SURVEYING - II

LAB MANUAL

B. Tech II Year - II Semester

NAME: ____

ROLL NO: _____________________________________

BRANCH: ______________________________________

DEPARTMENT OF
CIVIL ENGINEERING

Aurora's Technological & Research Institute
Parvathapur, Uppal, Hyderabad-98

Evaluation of Laboratory Marks for II Year (Internal Exams)

1. The internal lab examination schedules will be given by the Examination Branch.

2. During a year there will be three lab exams and each exam will be evaluated for 25 marks.

3. Average of three lab exams will be the final internal lab exam marks.

4. First laboratory exam will be conducted on First 1/3 of the total number of experiments, Second Laboratory Exam will be conducted on the Second 1/3 of experiments and the Third Laboratory Exam will be conducted on the last 1/3 of experiments.

The evaluation is as follows

I. Continuous evaluation - 15 marks
II. Internal Laboratory Exam - 10 marks

I. Continuous Evaluation

a) Day to day evaluation - 10 marks
Each experiment / program will be evaluated for 10 marks.
The splitting of marks is as follows

i) Attendance - 2 marks
The student should attend the lab regularly; if he/she is absent he/she will be losing 2 marks.

ii) Experiments / program and observation
The student should complete the program / experiment within the assigned time otherwise he / she will be losing 2 marks.

iii) Experiment result will carry 4 marks.

iv) Record 2 marks
Student must submit the record in the next lab session.

v) Average marks of the Half of the experiments will be considered for day to day evaluation for 10 marks separately for lab examination one and two.

b) Lab knowledge Test (Quiz) 5 marks

- A quiz will be conducted along with the internal lab exam and schedule will be given separately.

- The quiz will be conducted for 20 minutes. The quiz contains 20 questions of type multiple choice. Each question carrying 0.25 marks.

II. Internal laboratory examination - 10 marks

a) Exam - 7 marks
The Splitting of marks as follows
i) Experiments / Program write up - 4 marks
ii) Result and Graphs - 3 marks

b) Viva Voce - 3 marks

- The internal lab examination duration - 2 hours

- Every student will be given programs / experiments in the internal lab exam. In case the student wishes to change the programs / experiments 1 mark will be deducted. A time slot of 45 minutes is given for write up of programs / experiments.

- The student is expected to complete the assigned program / experiment within 1 hour and the remaining 15 minutes will be utilized for viva voce examination.

5. There shall be no supplementary exams in case the student fails to attend internal lab and quiz exam as per schedule.

Evaluation of Laboratory Marks (End exams)

1. The external lab examination schedules will be given by the Examination Branch.

2. Duration of External lab examinations - 3 Hours

3. Exam will be evaluated for 50 Marks

The Splitting of marks is as follows

I. Experiment write-up / Program with algorithm - 10 marks
II. Experiment Setup / Program execution - 10 marks
III. Result - 10 marks
IV. Viva –Voce - 20 marks
a) Written Viva - 10 marks
b) Oral Viva - 10 marks

Written Viva–Voce Exam will be consisting of 10 questions of short answer type and fill in the blanks. Each question will carry equal marks and allotted time is 15 minutes.

LAB CODE

1. Students should report to the labs concerned as per the timetable.

2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.

3. After completion of the experiment, certification of the staff in-charge concerned in the observation book is necessary.

4. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.

5. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.

6. Not more than three students in a group are permitted to perform the experiment on a set up.

7. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.

8. The components required pertaining to the experiment should be collected from Lab- in-charge after duly filling in the requisition form.

9. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.

10. Any damage of the equipment or burnout of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.

11. Students should be present in the labs for the total scheduled duration.

12. Students are expected to prepare thoroughly to perform the experiment before coming to Laboratory.

13. Procedure sheets/data sheets provided to the students' groups should be maintained neatly and are to be returned after the experiment.

14. DRESS CODE:
    Boys - Formal white shirt neatly tucked in, and white trousers, white / black / brown / tan shoes and belt, I-cards worn round neck
    Girls - Formal white Salwar Kameez, white / black / brown / tan shoes, I-cards worn round neck

PRINCIPLES OF SURVEYING

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The fundamental principles upon which the surveying is being carried out are

- Working from whole to part.
- After deciding the position of any point, its reference must be kept from at least two permanent objects or stations whose position have already been well defined.

The purpose of working from whole to part is

- To localize the errors and
- To control the accumulation of errors.

This is being achieved by establishing a hierarchy of networks of control points (Stations having known position). The less precise networks are established within the higher precise network and thus restrict the errors. To minimise the error limit, highest precise network (primary network) Fig.1 of control points are established using the most accurate / precise instruments for collection of data and rigorous methods of analysis are employed to find network parameters. This also involves most skilled manpower and costly resources which are rare and cost intensive.

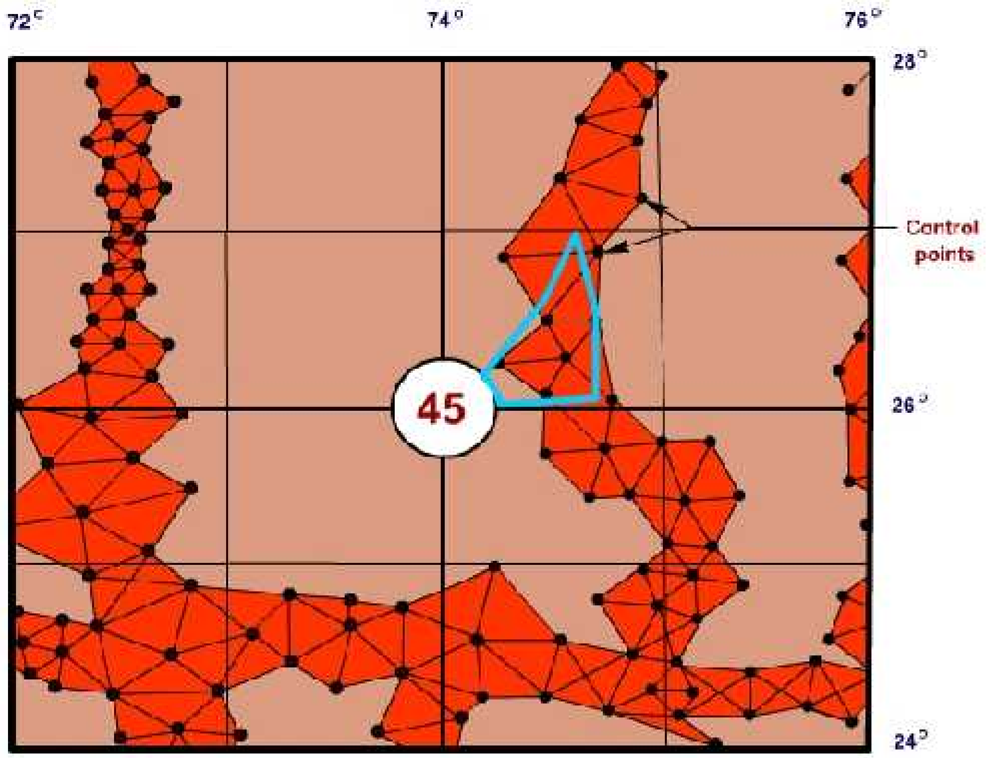


Fig.1 Network of Control Points

THEODOLITE SURVEYING

THEODOLITE SURVEYING

INTRODUCTION

The Theodolite is one of the most precise surveying instruments and is suitable for measurement of horizontal as well as vertical angles. It has a powerful telescope and so it can be used also for distance sighting. Theodolites are of two types. They are

i) Transit type
ii) Non-Transit type

A transit Theodolite is one in which the line of sight can be reversed by reversing the telescope through 180^0 in the vertical plane. The non-transit Theodolites are either plain Theodolites or Y-Theodolites in which the telescope can not be transited. Now day's only transit Theodolites are being used.

PARTS OF TRANSIT THEODOLITE

TRIVET
It is a plate having a central circular threaded hole for fixing hole for fixing the Theodolite on tripod stand by a wing nut. It is also called the base plate or lower tribrach.

FOOT SCREW
These are meant for leveling the instrument. There are three foot screws arranged in between trivet and tribrach.

TRI BRACH
It is a triangular plate carrying the three-foot screws at its ends.

LEVELLING HEAD
Trivet, foot screws and tribrach together form leveling head. Levelling the instruments, fixing the tripod, supporting the main instrument assembly are its uses.

SPINDELS (OR) AXES
Two spindles one inner and other outer. Inner one is solid and rigid and outer one is hollow. To outer spindle lower plate is attached. To inner spindle upper plate is attached.

LOWER PLATE
Graduated from 0^0 to 360^0 in clockwise direction provided with a lower clamping and tangent screw.

UPPER PLATE
Contains vernier 'A' and 'B' provided with upper clamping and upper tangent screw.

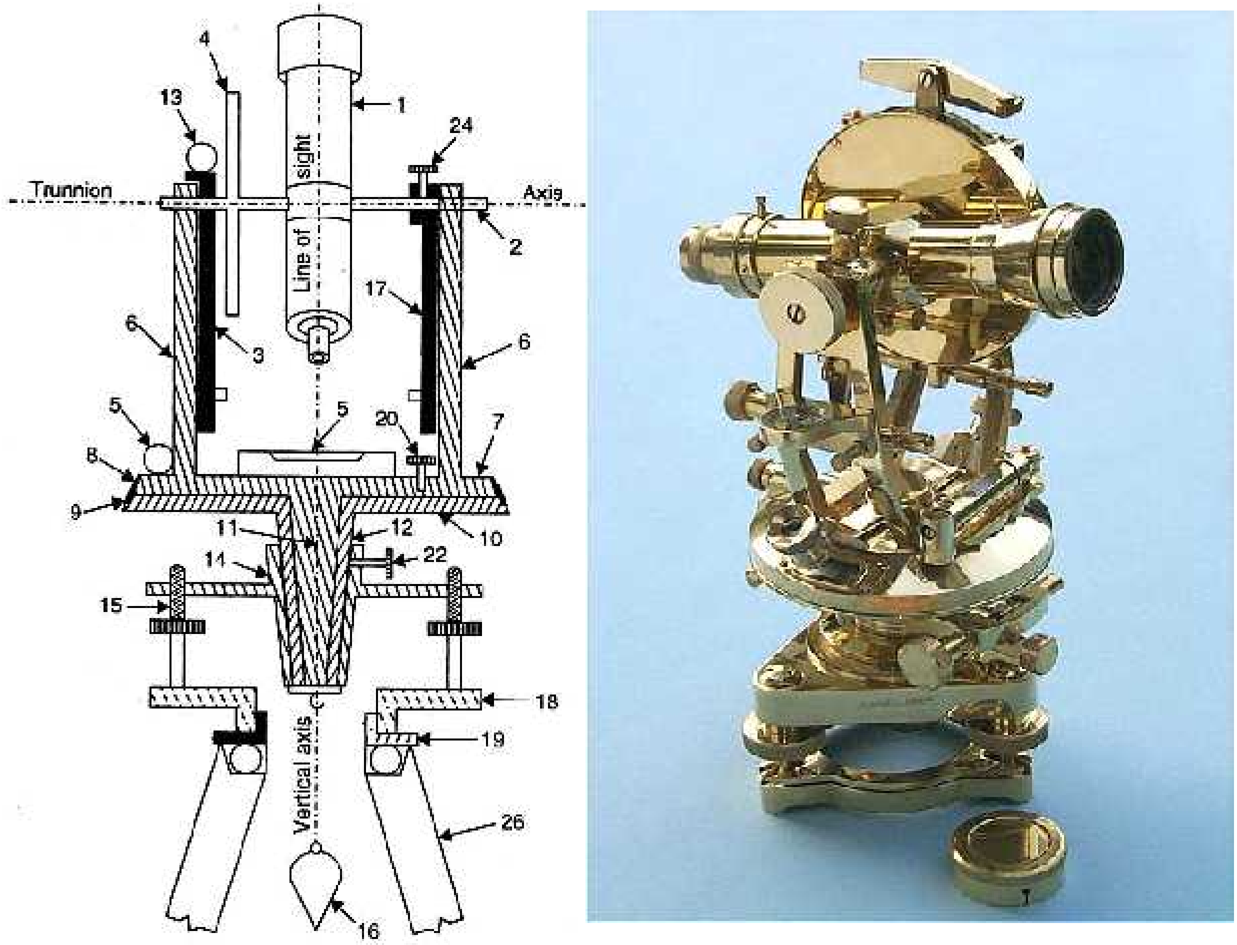


Fig.2 Theodolite and its Parts

1. TELESCOPE
2. TRUNNION AXIS
3. VERNIER FRAME
4. VERTICAL CIRCLE
5. PLATE LEVELS
6. STANDARDS (A-FRAME)
7. UPPER PLATE
8. HORIZONTAL PLATE VERNIER
9. HORIZONTAL CIRCLE
10. LOWER PLATE
11. INNER AXIS
12. OUTER AXIS
13. ALTITUDE LEVEL
14. LEVELLING HEAD
15. LEVELLING SCREW
16. PLUMB BOB
17. ARM OF VERTICAL CIRCLE CLAMP
18. FOOT PLATE
19. TRIPOD HEAD
20. UPPER CLAMP
21. LOWER CLAMP
22. VERTICAL CIRCLE CLAMP
23. TRIPOD

PLATE BUBBLE
It is meant for leveling the instrument at the time of measuring horizontal angles.

STANDARD (OR) A – FRAME
Two frames are provided on upper plate to support the telescope assembly.

TELESCOPE
Fitted in between standards. Perpendicular to the horizontal axes provided with a focusing screw, clamping screw and tangent screw.

VERTICAL CIRCLE
Fixed rigidly with the telescope and moves with it. Each quadrant is graduated from 0^0 to 90^0. Zero is marked at the ends of horizontal diameter.

INDEX BAR (OR) T-FRAME
Provided on the stand in front of the vertical circle. It carries the vernier 'C' and 'D'. These verniers are used for taking the readings of the vertical circle. The vertical log of Index bar is provided with a clip screw. At the lower end by means of which the altitude bubbles can be brought to the center.

ALTITUDE BUBBLE
Provided on top of index bar. It is to be leveled while taking vertical angle readings.

TRIPOD
The tripod head carries at its upper surface an external screw to which trivet plate of base plate of the leveling head may be screwed.

PLUMB BOB
It is used for centering the Theodolite.

COMPASS
Some Theodolites are provided with a compass, which can be either tubular type (or) trough type.

TERMS USED

CENTERING
Keeping the instrument exactly above the station mark, by means of a plumb bob is known as centering.

TRANSITING
Turning the telescope about the horizontal axis in the vertical plane through 180^0 is called transiting.

FACE LEFT
If the vertical circle of the Theodolite is on the left of observer at the time of taking readings. It is known as face left and also called as telescope normal (or) bubble up.

FACE RIGHT
If the vertical circle of the Theodolite is on the right of observer at the time of taking readings it is knows as face right. It is also called as telescope inverted (or) bubble down.

CHANGING FACE
Operation of bringing the vertical circle from one side of the observer to the other side is known as changing face. It is done by transiting the telescope and turning it through 180^0 in the horizontal plane.

SWINGING THE TELESCOPE
It is the process of turning the telescope in horizontal plane. If the telescope is rotated in clockwise direction. It is known as right swing. If the telescope is rotated in anticlockwise direction. It is known as left swing.

LINE OF COLLIMATION
It is the line joining the intersection of cross hairs and optical center of the objects glass and its continuation.

AXIS OF TELESCOPE
Imaginary line passing through the optical center of the objects glass and the optical center of the eyepiece.

AXIS OF BUBBLE TUBE
It is an imaginary line tangential to the longitudinal curve of the bubble tube at its middle.

HORIZONTAL AXIS
It is the axis about which the Theodolite of the telescope rotates in the horizontal plane.

VERTICAL AXIS
It is the axis about which the Theodolite of the telescope rotates in the vertical plane.

TEMPORARY ADJUSTMENTS
The temporary adjustments are to be done at every set up of the instrument. These mainly involves –
1. Centering
2. Leveling
3. Focusing

1. CENTERING THE THEODOLITE OVER THE STATION
(i) Place the tripod over the station and fix the Theodolite using wing out.
(ii) Approximate centering and leveling is done by tripod stand
(iii) Accurate centering is done with the help of shifting head.

2. LEVELLING
(i) Approximate leveling is made with the help of tripod legs
(ii) Accurate leveling is made with the help of foot screws.

3. FOCUSSING

THE EYE PIECE

A piece of white paper is held in front of the object glass and eye piece is moved in (or) out by turning it clockwise (or) anti clockwise until cross wires appear distinct and sharp.

THE OBJECT GLASS

The telescope is directed towards the objects and focusing screw is turned clockwise (or) anticlockwise until the image appears clean and sharp.

SETTING THE VERNIER

The vernier 'A' is set to zero. Lower clamping screw is fixed and upper clamping is rotated till the Index of vernier shows zero. Upper tangent screw is used for setting the vernier exactly to zero.

PRECAUTIONS

i) Leveling and centering must be done perfectly.

ii) Relation of fundamental lines at Theodolite must be maintained while taking readings.

iii) Ranging rod should not be disturbed for taking preceding angles.

iv) Care should be exercised in taking out the Theodolite from the box and in screwing it to the tripod. A Theodolite fitted on a tripod should never be set up on the floor as it may lead to serious damage. While placing the Theodolite into the box, the leveling head should be shifted to a central position and the foot screws should be evened all around. The clamp should be released during transit so that the different parts can yield without being damaged, in case it strikes some obstruction.

v) Clamps and screws should especially be carefully operated. Unnecessary pressure should not be used in tightening them. If the screws do not turn easily, they should be cleaned with a good solvent such as alcohol or gasoline.

vi) The wing nuts on the tripod must be tight so as to prevent slippage and rotation of the head. The tripod legs should be well spread out to furnish stability to the instrument and to permit placement of the telescope at a convenient height for the observer.

The vertical circle should be cleaned if tarnished in use. However, excessive rubbing should be avoided, otherwise the engraved graduations will get impaired.

vii) The Theodolite should be protected from moisture and dust as far as possible. If it has been exposed to moisture it should be wiped dry before replacing it in the box.

APPLICATIONS

Laying off horizontal angles, locating points on line, prolonging survey lines, establishing grades, determining difference in elevation, setting out curves etc.

EXERCISE 1

(A) MEASUREMENT OF HORIZONTAL ANGLE

Aim:
To determine the horizontal angle by using transit Theodolite

Equipment:
Theodolite, Tripod Stand, Ranging Rods, Plumb Bob and Pegs.

Principle:
The Theodolite is most accurate instrument used for measurement of horizontal and vertical angles. To measure the horizontal angle, the angles obtained are added and is divided with number of angles. Firstly for taking every angle vernier 'A' is made to zero, if it is provided with 'B' also make it to zero, otherwise its vernier reading is noted down. The angles are measured by keeping the telescope in normal and inverted positions. Then the readings are taken by swinging the telescope to the right and left, which is called as right swing and left swing.

The average included angle is obtained as

$$\text{Average included Angle} = \frac{\text{Sum of included angles of both faces}}{\text{No. of times}}$$

Procedure:
To measure horizontal angles say angle PQR (Fig.3), the following procedure is followed.

i) Set-up the instrument at Q and level it.
ii) Loose the upper clamp and turn the upper plate until the index arrow of the vernier 'A' nearly coincides with the horizontal circle. Now tight the upper clamp.
iii) Turn the upper slow motion (tangent) screw so as to make the two zeros exactly coincide, so that 'A' vernier reads zero and 'B' vernier reads 180^0.
iv) Loose the lower clamp and direct the telescope to sight station P. The approximate bisection of the station is done by sighting from over the telescope through a pin and hole arrangement provided over its top. Now tighten the lower clamp.
v) Bisect station 'P' exactly by using the lower slow motion (tangent screw)
vi) Unclamp the upper clamp and swing the telescope and bisect the station R. Now tighten the upper clamp and bisect R accurately using the upper tangent screw.
vii) Read the verniers, the reading of vernier 'A' gives the angle PQR directly while the vernier 'B' obtained by deducting 180^0.
viii) While entering the reading the full reading of vernier 'A', i.e., degree, minutes and seconds and only minutes and seconds of vernier 'B' are entered, the mean of the two readings gives the angle PQR.
ix) Change the face of the instrument repeat the procedure, thus a second value of the angle PQR is obtained. The average of these two values is the requirement i.e. to say required angle.

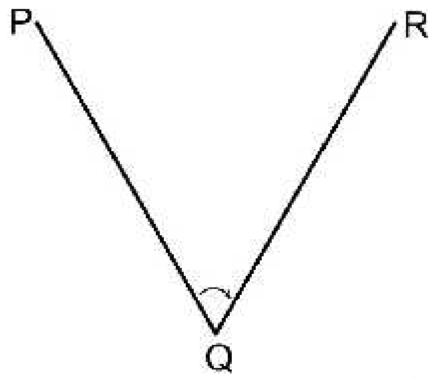


Fig.3 Measurement of Horizontal Angle

Observations and Calculations:

$\angle PQR$ =

Result:

The required average included angle PQR that is horizontal is determined by using transit theodolite as $\angle PQR$ =

Comments/Inference:

Write your comments and observations on the result obtained.

(B) MEASUREMENT OF VERTICAL ANGLE

Aim:

To measure the vertical angle subtended by the line of sight of a given rod with reference to the horizontal axis at a selected station.

Equipment:

Transit Theodolite, Tripod Stand, Plumb Bob, Ranging Rod and Pegs.

Principle:

The vertical angle is the angle made by an inclined line of sight with horizontal line of sight. Vertical angles are measured by using telescope clamping and telescope tangent screws.

Procedure:

1) Let ĎAOB is to be measured (Fig.4):

i) Setup the instrument doing the exact adjustments (centering, leveling and focusing the eyepiece)

ii) The centering is done with reference to altitude bubble.

iii) Keep the instrument in the left position make the vernier 'C' read zero with the help of vertical circle clamp & tangent screws.

iv) Bring the altitude bubble to zero when the telescope is horizontal.

v) Direct the telescope to the object and bisect it accurately by means of the vertical circle clamp and tangent screw.

vi) Read both the vernier 'C' and 'D' and take the average, which gives the value of vertical angle.

vii) Change the face and repeat the procedure.

viii) The required vertical angle is the average of face left and face right.

2) Let ĎAOC is to be measured (Fig.4):

i) The instrument is already setup on the station at 'O'.

ii) Direct the telescope to the top of the rod and bisect it accurately by means of the vertical.

iii) Read the both verniers 'C' and 'D' and take the average which gives the value of vertical angle 'α'.

iv) Then the telescope is bisected to the bottom of the rod. Then read the both verniers 'C' and 'D' readings the average gives the value of vertical angle 'β'.

v) The summation of α & β gives the $\angle$AOC.

vi) The face is changed and same procedure should be repeated then find $\angle$AOC.

vii) The average of this two gives the $\angle$AOC.

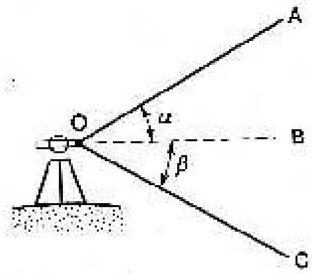


Fig.4 Measurement of Vertical Angle

<u>Observations and Calculations:</u>

α = β =

Horizontal Distance, D =

Vertical Height = D (Tanα+Tanβ)

<u>Result</u>:

The vertical angle to the given ranging rod is measured as $\angle$AOC =

Height of the given object =

<u>Comments/Inference:</u>

Write your comments and observations on the result obtained.

EXERCISE 2

(A) MEASUREMENT OF HORIZONTAL ANGLE
(BY REPETITION METHOD)

Aim:
To determine a horizontal angle by the method of repetition.

Equipment:
Transit Theodolite, Tripod, Plumb Bob, Ranging Rods and Pegs.

Principle:
In the method of repetition, the angle is measured and added to itself several times and divided by the number of times it is added. It is then possible to obtain the value of angle to a greater degree of accuracy than the least count of the vernier. The error due to imperfect graduations is also minimized.

Procedure:
The method of repetition is used to measure a 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 times by allowing the vernier to remain clamped each time at the end of each measurement instead of setting it back at zero when sighting at the previous station. Thus an angle reading is mechanically added several times depending upon the number of repetitions. The average horizontal angle is then obtained by dividing the final reading by number of repetitions. Generally six repetitions are done three with the telescope normal and three with the telescope inverted.

To measure the horizontal angle, say angle PQR (Fig.5) the following procedure is followed.

i) Setup the instrument at 'Q' and level it.
ii) Loosen the upper clamp and turn the upper plate until the index of vernier 'A' nearly coincide with the horizontal circle. Now tight the upper clamp.
iii) Turn the upper tangent screw so as to make the two zeros exactly coincide. So that 'A' vernier reads 0^0 and 'B' vernier reads 180^0.
iv) Sight station 'P', tighten the lower clamp and bisect station 'P' exactly by using the lower tangent screw.
v) Unclamp the upper clamp and swing the telescope, bisect station 'R' by using the upper clamp and upper tangent screw.
vi) Read both the verniers take average to get $\angle PQR$.
vii) Unclamp the lower clamp and swing the telescope and bisect station 'P' accurately by using the lower clamp and lower tangent screw.
viii) Read both the verniers check the vernier reading it should be the same (unchanged) as that obtained in step 6.
ix) Release the upper plate by using upper clamp and bisect station 'R' accurately by using upper tangent screw. The vernier will read twice the $\angle PQR$
x) Repeat the procedure for required number of times say three times and find out the value of $\angle PQR$.

xi) Change face and make three more repetitions as described above. Find the average angle with face right by dividing the final reading by three or what ever the number of repetitions.

xii) The average Horizontal angle is then obtained by taking the average of the two angles obtained with face left and face right.

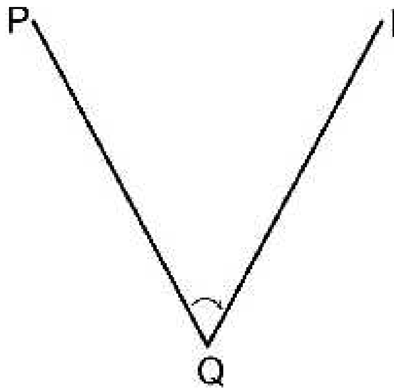


Fig.5 Measurement of Horizontal Angle (Repetition Method)

<u>Observations and Calculations:</u>

Observations are entered in the field book and the angles are calculated.

Inst At	Sight to	Right Face - Right swing												Left Face - Right swing												Average		
		A			B			Mean			Included angle			A			B			Mean			Included angle			Included angle		
		0	,	,,	0	,	,,	0	,	,,	0	,	,,	0	,	,,	0	,	,,	0	,	,,	0	,	,,	0	,	,,

<u>Result</u>:

The angle is measured by the method of repetition and the obtained Horizontal angle is $\angle PQR$ =

<u>Comments/Inference:</u>

Write your comments and observations on the result obtained.

(B) MEASUREMENT OF INCLUDED ANGLES BETWEEN VARIOUS POINTS (REITERATION METHOD)

Aim:
To measure included angles between various points around the instrument station.

Equipment:
Vernier Transit Theodolite, Tripod Stand, Plumb Bob, Ranging Rods and Pegs.

Principle:
Several angles at a station are measured one after the other and finally the origin is closed by sighting the first station. If there is any error in the first and final readings taken on the initial station, the error is distributed equally among all the measured angles.

Procedure:
It is most commonly used in triangulation survey. The method in measuring a horizontal angle is preferred when several angular measurements are to be made at a station all the angles are measured successively and finally the origin is closed. The final reading and vernier 'A' should be same as the initial zero. If not the discrepancy is equally distributed among all the angles.

To measure the angles AOB, BOC, COD, DOA etc. (Fig.6), by method of reiteration the following procedure is adopted.

Step (1): Set up instrument at 'O' and level it.
Step (2): Set the vernier 'A' to read zero using upper clamp and upper tangent screw.
Step (3): Direct the telescope towards point 'B' and bisect it exactly using the lower clamp and lower tangent screw.
Step (4): Loosen the upper clamp and bisect point 'C' accurately using upper tangent screw. Read the both vernier 'A' &' 'B and take mean value.
Step (5): Similarly bisect D etc, and Finally 'B' and read both the verniers in all the cases. The last reading and vernier 'A' should be 360^0. If not the discrepancy is noted and distributed.
Step (6): Repeat the procedure by changing the face.

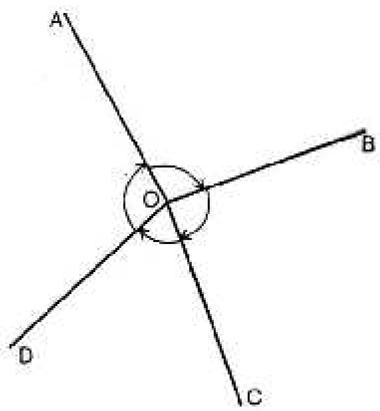


Fig.6 Measurement of Horizontal Angle (Reiteration Method)

Observations and Calculations:
Observations are noted down in the field book and angles are calculated.

Instrument Station	Sight To	Right Face					Right Swing						
		A			B			Mean			Included Angle		
		0	‘	“	0	‘	“	0	‘	“	0	‘	“

Instrument Station	Sight To	Left Face					Right Swing						
		A			B			Mean			Included Angle		
		o	′	″	o	′	″	o	′	″	o	′	″

Total included angle = Error =

Result:
The various angles at station 'O' are measured by reiteration are =

Comments/Inference:
Write your comments and observations on the result obtained.

EXERCISE 3

HEIGHTS AND DISTANCES (TRIGONOMETRIC LEVELLING)

(A) BASE ACCESSIBLE

Aim:
To find the elevation of the top of a spire / tower / building using the principle of trigonometric leveling.

Equipment:
Transit Vernier Theodolite, Tripod stand, Plumb bob, Tape, Leveling Staff and Pegs.

Procedure:
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.7.

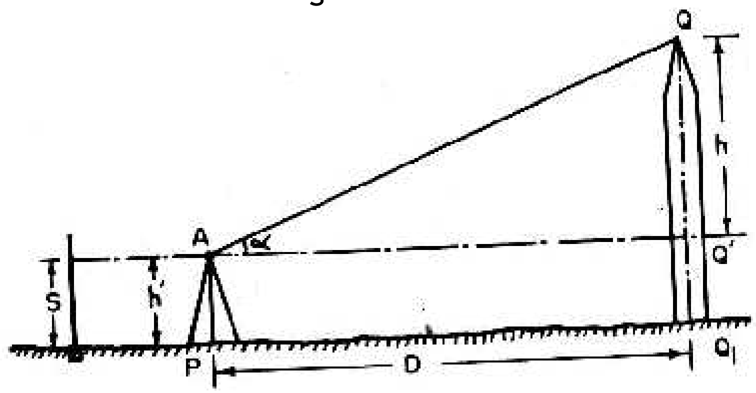


Fig.7 Base Accessible

Let,
P= instrument station
Q= Point to be observed
A= center of the instrument
D= horizontal distance between P and Q
h' = height of the instrument at P
Q'=Projection of Q on horizontal plane
S= Reading on staff kept on B.M, with line of sight on horizontal
α = Angle of elevation from A to Q

1. Setup the Theodolite at P and level if accurately w.r.t. the altitude bubble. See that the vertical circle reads $0^0 0' 0''$ when the line of sight is horizontal.
2. Direct the telescope towards Q and bisect it accurately clamp both the plates. Read the vertical angle 'α'.
3. Plunge the telescope and sight to the same point 'Q' and take the vertical angle 'α' calculate the avg. of the vertical angles measured in both faces.
4. With the vertical vernier set to zero reading and the altitude bubble in the center of its run take the reading on the leveling staff kept at A.B.M. Let it be 'S'.

Observations and Calculations:

Vertical Angle, α = Staff Reading, S (m) = Horizontal Distance, D (m) =

From Triangle AQQ': h = D tanα

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

(Or)

R.L. of Q (m) = R.L of instrument axis + D tanα

(Or)

R.L. of Q (m) = R.L of P + h' + D tanα, if R.L of P is Known

Result:

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

Comments/Inference:

Write your comments and observations on the result obtained.

(B) BASE INACCESSIBLE (SINGLE PLANE METHOD)

Aim:
To find the elevation of the top of a building using the principle of trigonometrical leveling with the instrument stations having their vertical axes in the same plane as the object.

Equipment:
Transit Vernier Theodolite, Tripod Stand, Plumb Bob, Tape, Leveling Staff and Pegs.

Procedure:
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.8.

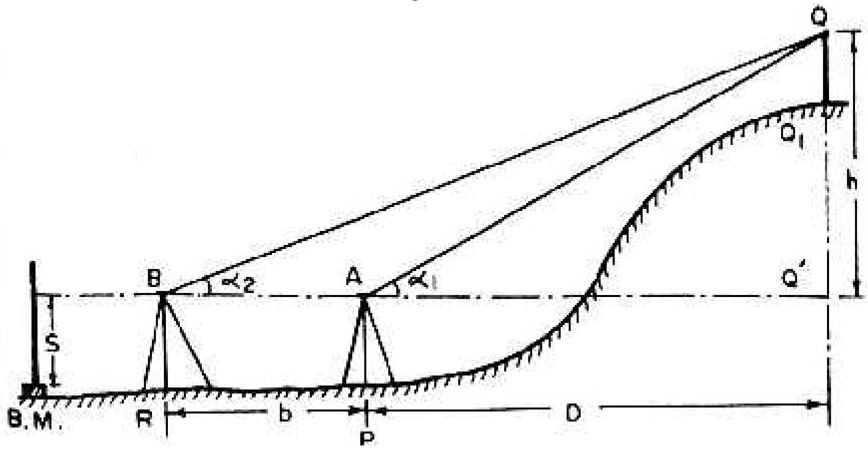


Fig.8 (a) Instrument Axis at Same Levels

h = QQ'
b = Horizontal dist. b/w P & R
D = Horizontal dist. b/w P & Q
α_1 = angle of elevation from A to Q
α_2 = angle of elevation from B to Q

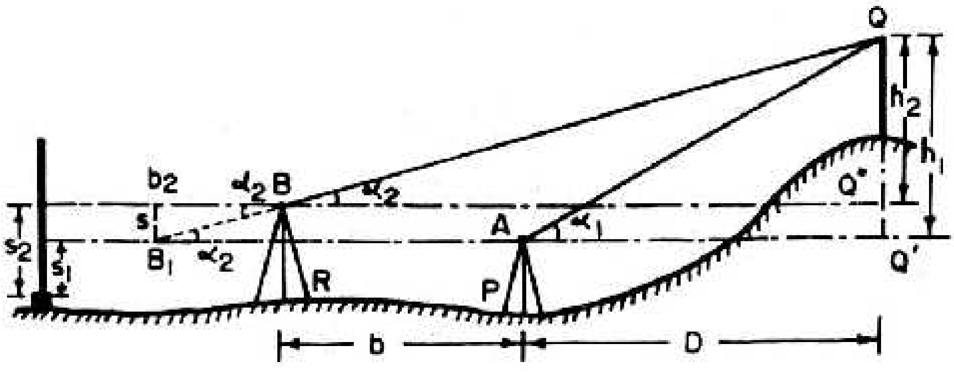


Fig.8 (b) Instrument Axes at Different Levels

1. Setup the Theodolite at P and level it accurately with respect to the altitude bubble. See that the vertical circle reads $0^0 0'0''$ when the line of sight is horizontal.
2. Direct the telescope towards Q and bisect it accurately clamp both the plates. Read the vertical angle α_1.
3. Transit the telescope so that the line of sight is reversed. Mark the instrument station R on the ground along the line of sight. Measure the dist. b/w P&R accurately. Let it be 'b' repeat the steps (2) & (3) for both face observations. The mean values should be adopted in the calculations.
4. With the vertical vernier set to zero reading and the altitude bubble in the center of its run take the reading on the leveling staff kept at A.B.M. Let it be 'S' if both the instrument axis are at same level and 'S_1' if they are at different levels.
5. Shift the instrument to R and set up the Theodolite there. Measure the vertical angle 'α_2' to Q with both face observations.
6. In case of instrument axis at different levels repeat the step (4) and let the reading at R be 'S_2'.

Observations and Calculations:

Vertical Angles, α_1 = Staff Readings S_1 (m) = (or) S (m) =

α_2 = S_2 (m) =

Horizontal dist. b/w P & R = b =

In case of instrument axis at same level:

From triangle AQQ'

$h = D \tan\alpha_1$

From triangle BQQ'

$h = (b + D) \tan\alpha_2$

$$D = \frac{b \tan\alpha_2}{\tan\alpha_1 - \tan\alpha_2}$$

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

In case of instrument axis at different levels:

$h_1 - h_2 = S_2 \sim S_1 = S$

$$D = \frac{S + b \tan\alpha_2}{\tan\alpha_1 - \tan\alpha_2}$$

$h_1 = D \tan\alpha_1$

$h_2 = (b + D) \tan\alpha_2$

R.L. of Q = R.L. of B.M. + S_1 + h_1

R.L. of Q = RL of B.M. + S_2 + h_2

Result:

R.L. of given point Q (m) =

Comments/Inference:

Write your comments and observations on the result obtained.

(C) BASE INACCESSIBLE (DOUBLE PLANE METHOD)

Aim:

To find the R.L. of the top of an object, when the base of the object is inaccessible and the instrument stations are not in the same vertical plane as the elevated object, adopt trigonometrical leveling (double plane method).

Equipment:

Transit Vernier Theodolite, Tripod Stand, Plumb Bob, Tape, Leveling Staff and Pegs

Procedure:

Let P&R be the two instruments stations which are not in the same vertical plane as that of the elevated object 'Q' as shown in Fig.9 P&R are should be selected such that the Δ^{le} PQR is a well conditioned triangle.

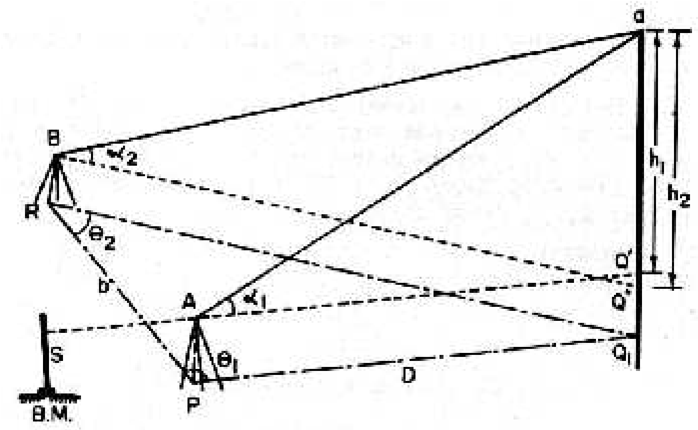


Fig.9 Base Inaccessible (Double Plane Method)

It is required to find out the elevation of the top of an object 'Q'

1. Setup the instruments at P and level it accurately w.r.t. the altitude bubble. Bisect the point Q and measure the angle of elevation 'α_1'.
2. Sight to point R with reading on horizontal circle as zero and measure the horizontal angle RPQ_1 (θ_1) from P.
3. Take a back sight 'S' on the staff kept at A.B.M.
4. Shift the instrument to R and measure 'α_2'and 'θ_2' from R.
5. Measure the distance b/w two instrument stations R & P (equals to 'b')

Let

Q_1= projection of Q on the horizontal line thought A,

Q_2= projection of Q on the horizontal line thought B,

AQ_1= horizontal line though A,

BQ_2= horizontal line though B,

AQQ_1 is the vertical plane simultaneously,

BQQ_2 is the vertical plane simultaneously,

PRQ_3 is a horizontal plane

θ_1= Horizontal angle measured at P,

θ_2= Horizontal angle measured at R,

α_1= Vertical angle measured at A,

α_2= Vertical angle measured at B.
From Δ^{le} AQQ', h_1= D tanα_1
From Δ^{le} PRQ_1, angle $PQ_1R = \theta_3 = 180^0 - (\theta_1 + \theta_2)$
By applying sine rule
$(PQ_1/\sin\theta_2) = (RQ_1/\text{Sing}\theta_1) = (RP/\sin\theta_3)$
$PQ_1 = D = b \sin\theta_2 / \{\sin(\theta_1+\theta_2)\}$
And $RQ_1 = b \sin\theta_1 / \{\sin(\theta_1+\theta_2)\}$

Observations and Calculations:

Vertical Angles, α_1 = Staff Readings S_1 (m) = Horizontal Angles, θ_1 =
α_2 = S_2 (m) =
θ_2 =

h_1 = D tanα_1 or $h_2 = RQ_1\tan\alpha$
R.L. of Q (m) = RL. Of A.B.M. + S_1 + h_1
(Or)
R.L. of Q (m) = R.L. of A.B.M. + S_2 (from B) + h_2 =

Result:
R.L. of given station Q (m) =

Comments/Inference:
Write your comments and observations on the result obtained.

EXERCISE 4

CURVE SETTING – DIFFERENT METHODS

(A) SETTING OUT A SIMPLE CURVE BY MEANS OF OFFSETS FROM LONG CHORD

Aim:
To setout the simple curve of given radius and length of long chord by means of offsets from the long chord.

Equipment:
Theodolite, Tripod Stand, Cross-Staff, Ranging Rods, Pegs, Chain and Tape.

Principle:
Setting out a curve by method of offsets from long chord is linear method. It involves setting out the normal offsets of the long chord at specified intervals and joining them.

The length of offsets at any distance 'x' from the mid points of the long chord is given by

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

Where 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

$$O_o = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2} \text{ (Mid Ordinate)}$$

Usually, the offsets from the mid of long chord towards the end are setout and the curve is symmetric over the central offset line.

Procedure:
1. The obtained length of long chord is first setout on the field by proper ranging and mid point is established (Fig.10)
2. The length of offsets at mid length is to be setout. For this, a person holds the cross-staff at required point and aligns the slit with the end station ranging rods. At this instant another person looks through the normal slit and guides a person with a ranging rod to come into its view thus along this line normal to long chord, the calculated offset is setout.
3. The cross staff is shifted to next point distance 'x' as specified and above step is repeated the offset corresponding to that distance is set out from that point.
4. Pegs are marked at the end of the offsets, the joining of which completes the setting.

Observations and Calculations:

Distance (X m) =

Ordinate (Y m) =

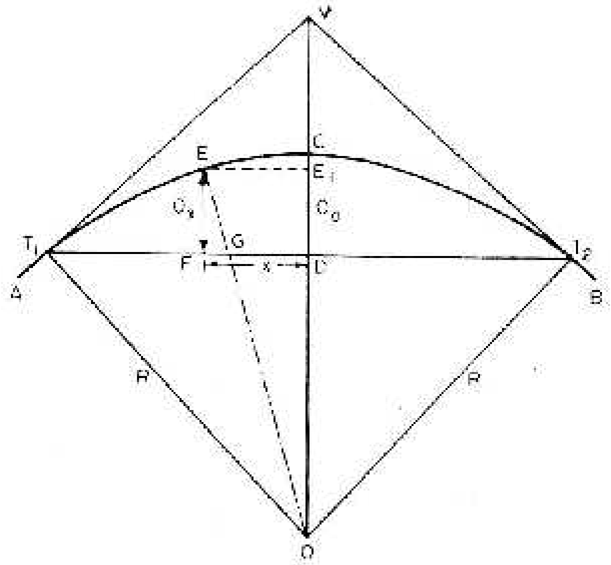


Fig.10 (a) Setting Out By Ordinates from the Long Chord

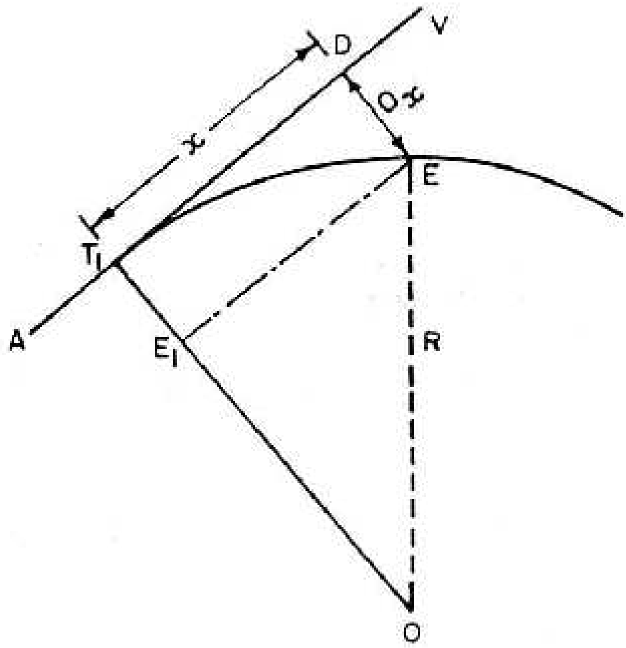


Fig.10 (b) Setting Out By Perpendicular Offsets

Result:

The simple curve is setout by the method of offsets from long chord in the field.

Comments/Inference:

Write your comments and observations on the result obtained.

Applications:

Curves are used on highways and railways where it is necessary to change the direction of motion.

(B) SETTING OUT A SIMPLE CURVE BY RANKINE'S METHOD

Aim:
Two tangents intersect at a given chainage & with the given deflection angle. Calculate all the data necessary for setting out a curve with a given radius by Rankine's method or Deflection Angle Method or One Theodolite Method. The peg interval is 30m.

Equipment:
Transit Theodolite, Tripod Stand, Tape & Chain, Ranging Rods, and Pegs.

Principle:
A substance of this method of setting out a simple curve is the location of various points on the curve from their total deflection angles.

Total deflection of a point is the angle made by a chord joining that point to the point of curvature with the rare tangent. It is indicated by 'Δ'.

A deflection angle of a chord is the angle made by the chord with the tangent drawn at the straight starting point of the chord. It is denoted by 'δ'. 'δ' for given chord lengths are determined by $¢ = \frac{1718.9}{R}C$

Where C = Length of chord, R = Radius of curve

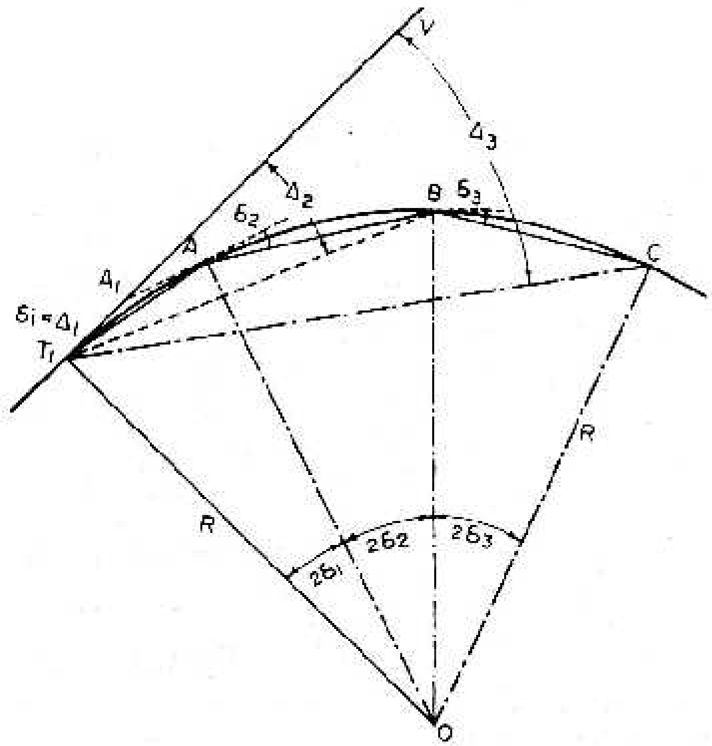


Fig.11 Setting Out By Rankine's Method

Procedure:

1. Locate points T_1, T_2 and V (Fig.11).
2. Setup the Theodolite exactly at point T_1 and make its temporary adjustments.
3. Set the 'A' – vernier to zero degrees and bisect the point V, clamp the lower plate.
4. Release the upper plate and set the 'A'-vernier to read Δ_1 the line of sight is thus directed along T_1 A.
5. Hold the zero of the tape at T_1 & take a distance C_1 (T_1A) and swing the tape with an arrow till it is bisected by the Theodolite. This establishes the first point A on the curve.
6. Set the second deflection angle Δ_2 on the vernier so that the line of sight is set along T_1B.
7. Hold the zero of the tape at point A and an arrow at the other end (AB), swing the tape about point A till the arrow is bisected at point B. This establishes the second point B on the curve.
8. The same steps are repeated till the last point T_2 is reached.

Observations and Calculations:

$¢ = \frac{1718.9}{R} C$ = deflection angle, $¢_1$,$¢_2$, $¢_3$… etc., are the successive deflection angles

Where C = Length of chord, C_1, C2,…etc., are the successive chord lengths

R = Radius of curve

Let ABCD ….. be the points on the curve the total deflection angles of which are Δ_1 Δ_2 Δ_3 … then

$\Delta_1 = \delta_1$

$\Delta_2 = \Delta_1 + \delta_2$

And $\Delta_n = \Delta_{n-1} + \delta_n$

Length of Long Chord L = 2R SIN $\Delta/2$

Tangent length (T_1V) = R Tan $\Delta/2$

Length of Curve = R Δ ($\Pi/180$)

Chainage of point T_1 = Chainage of V – T_1V

Chainage of point T_2 = Chainage of T_1 + Length of Curve

Result:

The required simple circular curve is set out in the field by Rankine's Method.

Comments/Inference:

Write your comments and observations on the result obtained.

(C) SETTING OUT A SIMPLE CURVE BY TWO-THEODOLITE METHOD

Aim:
Two tangents intersect at a given chainage with a given deflection angle. Calculate all the necessary data for setting out a curve with a given radius by two Theodolite method. The peg interval is 30m.

Equipment:
Two Transit Theodolites, Tripod Stands, Ranging Rods and Pegs.

Principle:
In this method two Theodolites are used one at T_1 (P.C) and the other at T_2 (P.T). The method is used when the ground is unsuitable for chaining and is based on the principle that the angle between the tangent and the chord is equal to the angle which that chord subtends in the opposite segment.

Thus, $\angle VT_1A = \Delta_1$ = deflection angle for 'A' but $\angle AT_2T_1$ is the angle subtended by the chord T_1A in the opposite segment. $\angle AT_2T_1 = \angle VT_1A = \Delta_1$

Similarly

$$\angle VT_1B = \Delta_2 = \angle T_1T_2B$$

$$\angle VT_1C = \Delta_3 = \angle T_1T_2C$$

$$\angle VT_1T_2 = \Delta_n = \angle T_1T_2V$$

Procedure:

1. Set up one transit at P.C. (T_1) and the other at P.T. (T_2) (Fig.12).
2. Clamp the both plates of each transit to zero reading.
3. With the zero reading, direct the line of sight of the transit T_1 towards V. Similarly, direct the line of sight of the other transit at T_2 towards T_1 when the reading is zero. Both the transits are thus correctly oriented.
4. Set the reading of each of the transits to the deflection angle for the first point 'A'. The line of sight of both the Theodolites are thus directed towards 'A' along T_1A and T_2A respectively.
5. Move the ranging rod or arrow in such a way that it is bisected simultaneously by cross hairs of the both instruments. Thus point A is selected.
6. To fix the second point 'B'. Set reading Δ_2 on both instruments & bisect the ranging rod.
7. Repeat the steps (4) & (5) for calculation of all the points.

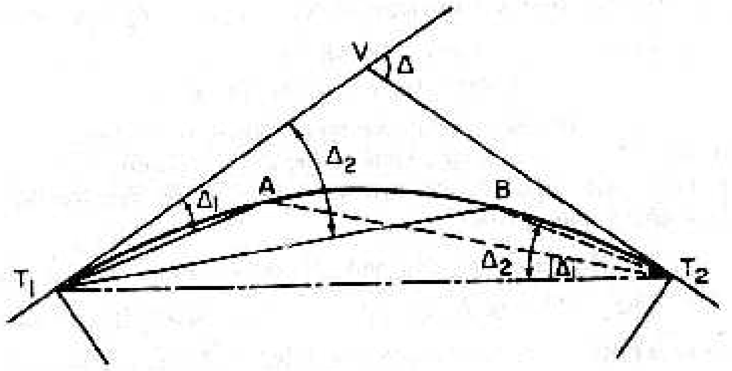


Fig.12 Setting Out By Two-Theodolite Method

Result:
The required simple circular curve is setout in the field by two-theodolite method.

Comments/Inference:
Write your comments and observations on the result obtained.

TACHEOMETRIC SURVEY

TACHEOMETRIC SURVEY

INTRODUCTION

Tacheometer in general sense, is a transit Theodolite fitted with anallactic lens (Fig.13) and a stadia diaphragm (Fig.14) consisting of one stadia hair above and the other at equal distance below the horizontal cross hair (Fig.15).

The stadia hairs are kept in the same vertical plane as the other cross hairs.

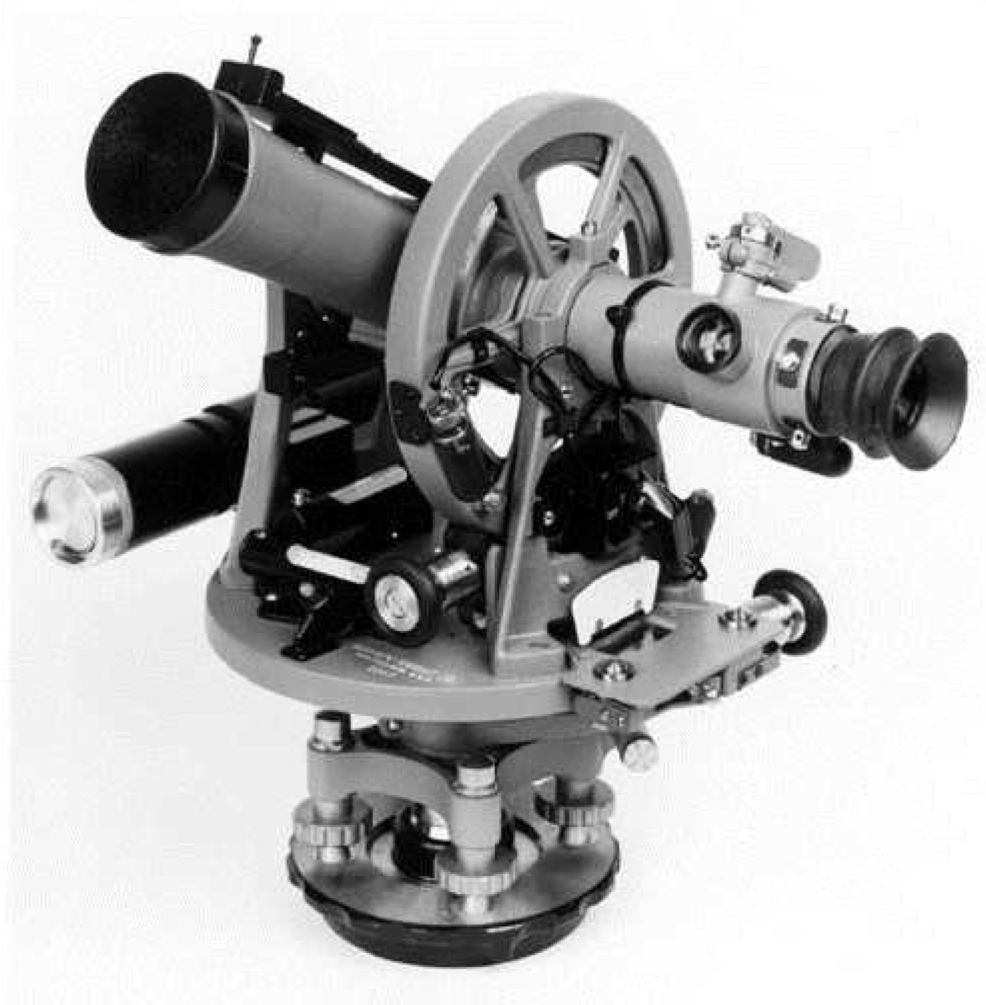


Fig.13 Tacheometer

TYPES OF STADIA DIAPHRAGM

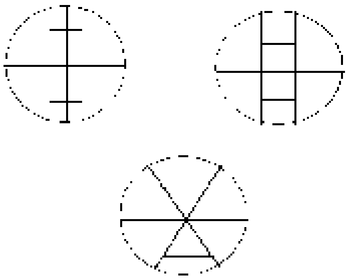


Fig.14 Stadia Diaphragms

STADIA RODS

1. For the short distances ordinary leveling staffs may be used
2. For greater distance the stadia rods of 3 to 4 meters in length are generally used

STADIA READINGS

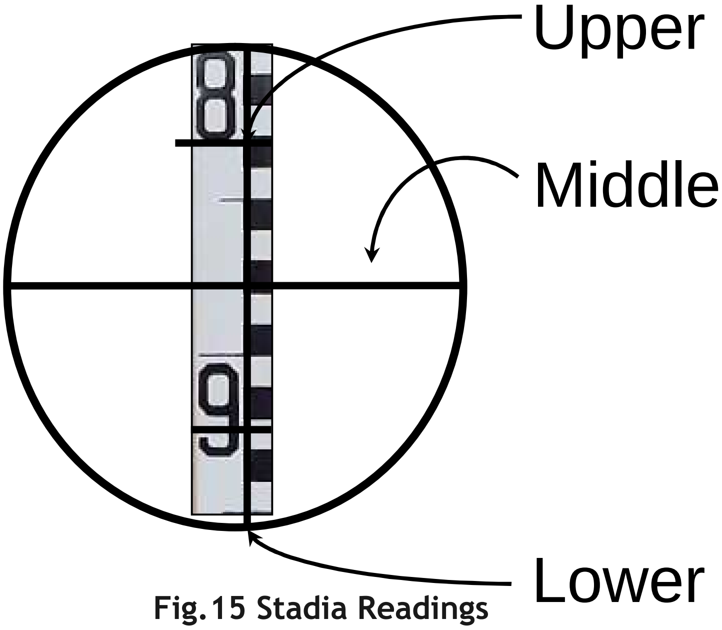


Fig.15 Stadia Readings

TYPES OF TELESCOPES USED IN STADIA SURVEYING

- The simple external-focusing telescope.
- The external-focusing anallactic telescope.
- The internal telescope

CHARACTERISTICS OF TACHEOMETER

- The value of the constant f/i should be 100.
- The telescope should be fitted with an anallactic lens.
- The axial horizontal line should be at center of the other two horizontal line
- The telescope should be powerful, the magnification being 20 to 30 diameter.
- The aperture of the objective should be 35 to 45mm in diameter.
- The magnifying power of the eyepiece should be greater to render staff graduations clearer at long distance.

PRECAUTIONS

i) Leveling and centering must be done perfectly.

ii) Relation of fundamental lines at Theodolite must be maintained while taking readings.

iii) Ranging rod should not be disturbed for taking preceding angles.

iv) Care should be exercised in taking out the Theodolite from the box and in screwing it to the tripod. A Theodolite fitted on a tripod should never be set up on the floor as it may lead to serious damage. While placing the Theodolite into the box, the leveling head should be shifted to a central position and the foot screws should be evened all around. The clamp should be released during transit so that the different parts can yield without being damaged, in case it strikes some obstruction.

v) Clamps and screws should especially be carefully operated. Unnecessary pressure should not be used in tightening them. If the screws do not turn easily, they should be cleaned with a good solvent such as alcohol or gasoline.

vi) The wing nuts on the tripod must be tight so as to prevent slippage and rotation of the head. The tripod legs should be well spread out to furnish stability to the instrument and to permit placement of the telescope at a convenient height for the observer.

vii) The vertical circle should be cleaned if tarnished in use. However, excessive rubbing should be avoided, otherwise the engraved graduations will get impaired.

viii) The Theodolite should be protected from moisture and dust as far as possible. If it has been exposed to moisture it should be wiped dry before replacing it in the box.

APPLICATIONS

❖ Tacheometer prime object is to prepare contour maps (or) plans requiring both the horizontal as well as vertical control.

EXERCISE 5

HEIGHTS AND DISTANCES USING PRINCIPLES OF TACHEOMETRIC SURVEYING

TACHEOMETRIC CONSTANTS

Aim:
To determine the Tacheometric constants using Tacheometer.

Equipment:
Tacheometer, Chain (or) Tape, Pegs and Levelling Staff.

Principle:
Distance between two points is given by (Fig.16)

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

Where f/i is called the multiplying constant.

(f + d) is called additive constant.

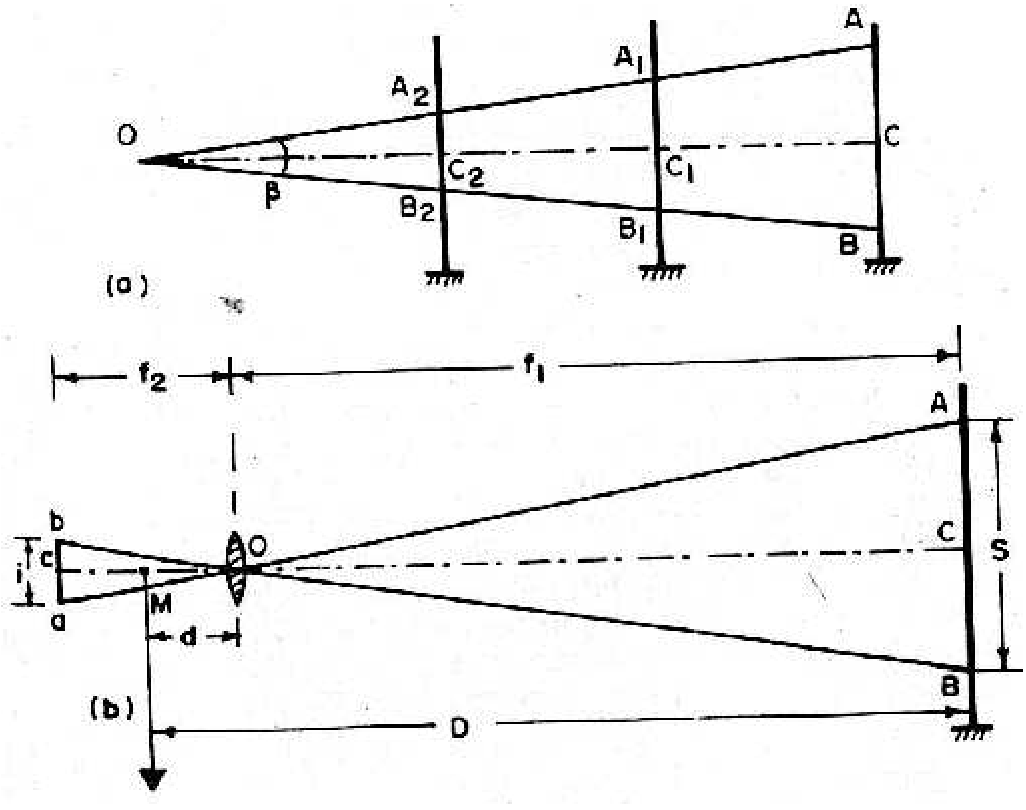


Fig.16 Tacheometric Constants

Procedure:

- Setup the instrument at one end of a straight line say 50m
- Drive pegs at 10m, 20m, 25m and at 50m lengths...
- Keep the staff on the pegs and observe the corresponding staff intercepts with horizontal sight.
- Knowing the values of 'S' and corresponding 'D' values for different peg intervals a number of similar equations can be formed by substituting the values of 'S' and 'D' in equation

$$D = KS + C$$

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

Observations and Calculations:

Horizontal Distance, D (m) =

Staff Intercept, S (m) =

$D = KS + C$

Result:

For the given instrument

f/i = multiplying constant (K) =

$f+d$ = Additive constant (C) =

Comments/Inference:

Write your comments and observations on the result obtained.

(A) DISTANCE BETWEEN ACCESSIBLE POINTS BY STADIA METHOD

Aim:
To measure the horizontal distance between two accessible points

Equipment:
Tacheometer, Tripod Stand, Tape, Plumb Bob, Pegs and Ranging Rods.

Principle:

1) Staff held Vertical:

a) Angle of elevation

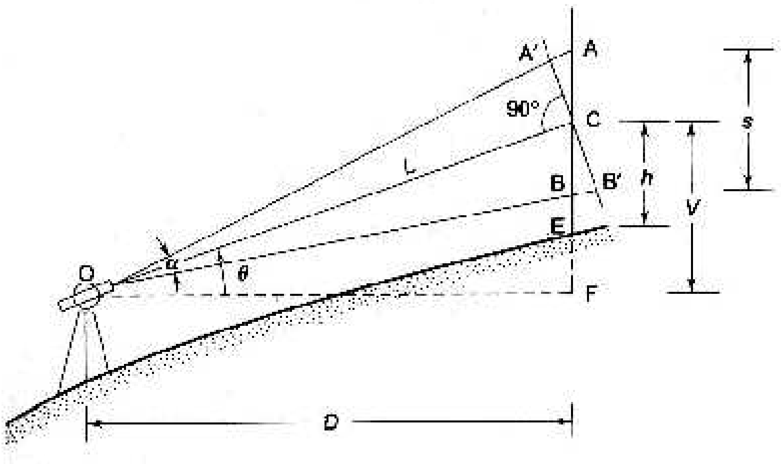


Fig.17 Angle of Elevation

From right angle triangle OFC (Fig.17)

$\angle OCF = 90 - {}^{-}$

$\angle BCB' = {}^{-}$

$\angle A'CB = \angle BCB' = {}^{-}$

Let 'α' be the angle

$\angle COA' = \sim / 2$

$\angle CA'O = 90 - (\sim / 2)$

$\angle CA'A = 180 - (90 - \sim / 2) = 90 + \sim / 2$

A'B' = A'C + B'C
= ACCOS θ+ BC COS θ
= (AC +BC) COS θ
= S COS θ

Inclined distance L= KS COS θ + C = K (A'B') + C

Horizontal distance D = KS COS^2 θ+ C COSθ

V = L SIN θ = FC
= (KS COS θ SIN θ) + C SIN θ

V = ½ KS SIN 2θ + C SIN θ

b) Angle of depression

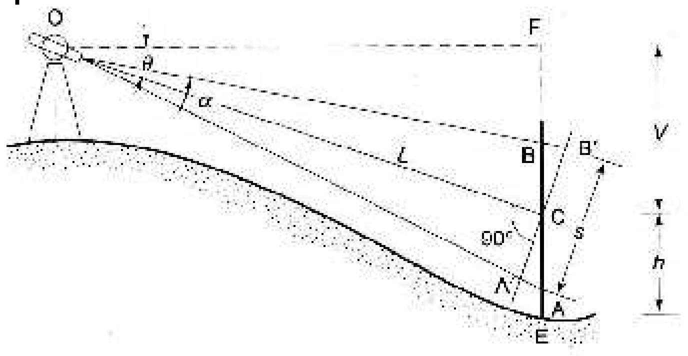


Fig.18 Angle of Depression

From Fig.18,
Inclined distance L= KS COS θ + C
Horizontal distance D = KS COS^2 θ+ C COS θ
V = L SIN θ
  = (KS COS θ SIN θ) + C SIN θ
V = ½ KS SIN 2θ + C SIN θ

2) Staff held Normal:
a) Angle of elevation

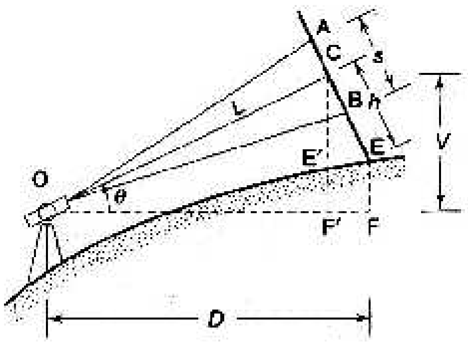


Fig.19 Angle of Elevation

From Fig.19,
L = KS + C
D = OF' + FF'
= L COS θ + H COS θ
D= (KS + C) COS θ + H SIN θ
V = L SIN θ
V = (KS + C) SIN θ

b) Angle of depression

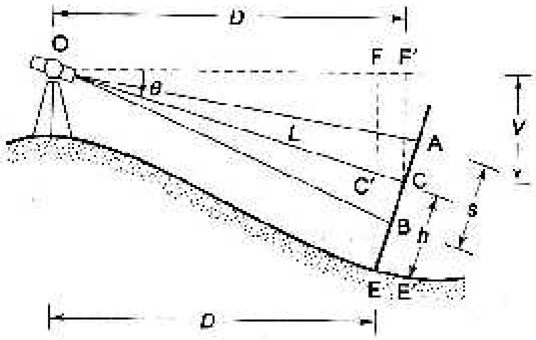


Fig.20 Angle of Depression

From Fig.20,
L = KS + C
D = OF' – FF'
= L COS θ - H COS θ
D= (KS + C) COSθ _ H SINθ
V = L SIN θ
V = (KS + C) SIN θ

Procedure:

1. Fix the two stations 'P' and 'Q', those are unknown distance.
2. Set the Theodolite over station 'O' & do the temporary adjustments and keep the instrument in face left position.
3. Set the vernier reading 'P' reading 0^0 0' 0" by using upper clamp screw and upper tangential screw.
4. Release the lower clamp, sight 'P' and clamp the lower clamp screw. Use the lower tangential screw for exact bisection.
5. Release the upper clamping screw and rotate clockwise direction to sight 'Q'. Use the upper clamp and upper tangent screw for exact bisection.
6. Note the readings of vernier 'P' and 'Q'. The average of vernier 'P' and 'Q' gives the angle 'θ' on face left (Fig.21).
7. Repeat the same procedure on face right, the average of face left and face right gives the angle POQ and measured distances OP and OQ.

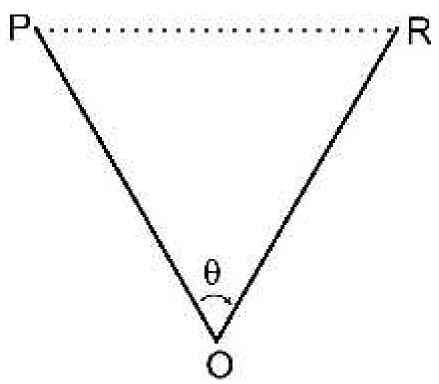


Fig.21 Measurement of Vertical Angle

Observations and Calculations:

D = KS $Cos^2θ$ + C Cosθ

$$PQ^2 = OP^2 + OQ^2 - 2\ \overline{OP}\ \ \overline{OQ}\ \ COS^{-}$$

Result:
The horizontal distance between accessible points "PQ' is =

Comments/Inference:
Write your comments and observations on the result obtained.

(B) DISTANCE BETWEEN TWO ACCESSIABLE POINTS BY TANGENTIAL TACHEOMETRY METHOD

Aim:
To determine the horizontal distance between two accessible points by tangential Tacheometer.

Equipment:
Tacheometer, Tripod Stand, Tape, Plumb Bob, Pegs and Ranging Rods.

Principle:
i) Both angles are angles of elevation:
Let
'P' position of the instrument
'M' Position of instrument axis
'Q' Staff station
A, B are position of vanes
'S' is the distance between the vanes (i.e. staff intercept)
'α_1' is the angle of elevation corresponding to 'A'
'α_2' is the angle of elevation corresponding to 'B'.
D Horizontal distance b/n P and Q = MQ^1.
V Vertical intercept between the lower vane and the horizontal line of sight.
H height of the instrument = MP
R is the height of the lower vane above the foot of the staff which is equal to staff reading at lower vane = BQ

Observations and Calculations:

Instrument at	Staff station	Horizontal angle	Vertical angle	Staff readings	Horizontal distance (m)
O	P Q				

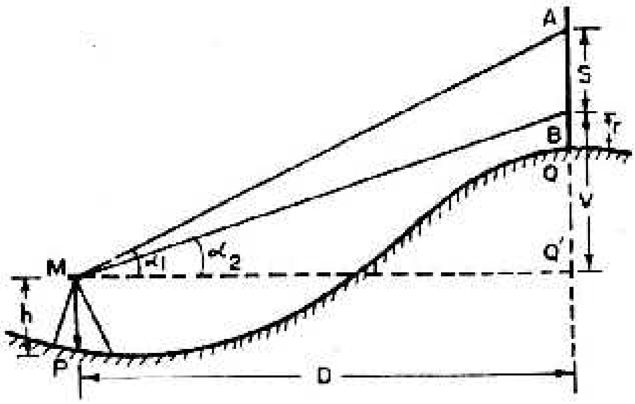


Fig.22 Both Angles are Angles of Elevation

From Triangle MBQ' (Fig.22),
V = D Tanα_2
Llary Triangle AMQ'
V + S = D Tanα_1
D = S / (Tanα_1 - Tanα_2)
V = S Tanα_2/ (Tanα_1 - Tanα_2)

ii) Both angles are angles of depression:

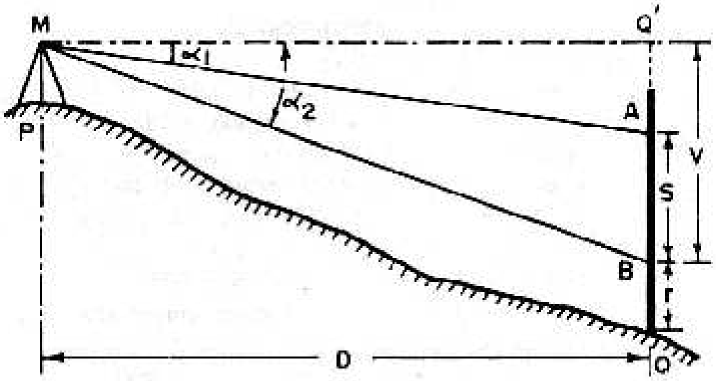


Fig.23 Both Angles are Angles of Depression

From Triangle MBQ' (Fig.23),
V= D Tanα_2
Llary Triangle AMQ'
V - S = D Tanα_1
D = S / (Tanα_2 - Tanα_1)
V = S Tanα_2/ (Tanα_2 - Tanα_1)

iii) One angle of elevation and the other of depression:

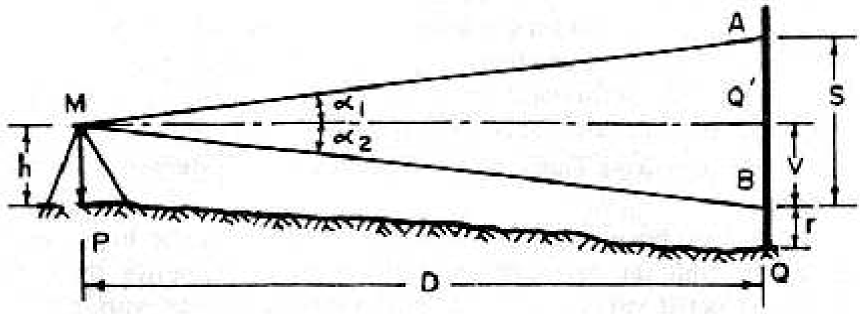


Fig.24 One Angle of Elevation and the Other of Depression:

From Triangle MBQ' (Fig.24),
V = D Tanα_2
ΔTriangle AMQ'
S - V = D Tanα_1
D = S / (Tanα_2 +Tanα_1)
V = S Tanα_2/ (Tanα_2 + Tanα_1)

<u>Procedure</u>:

i. Set up instrument at 'P' and do the temporary adjustments.
ii. Set the vernier 'A' to zero and vertical angle circle read to zero by using telescope clamping screw and tangent screw.
iii. Turn the telescope in vertical plane and bisect the point 'A' at a station 'Q'. The staffs intercept reading and corresponding reading on vertical circle is to be noted down.

iv. Thus, turn the telescope and bisect the staff at a point 'B' of station held at 'Q' of 1m reading & corresponding reading on vertical circle is to be noted down.

v. The horizontal distance between' 'P' and 'Q' points is to be calculated by using the formula.

$$D = \frac{S}{\tan \sim_1 \pm \tan \sim_2}$$

Where 'S' is the difference between two intercepts.

Result:

The horizontal distance between two accessible points is measured to be:

Comments/Inference:

Write your comments and observations on the result obtained.

SETTING OUT WORKS

SETTING OUT WORKS

INTRODUCTION

Setting out is a survey undertaken in order to transfer onto the site the plans prepared as a result of some previous survey. Setting out, in a sense, is the reverse of the conventional surveying. Here, instead of using data from the site to prepare plans, the plans and designs prepared by the designer are transferred accurately onto the actual site. It may be described as the fixing of well-defined points in the field showing the horizontal and vertical positions required by the plans.

To build according to the plan, a contractor must have reference lines and points established in the field. This involves placing of pegs or marks to define the lines and levels of work where after, the construction proceeds according to these marks. Some factors to be considered during setting out works are:

1. The reference lines and points should be well defined, not easily perishable, close to the work yet out of the way or actual construction operations.
2. A very high degree of accuracy should be maintained and only extremely low tolerances should be allowed. In order to achieve this, frequent and independent checking should be done.
3. The instruments used should be checked frequently and discrepancies, if any, should be removed.

In most of the setting out works, the principle is very simple, but in practice, difficulties like skew plans, obstructions, etc. are encountered which often necessitate the use of indirect methods. The use of surveying methods provides the tool for layout or setting out works as well as the control which makes the proper layout possible.

The contemporary construction scenario encompasses a wide variety of structures. As such, it will be impossible to cover every conceivable setting out problem in this book. Instead, a few more common and important ones are discussed herein.

DEFINITIONS

Some terms which are used frequently in setting out works are defined below.

Stake:The term stake refers to any type of keel, which is driven into the ground so as to act as a permanent identification mark. Stakes may be made of timber, steel, copper, etc. Generally these are pointed at one end to facilitate their anchoring into the ground. Depending upon the purpose it serves, it is termed as *guard, grade, or line stake*.

Post: In the setting out works, post is used to refer to any circular or square pole, generally wooden, which is used for various purposes, e.g. acting as a peg to support horizontal members like sight rails.

Batter-board: This is also known as a slope rail. In setting out works of large magnitudes, where absolute accuracy is required, batter-boards are used in conjunction with the wooden stakes or pins. A batter-board is generally a flat, square, wooden board, which is forced on top of a pin anchored in ground. Nails are driven in this board to indicate the direction of various lines that may give the

boundary of a building, mark of an excavation, etc. Strings or wires can be stretched between two batter-boards using the nails driven in them.
Batter-boards and wires over wooden stakes as shown in Fig.25.

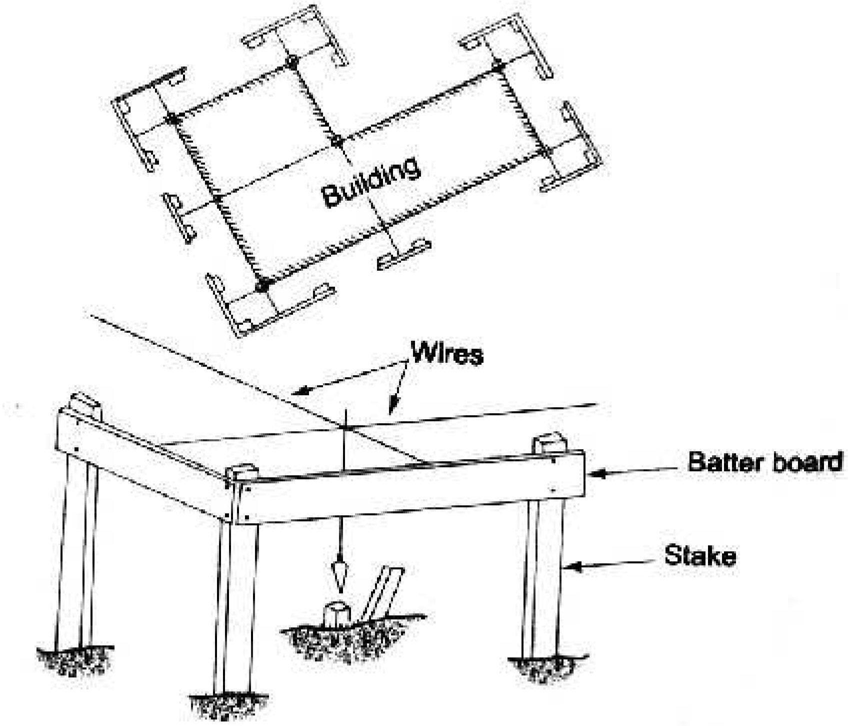


Fig.25 Batter-Boards and Wires Over Wooden Stakes

Batter board for a pipeline as shown in Fig.26.

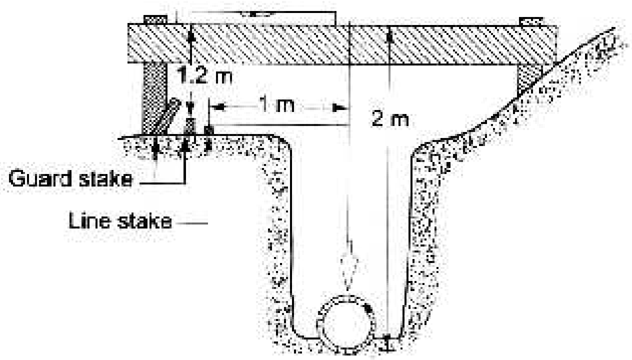


Fig.26 (a) Batter-board for a Pipeline

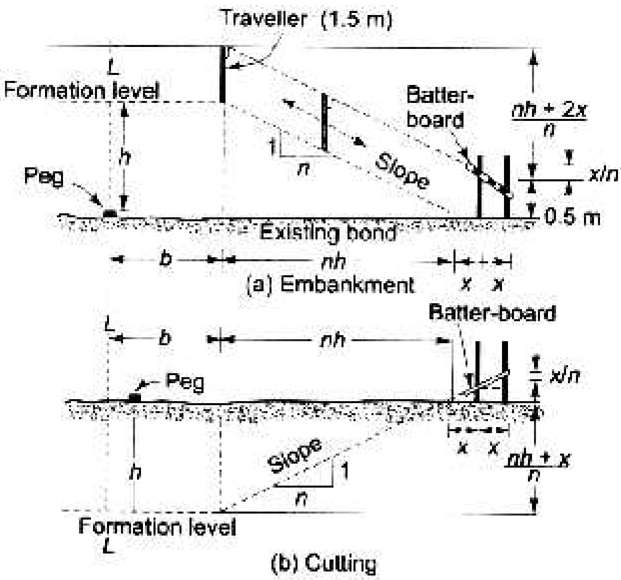


Fig.26 (b) Use of Batter-Board

Crosshead: A crosshead consists of two vertical posts 1-1.5 m high, firmly embedded in ground, on each side of the trench with a horizontal rail nailed to these posts across the trench.

Sight Rails: The horizontal member of the crosshead, i.e. the timber beam nailed to the posts is referred to as a sight rail. A sight rail is in itself a kind of batter-board. The upper edge of the crosspiece is set to a convenient height above the ground so that a surveyor may align his eye with the upper edge. A single sight rail is used for road works, footings, etc., whereas two sight rails at right angles are used for building corners. For trenches and large diameter pipes, sight rail is used. Sight rail shown in Fig.27 is used for highly undulating and steep grounds.

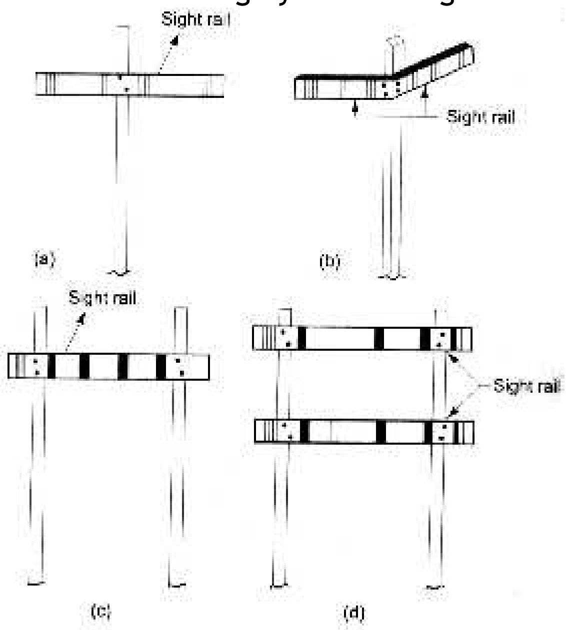


Fig.27 Sight Rails

Boning Rod: It is a T-shaped wooden rod as shown in Fig.28. The top piece is generally 10cm x 40 cm and is 3 cm thick. This is nailed to an upright pole. It is generally used in the layout of trenches for sewers, pipe lines, etc. The length of a boning rod for each trench section is kept the same.

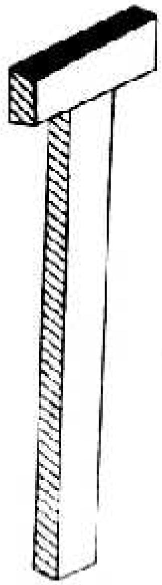


Fig.28 (a) Boning Rod

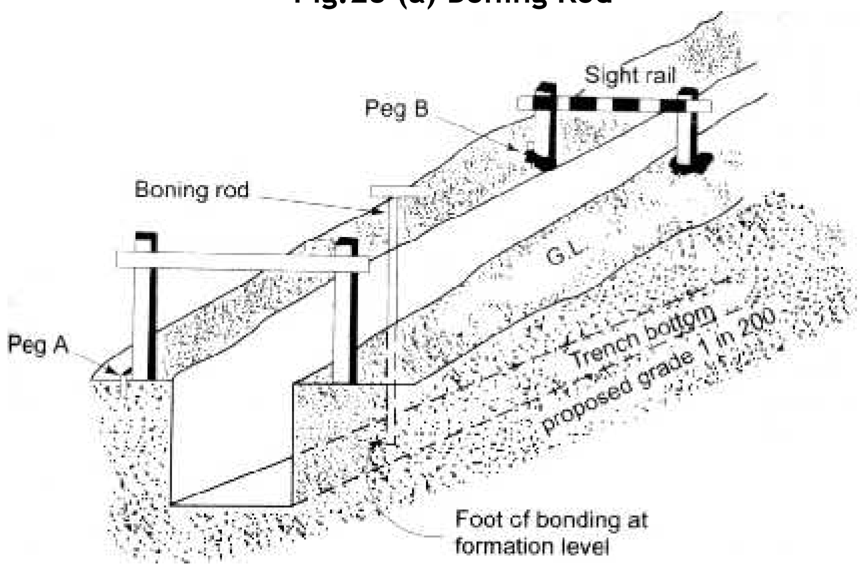


Fig.28 (b) Use of Boning Rod

Travelling Rod: A traveling rod (Fig.29) is a special type of boning rod in which the horizontal piece, called *traveler*, can be moved along a graduated vertical staff and can be conveniently clamped at any desired height.

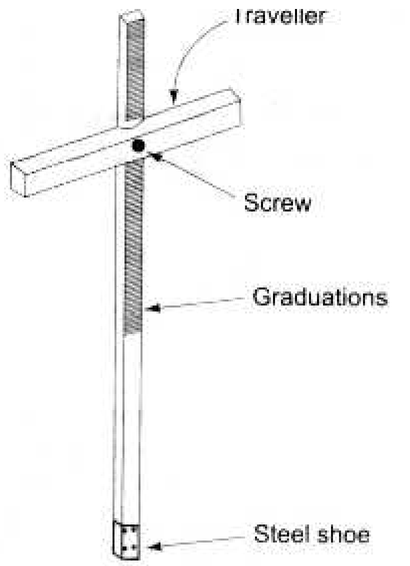


Fig.29 Travelling Rod

Precautions

1) Hold the tape such that it is in horizontal plane.
2) Hold the cross staff over the point in perfectly vertical position.
3) Use wooden or MS pegs for marking the points.
4) Place the batter board & sight-rails in horizontal position using the spirit level.

EXERCISE 6

SETTING OUT OF STRUCTURES

Aim:
To set out work for a given plan of a building.

Equipment:
Cross-Staff, Spirit Level, 30m Tape, 5m Pocket Tape, Pegs, Wooden Stakes And Threads/Wire/Rope.

Principle:
Setting out of a building involves the transfer of the architect's plan from paper onto the actual site. The object of setting out a building is to provide the builder with clearly defined outlines for excavations. Two methods are generally used for setting out a building.

Procedure:

A. *By using a circumscribing rectangle*

Since stakes cannot be set at the exact corner points of a building (if set so, these will be lost during excavations), these are fixed at the corners of a bigger rectangle circumscribing the actual chosen, but a distance of usually 2-4 m is considered to be ideal. The actual procedure consists of the following steps:

(a) Preparation of the foundation trench plan showing the width of the foundations for various walls.
(b) Temporary pegs are driven at the actual corner points of the building.
(c) Then using these pegs as reference, a parallel line, say AB as shown in Fig.30 of required length is set out at an arbitrarily selected distance (say 2m) from the actual center line.
(d) A chord is stretched between the pegs A and B. At A, a line is set out perpendicular to AB (with a tape using 3, 4, 5 method). On this line, the position D is marked by setting a peg.
(e) Step (d) is repeated at point B so as to obtain point C.
(f) Having now set out the reference rectangle ABCD, the actual corners can be marked using the sides of the reference rectangle ABCD.
(g) Once all the points are staked, a chord is passed around the periphery of the rectangle and the actual excavation lines are marked using lime.

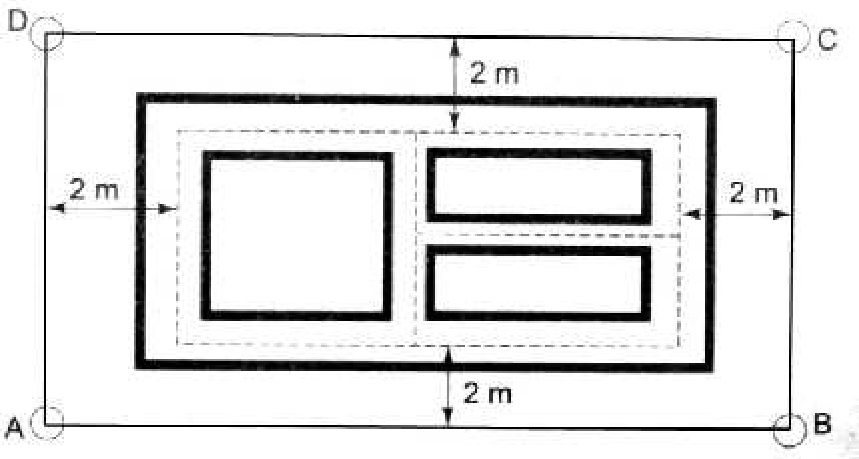


Fig.30 Setting-out Structures by Using a Circumscribing Rectangle

<u>**Checks**</u>:

(i) In steps (d) and (e), after marking points D and C, respectively, the diagonals BD and AC should be measured. These lengths should correspond to the distances on the plan.

(ii) After setting out the point C, the length CD should be measured and should be exactly same as that of AB.

B. ***By making use of the rectangle formed by centerlines of the outer walls of a building***

In this method the rectangle formed by the centerlines of the outer walls of the building is used. The steps involved are:

(a) The temporary stakes are fixed at the points that represent the corners of the center line rectangle. The procedure is similar to the one used in the first method while plotting the circumscribed rectangle.

(b) Since these pegs are not permanent and will be lost during excavation, the sides of the rectangle are produced on both the sides and permanent stakes are fixed on each of the prolongations, at a fixed distance, say 2m, as shown in Fig.31.

(c) By using these stakes, the position of any point can be obtained by plotting its coordinates using the reference stakes.

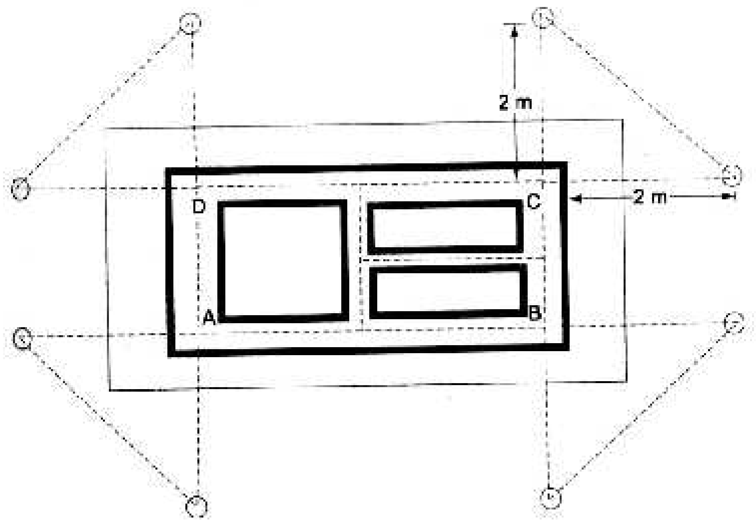


Fig.31 Setting-out by Using Rectangle Formed by Centerlines of the Outer Walls of a Building

TOTAL STATION

TOTAL STATION

INTRODUCTION

Total Station is three-dimensional surveying technology unit. Total station combines the follow three basic components into one integral unit (Fig.32).

- an electronic distance measurement instrument
- an electronic digital Theodolite
- a computer or microprocessor

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

and display the results on an LCD.

Total station can also store data either on board in internal memory or in external data collectors. Data can be uploaded and can be downloaded to a computer. It can also perform basic co-ordinate geometry functions like area and perimeter calculations.

Distance Measurement: When a distance is measured with a total station a electromagnetic pulse is used for measurement – this is propagated through the atmosphere from instrument to a prismatic reflector or target and back during measurement. Distances are obtained by measuring the time taken for a laser radiation to travel from the instrument to a prism (or target) and back. The pulses are derived from an infrared or visible laser diode and they are transmitted through the telescope towards the remote end of the distance being measured, where they are reflected from a reflector and return to the instrument. Since the velocity v of the pulses can be accurately determined, the distance D can be obtained using $2D = vt$, where t is the time taken for a single pulse to travel from instrument-target-instrument. This is also known as the timed-pulse or time of flight measurement technique, in which the transit time t is measured using electronic signal processing technique.

When measuring distances to a reflector telescope uses a wide visible red laser beam, which emerges coaxially from the telescope's objective.

When reflector less measurements are made telescope uses a narrow visible red laser beam which emerges coaxially from the telescope's objective

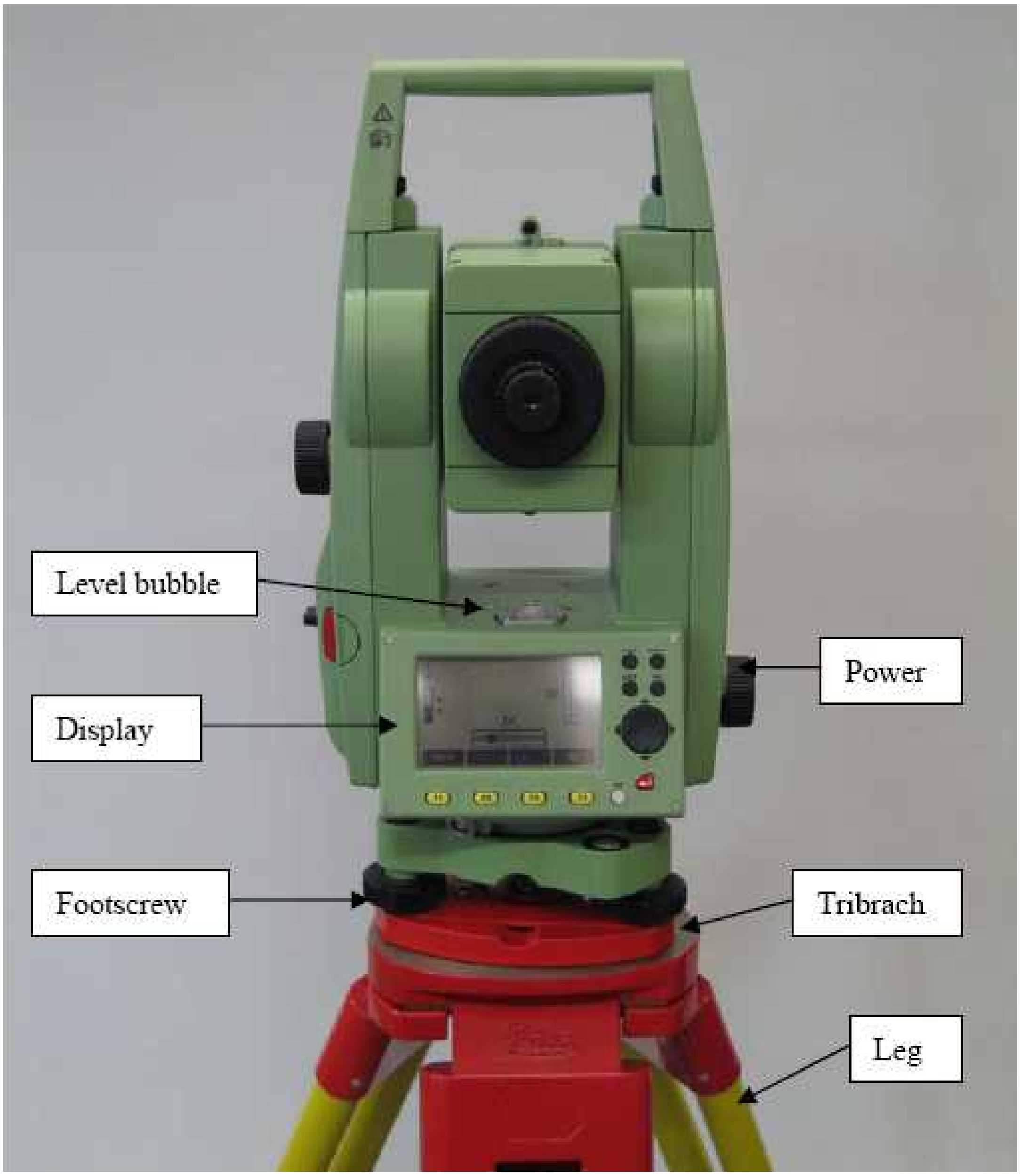


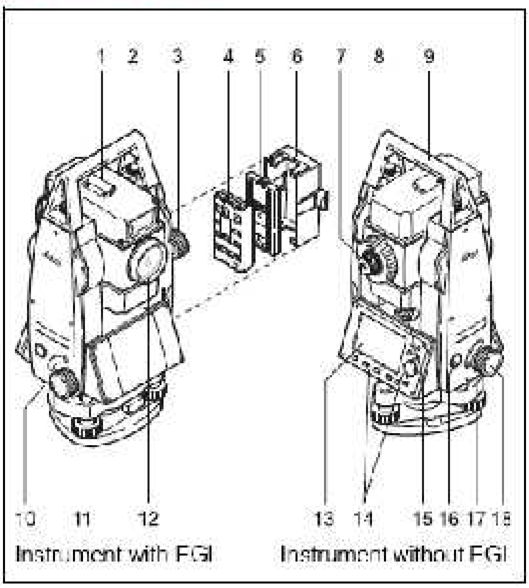
Fig.32 Total Station

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.

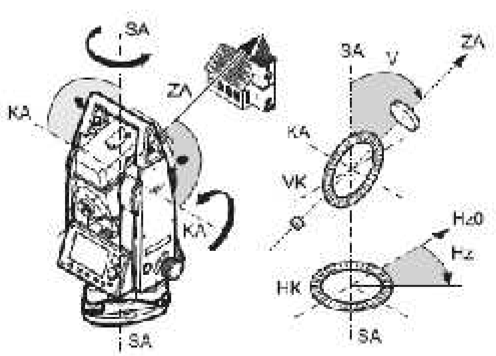
1. Never Place the Total Station directly on the ground.
2. Do not aim the telescope at the sun.
3. Protect the Total Station with an umbrella.
4. Never carry the Total Station on the tripod to another site
5. Handle the Total Station with care. Avoid heavy shocks or vibration.
6. When the operator leaves the Total Station, the vinyl cover should be placed on the instrument.
7. Always switch the power off before removing the standard battery.
8. Remove the standard battery from the Total Station before putting it in the case.
9. When the Total Station is placed in the carrying case, follow the layout plan.

Important parts



1) Optical sight
2) Integrated guide light EGL (optional)
3) Vertical drive
4) Battery
5) Battery stand for GEB111
6) Battery cover
7) Eyepiece; focussing graticule
8) Focussing telescope image
9) Detachable carrying handle with mounting screws
10) Serial interface RS232
11) Foot screw
12) Objective with integrated Electronic Distance Measurement (EDM); Beam exit
13) Display
14) Keyboard
15) Circular level
16) On/Off key
17) Trigger key
18) Horizontal drive

Technical terms and abbreviations



ZA = Line of sight / collimation axis
Telescope axis = line from the reticle to the centre of the objective.

SA = Standing axis
Vertical rotation axis of the telescope.

KA = Tilting axis
Horizontal rotation axis of the telescope (Trunion axis).

V = Vertical angle / zenith angle

VK = Vertical circle
With coded circular division for reading the V angle.

Hz = Horizontal direction

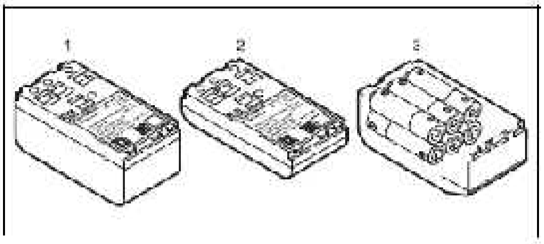
HK = Horizontal circle
With coded circular division for reading the Hz-angle.

Power Supply

Use the Leica Geosystems batteries, chargers and accessories or accessories recommended by Leica Geosystems to ensure the correct functionality of the instrument.

Power for the instrument can be supplied either internally or externally. An external battery is connected to the instrument using a LEMO cable.

- **Internal battery:**
  One GEB111 or 121 battery fit in the battery compartment.
- **External battery:**
  One GEB171 battery connected via cable.



1 GEB121
2 GEB111
3 Single cells in the battery adapter GAD39

Your Leica Geosystems instrument is powered by rechargeable plug-in batteries. For this product, we recommend the basic battery (GEB111) or the Pro battery (GEB121). Optionally six single cells can be used with the GAD39 battery adapter.

Six single cell batteries (1.5 V each) supply 9 Volts. The voltmeter on the instrument is designed for a voltage of 6 Volts (GEB111/ GEB121).

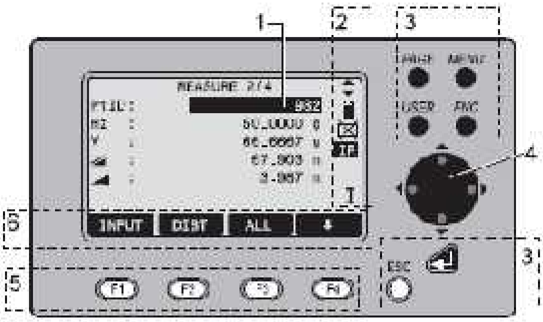
☞ The battery charge is not displayed correctly when using single cells. Use the single cells with the battery adapter as emergency power supply. The advantage of the single cells is in a lower rate of discharge even over long periods.

Operating the Instrument

The On / Off key is located on the side cover of the TPS400.

☞ All shown displays are examples. It is possible that local software versions are different to the basic version.

Keypad



1) Focus
   Actively measured field
2) Symbols
3) Fixed keys
   Keys with firmly assigned functions.
4) Navigation keys
   Control of input bar in edit and input mode or control of focus bar.
5) Function keys
   Are assigned the variable functions displayed at the bottom of the screen.
6) Softkey bar
   Displays functions that can be called up with the function keys.

Fixed keys

[PAGE] Scrolls to next page when a dialogue consists of several pages.

[MENU] Accesses programs, settings, the data manager, adjustments, communications parameters, system information and data transfer.

[USER] Key, programmable with function from the FNC menu.

[FNC] Quick-access to measurement-supporting functions.

[ESC] Quit a dialog or the edit mode with activation of the "previous" value. Return to next higher level.

↵ Confirm an input; continue to the next field.

Trigger key

The measurement trigger has three settings (ALL, DIST, OFF).

The key can be activated in the configuration menu.

Selection of Language

After switching on the instrument the user is able to choose his preferred language.

The dialog to choose the language is only shown if two languages are loaded onto the instrument and **Lang.choice: On** is set in Settings dialog.

To load an additional language connect the instrument to LGO Tools Version 4.0 or higher via the serial interface and load using "LGO Tools - Software Upload".

Distance measurement

A laser distancer (EDM) is incorporated into the instruments of the TPS400 series.

In all versions, the distance can be determined by using a laser beam which emerges coaxially from the telescope objective.

☞ **Measurements to strongly reflecting targets such as to traffic lights in** Reflector EDM **mode without prism should be avoided. The measured distances may be wrong or inaccurate.**

For applications without reflector, a special arrangement of the EDM, and appropriate arrangement of the beam paths, enable ranges of over five kilometres to be attained with standard prisms.

Miniprisms, 360° reflectors and reflector tapes can also be used, and measurement is also possible without a reflector.

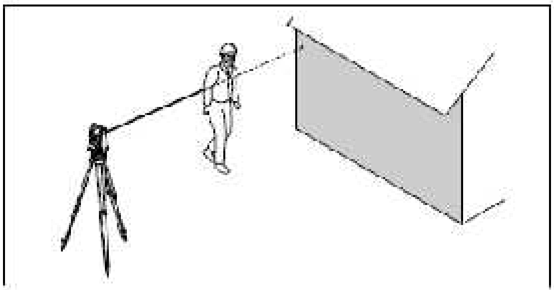
☞ **When a distance measurement is triggered, the EDM measures to the object which is in the beam path at that moment.**

If e.g. people, cars, animals, swaying branches, etc. cross the laser beam while a measurement is being taken, a fraction of the laser beam is reflected and may lead to incorrect distance values.

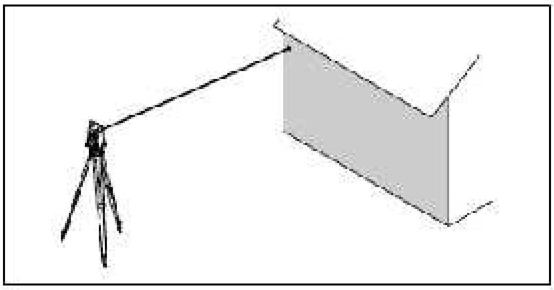
Avoid interrupting the measuring beam while taking reflectorless measurements or measurements using reflective foils. Measurements to prism reflectors are only critical if an object crosses the measuring beam at a distance of 0 to 30m and the distance to be measured is more than 300m.

In practice, because the measuring time is very short, the user can always find a way of avoiding these critical situations.

☞ Very short distances may be measured reflectorless in IR mode to well reflecting targets. Note that the distances are corrected with the additive constant defined for the active reflector.



Incorrect result



Correct result

Reflectorless

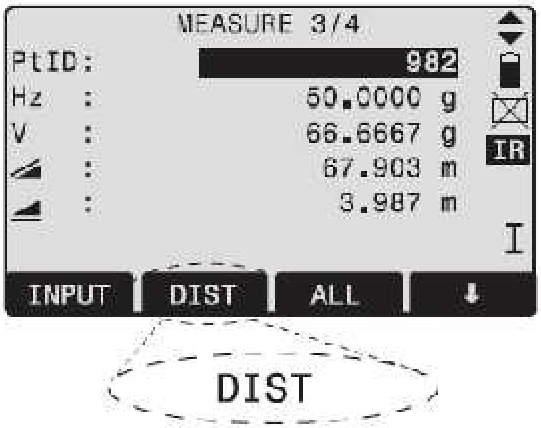
☞ Be sure that the laser beam is not reflected by anything close to the line of sight (e.g. highly reflective objects).

☞ When a distance measurement is triggered, the EDM measures to the object which is in the beam path at that moment. In case of temporary obstruction (e.g. a passing vehicle, heavy rain, fog or snow) the EDM may measure to the obstruction.

☞ When measuring longer distances, any divergence of the red laser beam from the line of sight might lead to less accurate measurements. This is because the laser beam might not be reflected from the point at which the crosshairs are pointing.
Therefore, it is recommended to verify that the R-laser is well collimated with the telescope line of sight (refer to the chapter "Checking and adjusting").

☞ Do not measure with two instruments to the same target simultaneously.

Softkeys



Under softkeys, a selection of commands and functions is listed at the bottom of the screen. They can be activated with the corresponding function keys. The available scope of each function depends on the applications / functions currently active.

General softkeys:

[ALL]	Starts distance and angle measurements and saves measured values.
[DIST]	Starts distance and angle measurements without saving measured values.
[REC]	Saves displayed values.
[ENTER]	Deletes current value in the display and is ready for the input of a new value.
[ENH]	Opens the coordinate input mode.
[LIST]	Displays the list of available points.
[FIND]	Starts the search for the point entered.
[EDM]	Displays EDM settings.
[IR/RL]	Toggles between reflector and reflectorless measurement modes.
[PREV]	Back to last active dialog.
[NEXT]	Continue to next dialog.
←	Returns to highest softkey level.
⬇	To next softkey level.
[OK]	Set displayed message or dialog and quit dialog.

☞ Find further information about menu/application specific buttons in the relevant sections.

Symbols

Depending on software version different symbols are displayed indicating a particular operating status.

◄► A double arrow indicates choice fields.

Using the navigation keys the desired parameter can be selected.

Quits a selection with the enter key or the navigation keys.

▲,▼,▲▼ Indicates that several pages are available which can be selected with [PAGE].

I, II Indicates telescope position I or II.

Indicates that Hz is set to "left side angle measurement" (anti clockwise).

Status symbol "EDM type"

IR Reflector EDM mode for measuring to prisms and reflective targets.

RL Reflectorless EDM for measuring to all targets.

Status symbol "Battery capacity"

The battery symbol indicates the level of the remaining battery capacity (75% full shown in the example).

Status symbol "Compensator"

Compensator is on

Compensator is off

Status symbol "Offset"

! Offset is active

Menu tree

[MENU] > F1 - F4 Confirm menu selection.

[PAGE] Scroll to next page.

Depending on user interface sequence and arrangement of menu items may be different.

Menu

- Programs
  - Surveying
  - Setting out
  - Free Station
  - Reference line
  - Tie Distance
  - Area & Volume
  - Remote Height
  - Construction
  - COGO
  - Reference Plane
- Settings
  - Contrast, Trigger Key, USER key, V-Setting,
  - Tilt Correction
  - Sector Beep, Beep, Hz Incrementation,
  - Reticle Illumin., DSP Heater
  - Data Output, GSI 8/16, Mask 1/2/3
  - Hz Collimation, Auto Off, Language
  - Min. Reading, Angle Unit, Distance Unit, Distance Decimals Temperature, Pressure
- EDM Settings
  - EDM-Mode
  - Prism Type
  - Prism Constant
  - Laser Pointer
  - Guide Light

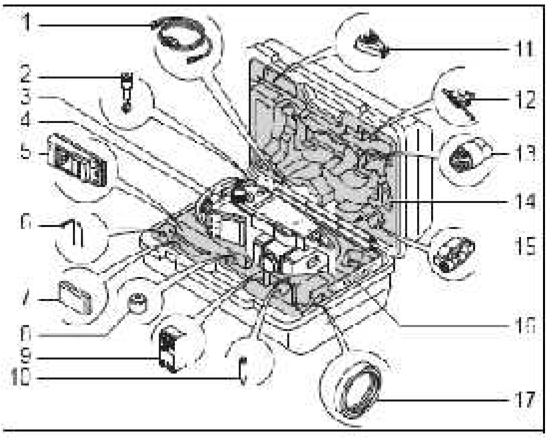
Menu

- File Management
  - Job
  - Fixpoints
  - Measurements
  - Codes
  - Initialize Memory
  - Memory Statistic
- Calibrations
  - Hz-Collimation
  - V-Index
  - View Calibration Data
- Communication Parameters
  - Baudrate
  - Databits
  - Parity
  - Endmark
  - Stopbits
- Data Transfer
  - Job
  - Data
  - Format
- System Info
  - Battery
  - Instrument temperature
  - Date
  - Time
- Start-up sequence
- PIN Protection

Measuring Preparation / Setting up

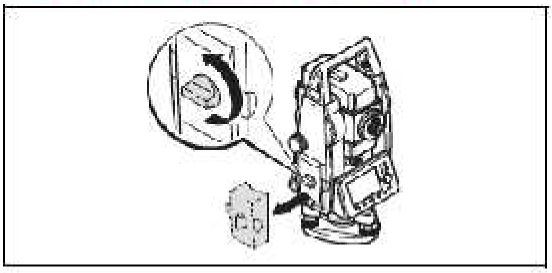
Unpacking

Remove TPS400 from transport case and check for completeness.

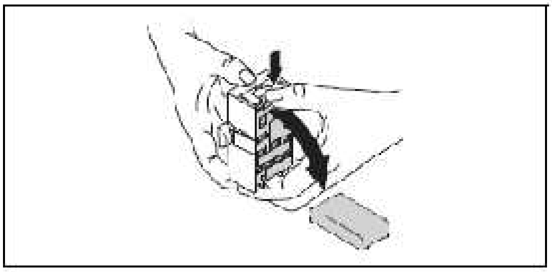


1) Data cable (optional)
2) Zenith eyepiece or eyepiece for steep angles (optional)
3) Total station
4) Removable tribrach (optional)
5) Battery charger and accessories (optional)
6) Adjustment tools
7) Battery GEB111 (optional)
8) GAD105 Mini prism adapter (optional)
9) Battery GEB121 (optional)
10) Tip for mini prism (optional)
11) Spacing bracket GHT196 for height meter (optional)
12) Height meter GHM007 (optional)
13) Protective cover / Lens hood
14) Mini prism rods
15) Mini prism + holder (optional)
16) User Manual
17) Counterweight for Zenith eyepiece (optional)

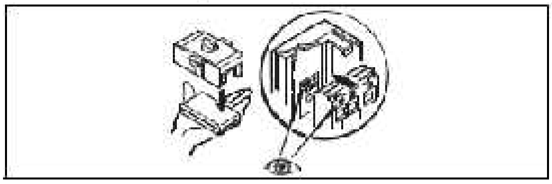
Inserting / Replacing Battery



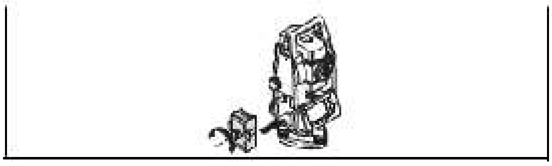
1. Remove battery holder.



2. Remove battery.



3. Insert battery into battery holder.



4. Insert battery holder into the instrument.

Insert battery correctly (note pole markings on the inside of the battery holder). Check and insert battery holder true to side into the housing.

- To charge the battery refer to chapter "Charging the batteries".
- For the type of battery refer to chapter "Technical data".

When using the GEB121 battery, remove the spacer for the GEB111 from the battery compartment.

Charging / first-time use

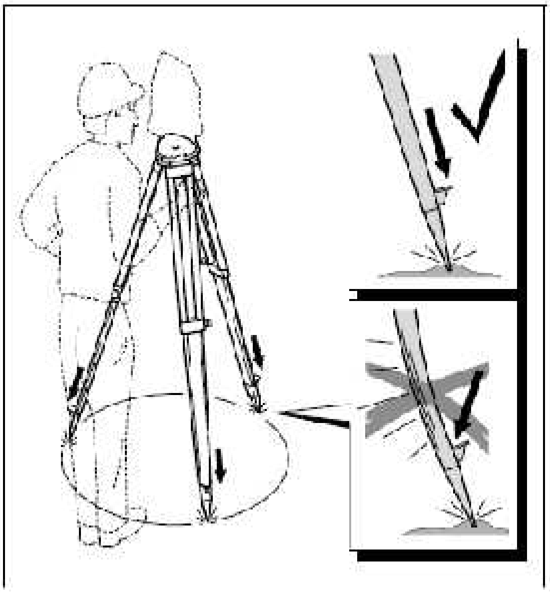
- The battery must be charged prior to using for the first time because it is delivered with an energy content as low as possible.
- For new batteries or batteries that have been stored for a long time (> three months), it is effectual to make 3 - 5 charge/discharge cycles.
- The permissible temperature range for charging is between 0°C to +35°C / +32°F to +95°F. For optimal charging we recommend charging the batteries at a low ambient temperature of +10°C to +20°C/+50°F to +68°F if possible.
- It is normal for the battery to become warm during charging. Using the chargers recommended by Leica Geosystems, it is not possible to charge the battery if the temperature is too high.

Operation/Discharging

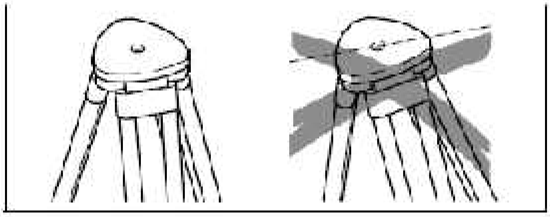
The batteries can be operated from -20°C to +55°C/-4°F to +131°F.

Low operating temperatures reduce the capacity that can be drawn; very high operating temperatures reduce the service life of the battery.

Setting up the tripod



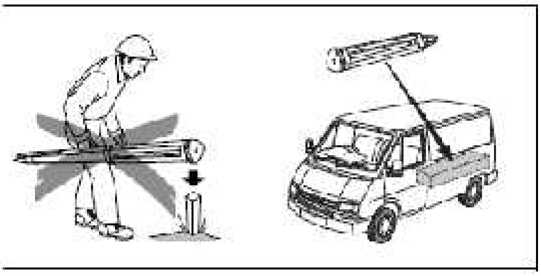
1. Loosen the clamping screws on the tripod legs, pull out to the required length and tighten the clamps.
2. In order to guarantee a firm foothold sufficiently press the tripod legs into the ground. When pressing the legs into the ground note that the force must be applied along the legs.



When setting up the tripod pay attention to a horizontal position of the tripod plate.

Slight corrections of inclination can be made with the foot screws of the tribrach. Larger corrections must be done with the tripod legs.

When using a tribrach with an optical plummet, the laser plummet cannot be used.



Careful handling of tripod

- Check all screws and bolts for correct fit.
- During transport always use the cover supplied.
- Use the tripod only for surveying tasks.

Instrument Setup

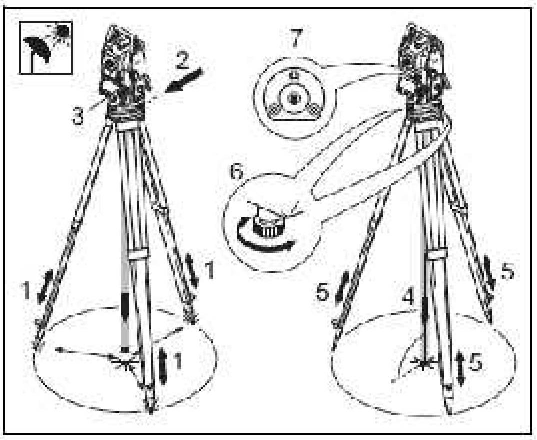
Description

This topic describes an instrument setup over a marked ground point using the laser plummet. It is always possible to set up the instrument without the need for a marked ground point.

☞ Important features:

- It is always recommended to shield the instrument from direct sunlight and avoid uneven temperatures around the instrument.
- The laser plummet described in this topic is built into the vertical axis of the instrument. It projects a red spot onto the ground, making it appreciably easier to centre the instrument.
- The laser plummet cannot be used in conjunction with a tribrach equipped with an optical plummet.

Setup step-by-step



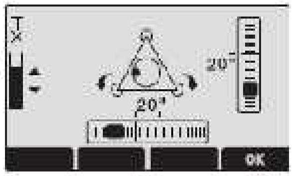
1. Extend the tripod legs to allow for a comfortable working posture. Position the tripod over the marked ground point, centring it as well as possible.
2. Fasten the tribrach and instrument onto the tripod.
3. Turn on the instrument and switch on the laser plummet and electronic level by pressing [FNC] > [Level/Plummet].
4. Move the tripod legs (1) and use the tribrach footscrews (6) to centre the plummet (4) over the ground point.
5. Adjust the tripod legs to level the circular level (7).
6. By using the electronic level turn the tribrach footscrews (6) to precisely level the instrument.
   ☞ Refer to "Levelling up with the electronic level step-by-step" for more information.
7. Centre the instrument precisely over the ground point (4) by shifting the tribrach on the tripod plate (2).
8. Repeat steps 6. and 7. until the required accuracy is achieved.

Levelling up with the electronic level step-by-step

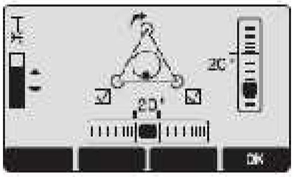
The electronic level can be used to precisely level up the instrument using the footscrews of the tribrach.

1. Turn on the instrument and switch on the electronic level by pressing [FNC] > [Level/ Plummet].
2. Centre the circular level approximately by turning the footscrews of the tribrach.

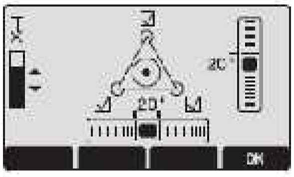
   The bubble of the electronic level and the arrows for the rotating direction of the footscrews only appear if the instrument tilt is inside a certain levelling range.
3. Turn the instrument until it is parallel to two footscrews.
4. Centre the electronic level of this axis by turning the two footscrews. Arrows show the direction for rotating the footscrews. When the electronic level is centred the arrows are replaced by checkmarks.



5. Centre the electronic level for the second axis by turning the last footscrew. An arrow shows the direction for rotating the footscrew. When the electronic level is centred the arrow is replaced by a checkmark.



   When the electronic level is centred and three checkmarks are shown, the instrument has been perfectly leveled up.

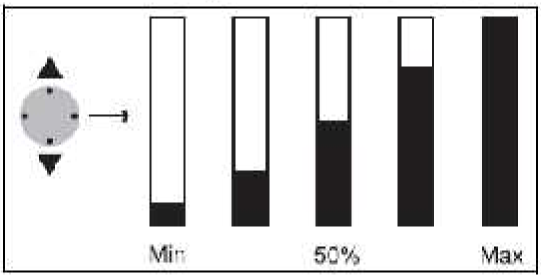


6. Accept with [OK].

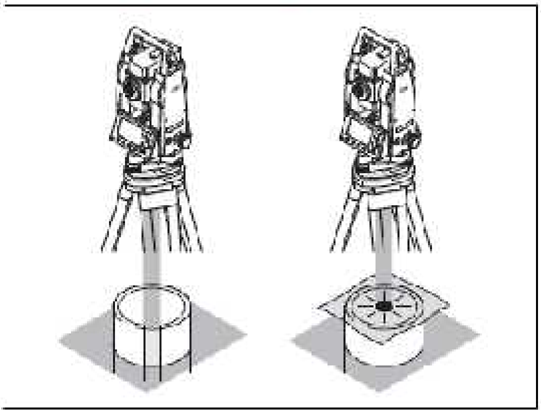
Laser intensity

Changing the laser intensity

External influences and the surface conditions may require the adjustment of the intensity of the laser. The laser can be adjusted in 25% steps as required.



Hints for positioning

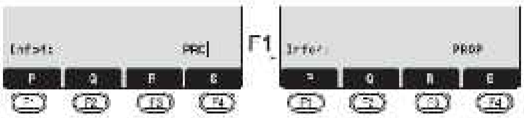


Positioning over pipes or depressions

Under some circumstances the laser spot is not visible (e.g. over pipes). In this case, the laser spot can be made visible by using a transparent plate so that the laser spot can be easily aligned to the centre of the pipe.

Input mode - method 1

In entry mode, enter text or numeric values.



[INPUT] 1. Delete entry, display numeric/ alpha numeric softkey bar. The cursor indicates that the instrument is ready for input.

F1 F3 2. Selection of range of characters/ range of numbers.

[>>>] Additional characters/ numbers.

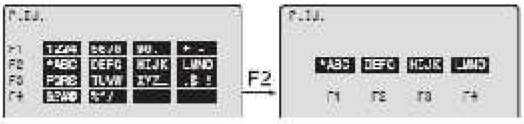
F1 F4 3. Select the desired character. Character shifts to the left.

4. Confirm entry.

[ESC] Deletes input and restores previous value.

Input mode - method 2

In entry mode, enter text or numeric values.



[INPUT] 1. The full range of available characters are displayed on the screen.

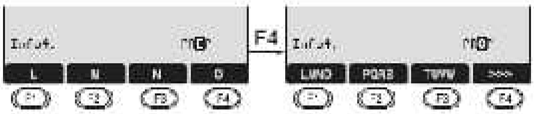
F1 - F4 2. Selection of range of characters/ range of numbers.

Proceed with steps 3 and 4 from method 1.

The method you like to use can be set in the settings.

Edit mode

Existing characters are changed in the edit mode.



1. Start edit mode. Vertical edit bar is positioned flush right.

Edit bar is positioned flush left.

F1 - F3 2. Select range of characters/ range of numbers.

[>>>] Additional characters / numbers.

F1 - F4 3. Overwrite existing characters.

4. Confirm input.

[ESC] Deletes change and restores previous value.

Erasing characters

1. Place cursor on character to be deleted.

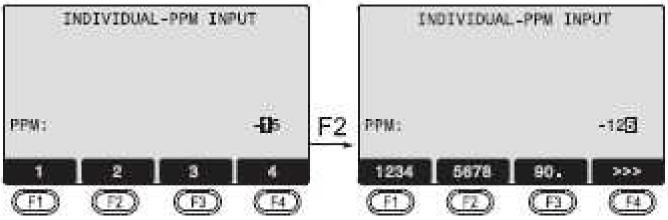
2. Pressing the navigation key deletes the relevant character.

3. Confirm input.

[ESC] Deletes the change and restores the previous value.

Inserting characters

If a character was skipped (e.g. -15 instead of -125) you can insert it later.



1. Place cursor on "1".
2. Inserts an empty character on the right of "1".
3. F1 - F3 Select range of characters /range of numbers.
4. F1 - F4 Select relevant character.
5. Confirm input.

Numerical and Alphanumerical input

Input is made with the softkey bar and the assigned function keys.

Position the marker in the relevant field.

[INPUT] 1. Calls up the input dialogue.

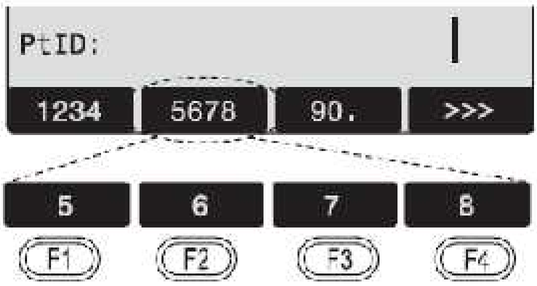
F1 F4 2. Select range of characters /range of numbers.

[>>>] Additional characters / numbers.

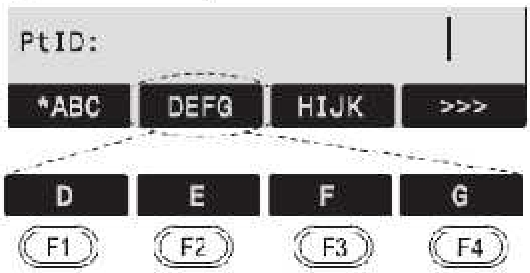
3. Confirm input.

Selection is limited to valid digits for entries, that due to their display characteristics, fall into a certain range (e.g. angles in degrees).

Numerical Input



Alphanumerical input



Pointsearch

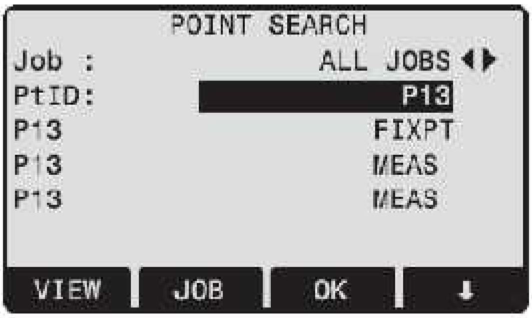
Pointsearch is a global function used by applications to e.g. find internally saved measured or fixed points.

It is possible for the user to limit the point search to a particular job or to search the whole storage.

The search procedure always finds fixed points before measured points that fulfil the same search criteria. If several points meet the search criteria, then the points are listed according to their age. The instrument finds the most current (youngest) fixed point first.

Direct search

By entering an actual point number (e.g. "P13") all points with the corresponding point number are found.



[VIEW] Displays the coordinates and the job of the selected point.

[ENH] For manual input of coordinates.

[OK] Confirm selected point.

[JOB] To select a different job.

Wildcard search

The Wildcard search is indicated by a "*". The asterisk is a place holder for any following sequence of characters.

Wildcards are always used if the point number is not fully known, or if a batch of points is to be searched for.

Starts point search.

Examples:

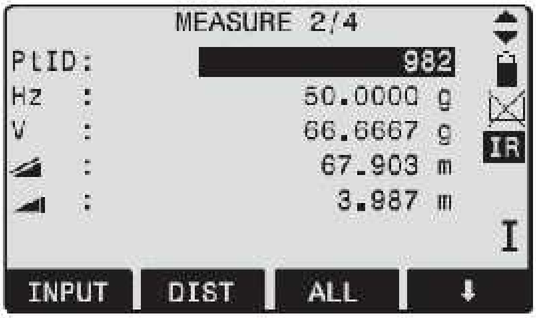
- * All points of any length are found.
- A All points with exactly the point number "A" are found.
- A* All points of any length starting with "A" are found (e.g.: A9, A15, ABCD).
- *1 All points of any length with a "1" as the second character are found (e.g.: A1, B12, A1C).
- A*1 All points of any length with an "A" as the first character and a "1" as the third character are found. (e.g.: AB1, AA100, AS15).

Measuring

After switching on and setting up correctly, the total station is immediately ready for measuring.
In the measurement display it is possible to call up fixed keys and function keys, as well as trigger keys and their functions.

☞ All shown displays are examples. It is possible that local software versions are different to the basic version.

Example of a possible measuring display:



F1 - F4 Calling up the assigned function

FNC Key

Under [FNC] several functions can be called up. Their applications are described below.

☞ Functions can also be started directly from the different applications.

☞ Each function from the FNC menu can be assigned to the [USER]-key (see chapter "Settings").

Light On /Off

Switches display light on / off.

Level/Plummet

This function enables the electronic bubble and the range of intensity settings of the laser plummet.

IR/ RL Toggle

Change between the two EDM types IR (on Reflectors) and RL (Reflectorless). New setting is displayed for about one second.

IR: Distance measurements with prisms.
RL: Distance measurements without prisms.
Find more information in chapter "EDM Settings".

Laser Pointer

Switches on or off the visible laser beam for illuminating the target point. The new settings are displayed for about one second and then saved.

Free-Coding

Starts "Coding" to select a code from a codelist or enter a new code. Some functionality like softkey button [CODE].

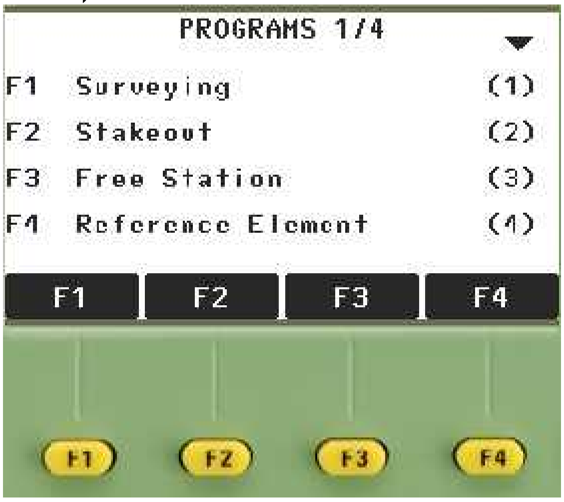
Units

Displays the current distance and angle unit and gives the possibility to change these.

BASIC STEPS INVOLVED IN SETTING UP A TOTAL STATION

1. SETTING UP TOTAL STATION OVER A POINT FOR THE FIRST TIME (Aligning to North)

1. Switch on the instrument.
2. Press USER key for Laser Beam for centering and leveling.
3. Press **MENU**.
4. Press **F1 (PROGRAMS)**.



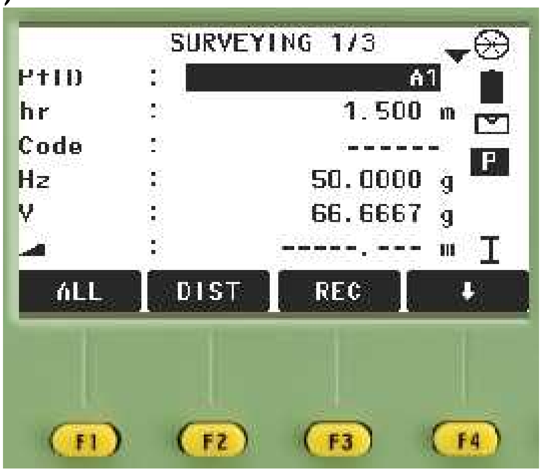
5. Press **F1 (SURVEYING)**.

6. Press **F1 (Set Job)**.

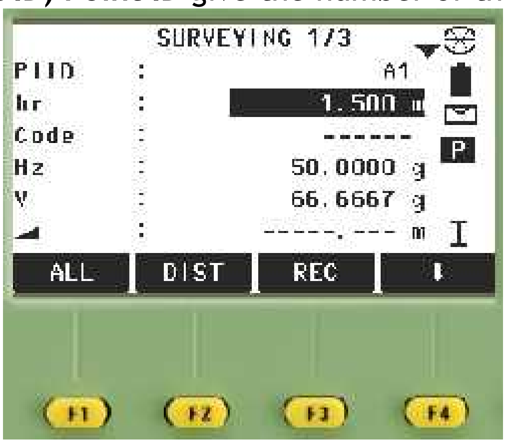
7. Press **F1 (NEW)** to give a new job name.

8. To write the name of the job. Press **F1 (INPUT)** and then using the Function keys **F1** to **F4** give the name. Then Press **Enter.**
9. Press **F4 (OK)**
10. Press **F2 (Set Station)** to give the station No. Press **F1 (INPUT)** to give the station number using the Function keys from **F1** to **F4**.
11. Press **F2 (FIND).**
12. Press **F4 (ENH).**
12. Enter the Easting, Northing and Elevation for the point and Press **F4 (OK)**
13. Now in front **of hi (Instrument Height)** give the height of the instrument.
14. Press **F4 (OK)**
14. Press **F3 (Set Orientation).**

15. Press **F1 (Manual Angle Setting).**
16. Point the instrument in the North direction and Press **F1 (Hz=0).**
17. Press **F3 (REC).**
18. Press **F4 (START).**



19. In front of the **(Pt ID) Point ID** give the number of the point to shoot.



20. In front of the **hr** (**Reflector height)** give the height to which the reflector is opened.

2. FOR SHIFTING THE STATION BY ALIGNING TO THE BACK POINT (Known Co-ordinates)

1. Switch on the instrument.
2. Press USER key for Laser Beam for centering and leveling.
3. Press **MENU.**
4. Press **F1 (PROGRAMS)**.
5. Press **F1 (SURVEYING)**.
6. Press **F2 (Set Station)** to give the station No.
7 In front of Station: Enter the Station Number where you are standing. **Press F1 (INPUT)** to give the station number using the Function keys from **F1** to **F4**.
Press **F2 (FIND)**.
8. Press **F4 (OK)**.
9. Now Give in front of **hi (height of Instrument)** and Press **F4 (OK).**
10. Press **F3 (Set Orientation)**.
11. Press **F2 (Coordinates)**.
12. In front of **BS (Back Sight)** give the number of the Back Point to which the Instrument is being aligned. By Pressing **F1 (INPUT)**
13. Press **F2 (FIND)**
14. Press **F4 (OK)**.
15. Press **PAGE**.
16. Now Sight the back point and Press **F1 (DIST).**
17 The value in front of Δ = will give the relative error in station shifting.
18. Press **F3 (REC).**
19. Now Press **F (OK)**.
20. Press **F4 (START)**
20. And we can continue with the surveying.
21. To see the Easting, Northing, and Elevation for a Point Press PAGE until you see East, North, Elevation.

EXERCISE 7

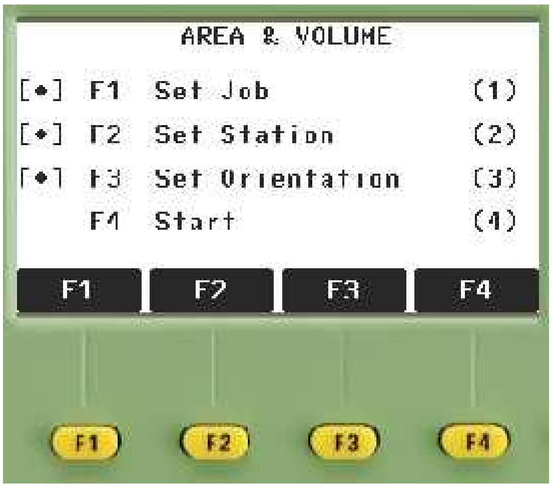
DETERMINATION OF AREA USING TOTAL STATION

Aim:
To determine area of a piece of land using Total Station.

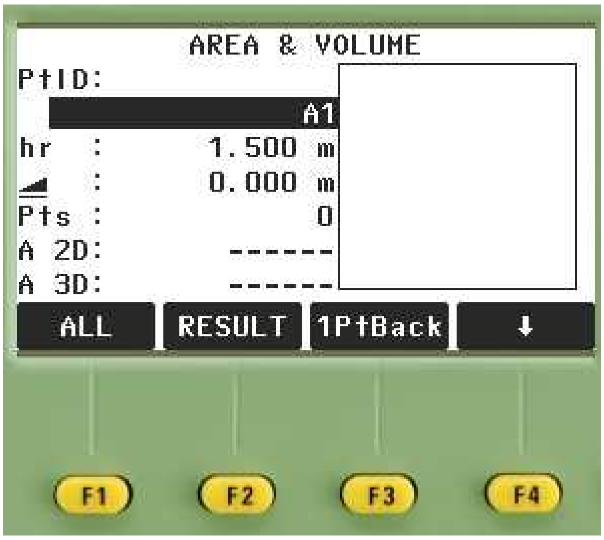
Equipment:
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows
5. Field Book

Procedure:
1) Using arrows mark the corners of the land whose area is to be found.
2) Choose a point for the Total station set up such that from this point all the points marked in step 1 are visible and set up the station on this point.
3) Press MENU.
4) Press F1 (Programs).
5) Press PAGE.

6) Press F2 (Area).



7) The First three steps (F1, F2 and F3) for station setup and orientation (refer to Step1 and Step 2).
8) Press F4 (Start).



The points whose area is to be found can be either in the memory or can be shot directly in the field.

9) In front of Point ID Enter the number of the first point, then sight the point by keeping the reflector on that point. Press F1 (ALL) or press the trigger.

10) Repeat step 9 for the remaining points in a proper sequence until you have shot all the points. Once you have shot all the point you can see the area displayed on the screen automatically.

Result:

The area of the given piece of land is, A =

Comments/Inference:

Write your comments and observations on the result obtained.

Applications:

In cadastral surveys it is required to make a plan of land showing all its boundaries and also obtain its area. This information about the land is useful for land development and selling and purchase of land.

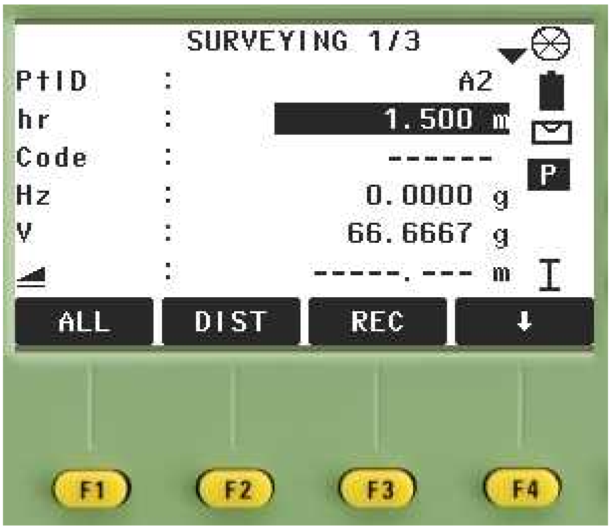
EXERCISE 8

TRAVERSING USING TOTAL STATION

Aim:
To do a closed traversing for at least five points using Total Station.

Equipment:
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows
5. Field Book

Procedure:
1. Identify the points on the ground for traversing and mark them arrows.
2. Choose a control point for using it as first station point such that at least one control point for back-sight is visible
3. Set up the instrument on the point chosen in step 2.
4. **Press** MENU
5. **Press** F1 (Programs)
6. **Press** F1 (Survey).
7. **For Setting up the job as you know the coordinates of two control points on the paper follow the following steps.**
8. **Press** F1 (Set Job).
9. **Press** F1 (New).
10. **Enter the New Job Name by pressing** F1 (Input).
11. **Give the name of the job by using the Function key** F1 to F4.
12. **Press** F4 (OK).
13. **Press** F2 (Set Station).
14. **In front of the station give the number of the station by giving the number of the station where you are standing.**
15. **Press** F2 (FIND).
16. **Press** F4 (ENH).
17. **Enter the** Easting, Northing and Elevation **of the point where you are standing.**
18. **Press** F4 (OK).
19. **In front of** hi (height of the Instrument) **Enter the Instrument height by measuring it.**
20. **Press** F3 (Set Orientation).
21. **Press** F2 (Coordinates).
22. **In front of BS (Back Sight) Enter the number of the back sight point to which you are aligning.**
23. **Press** F4 (ENH).
24. **Press** F4 (OK).
25. **Press** PAGE.
26. **Press** F4 **until you have** DIST **In front of** F1.
27. **The value in front of gives the relative error in the station shifting.**
28. **Press** F2 (REC).
29. **Press** F4 (NO).
30. **Press** F4 (Start).



31. Take foresight on first traverse point enter point ID and record its coordinates. (This point will be the next instrument station)
32. Shift the instrument to first traverse point and follow the standard procedure to obtain the coordinates of second traverse point.
33. Continue until you finish all traverse points.
34. Check whether there is any closing error. If it is there apply corrections to the coordinate and plot the traverse.

(If you are using advanced instruments closing error will be shown automatically in traverse report and traverse can be adjusted on board)

Result:

Record the coordinates obtained for each point in your field book. If there is a closing error apply correction to all the coordinates. Plot the survey on a drawing sheet using the corrected coordinates.

Comments/Inference:

Write your comments and observations on the result obtained.

Applications:

In control surveys and topographical surveys it is required to do traversing. In control surveys, using the existing control points it is required to establish new control points. In topographical surveys using the existing control points and also by establishing new control points it is required obtain the coordinates of various details like buildings, roads and other features.

EXERCISE 9

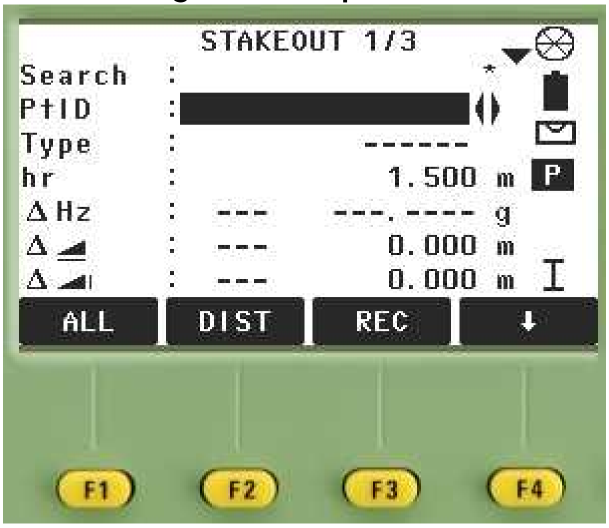
CONTOURING USING TOTAL STATION

Aim:
To prepare Contour map of an area using Total Station

Equipment:
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows
5. Field Book

Procedure:
1. Obtain the coordinates of all the grid points and record them in your field book
2. Choose a control point from where all the grid points and at least one control point for back-sight are visible.
3. Set up the instrument on the point chosen in step 2.
4. **Press** MENU
5. **Press** F1 (Programs)
6. **Press** F2 (Stake Out).
7. **For Setting up the job as you know the coordinates of two control points on the paper follow the following steps.**
8. **Press** F1 (Set Job).
9. **Press** F1 (New)**.**
10. **Enter the New Job Name by pressing** F1 (Input).
11. **Give the name of the job by using the Function key** F1 to F4.
12. **Press** F4 (OK).
13. **Press** F2 (Set Station)**.**
14. **In front of the station give the number of the station by giving the number of the station where you are standing.**
15. **Press** F2 (FIND).
16. **Press** F4 (ENH)**.**
17. **Enter the** Easting, Northing and Elevation **of the point where you are standing.**
18. **Press** F4 (OK).
19. **In front of** hi (height of the Instrument) **Enter the Instrument height by measuring it.**
20. **Press** F3 (Set Orientation).
21. **Press** F2 (Coordinates).
22. **In front of BS (Back Sight) Enter the number of the back sight point to which you are aligning.**
23. **Press** F4 (ENH).
24. **Press** F4 (OK).
25. **Press** PAGE.
26. **Press** F4 **until you have** DIST **In front of** F1.
27. **The value in front of gives the relative error in the station shifting.**
28. **Press** F2 (REC).
29. **Press** F4 (NO).

30. **Press** F4 (Start).
31. **Press** F4 **until you have** MANUAL **in front of** F3**.**
32. **Enter** East, North **and** Height **for the point to be staked.**



33. Now Move the Instrument until Hz equal to zero.
34. Now move the prism in this line of sight to the distance given in front of Δ : --- 0.000 m from the instrument station.
35. Now with moving the instrument horizontally with moving the telescope up and down only tell the prism man to come in line of sight of that point. Again Press F2 (DIST) do this until the value comes near to the limiting factor and you have the point. Then press All or trigger button to record the point.
36. For the next point again Press F4 until you have manual in front of F3 and again enter the coordinates of the next point to be staked repeat this process for all the points.
37. You can view x, y, z coordinates all the points in file management.

<u>Result:</u>
Record the coordinates of all the points surveyed in your field book and using this data create a contour map of the area surveyed.

<u>Comments/Inference:</u>
Write your comments and observations on the result obtained.

<u>Applications:</u>
In topographical surveys, it is required to obtain contour maps/ plans of an area. Contour maps are useful in planning and construction of pipeline works, road works and residential colonies etc.

EXERCISE 10

DETERMINATION OF REMOTE HEIGHT USING TOTAL STATION

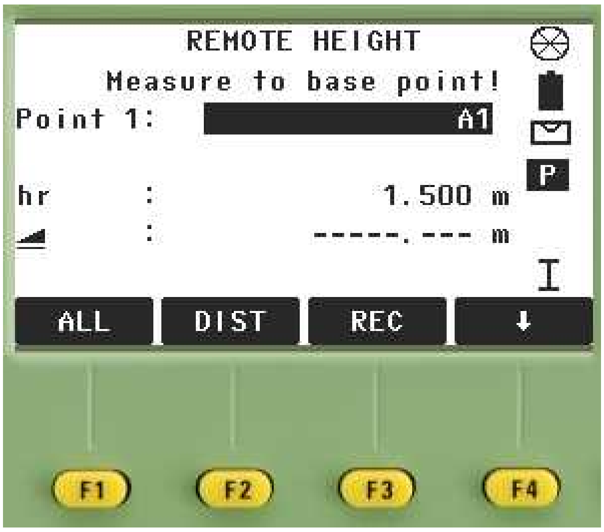
Aim:
To determine remote height of a point using Total Station.

Equipment:
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows
5. Field Book

Procedure:
The Remote height program is used to find the elevation of the remote points where it is possible to place the prism directly below the point the point whose remote elevation is to be found.

1. Identify the point whose elevation has to found out
2. Choose a point for the Total station set up such that from this point both the point under consideration and its projection on the ground are visible, then set up the station over this point.
3. Press MENU.
4. Press F1 (Programs).
5. Press PAGE button.

6. Press F3 (Remote Height).
7. **The First three steps (F1, F2 and F3) for station setup and orientation (refer to Step1 and Step 2).**
8. Press F4 (Start).



9. Focus on the required point and turn telescope towards ground and guide the prism man for properly placing the prism on the ground.
10. Now put the prism on the base point and Sight it and press F3 (ALL).
11. Now move the telescope and focus the top point whose elevation is to be found.
12. The height value will be displayed on the screen.

Result:
The remote height of a point, h =

Comments/Inference:
Write your comments and observations on the result obtained.

Applications:
In construction of structures like buildings and bridges etc., it is required to find height of some points which are difficult to access.

EXERCISE 11

SETTING OUT USING TOTAL STATION

Aim:
To set out column centres of a proposed building.

Equipment:
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows
5. Field Book

Procedure:
1. Obtain the coordinates of all the column centers.
2. Choose a control point from where all column positions and at least one control point for back-sight are visible.
3. Set up the instrument on the point chosen in step 2.
4. **Press** MENU
5. **Press** F1 (Programs)
6. **Press** F2 (Stake Out).
7. **For Setting up the job as you know the coordinates of two control points on the paper follow the following steps.**
8. **Press** F1 (Set Job).
9. **Press** F1 (New).
10. **Enter the New Job Name by pressing** F1 (Input).
11. **Give the name of the job by using the Function key** F1 to F4.
12. **Press** F4 (OK).
13. **Press** F2 (Set Station).
14. **In front of the station give the number of the station by giving the number of the station where you are standing.**
15. **Press** F2 (FIND).
16. **Press** F4 (ENH).
17. **Enter the** Easting, Northing and Elevation **of the point where you are standing.**
18. **Press** F4 (OK).
19. **In front of** hi (height of the Instrument) **Enter the Instrument height by measuring it.**
20. **Press** F3 (Set Orientation).
21. **Press** F2 (Coordinates).
22. **In front of** BS (Back Sight) **Enter the number of the back sight point to which you are aligning.**
23. **Press** F4 (ENH).
24. **Press** F4 (OK).
25. **Press** PAGE.
26. **Press** F4 **until you have DIST In front of F1.**
27. **The value in front of gives the relative error in the station shifting.**
28. **Press** F2 (REC).
29. **Press** F4 (NO).
30. **Press** F4 (Start).

31. **Press** F4 **until you have MANUAL in front of F3.**
32. **Enter** East, North **and** Height **for the point to be staked.**

33. **Now Move the Instrument until** Hz **equal to zero.**
34. **Now move the prism in this line of sight to the distance given in front of** Δ : --- 0.000 m **from the instrument station.**
35. **Now with moving the instrument horizontally with moving the telescope up and down only tell the prism man to come in line of sight of that point. Again Press F2 (DIST) do this until the value comes near to the limiting factor and you have the point.**
36. **For the next point again Press** F4 **until you have manual in front of F3 and again enter the coordinates of the next point to be staked repeat this process for all the points.**

<u>Result:</u>
Record the details of points set out in your field book.

<u>Comments/Inference:</u>
Write your comments and observations on the result obtained.

<u>Applications:</u>
In setting out a building, a surveyor has to set out position of columns and other elements of the building in both horizontal and vertical planes.

EXERCISE 12

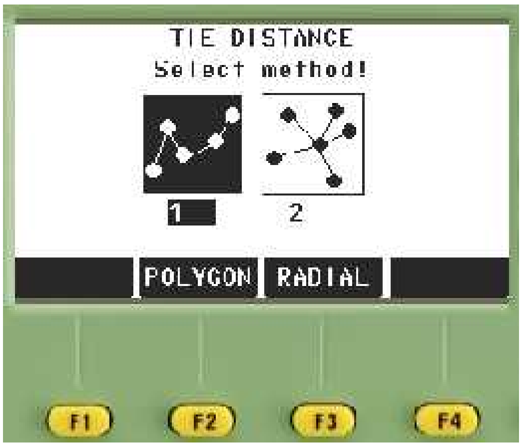
DISTANCE, GRADIENT AND DIFFERENCE OF HEIGHT BETWEEN TWO INACCESSIBLE POINTS USING TOTAL STATION.

Aim:
To obtain the distance, gradient and difference of height between two in accessible points using the Total Station.

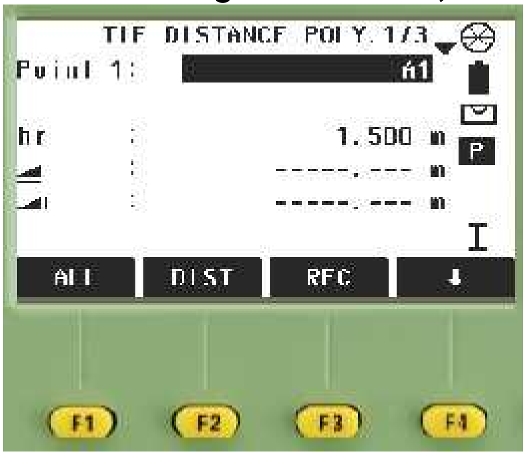
Equipment:
1. Total Station
2. Tripod
3. Prism and Pole
4. Field Book

Procedure:
The Tie Distance Program is used to find the horizontal distance between two points by measurement in the field.
1. **Identify the two points for measuring the distance.**
2. **Choose a point for the Total station set up such that from this point the two points marked in step 1 are visible and set up the station on this point.**
3. **Press** MENU.
4. **Press** PAGE.

5. **Press** F1 (Tie Distance).
6. The First three steps (F1, F2 and F3) for station setup and orientation (refer to Step1 and **Step 2).**
7. **Press F4 (Start).**
8. **There are two type of distance Polygonal and Radial.**



9. **The Polygonal is the point-to-point distance where as the Radial is used for finding the distance from a single point being kept fixed.**
10. **When the Points are not in memory and you want to operate the program by taking the measurements right in the field,**



11. **In front of the point enter the number of the point and Press** F3 (ALL).
12. **In front of the point2 Enter the number of the second point again sight it and press** F3 (ALL).
13. **Now you can see the results displayed on the screen.**

Result:

The distance (d), gradient (s) and difference of height (h) between two in accessible points are, d = , s = , h =

Comments/Inference:

Write your comments and observations on the result obtained.

Applications:

In topographical surveys, some times features like buildings etc. are not accessible. Therefore a surveyor should be familiar with the technique of obtaining the horizontal distance, difference in height and hence the gradient between two inaccessible points.