JHARKHAND Rai University RANCHI

MINING ENGINEERING LAB MANUAL

MINE SURVEYING II
DIPLOMA

LIST OF EXPERIMENTS

EXPERIMENT NO. 01

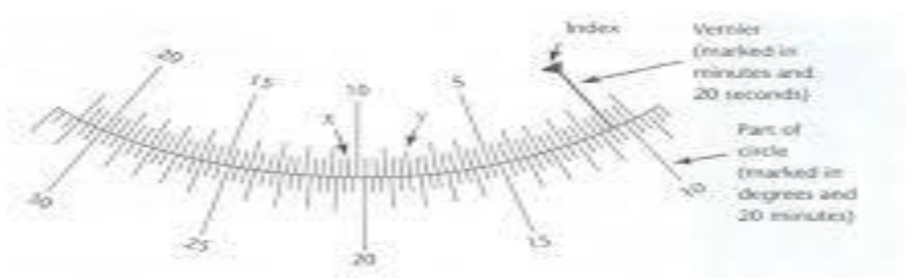
AIM: Demonstration of theodolite reading the vernier

INSTRUMENTS REQUIRED: Theodolite

THEORY: The vernier scale is a clever way of improving the precision of a reading on an instrument scale. It has been used on quite a number of instruments. The scale has been especially useful for the so very fine angle scales of a theodolite. Although it has been largely replaced by optical and electronic micrometers, it is still in use.

The same concept can be applied to a circular scale like that used on a theodolite. In the image below, the main outer scale is graduated in intervals of 30 minutes. Each interval on the vernier scale has an arc measure of 29 minutes. Again, count graduations up to the point at which a mark aligns with one on the lower scale. This will show the number of minutes to add to the direct reading.

METHOD OF READING VERNIER



How to Read a Vernier Scale on the Theodolite

The theodolite employs a Vernier scale, which, with a little practice, can accurately measure angles to the minute.

- Learn angle basics. Before you can understand the Vernier scale on a theodolite, you must know how angles are broken up. A full circle consists of 360 degrees. Each degree (or 1/360 of a circle) can be divided into 60 minutes.
- Look at the Vernier scale on your theodolite or refer to the Vernier model in the References. The outer circle on the scale is fixed, while the inner scale is rotated as the scope of the theodolite is rotated. Each interval marking signifies 30 minutes, or 1/2 of a degree.

- Study the outer scale. The top number tells you what the angle is to the right. If you were to draw an arc to the right from the theodolite to the object being surveyed the top number would give you the angle measure of that arc. The complementary arc to the leftis read using the bottom number. Adding the angle to the right and the angle to the left will always equal 360 degrees. Note that the number on top decreases from left to right while the bottom number decreases.
- Find the "0" mark on the inner (movable) scale. This is your baseline. Wherever the 0 falls in relation to the outer scale is your degree measure. If the 0 mark falls right on the 130 (top) 230 (bottom) line, then your angle right is 130 degrees and your angle left is 230 degrees.
- Count the minutes. If the 0 mark of the inner scale falls directly on a mark on the outer scale, your degree measure exact. If, however, the 0 mark falls in between two interval markings, then your degree measure is not exact. Moving toward the right of the 0 mark, count the interval markings until one lines up directly with the interval mark beneath it. This is the minutes of your angles.

EXPERIMENT NO. 02

AIM: Temporary adjustments of theodolite & measurement of horizontal angle by repetition method**.**

TEMPORARY ADJUSTMENT OF THEODOLITE:-

There are three temporary adjustments of a theodolite. These are:

1. Setting up the theodolite over a station.
2. Leveling up.
3. Elimination of parallax.

SETTING UP:

It includes two operations

1. Centering a theodolite over a station: Done by means of plumb bob. Recently use of optical plummet has made the job of centering very easy.
2. Approximately leveling it by tripod legs only: Done by moving tripod legs radially or circumferentially.

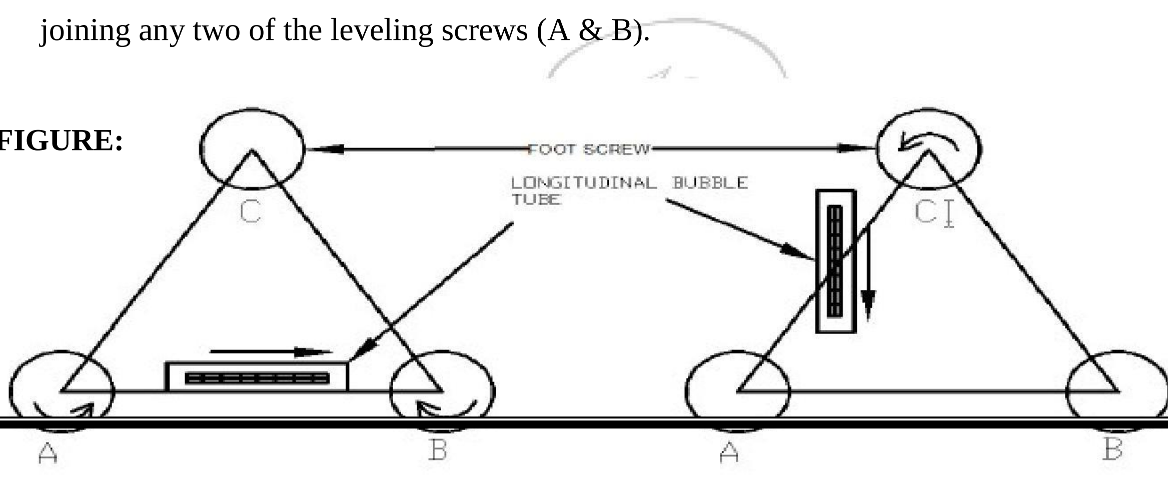
LEVELING UP:

Having centered and approximately levelled the instrument, accurate levelling is done with the help of foot screws with reference to the plate levels, so that the vertical axis shall be truly vertical.

To level the instrument the following operations have to be done.

1. Turn the upper plate until the longitudinal axis of the plate level is roughly parallel to a line joining any two of the leveling screws (A & B).

FIGURE:



2. Hold these two leveling screws between the thumb and first finger of each hand uniformly so that the thumb moves either towards each other or away from each other until the bubble comes to the center.
3. Turn the upper plate through 90º i.e. until the axes of the level passes over the position of the third leveling screw ‘C’.
4. Turn this leveling screw until the bubble comes to the center.
5. Rotate the upper plate through 90º to its original position fig(a) and repeat step(2) till the bubble comes to the center.
6. Turn back again through 90º and repeat step 4 .
7. Repeat the steps 2 and 4 till the bubble is central in both the positions.
8. Now rotate the instrument through 180º. The bubble should be remaining in the center of its run,
provided it is in correct adjustment. The vertical axis will then be truly vertical.

ELIMINATION OF PARALLAX:

Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. Unless parallax is eliminated, accurate sighting is not possible. Parallax can be eliminated in two steps.

1. **FOCUSSING THE EYE-PIECE:**

   Point the telescope to the sky or hold a piece of white paper in front of the telescope. Move the eyepiece in and out until a distant and sharp black image of the cross-hairs is seen.

2. **FOCUSSING THE OBJECT:**

   Telescope is now turned towards object to be sighted and the focusing screw is turned until image appears clear and sharp.

MEASUREMENT OF HORIZONTAL ANGLE BY REPETITION METHOD:-

To measure the horizontal angle between the ‘OA’ and ‘OB’

O – Instrument Station

A – Ranging Rods No.1

B – Ranging Rod No.2

INSTRUMENTS REQUIRED:

(i) Theodolite

(ii) Tripod

(iii) Ranging Rods

(iv) Arrows

PROCEDURE:

The method of repetition is used to measure the horizontal angle to a finer degree of accuracy than that obtainable with the least count of the vernier. By this method an angle is measured two (or) more time by allowed the vernier to remain clamped each time at the end of each measurement of the previous station. Thus an angle reading is mechanically repetitions. The average horizontal angle is then obtained by dividing the final reading by number of repetitions.

To measure the angle of horizontal AOB, the following Procedure:

- Set the instrument at station ‘O’ and level it with the help of alidade bubble and foot screw. Set zero reading (or) vernier A note the reading at vernier B.
- Loose the lower clamp and direct the telescope towards the point ‘A’ accurately by lower tangential screw.
- Then unclamp the upper clamp and turn the instrument clockwise about inner axis towards ‘B’ accurately with the upper tangential axis.
- Unclamped the lower clamp and turn the telescope N sight A. Again bisect ‘A’ accurately by using the lower tangential screw. It should be noted that the vernier reading will not be changed in this operation. Since the upper plate is clamped to the lower.
- Unclamp the upper clamp; turn the telescope clockwise and Sight ‘B’ accurately by upper tangent screw.
- Repeat the process until the angle i.e. for repeated no. of times say three times. The average angle with face left will be equal to the final reading divided by number of repetition (3)

TABULATION:

FACE LEFT READINGS-

Inst. at	**Sight to**	**Face Left**					**Mean**	**Included angle**
		Vernier A			**Vernier B**			
		o	**‘**	**“**	**‘**	**“**		

FACE RIGHT READINGS-

Inst. at	**Sight to**	**Face Right**					**Mean**	**Included angle**
		Vernier A			**Vernier B**			
		o	**‘**	**“**	**‘**	**“**		

Result:

The horizontal angle between the two points is found out by the method of repetitions using theodolite and found as -------------------

EXPERIMENT NO. 03

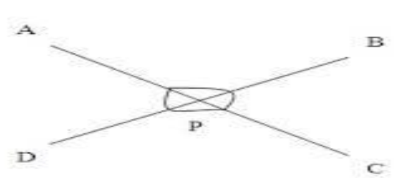
AIM: Measurement of horizontal angle by reiteration method.

INSTRUMENT REQUIRED:

(i) Theodolite
(ii) Tripod
(iii) Ranging Rod
(iv) Arrows

PROCEDURE:

- Set the instrument at 'P' and fix the ranging rods at ABCD of the closed traverse.
- Then centering with altitude bubble, leveling and elimination of parallax is done there are the preliminary adjustments.
- Now set the vernier to zero.
- Now right A and at A the angles is found to be zero fight the upper and lower clamp.
- Now loose the upper clamp and turn the telescope and right B.
- Now tight the upper clamp and table reading.
- After taking reading loose the upper clamp and Sight C and tight the upper clamp and take reading.



TABULATION:

FACE LEFT READINGS-

Inst. at	Sight to	Face Left					Mean	Included angle
		Vernier A			Vernier B			
		o	‘	“	‘	“		

FACE RIGHT READINGS-

Inst. at	Sight to	Face Right					Mean	Included angle
		Vernier A			Vernier B			
		o	‘	“	‘	“		

Result: Thus the Horizontal angles are round by reiteration method.

EXPERIMENT NO. 04

AIM: Observation of magnetic bearing of a line by Theodolite by compass attachment.

INSTRUMENT REQUIRED:

(i) Theodolite

(ii) Tripod

(iii) Ranging Rod

THEORY:

The angle which a line makes with the magnetic meridian is called a magnetic bearing of a line.

PROCEDURE:

For measuring, Bearing through compass or tabular compass is attached to theodolite.

- Set the vernier A to $0°0'0''$ of the horizontal circle after setting theodolite over 0 and level it.
- Loosen the lower clamp magnetic needle is then realized to swing on pivot of compass. Rotate the instrument till needle roughly point to the north by using lower tangent screw and correct direction of magnetic needle is obtain.
- Loose the upper clamp and direct the telescope towards A and bisect it exactly by using upper clamp and upper tangent screw. Read both verniers.
- Change the face and repeat the process. The average of two values gives correct bearing of line AB.

OBSERVATION TABLE:

INST. AT STATION	OBJECT	FACE	READING					Mean Vernier A	Mean Vernier B	Mean Face Angle
			Vernier A			Vernier B				
			o	‘	“	‘	“			

RESULT:

Direct angle between A & C = ...

Deflection Angle between A & C = ...

Magnetic Bearing of a line OA = ...

EXPERIMENT NO. 05

AIM: Prolongation of a survey line with the help of a Theodolite.

INSTRUMENT REQUIRED:

(i) Theodolite

(ii) Tripod

(iii) Ranging Rod

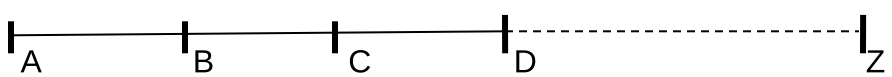
THEORY:

There are two methods of prolonging a given line such as AB
(1)Fore sight method, and
(2)Back Sight Method

PROCEDURE:

(1) Fore Sight Method

As shown in the fig. below



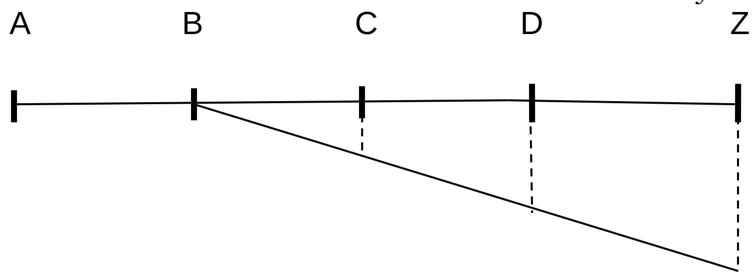
i) Set up the theodolite at A and level it accurately .Bisect the point b correctly. Establish a point C in the line beyond B approximately by looking over the top of the telescope and accurately by sighting through the telescope.

ii) Shift the instrument to B, take a fore sight on C and establish a point D in line beyond C.

iii) Repeat the process until the last point Z is reached.

(2) Back Sight Method

As shown in the fig. below



i) Set up the instrument at B and level it accurately.

ii) Take a back sight on A.

iii) Tighten the upper and lower clamps, transit the telescope and establish a point C in the line beyond B.

iv) Shift the theodolite to C, back sight on B transit the telescope and establish a point D in line beyond C.
Repeat the process until the last point (Z) is established.

RESULT: The Prolongation of a survey line is done using theodolite.

EXPERIMENT NO. 06

AIM: Measurement of Vertical angles using theodolite.

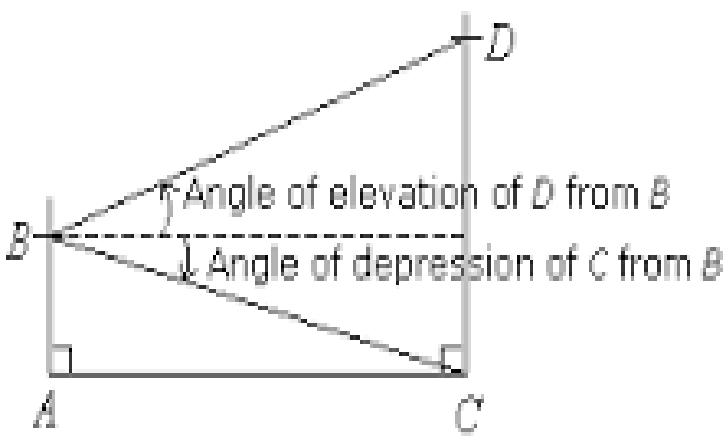
INSTRUMENT REQUIRED:

(i) Theodolite

(ii) Tripod

(iii) Ranging Rod

THEORY:
The vertical angle includes both angle of elevation and angle of depression.
The **angle of elevation** of an object as seen by an observer is the angle between the horizontal and the line from the object to the observer's eye (the line of sight).
If the object is below the level of the observer, then the angle between the horizontal and the observer's line of sight is called the **angle of depression**.



PROCEDURE:
1) Set up the theodolite at a convenient distance from the object and measure the horizontal distance between them accurately by using steel or invar tape. Let this distance be d meters .Then set up and center the instrument over the station and level it accurately with reference to the altitude bubble.

2) Set the zero of the vertical vernier exactly to the vertical circle clamp and

tangent screw.

3) Loosen the vertical circle clamp and bisect the telescope towards the top of the object. When it is sight approximately clamp the vertical circle, bisect the object exactly by turning the tangent screw.

4) Read both verniers, the mean of two readings give the value of required angle α

5) Now loosen the vertical clamp and bisect the bottom of given object exactly by using vertical tangent screw. The mean of two readings give the value of required angle α.

6) Change the face of the instrument and repeat it.

RESULT:

The vertical angles of the object are as follows:
Mean angle of Elevation =
Mean angle of depression =

EXPERIMENT NO. 07

AIM: Demonstration of Total station.

INSTRUMENT REQUIRED: Total Station

THEORY:

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

CAPABILITY OF A TOTAL STATION:

Microprocessor unit in total station processes the data collected to compute:

1. Average of multiple angles measured.
2. Average of multiple distance measured.
3. Horizontal distance.
4. Distance between any two points.
5. Elevation of objects and
6. All the three coordinates of the observed points.

Data collected and processed in a Total Station can be downloaded to computers for further processing.

Total station is a compact instrument and weighs 50 to 55 N. A person can easily carry it to the field. Total stations with different accuracy, in angle measurement and different range of measurements are available in the market. Figure below shows one such instrument manufactured by SOKKIA Co. Ltd. Tokyo, Japan.

BRIEF DESCRIPTION OF IMPORTANT OPERATIONS OF TOTAL STATION:

Distance Measurement:

Electronic distance measuring (EDM) instrument is a major part of total station. Its range varies from 2.8 km to 4.2 km. The accuracy of measurement varies from 5 mm to 10 mm per km measurement. They are used with automatic target recognizer. The distance measured is always sloping distance from instrument to the object. Angle Measurements: The electronic theodolite part of total station is used for measuring vertical and horizontal angle. For measurement of horizontal angles any convenient direction may be taken as reference direction. For vertical angle measurement vertical upward (zenith) direction is taken as reference direction. The accuracy of angle measurement varies from 2 to 6 seconds.

Data Processing :

This instrument is provided with an inbuilt microprocessor. The microprocessor averages multiple observations. With the help of slope distance and vertical and horizontal angles measured, when height of axis of instrument and targets are supplied, the microprocessor computes the horizontal distance and X, Y, Z coordinates. The processor is capable of applying temperature and pressure corrections to the measurements, if atmospheric temperature and pressures are supplied.

Display:

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

Electronic Book:

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

USE OF TOTAL STATION

The total station instrument is mounted on a tripod and is levelled by operating levelling screws. Within a small range instrument is capable of adjusting itself to the level position. Then vertical and horizontal reference directions are indexed using onboard keys. It is possible to set required units for distance, temperature and pressure (FPS or SI). Surveyor can select measurement mode like fine, coarse, single or repeated.

When target is sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriate keys they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information about the point and displays on screen.

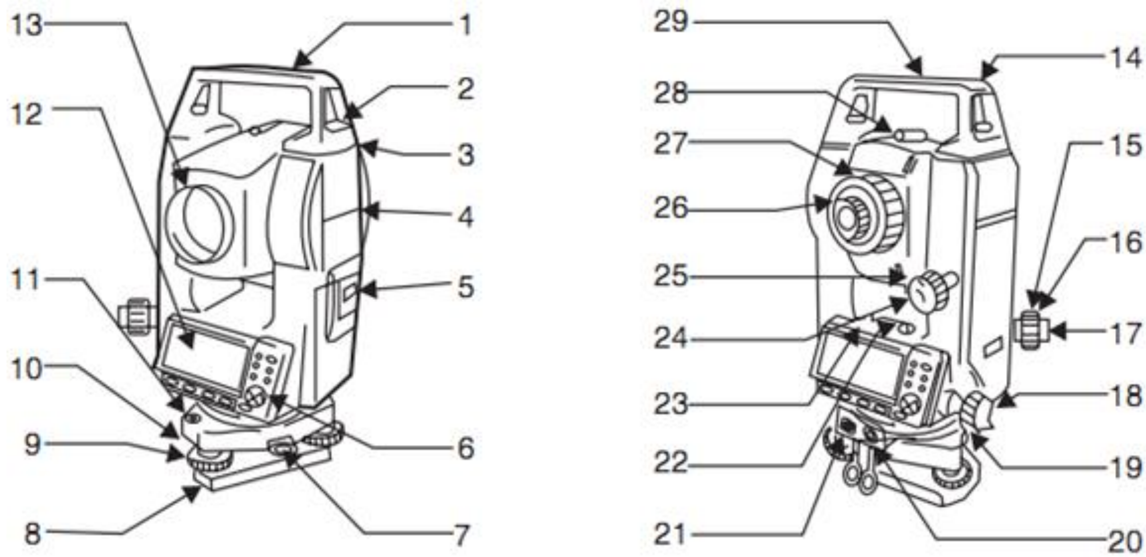
This information is also stored in the electronic notebook. At the end of the day or whenever electronic note book is full, the information stored is downloaded to computers.

Advantages of Using Total Stations

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

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

FIGURE:



1. Handle
2. Handle securing screw
3. Data input/output terminal (Remove handle to view)
4. Instrument height mark
5. Battery cover
6. Operation panel
7. Tribrach clamp (SET300*S*/500*S*/600S: Shifting clamp)
8. Base plate
9. Levelling foot screw
10. Circular level adjusting screws
11. Circular level
12. Display
13. Objective lens
14. Tubular compass slot
15. Optical plummet focussing ring
16. Optical plummet reticle cover
17. Optical plummet eyepiece
18. Horizontal clamp
19. Horizontal fine motion screw
20. Data input/output connector (Besides the operation panel on SET600/600*S*)
21. External power source connector (Not included on SET600/600*S*)
22. Plate level
23. Plate level adjusting screw
24. Vertical clamp
25. Vertical fine motion screw
26. Telescope eyepiece
27. Telescope focussing ring
28. Peep sight
29. Instrument center mark

EXPERIMENT NO. 08

AIM: Demonstration of EDM.

INSTRUMENT REQUIRED: EDM

THEORY:

Electronic distance measuring instrument is a surveying instrument for measuring distance electronically between two points through electromagnetic waves. Electronic distance measurement (EDM) is a method of determining the length between two points, using phase changes, that occur as electromagnetic energy waves travels from one end of the line to the other end. As a background, there are three methods of measuring distance between two points:

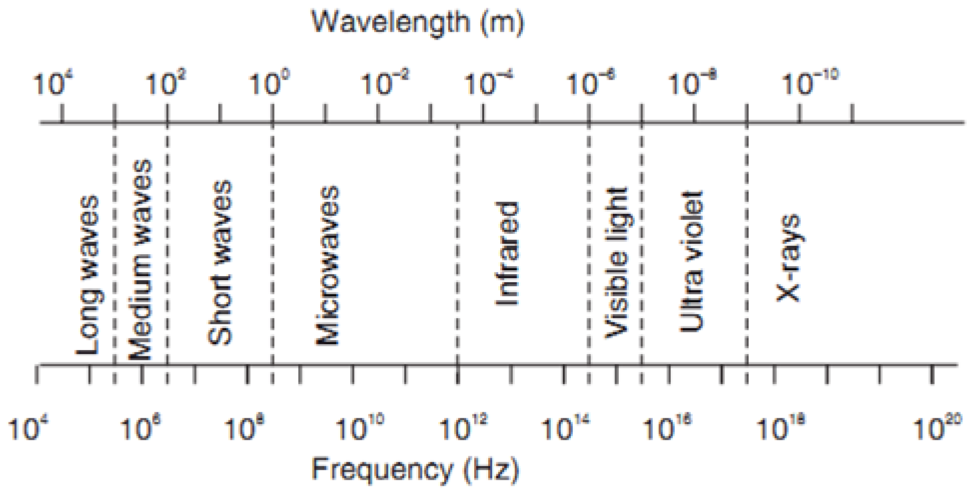
DDM or Direct distance measurement – This is mainly done by chaining or taping.

ODM or Optical distance measurement – This measurement is conducted by tacheometry, horizontal subtense method or telemetric method. These are carried out with the help of optical wedge attachments.

EDM or Electromagnetic distance measurement – The method of direct distance measurement cannot be implemented in difficult terrains. When large amount of inconsistency in the terrain or large obstructions exist, this method is avoided.

Electronic distance measurement in general is a term used as a method for distance measurement by electronic means. In this method instruments are used to measure distance that rely on propagation, reflection and reception of electromagnetic waves like radio, visible light or infrared waves.

Sun light or artificially generated electromagnetic wave consists of waves of different lengths. The spectrum of an electromagnetic wave is as shown below:



Among these waves microwaves, infrared waves and visible light waves are useful for the distance measurement. In EDM instruments these waves are generated, modulated and then propagated. They are reflected at the point up to which distance is to be measured from the instrument station and again received by the instrument.

The time taken by the wave to travel this 2x distance may be measured and knowing the velocity of wave, the distance may be calculated. However time is too short, measuring the time taken is difficult. The improved techniques use phase difference method in which the number of completed wave and incomplete wave is measured. Knowing the length of wave, distances are calculated.Built up microprocessors provided in the instrument calculate the distances and display it by liquid crystal display (LCD).

<u>TYPES OF EDM INSTRUMENT:</u>

EDM instruments are classified based on the type of carrier wave as

1. Microwave instruments
2. Infrared wave instruments
3. Light wave instruments.

1. Microwave Instruments

These instruments make use of microwaves. Such instruments were invented as early as 1950 in South Africa by Dr. T.L. Wadley and named them as Tellurometers. The instrument needs only 12 to 24 V batteries. Hence they are light and highly portable. Tellurometers can be used in day as well as in night.

The range of these instruments is up to 100 km. It consists of two identical units. One unit is used as master unit and the other as remote unit. Just by pressing a button, a master unit can be converted into a remote unit and a remote unit into a master unit. It needs two skilled persons to operate. A speech facility is provided to each operator to interact during measurements.

2. Infrared Wave Instruments

In this instrument amplitude modulated infrared waves are used. Prism reflectors are used at the end of line to be measured. These instruments are light and economical and can be mounted on theodolite. With these instruments accuracy achieved is ± 10 mm. The range of these instruments is up to 3 km.

These instruments are useful for most of the civil engineering works. These instruments are available in the trade names DISTOMAT DI 1000 and DISTOMAT DI 55.

3. Visible Light Wave Instruments

These instruments rely on propagation of modulated light waves. This type of instrument was first developed in Sweden and was named as Geodimeter. During night its range is up to 2.5 km while in day its range is up to 3 km. Accuracy of these instruments varies from 0.5 mm to 5 mm/km distance. These instruments are also very useful for civil engineering projects.

<u>Operations of EDM:</u>

It is essential to know the fundamental principle behind EDM to work with it. The electromagnetic waves propagate through the atmosphere based on the equation

$$V = f.\lambda = \left(\frac{1}{T}\lambda\right)$$

$f = 1/T$; (T=Time in seconds)

Where ‘v’ is the velocity of electromagnetic energy in meters per second(m/sec); f is the modulated frequency in hertz (Hz) and is, the wavelength measured in meters. Mainly the waves that are propagated can be represented like a sine wave . Another property of wave called as phase of wave , is a very convenient method of small fraction of wavelength during measurement in EDM. The points A, B, C etc. represents various phase points

Say AB is the survey line to me measured, having a length of D. The EDM equipment is placed at ends A and B. A transmitter is placed at A and a receiver is placed at B. the transmitter lets propagation of electromagnetic waves towards B. A timer is also placed. At the instant of transmission of wave from A the timer at B starts and stops at the instant of reception of incoming wave at B. This enable us to know the transit time for the wave from the point A to B.

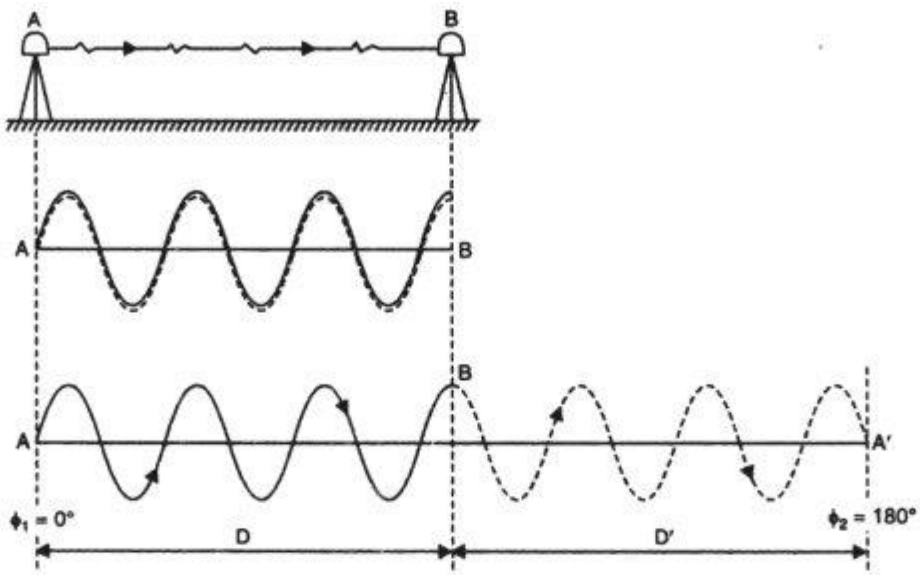


Fig. Transit Time Measurement Demonstration

From the transit time and known velocity, the distance can be easily measured. Now to solve the problem arise due to difficulty in starting the timer at B, a reflector can be placed as shown below instead of a receiver at B.

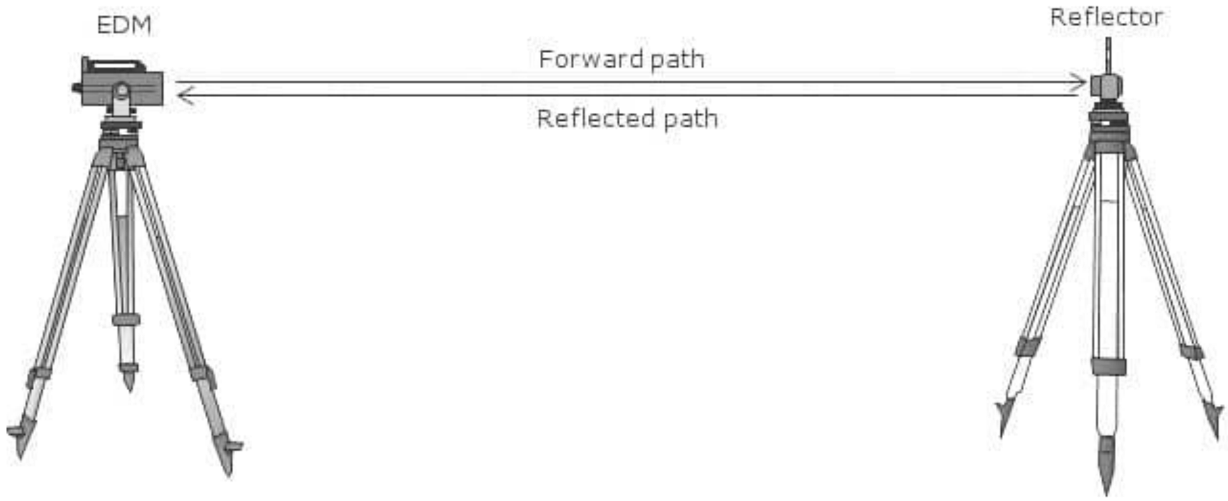


Fig. Transit measurement arrangement with the help of a EDM and reflector

ERROR IN EDM

1. **Personal Errors**
2. **Instrumental Errors**
3. **Natural Errors**

ADVANTAGE:

The advantage of using EDM instruments is the speed and accuracy in measurement. Several obstacles to chaining are automatically overcome when these instruments are used.

FIGURE:

EXPERIMENT NO. 09

AIM: To set out the simple curve by Rankine's method of Deflection angles by using Single theodolite method.

INSTRUMENTS REQUIRED:

1. Theodolite,
2. Chain (or) Tape,
3. Ranging rods,
4. Pegs or Arrows.

PRINCIPLE:

The deflection angle to any point on a circular curve is measured by one – half the angle subtended by the arc from point of curve to that point. It is assumed that the length of the arc is approximately equal to its chord.

Curves are provided in traffics for the line of communication like highways, railways and canals etc. to have a gradual change in direction. Generally, circular curves are provided even though the parabolic curves may also be employed. A simple curve is an arc of a circle connecting two straights.

PROCEDURE:

1. Tangent length (t) is determined using the following formula:-

$$t = R \tan\Phi/2$$

2. Length of the curve (l) is determined using the following formula

$$l = \Phi \Pi R/180$$

3. Chainage of T1 is determined as follows:-

   Chainage of T1= Chainage of point of intersection (P.I) –Tangent length (t).

4. Chainage of T2 is determined as follows:-

   Chainage of T2= Chainage of T1+ Length of the curve (l).

5. Tangent points T1 and T2 are located on the field.

6. Lengths of first sub chord, normal chords and last sub chord are calculated so that the pegs are at full chain stations.

7. Tangential angles $\delta 1$, $\delta 2$, $\delta 3$ -------etc and total Deflection angles $\Delta 1, \Delta 2, \Delta 3$------- etc are calculated as follows.

$$\delta = 1719C/R \text{ minutes}$$

$$\Delta 1 = \delta 1,$$

$$\Delta 2 = \Delta 1 + \delta 2,$$

$$\Delta 3 = \Delta 2 + \delta 3$$

And $\Delta n = \Delta n\text{-}1 + \delta n$

Note: -The total deflection angle $\Delta n = \Phi/2$ Where, Φ is the deflection angle of the curve or central angle of the curve.

8. Theodolite is set up at the point of curve T1 and levelled.

9. Vernier A is set to zero and upper clamp is clamped. Lower clamp is loosened and intersection point B is bisected exactly using the lower tangent screw. Thus the line of sight is maintained in the direction of
T1B and the vernier A kept zero.

10. Upper clamp is loosened and the deflection angle $\Delta 1$ is set at vernier A. The line of collimation is now directed along the chord T1
D, and the upper clamp is clamped.

11. Zero end of the Tape is held at T1 and an arrow is placed at a distance equal to first chord length of T1D = C1 on the tape. Tape is swung around T1 till the arrow is bisected by the line of sight. Thus the first point D is established on the curve. First peg is fixed at D.

12. Upper clamp is loosened and the deflection angle $\Delta 2$ is set at vernier A. The line of collimation is now directed along the chord T1
E, and the upper clamp is clamped.

13. Zero end of the Tape is held at D and an arrow is placed at a distance equal to second chord length of DE = C2= C on the tape. Tape is swung around D till the arrow is bisected by the line of sight. Thus the first point E is established on the curve. Second peg is fixed at E.

14. The same procedure is repeated till the last point is reached. As
a check, the location of last point is verified whether it coincide the tangent point T2 fixed already from the P.I or not.

Note:-In the case of left handed curves, the vernier should be set to (360°-Δ1), (360°-Δ2), (360°-Δ3) etc to obtain successive points on the curve after sighting the intersecting point with both the plates clamped at zero.

RESULTS:- By tangential angle method the simple circular curve was plotted on the ground .

EXPERIMENT NO. 10

AIM: To Find constants of a given tacheometer.

INSTRUMENTS REQUIRED:

1. Tacheometer with stand,
2. Levelling Staff,
3. Ranging rods,
4. tape

THEORY:

PRINCIPLE OF STADIA METHOD

The stadia method is based on the principle that the ratio of perpendicular to the base is Constant in similar isosceles triangles. In fig let two rays OA and OB be equally inclined to the central ray OC. Let A2B2, A1B1 and AB be staff intercepts.

Constant K= ½ Cotβ/2

This constant k entirely depends upon the magnitude of the angle β. If β is made equal to 34’22”, the constant k=1/2Cot 17’11”=100.

In this case the distance between the staff and the point o will be 100 times the intercept. In actual practice, observation may be made with inclined line of sight. in the later case, the staff may be kept either vertically or normal to the line of sight. We shall first derive the distance elevation formulae for the horizontal sights.

An ordinary transit theodolite fitted with stadia hair is known as Tacheometer. This method completely eliminated the use of tape or chain and is very rapid and convenient.

PROCEDURE:

1. The theodolite is mounted on the tripod stand.
2. A metric chain of 20m or 30m length is unfolded and streched straight.
3. The theodolite is centered over an arbitrarily selected station from where a chain line is run along a straight course and from where the staff station selected at uniform intervals on the chain line can be sighted without any obstruction and the instrument is levelled using the foot screws and both the

plate bubble and the altitude bubble are brought to the centre of the run. The line of sight is made horizontal by setting both the vernier C and D on the vertical circle at 0°00’00” .

4. The levelling staff is held vertically on the stations selected at uniform intervals on the chain line and the stations are sighted in sequence through the telescope.
5. The stadia hair readings are observed for every staff station and are recorded along with the respective horizontal distance of the station from the instrument station
6. The staff intercept is calculated for every observation.
7. The horizontal distance and the corresponding staff intercepts are substituted in the distance equation for horizontal line of sight and as many equations as the number of observations are formulated.
8. These equations are solved for the values of tacheometric constants.

TABULATION:

S.No.	Distance D (m)	Stadia Hair Reading (m)			Staff Intercept S (m)
		Top	Middle	Bottom	
1	20				
2	40				
3	60				
4	80				

$D_1=KS_1+C$ ---------------- (1)
$D_2=KS_2+C$ .... (2)
$D_3=KS_3+C$ .... (3)
$D_4=KS_4+C$ .... (4)

RESULT:
The tacheometric constant of the given instrument are determined

i. Multiplying Constant K =
ii. Additive Constant C =