INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

ADVANCED SURVEYING LABORATORY									
V Semester: CE									
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACEC21	Core	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 45**				**Total Classes: 45**		
Prerequisite: Surveying and Geomatics Laboratory								

I. COURSE OVERVIEW:

Advanced Surveying is intended to enhance the learning experience of the student in topics encountered in Surveying and Geomatics. Surveying refers to tracing points on ground or field. This course gives an overview on surveying with respect to tracing of points locating inaccessible distances, tracing curve and path, contours etc., This course also focuses on advanced surveying techniques, including EDM, photogrammetry and Remote sensing. Further the course is useful to solve the complex problems related to measuring inaccessible distances, remote elevation and distances by collecting andevaluating data such as horizontal distances, vertical distances, slopes and elevations.

II. COURSES OBJECTIVES:

The students will try to learn

1. The concept of surveys and technology involved in measuring field parameters using traditional and modern instruments.
2. The operating principles of various levelling instruments and analyze their performance characteristics under various terrains.
3. The measurement of alteration works, detecting land use and land cover, creating base maps for visual reference.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO1 Recall the concept of traversing in theodolite for measuring horizontal and vertical angles.
CO2 Demonstrate trigonometric leveling for locating inaccessible heights and distances.
CO3 Identify the suitable repetition and reiteration methods in theodolite survey for tracing out the centering point on ground.
CO4 Examine the reduced levels using leveling apparatus for illustrating longitudinal section and cross section and plotting.
CO5 Examine contours for investigating the suitable path along the alignment at conflict points.
CO6 Utilize the concept of remote elevation and remote distance in total station at various operating conditions and data record keeping.

IV. COURE SYLLABUS:

EXCERCISES ON ADVANCED SURVEYING LABORATORY

Note: Students are encouraged to proper dress code field practice sessions.

1. Advanced Surveying Laboratory

1.1. Introduction to Advanced Surveying Laboratory

This Laboratory course is intended to enhance the learning experience of the student in topics encountered in Surveying and Geomatics. In this lab, students are expected gain knowledge on advanced surveying is equipped with the instruments and tools students use throughout the surveying course. Students learn techniques for gathering field data with both traditional and modern instruments. A set of traditional and modern instruments are used, including theodolite, total station, level rods, tripods, tape measures, chaining pins, and other common surveying tools and ancillary equipment.

1.2. Study of Theodolite in detail-practice for measurement of horizontal and vertical angles

The theodolite is the accurate instrument used for measuring horizontal and vertical angles. It consists of a telescope by means of which distant objects can be sighted. The telescope has two distinct motions one in the horizontal plane and the other in the vertical plane, the former being measured on a graduated horizontal circle by means of a set of vertical and the latter on a graduated vertical circle by two verniers in fig. 1.1. It can also be used for various other purposes such as laying off horizontal angles, locating points on a line, prolonging survey lines, establishing grades, determining difference in elevations.

I. Classification of theodolite
II. Components of Theodolite
III. Fundamental Axes of Theodolite
IV. Applications in real world

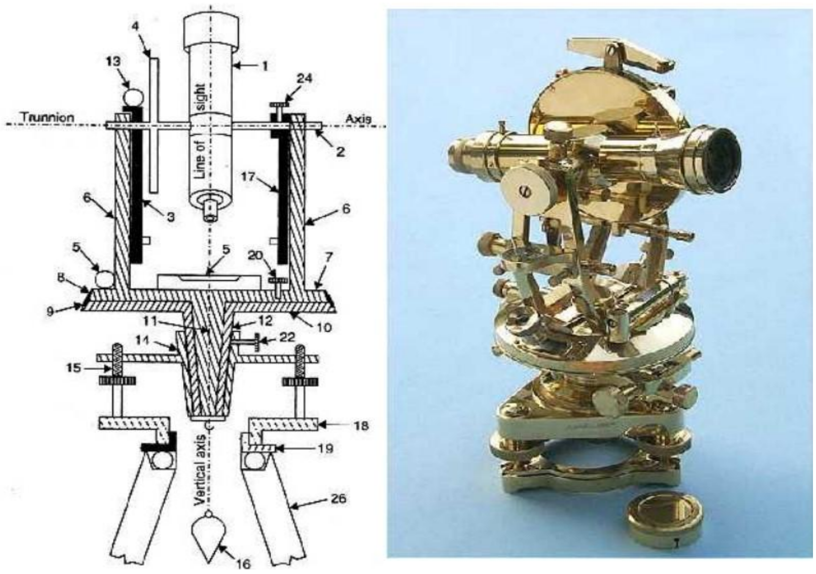


Fig. 1.1 Components of theodolite

Try: The following questions are to be answered about the transit theodolite

1. Write are the types of telescopes used in survey.
2. Demonstrate the various components of theodolite.

3. Transit the theodolite from the face left to face right and vice Versa.

2. Measurement of Horizontal Angle by the Method of Repetition and Reiteration

The horizontal angle measurement by a theodolite is a fundamental process in surveying and construction tasks. To measure horizontal angles accurately using a theodolite, follow these methods

I. Method of repetition
II. Method of reiteration

2.1. Method of repetition

The method of repetition is used to measure a horizontal angle in fig. 2.1 to a finer degree of accuracy than that obtainable with the least count of the vernier. Hence, an angle reading is mechanically added several times depending upon the number of repetitions.

Finding Angle POQ:

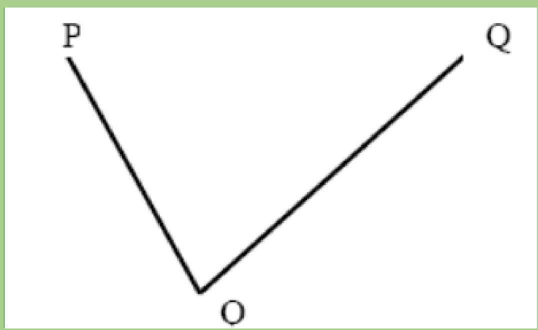


Fig. 2.1 Angle POQ

Repetition	Sight to	Face left Swing right											Face right Swing left											Average included angle POQ		
		Vernier A			Vernier B		Mean			Included Angle			Vernier A			Vernier B		Mean			Included Angle					
		°	′	″	′	″	°	′	″	°	′	″	°	′	″	′	″	°	′	″	°	′	″	°	′	″
	P																									
	R																									
	P																									
	R																									
	P																									
	R																									

Angle POQ =

Try: Demonstrate the following

1. Measure the angle between the boundary lines in the site by the Method of Reptation.
2. Find the angle the two roads at junction using Method of Reptation.

2.2. Method of reiteration

The method known as direction method or reiteration method or method of series is suitable for the measurements of the angles of a group having a common vertex point in fig. 2.2. Several angles are measured successively and finally the horizon is closed.

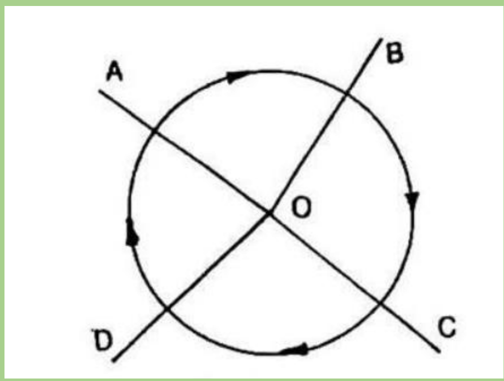


Fig. 2.2 Method of Reiteration

Inst Station	Sight to	Angle	Face left Swing Right											Face right Swing Right											Average included angle		
			Vernier A			Vernier B		Mean			Included Angle			Vernier A			Vernier B		Mean			Included Angle					
			°	′	″	′	″	°	′	″	°	′	″	°	′	″	′	″	°	′	″	°	′	″	°	′	″

Total Angle = Error =

Angle AOB =
Angle BOC =
Angle COD =
Angle DOA =

Try: Demonstrate the following

1. Measure the angle between stations in the closed boundary in the given in the site by the method of Reiteration.
2. Measure the horizontal angles between the corners of the basketball court from the center point.

3. Trigonometric Leveling

Trigonometric Leveling is the branch of Surveying in which we find out the vertical distance between two points with the help of some measurements of the vertical angles and the known distances shown in fig. 3.1. The known distances are either assumed to be horizontal or the geodetic lengths at the mean sea level (MSL). The distances are measured directly (as in the plane surveying) or they are computed as in the geodetic surveying.

3.1. Elevation of a point when base is accessible

It is required to find the elevation (R.L.) of the top of a tower 'Q' from the instrument station 'P' as shown in Fig.3.1.

Finding the R.L of Elevation of tower Q:

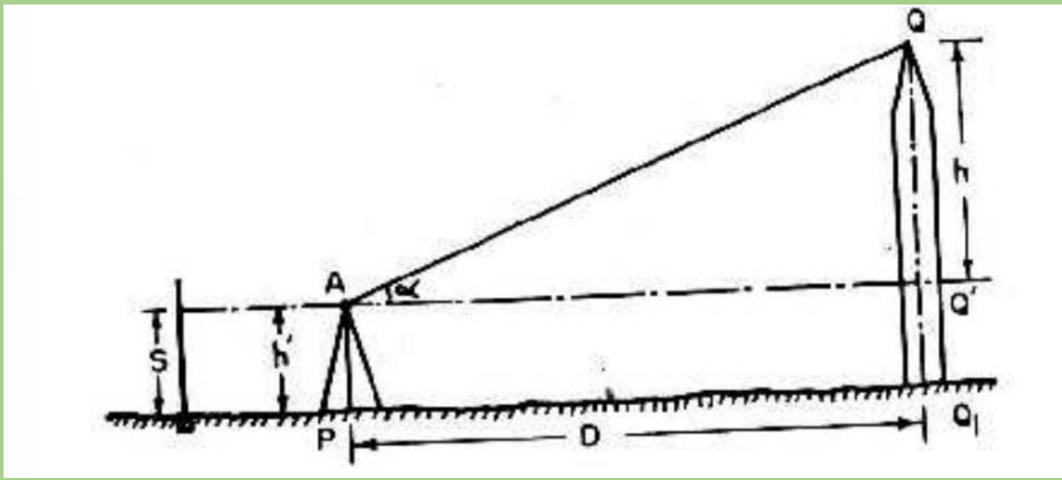


Fig. 3.1. When P is lower than R

$$H = D \tan\alpha_1$$

Where D = Horizontal distance between P and Q1

α = Vertical angle to A from Q

S = Staff reading

h' = height of the instrument at P

R.L. of Q (m) = R.L. of B.M. + S + D tanα

=

Try: Demonstrate the following

1. Measure the height of Electric pole using the trigonometric levelling.
2. What is the height of the Cell basketball Post.

3.2. Elevation of a point when base is inaccessible

It is required to find the elevation (R.L.) of the top of a building 'Q' from the instrument stations P & R as shown in Fig.3.2(a)

Finding the R.L of Elevation of tower Q:

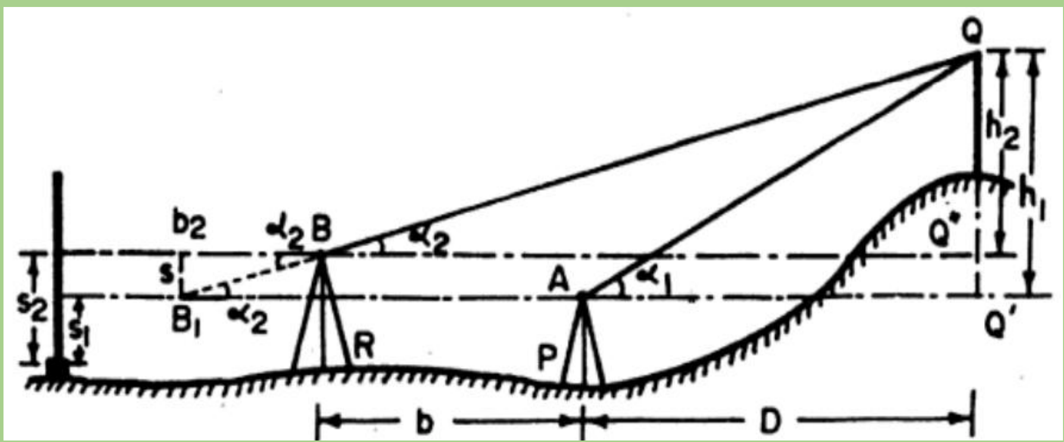


Fig. 3.2(a). When P is lower than R

It is required to find the elevation (R.L.) of the top of a building 'Q' from the instrument stations P & R as shown in Fig.3.2(b)

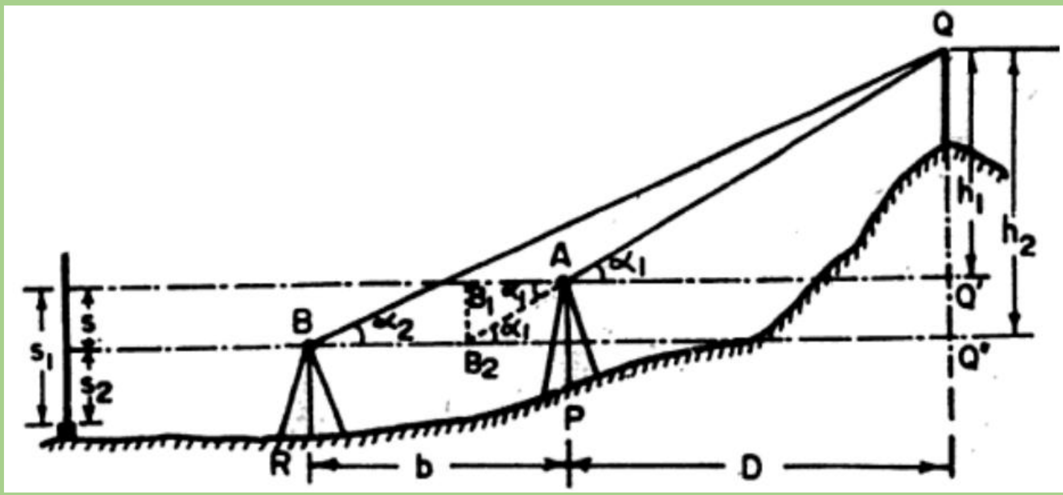


Fig. 3.2(b). When P is higher than R

$$D = \frac{(b \pm s\cot\alpha_2)\tan\alpha_2}{\tan\alpha_1 - \tan\alpha_2}$$

Where D = Horizontal distance between P and Q
b = Horizontal distance between Instrument stations
A = Telescope level of station P
B = Telescope level of station R
α_1= Vertical angle to Q from A
α_2= Vertical angle to Q from B
H = D $\tan\alpha_1$

Use + sign with $s\cot\alpha_2$ when the P is lower than R and
- sign with $s\cot\alpha_2$ when the P is higher than R

R.L. of Q (m) = R.L. of B.M. + S + h
=

Try: Demonstrate the following

1. Measure the height of college building shown using the trigonometric levelling.
2. Calculate the height of the Cell tower.

4. Curve Setting - different methods

A Curve setting using a theodolite is a technique used in construction and civil engineering for accurately measuring and laying out curves such as roads, railways, and pipelines shown in fig. 4.1 and fig. 4.2. The theodolite is an instrument that measures horizontal and vertical angles, making it an ideal tool for laying out curves.

1. Rankine's method
2. Ordinates from the Long Chord method

4.1. Setting the curve by Rankine's method

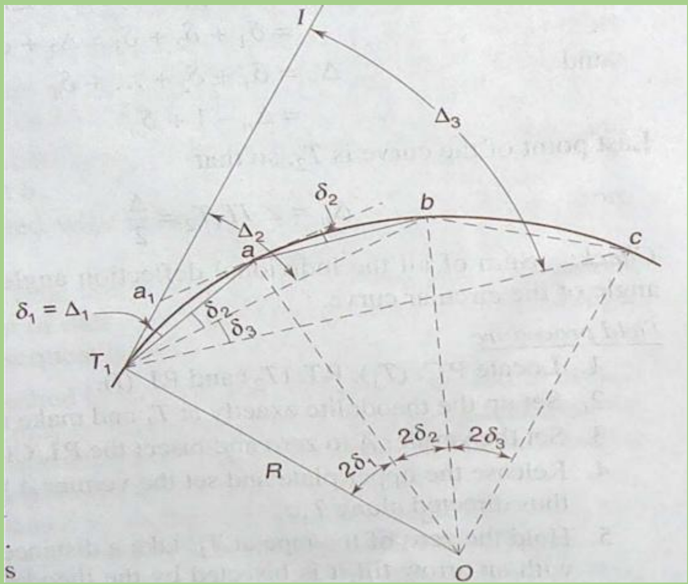


Fig. 4.1. Rankine's Method of Curve setting

Hint:

$$\delta_1 = 1718.9\,\frac{C_1}{R}\,\text{minutes}$$

δ_1, δ_2, δ_3 … etc., are the successive deflection angles

C = Length of chord, C1, C2,…etc., are the successive chord lengths

R = Radius of curve

Hence the curve plotted using the Rankine's Method.

Try: Plot a simple curve for road profile the given data using a Rankine's method.

4.2. Setting the curve by Ordinates from the Long Chord method

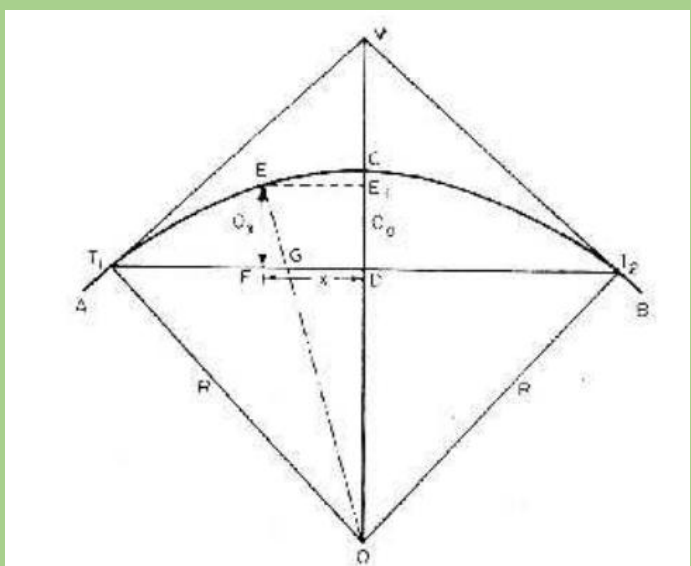


Fig. 4.2. Setting Out By Ordinates from the Long Chord

Hint:

$$O_x = \sqrt{R^2 - x^2} - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

Ox = length of offset at a distance 'x' from the mid of long chord.
X = specified distance between offsets.
L = length of the long chord.
R = Radius of the curve

Hence the curve plotted using Ordinates from the Long Chord.

Try: Plot a simple curve for road profile the given data using a Long Chord method.

5. Heights and distances using principles of Tacheometric survey

5.1. Finding Tacheometric constants

The Tacheometer is an instrument which is generally used to determine the horizontal as well as vertical distance. When one of the sights is horizontal and staff held vertical then the RLs of staff station can be determined as we determine in ordinary leveling. Tacheometer prime object is to prepare contour maps (or) plans requiring both the horizontal as well as vertical control in fig. 5.1.

Finding Tacheometric constants:

$$D = \frac{f}{i} * s + (f + d)$$

Where $\frac{f}{i}$ is the multiplying constant (K)
$(f + d)$ is the additive constant. (C)
S is the staff intercept.

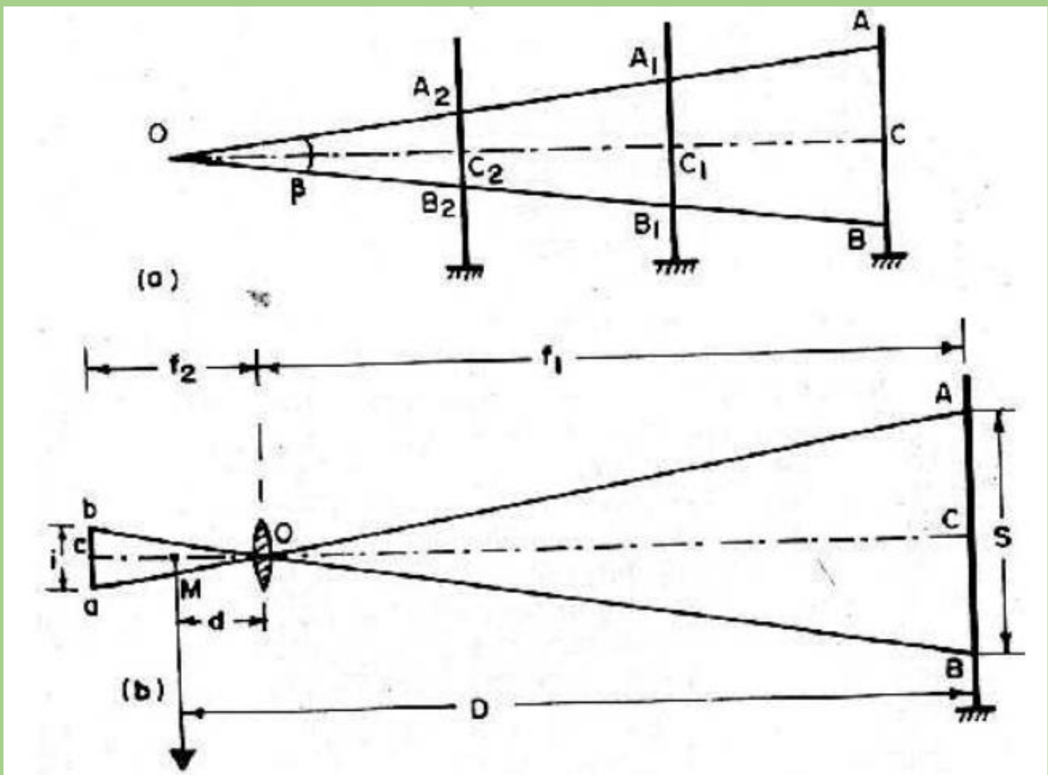


Fig. 5.1 Tacheometric Constants

D = KS + C

The simultaneous equations are taken two at a time to find the values of 'K' and 'C'.

Instrument Station	Staff Station	Distance	Stadia Reading			Stadia Intercept(S)
			Top	Middle	Bottom	

- f/i = Multiplying constant(K) =
- f+d = Additive constant (C) =

5.2. Horizontal distance elevation by stadia tachometric surveying

If the staff station is above as in fig 5.2 or below as in fig 5.3 or the line of collimation then the elevation or depression of such point can be determined by calculating vertical distances from instrument axis to the central hair reading and taking the angle of elevation or depression made by line of sight to the instrument made by line of sight to the instrument axis.

Determination of elevation of points by Tacheometric surveying:

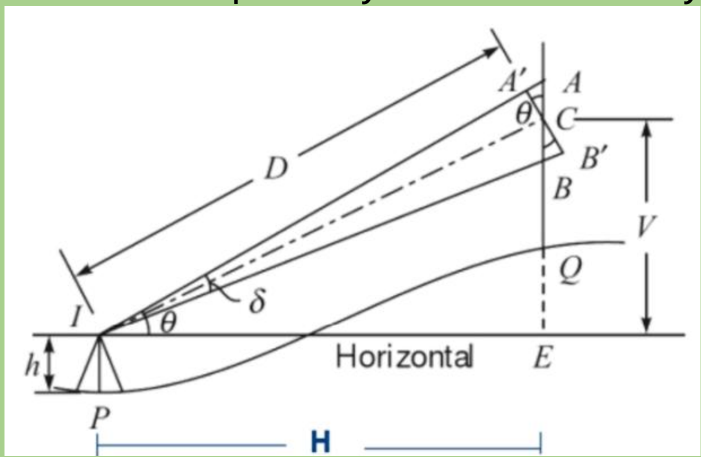


Fig. 5.2 Incline sight (Elevation)

Horizontal distance

$$H = D\cos\theta = KS\cos^2\theta + C$$

Vertical distance

$$V = \frac{1}{2}KS\sin 2\theta + C\sin\theta$$

R.L of Q = R.L of P + h + V – CQ

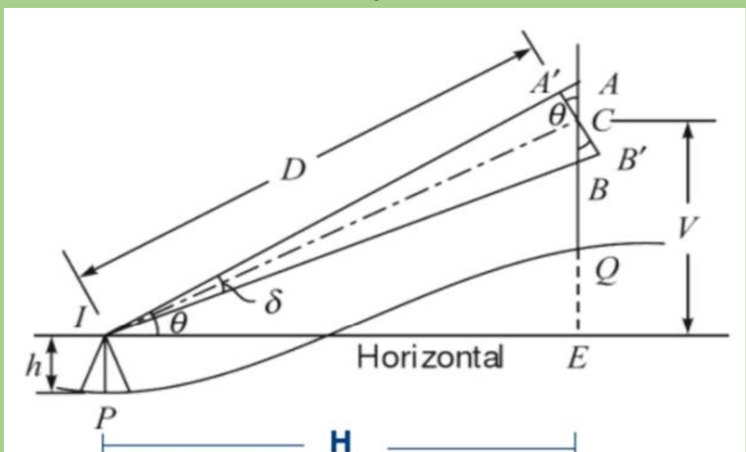


Fig. 5.2 Incline sight (Depression)

R.L of Q = R.L of P + h - V – CQ

Try: Demonstrate the following

1. Measure the height and horizontal distance of college building shown using the tacheometric method.
2. Find the Tacheometric constants of given Theodolite.

6. Setting Out Works

Setting out is bringing the dimensions from a plan to the real situation. The activity consists of establishing the exact location and measurements of the house to be built. Setting out works in surveying is a critical phase in construction and civil engineering projects, as it ensures that the built structures align with the intended design and meet quality standards in fig. 5.1.

6.1. Setting Out works for Building

The main aim of setting out is to ensure that the various points are positioned correctly in all three dimensions. Building Set out:

1. A centre line sketch of building is prepared as in fig.6.1.
2. The base line is set out with reference to given reference points.
3. The ends of the centre line of the walls point A and point B from the base line are marked.
4. As the end marks A, B, C etc. are distributed during excavation stakes are fixed at l, m, n etc., a little away about 2 to 3 m from end mark and accurately using string.
5. The centre line for all the other walls AD, BC etc. are marked by dropping perpendicular by using chain or tape 3:4:5 method for an important and big building when sides are long a theodolite may be employed to accurately set out and range the line.
6. For every wall the pegs are driven a little way from the marking end and field accurately with a string.
7. The diagonals are measured and checked with the corresponding calculated lengths.

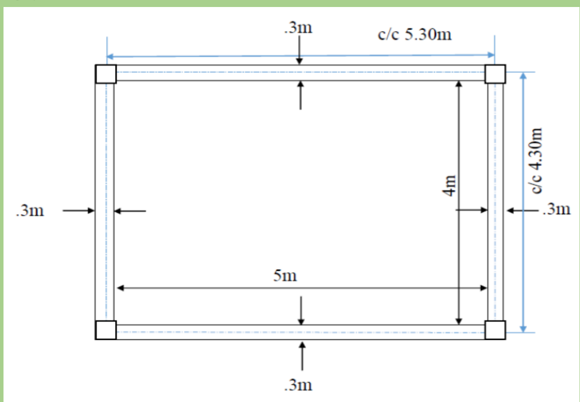


Fig. 6.1. Setting out work for building

Try: Demonstrate the following

1. Prepare the building plan for 2 BHK House.
2. Transfer the prepared plan on the ground using setting out works.

7. Study of Total Station

7.1. Introduction

A total station is an optical surveying instrument that uses electronics to calculate angles and distances. Total Station is three-dimensional surveying technology unit. Total station combines the follow three basic components fig. 7.1 into one integral unit.

I. an electronic distance measurement instrument
II. an electronic digital Theodolite
III. a computer or microprocessor

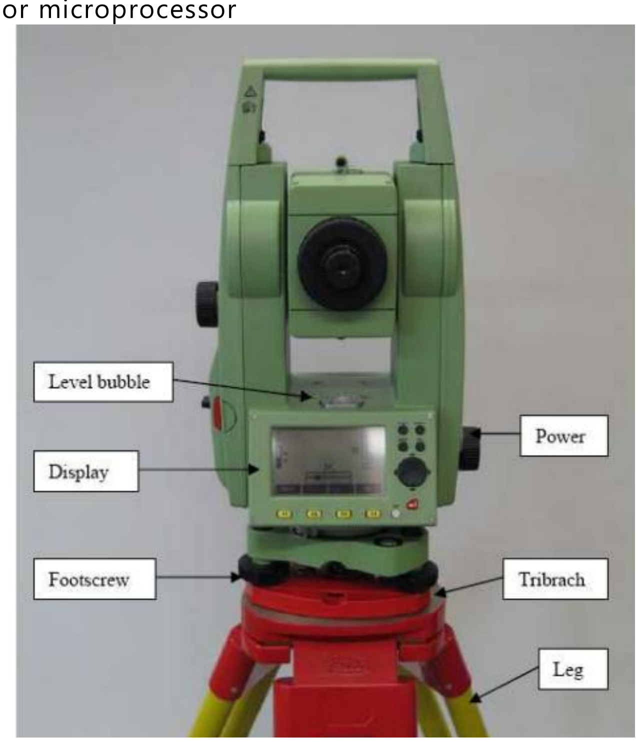


Fig. 7.1. Total Station

7.2. Functions of Total Station

Total station can automatically measure horizontal and vertical angles as well as slope distances from a single setup. From these data it can instantaneously compute:

- Horizontal and vertical distance components
- Elevations
- coordinates

7.3. Precautions

Total stations are very expensive and can be damaged by forcing or dropping the equipment. Please be extremely careful with this expensive equipment and make sure it does not get wet.

I. Never Place the Total Station directly on the ground.
II. Do not aim the telescope at the sun.
III. Protect the Total Station with an umbrella.
IV. Never carry the Total Station on the tripod to another site
V. Handle the Total Station with care. Avoid heavy shocks or vibration. 6. When the operator leaves the Total Station, the vinyl cover should be placed on the instrument.
VI. Always switch the power off before removing the standard battery.
VII. Remove the standard battery from the Total Station before putting it in the case.
VIII. When the Total Station is placed in the carrying case, follow the layout plan.

Try: The following questions are to be answered about the Total station

1. What Total station operations
2. What is the command we use for horizontal station.

8. Observations of vertical and horizontal angles using total station

8.1. Introduction

A total station is an optical surveying instrument that uses electronics to calculate angles. and distances as in fig. 8.1. It is based on the measurement of time for the distance travelled by wave. Total Station Generates a beam that is sent to the prism and returned back. The Time-of-Flight is determined by the Total Station. Knowing the speed of light, the distance can be computed as- Distance = Velocity x Time.

Here are the steps to vertical and horizontal angles using Total station:

Fig. 8.1 vertical and horizontal angles using Total station

I. Click on EQUIPMENT SETUP Button.
II. After this, you need to setup auto level instrument by placing it on the tripod using keyboard keys i.e. q:left movement, w:right movement, s:up movement, x:down movement.
III. After this, click on LEVEL SETUP Button & setup blue bubble dot to the center by using keyboard keys i.e. l: left movement, r: right movement, u: up movement, d:down movement.
IV. After this, click on the NEXT Button.
V. Press t key and p key to show tripod & prism.
VI. Click on the START Button.
VII. Press v key for total station view of object.
VIII. Click on the VIEW READINGS Button to show readings.
IX. Click on the FINISH Button to close the simulation.

9. Determination of area using Total station

Determining the area of a piece of land or any other area using a total station is a common practice in surveying and land measurement in fig. 9.1. A total station is a surveying instrument that combines the capabilities of an electronic theodolite and an electronic distance measurement (EDM) device.

9.1. Steps involved in determining area using Total station

Here are the steps to determine the area using a total station:

I. Set Up the Total Station
II. Establish Control Points:
III. Measure Points

IV. Data Collection
V. Create a Closed Traverse
VI. Calculate Coordinates
VII. Calculate Area
VIII. Check for Errors
IX. Reporting

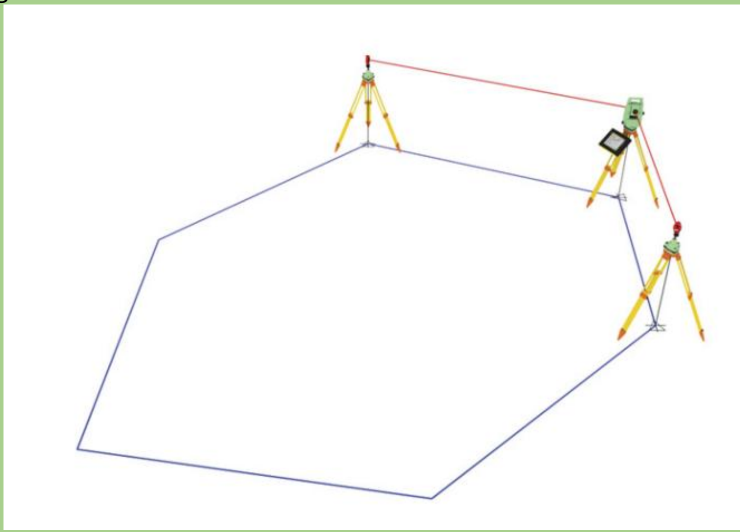


Fig.9.1 Calculation of Area using Total Station

Area of the given area =

Try: The following questions are to be answered about the transit theodolite

1. Calculate the area of parking area using the Total station.
2. Find the area of the playground using the total station.

10. Traversing

Traversing with a total station is a fundamental technique in surveying and construction to determine the coordinates and distances between points on the Earth's surface in fig 10.1. The accuracy of your traverse depends on various factors, including the quality of your equipment, proper calibration, environmental conditions, and your surveying skills.

10.1. Traversing using Total Station

Here are the general steps to perform a traverse using a total station

I. Setup and Instrument Calibration
II. Choose Traverse Points
III. Measure Angles
IV. Measure Distances
V. Move to the Next Point
VI. Compute Coordinate
VII. Check Closure
VIII. Adjustment (if necessary)
IX. Document Results

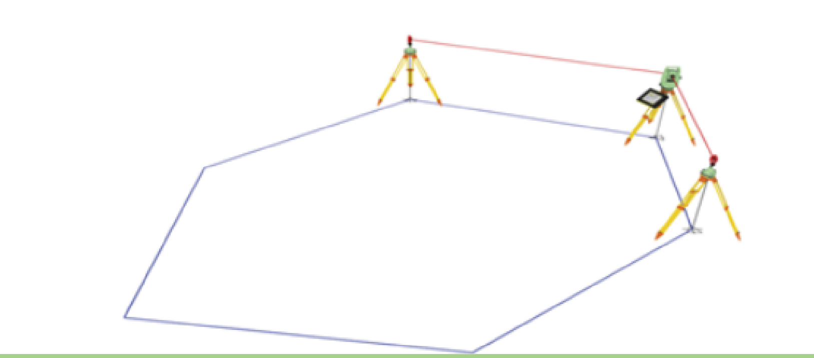


Fig. 10.1. Closed traverse

Try: The following questions are to be answered traversing

1. Create a closed traverse for playground using the Total station.
2. Find the traverse for the pond.

11. Contouring

Contouring using a total station is a surveying technique used to create contour maps that represent the elevation of the land's surface in fig 11.1. This process involves measuring elevations at various points on the terrain and then interpolating between those points to create contour lines.

11.1. Contouring using Total Station

I. Fix the total station over a station and level it.
II. press the power button to switch on the instrument.
III. select MODE B --------> S function-------->file management-----> create (enter a name) ------->accept
IV. then press ESC to go to the starting page
V. then set zero by double clicking on 0 set(F3)
VI. Then go to S function ------> measure-----> rectangular co-ordinate----->station --> press enter.
VII. Here enter the point number or name, instrument height and prism code.

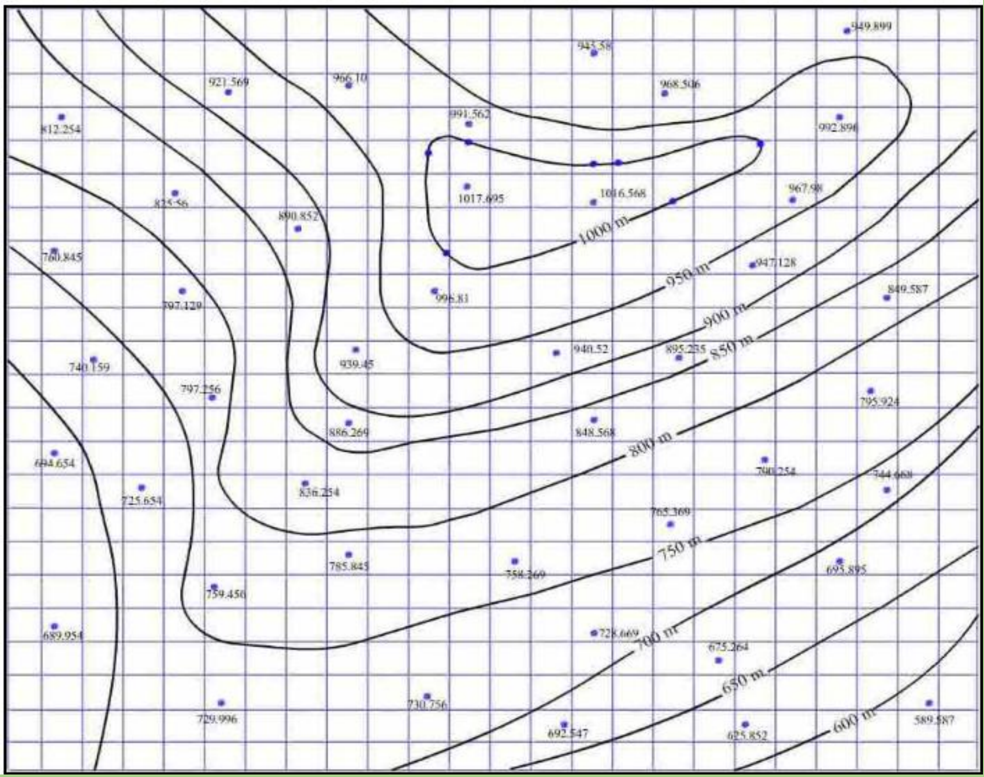


Fig. 11.1 Contouring

VIII. Then press accept (Fs)

IX. Adopt Cross section method for establishing the major grid around the study area.

X. Then press MEAS/SAVE (F3) Repeat the steps

The contour of given land is drawn in the sheet.

Try: The following questions are to be answered about contouring

1. Draw contours 2D surface for water bodies.
2. Draw contours 2D surface for Hills.

12. Determination Of Remote Height Using Total Station

Remote height measurement using a total station is a surveying technique used to determine the elevation or height of a point that is not accessible for direct measurement, such as the top of a tall building, a tree canopy, or a cliff edge in fig. 12.1. This method relies on trigonometry and the total station's ability to measure horizontal and vertical angles accurately.

12.1. Traversing using Total Station

1. SETUP instrument and do all necessary adjustment.
2. Allocate the [REM] soft key from menu.
3. Press the REM to begin the calculation of height.
4. Sight the telescope to base point of target object and press [MEA] and then [REM].
5. Then move the telescope vertically and sight the telescope to the target top point and then lock the telescope. Press STOP to stop measurement. The measured distance data displayed.
6. Press [ESC] to finish and return to [MEA] mode screen.

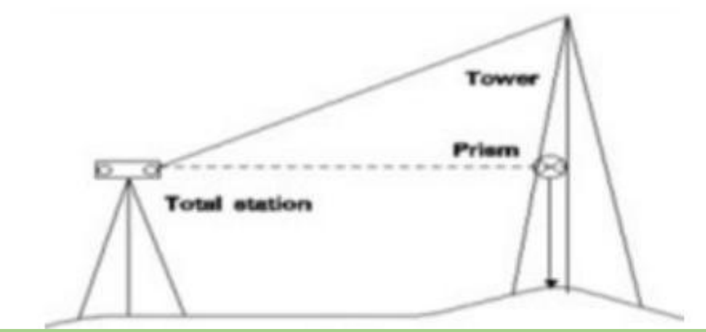


Fig.12.1 Remote Elevation measurement

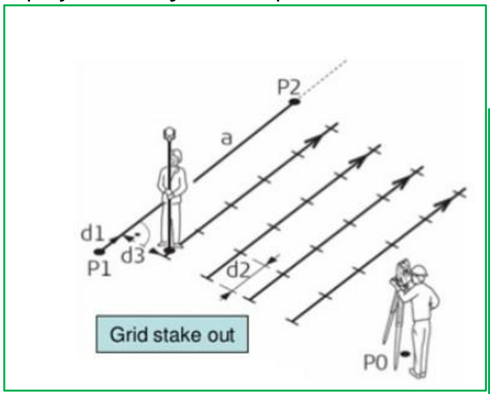
Height of the building =

Try: The following questions are to be answered about REM

1. Determine the remote height of tall buildings using REM in Total station.
2. Determine the remote height of towers using REM in Total station.

13. Stake-Out

Stakeout is a crucial procedure in surveying and construction, where specific points or features on the ground are located and marked for various purposes such as building construction, infrastructure development, or land boundary demarcation in fig.13.1. Stakeout typically involves using coordinate data to guide the placement of stakes, markers, or other physical objects at precise locations on a construction site or survey area.



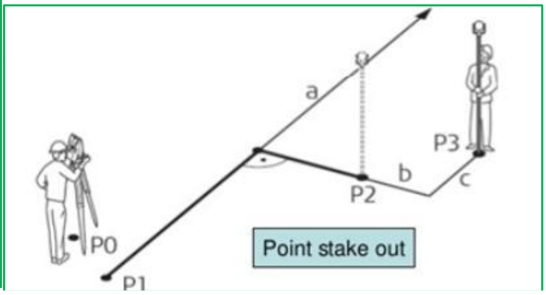


Fig. 13.1 Stake out using Total Station

13.1. Stake out using total station

1. Place the total station in the spot from which you want to stake out points after you have finished entering the coordinates for the area into the total station's internal memory.
2. Make sure that the total station is level and on secure, even ground before continuing.
3. Press the "Power" button to turn on the instrument.
4. Press the "Menu" button and use the navigation arrows to move down to the "Stake Out" menu option in fig.13.2. Press the "SELECT" button to enter the stake out menu.
5. Select the method to stake out the point. Select "XY" to stake out by coordinates which will be the most common method.
6. Press the "Yes" button to continue the process using the coordinates on the screen.
7. If the coordinates are incorrect, press the "No" button to try again.
8. In the next screen, use the keypad to enter the coordinates or distances and press the "OK" button to measure. ix. The results will be displayed on the following screen.

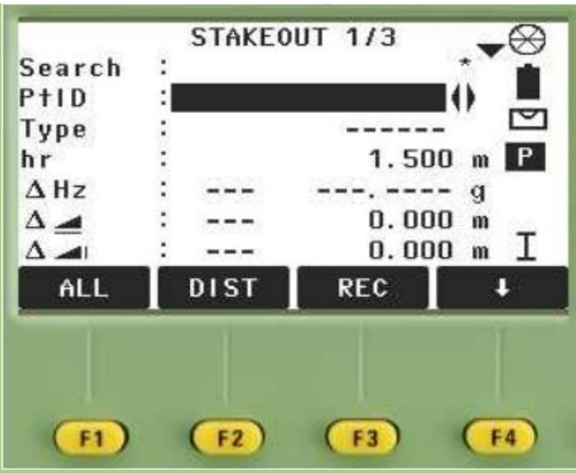


Fig. 13.2 Stake out Function

Try:

I. Develop a program to locate missing point on ground.
II. Develop a program to locate Benchmark on ground.

V. TEXT BOOKS:

1. Anderson, James M. Mikhail, “Surveying: Theory and Practice”, Tata Mc Graw Hill Education, 2012.
2. S. S. Bhavikatti, “Surveying Theory and Practice”, IK Books, New Delhi, 2010
3. H. S. Moondra, Rajiv Gupta, “Laboratory Manual for Civil Engineering”, CBS Publishers Pvt Ltd., New Delhi, 2nd Edition, 2013

VI. REFERENCE BOOKS:

1. P Venugopala Rao, Vijayalakshmi Akella, Textbook on surveying, PHI Learning, New Delhi, 1 st Edition, 2015.

VII. ELECTRONICS RESOURCES:

1. https://www.iare.ac.in/sites/default/files/lab1/IARE Advanced Surveying laboratory.pdf
2. https://www.dbit.ac.in/ce/syllabus/advanced-surveying-lab.pdf
3. https://edudravida.in/22301-2/
4. https://www.docdroid.net/nrxmNRY/advanced-surveying-lab-manual-docx

VIII. MATERIALS ONLINE:

1. Course Description
2. Laboratory manual