CIVIL ENGINEERING DEPARTMENT

LABORATORY MANUAL

SURVEYING

B.E. – II (3^{RD} SEMESTER)

Shantilal Shah
Enginnering College

NAME: ____________________

SEMESTER & CLASS: ____________________

ENROLMENT NO. ____________________ ACADEMIC YEAR: ____________________

SHANTILAL SHAH ENGINEERING COLLEGE, BHAVNAGAR

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EXPERIMENT NO.:- 1 DATE:

PLANE TABLE SURVEYING

Objective: Locating a building by plane table.

Instruments:

- The plane table with tripod
- Measuring Tape
- Peg
- Ranging rod
- Hammer

Accessories:

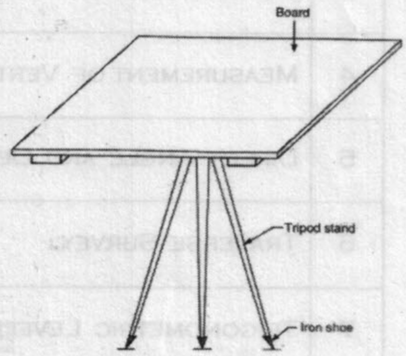
- Alidade
- Spirit Level
- Plumbing fork (U-fork)
- Trough compass
- Drawing paper

Introduction:

The system of surveying in which field observation and plotting work i.e. both are done simultaneously is called plane table surveying. It is particularly adopted for small scale or medium scale mapping in which great accuracy in the details is not required.

Plane Table:

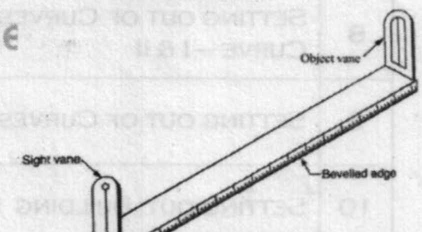
The drawing board made of well-seasoned wood such as teak or pine which is used for the purpose of plotting is called plane table. It is available in sizes 500 x 400 x 15 mm, 600 x 500 x 15 mm and 750 x 600 x 20mm. The top surface of board is perfectly plane and to the underneath it is fitted with a leveling head or ball and socket arrangement. The table is mounted on a tripod by means of a central screw with a wing nut or in such a manner so that the board can be revolved, leveled and clamped in any position.



Plane table with stand

Alidade:

An alidade is a straight edge ruler having some sighting device. It is used for sighting the object and drawing rays. Alidades are of two types: (1) Plain alidade, (2) Telescopic alidade.

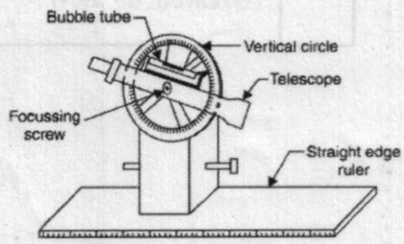


Plain Alidade

Plain alidade is a ruler of about 450mm long and made of metal of wood. Both the edges are beveled and graduated. Sight vane is provided with narrow slit and object vane is provided with a horse hair. The vanes, when unfolded, are perpendicular to ruler.

The beveled graduated edge is known as the fiducial edge.

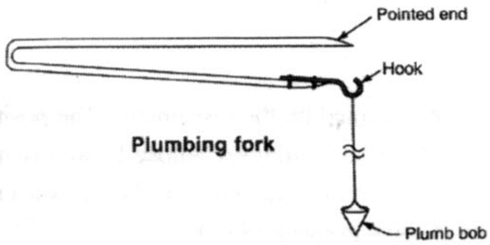
Telescopic alidade is provided with a telescope to take inclined sights and accuracy of sighting. It is also provided with graduated circle to measure vertical angle of the sight.

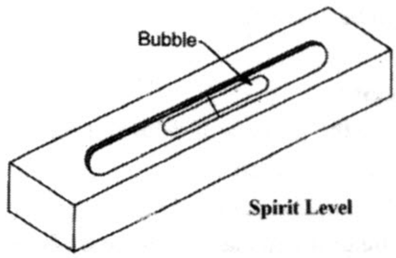


Telescopic Alidade

PLANE TABLE SURVEYING

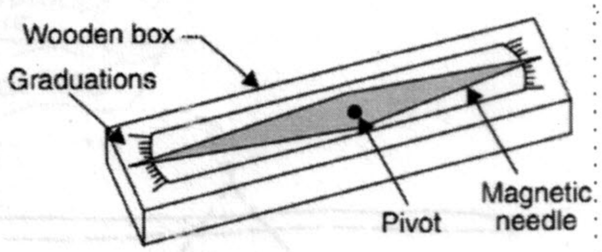
Spirit Level:
A small sprit level circular or rectangular is required for seeing if the table is properly level. The spirit level must have flat base so that it can be placed on the table. The bubble is visible on the top with graduated glass tube. Leveling is checked by placing the level tube on the board in two positions at right angle to each other.





Plumbing Fork:
The plumbing fork to which is attached a plumb bob, is used for centering the plane table over the station i.e. for transferring the ground point on to sheet, so that both the points should be in the same vertical line. It consists of two light metal arms as shown in fig. approximately of equal lengths. A hook for suspending a plumb bob is provided at the lower arm. The upper arm is placed on the plane table while the lower arm with a plumb bob is moved below the table for centering over the station mark, thus upper arm will give the corresponding position on the paper.

Trough Compass:
The compass which is used to mark the direction of the magnetic meridian on the plane table is called trough compass. Centre of the box is provided a magnetic needle. The trough compass has graduated scales at the end are with zero degree at the center and up to 5° on either side of the zero line.



Methods of Plane table survey:

A) **Radiation method:**
This method is suitable for locating the object from a single station. In this method, rays are drawn from the station to the objects, and the distance from the station to the object is measured and plotted to any suitable scale along the respective rays.
This method is suitable when the area is small and all the objects are visible from the instrument station.

B) **Intersection method:**
In this method, two stations are selected so that they are visible from each other. The line joining the two stations is called base line. The length of the lines joining the two stations should be very accurate. Rays are drawn from these two stations to the visible but inaccessible object. The intersection of these two rays gives the position of the object or station.
This method is suitable when stations or objects are inaccessible but visible.

PLANE TABLE SURVEYING

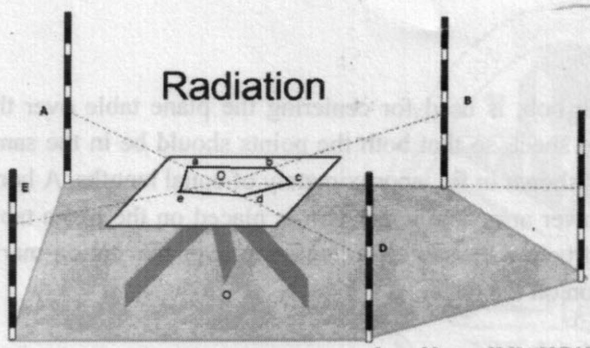
C) Traversing:

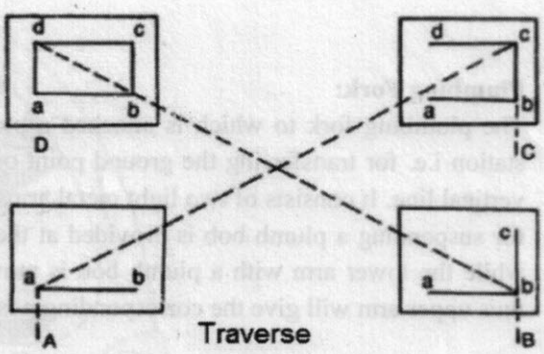
This method works on a principle of traversing. This method is widely used to lay down survey lines between the instrument stations and of a closed or open traverse. Fielding and plotting is done simultaneously with the help of above two methods.

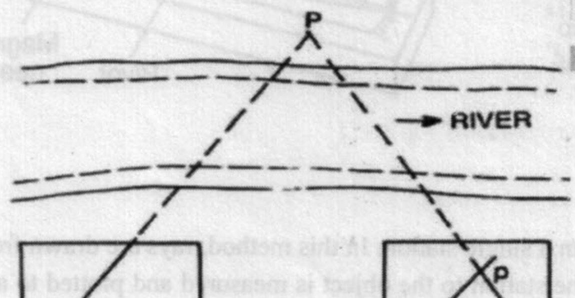
This method is suitable for connecting the traverse station. It is most suitable when a narrow strip of terrain is to be surveyed.

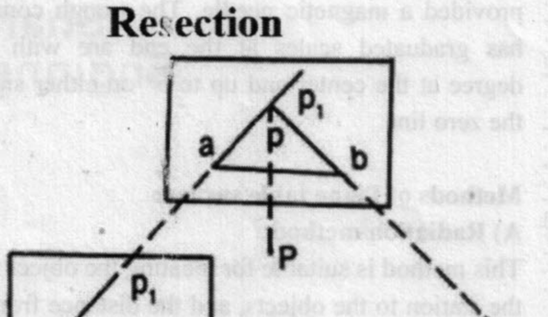
D) Resection:

It is used for the process of determining the location of station occupied by the instrument. The position of the station occupied by the plane table is located with reference to stations whose locations have been plotted on the paper. The resection of two rays will be the point representing the station to be located. The problem can be solved by back ray, two points or three points problem.









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EXPERIMENT NO.:- 2 DATE:

TRANSIT VERNIER THEODOLITE

Objective: To study Transit vernier theodolite and operation of theodolite.

Instruments:

- Transit vernier theodolite with stand

Introduction:

The theodolite is the most intricate and accurate instrument used for measurement of horizontal and vertical angles. It has wide applicability in surveying such as laying off horizontal angles, locating points on a line, prolonging survey lines, establishing grades, determining difference in elevation, setting out curve, etc.

The essential parts of the theodolite are shown in fig of transit vernier theodolite.

Equipment Parts:

Leveling Head:

It consists of two parallel triangular plates called trivet and tribrach. Its uses are: 1) To support the main part of the instrument, 2) To attach the theodolite to the tripod, (3) To get the theodolite in level.

Lower Plate:

It is an annular horizontal plate with a beveled graduated edge. Graduations are provided from 0° to 360° in a clockwise direction. The diameter of the plate is used to designate theodolite i.e. 100mm theodolite.

Upper plate:

It is a horizontal plate of smaller diameter attached to a solid, vertical spindle. The beveled edge of the plate consists of two verniers on diametrically opposite parts of the circumference.

Foot screw:

They are used to level the instrument.

Equipment Terms:

Temporary Adjustments:

(1) Setting and centering up of the instrument:

Setting up a tripod approximately level and centering the instrument over a station point.

(2) Leveling up:

Accurate leveling of the instrument is carried out by foot screws.

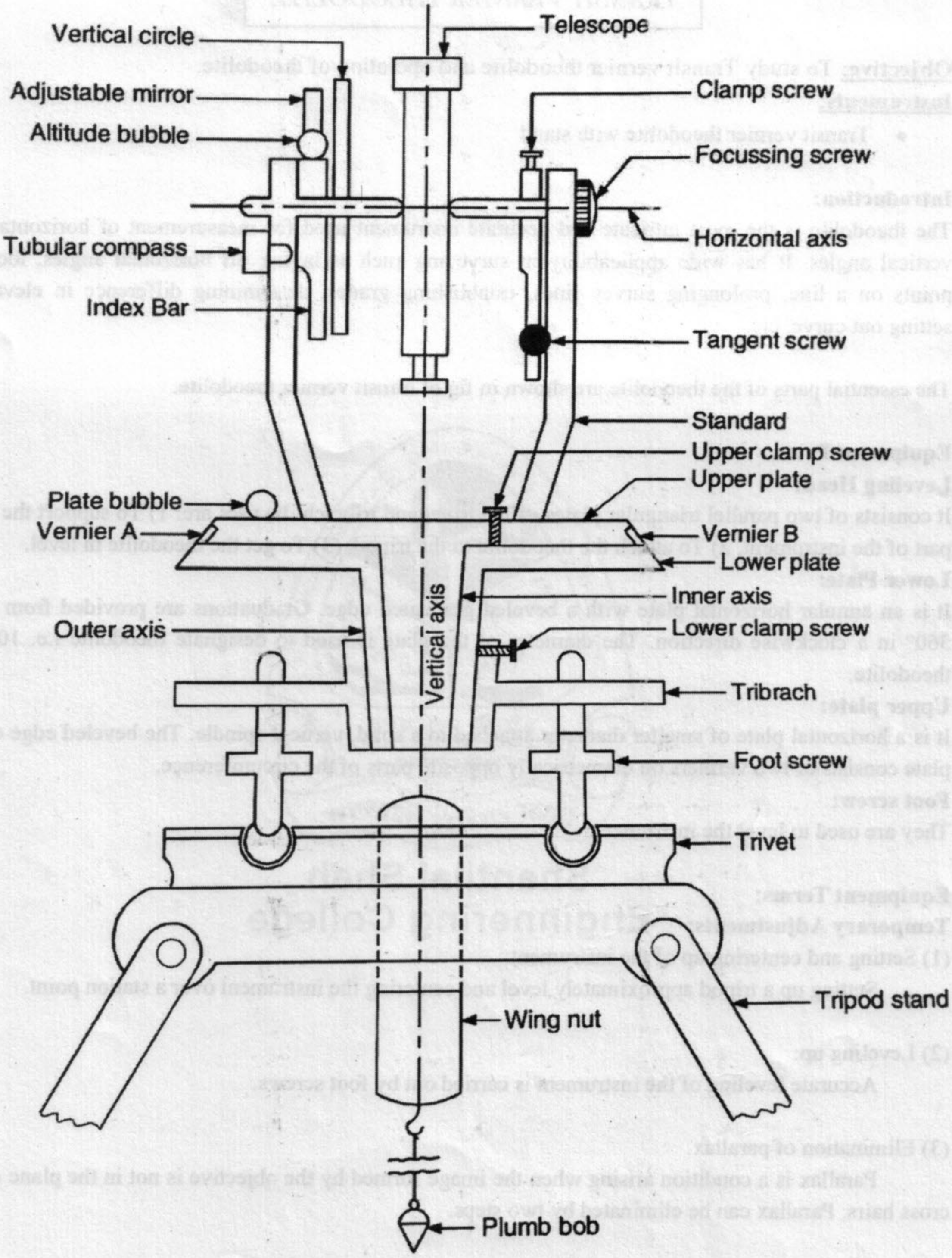
(3) Elimination of parallax.

Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. Parallax can be eliminated by two steps.

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

(b) Focusing the object: Telescope is now turned towards object to be sighted and the focusing screw is turned until image appears clear and sharp.

TRANSIT VERNIER THEODOLITE



Different parts of Transit Vernier Theodolite

Grade: Signature

EXPERIMENT NO.:- 3 DATE:

Measurement of Horizontal Angle

Objective: To measure horizontal angles by theodolite.

Instruments:

- Transit vernier theodolite with stand
- Wooden peg
- Plumb bob
- Ranging rod
- Hammer

Introduction:

Two methods are used to measure horizontal angle between two lines.

(A) Repetition Method

(B) Reiteration Method

For more precise work, angles are taken repeatedly with both the faces of the instrument.

A. Repetition Method:

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 to zero when sighting the previous station.

Procedure:

1. Let POR is the horizontal angle to be measured between the lines OP and OR with center 'O'.
2. After temporary adjustments with normal position of the theodolite, bisect the object 'P' accurately after setting the 0° reading on vernier 'A'. Note the reading of vernier at 'B'. (Both screws in locked position)
3. Unlock the upper clamp and swing the instrument in clockwise towards 'R'. Lock the upper clamp and bisect accurately with upper tangent screw.
   Note the reading of verniers 'A' and 'B' to get approximate value of an angle.
4. Unlock the lower clamp (with locked upper clamp) and swing the telescope to bisect the point 'P' again, accurately by lower tangent screw. (Note that vernier reading should not differ)
5. Unlock the upper clamp and swing the instrument towards 'R' again and make accurate bisection with upper tangent screw.
   Note the reading of verniers 'A' and 'B'.
6. Repeat the procedure until the required repetition is achieved. (Usually min.3)
   The average of the repetitions of the angles will give the accurate measurement.
7. Repeat steps (1) to (6) for the face right position of the instrument.
8. The average reading of both instrument facing is taken as the final value of an angle 'POR'.

Any number of repetitions may be made. However three repetitions in each face of instrument is sufficient and desirable.

B. Reiteration Method:

The method is also known as method of series is suitable for the measurements of the angle of group having a common vertex point or several angles are to be measured at a same station. In this method all angles are measured successively so that the final reading at the vernier 'A' should be same as its initial reading

Observation Table (Repetition method)

Instrument Station	Sighted to	Face : Left						Swing : Right			Horizontal Angle	Instrument Station	Sighted to	Face : Right						Swing : Right			Horizontal Angle	Average Horizontal Angle
		Vernier- A			Vernier- B			Mean						Vernier- A			Vernier- B			Mean				
		°	′	″	°	′	″	°	′	″				°	′	″	°	′	″	°	′	″		

Observation Table (Reiteration method)

Instrument Station	Sighted to	Face : Left									Swing : Right			Correction	Corrected Horizontal Angle		
		Vernier- A			Vernier- B			Mean			Horizontal Angle						
		°	′	″	°	′	″	°	′	″	°	′	″		°	′	″

Instrument Station	Sighted to	Face : Right									Swing : Right			Correction	Corrected Horizontal Angle			Average Horizontal Angle
		Vernier- A			Vernier- B			Mean			Horizontal Angle							
		°	′	″	°	′	″	°	′	″	°	′	″		°	′	″	

Measurement of Horizontal Angle

Procedure:

1. Let POQ, QOR, ROS, SOP are the angles to be measure.
2. Set the instrument over the center 'O'. Set vernier 'A' to zero and bisect 'P' accurately.
3. Unlock the upper clamp and swing the telescope to bisect next point in clockwise direction, say 'Q'. Bisect accurately with tangent screw.
   Note the reading on vernier 'A' and 'B'. This will be the angle between POQ.
4. Repeat the process to bisect R without changing the preceding angle. Similarly, repeat the process for stations S, and P closing the circle.
   Note each angle at each bisection from the center 'O' successively.
5. At final sighting of 'P', the readings on vernier should be the same as the original setting at starting.
6. Repeat the process with the inverted position of the instrument.

Results:

Conclusion:

Grade:

Signature

EXPERIMENT NO.:- 4 DATE:

Measurement of Vertical Angle

Objective: To measure vertical angles by theodolite.

Instruments:

- Transit vernier theodolite with stand
- Wooden peg
- Plumb bob
- Ranging rod
- Hammer

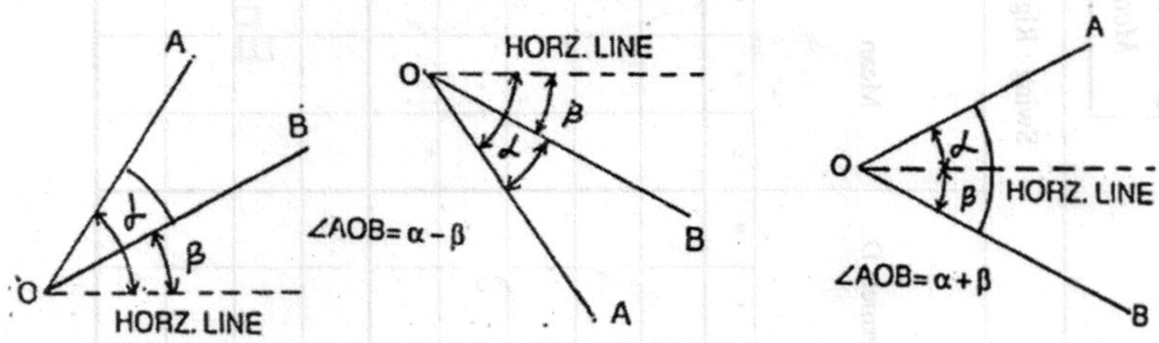
Introduction:

Vertical angle is the angle which the inclined line of sight to an object makes with the horizontal. It may be an angle of elevation or angle of depression. To measure vertical angle, the instrument should be leveled with reference to altitude bubble.

Procedure:

1. After temporary adjustments with normal position of the theodolite, further level the instrument with respect to the altitude level fixed on the index arm.
2. Loose the vertical circle clamp and rotate the telescope in vertical plane to sight the object. Use vertical circle tangent screw for accurate bisection.
3. Read both verniers of vertical circle. The mean of the two gives the vertical circle.
4. Similar observation with another face is made. The average of the two will give the required angle.

If the points lie on same side (either above or below) of the horizontal plane, the vertical angle between the points is the difference between the measured angles. If they lie on either side (above and below) of the horizontal plane, the vertical angle between the points is the sum of the angles measured.



Results:

Measurement of Vertical Angle

Instrument Station	Sighted to	Face : Left						Swing : Right			Vertical Angle
		Vernier- C			Vernier- D			Mean			
		°	′	″	°	′	″	°	′	″	

Instrument Station	Sighted to	Face : Right						Swing : Right			Vertical Angle	Average Vertical Angle
		Vernier- C			Vernier- D			Mean				
		°	′	″	°	′	″	°	′	″		

Grade:

Signature

EXPERIMENT NO.:- 5 DATE:

Direct Angle and Deflection Angle

Objective: To measure direct angles and deflection angle between given lines.

Instruments:

- Transit vernier theodolite with stand
- Wooden peg
- Plumb bob
- Ranging rod
- Hammer

Introduction:

Direct angles are the angles measured clockwise from the preceding (previous) line to the following line. They are also known as angles to the right or azimuths from the back line and may vary from 0° to 360°.

Direct angles are used in open traverse.

A Deflection angle is the angle which a survey line makes with the prolongation of the preceding line. It is designated as right and Left according to as it is measured to the clockwise or anti-clockwise from the prolongation of the previous line. Its value may vary from 0° to 180°.

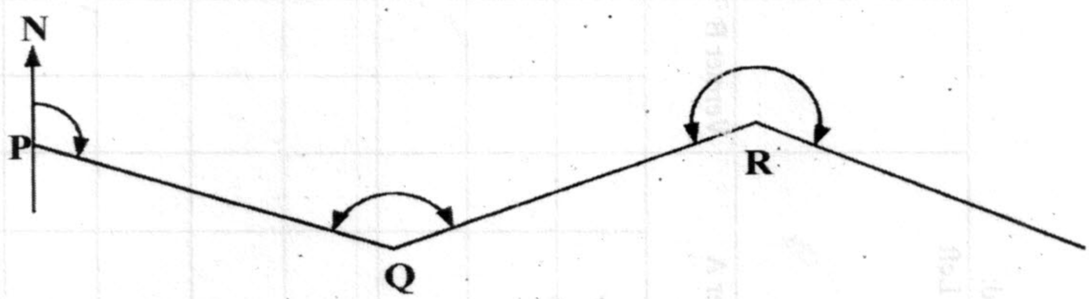
Deflection angles are used in open traverse. Generally for the surveys of Rivers, Coast lines, Roads, Railway lines, etc.

Direct Angle:

Procedure:

1. Set up the instrument at starting station P. Perform leveling procedure.
2. Bisect next station Q and measure the bearing of line PQ. Take same angle two times by repetition method. Change the face and again measure angles.
3. Shift the instrument to station Q, setup and level accurately. Set the vernier P to zero.
4. Unclamp lower clamp and sight preceding station P.
5. Unclamp upper clamp and bisect next station R by swinging the instrument in clockwise direction. Measure the angle on both verniers by repetition method. Change the face and again measure angles.
6. Likewise determine all the other angles by repeating above procedure.

Note: Don't forget to Change the face of the instrument at each station



Direct Angle and Deflection Angle

Direct Angle Method:

Instr. At	Sighted to	Face : Left				Face: Right				Average Horizontal Angle
		Vernier A	Vernier B	Mean	Horizontal Angle	Vernier A	Vernier B	Mean	Horizontal Angle	

Direct Angle and Deflection Angle

Deflection Angle Method:

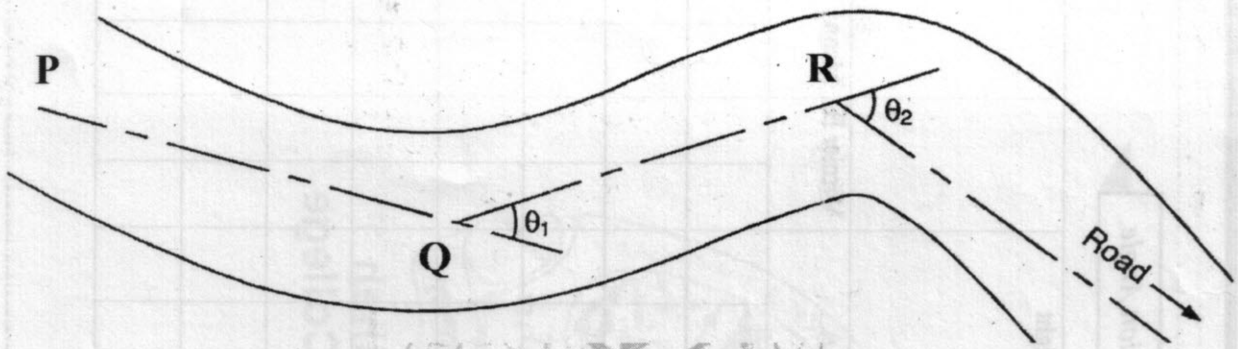
Instr. At	Sighted to	Face : Left				Face: Right				Average Horizon Angle
		Vernier A	Vernier B	Mean	Horizontal Angle	Vernier A	Vernier B	Mean	Horizontal Angle	

Direct Angle and Deflection Angle

Deflection Angle:

Procedure:

1. Set the instrument at starting station P. Level it. Bisect Q and measure bearing of line PQ as usual. Plunge the instrument and,
2. Shift the instrument at next station Q, with 0° at vernier A, bisect preceding point P. Now transit the telescope and bisect next station R by rotating instrument in anti-clockwise direction. Take the measurement on verniers A & B. This will give deflection angle of line QR.
3. Repeat the procedure for next lines.



Results:

Direct Angle:

Deflection Angle:

Grade: Signature

EXPERIMENT NO.:- 6 DATE:

Traverse Survey

Objective: To conduct traverse survey with theodolite.

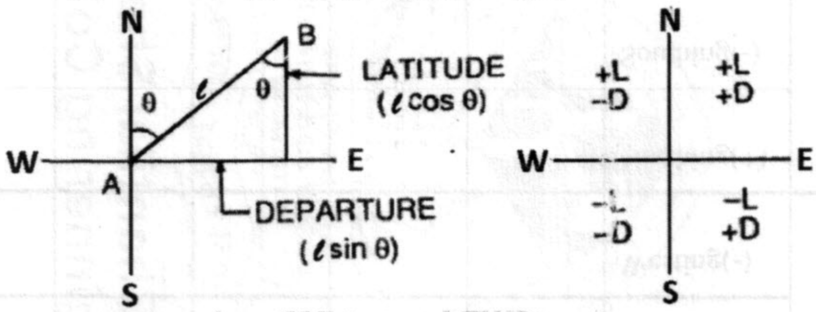
Instruments:

- Transit vernier theodolite with stand
- Wooden peg
- Plumb bob
- Ranging rods
- Hammer

Introduction:

A traverse is a series of connected lines whose lengths and directions are measured in field. Traversing is done by five methods: (i) Fast angle method, (ii) Loose needle method, (iii) Included angle method, (iv) Direct angle method, (v) Deflection angle method. The first three methods are used for closed traverse and later two are used for open traverse.

The theodolite traverse is not plotted according to interior angles or bearings. It is plotted by computing the latitudes and departures of the points (consecutive coordinate) and then finding the independent coordinates of the points.



Procedure:

(1) Reconnaissance: The area to be surveyed is first examined to decide the best positive way of starting work. It should be remembered that the traverse legs should pass through fairly level ground.

(2) Marking the stations: The traverse stations are marked on the ground by wooden pegs. Reference sketches should be made so that stations may be located even if the station pegs are removed.

(3) Measurements of interior angles: The interior angles of the traverse are measured by the method of measuring horizontal angles. The lengths of the traverse legs are measured accurately and so is the magnetic bearing of the line. All these measurements are entered into the traverse table.

(4) Magnetic bearing: The tubular compass is attached to the left hand standard. Then the telescope is swing in clockwise or anti-clockwise direction until the needle of the compass coincides with 0°0′ mark. Then the vernier reading is taken that gives the magnetic bearing.

Closing Error:

In a closed traverse the algebraic some of latitudes and departures must be equal to zero.

But due to the errors in the field measurements, sometimes finishing point may not coincide with the starting point of a closed traverse. The distance by which a traverse fails to close is known as closing

Traverse Survey

					Consecutive coordinates													
					Latitude		Departure		Corrections				Corrected Consecutive Coordinates				Independent Coordinates	
Inst. Station	Line	Length	WCB	RB	Northing(+)	Southing(-)	Easting(+)	Westing(-)	Northing(+)	Southing(-)	Easting(+)	Westing(-)	Northing(+)	Southing(-)	Easting(+)	Westing(-)	Northing(+)	Southing(-)

Traverse Survey

Calculations:

Examples:

- Prepare Gale's Traverse table to adjust the closing error of the closed traverse ABCDA for following data

Line	AB	BC	CD	DA
Length (M)	110	80	95	160
Corrected W.C.B	110°	170°	250°	350°

- The survey data of a traverse are given in table below. The length and bearing of line DA were not recorded during survey. Find the missing measurements.

Line	AB	BC	CD	DA
Length (M)	201.8	288.4	192.6	?
Corrected W.C.B	N45°0′W	N60°30′W	S34°45′W	?

- The latitude and departures of the lines of a closed traverse are given below. Calculate the area of traverse by Co-ordinates method and Meridian distance method.

Line	Northing	Southing	Easting	Westing
AB	-	157.20	154.80	-
BC	210.50	-	52.50	-
CD	175.40	-	-	98.30
DA	-	228.70	-	109.0

Grade: Signature

EXPERIMENT NO.:- 7 DATE:

Trigonometric Leveling

Objective: To determine reduce levels of various points using trigonometric leveling.

Instruments:

- Transit vernier theodolite with stand
- Leveling Staff
- Plumb bob
- Hammer
- Ranging rods
- Metallic Tape
- Wooden peg

Introduction:

Trigonometric leveling is the process of determining the differences in elevations of stations from observed vertical angles and horizontal distances.

Depending upon horizontal distance between stations, trigonometric leveling can be subdivided into two types: (i) Plane Trigonometric Leveling, (ii) Geodetic Trigonometric Leveling

Trigonometric leveling is not as accurate as direct leveling. It is generally used in topographic work and in very rugged terrains where direct leveling is difficult.

Procedure: (Case-1 When base of the object is accessible.)

(1) Setup the theodolite at P and level it with respect to altitude bubble.

(2) Bisect top point R of the object at Q accurately. Read the vertical angle at both the verniers C & D and compute the average vertical angle α.

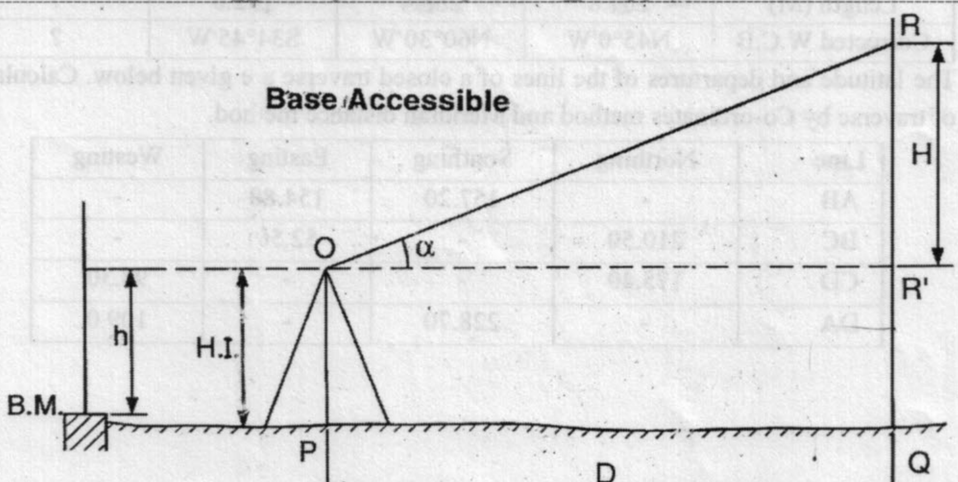
(3) With the vertical vernier set to zero reading, take the reading on the staff kept at nearby B.M.(h). If R.L. of station P is given the compute Height of Instrument (H.I.).

(4) Measure the horizontal distance (D) between station P and object base at Q with the tape.

(5) Now compute R.L. of top of the object with below equations.

R.L. of the point R = R.L. of B.M. + h + H (where $H = D * \tan\alpha$)

If R.L. of station P is given, R.L. of R = R.L. of P + H.I. + H



Trigonometric Leveling

Procedure: (Case-2 When base of the object is inaccessible, Instrument axis at same level.)

(1) Setup the theodolite at P and level it with respect to altitude bubble.

(2) Bisect top point S of the object accurately. Read the vertical angle at both the verniers C & D and compute the average vertical angle SP'R' = α_1 .

(3) With the vertical vernier set to zero reading, take the reading on the staff kept at nearby B.M. (h)

(4) Plunge the telescope and shift the instrument on station Q and set it so that line of collimation remains at level (h) when staff on B.M. is bisected. Measure the horizontal distance (d) between P&Q with the tape.

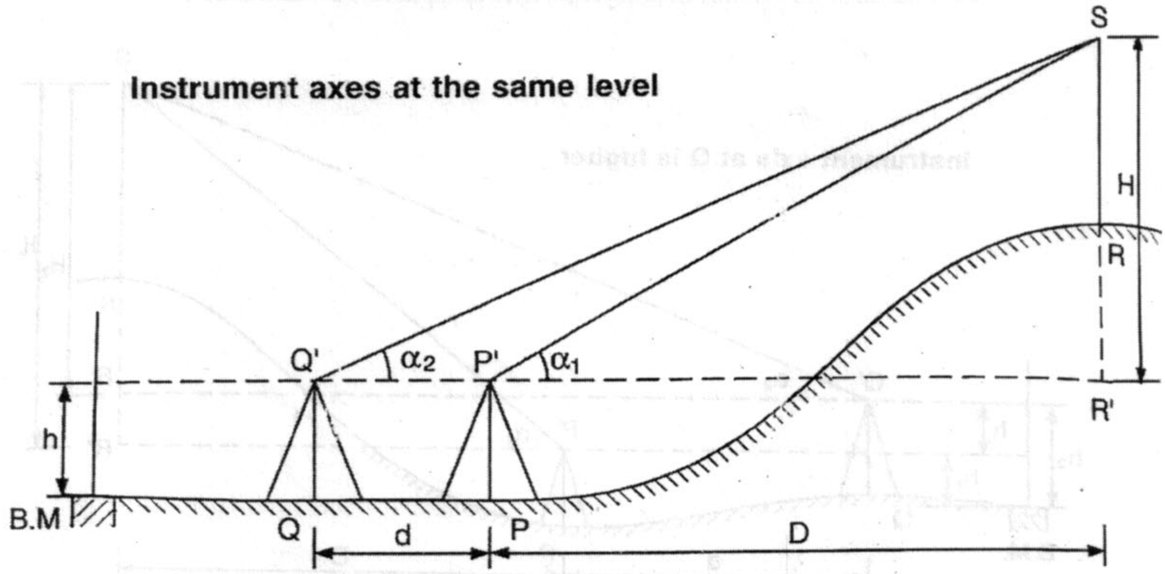
(5) Sight the top point S, and measure the vertical angle SQ'R' = α_2 .

(6) Determine the elevation of point S as mentioned below.

$$D = \frac{d * tan\alpha_2}{tan\alpha_1 - tan\alpha_2}$$

$$H = D * tan\alpha_1 = \frac{d * tan\alpha_2 * tan\alpha_1}{tan\alpha_1 - tan\alpha_2}$$

R.L. of the point S = R.L. of B.M. + h + H



Trigonometric Leveling

Procedure: (Case-2 When base of the object is inaccessible, Instrument axis not at same level.)

(1) Setup the theodolite at P and level it with respect to altitude bubble.

(2) Bisect top point S of the object accurately. Read the vertical angle at both the verniers C & D and compute the average vertical angle SP'R" = α_1 .

(3) With the vertical vernier set to zero reading, take the reading on the staff kept at nearby B.M. (h_1)

(4) Plunge the telescope and shift the instrument on station Q. Read the vertical angle at both the verniers C & D and compute the average vertical angle SQ'R' = α_2 .

(5) With the vertical vernier set to zero reading, take the reading on the staff kept at nearby B.M. (h_2)

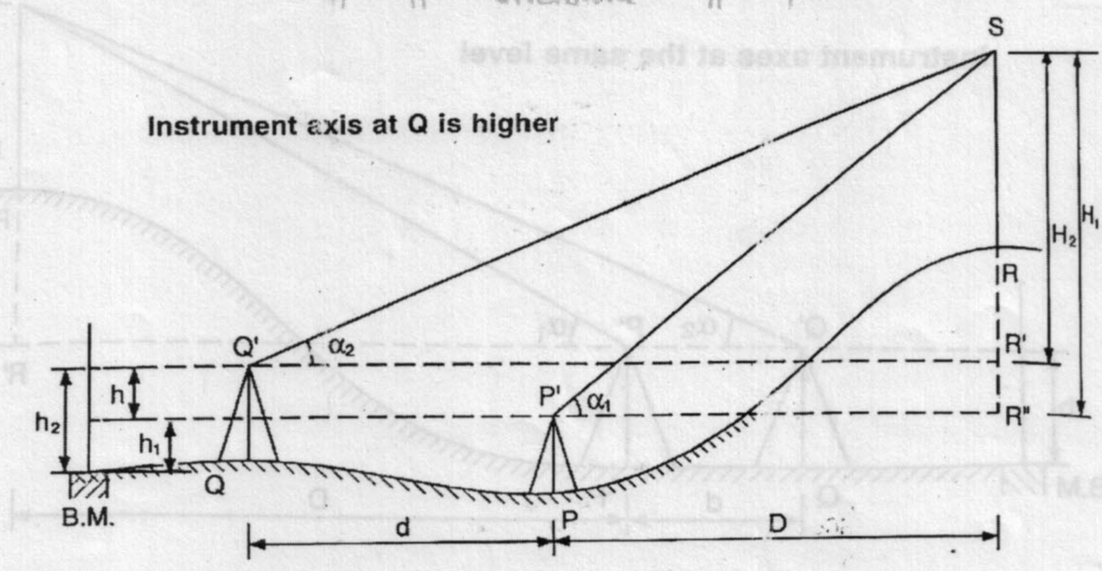
(6) Measure the horizontal distance (d) between P&Q with the tape.

(7) Determine the elevation of point S as mentioned below.

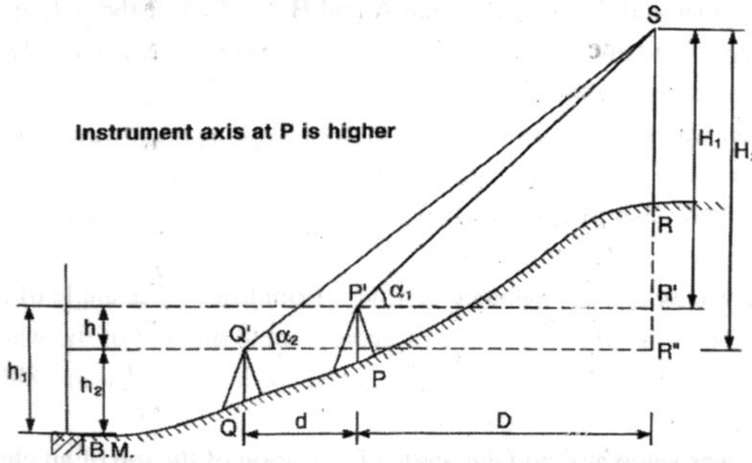
$$D = \frac{h + d * tan\alpha_2}{tan\alpha_1 - tan\alpha_2}$$

$$H_1 = D * tan\alpha_1 = \frac{(h + d * tan\alpha_2) * tan\alpha_1}{tan\alpha_1 - tan\alpha_2}$$

R.L. of the point S = R.L. of B.M. + h_1 + H_1



Trigonometric Leveling

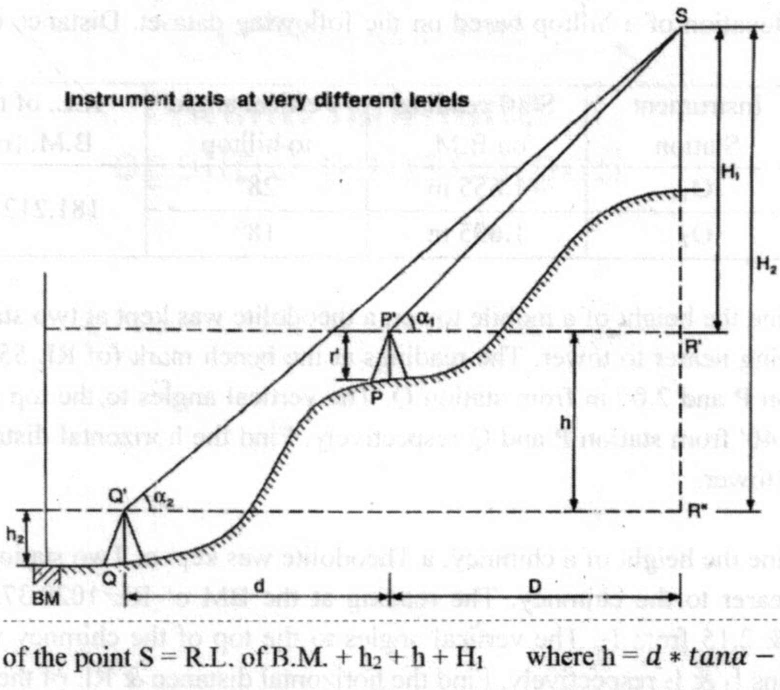


$$D = \frac{h - d * tan\alpha_2}{tan\alpha_1 - tan\alpha_2}$$

$$H_1 = D * tan\alpha_1 = \frac{(h - d * tan\alpha_2) * tan\alpha_1}{tan\alpha_1 - tan\alpha_2}$$

R.L. of the point S = R.L. of B.M. + h_1 + H_1

Note: Use (+) sign when instrument axis at P is lower and (–) sign when it is higher than at Q.



R.L. of the point S = R.L. of B.M. + h_2 + h + H_1 where $h = d * tan\alpha - r - r'$

Trigonometric Leveling

Examples:

- An instrument was setup at A and the angle of elevation of the top of an electric pole BC was 31º20′. The horizontal distance between A and B, the foot of the pole was 378.80 m. Determine the RL of top of the pole C, if the staff reading held on a BM (RL 180.0) was 3.145 m. with telescope in horizontal plane.
- An instrument was set at P and the angle of depression to a vane 2 m above the foot of staff held at Q was 5°36′. The horizontal distance between P and Q was known to be 3000 m. Determine the RL of the staff station Q, given that staff reading on a BM of elevation 436.050 was 2.865 m.
- A theodolite was set up at a distance of 150 m from tower. The angle of elevation to the top of the parapet was 10°8′ while the angle of depression to the foot of the wall was 3°12′. The staff reading on the B.M of RL 50.217 with the telescope horizontal was 0.880. Find the height of the tower and the RL of the top of the parapet.
- A theodolite was setup at P and the angle of elevation of the top of an electric pole QR was 25˚30′. The horizontal distance between P and Q, the foot of the pole was 500m. Determine the RL of the top of the pole if the staff reading held on a BM or RL 100m was 3.535m with the telescope in horizontal plane.

- Find out elevation of a hilltop based on the following dataset. Distance between O_1 and O_2 is 100 m.

Instrument Station	Staff reading on B.M.	Vertical angle to hilltop	R.L. of the B.M. (m)
O_1	1.545 m	28° 42′	101.505 m
O_2	1.545 m	18° 06′	

- Find out elevation of a hilltop based on the following dataset. Distance between O_1 and O_2 is 123 m.

Instrument Station	Staff reading on B.M.	Vertical angle to hilltop	R.L. of the B.M. (m)
O_1	1.655 m	28°	181.212 m
O_2	1.655 m	18°	

- To determine the height of a mobile tower, a theodolite was kept at two stations P and Q, 150 m apart, P being nearer to tower. The readings at the bench mark (of RL 555.055m) were 1.15 m from station P and 2.05 m from station Q. The vertical angles to the top of the tower were 17º 15′ and 8º 40′ from station P and Q respectively. Find the horizontal distance and RL of top of the mobile tower.

- To determine the height of a chimney, a Theodolite was kept at Two stations I_1 & I_2 200m apart. I_1 being nearer to the chimney. The reading at the BM of RL 1020.375m were 1.35m from station I_1 & 2.15 from I_2. The vertical angles to the top of the chimney where 19°30′ & 8°15′ from stations I_1 & I_2 respectively. Find the horizontal distance & RL of the top of the chimney.

Trigonometric Leveling

- Calculate the reduced level of the top of a chimney from the following observations. The top of Chimney & the station P & Q are in the same vertical plane. Inst. Station P & Q are 100m apart and station Q being nearer to the chimney.

Instrument Station	Staff reading on B.M.	Vertical angle to hilltop	R.L. of the B.M. (m)
P	3.750m	18° 06′	100m
Q	2.870m	28° 42′	

- Determine the reduced level of a roof of a ten storeyed hotel from the following observations.

Instrument Station	Staff reading on B.M.	Vertical angle to hilltop	R.L. of the B.M. (m)
A	2.625m	19° 48′	500m
B	1.510m	14° 25′	

- Derive the expressions for computing horizontal distance and elevation in trigonometric leveling while base of the object is inaccessible and instrument stations are in the same vertical plane with the elevated object for the instrument axis at same level.
- Derive formula for vertical and horizontal distances in trigonometric leveling when two instruments are set at different level and base of the object is inaccessible.

Grade:

Signature

EXPERIMENT NO.:- 8 DATE:

Setting out of curves- simple circular curve- I

Objective: To setting out of Simple Circular Curve by Long Chord Method.

Instruments:

- Metallic Tape
- Chain
- Optical square
- Open cross staff
- Arrow
- String
- White powder

Introduction:

Curves are used in roads and railway tracks to change the direction of motion of vehicles. Curves can be classified into horizontal curves (curves in horizontal plane) and vertical curves (curves in vertical plane). Vertical curves are used in hilly terrain.

Curves are also classified based on their profile. (i) Circular Curve, (ii) Parabolic Curve, (iii) Transition Curve, (iv) Reverse Curve, (v) Combined Curve, (vi) Spiral Curves. etc.

Procedure:

(1) Set the curve by locating intersection (I) of two tangent points of long chord as per length calculated with chain.

(2) Measure the tangent length backward and forward from **I** to locate the tangent points T_1 and T_2 respectively.

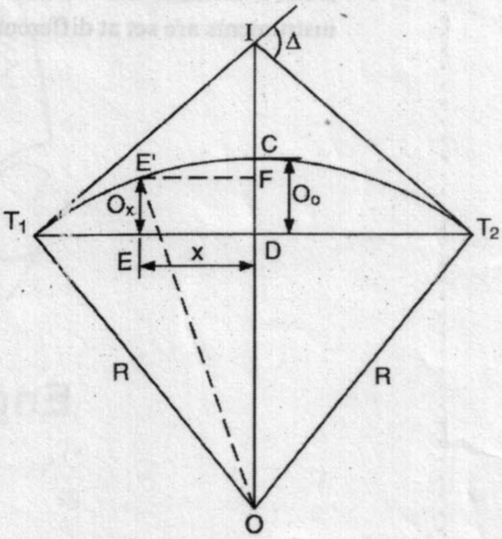
(3) Once the tangent points are located, measure the distance of the long chord T_1T_2. Bisect T_1T_2 to get the Midpoint of the chord (D).

(4) If the distance ***x*** is measured from D, then measure a chain length 20 or 30 m from D. Set out a right angle offset of the calculated length from this point.

(5) Locate further points by measuring 20 or 30m lengths and setting off the calculated lengths of offsets.

(6) Repeat the procedure on the other side of D.

(7) If the approximate method is used, then measure the lengths from T_1.



Offsets from the long chord

(8) After marking all the ordinates, connect the end point of ordinates and draw a smooth line with white powder which will take a shape of simple circular curve.

a. Length of long chord $T_1T_2 = 2R\sin(\emptyset/2)$

b. Mid Ordinate $O_0 = R - R\cos(\emptyset/2)$ OR $CD = R - \sqrt{R^2 - (L/2)^2}$

Set out Curve:

A simple circular curve has radius of __800__ m. The deflection angle is _36°_. Calculate the offsets from the long chord at __20__ m interval.

Setting out of curves- simple circular curve-II

Objective: To setting out of Simple Circular Curve by Two Theodolite Method.

Instruments:

- Transit Vernier Theodolite
- Arrow
- String
- White powder

Introduction:

This method is most useful in rough ground and measurements of horizontal distances are eliminated hence providing very accurate curvature. The geometrical construction is shown in fig.

Procedure:

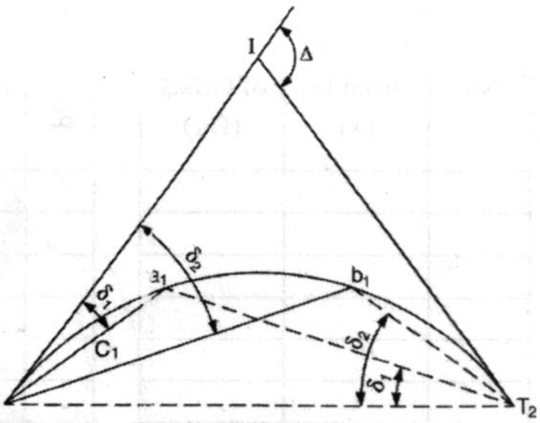
(1) Fix the intersection point **I** and tangent points T_1 and T_2 accurately.

(2) Set up the theodolite at T_1 and a second one at T_2.

(3) Set the theodolite at T_1 to zero and sight the point I. Direct the theodolite at T_2 to sight T_1 with the vernier set to zero.

(4) Turn the theodolite clockwise to set the deflection angle δ_1 accurately in both the theodolite.

(5) Direct a person to move ranging rod at $\mathbf{a_1}$ such that it intersects line of sight of both the theodolites. The point $\mathbf{a_1}$ is marked on the ground.



Two theodolite method

(6) Repeat the procedure with other deflection angle with both the theodolites reading the same angle. Locate number of such points closely to derive an actual profile of the curve.

a. From T_1 $\delta_1 = \frac{90C_1}{\pi R}$ (in degrees) OR $\delta = \frac{1718.9C_1}{R}$ (in minutes)

Set out Curve:

Two straight AB and BC meet at a chainage of 3480m. A right handed simple circular curve of 300m radius joins them. The deflection angle between the two straights is 60°. Tabulate the necessary data to layout the curve. Take the chord interval as 30m.

Calculations:

Setting out of curves- simple circular curve-1

Tables:

Long Chord Method		
Sr. No.	Distance from D (x)	Length of Offset (Ox)

Two Theodolite Method					
Point	Chord Length	Tangent angle	Deflection angle	Theodolite Reading at T1	Theodolite Reading at T2

Examples:

- Two straights intersect at chainage 2056.44m and the angle of intersection is 120°. If the radius of the simple curve to be introduced is 600m find the following (i) Tangent distance (ii) Chainage of the point of commencement (iii) Chainage of the point of tangency (iv) Length of the long chord.
- Two tangents intersect at a chainage of 1400m the deflection angle being 24°. Calculate the following quantities for setting out a curve of radius 275m. (i) Tangent Length (ii) Length of Long Chord (iii) Length of Curve (iv) Chainage of point of commencement and tangency (v) Apex distance.
- A curve has a radius of 400m and a deflection angle of 40°. The chainage of T1 is 1804.25m. Compute and tabulate the angles and theodolite readings to set out the curve using Rankine's method.
- Two tangents intersect at the chainage 1190 m, the deflection angle being 36°.Calculate all the data necessary for setting out a curve with a radius of 300 m by deflection angle method. The peg interval is 30m.
- Calculate perpendicular offsets at 20 m. interval from center on either side to set out a simple circular curve of 280 m. radius and deflection angle is 60º.

Grade: Signature

EXPERIMENT NO.:- 9 DATE:

Setting out of curves- Compound curve

Objective: To setting out of combined (Transition-Circular-Transition) Curve by deflection angle Method.

Instruments:

- Transit Vernier Theodolite
- Arrow
- White powder
- Metallic Tape
- String
- Ranging Rod

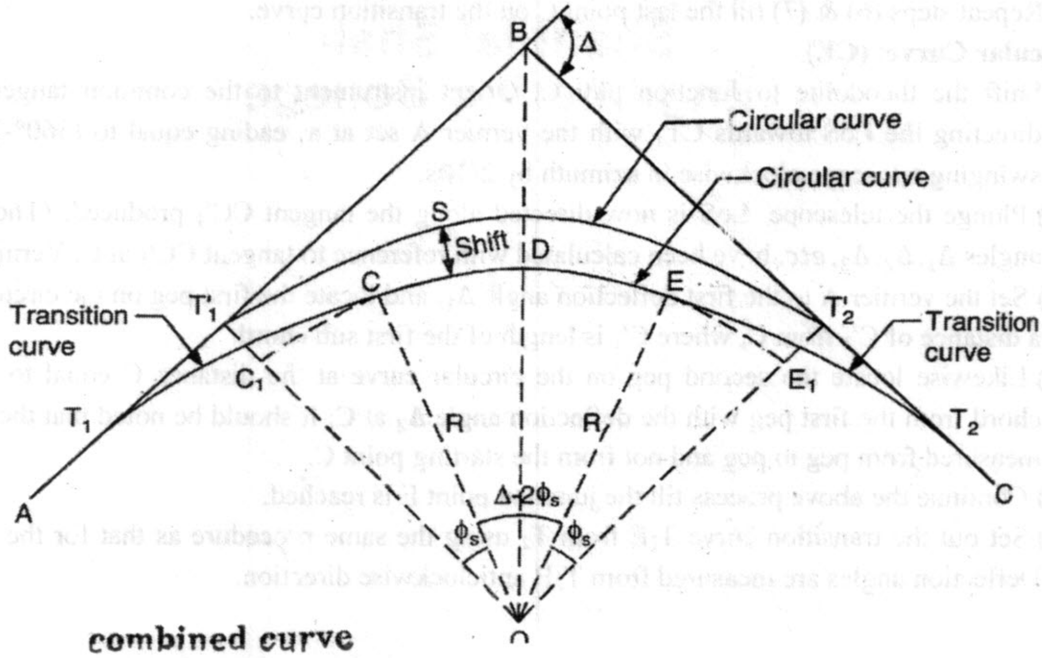
Introduction:

Combined curves are a combination of simple circular curve and transition curves and are preferred in railways and highways.

When transition curves are introduced at both the ends of a circular curve, the resulting curve is known as a combined or compound curve.

Computation:

- Compute the spiral angle $\emptyset s = \frac{L}{2R}$ $(in\ rad)$ OR $\emptyset s = \frac{L*180}{2\pi R}$ $(in\ deg)$
- Compute the Shift, $S = \frac{L^2}{24R}$
- Compute the total tangent length, $T_t = BT_1 = (R+S)\tan(\frac{\Delta}{2}) + \frac{L}{2}$
- Compute the length 'l' of circular curve, $l_c = \frac{\pi R\ (\Delta - 2\emptyset s)}{180}$
- Determine the chainage of the salient points,
- Chainage of $T_1 = chainage\ of\ B - BT_1$, Chainage of $C = chainage\ of\ T_1 + L$
- Chainage of $E = chainage\ of\ C + L_c$, Chainage of $T_2 = chainage\ of\ E + L$



combined curve

Setting out of curves- Compound curve

- Length of the normal chord is kept, generally, 10m for the transition curve and 20m for circular curve.
- Compute the deflection angles,
- For transition Curve, $\alpha = \frac{573\, l^2}{RL}\ (min.)$, l is measured from T_1. (The deflection angle for each chord is the total angle referred to the initial tangent.) At the junction of Transition curve and circular curve, l = L, $\alpha_n = \frac{573\, L^2}{RL} = \frac{573\, L}{R}$ (Check , $\alpha_n = \frac{\emptyset s}{3}$)
- For circular curve, $= \frac{1718.9\, C}{R}\ (min.)$, C is the length of chord.
- The total deflection angle are: $\Delta_1 = \delta_1$, $\Delta_2 = \Delta_1 + \delta_2$, $\Delta_n = \Delta_{n-1} + \delta_n$ (check, $\Delta_n = \frac{\Delta - 2\emptyset s}{2}$)

Procedure:

(1) Locate the tangent point T1 by measuring back along the rear tangent, the total tangent length BT1 from the point of intersection B.

Transition Curve: (T_1C)

(2) Set the theodolite over the point T_1. Set the vernier A to zero

(3) Direct the line of sight to the point B and bisect exactly.

(4) Set the vernier A to the first deflection angle (α_1) by using upper clamp and tangent screw. Line of Sight (LoS) now points towards the first arrow mark on the transition curve.

(5) With the metallic tape (zero at T_1) and ranging rod kept at the arrow mark corresponding to the first chord, swing the tape until the ranging rod is bisected by the LoS. Fix the peg at the first rod point.

(6) Set the vernier A on the second deflection angle (α_2) to direct the LoS to the second peg.

(7) With the metallic tape (zero at T_1) and ranging rod kept at cumulative length (1^{st} chord + 2^{nd} chord), swing an arc till the rod is bisected by the LoS. Fix the second peg at the rod.

(8) Repeat steps (6) & (7) till the last point C on the transition curve.

Circular Curve: (CE)

(9) Shift the theodolite to Junction pint C. Orient instrument to the common tangent CC'_1 by directing the LoS towards CT_1 with the vernier A set at a reading equal to (360°-2/3Øs), and swinging telescope clockwise in azimuth by 2/3Øs.

(10) Plunge the telescope. LoS is now directed along the tangent CC'_1 produced. (The deflection angles $\Delta_1, \Delta_2, \Delta_3, etc.$ have been calculated with reference to tangent CC'_1 at C. Vernier A zero.)

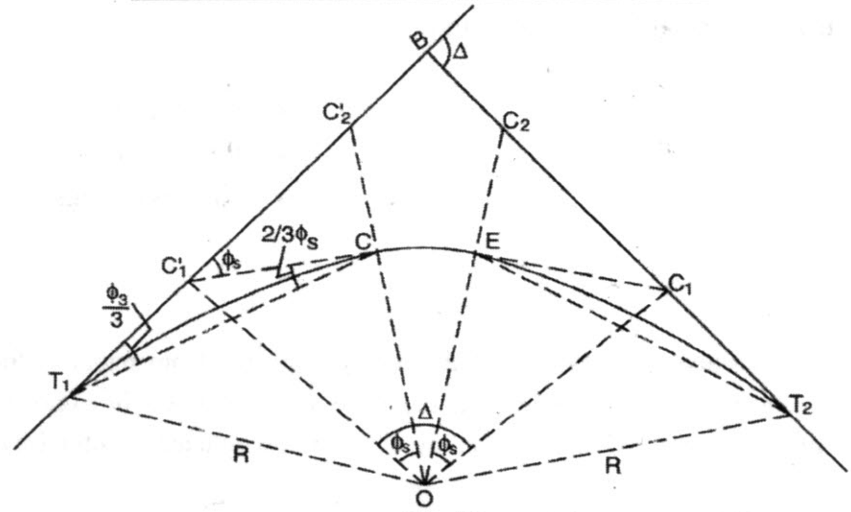
(11) Set the vernier A to the first deflection angle Δ_1, and locate the first peg on the circular curve at a distance of C'_1 from C, where C'_1 is length of the first sub chord.

(12) Likewise locate the second peg on the circular curve at the distance C equal to the normal chord from the first peg with the deflection angle Δ_2 at C. It should be noted that the distance is measured from peg to peg and not from the starting point C.

(13) Continue the above process till the junction point E is reached.

(14) Set out the transition curve T_2E from T_2 using the same procedure as that for the curve T_1C. Deflection angles are measured from T_2B anticlockwise direction.

Setting out of curves- Compound curve



Set out Curve:

- Two straight AB and BC intersect at chainage 1200m, the deflection angle being 60°. It is proposed to insert a circular curve of radius 250m with a transition curve of length 80m at each end. Calculate all data necessary for setting out the curve by the deflection angle method, taking a peg interval of 10m for the transition curve and 20m for the circular curve. Prepare the setting out table, taking the least count of theodolite 20″.

Examples:

- In respect to calculation for setting out combined curve. If Δ=34°30′, radius of circular curve is 400m, length of transition curve 60m. Calculate shifts, tangent length and spiral angle.
- A compound curve is to connect two straights having a deflection angle of 90°. The lengths of two tangents are 350 m and 400 m respectively. Calculate the lengths of the two arcs if the radius of the first curve is to be 300 m.
- A transition curve is required for a circular curve of 200 m radius, the gauge being 1.5 m and maximum super elevation is restricted to 15 cm. The transition is to be designed for a velocity such that no lateral pressure is imposed on the rails and the rate of gain of lateral acceleration is 30 cm/sec^3. Calculate the required length of transition curve and design speed.

Grade:

Signature:

EXPERIMENT NO.:- 10 DATE:

Setting out building foundation

Objective: To setting out of building foundation.

Instruments:

- Metallic Tape
- A long chord
- White powder
- Hammer
- Steel Tape
- Plumb bob
- Arrows or Pegs

Introduction:

Setting out of building involves the transfer of the foundation plan from paper to the actual size. The object of setting out is to provide the builder with clearly defined outlines for excavation. Two methods are generally used for setting out works i.e. Circumscribing Rectangle and Center-Line Rectangle.

Procedure: (Circumscribing rectangle)

(1) Select any suitable distance of the outer rectangle from the center line of the foundation plan.

(2) Prepare the foundation trench plan showing the width of wall foundations.

(3) Temporary pegs are driven at the actual corner points of the foundation plan.

(4) Then using these pegs, a parallel line PQ of required length is set out at an arbitrary selected distance from the actual center line.

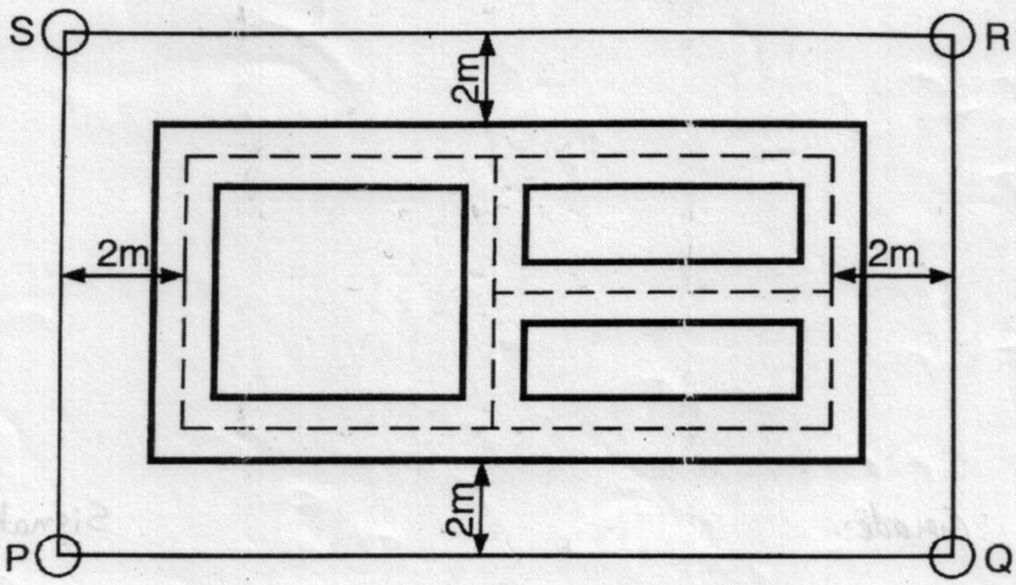
(5) A chord is stretched between the pegs P & Q. At P a line is set out perpendicular to PQ (with a tape using 3, 4, 5 method). On this line position of S is marked by setting a peg.

(6) Step (5) is repeated at point Q so as to obtain point R.

(7) After reference rectangle is set, the actual corners can be marked using the sides of reference rectangle.

(8) Once all points are staked, a cord is passed around the periphery of the rectangle and the actual excavation lines are using white powder.

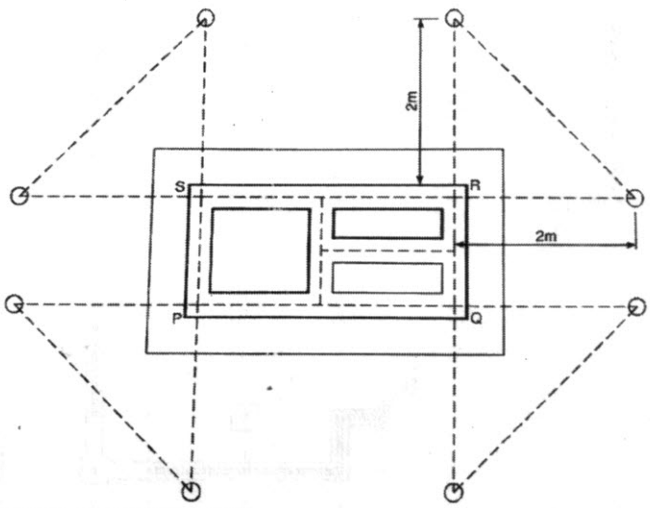
(9) Checks: Diagonals should be measured and parallel lines should be of exact same length.



Setting out building foundation

Procedure: (Center Line rectangle)

(1) The corners are located by measuring their coordinates with reference to the sides of this rectangle. The temporary stakes are fixed at these points. (These stakes are not permanent and will be lost in excavation.)

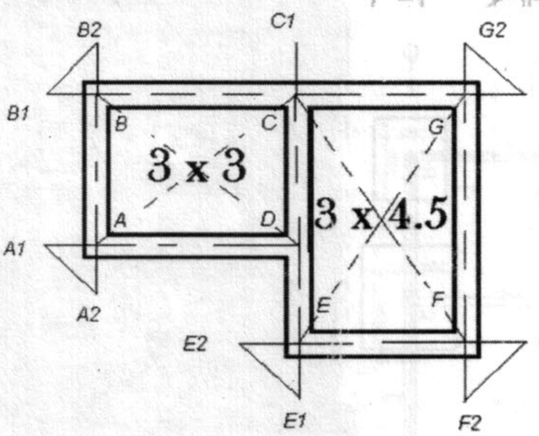


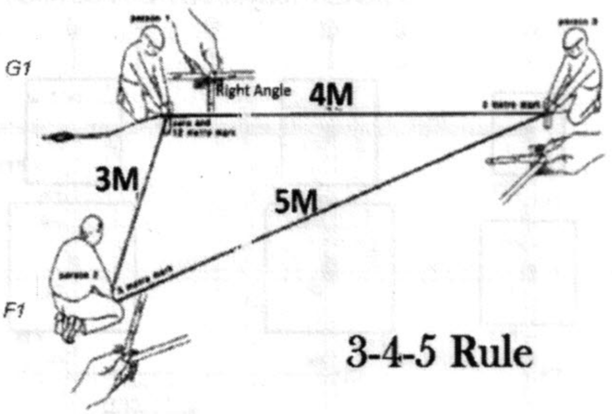
(2) The sides of the center line rectangle are produced on both the sides and permanent stakes are fixed on each of the prolongations, at a fixed distance. (As shown in fig.)

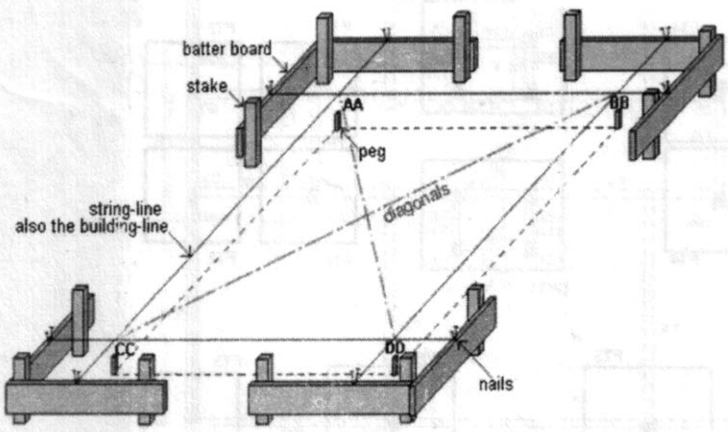
(3) By using these stakes, the positions of any point can be obtained by plotting its coordinates using the reference stakes.

In case of precise works, a theodolite should be used for setting out right angles.

Set out Plan:



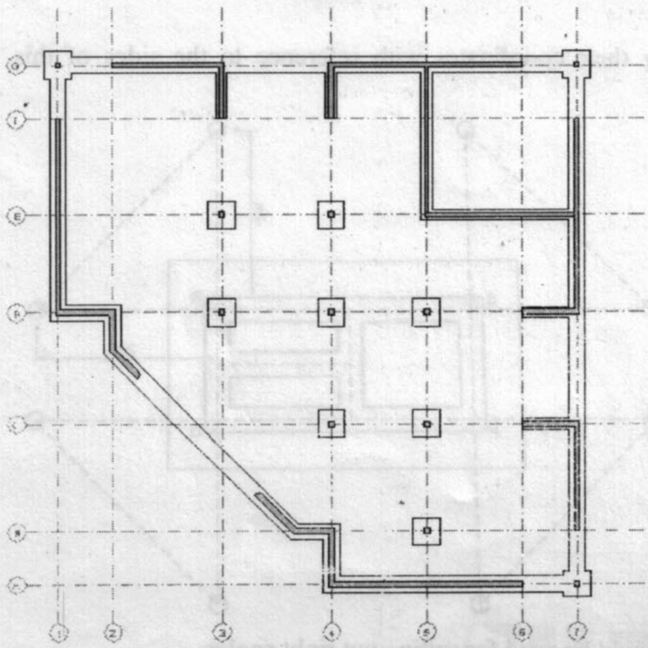


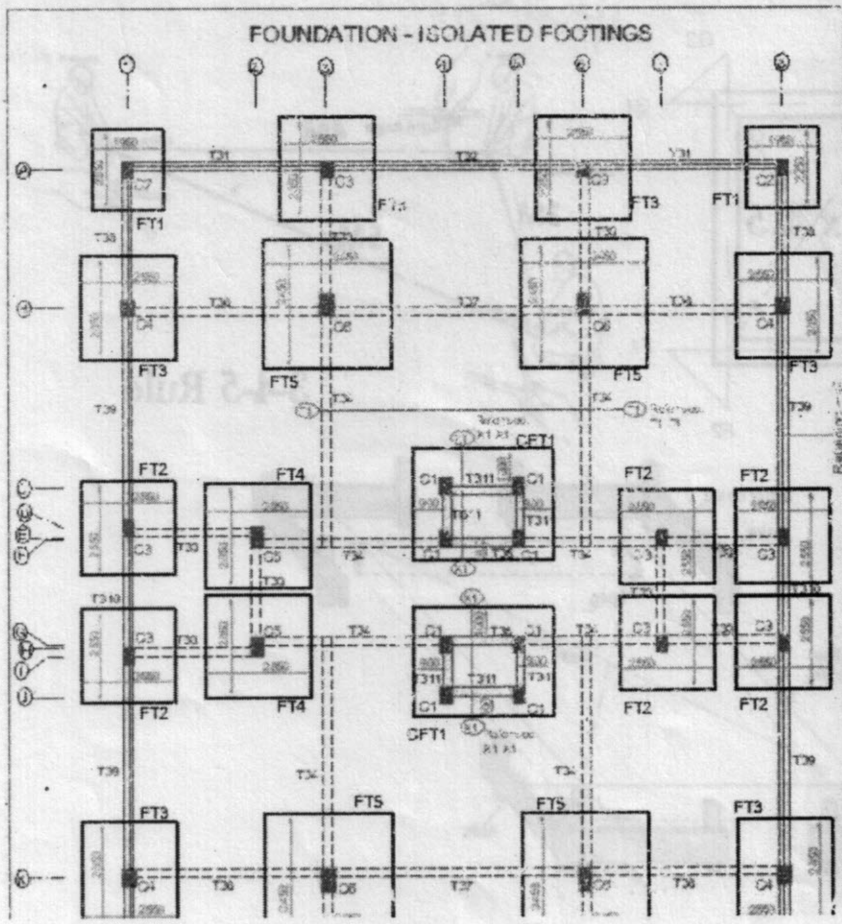


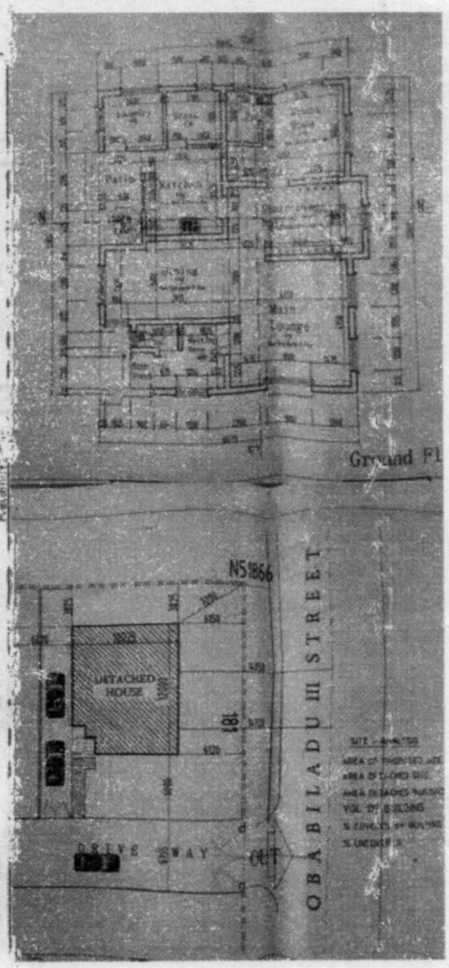
Setting out building foundation

For your Information:

Foundation plan







Grade: Signature