MODULE – II

Surveying

- It is defined as the process of measuring horizontal distances, vertical distances and included angles to determine the location of points on, above or below the earth surfaces.
- The term surveying is the representation of surface features in a horizontal plane.
- The process of determining the relative heights in the vertical plane is referred as levelling.

Objectives of Surveying:

- The data obtained by surveying are used to prepare the plan or map showing the ground features.
- When the area surveyed is small and the scale to which its result plotted is large, then it is known as Plan .
- When the area surveyed is large and the scale to which its result plotted is small, then it is called as a Map.
- Setting out of any engineering work like buildings, roads, railway tracks, bridges and dams involves surveying

Main divisions of surveying:

Types of Surveying

• Plane surveying

• Geodetic surveying

Concept:

• Since the shape of the earth is spheroidal, the line connecting any two points on the earth surface is not a straight line, but a curve.

• When the surveys extend over a large areas or when the accuracy required is great, the curvature of earth has also to be taken into account.

• For small distances the difference and the subtended chord

Plane Surveying:

• The surveying where the effect of curvature of earth is neglected and earth's surface is treated as plane, is called surveying.

• The degree of accuracy in this type of surveying is comparatively low.

• Generally when the surveying is conducted over the area less than 260 Sq.Km., they are treated as plane surveying.

• Plane surveying is conducted for the purpose of engineering projects.

Geodetic Surveying:

• The effect of curvature is taken into account.

• It is also known as "Trigonometrical Surveying".

• It is a special branch of surveying in which measurements are taken with high precision instruments.

• Calculations are also made with help of spherical trigonometry.

• It is generally adopted by the Great Trigonometrical Survey Department of India". (GTS).

Classification of surveying:

- **Based on location of survey**

• Land Surveying

• Marine or Navigation or Hydrographic Surveying

• Astronomical Survey

Land Surveying: Land survey is a one, in which the relative points or objects on the earth's surface is determined.

Marine or Navigational or Hydrographic Survey: Marine surveying is one in which in which the relative position of objects under water is determined.

Astronomical Surveying: It is one in which observations are made to locate the heavenly bodies such as sun, moon and stars.

- **Based on the purpose of survey**
  - Topographical survey.
  - Cadastral survey
  - City survey
  - Engineering survey.

Topographical Survey: It is used for determining the natural and artificial features of the country such as rivers, lakes, hills and canals.

Cadastral Survey: It is used to locate additional details such as boundaries of fields of fields, houses and other properties.

City Survey: It is used for town planning schemes such as laying out plots, constructing streets, laying water supply and sewer lines.

Engineering Survey : It is used to collect data for design and construction of Engineering works such as roads, railways, bridges dams etc.,

- Based on the instruments or method employed as:
- Chain and tape survey.
- Compass and Theodolite survey.
- Plane table survey.
- Triangulation survey.
- Tacheometric survey.
- Hydrographical survey.
- Photographical and aerial survey.

Basic principle of surveying:

The following two basic principles should be considered while determining relative position of points on the surface of earth:-

1. Determining suitable method for locating a point: - it is always practicable to select two points in the field to measure the distance between them. These can be represented on paper by two points placed in a convenient position.
2. Working from whole to the part: - in surveying an area, it is essential to establish first of all a system of control points with great precision. Minor control points can then be established by less precise method and the details can be located afterwards by method of triangulation or traversing between control points.

Linear Measurements

Methods of Liner measurements:

Direct Method: The direct methosare employed in field using a tape or a chain.

Optical Method:

- In optical methods the distances are measured indirectly using principles of optics.
- The instrument used is called as tacheometer, which is a theodolite fitted with stadia diaphragm.

Approximate Methods

1. Pacing: - The distance is measured by counting the number of steps.
   Distance covered = No. of steps x Average length of step
2. Passometer: - Number of steps are recorded by a device similar to apocket watch and operates automatically due to the motion of body.
3. Pedometer: - It registers directly distance travelled.
4. Odometer: - Simple device attached to the wheel of the bicycle or a vehicle.It records number of revolutions made by the wheel.
5. Speedometer: - Measures the instantaneous speed and distance travelled by a vehicle.

Chain Surveying

Chain surveying is a method of surveying in which only linear measurements are directly made in the field. The main instruments used are chain, tape, offset rods, cross staff, optical square. This is the simplest method of surveying which is resorted in the following cases:

1. For small areas.
2. To prepare large scale maps and to locate boundaries very accurately.
3. The site is an open ground without complicated undulating profiles, obstacles etc.
4. The ground is fairly level.

Principle of chain surveying:

The plot is divided into a number of well conditioned (nearly equilateral) triangles. This triangle is surveyed. The area within each primary triangle can be divided into minor or secondary

triangles which are all surveyed for their exact location within each primary triangle. This process is based on working from whole to part and the accumulation of errors is avoided.

Accessories used in Chain Surveying:

The different accessories used in chain surveying are

- Metre Chain
- Arrows
- Pegs
- Cross staff
- Measuring Tape
- Ranging rod/Offset rod.

The chain: A chain is a unit of length. The chain is composed of links, connected each to each by two rings, and furnished with a tally mark at the end of every ten links.

Tallies - The tallies are of brass, and have one, two, three or four notches, as they mark ten, twenty, thirty or forty links from either end. The fiftieth link is marked by a rounded tally to distinguish it from the others.

Following are the various types of chain in common use:

1) Metric chains

2) Gunter` s chain or surveyors chain

   - It's length is 66 ft composed of 100 links

3) Engineers chain

   - It's length is 100 ft composed of 100 links

4) Revenue chain

   - It's length is 33 ft composed of 16 links

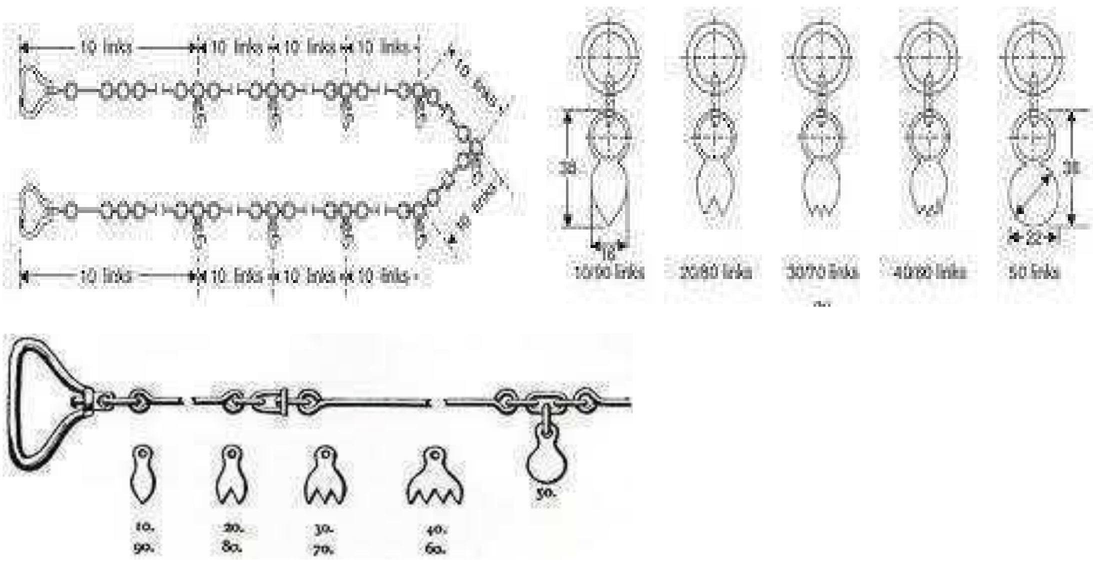


Fig. Chains

Metric chain: Metric chains are made in lengths 20m and 30m. Tallies are fixed at every fivemeter length and brass rings are provided at every meter length except where tallies are attached.

Tapes: Tapes are used in surveying to measure horizontal, vertical, and slope distances. They may be made of a ribbon or a band of steel, an alloy of steel, cloth reinforced with metal or synthetic materials. Tapes are issued in various lengths and widths and graduated in a variety of ways. The following are the various types of tapes

i. Cloth tape
ii. Metallic tape
iii. Steel tape
iv. Invar tape

Among the above, metallic tapes are widely used in surveying. A metallic tape is made of varnished strip of waterproof line interwoven with small brass, copper or bronze wires. These are light in weight and flexible and are made 2m, 5m 10m, 20m, 30m, and 50m.

Metallic Tapes:

A metallic tape is made of high-grade synthetic material with strong metallic. Strands (bronze-brass- copper wire) woven in the warped face of the tape and coated with a tough plastic for durability. Standard lengths are 50 and 100 ft. Metallic tapes are generally used for rough measurements, such as cross-sectional work, road-work slope staking, side shots in topographic surveys, and many others in the same category.

Steel Tapes

For direct linear measurements of ordinary or more accurate precision, a steel tape is required. The most commonly used length is 100 ft, but tapes are also available in 50-, 200-, 300-, and 500-ft lengths. Various types of surveying tapes are shown in figure 2.

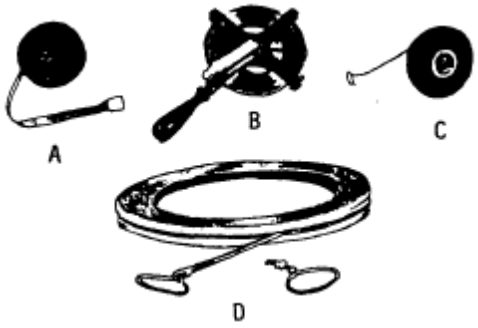


Figure 2: Surveying tapes.

Invar Tapes

Nickel-steel alloy tapes, known as Invar, Nilvar, or Lovar. These tapes are used primarily in high-precision taping. These tapes must be handled in exactly the same manner as other precise surveying instruments.

Arrows:

Arrows are made of good quality hardened steel wire of 4 mm diameter. The arrows are made 400 mm in length, are pointed at one and the other end is bent into a loop or circle.

Ranging rods:

Ranging rods are used to range some intermediate points in the survey line. The length of the ranging rod is either 2m or 3m . They are shod at bottom with a heavy iron point. Ranging rods are divided into equal parts 0.2m long and they are painted alternately black and white or red and white or red, white and black. When they are at considerable distance, red and white or white and yellow flags about 25 cm square should be fastened at the top.

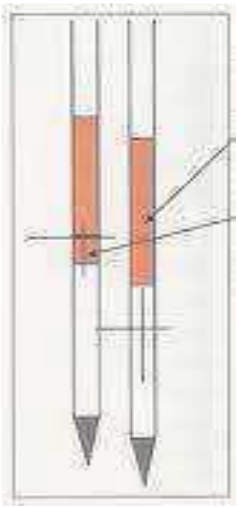
Offset Rod:

• It is a ranging rod with two short, narrow, vertical sighting slots passing through the centre of the section.

• A hook is fitted of a groove is cut at the top to enable pulling or pushing of the chain through obstruction like hedges.

• Offset rods are meant for setting outlines approximately at right angles to the main line.

Arrows



Ranging rods

Plumb Bob

Plumb-bob:

It consists of a solid conical piece and a string attached to it at its centre.

• When in use, the solid piece is at the bottom.

• It is used to test the verticality of the ranging rods and to transfer the points to the ground.

• Plumb bob is used while doing chain surveying on sloping ground.

Pegs:

These are rods made from hard timber and tapered at one end, generally 25mm or 30mm square and 150mm long wooden pegs are used to mark the position of the station on.

Cross Staff:

The simplest instrument used for setting out a right angle. The common forms of cross staff are shown in Figure

Metal cross staff

Wooden cross staff.

Ranging out Survey Line

In measuring the length of a survey line called chain line, it is necessary that the chain should be laid out on the ground in a straight line between the end stations.

Ranging: The process of establishing intermediate point on a straight line between two end points is known as ranging. Ranging must be done before a survey line is chained. It may be necessary to establish a number of intermediate points prior to chaining when chain line is much longer. Ranging may be done by direct observation by the naked eye or by line ranger or by Theodolite. Generally, ranging is done by naked eye with the help of three ranging rods.

Ranging is of two kinds:

1. Direct Ranging
2. Indirect or reciprocal ranging

1. Direct Ranging: When intermediate ranging rods are fixed on a straight line by direct observation from end stations, the process is known as direct ranging. Direct ranging is possible when the end stations are intervisible.

Assume that A and B two end stations of chain line (Refer Figure), where two ranging rods are already fixed. Suppose it is required to fix a ranging rod at the intermediate point P on the chain line in such a way that the points A, P & B are in same straight line. The surveyor stands about two meters behind the ranging rod at A by looking towards line AB. The assistant holds ranging rod at P vertically at arms length the rod should be held tightly by the thumb and forefinger. Now the surveyor direct the assistant to move the ranging rod to the left or right until the three ranging rods come exactly the same straight line. The ranging will be perfect, when the three ranging rods coincide and appear as a single rod. When the surveyor is satisfied that the ranging is prefect, he signals the assistant to fix the ranging rod on the ground. By following the same procedure, the other ranging rods may be fixed on the line.

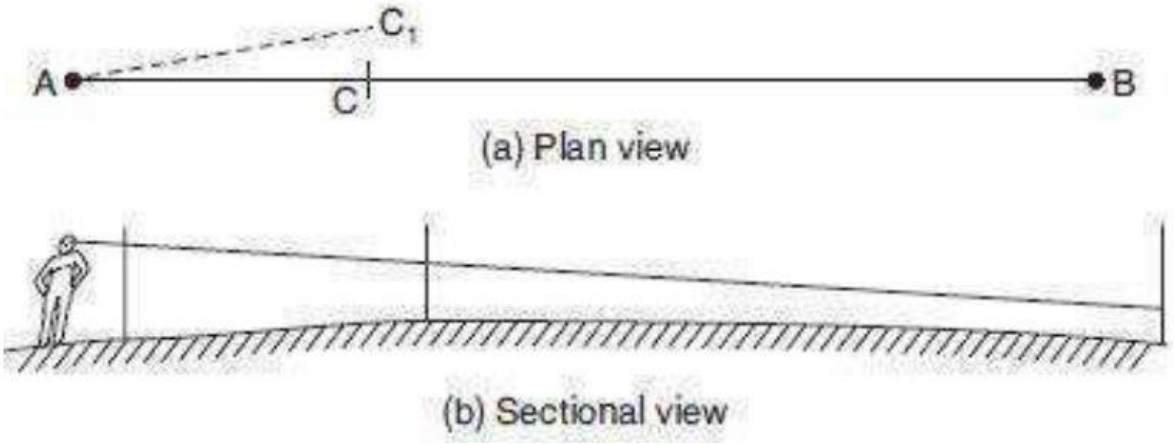


Figure: Direct Ranging

2. Indirect or Reciprocal Ranging: Indirect ranging is used when the end stations are not intervisible due to high ground or a hill or if the ends are too long. In such cases, intermediate points can be fixed on the survey line by a process known as reciprocal ranging.

Let A & B be the two stations with rising ground or a hill (Refer Figure). Let two chainmen with ranging rods take up positions at M and P, such that, chainmen at M1 can see both rods at P1 and B and the chainmen at P1 can see the ranging rods at M1 and A. The chainmen at P1 directs the chainmen at M1 to shift the ranging rod at M2 in line with A and then chainman at M2 directs the chainmen at P1 to shift the ranging rod to P2 in line with B, by successively directing each other to be in line with the end points. Their positions will be changed until finally they are both in line with A & B exactly on line AB. Now the four ranging rods at A M P & B are on same straight line. This method may also be used in ranging a line across a valley or river.

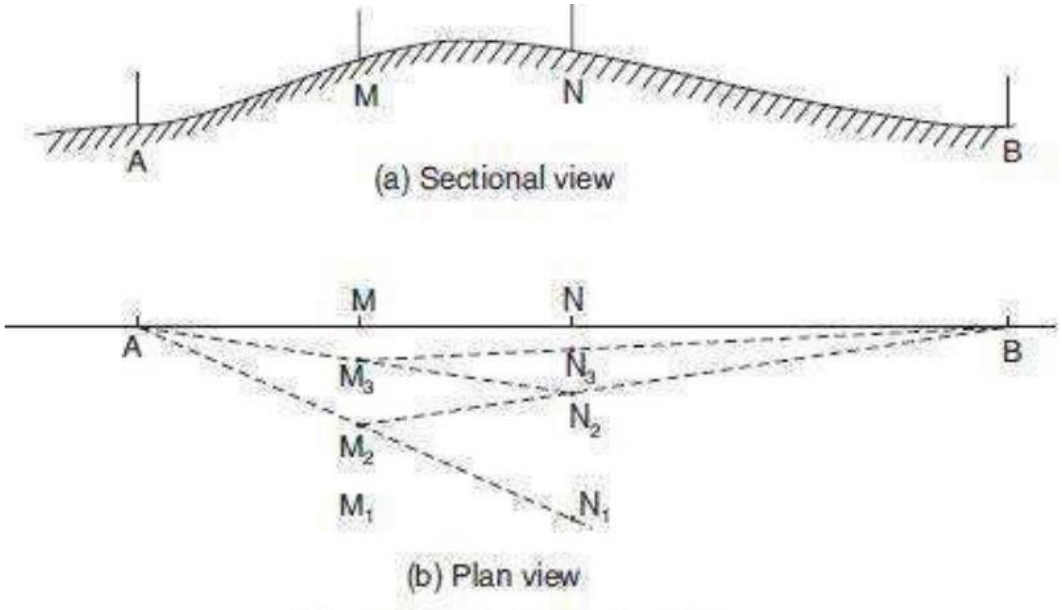


Figure : Indirect or Reciprocal Ranging

Survey Station

Survey stations are of two kinds

1. Main Stations
2. Subsidiary or tie

Main Stations: Main stations are the end of the lines, which command the boundaries of the survey, and the lines joining the main stations re called the main survey line or the chain lines.
Subsidiary or the tie stations: Subsidiary or the tie stations are the point selected on the main survey lines, where it is necessary to locate the interior detail such as fences, hedges, building etc.
Tie or subsidiary lines: A tie line joints two fixed points on the main survey lines. It helps to checking the accuracy of surveying and to locate the interior details. The position of each tie line should be close to some features, such as paths, building etc.
Base Lines: It is main and longest line, which passes approximately through the centre of the field. All the other measurements to show the details of the work are taken with respect of this line.
Check Line: A check line also termed as a proof line is a line joining the apex of a triangle to some fixed points on any two sides of a triangle. A check line is measured to check the accuracy of the framework. The length of a check line, as measured on the ground should agree with its length on the plan.

Offsets:

These are the lateral measurements from the base line to fix the positions of the different objects of the work with respect to base line. These are generally set at right angle offsets. It can also be drawn with the help of a tape. There are two kinds of offsets:
1) Perpendicular offsets, and
2) Oblique offsets.
The measurements are taken at right angle to the survey line called perpendicular or right angled offsets. The measurements which are not made at right angles to the survey line are called oblique offsets or tie line offsets.
Advantages and disadvantages of chain surveying:
Advantages:
• It is simple
• It does not require any costly equipment
• It is adopted for preparing plans for small area
Disadvantages:
• It cannot be used for large areas
• It cannot be used in thick bushy areas with ups and downs.
• Chain surveying is not always accurate.

Compass Surveying – Prismatic Compass:

Whenever a number of base lines are to be run for obtaining the details as in traversing, just linear measurements made by chain surveying will not be sufficient. The angles included between the adjacent lines should also be measured. Compass is one of the instruments used to measure the angles.
Prismatic Compass:
Description:
- A magnetic needle is balanced over a pivot in a circular box of 85 mm to 110 mm in diameter.

- A graduated aluminium ring is attached to the magnetic needle.
- An agate cap keeps the aluminium ring stable.
- The box is covered by a glass lid.
- Object vane and eye vane are provided at diametrically opposite ends.
- Eye vane caries a reflecting prism which can be raised or lowered as desired.
- A vertical horse hair or fine wire is provided at the middle of the object vane.
- The graduations in the aluminium ring are made in the clockwise direction starting with 0^o at South and 180^o at North with inverted markings.
- A triangular prism fitted below the eye slit enables magnification of readings to suit observer's eye.
- Based on this prism arrangement, the compass is named prismatic compass.
- Compass is fixed over a tripod with ball and socket arrangement.
- A braked pin is provided below the object vane to damp the oscillations of the magnetic needle while taking readings.

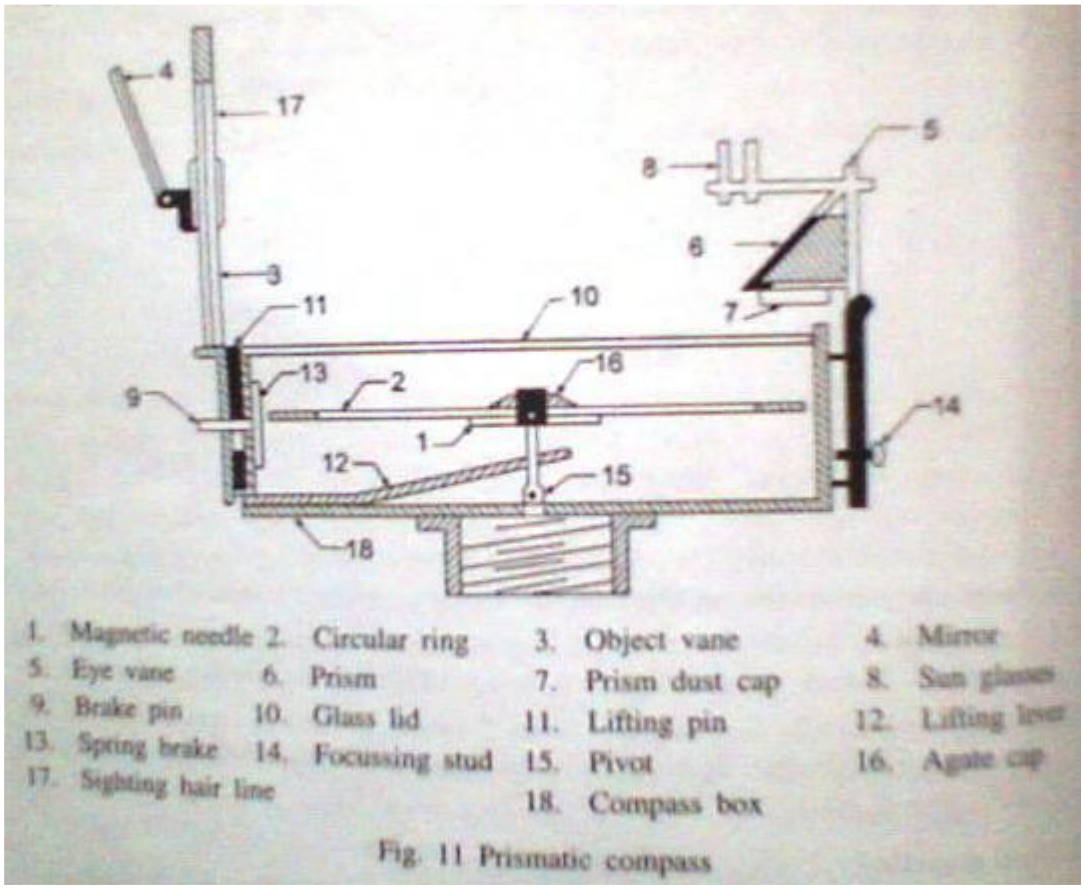


Fig. 11 Prismatic compass

Working Principle:

• The magnetic field aligns itself with the magnetic meridian (N-S direction)
• The line of sight is actually the line joining the object vane and eye vane
• The angle between the N-S direction and the line of sight is observed in the compass
• This angle is actually the angle between N-S direction and the line on the ground
• This angle made by the line with the N-S direction is called the bearing of the line.
• Compass is used to measure the bearing of the different lines from which the angles included between the adjacent lines are computed.

Definitions:

Meridian: The direction of a line is expressed in terms of horizontal angle which the line makes with a reference lne. This reference line is called as meridian. There are 4 types of meridian

1. True Meridian: The line joining the true north (geographical north) and true south (geographical south) is called as true meridian.

2. Magnetic Meridian: The line joining magnetic north and magnetic south. It is the direction indicated by a freely suspended balanced magnetic needle at that point.

3. Grid Meridian: In order to survey a very large area such as a state or a country, true meridian of a central place is often taken as the reference meridian for the whole state or the country. This reference meridian is called as grid meridian.

4. Arbitrary Meridian: It is the meridian that is taken in any convinient arbitrary direction. Any reference line can be taken as arbitrary meridian.

Magnetic Declination: Angle between true meridian and magnetic meridian.

Bearing: The bearing of a horizontal line is the angle which it makes with the reference line/meridian. There are 4 types of bearings

1. True Bearing
2. Magnetic Bearing
3. Grid Bearing
4. Arbitrary Bearing

True Bearing:

• True bearing of a line is the angle between the true meridian and the line.
• The angle is always measured in the anticlockwise direction.

Magnetic Bearing:

• It is the angle between the magnetic meridian and the line.
• The angle is always measured in the clockwise direction
• It is the direction shown by a freely suspended magnetic needle

Bearing Designation:

Whole Circle Bearing:

• The bearing of lines measured from the North is called Whole Circle Bearing.

• The angle is reckoned in the clockwise direction from 0o coinciding with the north.

Quadrant Bearing:

• The whole circle is divided into four quadrants.

• The bearing is expressed with N or S as prefix and E or W as suffix.

• Quadrant Bearing is also known as Reduced Bearing.

Bearing of a line:

Fore Bearing and Back Bearing:

• Every line has two bearing namely fore bearing and back back bearing

• Fore bearing is the bearing taken in the direction of surveying and Back bearing is the bearing taken in the reverse direction.

• The difference between the fore bearing and the back bearing should be 180o.

• It means that one or both stations of the line are subjected to local attraction.

• Thus, local attraction is the influence caused on the measured bearings of lines due to the presence of materials like railway track, current carrying wires or cables, etc.,

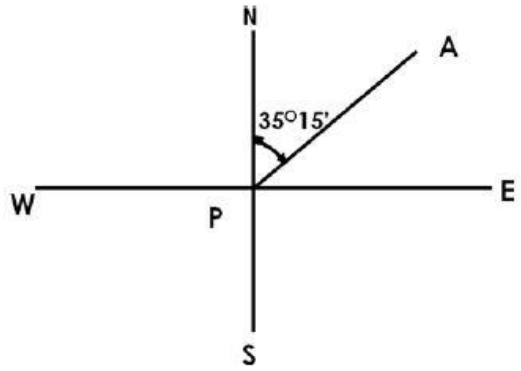
To find QB from WCB:

Exp.1

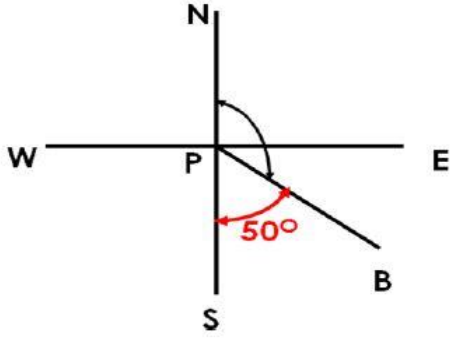
Solution:

Line PA lies in 1st quadrant.

Quadrant Bearing bearing of PA = N 35º 15’ E



Exp.2



Solution:

Line PB lies in 2nd quadrant.

Quadrant Bearing bearing of PB = S 50o 00’ E

LOCAL ATTRACTION

Detection of local attraction: Local attraction at a place can be detected by observing bearings. If the fore and back bearings of the line differ exactly by 180°, there is no local attraction at either station provided instrumental and observational errors are eliminated. But if this difference is not equal to 180°, then local attraction exists there either at one or at both ends of the line. The list of materials which cause local attraction are:

(i) Magnetic rock or iron ore,

(ii) Steel structures, iron poles, rails, electric poles and wires,

(iii) Key bunch, knife, iron buttons, steel rimmed spectacles, and

(iv)Chain, arrows, hammer, clearing axe etc.

Electronic Distance Measuring Instruments (EDM)

In surveying, the standard measurement device for many years remained the steel tape measure. Newer electronic measuring devices, however, have begun to take the place of the tape. In surveying applications, surveyors can take electronic distance measurements from helicopters covering distances and terrain that would have been near impossible with older methods.

The instrument comprises an electronic distance meter, a unit for determining a vertical angle for aligning the instrument with a measuring point, and a unit for obtaining a horizontal angle for the alignment of the instrument with a measuring point.

Fig:EDM

Total Station

A total station is an electronic/optical instrument used in modern surveying. The totalstation is an electronic theodolite (transit) integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.

Coordinate measurement: Coordinates of an unknown point relative to a known coordinate can be determined using the total station as long as a direct line of sight can be established between the two points. Angles and distances are measured from the total station to points under survey,

and the coordinates (X, Y, and Z or easting, northing and elevation) of surveyed points relative to the total station position are calculated using trigonometry and triangulation.

Fig: Total Station

Applications:

a. Total stations are mainly used by land surveyors and Civil Engineers, either to record features as in Topographic Surveying or to set out features (such as roads, houses or boundaries).

b. They are also used by archaeologists to record excavations and by police, crime scene investigators, private accident reconstructions and insurance companies to take measurements of scenes.

c. Mining: Total stations are the primary survey instrument used in mining surveying.