Arrows (c) Plumb bob

(d) Ranging rods (e) Offset rods (f) Clinometer

(g) Cross-staff (h) Optical Square (i) Prism S

Surveying Chain

A Surveying Chain, or simply a chain, is commonly used for measurement of distances where a very high accuracy is not required. A chain consists of a number of large links made of galvanised mild steel wire of 4mm diameter.

Ranging – Purpose, signaling:-

The process of establishing an intermediate point on a straight line between two endpoints is known as ranging. It is necessary to align intermediate points on the chain line so that the measurements are along the line.

Ranging poles are used to mark areas and to set out straight lines on the field. They are also used to mark points which must be seen from a distance, in which case a flag may be attached to improve the visibility. Ranging poles are straight round stalks, 3 to 4 cm thick and about 2 m long.

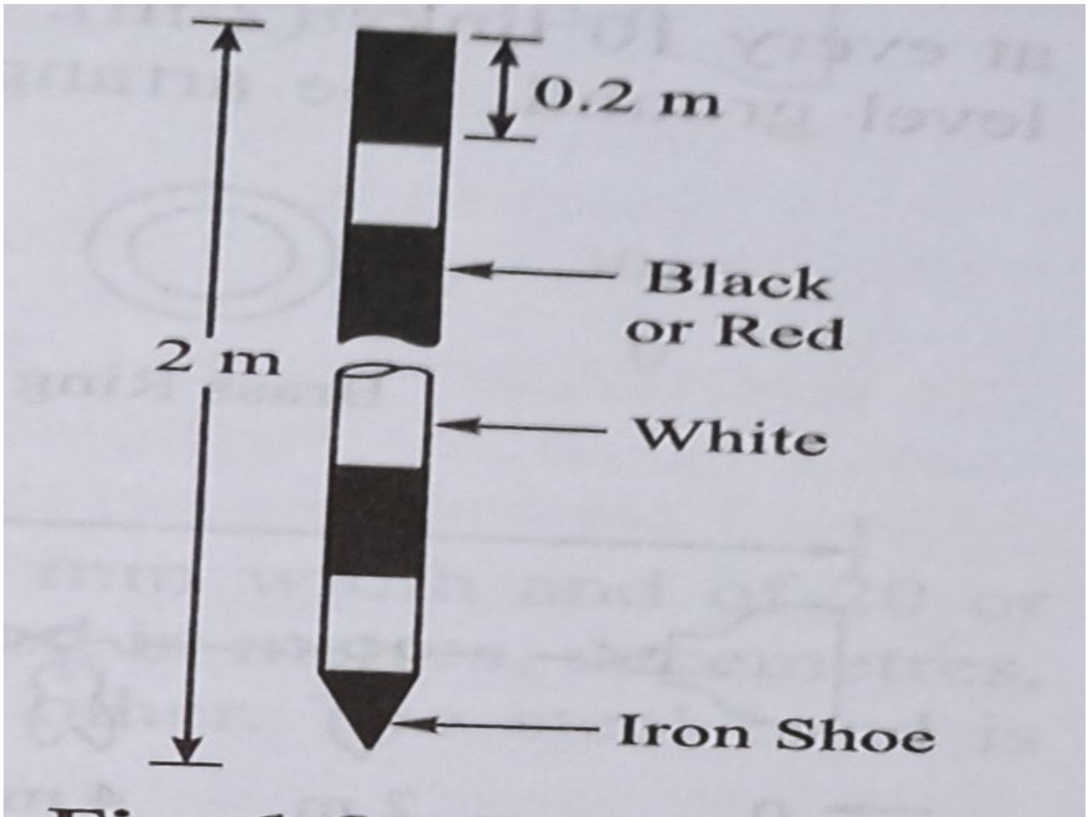


Fig. 1.2 Ranging Rod

They are made of wood or metal. Ranging poles can also be home made from strong straight bamboo or tree branches.

REMEMBER: Ranging poles may never be curved.

Ranging poles are usually painted with alternate red-white or black-white bands. If possible, wooden ranging poles are reinforced at the bottom end by metal points.

Pegs:-

Pegs are used when certain points on the field require more permanent marking. Pegs are generally made of wood; sometimes pieces of tree-branches, properly sharpened, are good enough. The size of the pegs (40 to 60 cm) depends on the type of survey work they are used for and the type of soil they have to be driven in. The pegs should be driven vertically into the soil and the top should be clearly visible.

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Direct and indirect ranging:-

While measuring the survey lines, the chain or the tape has to be stretched along the survey line along that joins two terminal stations. When the line to be measured has a smaller length compared to the chain, then the measurement goes smooth. If the length of the line is greater, the survey lines have to be divided by certain intermediate points, before conducting the chaining process. This process is called ranging.

The process of ranging can be done by two methods:

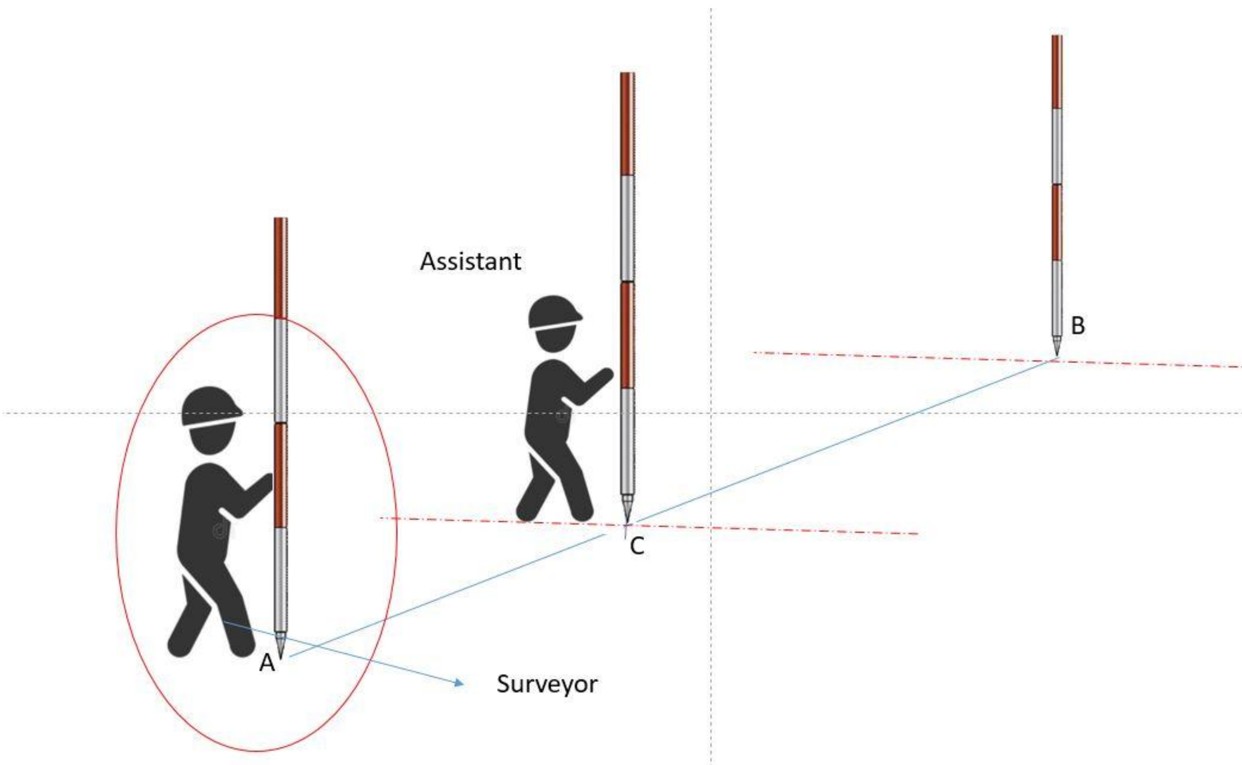
1. Direct Ranging
2. Indirect Ranging

1. Direct Ranging

Direct ranging is the ranging conducted when the intermediate points are intervisible. Direct ranging can be performed by eye or with the help of an eye instrument.

Ranging by Eye

As shown in figure-1 below, let A and B are the two intervisible points at the ends of the survey line. The surveyor stands with a ranging rod at the point A by keeping the ranging rod at the point B. The ranging rod is held at about half metre length.



The assistant then takes the ranging rod and establishes at a point in between AB, almost in line with AB. This is fixed at a distance not greater than one chain length from point A.

The surveyor can give signals to the assistant to move traverse till the rod is in line with A and B. In this way, other intermediate points are determined.

Ranging by Line Ranger

The figure-2 below shows a line ranger that has either two plane mirror arrangement or two isosceles prisms that are placed one over the other. The diagonals of the prism are arranged and silvered such that they reflect incident rays.

Line ranger – features and use, error due to incorrect ranging:-

In order to handle the instrument in hand a handle with hook is provided. The hook is to enable a plumb- bob to help transfer the point to the ground.

In order to range the point 'P', initially two rods are fixed at points A and B. By eye judgment, the surveyor holds the ranging rod at P almost in line with AB.

The lower prism abc receives the rays coming from A which is then reflected by the diagonal ac towards the observer. The upper prism dbc receives the rays from B which is then reflected by the diagonal bd towards the observer. Hence the observer can see the images of the ranging rods A and B, which might not be in the same vertical line as shown in figure-2(c).

The surveyor moves the instrument till the two images come in the same vertical line as shown in figure-2(d). With the help of a plumb bob, the point P is then transferred to the ground. This instrument can be used to locate the intermediate points without going to the other end of the survey line. This method only requires one person to hold the line ranger.

2. Indirect Ranging

Indirect ranging is employed when the two points are not intervisible or the two points are at a long distance. This may be due to some kind of intervention between the two points. In this case, the following procedure is followed.

As shown in figure-3, two intermediate points are located M1 and N1 very near to chain line by judgment such that from M1, both N1 and B are visible & from N1 both M1 and A are visible.

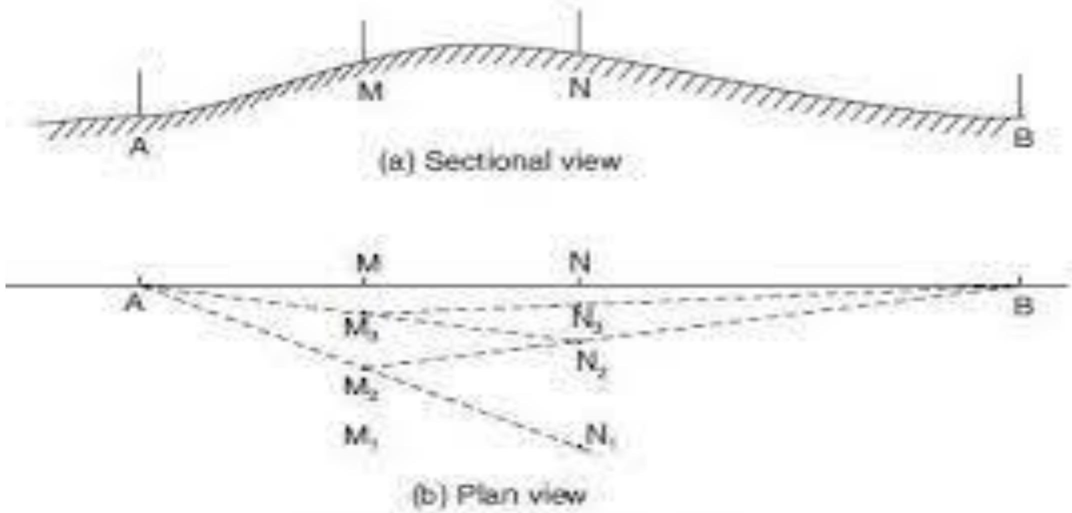


Fig. 12.19. Reciprocal ranging

t M1 and N1 two surveyors stay with ranging rods. The person standing at M1 directs the person at N1 to move to a new position N2 as shown in the figure. N2 must be inline with M1B.

Next, a person at N2 directs the person at M1 to move to a position M2 such that it is in line with N2A. Hence, the two persons are in points are M2 and N2.

The process is repeated until the points M and N are in the survey line AB. Finally, it reaches a situation where the person standing at M finds the person standing at N in line with NA and vice versa. Once M and N are fixed, other points are fixed by direct ranging.

Methods of chaining –Chaining on flat ground:-

Chain surveying is an old method of surveying that involves measuring distances and angles between points on the ground with a chain or tape measure, often using trigonometry to calculate the distance between two points in space.

Method chaining, also known as the named parameter idiom, is a common syntax for invoking multiple method calls in object-oriented programming languages.

Each method returns an object, allowing the calls to be chained together in a single statement without requiring variables to store the intermediate results.

Basic chain surveying terminology

The following is a concise explanation of a number of terms that are frequently used in chain surveying:

Main stations

As the name implies, the main stations are the terminals of the primary survey lines that make up the framework.

Tie or subsidiary stations

For the purpose of calculating the interior details, these are the transitional stations that are included in the major survey lines. Some examples of these kinds of interior elements include things like fences, hedges, and so on.

Base line

The baseline is the primary survey line as well as the longest one. It is the line in relation to which all other metrics for the purpose of describing the activity are obtained. In most cases, it begins in the exact middle of the level field (i.e. diagonally).

Chain lines

Main survey lines are another name for chain lines, which are also extensively used. These connect any two of the primary stations.

Tie lines

The term “tie line” may sometimes be used interchangeably with the term “subsidiary line.” These lines connect the various subsidiary stations with one another. These lines are useful for ensuring that the interior details are accurate.

Check lines

These are often referred to as the proof lines. They serve the purpose of ensuring that the framework is accurate. The span of the check line, as determined on the ground, has to be the same as the extent of the check line, as shown on the plan.

Offsets

Offsets are lateral measures that are measured from the baseline. Offsets may be positive or negative. The primary objective of using offsets is to find the location of various objects in relation to the baseline. Offsets may be either perpendicular or oblique, and these two orientations are the most common ones in practice.

Types of instruments used for chain surveying

The following is a list of the many kinds of equipment that are used in the process of chain surveying:

Chains

When doing a chain survey, chains are an extremely important piece of equipment to have on hand for the actual surveying process. Chains are often deployed to get accurate measurements of horizontal distances.

Arrows

The marking pens are often made of steel wire, and a chain survey typically includes ten arrows for use. The length might be anything between 25 and 50 millimeters. However, the specified length will be based on the IS-Code. A circle or loop is twisted into the arrows opposite end for portability.

Pegs

Putting in a peg at the end of a survey line or at a position station indicates the end of the line. With the aid of the wooden hammer, they are driven into the ground and retained at a height of 40 mm. Pegs typically measure 150 millimeters in length and have a square top that is 30 millimeters in size. Pegs are typically made of wood and are widely accessible.

Ranging Rods

Two to three-metre-long rods made of steel or dry, seasoned wood are used for the range of points. White and black, white and red, or white, black and red coatings alternate to provide the band’s signature look.

Since the band is 200 mm in length, it may be used for a rough measurement with the shorter 2 m ranging rod, which is more often used. At 200 metres, you won't be able to see their octagonal or circular cross-sections.

ALL ABOUT: Ranging Rods

Plumb Bob

When chaining along a slope, a plumb bob is used to accurately transfer marks to the surface. It's also used to evaluate the verticality of range poles and to precisely centre the theodolite compasses, plane tables, etc., over a station mark.

Cross Staff

This instrument is used to mark the starting and ending points of a chain line at right angles. Pole shoes are used to secure the unit to the ground, and it consists of a framework or container with two sets of vertical slots.

Offset Rod

The function of the range rod and the offset rod are equivalent. They have a hooked iron shoe on one end and a groove or a hook on the other to help you push or drag the chain over obstacles like hedges.

Surveying chain types

The following is a list of the several kinds of chains that are often used in surveying:

Metric Chain

The most common lengths of metric chains are five metres, ten metres, twenty metres, and thirty meters. To facilitate fraction readings along a surveying chain, tallies are installed every meter along a 5- and 10-metre chain, and every 5 metres along a 20- and 30-metre chain. Apart from where the tallies are fastened, there is a little brass ring at each metre.

Surveyor's Chain

A Gunter's chain, also known as a Surveyor's chain, has a total length of 66 feet and is made up of 100 connections, each of which is 0.66 feet (7.92 inches) in length. The standard length of a chain used in surveying is 66 feet, which was chosen for its practicality in calculating land areas.

Engineer's Chain

The engineer's chain has a total length of one hundred feet and is made up of one hundred links, each of which is one foot in length. When using this kind of chain for surveying, a brass label is affixed once every ten links. The tags have notches on them, which indicate the number of ten-link segments that are present between the tags and the ends of the chain.

Revenue Chain

The length of this type of chain is 33 feet, and it comprises 16 links. In the field of surveying, this particular type of chain is used for the purpose of measuring fields during cadastral surveys.

Steel Band

These chains are made from one continuous, thin steel link anywhere from 12 mm to 16mm in width and 0.3 mm to 0.6 mm in thickness. Band chains may also include graded etching in centimeter increments as an alternative to the brass studs that divide this chain every 20 centimeters. Band chains in surveying are coiled on steel crossovers or metal lurches, making them easy to use and manage.

Consecutive stages in a survey chain

Reconnaissance

Reconnaissance refers to the first exploration of the region subject to a chain survey. The surveyor will go over the location to be mapped out and make any necessary adjustments before beginning the survey, including inspecting the land on foot, making a note of the location of borders, roads, rivers, and other obstacles to chain lines, as well as the locations of potential stations.

Marking stations

Marking a station may be done with a range rod or a wooden peg, by putting a spike or nails into a hard surface, or by embedding a stone with a cross-shaped mark.

Reference sketches

After the station has been marked, it has to be referenced or localised, using a method of measurement known as ties, which is taken from three fixed places that are simple to identify, such as the building's corner.

Running survey line

Following the completion of the preparatory work, the chaining procedure begins at the baseline and is carried out constantly along each line of the framework. Therefore, the chain is put down and held in place while offset measurements are recorded to pinpoint the neighboring features. Wherever it is essential, perform ranging. Take a reading of the change as well as the offset, then record it in the record sheet.

Errors in chain surveying

Chain surveying is prone to making three significant errors. They are as follows:

Personal Errors

Personal errors are defined as mistakes that are made by the surveyor as a result of their own carelessness or poor judgment. These flaws are significant and cannot be discovered with relative ease. To reduce the likelihood of these types of mistakes occurring, the appropriate safeguards need to be followed. Some personal mistakes are:

- Wrong recording
- Poor ranging
- Inadequate plumbing
- Wrong reading
- Reading from the incorrect ends of the chain

Compensating Errors

This kind of error might have both beneficial and harmful effects. This means that compensation is more likely to occur when a substantial number of measurements are taken. The probability theory may be used to evaluate the severity of such mistakes. Several common mistakes are as follows:

- Even if the overall length of the chain has been adjusted, there is a possibility that a portion of it is inaccurate.
- It is possible that not all of the graduations on the tape are the same.
- There may be some rough plumbing involved in the procedure of stepping when gauging the slope of the ground.

Cumulating Errors

Mistakes that tend to crop up again along the same general path are referred to as cumulative errors. It is possible that the mistake is negligible for each individual reading, but when a significant number of observations are taken, it is necessary to take this into account since the inaccuracy is often focused on one side. The following are some instances of such errors.

- Bad repositioning
- Inaccurate chain length
- Temperature variation
- Changes in applied pull
- A sag in the chain if the measurement of horizontal distance on hilly terrain is halted

Merits of chain surveying

The following is a list of some of the benefits that may be achieved by chain surveying:

- The chain surveying technique is the most straightforward approach to surveying. It is not very difficult to carry out.
- It does not need any expensive equipment or instruments to be used.
- A reasonable degree of precision in the preparation of the design for small areas is the desired quality.

- The computations and charting are also quite easy to understand.

see Precision Mapping Method

Negative aspects of chain surveying

The following is a list of some of the downsides that are associated with chain surveying:

- The use of chain surveying is not recommended for vast regions. As the chaining together of huge regions becomes more laborious.
- It is rather challenging to be performed in places that are densely populated or overgrown.
- It is not appropriate for use on terrain that has undulations since chaining in such places is complex and prone to mistakes.
- It is possible that the findings that were acquired would not always produce correct outcome.

Setting perpendicular with chain & tape, Chaining across different types of obstacles –Numerical problems on chaining across obstacles:-

To set out right angles in the field, a measuring tape, two ranging poles, pegs and three persons are required.

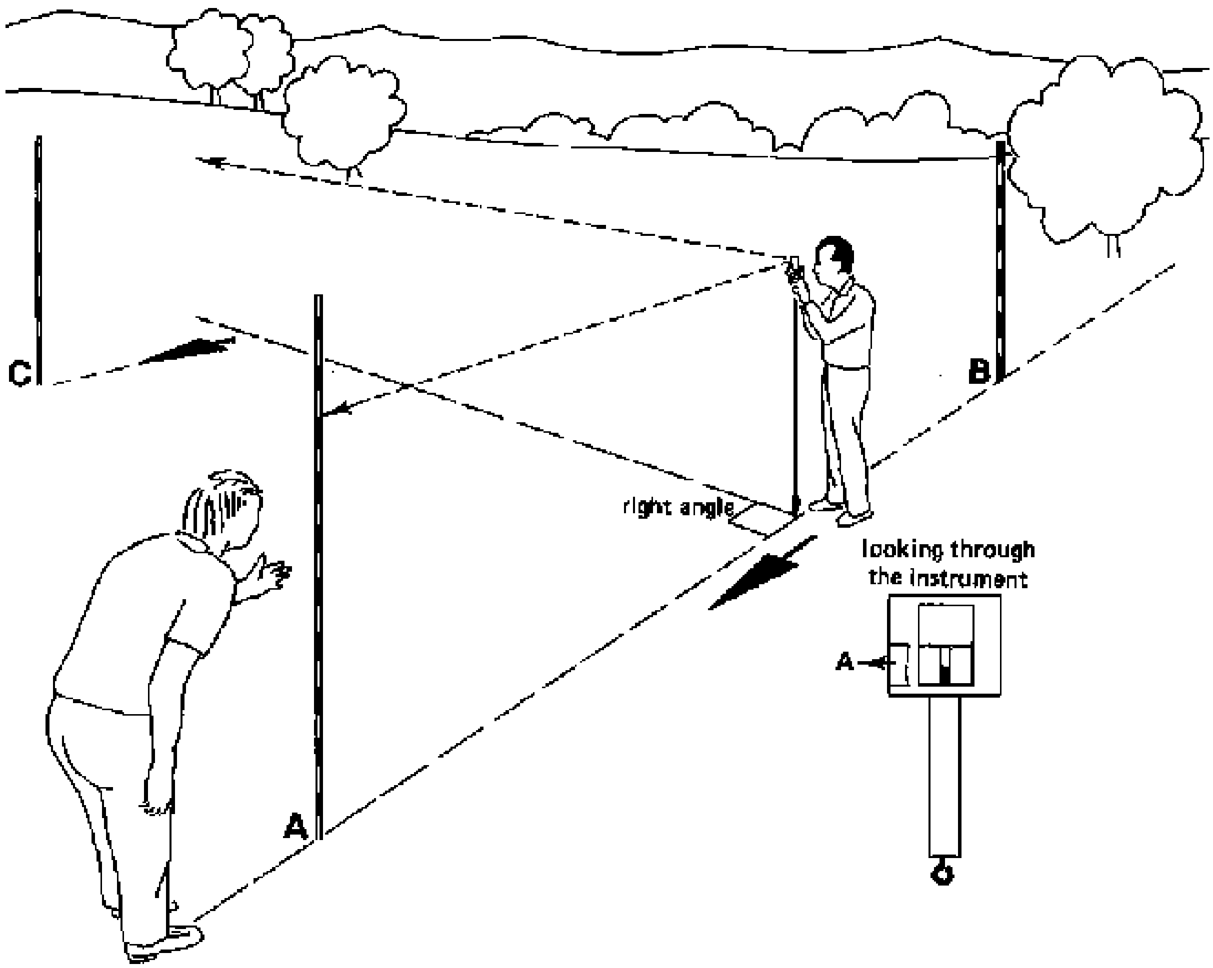
The first person holds together, between thumb and finger, the zero mark and the 12 metre mark of the tape. The second person holds between thumb and finger the 3 metre mark of the tape and the third person holds the 8 metre mark.

When all sides of the tape are stretched, a triangle with lengths of 3 m, 4 m and 5 m is formed (see Fig. 20), and the angle near person 1 is a right angle.

<u>NOTE:</u> Instead of 3 m, 4 m and 5 m a multiple can be chosen: e.g. 6 m, 8 m and 10 m or e.g. 9 m, 12 m and 15 m.

<u>Step 1</u>

In Fig. 2 la, the base line is defined by the poles (A) and (B) and a right angle has to be set out from peg (C). Peg (C) is on the base line.



Step 2

Three persons hold the tape the way it has been explained above. The first person holds the zero mark of the tape together with the 12 m mark on top of peg (C). The second person holds the 3 m mark in line with pole (A) and peg (C), on the base line. The third person holds the 8 m mark and, after stretching the tape, he places a peg at point (D). The angle between the line connecting peg (C) and peg (D) and the base line is a right angle (see Fig. 21b). Line CD can be extended by sighting ranging poles.

Setting out Perpendicular Lines: the Rope Method

A line has to be set out perpendicular to the base line from peg (A). Peg (A) is not on the base line.

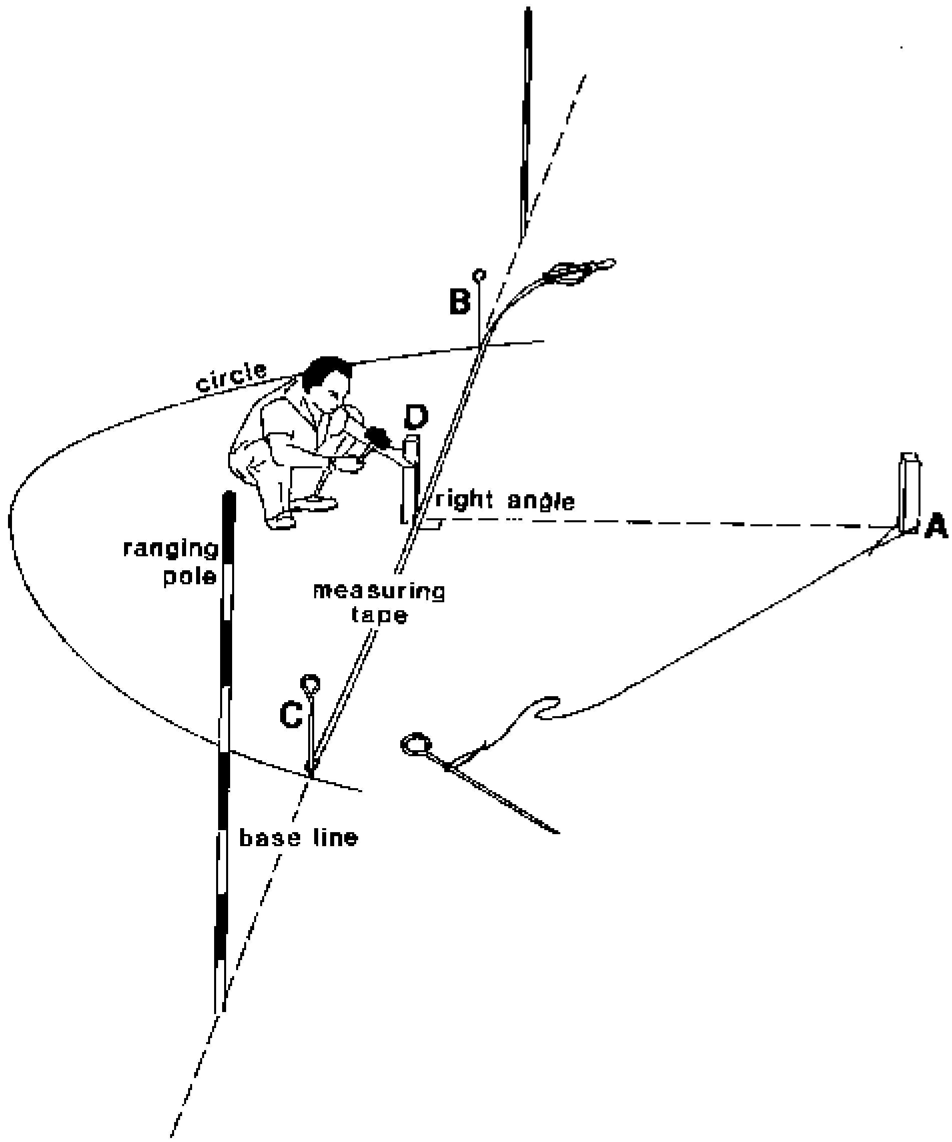
A long rope with a loop at both ends and a measuring tape are used. The rope should be a few meters longer than the distance from peg (A) to the base line.

Step 1

One loop of the rope is placed around peg (A). Put a peg through the other loop of the rope and make a circle on the ground while keeping the rope straight. This circle crosses the base line twice (see Fig. 22a). Pegs (B) and (C) are placed where the circle crosses the base line.

Step 2

Peg (D) is placed exactly half way in between pegs (B) and (C). Use a measuring tape to determine the position of peg (D). Pegs (D) and (A) form the line perpendicular to the base line and the angle between the line CD and the base line is a right angle.



Optical Squares

Optical squares are simple sighting instruments used to set out right angles. They can be provided either with mirrors or with one or two prisms. Because of practical difficulties in using squares with mirrors, they have been replaced by squares with prisms: "prismatic squares". There are two major types of prismatic squares: single prismatic squares and double prismatic squares; both will be dealt with in the sections which follow.

The single prismatic square

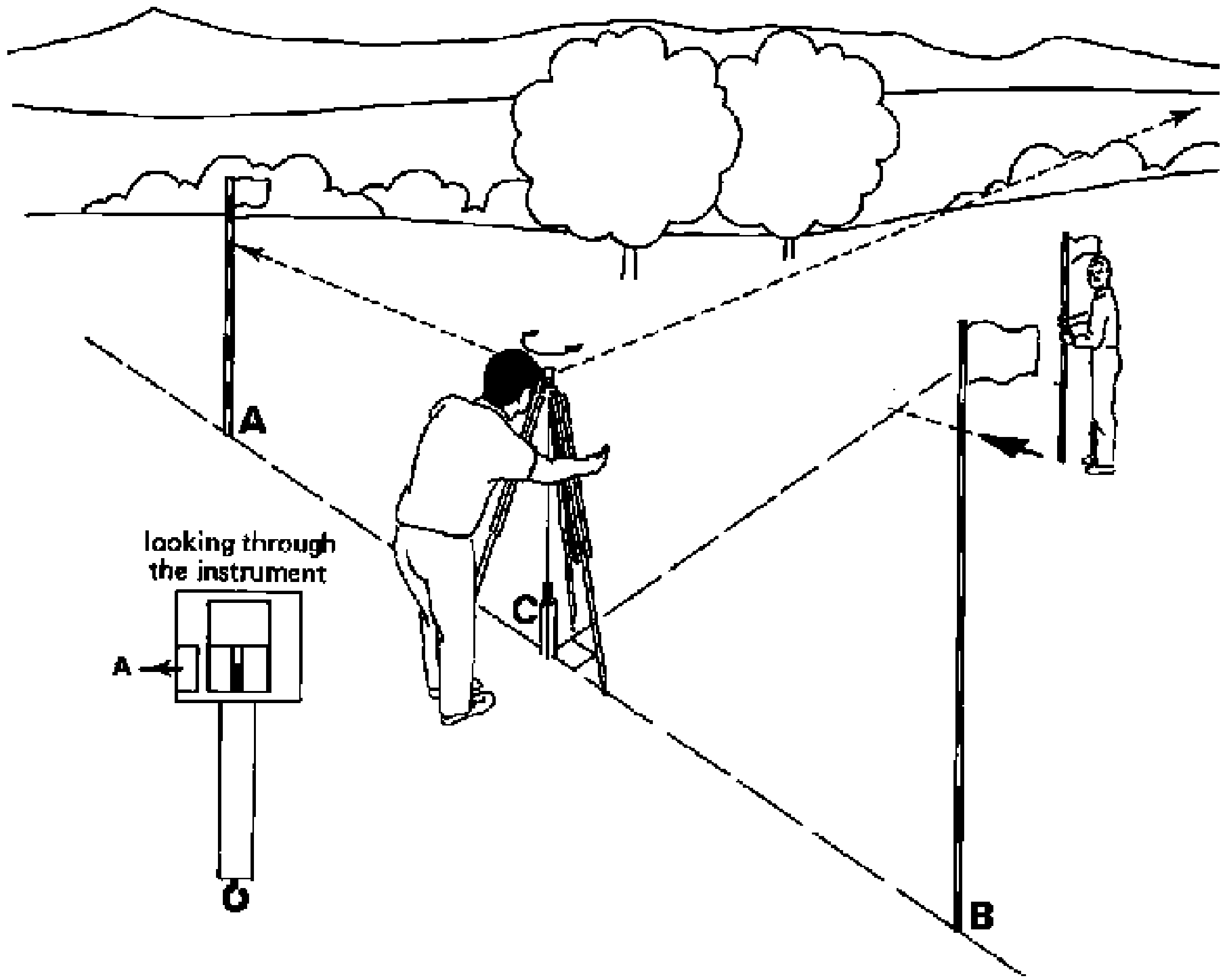
The prism of the single prismatic square is fitted in a metal frame with a handle. Attached to the handle is a hook to which a plumb bob can be connected (see Fig. 23). The special construction of the prism enables to see at right angles when looking through the instrument. The single prismatic square or single prism can be used to set out right angles and perpendicular lines.

Setting out right angles

peg (C) is on the base line which is defined by poles (A) and (B). A right angle has to be set out, starting from peg (C).

<u>Step 1</u>

The prismatic square has to be placed vertically above peg (C). This can be achieved by using a plumb bob. The instrument can be hand-held by the operator, but even better is to install the ins trument on a tripod.



Step 2

The instrument is slowly rotated until the image of pole A can be seen when looking through the instrument (see Fig. 24b).

Step 3

An assistant should hold pole (D) in such a way that it can be seen when looking through the opening just above the prism. At the indication of the operator, pole (D) is slightly moved so that pole (D) forms one line (when looking through the instrument) with the image of pole (A) (see Fig. 24c). The line connecting pole (D) and peg (C) forms a right angle with the base line.

4.3.1.2 Setting out perpendicular lines

In Fig. 25, the base line is defined by poles (A) and (B). A line perpendicular to the base line has to be set out from pole (C); pole (C) is not on the base line.

The procedure to follow is:

<u>Step 1</u>

The operator should stand with the instrument on the base line (connecting A and B). To check this, the assistant, standing behind pole (A) (or B), makes sure that the plumb bob, attached to the instrument, is in line with poles (A) and (B) (see Fig. 25a). The operator then rotates the instrument until the image of pole (A) can be seen.

<u>Step 2</u>

The operator then moves the instrument along the base line until he finds a position for which (when looking through the instrument) pole (C) is in line with the image of pole (A) (see Fig. 25b). While searching for the right position, the operator must keep the instrument always in line with poles (A) and (B). This is done under the guidance of the assistant standing behind pole (A).

<u>Step 3</u>

When the correct position of the instrument is found, peg (D) is placed right under the plumb bob. The line connecting pole (C) and peg (D) is a line perpendicular to the base line (see *Fig.* 25c).

Purpose of chain surveying, concept of field book. Selection of survey stations, base line, tie lines, Check lines

Chain surveying or measurements are utilized in this prosecution to assess more or less the ground level. To criterion the small areas. It can be also used to formulate a small-scale map. It is also used for well-checked triangles that are simple to structure.

The principle of chain surveying is triangulation. This means that the area to be surveyed is divided into a number of small triangles which should be well conditioned. In chain surveying the sides of the triangles which should be well conditioned.

Field books contain valuable information which details and describes the layout, elevations, and quantities of features and materials incorporated in a construction contract. As such, they are part of the official and legal record of the work done.

Selection of Survey Station

The following points should be kept in mind while selecting a station:

- The stations should be mutually inter-visible
- Main principle of chain survey should strictly be observed
- If possible, line through the whole length of area should be drawn
- All triangles should be well defined
- A check line should be provided in each triangle
- Survey lines should be as few as possible
- A number of tie lines should be drawn
- Position of survey lines should be such that to avoid obstacles to chaining and ranging
- It should be on level ground
- The sides of triangle should pass as close to the boundary as possible.

Important Lines

1. Base line
2. Check line
3. Tie line

Base Line

- The longest of the chain lines used in making a survey is generally regarded as Base line.

- It is the most important line because it fixes up the direction of all other lines, since on base line, is built framework of a survey.
- It should be laid on level ground, as possible through the center and length of the area.
- It should be correctly measured and should be measured twice or thrice.

Check Line

- A check line also called proof line is a line joining the apex of a triangle to some fixed point on the opposite side.
- A check line is measured to check the accuracy of the framework.
- Thus there is a complete check on the field measurement as well as on the accuracy of the plotting work.

Tie Line

A tie line is a line joining fixed points termed as Tie station on the main survey lines.

- A tie line usually fulfills a dual purpose i.e. it checks the accuracy of the framework and enables the surveyor to locate the interior details which are far away from the main chain line.

Offsets – Necessity, Perpendicular and Oblique offsets, Instruments for setting offset – Cross Staff, Optical Square

Offset is the perpendicular distance taken from either side of the chain line running in a particular direction. The purpose of offset is to locate the objects which lie in the vicinity of the main survey line.

"Offset" In Surveying

-Perpendicular offset

-Oblique offset

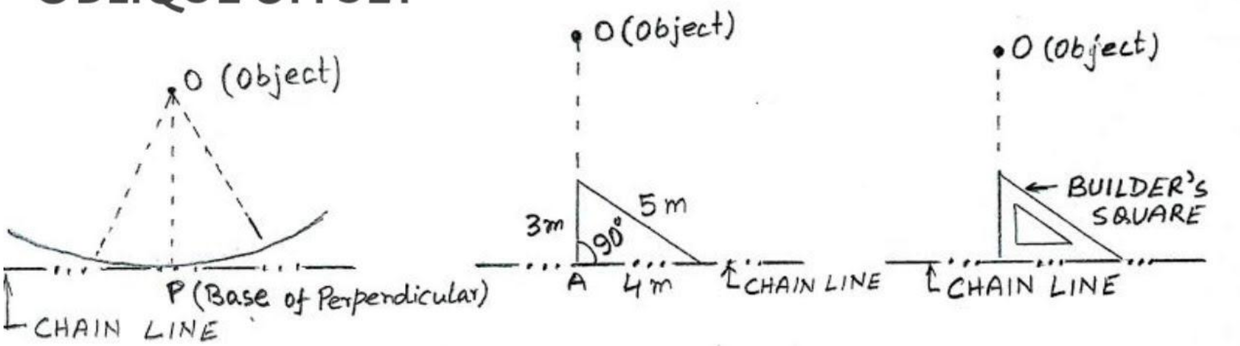
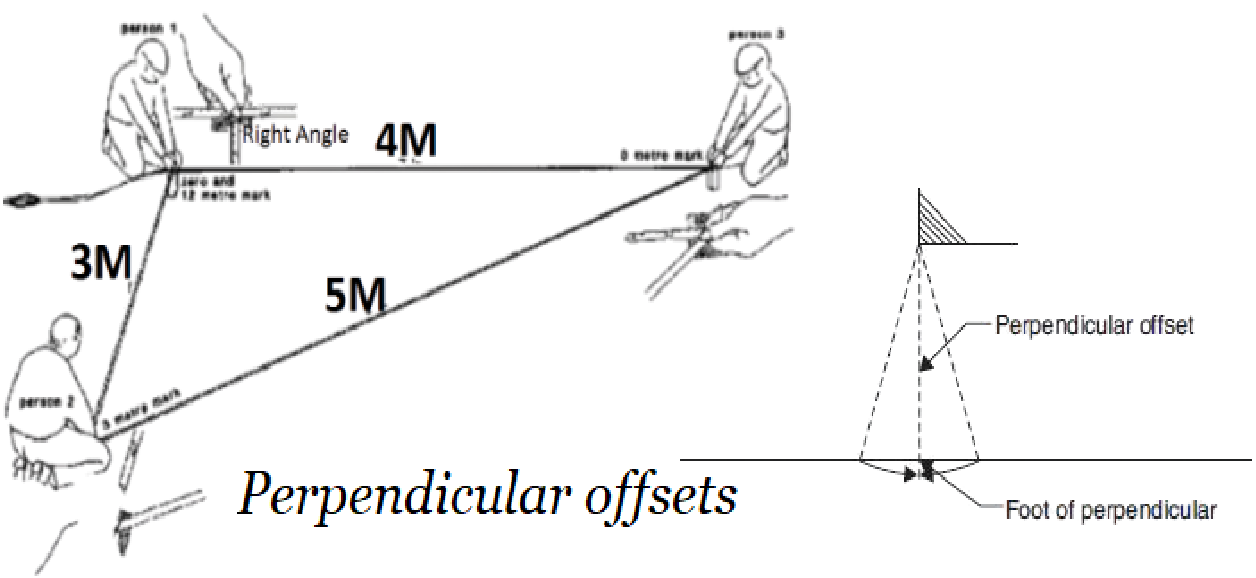


Fig 11.a Fig. 11.b Fig. 11.c

Oblique Offset: Any offset not perpendicular to the chain line is said to be oblique. These are taken when the objects are at a long distance from the chain line or when it is not possible to set up the right angle due to some difficulties. It involves more measurements and difficulties than perpendicular offsets.



OFFSET: Lateral distance of any object (natural or man made) from a survey line.

Maximum/limiting length of offset depends upon:

1. scale adopted
2. Nature of ground
3. Degree of accuracy required
4. Method of setting out the offset.

INSTRUMENTS:

1. OPTICAL SQUARE:

It is used for setting out a line at 90 degree to another line.

2. PRISM SQUARE:

It works on same principle as that of optical square.

used for setting out a line at 90 degree to another line.

its merit is that no adjustment is required because angle b/w reflecting surfaces is constant that is 45 degree.

3. SITE SQUARE:

Used for setting out straight lines and offset lines at 90 degree.

4. CROSS STAFF:

Consists of either a frame or a box with two pairs of vertical slits and is mounted on a pole shod for fixing into the ground.

A. OPEN CROSS STAFF:

It is provided with two pairs of vertical slits giving two lines of sight at right angles WRT to each other.

B. FRENCH CROSS STAFF:

It consists of a hollow octagonal box and is used to set out angles of either 45 degree or 90 degree.

C. ADJUSTABLE CROSS STAFF:

It consists of two cylinders of equal diameter placed one over each another and is used to set of any angle.

It consists of two cylinders of equal diameter placed one over each another and is used to set of any angle.

Errors in chain surveying –compensating and accumulative errors causes & remedies, Precautions to be taken during chain surveying.

Cumulative Error and Compensating Error

The error that occurs during the chaining process in the same direction is called as cumulative error. This type of error accumulates with the process of chaining.

An error that occurs in either direction during the chaining process is called as compensating error. As these errors take place in either direction, the values compensate.

Causes of Errors

The basic reasons for errors caused in the chaining process in surveying are due to:

1. The Chain or tape with erroneous length
2. Inefficient Ranging
3. Inefficient Straightening
4. Careless holding and marking
5. Sag in Chain
6. Personal Mistakes
7. Variations in Pull

8. Variations in Temperature
9. Non-Horizontality

1. Erroneous Length of the Chain or the Tape

This error is a cumulative error that can either take a negative or a positive value. This is the error due to the wrong length of the chain which is considered as one of the serious error.

If the length of the chain is long, then the measured distance is smaller and the error is negative. And when the length of the chain is short, then the measured distance is long. Hence the error is positive. Time to time checking of the chain helps to provide adequate corrections.

2. Errors due to Inefficient Ranging

Inefficient ranging implies the measurement by placing the chain out of the survey line. This mistake always gives a longer distance value. Hence the error is a positive error which is also a cumulative error type.

For each and every repetition of the mistake, the error is cumulative and the final effect on the result is large. If offset distance is also measured, then the error becomes very serious.

3. Errors due to Inefficient Straightening

While measuring a sloped or irregular ground, the chain must be held straight. Otherwise the resultant value measured is greater than the true length. This hence causes a cumulative positive error.

4. Errors due to Careless Holding and Markings

This error is caused due to an inexperienced chain man. Sometimes, the follower may hold the handle to one side of the arrow or to the other end. The leader trusts his activity and proceeds the work and marks the points.

This error mostly compensates and hence is a compensating error.

5. Error due to Sag in Chain

This is a cumulative positive error. While measuring a sloped ground or stepped ground, there are chances for the chain to sag and the value obtained is higher. Hence the error is positive.

6. Personal Mistakes

Personal mistakes during the chaining results in irregular effects like:

- Displacement of Arrows: Any change in position of the arrow during the chaining activities completely affects the original location of the arrow. Hence it is recommended to mark a point on the ground while fixing the arrow.
- Misreading: Certain confusion while reading tally of a 5m and 15m chain, and confusing between 6 and 9 are some of the mistakes faced while reading the measurements.
- Miscounting the Chain Length: This error can be avoided by following a systematic procedure to count the number of arrows.
- Erroneous Booking: Sometimes, the surveyor may hear the reading wrong and write it on the book. To avoid this the chainman must say the reading loud and the surveyor should repeat it loud and enter the field book.

7. Errors due to Variation in Pull

A pull more than the calibrated pull of the chain brings some error. The chainman either apply more or less pull, which makes the error cumulative. If the pull applied is not known, the error is compensating error.

8. Errors due to Variation in Temperature

This is a cumulative error with either positive or negative value. A temperature other than the standard calibrated temperature of the tape results in length variation of the tape. These results in either showing a greater distance or shorter distance based on which the error can be positive or negative.

9. Errors due to Non-Horizontality

This is a cumulative positive error. While measuring the slope or irregular ground, if the chain is not held horizontal, it results in a longer distance than actual. Thus the error is positive.

Precautions to be taken during chain surveying.

Chain surveying is considered to be the simplest method of surveying in which measurements are taken in the field and other supplementary works like plotting calculations are carried out in office. The measurements in chain surveying are linear- angular measurements are not considered.

Moreover, it provides fairly accurate result provided that the work is conducted carefully. Chain surveying is suitable for small areas with few details. Tools and equipments required include chain, tape, ranging rod, arrows and, sometimes, a cross staff.

In this type of surveying, survey stations (main stations, tie or subsidiary stations) shall be specified carefully otherwise the outcome of the surveying process may not be accurate.

Applicability of Chain Survey

Obviously, chain surveying cannot be used in all cases. It can be used if the area under consideration meets the following conditions:

1. The area shall be fairly small.
2. The ground is moderately levelled.
3. The area needs to be open.
4. The ground has few and simple details

Chain Survey Tools

1. Chain

2. Tape
3. Ranging-Rod
4. Arrows
5. Cross staff

Chain Survey Stations

Survey stations are points of importance at the beginning and end of a chain line. There are two major types of stations in chain surveying:

1. Main stations

Main stations are the end of lines that determine the boundary of the surveying.

2. Tie (Subsidiary) Stations

Tie stations are points which are specified on the chain line (main survey lines) where it is required to identify interior details like buildings and fences.

Factors Affecting Survey Station Selection

1. Stations should be visible from at least two or more stations.
2. As far as possible, main lines should run on level ground.
3. All triangle shall be defined properly (No angle less than 30º).
4. Each triangle should have at least one check line.
5. Survey lines should be as few as possible.
6. Obstacles to ranging and chaining should be avoided.
7. Sides of the larger triangles should pass as close to the boundary lines as possible.
8. Trespassing and frequent crossing of the roads should be avoided.

Line Types in Chain Survey

1. Base Lines

It is the main and longest line from which all measurements to demonstrate details of the work are taken. The base line passes through the center of the field.

2. Chain Line (Main Survey) Lines

The lines that join main stations are termed as chain line or main survey lines.

3. Tie (Subsidiary) Lines

It joins two fixed points on the chain line. The advantage of tie line appears while checking surveying accuracy in locating interior details such as buildings and paths.

4. Check (Proof) Lines

It joins triangle apex to some fixed points on any two sides of a triangle. It is used to examine the accuracy of the framework. The length of check line measured on ground shall be consistent with its length on the plan.

Lateral measurements from the baseline are termed as offsets. They are used to fix locations of various objects with respect to the baseline. Commonly, offsets are established at right angle. There are two major type of offsets, namely: perpendicular offsets and oblique offsets.

Chain Survey Procedures

1. Firstly, inspect the area to be surveyed and prepare key plan. This stage is termed as reconnaissance phase.
2. Then, mark stations using suitable means such as fixing ranging poles, driving pegs, and digging and fixing a stone.
3. After that, specify the way for passing the main line which should go through the center of the field.
4. Fix ranging road on stations
5. Then, the chaining can begin.
6. Make ranging wherever necessary.
7. Measure the change and offset and record them.

Chapter -3

ANGULAR MEASUREMENT AND COMPAS SURVEYING

Measurement of angles with chain, tape & compass:-

There are various surveying instruments for measurement of angles and elevations. Types, properties, uses and details of these surveying equipment is discussed. Among the variety of instruments that are available to measure angles and elevations, it is important to choose the best one that is more suitable for the specific job. The best source of information for a specific instrument is the reference of owner's manual or the product catalog that is provided by the manufacturer.

Equipment Used for Measuring Angles and Elevations in Surveying
The common equipment used for measuring angles and elevations in surveying are:

- Hand level
- Abney level
- Dumpy level
- Automatic level
- Laser level
- Transit
- Theodolite

Hand Levels for Measurement of Elevation and Slope in Surveying

As the name tells, these are levels that are held in the hands of the operator. Hand levels are the simplest level among the surveying instruments. The hand level employs a spirit level and a single cross-hair. 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. The common magnification of hand level is from zero to 5x. Hand levels with more sophisticated mechanism will have stadia hairs to measure the horizontal distance.

The hand level is primarily used to estimate the elevation and the slope. The slope is defined as the rate of change of elevation. To measure the slope with the hand level, it is essential to stand at the bottom of the slope and hold the hand level in a horizontal position. Now the point where the line of sight strikes the ground is marked. With the help of the distance to this point and the height of user's eye from the ground, the slope is determined.

% slope = (Rise/Run) x 100

The eye height of the user is the rise. The distance from the observation point to where the line of sight strikes the ground is the run. The distance can be measured by pacing. The result is found to have low precision, because of the low precision of measuring distance by pacing and the measured distance is the sloped distance (not horizontal distance).

Abney Level for Measurement of Angles and Slope in Surveying

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.

Using a stick or rod of known height with the hand level and the Abney level helps to improve the accuracy of measurement. The use of stick also helps in keeping the level steady.

Dumpy Level for Measurement of Angles and Elevation in Surveying

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.

Dumpy Level in Surveying

A mechanism called the leveling plate rotates in 360 degrees. This is the platforms onto which the telescope and the spirit level are mounted. The whole mechanism is placed on a plate that is attached to a tripod. This is later leveled to start the surveying.

Automatic Level for Measurement of Angles and Elevation

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.

Fig.4: Automatic Level

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.

Laser Level for Measurement of Angles and Elevation

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.

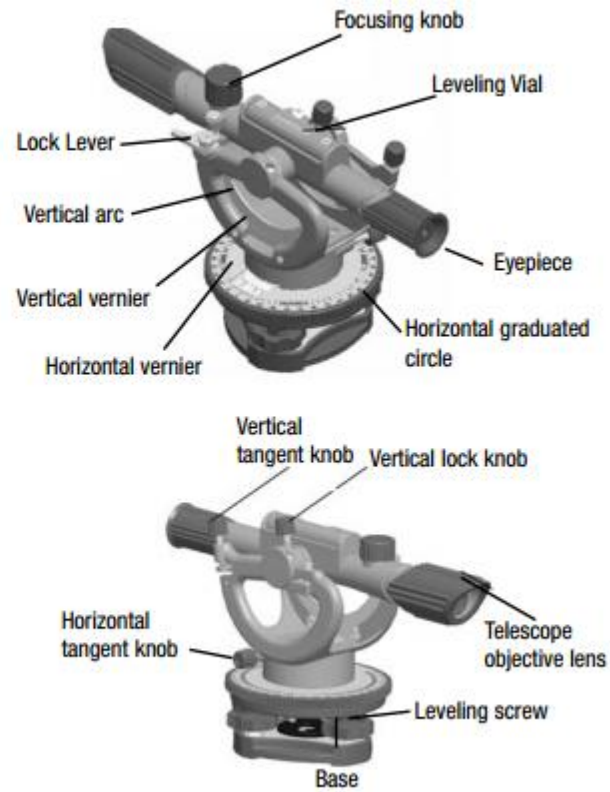
Fig.5: Laser Level

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. Once the system is turned on, it does not need any supervision further. After which the surveyor can record the rod readings by walking around the area anywhere within the range of the beam. This system also has the advantage of multiple detectors which can be used with a single laser. This will thus enable to record data simultaneously by more than one person.

Transit Level for Measurement of Angles and Elevation

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.

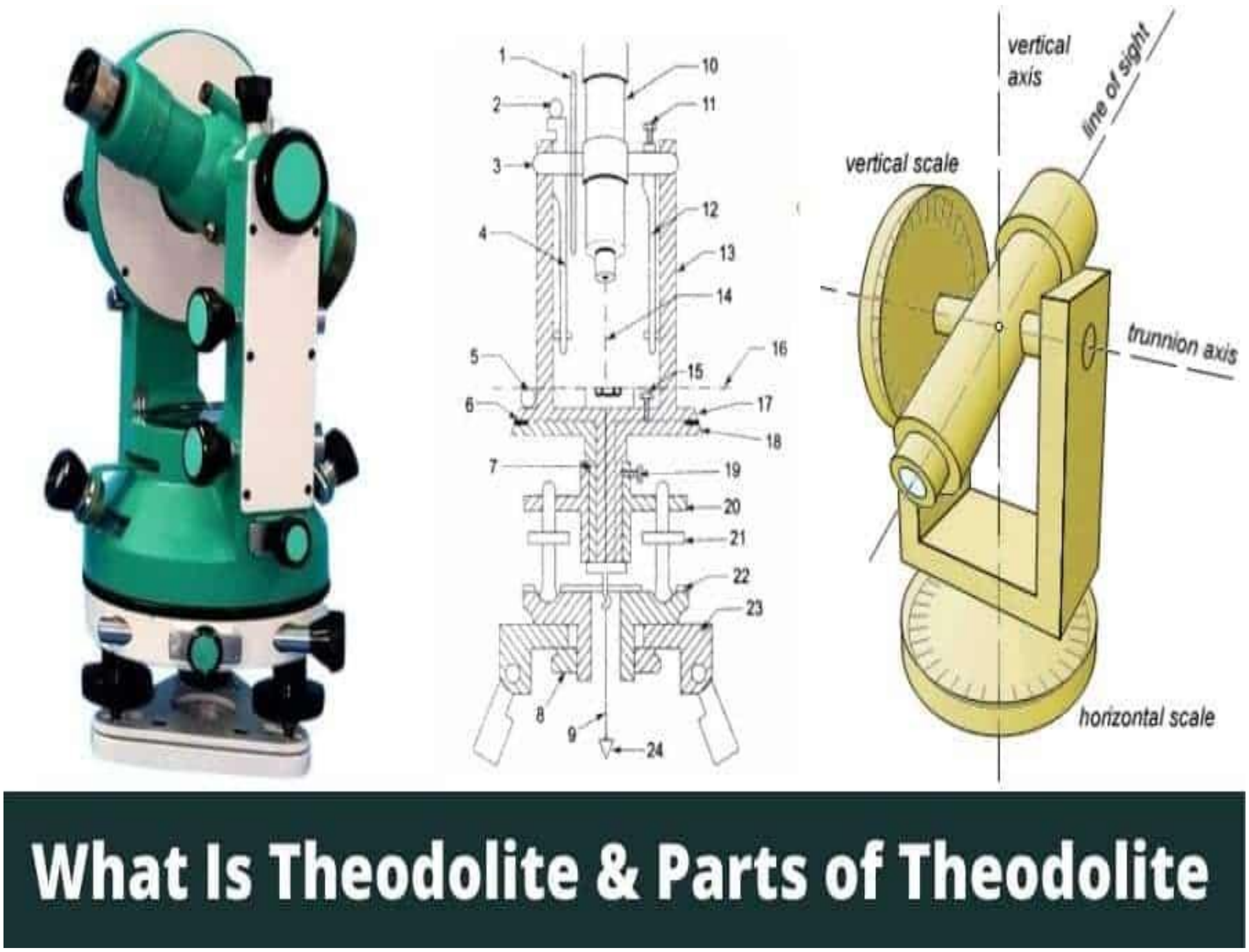
Fig.6: Transit Level

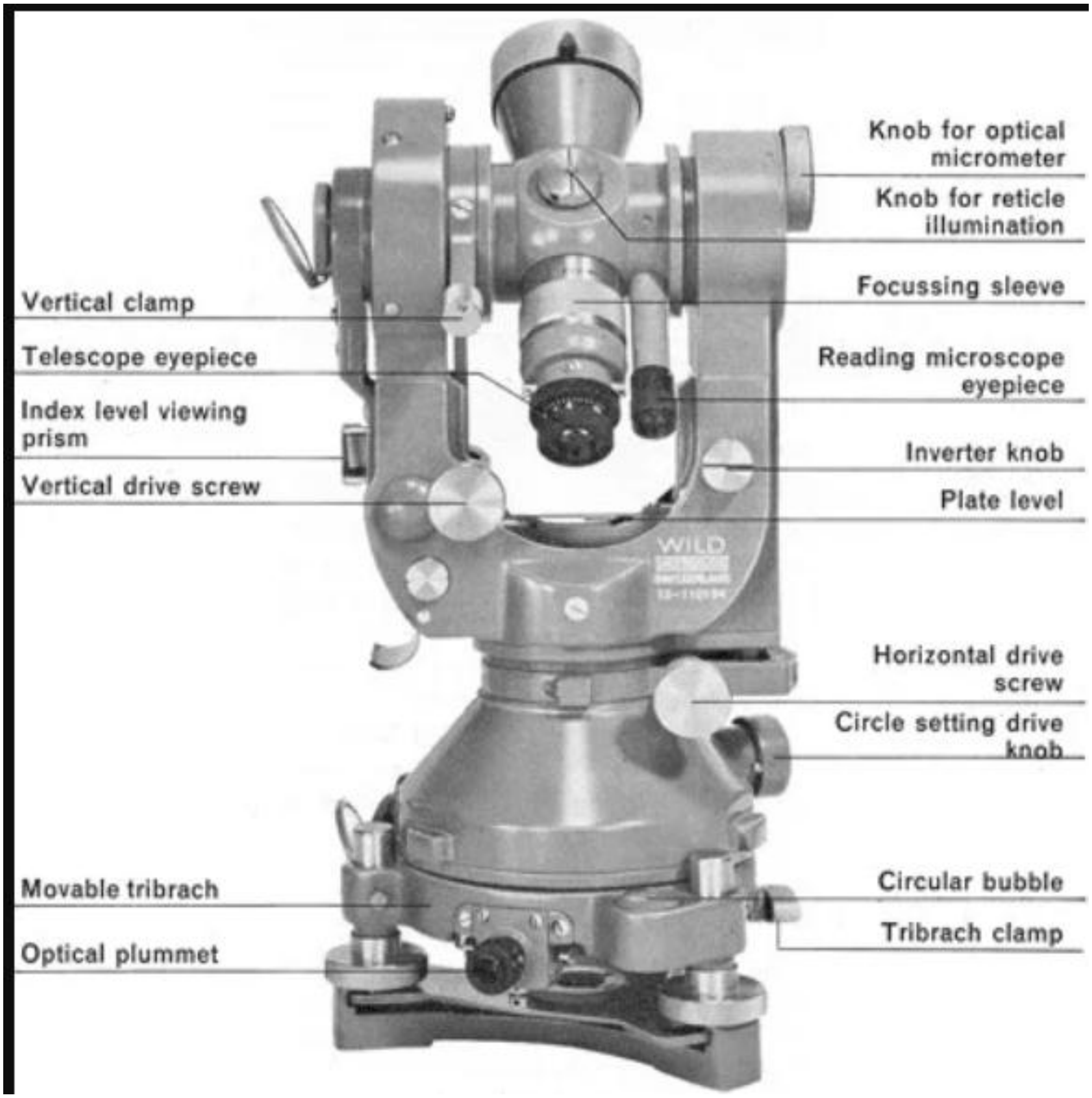


Theodolite for Measurement of Angles in Surveying

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.

Fig.7: Theodolite in Surveying


vertical axis
line of sight
vertical scale
trunnion axis
horizontal scale
What Is Theodolite & Parts of Theodolite



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.

Compass – Types, features, parts, merits & demerits, testing & adjustment of compass:-

Types of compass:-

Another type of survey instrument that forms the subject of this section is the compass. Here, we will explain the meaning, types of compass survey and also introduce and discus the concept of bearing. Objectives ·

To introduce the students to the meaning and types of compass survey ·

To enable students understand the concept of bearing.

Meaning and types of compass survey

In compass survey, the direction of the survey line is measured by the use of a magnetic compass while the lengths are by chaining or taping. Where the area to be surveyed is comparatively large, the compass survey is preferred, whereas if the area is small in extent and a high degree of accuracy is desired, then chain survey is adopted. However, where the compass survey is used, care must be taken to make sure that magnetic disturbances are not present. The two major primary types of survey compass are: the prismatic compass and surveyors compass Compass surveys are mainly used for the rapid filling of the detail in larger surveys and for explanatory works. It does not provide a very accurate determination of the bearing of a line as the compass needle aligns itself to the earth’s magnetic field which does not provide a constant reference point.

THE PRISMATIC COMPASS

This is an instrument used for the measurement of magnetic bearings. It is small and portable usually carried on the hand. This Prismatic Compass is one of the two main kinds of magnetic compasses included in the collection for the purpose of measuring magnetic bearings, with the other being the Surveyor's Compass. The main difference between the two instruments is that the surveyor's compass is usually larger and more accurate instrument, and is generally used on a stand or tripod.

• The prismatic compass on the other hand is often a small instrument which is held in the hand for observing, and is therefore employed on the rougher classes of work. The graduations on this prismatic compass are situated on a light aluminum ring fastened to the needle, and the zero of the graduations coincides with the south point of the needle. The graduations therefore remain stationary with the needle, and the index turns with the sighting vanes. Since the circle is read at the observer's (rather than the target's) end, the graduations run clockwise from the south end of the needle (0º to 360º), whereas in the surveyor's compass, the graduations run anti-clockwise from north.

• The prismatic attachment consists of a 45º reflecting prism with the eye and reading faces made slightly convex so as to magnify the image of the graduations. The prism is carried on a mounting which can be moved up and down between slides fixed on the outside of the case.

• The purpose of this up-and-down movement is to provide an adjustment for focusing. The image of the graduations is seen through a small circular aperture in the prism mounting, and immediately above this aperture is a small V cut on under revision top of the mounting, over which the vertical wire in the front vane may be viewed. Using the V cut, the vertical wire and the station whose bearing is required are viewed in one line; the bearing is directly read off the graduated arc at the point immediately underneath the vertical wire.

• The mirror located in front of the forward vane slides up and down the vane, and is hinged to fold flat over it or to rest inclined at any angle with it. This mirror is used for solar observations, or for viewing any very high object, and is not a normal fitting to a compass. The two circular discs in front of the back vane are dark glasses which can be swung in front of the vane when solar observations are being taken.

COMPONENTS OF A PRISMATIC COMPASS

Prismatic compass consists of a non-magnetic metal case with a glass top and contain the following: Elements of prismatic compass.

 Cylindrical metal box: Cylindrical metal box is having diameter of 8to 12 cm. It protects the compass and forms entire casing or body of the compass. It protect compass from dust, rain etc. Under revision

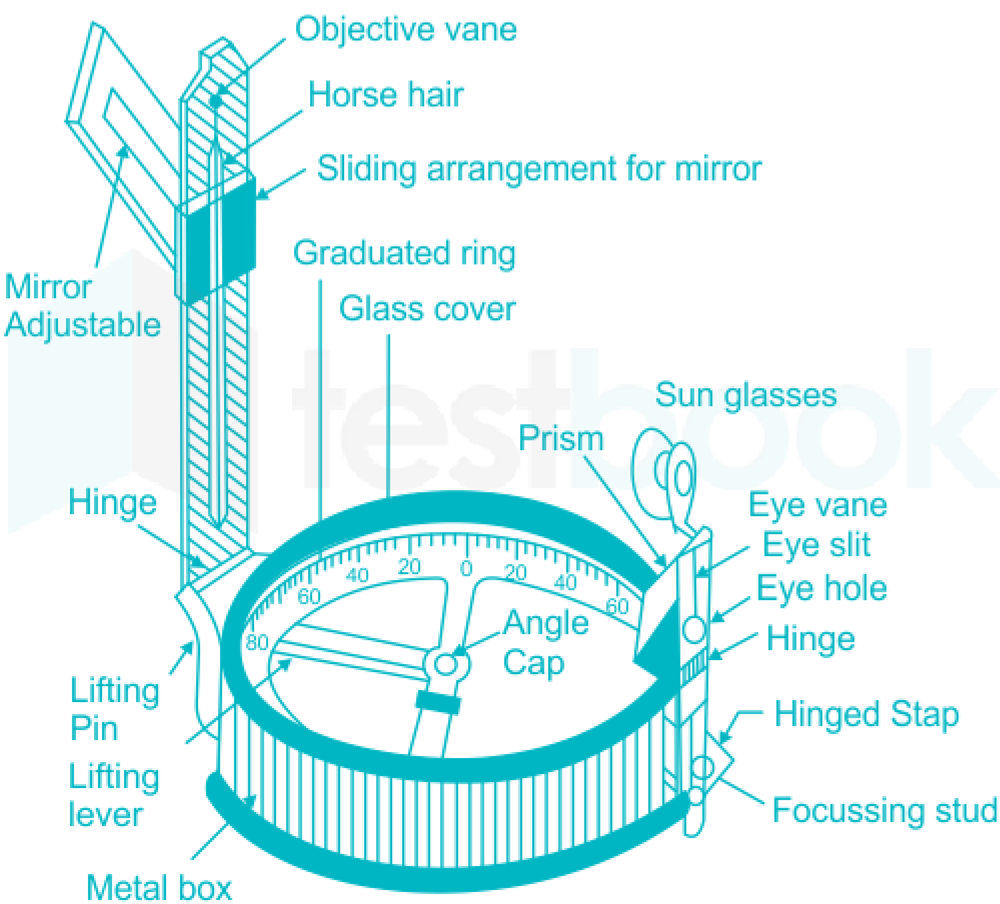
 Pivot: pivot is provided at the center of the compass and supports freely suspended magnetic needle over it.
 Lifting pin and lifting lever: a lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin. The lifting pin with the help of lifting lever then lifts the magnetic needle out of pivot point to prevent damage to the pivot head.

 Magnetic needle: Magnetic needle is the heart of the instrument. This needle measures angle of a line from magnetic meridian as the needle always remains pointed towards north South Pole at two ends of the needle when freely suspended on any support.

 Graduated circle or ring: This is an aluminum graduated ring marked with 0o to 360o to measures all possible bearings of lines, and attached with the magnetic needle. The ring is graduated to half a degree.

 Prism:

Prismatic Compass Parts



Prism is used to read graduations on ring and to take exact reading by compass. It is placed exactly opposite to object vane. The prism hole is protected by prism cap to protect it from dust and moisture.

- Object vane: object vane is diametrically opposite to the prism and eye vane. The object vane is carrying a horse hair or black thin wire to sight object in line with eye sight.

- Eye vane: Eye vane is a fine slit provided with the eye hole at bottom to bisect the object from slit.

 Glass cover: its covers the instrument box from the top such that needle and graduated ring is seen from the top.

 Sun glasses: These are used when some luminous objects are to be bisected. Reflecting mirror: It is used to get image of an object located above or below the instrument level while bisection. It is placed on the object vane.

 Spring break or brake pin: to damp the oscillation of the needle before taking a reading and to bring it to rest quickly, the light spring break attached to the box is brought in contact with the edge of the ring by gently pressing inward the brake pin.

Designation of angles- concept of meridians – Magnetic, True, arbitrary; Concept of bearings – Whole circle bearing, Quadrantal bearing, Reduced bearing, suitability of application, numerical problems on conversion of bearings:-

Types of Angles

There are majorly six types of angles in Geometry. The names of all angles with their properties are:

- Acute Angle: It lies between 0° to 90.
- Obtuse Angle: It lies between 90° to 180°
- Right Angle: The angle which is exactly equal to 90°
- Straight Angle: The angle which is exactly equal to 180°
- Reflex Angle: The angle which is greater than 180 degrees and less than 360 degrees
- Full Rotation: The complete rotation of angle equal to 360 degrees

Interior and Exterior Angles

In case of a polygon, such as a triangle, quadrilateral, pentagon, hexagon, etc., we have both interior and exterior angles.

Interior angles are those that lie inside the polygon or a closed shape having sides and angles.

Exterior angles are formed outside the shape, between any side and line extended from adjacent sides.

For example, an image of a pentagon is given here, representing its interior angles and exterior angles.

Positive & Negative Angles

- Positive Angle- An Angle measured in Anti-Clockwise direction is Positive Angle.
- Negative Angle- An angle measured in Clockwise direction is Negative Angle.

Vertex- The corner points of an angle is known as Vertex. It is the point where two rays meet.

Arms– The two sides of angle, joined at a common endpoint.

Initial Side – It is also known as the reference line. All the measurements are done taking this line as the reference.

Terminal Side- It is the side (or ray) up to which the angle measurement is done.

Meridian

Meridian is a reference direction with respect to which the direction of lines is mentioned. There are three types of meridian – True Meridian, Magnetic Meridian & Arbitrary Meridian

1 – True Meridian

It is the reference direction of North Pole of earth from a given station point. It is also called geographic meridian.

2 – Magnetic Meridian

It is the direction of North Pole indicated by magnetic needle.

3 – Arbitrary Meridian

This is any assume direction to a well-defined object. It may be useful for small areas. e.g A mosque is taken as reference and location of road will be mentioned with respect to this mosque. Direction of magnetic north with respect to true north is called magnetic direction.

Bearings

Bearing is the angle which a certain line make with a certain a certain meridian. Bearing with respect to true meridian is called true bearings while magnetic bearing is the angle which a line makes with respect to magnetic meridian. There are two ways to represent the bearings,

- Whole circle bearing (W.C.B)
- Reduced Bearing (R.B)

1) Whole Circle Bearing (W.C.B)

It can be taken 0° to 360°. Quadrants are taken clock-wisely and angles are also determined in clockwise direction.

2) Reduced Bearing

Reduced bearing or Quadrant bearing is the angle which a line makes from North or South Pole whichever may be near. It is value is from 0° to 90°.

To measure everything in this world, we need a unit in a similar angle measurement requires three units of measurement:

It is represented by ° (read as a degree). It most likely comes from Babylonians, who used a base 60 (Sexagesimal) number system. In their calendar, there was a total of 360 days. Hence, they adopted a full angle to be 360°. First, they tried to divide a full angle into angles using the angle of an equilateral triangle. Later, following their number system (base 60), they divided 60° by 60 and defined that as 1°. Sometimes, it is also referred to as arc degree or arc-degree which means the degree of an arc.

An angle is said to be equal to 1° if the rotation from the initial to the terminal side is equal to 1/360 of the full rotation.

A degree is further divided into minutes and seconds. 1′ (1 minute) is defined as one-sixtieth of a degree and 1” (1 second) is defined as one-sixtieth of a minute. Thus,

1°= 60′ = 3600”

Radian of an Angle

This is the SI unit of angle. Radian is mostly used in Calculus. All the formula for derivatives and integrals hold true only when angles are measured in terms of a radian. It is denoted by ‘rad’.

The length of the arc of a unit circle is numerically equal to the measurement in radian of the angle that it subtends.

In a complete circle, there are 2π radians.

360 = 2π; radian

Therefore, 1 radian = 180°/π

Guardian of an Angle

This unit is least used in Mathis. It is also called a gon or a grade.

An angle is equal to 1 gradian if the rotation from the initial to terminal side is 1/400 of the full rotation. Hence, the full angle is equal to 400 guardians.

It is denoted by ‘grad’.

Figure 3 shows the example of angles in guardian.

Whole circle bearing:-

The horizontal angle made by a line with the magnetic north in the clockwise direction is the whole circle bearing of the line. This system is also known as the azimuthal system.

Whole Circle Bearing Formula

In whole circle bearing, the value of the bearing varies from 0° to 360°. Just measure the angle between true north lines to the survey line to find the WCB. Don't forget to measure the clockwise angle in determining the whole circle bearing.

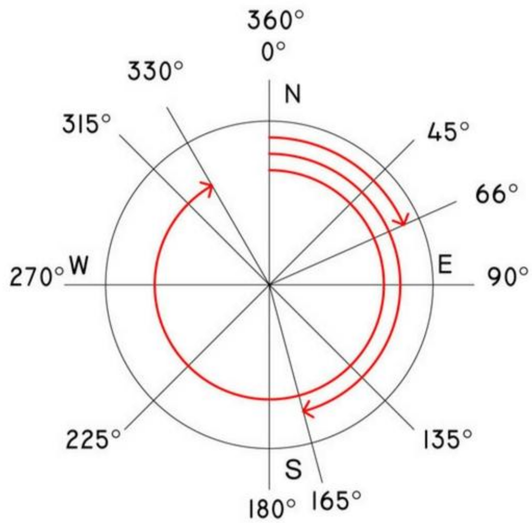
If a survey line falls in the first quadrant, its WCB varies from 0° to 90°. Similarly, in the second quadrant, WCB value varies from 90° to 180°; in the third quadrant, WCB value varies from 180° to 270°; in the fourth quadrant, WCB value varies from 270° to 360°.

Whole Circle Bearing Example

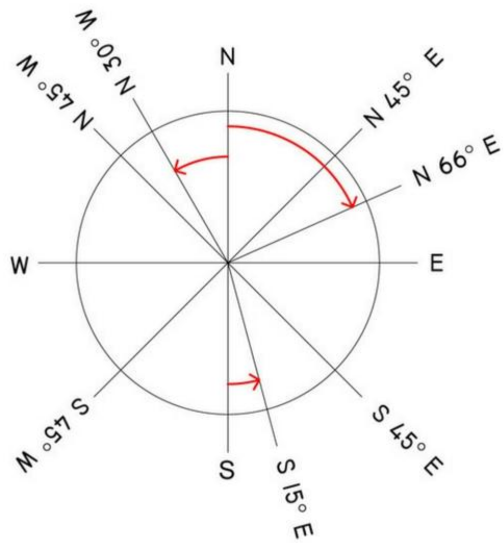
To understand the whole circle bearing measurement clearly, please carefully observe the following image illustrations.

In the above images, the vertical line N is indicating the north line. In Fig 1, line X is in the first quadrant. It is at an angle of 46° with the north line in the clockwise direction. Therefore, whole circle bearing (W.C.B) of line X is 46°.

On the other hand, the line Y in Fig 2, is making 226° angle with the north line in the clockwise direction. So, whole circle bearing (W.C.B) of line Y is 226°.



Whole Circle Bearing



Quadrantal Bearing

He horizontal angle made by a line with the magnetic north or south (whichever is closer from the line) in the eastward or westward direction is the *Quadrantal Bearing* or *Reduced Bearing* of the line.

In quadrant bearing or reduced bearing, both north and south are considered as reference meridians. Depending upon the position of a survey line, the direction of the reference meridian to the line can be either clockwise or anticlockwise. In the expression of the reduced bearing value of a line, quadrant has to be mentioned in which the line lies.

In Whole Circle Bearing - Bearings are measured clockwise from north of reference meridian; In Reduced Bearing - Bearings are measured either clockwise or anti-clockwise from north/south whichever is close to the line.

In Reduced Bearing (RB), the bearing of a survey line is measured either in a clockwise or anti-clockwise direction from either of the north or south direction whichever is close to the line. The reduced bearing is also known as Quadrantal Bearing System.

Quadrant Bearing (QB)

The horizontal angle made by a line with the magnetic north or south (whichever is nearer to the line) in the eastward or westward direction is the quadrant Bearing or Reduced Bearing of the line.

In quadrant bearing or reduced bearing system, both north and south are considered as reference meridians. Depending upon the position of a survey line, the direction of the reference meridian to the line can be either clockwise or anticlockwise.

In the expression of the reduced bearing value of a line, quadrant (or direction like North-East, North-West, South-East and South-West)has to be mentioned in which the line lies.

Characteristics of reduced bearing

- Angles vary from 0 degrees to 90 degrees.
- It is measured from either clockwise/anti-clockwise from north/south (If the line is closer to the south and going towards west, it is read as S β° W)
- Four quadrants are possible namely NE, SE, SW and NW.
- RB system is used in Surveyor's compass.

Use of compasses – setting in field-centering, leveling, taking readings, concepts of Fore bearing, Back Bearing, Numerical problems on computation of interior & exterior angles from bearings

A compass is a navigational instrument for determining direction relative to the Earth's magnetic poles. It consists of a magnetized pointer (usually marked on the North end) free to align itself with Earth's magnetic field. The compass greatly improved the safety and efficiency of travel, especially ocean travel.

Leveling: The top of the table is leveled by moving the legs of the tripod.

(c) Centering: There are two types of operations involved in the centering of the plane table.

(d) Orientation: It is the process of a plane table survey of setting the position of the board at the survey station.

Understanding forward and back bearings

Taking a forward bearing:-

The first compass bearing we need to take at the lake is from our unknown location to our cabin on the far shore. The bearing we end up with represents the angle between a line from Magnetic North to our location, and a line from our location to the cabin. This bearing is a "forward bearing."

But when we go to plot this bearing on our map, we can't plot the angle from our current location since that is what we are trying to find. Instead we plot a bearing from the cabin, as if someone there took a bearing "looking BACK towards our location." This would be called a "back bearing" and will be 180° different from our "forward bearing."

How to determine a back bearing

One technique is to do the math. Add or subtract 180° from you forward bearing to get your back bearing. You want the result to fall between 0° and 360°, so if the forward bearing is less than 180°, add 180° to it, and if it's greater than 180°, subtract 180°.

Calculating a back bearing:-

If you are bad with math in your head, the "200/20" trick might help you. When your bearing is less than 180°, add 200° and then subtract 20° (same as adding 180°). When your bearing is greater than 180°, subtract 200° and then add 20° (same as subtracting 180°).

Forward and back bearings as seen through a sighting compass.

There are also lots of tricks that avoid doing the arithmetic entirely...

Most sighting compasses show the back bearing in a smaller font size above or below the forward bearing.

When you are taking a bearing with a base plate compass, and you want a back bearing instead of a forward bearing, box the compass needle with the south end where the north end would usually be. The resulting bearing will be 180° different.

Aligning North needle with South for a back bearing:-

When you are plotting your bearing, start by plotting a short segment of the forward bearing. When you extend the line, extend it in the opposite direction.

Next get straight in your head, where you will be plotting the bearing from on the map, and whether you will be plotting a forward bearing or a back bearing. You will always be starting to plot your bearing from the known location and then extending your line towards the unknown location.

If you took the bearing from the known location, you will be plotting a forward bearing, starting at the known location.

If you took the bearing from the unknown location, you will be plotting a back bearing, starting at the known location.

Effects of earth's magnetism – dip of needle, magnetic declination, variation in declination, numerical problems on application of correction for declination.

Effects of earth's magnetism:-

Generated by the motion of molten iron in Earth's core, the magnetic field protects our planet from cosmic radiation and from the charged particles emitted by our Sun. It also provides the basis for navigation with a compass.

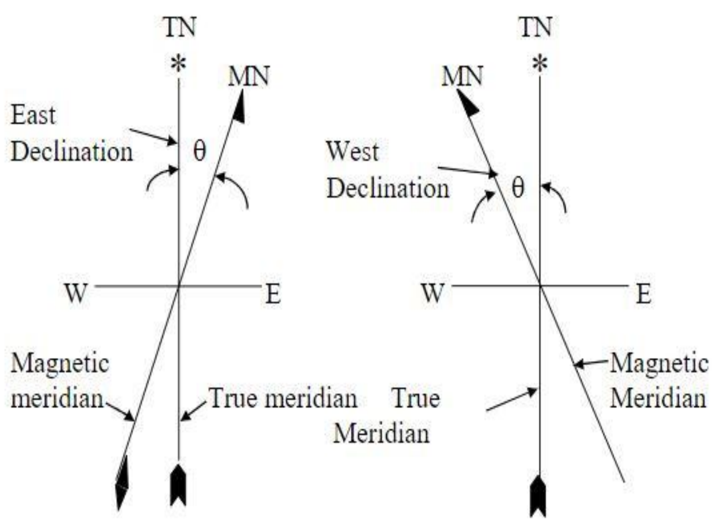
Dip of needle:-

The angle formed, in a vertical plane, by a freely suspended magnetic needle, or the line of magnetic force, with a horizontal line; - called also inclination.

Magnetic declination:-

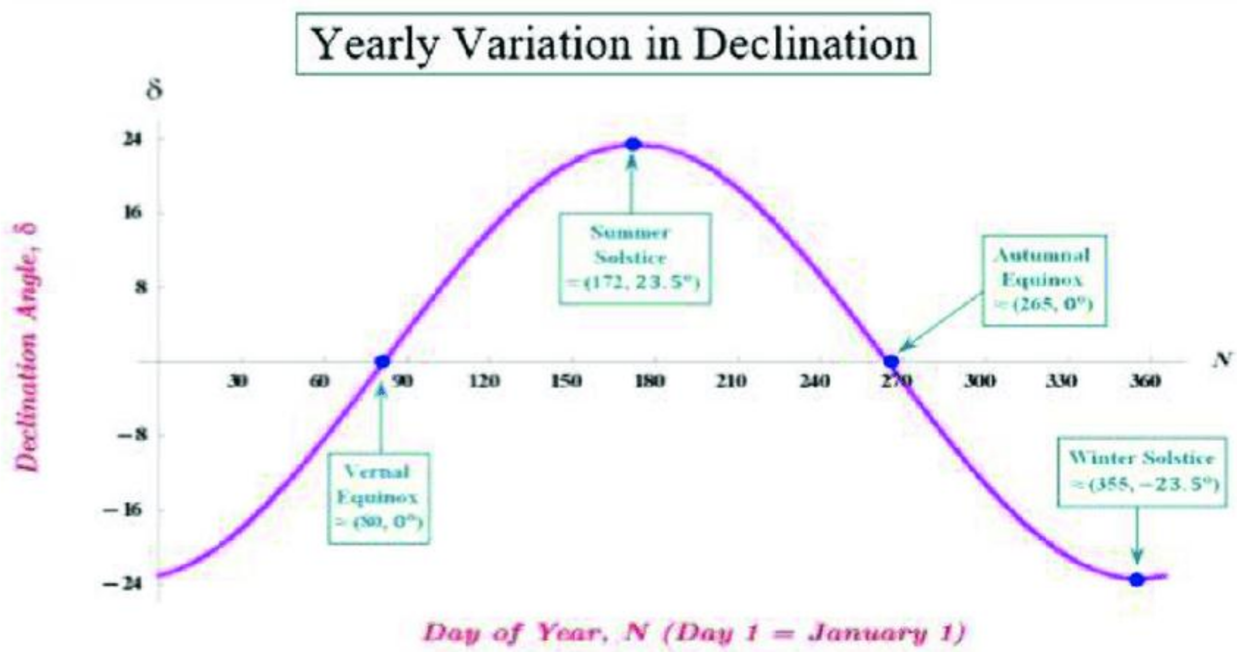
Magnetic declination (sometimes called magnetic variation) is the angle between magnetic north and true north. Declination is positive when this angle is east of true north and negative when it is west. Magnetic declination changes over time, and with location.

Declination value is needed to determine true north, because compasses point toward magnetic north.



Variation in declination:-

Variation in magnetic declination: The changes in direction of the magnetic meridian at any given place are not constant. Variations in magnetic declination can be categorized as daily, annual, secular, and irregular.



Errors in angle measurement with compass – sources & remedies:-

He following are the kinds of errors that may occur while taking readings during compass survey.

Instrumental Errors

1. Errors due to manipulation and sighting
2. Natural Errors

1) Instrumental Error

Instrumental errors occur due to faulty adjustments of the instruments. The reasons for instrumental errors are mentioned below:

- The needle of the compass may not be perfectly straight.
- The pivot point may be eccentric.
- The ring's graduations may not be uniform.
- The pivot point is dull.
- The needle is sluggish due to magnetism.
- The needle neither moves horizontally nor moves freely on the pivot due to the dip of a needle.
- The sight vane may not be vertical.

2) Errors due to manipulation and sighting

They are also known as personal errors and these errors are due to the following reasons that are mentioned below:

- Due to inaccurate centering of the compass over the station.
- Due to inaccurate leveling of compass box when the instrument is set up.
- Improper bisection of ranging rods at the station.
- By taking wrong readings through the graduations of the prism.
- Carelessness in recording the observed readings.
- Due to any magnetic object nearby.

3) Natural Errors

These types of errors may occur due to various natural causes which affect the working of the compass. There are some reasons:

- Due to magnetic changes in the atmosphere like on a cloudy or stormy day.
- The magnetic declination may vary.
- Local attraction that can be due to proximity steel structures, electric lines.

Here we discuss some Natural errors that how can they occur with a brief description.

Types of Natural Errors in Compass Surveying

1. Magnetic Declination
2. Local Attraction

1) Magnetic Declination

The horizontal angle between the magnetic meridian and the true meridian is called magnetic declination.

- Declination west

It occurs when the north end of the magnetic needle is pointed towards the west side of the true meridian.

- Declination east

It occurs when the north end of the magnetic needle is pointed towards the east side of the true meridian.

Isogonic lines

The lines that are passing through the points have equal magnetic declination.

Agonic lines

The lines that are passing through the points have zero magnetic declination.

Variation of Magnetic Declination

Magnetic declination at a place is not constant. The variation in it occurs due to the following reasons.

1) Secular Variation

- In this type, the magnetic behavior changes and it acts like a pendulum with respect to the true meridian.
- It occurs after every 100 years when it swings from one direction to the opposite direction, and the declination varies.

2) Annual Variation

- This variation that occurs due to the rotation of the earth, in an elliptical path during the sun is called Annual Variation.
- Its amount of variation is about 1 to 2 minutes.
- It's a yearly variation in magnetic declination.

3) Diurnal Variation

- This variation that occurs due to the rotation of the earth, on its own axis in 24 hours is called Diurnal Variation.
- Its amount of variation is about 3 to 12 minutes.
- It's a daily variation in magnetic declination.
- This variation is more in summers and less in winters.
- This can also change from year to year.

4) Irregular Variation

- The variation that occurs due to natural causes happened suddenly like earthquakes and volcanic eruptions etc.

2) Local Attraction

When the magnetic needle is freely suspended or pivoted, it indicated the north direction but when the needle comes near any magnetic substance like iron, steel and electric wires, etc. It is found to get deflected from its true direction.

This disturbance that occurs due to the presence of a magnetic substance is known as Local Attraction.

Detection of Local Attraction

The presence of local attractions at any station can be detected by observing the fore and back bearing of the line. If the difference between the fore and back bearing is 180^o then both end stations are free from the local attraction. If the difference is not equal to 180^o then it may be due to the following reasons.

- Error in the observation of fore and back bearing.
- The presence of local attractions at either station.
- The presence of local attractions at both stations.

Methods for the correction of Local Attraction

1. By calculating the included angles at the affected stations.
2. By checking the required corrections, starting from the unaffected bearing.

Method of Application of correction

1) First Method

- The angles of the traverse are calculated from the observed bearing.
- After that, an angular check is applied by which the sum of interior angles should be equal to this equation.

Where n = No. of sides of traverse

- If it's not applicable then the total error is equally divided among all the angles of the traverse.

- This method is laborious and is not generally employed.

2) Second Method

- In the second method, there is no need to calculate the angles of the traverse.
- In this method, the unaffected line is first detected.
- Then by the reference of this line, the bearing of other affected lines is corrected.
- This method is easy to understand and generally applied for correction.

Precautions for Compass Surveying

These are some of the precautions that can be useful while conducting a compass traverse.

- The centering and the leveling should be done perfectly.
- The readings should be taken along the line of sight, not from any other side.
- Try to select stations that are far away from the magnetic effects.
- Observer should also avoid taking any magnetic substance.
- To stop the rotation of the graduated ring, the brake pin should be pressed gently not suddenly.

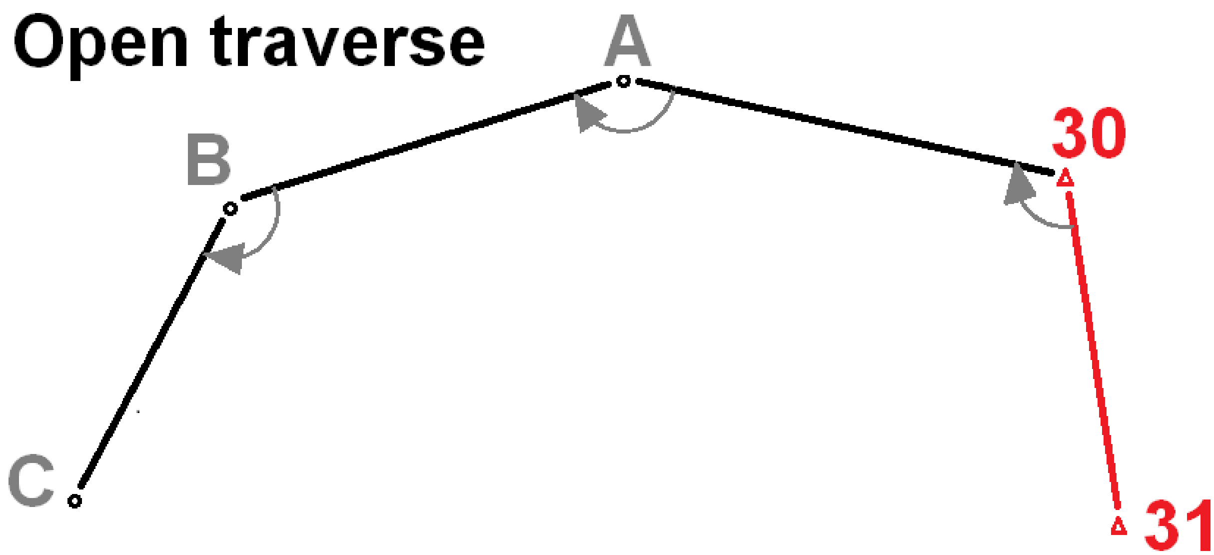
Principles of traversing – open & closed traverse, Methods of traversing:-

Traverse survey:

If the bearing and distance of a place of a known point is known: it is possible to establish the position of that point on the ground. From this point, the bearing and distances of other surrounding points may be established. In the process, positions of points linked with lines linking them emerge. The traversing is the process of establishing these lines, is called traversing, while the connecting lines joining two points on the ground. Joining two while bearing and distance is known as traverse. A traverse station is each of the points of the traverse, while the traverse leg is the straight line between consecutive stations. Traverses may either be open or closed.

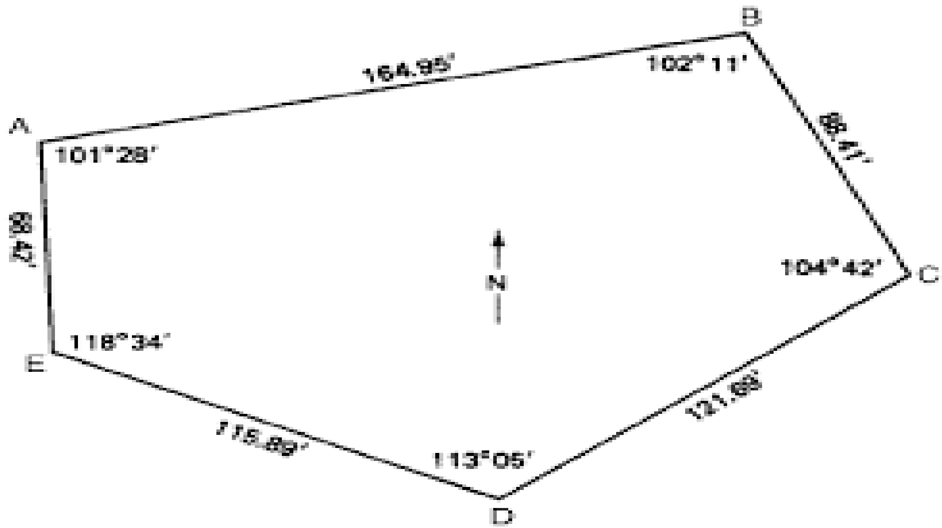
Open Traverse:

When a sequence of connected lines extends along a general direction and does not return to the starting point, it is known as 'open traverse' or (unclosed traverse). Here ABCDE represents an open traverse.

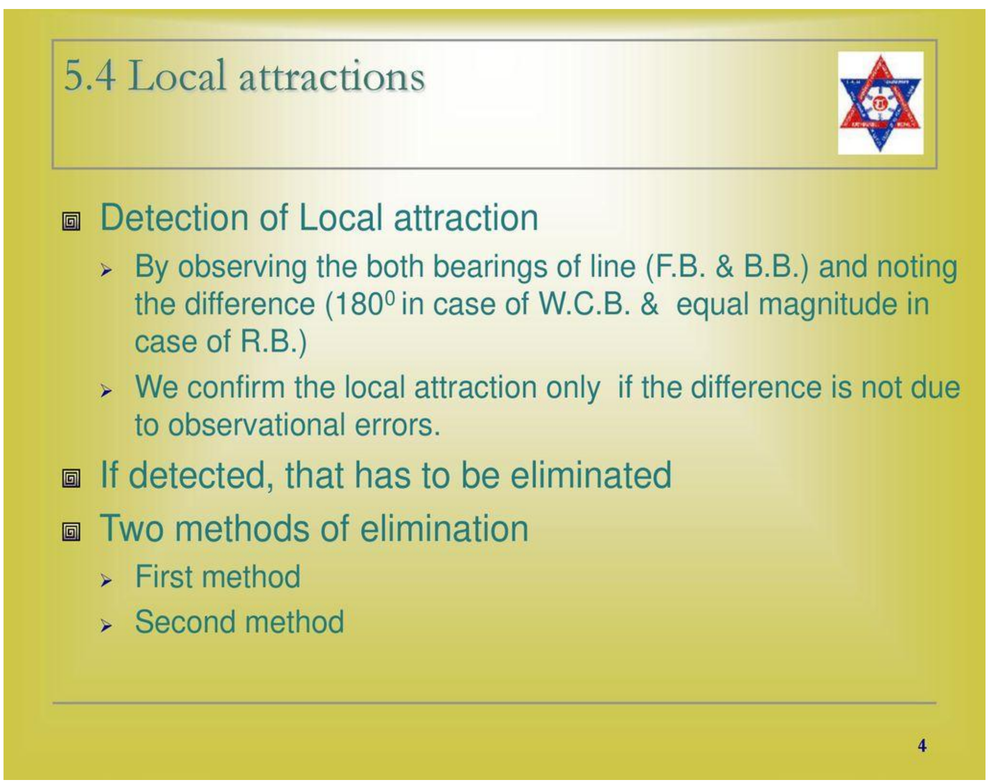


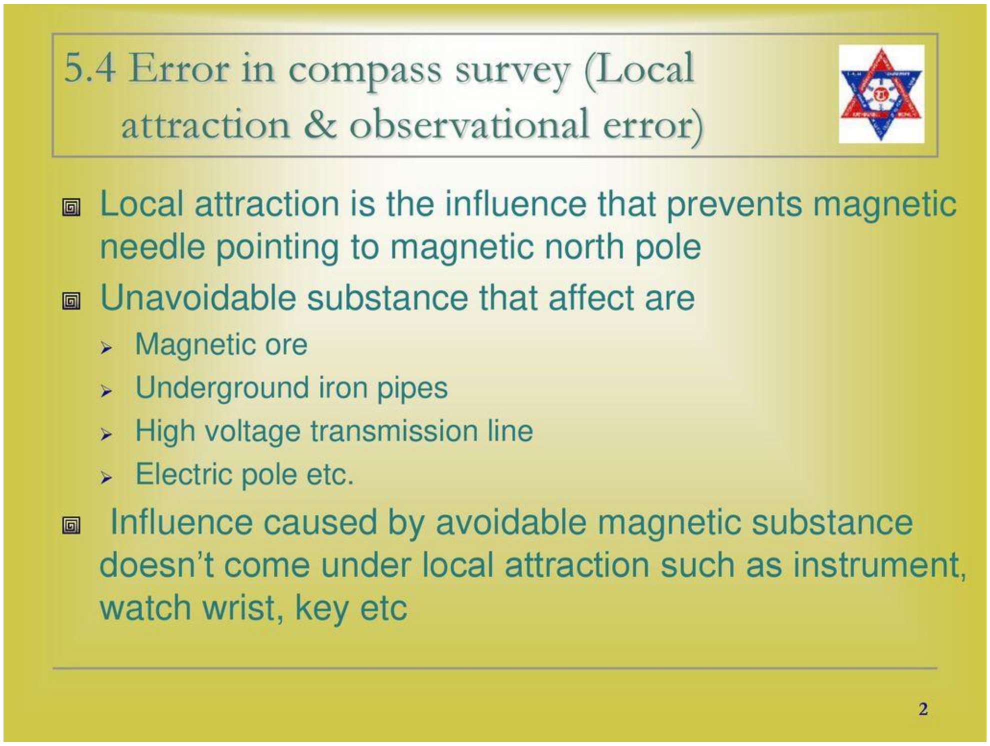
Closed Traverse:

When a series of connected lines forms a closed circuit, i.e. when the finishing point coincides with the starting point of a survey, it is called as a 'closed traverse', here ABCDEA represents a closed traverse.



Local attraction – causes, detection, errors, corrections, Numerical problems of application of correction due to local attraction:-





Local Attraction | Methods for Correcting the bearings affected by Local Attraction

The deflection of a magnetic needle from its true position due to the presence of magnetic influencing material such as iron ore, magnetic rock, underground pipeline, electric cables, iron pipes, electric poles in its vicinity is called "Local Attraction".

Methods of correcting the bearings

There are two methods of correcting the bearings affected by local attraction:

1. Included angle Method
2. Error Computation

Included angle Method

In this method, the included angles of the traverse are calculated first, then starting from the line which is unaffected by local attraction and using the included angles, the corrected bearings of the traverse are computed.

Error Computation Method

In this method, the direction and the amount of local attraction at each survey station is determined.

Then starting from the line which is unaffected by local attraction, the corrected bearing of the traverse are computed.

This method is more accurate than the included angle method.

Hence it is adopted by most of the surveyors.

Precautions

The substance of attraction with the surveyor such as bunch of keys, iron buttons, spectacles etc.

It should be kept away from the compass.

The chain, arrows, clearing axe etc. should be kept away from the compass.

If the entire area is magnetic, then compass surveying is not suitable in those places.

The correction to the survey lines are made starting from the line free from local attraction.

Errors in compass surveying – sources & remedies. Plotting of traverse – check of closing error in closed & open traverse, Bowditch's correction, Gales table:-

Instrumental Error

Instrumental errors occur due to faulty adjustments of the instruments. The reasons for instrumental errors are mentioned below:

- The needle of the compass may not be perfectly straight.
- The pivot point may be eccentric.
- The ring's graduations may not be uniform.
- The pivot point is dull.
- The needle is sluggish due to magnetism.
- The needle neither moves horizontally nor moves freely on the pivot due to the dip of a needle.
- The sight vane may not be vertical.

3) Errors due to manipulation and sighting

They are also known as personal errors and these errors are due to the following reasons that are mentioned below:

- Due to inaccurate centering of the compass over the station.
- Due to inaccurate leveling of compass box when the instrument is set up.
- Improper bisection of ranging rods at the station.
- By taking wrong readings through the graduations of the prism.
- Carelessness in recording the observed readings.
- Due to any magnetic object nearby.

4) Natural Errors

These types of errors may occur due to various natural causes which affect the working of the compass. There are some reasons:

- Due to magnetic changes in the atmosphere like on a cloudy or stormy day.
- The magnetic declination may vary.
- Local attraction that can be due to proximity steel structures, electric lines.

Here we discuss some Natural errors that how can they occur with a brief description.

Plotting of traverse:-

Methods of Traversing

There are several methods of traversing, depending on the instruments used in determining the relative directions of the traverse lines. The following are the principal methods:

1. Chain traversing
2. Chain and compass traversing
3. Transit type traversing a)By fast needle method b)By measurement of angles between the lines
4. Plane table traversing

Brief descriptions of these traverse surveying methods are given below.

Chain Traversing

The method in which the whole work is done with chain and tape is called chain traversing. No angle measurement is used and the directions of the lines are fixed entirely by linear measurements Angles fixed by linear or tie measurements are known as chain angles. The method is unsuitable for accurate work and is generally used if an angle measuring instruments such as a compass, sextant or theodolite is available.

Chain and Compass Traversing

In chain and compass traversing, the magnetic bearings of the survey lines are measured by a compass and the lengths of the lines are measured either with a chain or with a tape. The direction of the magnetic meridian is established at each traverse station independently. The method is also known as a tree or loose needle method.

Traversing by Fast Needle Method

The method in which the magnetic bearings of traverse lines are measured by a theodolite fitted with s compass is called traversing by fast needle method. The direction of the magnetic meridian is not established at each station but instead, the magnetic bearings of the lines are measured with a reference so that direction of the magnetic meridian established at the first station. There are three methods of observing the bearings of lines by fast needle method.

1. Direct method with transiting,
2. Direct method without transiting,

3. Back bearing method.

Traversing By Direct Observation of Angles

In this method, the angles between the lines are directly measured by a theodolite and the magnetic bearing of other lines can be calculated in this method. The angles measured at different stations may be either

1. Included Angles and
2. Deflection Angles

Traversing by Included Angle

An included angle at a station is either of the two angles formed n\by two survey lines meeting there and these angles should be measured clockwise. The method consists simply in measuring each angle directly from a back sight on the preceding station. The angled may also be measured by repetition. The angles measured from the back station may be interior or exterior depending on the direction of progress.

Bowditch Method:-

It is done when both linear and angular measurement with highly accuracy. According to Bowditch rule, error in linear measurement is directly proportional to square root of length of line and error in angular measurement are inversely proportional to square root of length of line.