R. C. Patel College of Engineering & Polytechnic, Shirpur

Department of Civil Engineering

Name of Subject: - **ADVANCED SURVEYING (ASU)**

Course Code: - **313321**

Scheme:- **CE-3K**

Semester:- **Third**

Unit No. 03 - Advanced Surveying Equipment's

CO3 - Prepare layout plans using relevant surveying instruments.

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
III	Advanced Surveying Equipment's	CO3	10	02	08	06	16

THEORY SYLLABUS CONTENT

Unit - III Advanced Surveying Equipment's

3.1 Electronic Distance Meter (EDM): Principle of Electronic Distance Meter (EDM), component parts and their Functions, use of EDM.

3.2 Electronic Digital Theodolite: Construction and Features of Electronic Digital Theodolite, procedure of angle measurement.

3.3 Total Station: Introduction, component parts with their functions, and Applications of Total Station, Temporary adjustments, sources of errors in Total Station, Measurements of Horizontal angles, vertical angles, distances and coordinates using Total Station. Traversing, Profile Survey and Contouring with Total Station.

3.4 Building Site layout using Total Station: Procedure.

Subject Incharge

Mr. D. B. Wagh

Unit No. 03
Advanced Surveying Equipments

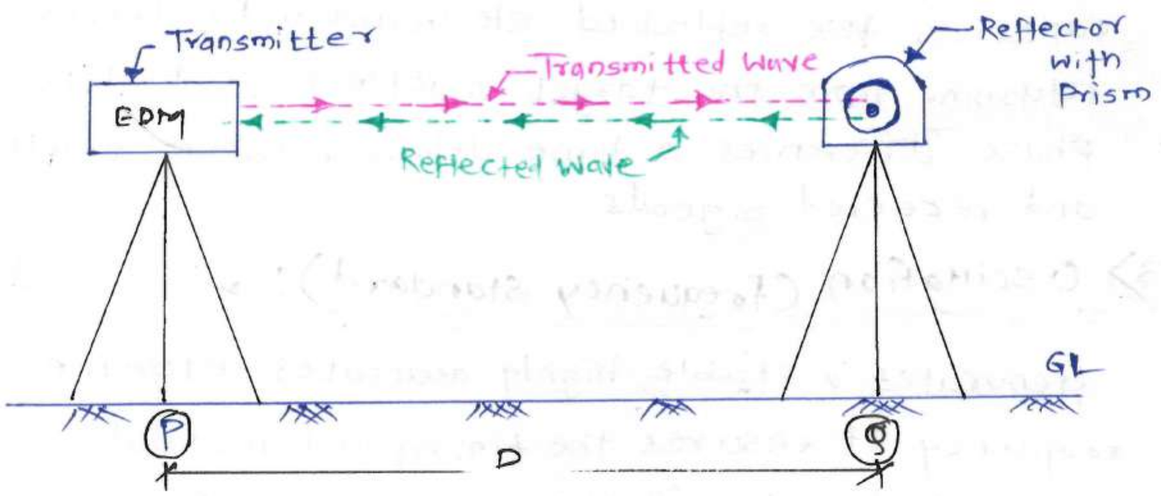
1) Electronic Distance Meter (EDM)

EDM is modern surveying method that determines the length between two points by sending electro-magnetic waves - such as light, infrared, or microwave signals - from an instruments to a target and measuring the time it takes for a signal to return or the phase shift to the wave.

⇒ This method highly precise measurments, often in milimeters, and can cover distances up to 100 kilometers under Ideal conditions.

⇒ EDM has largely replaced traditional tools like chains and tapes due to speed, accuracy, and efficiency.

⇒ Principle of Electronic Distance Meter



⇒ Let the distance between P and Q be 'D' which is to be measured.

⇒ A wave transmitted from the transmitter at at station 'P' with certain phase angle. There is a reflector at the other end 'Q'. Reflector consist of prism. the wave strikes on reflector at Q and then gets reflected from Q.

⇒ It is received back at the transmitter end at 'P' with different phase angle. for finding the distance, the phase difference between transmitted and reflected waves is measured and converted into distance.

Component parts of EDM and Function

1) Transmitter (Emitter) :-

Generates and emits electromagnetic waves (infrared, laser, or microwave) toward the target. It modulates the carrier wave at precise frequencies used for distance calculation.

2) Receiver :-

Captures the reflected electromagnetic waves returning from the target or reflector. It detects phase differences or time delays between emitted and received signals

3) Oscillation (frequency standard) :→

Generates a stable, highly accurates reference frequency. It ensures the timing and modulation are consistent, directly affecting measurement accuracy.

4) Modulator :-

Modulates the carrier wave at known frequencies (e.g: 10 MHz, 1 MHz). The modulation pattern is what allows the instruments to measure phase shift and compute distance.

5) Reflector / Retroreflector (Prism) :-

A corner-cube prism placed at the target point. It reflects the incoming signal back precisely toward the source, regardless of angle of incidence.

6) Phase Comparator (measuring unit) :-

Compares the phase of the emitted wave that of the received wave. The phase difference corresponds to the fractional part of the distance traveled by wave.

7) Microprocessor / computing unit :-

Processes the phase difference data, applies corrections (Atmospheric, instrumental) and computes the final slope distance. It controls the overall operation of the EDM.

8) Display Unit :-

Shows the measured distance (slope or horizontal) along with data like signal strength, battery level, & error codes.

9) Power Supply (Battery) :-

Supplies electrical power to all EDM components. Typically a rechargeable NiMH or Li-ion battery.

Uses of EDM

1) It is useful for measuring the distances that are difficult to access.
2) It is useful in topographical survey.
3) Measurement of base line in triangulation survey can be carried out speedily and accurately
4) Measurement of distances in difficult work sites such as construction of gravity dams.
5) It is useful in fixing alignment of road, railways, canals, etc.

* Operations with EDM

It involves :-
1) Set up
2) Aiming
3) measurement
4) Record.

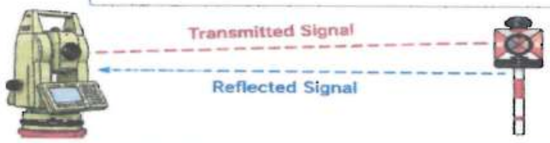
Procedure:-

Let Distance AB is to be measured.

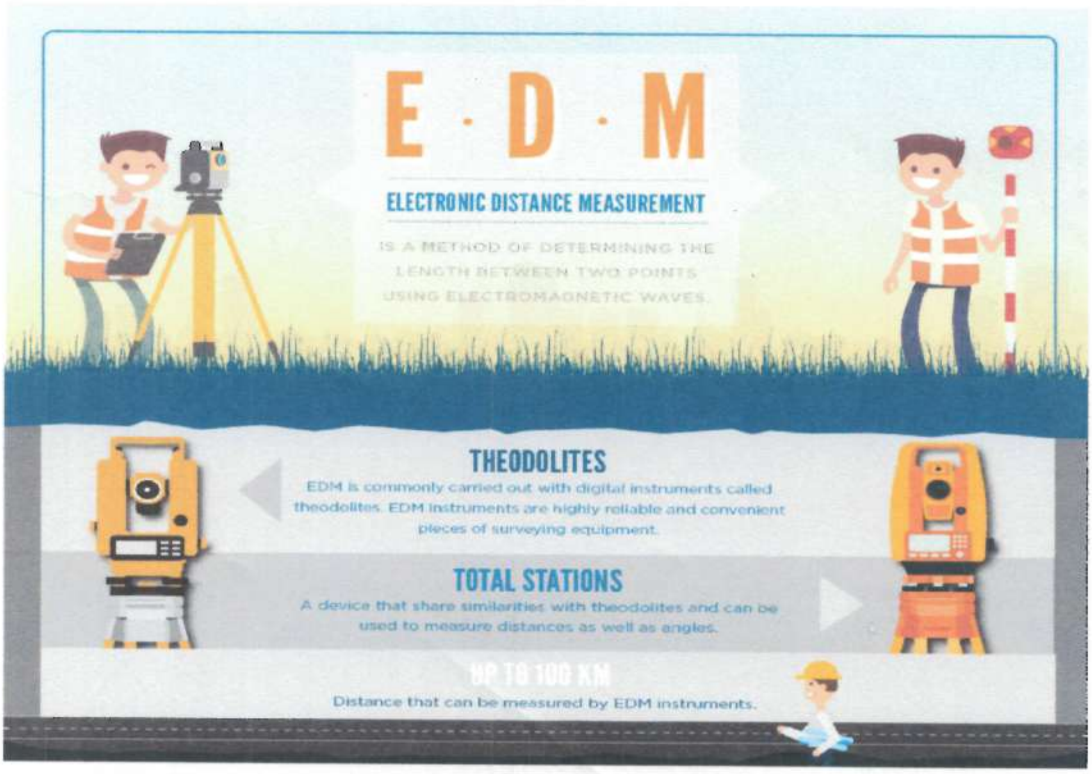
1) set EDM at station A. Touch ON/off switch. Display Panel will give reading 0.0
2) Hold the reflector at B.
3) Telescope of EDM sighted towards B with cross hair at center of reflector.
4) Press range or Enter switch and in few seconds distance will be displayed. Distances displayed will be horizontal distance and sloping distance between A and B, also elevation different between A and B.

WORKING FLOW DIAGRAM OF EDM

POWER SUPPLY (BATTERY) →	Provides electrical power to all the electronic components of EDM.
TRANSMITTER →	Generates electromagnetic waves (Laser / Infrared / Microwave) and sends them towards the target.
MODULATOR →	Modulates the transmitted wave with a known frequency.
REFLECTOR (PRISM) →	Reflects the transmitted wave back to the instrument.



RECEIVER →	Receives the reflected signal and converts it into an electrical signal.
PHASE COMPARATOR / MEASURING UNIT →	Compares the phase difference between the transmitted and received signals and produces a measurement signal.
MICROPROCESSOR (COMPUTING UNIT) →	Processes the measurement signal, performs necessary calculations and corrections, and determines the distance.
DISPLAY UNIT →	Displays the measured distance and other information in numeric form.
CONTROL PANEL / KEYBOARD →	Used to operate the instrument, enter settings, start measurement and store data.



Micro - Optic Theodolites :-

The special features :-

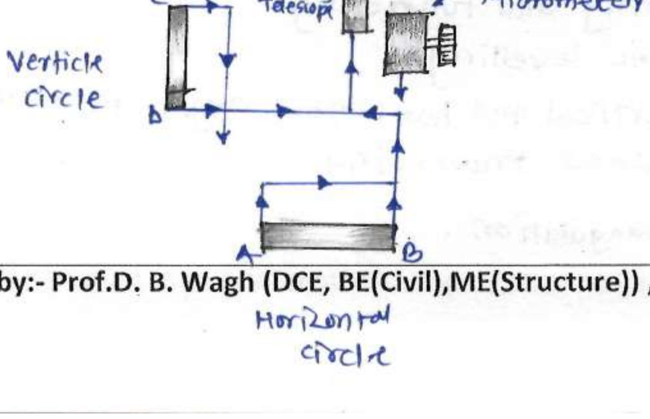
1) Conventional metal circles are replaced by glass circles on which the graduations are etched (made by) photographic metnods.

2) A micro - optic theodolite is basically a refined form of optical theodolite designed to read angles very precisely (often to 1") using a small internal optical reading system instead of big external verniers

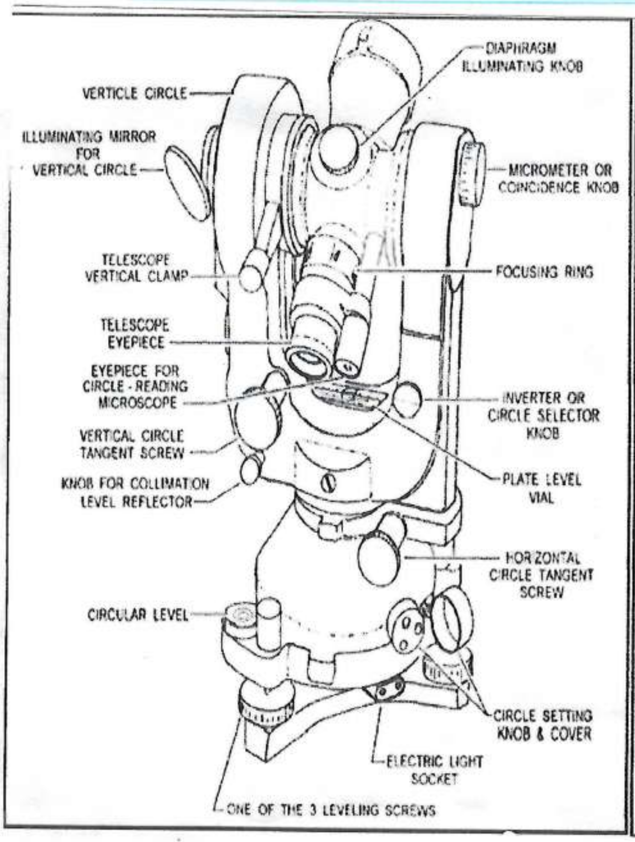
3) It is used for measuring horizontal vertical angles.

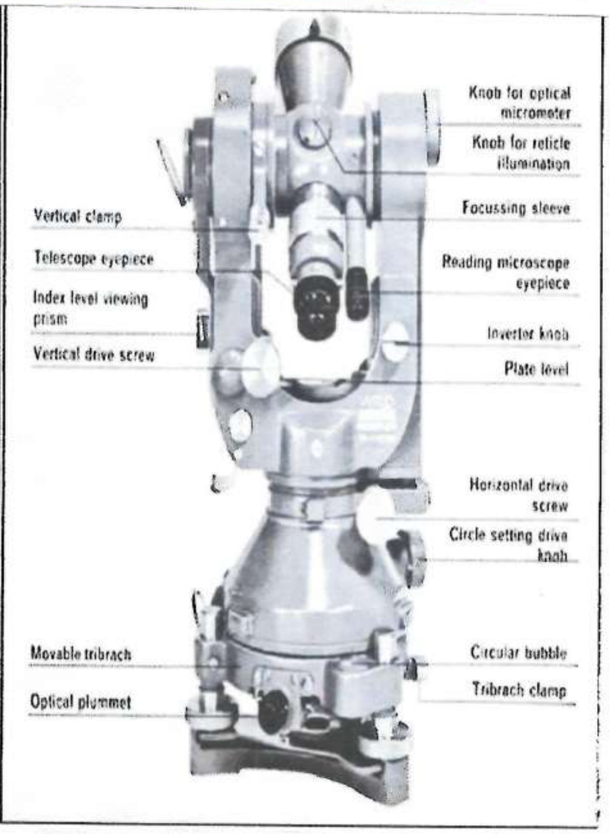
4) Instead of reading divisions directly on the circle, It uses a microseope system (micro-optic) to view highly magnified scale and Vernier.

* Construction Details of 1" Micro optic theodolite



* Component Parts of Micro-Optic Theodolite





1) Telescope
2) Tube level
3) Foot screws
4) Tribatch and Trivet
5) Optical micrometer
6) magnification with standard eyepiece
7) Horizontal circle
8) Vertical circle
9) Focusing knob

* Use of Micro-optic Theodolite

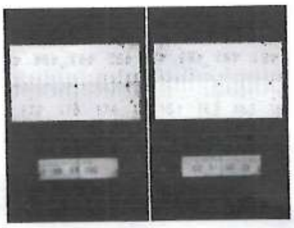
1) It is used in geodetic survey and engineering measurment
2) for setting out in civil engineering
3) used survey of mining and tunneling
4) Used in trigonometric levelling
5) Use to measured vertical and horizontal angle more accurately
6) It is used for campass traversing
7) Used for minor triangulation.

⇛ Electronic Digital Theodolite :-

⇒ Digital theodolites are very fine instruments for angle ~~and distance~~ measurements. using optical encoders.

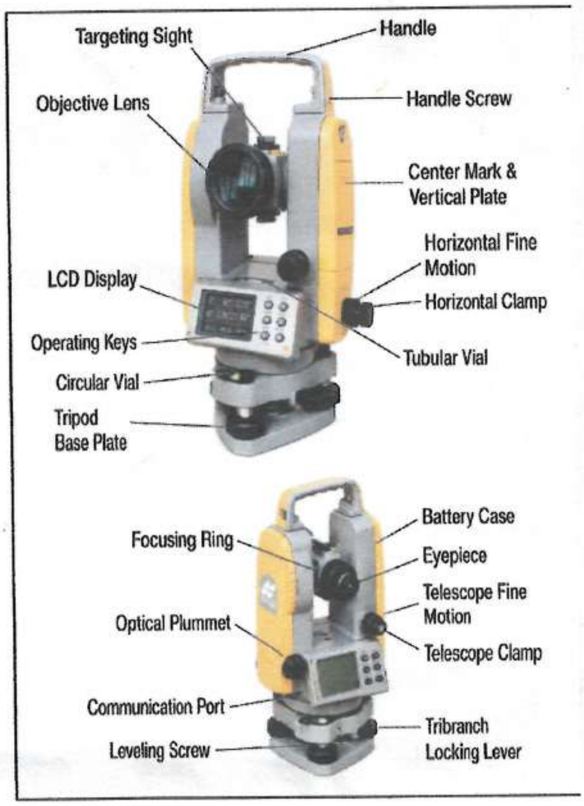
⇒

Digital theodolite removed optical theodolite
Because the procedure of angles reading is more easily



Optical Theodolite

Digital Theodolite



Different parts of theodolite and their functions :-

A telescope is a focusing instrument that has an objective piece at one end and an eyepiece at the other end. It rotates about a horizontal axis in the vertical plane. The graduations are up to an accuracy of 20'.

1) Target or sight :-

The telescope has a sight on the top of it that is used to align the target.

2) Eyepiece :-

The telescope contains an eyepiece that the user looks through to find the target being sighted.

3) Objective lens :-

The objective lens is used to sight the object, and with the help of mirrors inside the telescope. it allows the object to be magnified.

4) Crosshair focusing screw and telescopic focusing screw:-

Both screw are used to remove 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 removed, accurate sighting is impossible.

5) Horizontal clamp or horizontal screw :-

A Horizontal clamp is used to stop the horizontal motion of the theodolite. For more precise reading, a horizontal screw is used, which moves slowely and gradually to set the instrument at an accurate horizontal angle.

6) Vertical clamp and vertical screw :-

A vertical clamp is used to stop the vertical motion of the telescope.

7) Tribatch :-

It consist of base plate, leveling head, and levelling screw. It is used for levelling the theodolite.

8) Optical plummet :-

Optical plummet is used for centering the theodolite at a station.

9) Display screen :-

The display screen shows readings (horizontal angle and vertical angle), which are taken by theodolite.

10) Tripod :-

Tripod is nothing but a stand on which theodolite is mounted.

11) plumb bob :-

A plumbob is a tool having a cone-shaped weight attached to a long thread which is used for centering of theodolite.

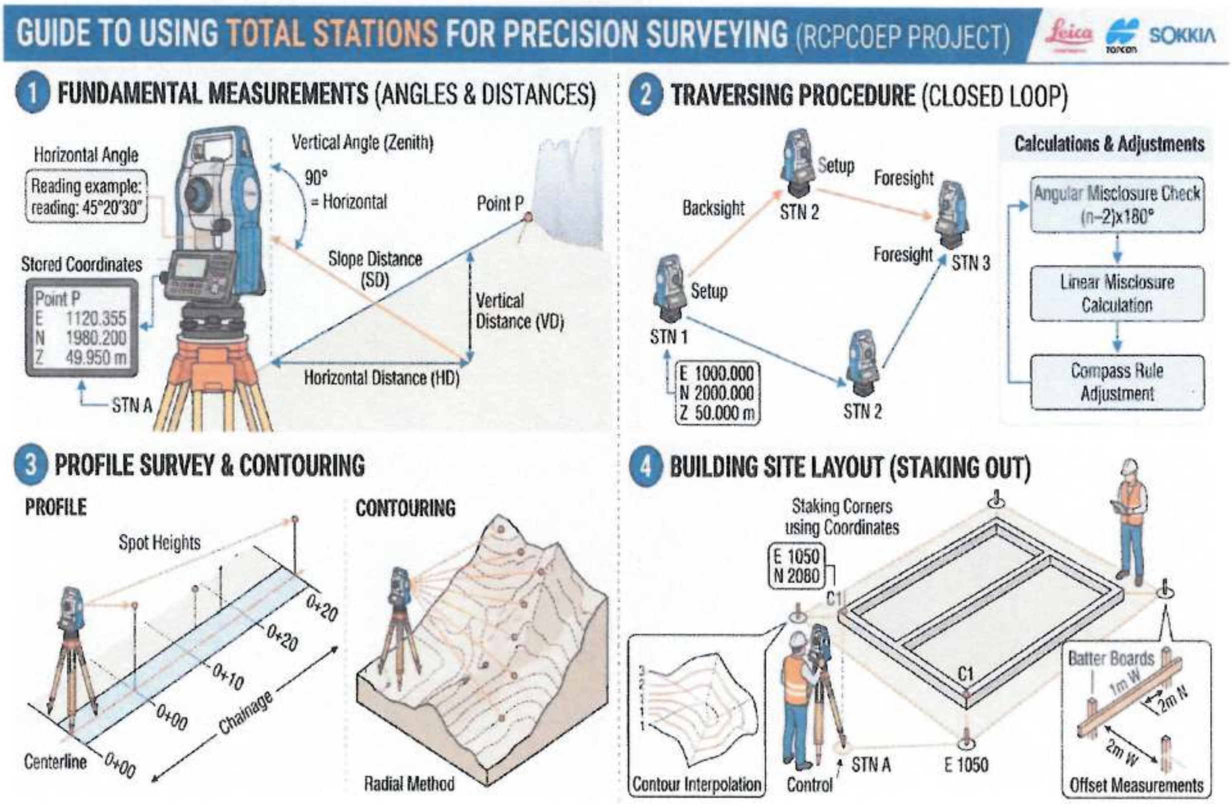
* Features of Electronic theodolite :- (Digital)

Following are the features of digital theodolite

1) Dual side display and keyboard with push button keys
ii) Built in illumination for night operation.
iii) Rechargeable Nicd battery with auto power cut off.
iv) Compatibility with EDMs
v) Communication port with RS-232 c compatibility
vi) keys are commonly used :-
   (a) ON-OFF key for starting measurment or ending of the measurment
   (b) RCL for recalling data from memory as well as changing sign (+ or -)

Total station :-

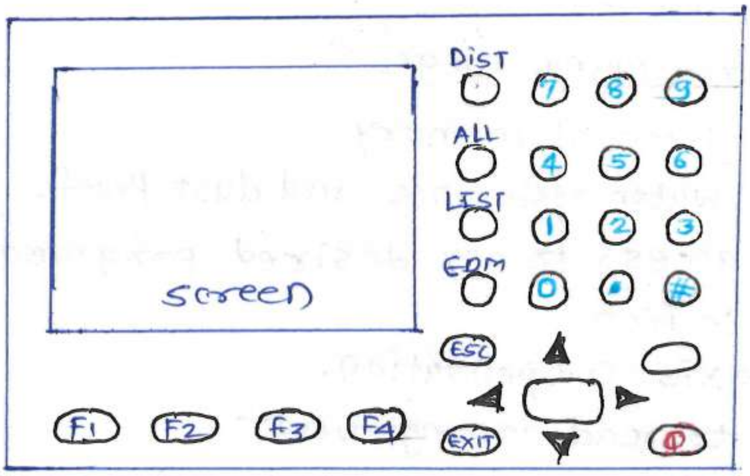
Total station :-



* Salient Features of Total Station :→

1) High accuracy
2) Long measuring range
3) Large Internal memory
4) It is water resistance and dust Proof.
5) Easy access to any desired programme and mode of selection.
6) Try axis compensation.
7) Easy to read arrangement
8) Automatic atomospheric correction.
9) Guide message ~~resolution~~. arrangement.
10) Higher distance resolution.
11) Two speed tangent movement.
12) Detachable tribach facility
13) Eighteen different programmes (modes of measurements)
14) High accurracy and long measuring range
   (a) High accuracy : ±(2mm + 2ppm)
   (b) Long measuring range with mini prism is 0.9km
   Long measuring range with single prism is 2km
   Long measuring range with 3 prism is 2.7km.
15) Versatile application programs :.
   (a) on board data collection, stakeout/survey road calculation and many more functions.
   (b) Integrated alphanumeric key realizes the quicker operation
   (c) Large internal memory up to 24000 points.
16) Enhanced absolute encoder.
   Adopted absolute encoder, which not not required zero set and it can also realize stable measurement with less reading error.
17) No worry about sudden bad weather.

* soft keys and their function



keys :-

ALL ⇒ starts angle and distance measurement and saves measured values.

DIST ⇒ starts angle and distance measurement without saving measured valued.

REC ⇒ saved displayed

ENH ⇒ Opens the coordinate input mode

LIST ⇒ Displays the list of available points.

search ⇒ starts the search for input points.

EDM ⇒ Display EDM setting

ESC ⇒ Return to the previous mode or display

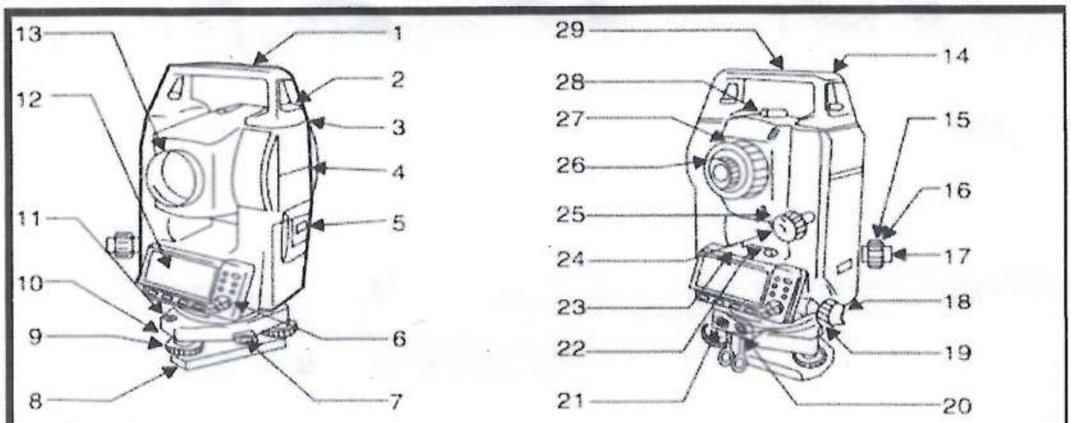
con ⇒ continues to next mode or display.

[ ] ⇒ Return to highest soft key Level

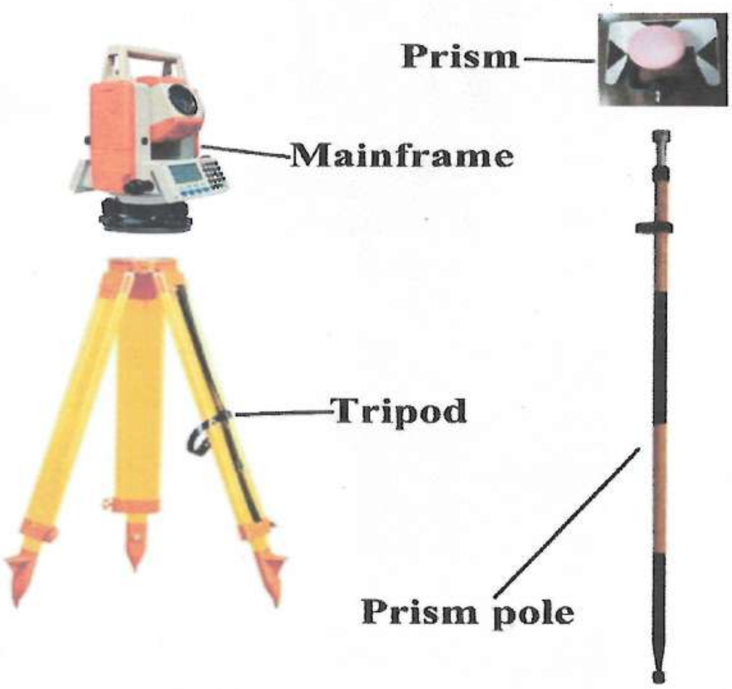
[↓] ⇒ —"—

ENT ⇒ sets displayed massage or dialog and quits dialog.

* Component parts with their Functions :-



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



* Application of Total Station :-

1) To measure horizontal, vertical and sloping distance.
2) To measure horizontal and vertical angles.
3) To measure the level difference between points.
4) To carry out contouring.
5) To prepare the map and drawings using software
6) To prepare layout of building
7) To measure area and volume.

* 8) All the field data is stored in electronic notebook and this stored information is downloaded on computer which can be used for further processing by using various software like auto cad, auto civil, auto plotter clubbed with auto cad which can be used to plotting countours, section, cross section, thus reducing human efforts.

* 9) 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)

* Temporary adjustment of a total station:-

Temporary adjustments of total station are essential for ensuring accurate measurements.

1) centering : placing the instrument exactly over the survey station point using a plumb bob or optical plummet.

2) Levelling :- Making the instrument's vertical axis truly vertical using the foot screws and the circular/plate bubble

3) Focusing :- Adjusting the telescope for clear vision of the object and crosshairs.

4) Elimination of Parallax :- focusing eyepiece to see the crosshairs clearly and focusing the objectives lens to see target clearly.

* These adjustments are repeated every time the Instrument is moved to maintain accuracy and consistency in fieldwork.

* Sources of Errors in total station :-

1) Calibration Error.
2) Horizontal colimaton Error (Line of sight Error)
3) Tilting Axis Error
4) Compensator Index Error
5) Vertical collimation Error (Index Error)

1) Calibration Error :-

Calibration error occurs when the instrument's internal setting deviate from their correct values due to shock, transportation, temperature variation, or prolonged use.

Causes :-

a) Long storage periods.
b) Rough transportation
c) Mechanical shocks
d) Temperature changes
(e) Continuous use over long periods.

Prevention

(a) calibrate before first use
(b) calibrate after transportation.
(c) calibrate after major temperature changes.
(d) perform regular calibration for precision surveys.

2) Horizontal Collimation Error (Line of sight Error):-

This error occurs when the line of sight is not perpendicular to the tilting axis of the telescope.

Effect:

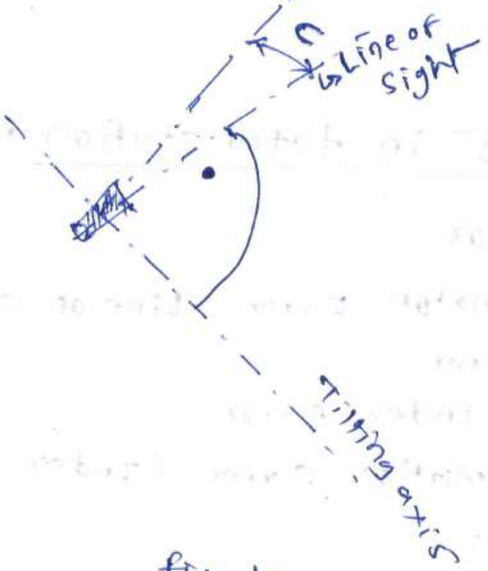
(a) Affects horizontal angle measurements

(b) Errors increases for steep sights.

Elimination:-

(a) Observe in both face left (FL) and face Right (FR)

(b) Use the Instrument's electronic calibration function.



where,

c = deviation between actual line of sight and line perpendicular to the tilting axis

fig. line of sight error.

3) Tilting Axis Error:-

Occurs when the tilting axis is not perpendicular to the vertical axis of the instrument.

Effect:-

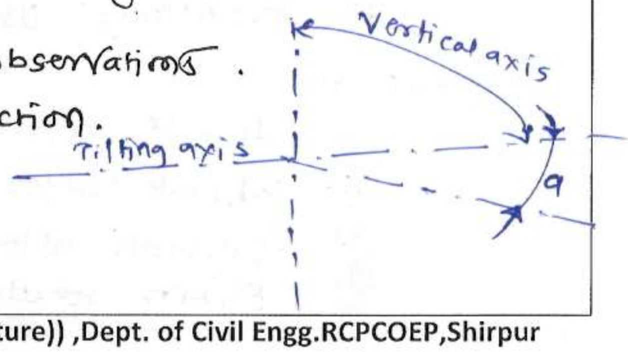
(a) causes errors when observing steep targets.

(b) Affects horizontal angle readings.

Elimination:-

(a) Face Left and Face Right observations.

(b) Electronic calibration correction.



4) Compensator Index Error :-

Even after careful levelling, small residual tilts remain the compensator measures and corrects these tilts. If the compensator zero point is correct, compensator index error occurs → (a) Longitudinal Error (L)
(b) Transverse Error (T)

Effect :- Produced errors in horizontal and vertical angle measurement.

Elimination :- (a) Determine through calibration
(b) Apply automatic correction using the total station software.

5) Vertical Collimation Error (Index Error)

occurs when the 0° - 180° line of the vertical circle does not coincide with the vertical axis of the instrument.

Effect :-

(a) Affects all vertical angle measurements.

Elimination :-

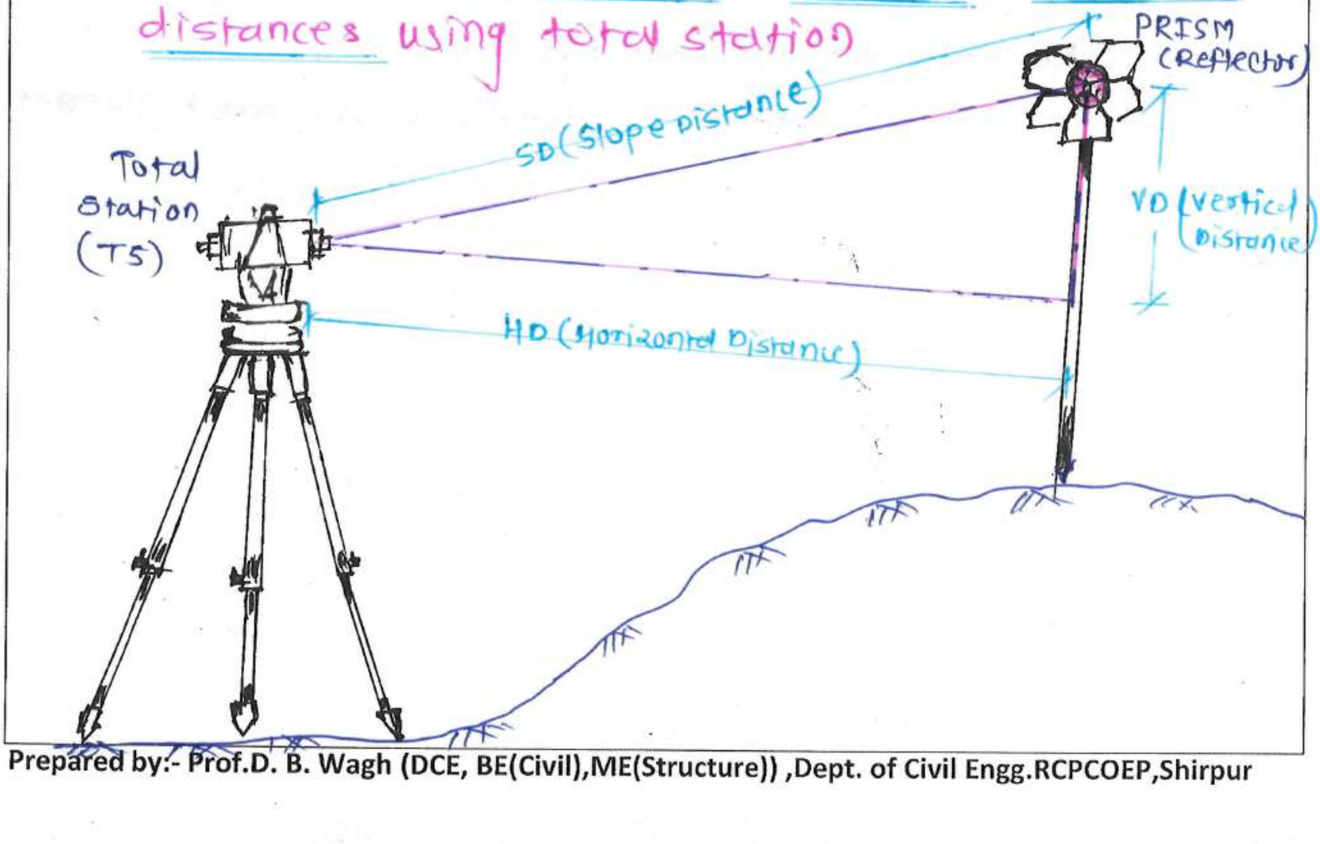
(a) Take Face left and Face Right readings.

(b) Use calibration function to determine and correct the error.

* Measurement of Horizontal, and vertical angle

1) Setup and level the total station at point.
2) Point the total station to the point that marks the left hand side of the angle. Lock the motion and set zero on the instrument.
3) Free the motion and aim the total station to the point that marks the right hand side of the angle
4) Rotate the total station back to the first point. If there was no error in your measurement, the horizontal angle reading should be zero (or 360°). Document the error in measurements.
5) Turn the total station back to the left pointing again to the first point and write the measured angle in your field notes.
6) Repeat the procedure for vertical angle between the selected points of observation and calculate the average angle to get the accurate angle. and record field book page.

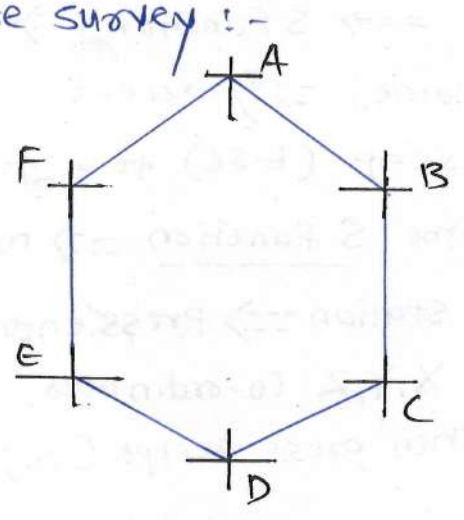
* Measurement of Horizontal, vertical and slope distances using total station



1) carry out temporary adjustments of total station precisely.
2) Establish a temporary benchmark on the field.
3) While holding the tripod, loosen the tripod leg clamps and extend the tripod up to height near your neck and chin. Tighten the leg clamps. Spread out the tripod legs evenly. about two to three feet for each leg, and center it over your benchmark stake. the top of your tripod should be mostly level and parallel with a horizontal plane.
4) Attach the Tribach to tripod and level the instrument accurately with the help of level tube and bubble. Using optical plumate make the centering of the instrument accurately on the ground over the station point.
5) press the power button to switch on the instrument.
6) select the mode - function - create file - accept.
7) set zero using appropriate function.
8) Setup a reflector vertically beneath the point, the hight of which is to be determined.
9) Target the reflector, the height different H between the ground ground point and the high point is now calculate and displayed at the touch of a button.

* Traversing with total station :-

closed traverse survey :-



procedure :-

1) Traverse station are established at the proposed site (say) (Peg 1, Peg 2, Peg 3 & Peg 4 etc.)

2) Total station is plumbed over peg 1 and accurately levelled. Prism are plumbed over peg 2 & 4.

3) Take bearing of first line bisecting prism at peg 2.

4) Sight the prism at peg. 4. measure the distance between peg 4 and peg 1. set the Instrument to zero. rotate the Instrument and bisect prism at peg 2. Vertical and horizontal angles are displayed in relation to peg 4. The reading is taken and entered in the field book. Distance between peg 1 and 2 also measured with same technique.

5) Record face left horizontal angle reading.

6) Transit the Instrument to change the face right setting.

7) Record face right horizontal angle by same procedure.

8) The total station is moved to peg 2. prisms are plumed over peg 1 and 3. Horizontal distances and angles are measured and recorded similarly.

* Preparing contour map by using total station

1) Preliminary set up :-

Fix the total station over a station and level it. Press on button to on, levelled it and bisect the prism at target.

Select mode B ==> S function ==> File management ==> create (enter name) ==> accept.

the press escap (ESC) to go to the starting page

2) then go to the S function ==> measure ==> rectangular coordinate ==> station ==> Press enter. Here enter the Point number, X, Y, Z Co-ordinates. Instrument height and Prism code. Then press accept (F5)

3) Adopt cross section method for establishing the major grid around the study area. project suitably spaced cross sections on either side of the centre line of the area. Choose several points at reasonable distances on either side.

4) orient the instrument to the magnetic north or any other reference direction. Then set zero by double clicking on 'O' set (F3)

5) keep the reflecting prism on the first point and turn the total station to the prism, focus it and bisect it exactly using horizontal and vertical clamps. then select MEAS and the display panel will show the point specification. Now select edit and re-enter the point number or name point code and enter the prism height that we have set.

6) Then press MEAS/SAVE (F3) so that the measurement to the first point will automatically be saved and the display panel will show the second point. Then turn the total station to second point and do the same procedure. Repeat the steps to the rest of the stations and get all point details.

7) Transfer the data stored in ~~File~~ file to computer in appropriate format

8) Using appropriate application software, contour map will be prepared.

* Layout of small Building by using total station:-

1) on the plan supplied by an architech, Number the column serially from left to right and top to bottom starting from top left corner

2) Work out coordinators of column centre with respect to one plot corner or well defined point, assuming line parallel to any one face of building as meridian.

3) create an axcel document with 4 independent columns one for column number and rest three for N, E & H cordinates. Upload this file to total station by using transfer software provided with Instrument

4) Set the total station at site at a point with respect which the coordinates of column centre are work out. Initiate the total station by providing with the coordinates of station and by

orienting the telescope along the reference meridian.

5) Now, activate the setting out programme of the total station. open the uploaded file and bring in the coordinates of any column to be set out.

6) Hold prism pole at tentative position of that column on ground, bisect it and get measured its coordinates.

7) In next reading machine will display the discrepancies in the coordinates of the point and point to be set out.

8) Direct the reflector main accordingly to occupy the new position bisect him again and get measured it's coordinates to know the discrepanancy.

9) Repeat the process till you get no discrepancy in the coordinates of point occupied & point to be set out. In this way get ~~no discrepancy~~ marked centres of rest of the columns.

10) Check the accuracy of the process of setting out by computing the diagonal distance between the extreme column centres to their calculated values.

Important Questions

1> Enlist components parts of digital theodolite (W24)

2> List component parts of EDM (S-25)

3> State any two uses of digital theodolite (W-25)

4> Differentiate between theodolite and tacheometer w.r.t. accuracy, measurement, suitability, no. of stations required (S-25)

5> Explain the procedure of measurement of vertical angle using digital theodolite (S-25)

6> Explain principle of EDM with neat sketch (W-24)

7> List any four function keys of total station with its uses (S-25)

8> Explain the procedure of measurement of horizontal angle total station (W-24)

9> Write any four uses of EDM (S-25)

10> Explain the procedure of measurement of horizontal angle by ~~angle~~ using digital theodolite (W-24)

11> Describe the sources of errors in total station (S-25)

12> Explain the procedure of measurement of vertical angle using digital theodolite (W-25)

13> State any four component parts of micro-optic theodolite (W-25)

14> State the principle of EDM with sketch (S-25)

15> State the four advantages of total station. (W-25)