CE 104

Practical Surveying Sessional

(Lab Manual)

Department of Civil Engineering

Ahsanullah University of Science and Technology

September, 2023

Preface

This course is designed to provide civil engineering undergraduates with basic understanding of the theory and practice of engineering surveying techniques. Students will apply the knowledge gained from theoretical surveying to practice. Fieldworks covered in this manual include chain surveying, plane table surveying, theodolite traverse surveying, leveling, tacheometry, curve setting, house setting, just to name a few topics. Procedures outlining each fieldwork have been comprehensively covered. In addition, the practical aspects of specialized instruments have been covered in detail, including plane table, theodolite and level. It is hoped that students will gain valuable insight into surveying after completion of this course, which will also help them in their professional lives.

The authors highly indebted to their colleagues for their constant support and guidance during the course of preparing this manual. In addition, the authors would like to thank the University of Asia Pacific (UAP), whose manual guided the authors in preparing this manual. In addition, surveying concepts were taken from Surveying volumes 1, 2 and 3 by Dr. B.C. Punmia, while the pictures were collected from the internet.

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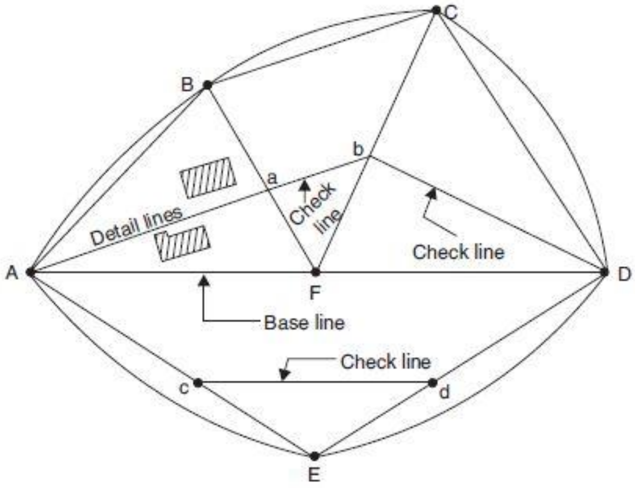
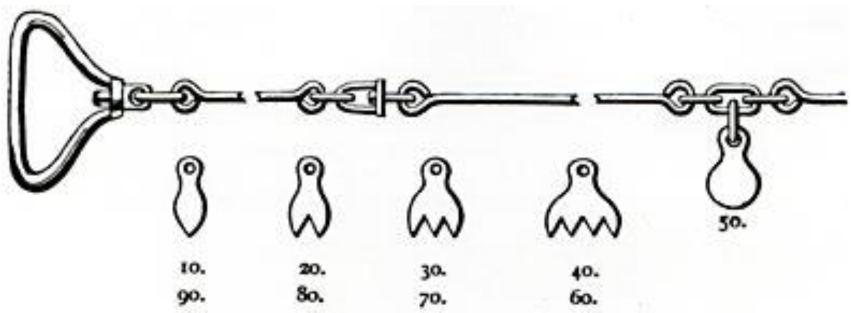
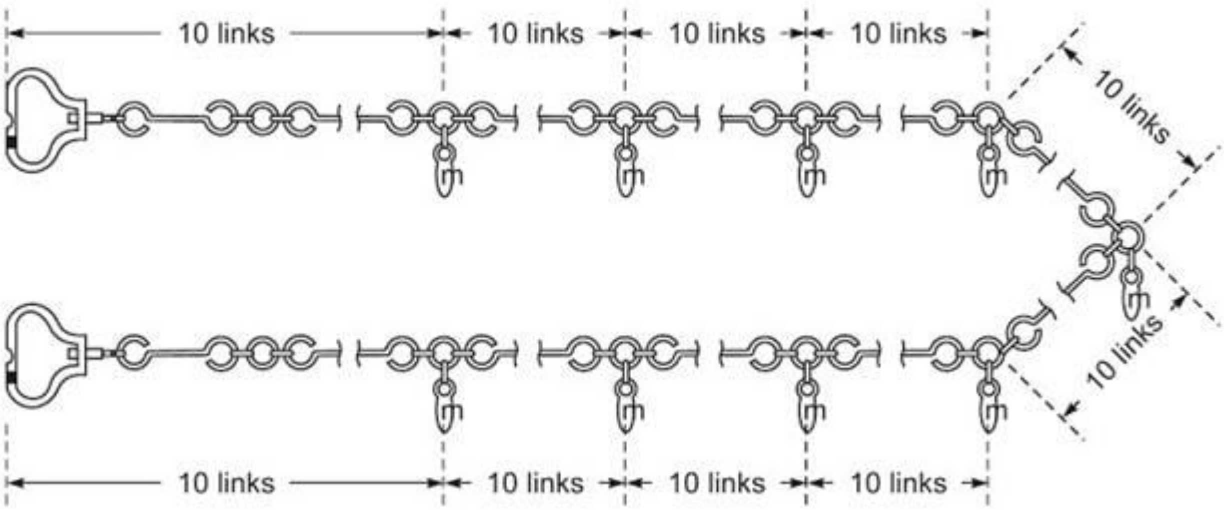
Fieldwork No. 1
CHAIN SURVEYING







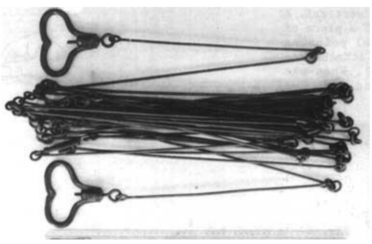
Objective: To plot a small area by chain surveying

Theory:
Chain surveying is that type of surveying in which only liner measurements are made in the field. It is a method of surveying in which the area to be divided into a number of triangles. The lengths of the sides are measured and the interior details are recorded. The whole area is then plotted on a drawing sheet to a suitable scale to prepare a map.

The principle of chain surveying is triangulation. This means that the area to be surveyed is divided into a number of small triangles which should be well conditioned. To divide a small area into a number of triangles, measure the perpendicular distance (offsets) of various objects in the field from the line and record in the field book from which the area can be plotted on a drawing sheet to a suitable scale.

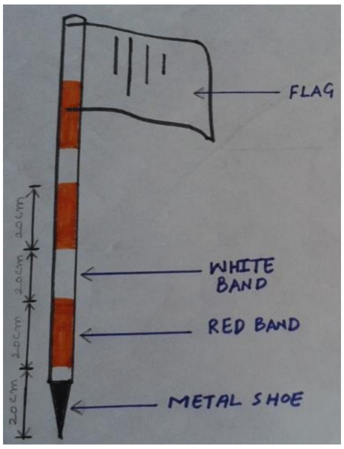
Significance:
Chain survey is the simplest and commonest method used in surveying exercises. Because of its ease of use, it is used during reconnaissance survey as a quick method of surveying to get a rough idea in the location to be surveyed. After participating in this fieldwork students will become more comfortable with handling chain and ranging rods. They will be more aware to obstacles in chaining and ranging and will learn to overcome the difficulties in chaining and ranging.

Instruments:
1. Chain (Engineer's chain)
2. Tape
3. Arrows
4. Ranging rod
5. Offset rod
6. Optical square
7. Wooden Hammer
8. Field book
9. Pencil

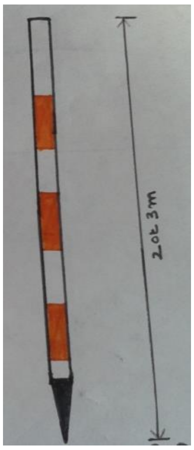

Chain


Tape


Arrow



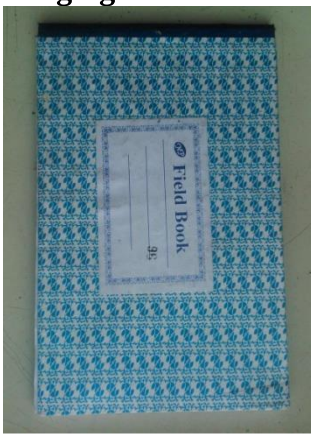
Ranging Rod



Offset Rod

Wooden Hammer

Optical Square



Field Book

Pencil

Figure 1.1: Instruments Used in Chain Surveying

Procedure:

The entire procedure for chain surveying can be divided into three major groups.

a. *Field work*
b. *Keeping of records in the field book*
c. *Plotting of data to prepare maps*.

a. **Field work:** It includes reconnaissance, selection of station, measurement of lines and taking offsets of different objects in the field.

i. **Reconnaissance:** Before starting the actual survey measurement, the surveyor will work around the area to fix the base position of survey lines and survey position. During reconnaissance, the surveyor will prepare a rough sketch of the area showing the possible stations and from there the arrangement o different lines.

ii. **Selection of station:** The station should be marked by driving wooden pegs. If possible, every station should be located with respect to three permanent objects.

iii. **Measurement of lines and taking offsets:** After selecting survey station, the chaining will be started from base line. Two ranging rods are fixed on the two station in a survey line and distance is measured with chain. The chain should be properly stretched so that no sag in it. As the measurement proceeds, offsets are taken on the both sides of the survey lines and recorded in the field book. Offsets should be taken in order of their chainages. In this way, all the lines including tie and check lines are measured and offsets taken and recorded in the field book.

b. **Keeping of records in the field book:** All the details including a rough sketch of different types of stations, offsets etc. in the field are recorded in a book called Field Book. The record keeping starts from the bottom of the end page of the field book.

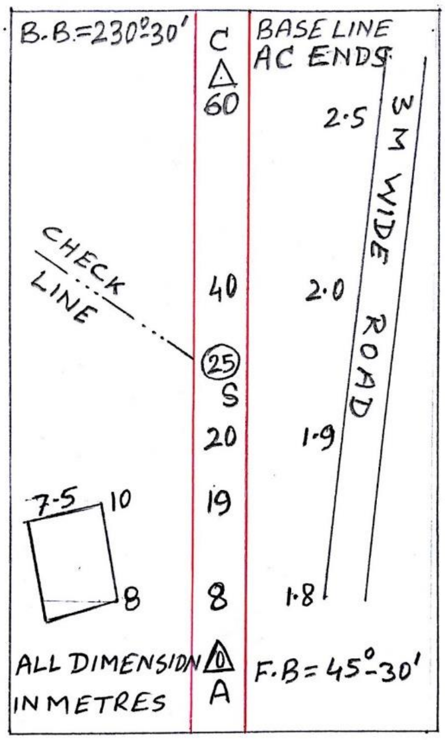


Figure 1.2: Dara records in Field book

c. **Plotting of data to prepare maps:**

- Before plotting the details of chain survey on a drawing paper, a suitable scale should be chosen first because drawings are prepared to a reduced scale.
- The triangle is first plotted from its known sides according to a suitable reduce scale.
- Then tie lines and check lines are drawn and checked the accuracy of the work.
- Now offsets like building, trees, electric posts etc. lines are taken up one by one.

Types of Chains:

1. Engineer’s chain: 100 feet long, 100 links, 1 feet per link
2. Gunter’s chain: 66 feet long, 100 links, 0.66 feet per link
3. Metric Chain
4. Revenue Chain
5. Steel Band or Band Chain

Field book:
Field book is an oblong book hinged at the narrow edge having a chain represented in it either by one or two red or blue lines ruled down the centre of the length of each page.

Check lines: These lines are selected to check the accuracy of the plotted network of triangles. It joins the apex of a triangle to some fixed point on the opposite side. This can be any other line also, such as joining two fixed points on the sides of the triangle. The measured length should agree with its length on the plotted plan.

Tie Line: This line is selected to pass closer to the details which are otherwise away from the main survey lines to avoid long offsets. This can also be used as a check line at the same time.

Offsets: Offsets are lateral distances measured from the survey lines to the objects or features which are plotted. They can be on either side in the chain. There are two types:

1. Perpendicular offsets
2. Oblique offsets

Well-proportioned Triangle:

There is equal liability of error in all the sides of a triangle; the best form is equilateral triangle. In any case, to get a well-proportioned triangle, no angle should be less than 30˚. The following points should be borne in mind:

1. The number of stations should be minimum and as far as possible, they should form well-conditioned triangles.
2. Inter-visibility of stations should be checked.
3. The framework must have one or two base lines. If possible a "base line" should pass through the centre of the area on which the main network will be based. If two base lines are used, they must intersect in the form of letter X.
4. The lines should be arranged in such a way that the offsets are short in length. If necessary, additional lines should be selected to achieve this objective.
5. The main lines should form well-conditioned triangles.
6. Each triangle or portion of the skeleton should be provided with sufficient check lines.
7. The lines should be selected in such a way as to avoid obstacles in chaining and ranging as far as possible.
8. Lines should pass over level ground, if possible.

Errors in Chaining:

It is always very difficult practically to measure length accurately. The permissible error with a steel tape is 1 in 2000 in a flat country and 1 in 3000 for a rough undulated country. The errors may be either cumulative or compensating. A cumulative error is that which occurs in the same direction and tends to accumulate, while a compensating error may occur in both directions and tends to compensate or cancel one another. Errors are regarded as positive (+) or negative (-) accordingly when they make the result too great or too small.

1. **Erroneous length of Chain or Tape (Cumulative, + or -):** The error due to wrong length of the chain is always cumulative and is the most serious. As stated earlier, if the length of the chain is more, the measured distance is \css, the error is negative and the correction is positive. On the other hand, if the length of the chain is less, the measured distance is more, the error is positive and the correction is negative. However, it is possible to apply proper correction if the length is checked from time to time.
2. **Bad ranging (cumulative, +):** If the chain is stretched out of the line, the measured distance will always be more and hence the error will be positive. For

each stretch of the chain, the error will be cumulative and the effect will be too great a result

3. **Careless holding and marking (compensating, ±):** The follower may sometimes hold the handle to one side of the arrow and sometimes to the other side. The leader may not insert the arrow vertically into the ground or exactly at the end of a chain. The error of marking due to an inexperienced chainman is often of a cumulative nature, but with ordinary care such errors tend to compensate.
4. **Bad straightening (cumulative, +):** If the chain is not straight, the measured distance will always be too great. The error is, therefore, of cumulative character and positive.
5. **Non-horizontality (cumulative, +):** If the chain is not horizontal, especially in case of sloping or irregular land, the measured distance will always be too great. The error is therefore of cumulative character and positive.
6. **Sag in Chain (cumulative, +):** If distance is measured by stepping or when the chain is stretched above the ground due to undulations of ground, the chain sags and takes the form of a catenary. The measured distance is, therefore, too great and the error is cumulative and positive.
7. **Variation in temperature (cumulative, + or -):** When a chain or tape is used at a temperature which is more than the temperature at which it was calibrated, its length increases. The measured distance is thus less and the error becomes negative. When a chain is used at a temperature which is less than that at which it was calibrated, its length decreases. The measured distance is thus more and the error is positive. In either case, the error is cumulative.
8. **Variation in pull (compensating, ± or cumulative, + or -):** If the pull applied in stretching a chain or tape is not equal to the standard pull at which it was calibrated, its length changes. If the pull applied is irregular, i.e. sometimes more and sometimes less, the error tends to compensate. However, an inexperienced chainman may apply too great or too small a pull every time and the error becomes cumulative.
9. **Personal mistakes:** Personal mistakes always produce quite irregular effects. The most common mistakes are:
    i. Displacement of arrows: If an arrow is disturbed from its position either by knocking or by pulling the chain, it may be replaced wrongly. The error may be a serious one. To avoid this, a cross must be marked at the point at which the arrow is inserted.
    ii. Miscounting chain or tape lengths: This is a serious blunder, but may be avoided if a systematic procedure is adopted to count the number of arrows.
    iii. Misreading the chain or tape: A confusion is likely between reading a 5 m tally or a 15 m tally, since both are of similar shape. A-chainman may pay more attention on the cm reading on the tape and make the meter reading wrong. A surveyor may sometimes read 6 in place of 9 or 12.46 in place of 12.64. This type of mistakes may be sometimes very serious.
10. **Erroneous booking:** The surveyor may enter 246 in place of 264, etc. To avoid such possibility, the surveyor should first speak out the reading loudly and the surveyor should repeat it while entering in the field book.

Corrections for Linear Measurements:

We have seen the different sources or errors in linear measurements. For most of the errors, proper corrections can be applied. In ordinary chaining, however, corrections arc not necessary, but in important and precise works, corrections must be applied. Since in most of the case a tape is used for precise work, the corrections arc sometimes called as "tape corrections", though they can also be applied to the measurements taken with a chain. For precise measurements, the following corrections are made:

1. Correction for Standardization
2. Correction for Slope
3. Correction for Temperature
4. Correction for Pull or Tension
5. Correction for Sag

Chain surveying is recommended when:

1. The ground surface is more or less level
2. A small area is to be surveyed
3. A small-scale map is to be prepared and
4. The formation of well-conditioned triangles is easy

Chain surveying is unsuitable when:

1. The area is crowded with many details
2. The area consists of too many undulations
3. The area is very large and
4. The formation of well-conditioned triangles becomes difficult due to obstacles

Assignments:
(a) Plot the interior details of the area surveyed in a drawing sheet.
(b) Viva-voce.

Instruction: Drawing has to be submitted individually.

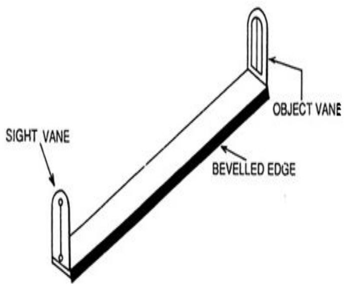
Fieldwork No. 2
PLANE TABLE SURVEYING

Objective: Plotting interior details like trees, buildings, lamp posts using Plane Table surveying.

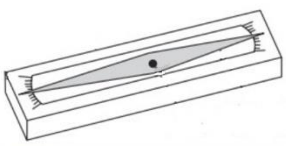
Theory:
It is a method of surveying in which observations and plotting are done simultaneously. To plot various object like buildings, tress, roads, electric poles or any other permanent object on the drawing sheet by visual observations.

Significance:
Plane table surveying is used when the ground is not level and smooth, or when distances are so large that they cannot be measured with single tape. After participating in this fieldwork students will become more comfortable with handling alidade. This survey is most suitable for small scale maps.

Instrument:
a. Drawing Board
b. Tripod stand
c. Alidade
d. Trough Compass
e. Plumb bob
f. Plumbing fork or U fork
g. Spirit Level
h. Tape or Chain
i. Drawing Sheet
j. Scotch tape

Drawing Board with Tripod Stand **Alidade** **Drawing Sheet**





Trough Compass **Plumb Bob** **Plumbing Fork** **Spirit Level** **Scotch Tape**

Figure 2.1: Instruments used in Plane Table Surveying

Procedure:

(i) Setting up the table:

- The table is placed over the station A. and centered with the help of the plumb bob in such a way that the point on the drawing sheet should be vertically above station A on the ground.
- Putting a spirit level at any position on the table now levels the table. At every position on the table the bubble should be always at the centre of its run. If not, then adjusting the legs of the tripod does this. In case the spirit level is not available, approximately a round shapes wooden pencil can be used to level the table. The pencil should remain fixed at any position on the table if it leveled.

(ii) Orientation:

- The table is set up over station A. Now a trough compass is placed at one corner of the drawing sheet and moved in such a way that the needle assumes its normal North-South position.
- A line drawn along the longer edge of the compass and arrow is put at the north end. The table is now oriented with respect to the magnetic meridian.
- When the tables is placed over any other station, the trough compass is placed with its longer edge in coincides with the previously drawn N-S line. The table is now rotated until the needle assumes its normal N-S direction.
- Then the screw clamps the table. Now the table is oriented over that station. Since the magnetic needle is subjected to the influence of local attraction, it is not a very accurate method.

<u>Practical Points for Consideration:</u>

1. Levelling the table:

Approximate leveling is done by adjusting the legs of the tripod. The table is kept a few centimeters lower than the observer's elbows when standing in a comfortable position for convenience in drafting, and in order to press down the table on the stand, which might disturb its level. The table is first placed in such a way that it is approximately oriented and centered. The leveling is then completed either by spirit level (in two perpendicular positions), by adjusting the leveling screws if available, or with the ball-and-socket joint of the tripod, if any.

2. Orienting the table:

This involves positioning the table in such a manner that all lines on the are parallel to the corresponding lines on the ground (i.e. lines on the paper and lines on the ground are on the same vertical plane). This is essential when there is more than one station, else wrong positions of the stations will be obtained. The table may be oriented by (1) compass, (2) back sighting or (3) resection.

3. Centering the table:

This involves setting the point on the paper vertically above the corresponding ground station using plumb fork. If the plotted point representing the ground station lies on the vertical axis of the plane table, its position does not change when the table is turned about this axis during the orienting operation, otherwise it gets shifted.

<u>In other words, the operation of orienting and centering are interrelated; if perfect centering is called for, repeated orienting and centering may be required.</u>

Methods of Plane Tabling:

a. Radiation b. Intersection c. Traversing d. Resection

Errors in Plane Tabling:

The errors include:

1. Instrumental errors: errors due to bad quality of the instrument. This includes all errors described for theodolite, if telescopic alidade is used.
2. Errors in plotting
3. The expansion and contraction of the drawing sheet.
4. Error due to manipulation and sighting.

Uses of Plane Tabling:

1. To conduct complete surveys for topographical work and for explanatory and reconnaissance surveys.
2. To pick up details after control points have been fixed by more precise surveys, such as tacheometric or photogrammetric surveys.

Intersection Method:

In this method an object is located on the drawing sheet by the intersection of the rays or lines drawn from two stations. This is the swiftest method of locating an object, which is inaccessible. In these methods no linear measurement except the base line is required.

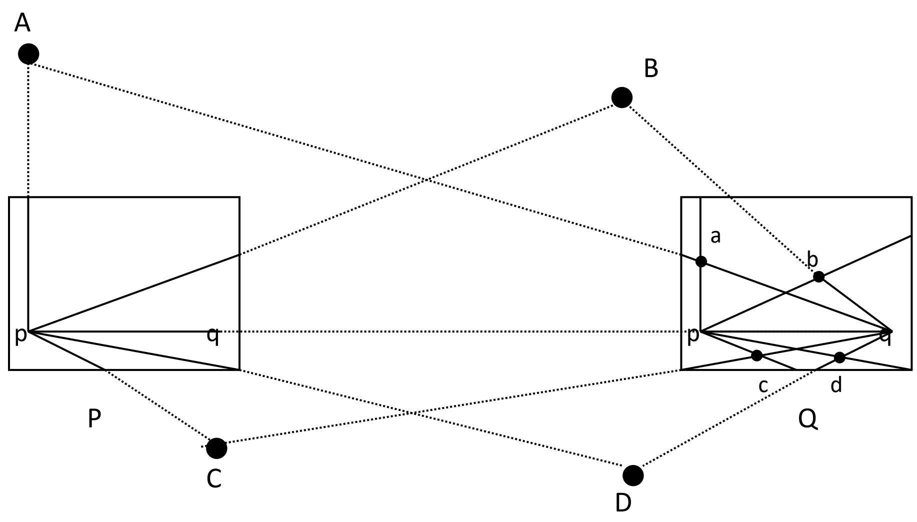


Figure 2.2: Intersection Method

As shown in Fig. 2.2, the base line connecting two points P and Q on the ground is measured. The line is selected in such a way that maximum number of objects in the fields is visible from both P and Q. The plane table is set over the station P, leveled, centered and oriented. From point P, on the drawing sheet rays of the object A, B, C and D are drawn by the alidades. Now the table is placed over station Q and oriented with respect to QP. From this point Q again rays of the same object are drawn with the alidade. The positions of the objects A, B, C and D are obtained on the drawing sheet as a, b, c and d respectively when the rays from q cut the corresponding rays from p.

Advantages of Plane Tabling:

1. There is no possibility of omitting necessary measurements.
2. Surveyor can compare plotted work with actual features of the area.
3. Contour and irregular objects may be represented accurately.
4. It obviates most direct measurements in field. Measurement notes are seldom required, and potential for booking mistakes is eliminated.
5. It is useful in magnetic areas where compasses might not yield accurate readings.
6. It is simple, cheap and does not require much skill to produce satisfactory map.
7. It is most suitable for small scale maps.

Instruction: The final output (drawing) of the features identified on site will be drawn on site. There will be one file from each group.

Fieldwork No. 3
THEODOLITE TRAVERSE SURVEYING

Objective: To survey a plot bounded by a polygon (a pentagon in this case).

Theory:

Traversing is a type of survey where the framework is formed by a number of connected survey lines. The directions of the survey lines are measured by a direction-measuring instrument (like theodolite), while the lengths are measured by a tape (or chain).

Bearing: The Bearing of a line is its direction relative to a given meridian and always measured in the clockwise direction.

Backward Bearing (B.B.): If the bearing of a line **AB** is measured from **B** toward **A**, it is known as **Backward Bearing** or **Back Bearing**.

Forward Bearing (F.B.): If the bearing of a line **AB** is measured from **A** toward **B**, it is known as **Forward Bearing** or **Fore Bearing**.

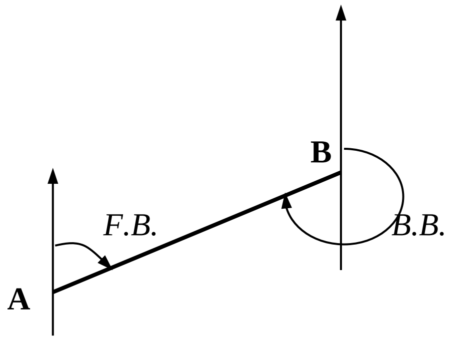


Figure 3.1: Forward and Back Bearing

Closing Error:

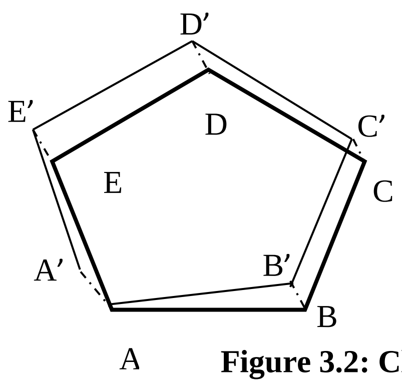


Figure 3.2: Closing Error

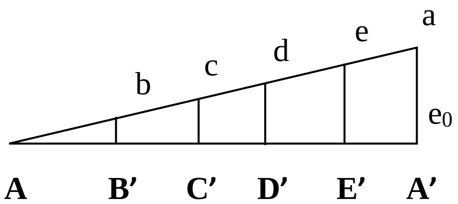


Figure 3.3: Correction of Closing Error

In Fig. 3.2, AB′C′D′E′A′ represents an unbalanced traverse with a closing error equal to AA′ since the first point A and the last point A′ are not coinciding.

In Fig. 3.3, AB', $C'D'$, $D'E'$, $E'A'$ represent the length of the sides of the traverse.

Ordinate aA' = Closing Error AA'

$aA' \parallel bB' \parallel cC' \parallel dD' \parallel eE'$, also $AA' \parallel BB' \parallel CC' \parallel DD' \parallel EE'$.

$aA' = e_0$, $bB' = BB'$, $cC' = CC'$, $dD' = DD'$, $eE' = EE'$.

The polygon ABCDE so obtained represents the adjusted traverse. This is the Graphical method of closing error.

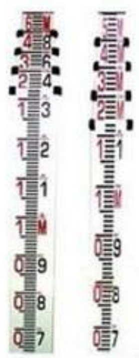
Significance:

The use of theodolite in traversing surveys is very fundamental and has become one of the most common methods in geomatic engineering work such as, general purpose angle measurement; provision of control surveys; contour and detail mapping; and setting out and construction work.

Instruments:

a. Theodolite
b. Staff Rod
c. Drawing Sheet
d. Drawing Board
e. Pencil.

Theodolite



Staff Rod

Figure 3.4: Instruments Used in Theodolite Surveying

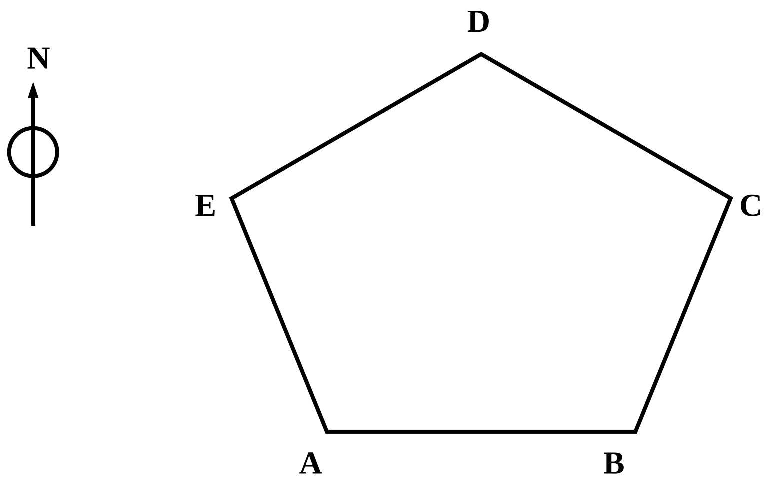


Figure 3.5: Polygon Area

Procedure:

(i) Take forward bearing and backward bearing of line AB, BC, CD, DE and EA.
(ii) Make corrections for local attraction and plot the area in a drawing sheet.
(iii) Adjust the closing error by Graphical Method.

Line	Length	Forward Bearing	Backward Bearing
AB			
BC			
CD			
DE			
EA			

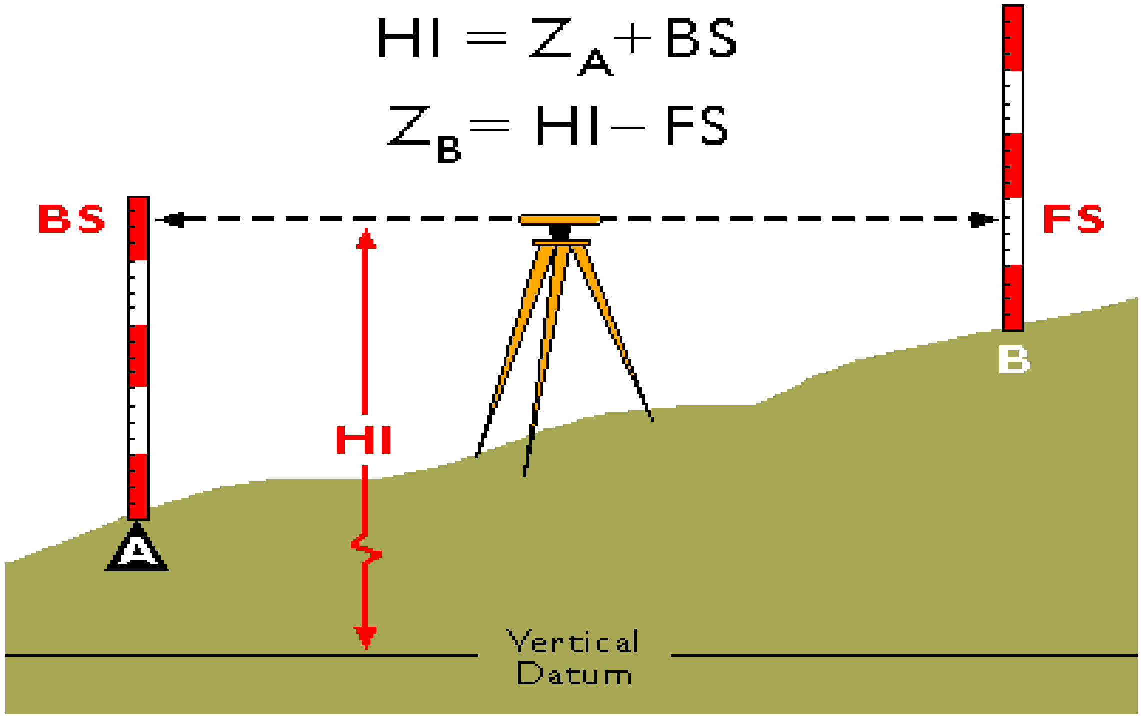
Students should have clear concept regarding **whole circle bearing** and **reduced bearing**. Besides, students should know about **magnetic declination** and its effect on bearings. Moreover, the student needs to understand **true meridian, true bearing, magnetic meridian and magnetic bearing**. Furthermore, students need to grasp adequate knowledge regarding **latitude** and **departure**. All such concepts are covered in **CE 103 Surveying** theory course. Math problems may be used to assess student’s knowledge regarding bearings, latitudes and departures

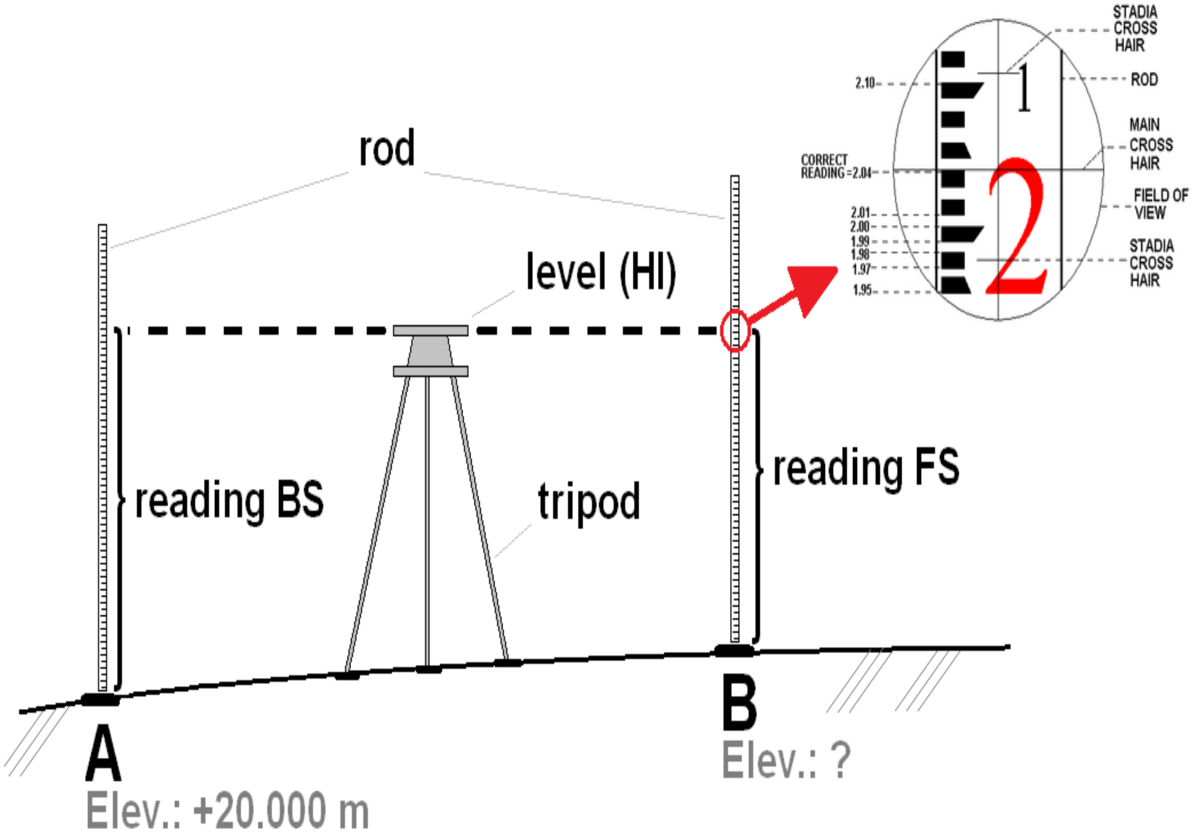
Submission:

(i) Traverse chart of the area showing corrections for local attraction.
(ii) Plot of the area on a drawing sheet showing closing error by Graphical Method.

Instruction: Drawing has to be submitted individually.

Fieldwork No. 4
LEVELING/ROUTE SURVEYING





Objective:
To determine the reduced level of different points on the ground

Methodology:
(a) Line of Collimation Method / Height of Instrument Method
(b) Rise and Fall Method

Significance:
Leveling helps the surveyor or cartographer to make contour maps of the land sea surface. This is because it determines the benchmark. It helps pipe transport engineers to ensure appropriate slope of the land that will allow smooth movement of the liquid in the transit e.g water and liquid. In addition, it helps contractors to lay a level ground on which they can elect the building. Besides, it is vital to the construction of routes of transport like roads and railways.

Instrument:
1. Level
2. Leveling Staff
3. Tape or chain
4. Leveling field book (optional)

Figure 4.1: Level

Definitions:
(a) <u>Mean Sea-Level</u>: It is the average elevation of the surface of the sea. In Bangladesh, the mean sea-level at Cox’s Bazar is taken as zero.

(b) <u>Datum</u>: It is an imaginary surface with respect to which the heights of different points on the earth surface are determined.

(c) <u>Reduced Level</u>: The reduced level of a point is its vertical distance above or below the datum.

(d) <u>Bench Mark</u>: A bench mark is a fixed point on the ground of known elevation.

(e) Height of the instrument: The elevation of the line of collimation above datum is termed as the height of the instrument.

(f) Level Surface: Any surface parallel to the mean spheroid of the earth is called a level surface and the line drawn on the level surface is known as a level line.

(g) Horizontal surface: Any surface tangential to the level surface at a given point is called a horizontal surface. It is the surface defined by the bubble tube.

(h) Vertical Line: The vertical line is the plumb line at that point.

(f) Station: A station is a point whose elevation is to be determined.

(g) Change point/ Turning Point: It is an intermediate station on which two readings are taken while the position of the instruments is shifted.

(h) Back, Inter and Fore readings: In any set up of the leveling instrument, the first staff reading on a station is termed as back reading (B.R.) and the last staff reading on a station is termed as the fore reading (F.R.) and the reading on the intermediate stations are termed as inter readings (I.R.)

Procedure:

(a) Select any suitable place for setting up the instrument. Place the instrument and try to adjust it. Adjustment procedure should be consist of the followings,

(i) Setting up the level (ii) Leveling up (iii) Elimination of parallax

(b) Consider the station A as Bench Mark whose elevation is 7.00 m

(c) Take staff reading at every station. Mind it at change point (station E) you have to take both back and fore readings.

Errors in Leveling:

1. Instrumental errors (level, bubble tube, staff)
2. Personal errors (errors in reading the staff, errors in recording and computing, errors in sighting and defective focusing, etc.)
3. Errors due to natural causes

Assignments:

(a) Find out the reduced levels of the above points by both methods,

Group 1 : Line of Collimation Method

Group 2 : Rise and Fall Method

(b) Check your result using the following formula:

Sum of Back Reading – Sum of Fore Reading

= Total Rise – Total Fall

= Last R.L. – First R.L.

(c) Draw the profile of the earth surface through this points

(d) If you want to make a road whose elevation is average of the minimum and maximum stations elevation, then show the filling and cutting areas by giving hatch lines on your graph.

(e) Compare the two methods.

(f) Viva-voce

Example of a Data Sheet:

Elevation of Bench Mark (B.M.): 7.00 m (which is the average elevation of Dhaka city)

Station	**Distance (m)**	**Staff Reading at station**			**H. I.**	**Difference**		**Reduced Level (m)**	**Remarks**
		Back (m)	**Inter (m)**	**Fore (m)**		**Rise (m)**	**Fall (m)**		
A	0								B.M.
B	15								
C	30								
D	45								
E	60								Change Point
F	75								
G	90								
H	100								

H.I.: Height of the Instrument

Exam questions: Your exam questions will be given completely on your job.

Submission:

(i) A completed table of showing the Reduced Levels of points measured.
(ii) A graph showing the vertical ground profile of area investigated.

Instruction: File has to be submitted individually.

Fieldwork No. 5
HOUSE SETTING

Objective:
To mark the excavation lines, centre lines of all the columns of the plan of a proposed building on the actual site of work as per plan of the building to facilitate earth cutting.

Requirements:
Detailed plan and drawings of the building and site plan of the area are required. Site plan and detailed plan should be studied thoroughly. These drawings are commonly known as "Foundation Trench Plan" or "Lay-out Plan".

Significance:
House setting is the first step in excavation of earthwork for any construction. After participating this fieldwork

Materials required:
1. Strings
2. Wooden Pegs
3. Lime powder

Procedure:
(i) First locate any back corner on the ground of the plan.
(ii) Then establish the two lines intersect at that point by inserting pegs on the ground at some distances (say 6 ft). Check with 3-4-5 rule.
(iii) Fixed other two exterior lines.
(iv) Check the diagonals after fixing the perimeter of the building.
(v) All the pegs lie on the column line are driven at equal distances
(vi) Intersection of rope indicates the position of the column.
(vii) Mark the excavation lines on the ground with the help of lime powder.
(viii) Check the diagonals of all grids and adjust if necessary.
(ix) Mark the plinth level
(x) From the plinth level fixed the depth of the footings by using water level at two points.

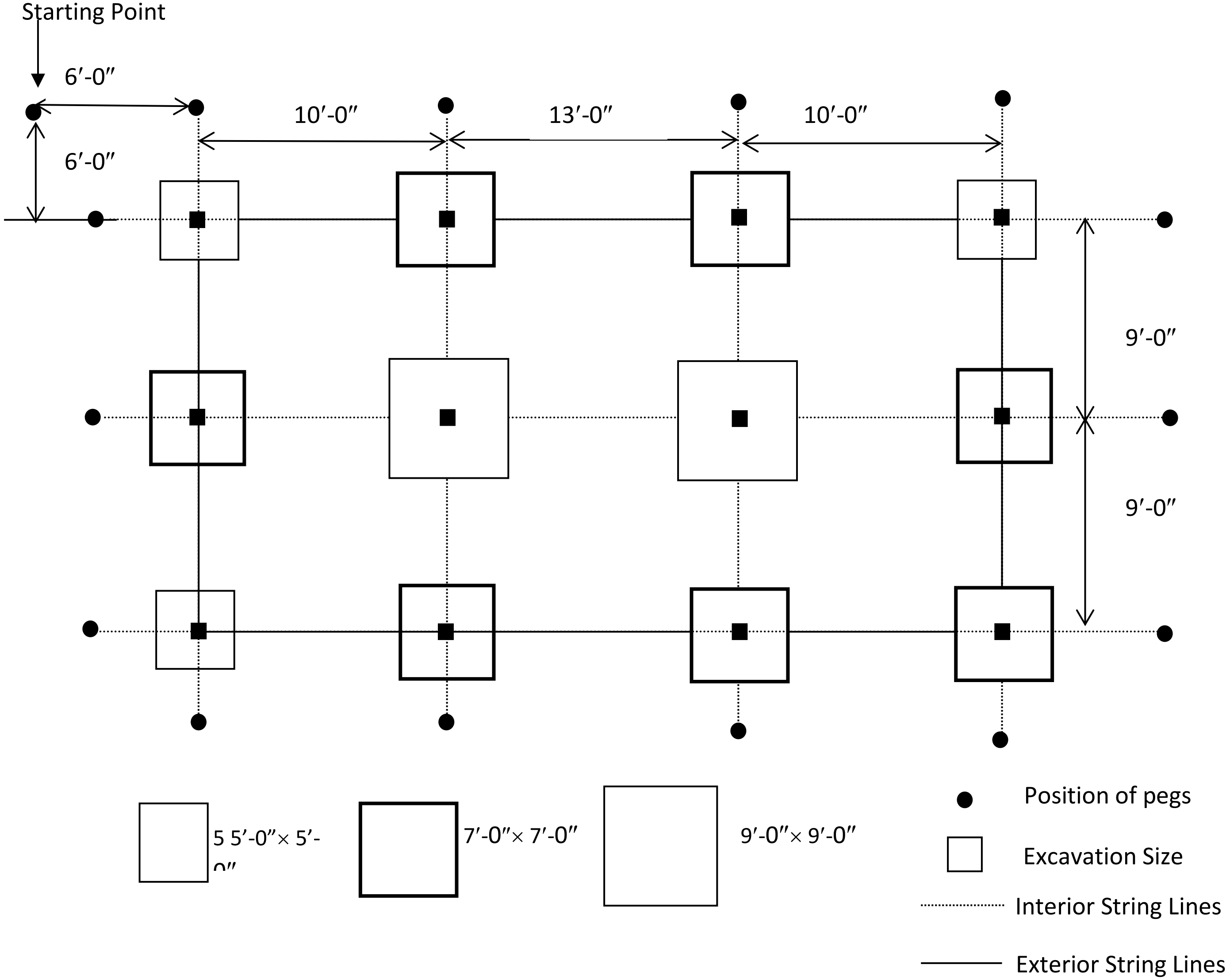


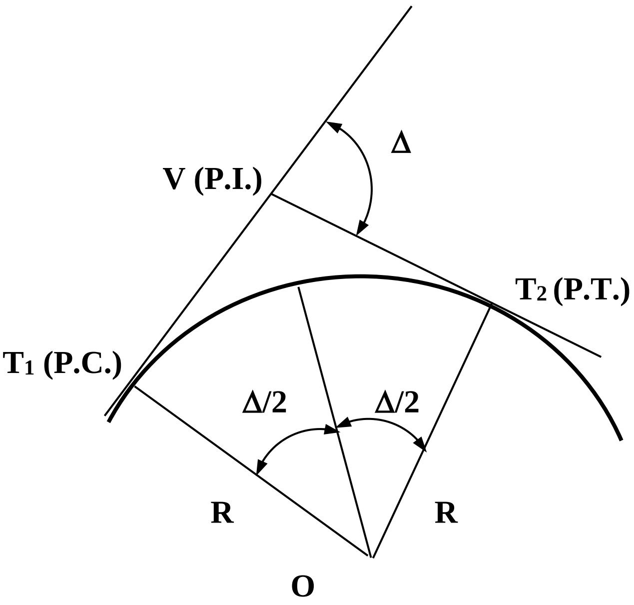
Figure 5.1: Foundation Trench Plan

Fieldwork No. 6
SETTING OUT A SIMPLE CIRCULAR CURVE ON THE FIELD

Objective: Setting out a simple circular curve in the field by a linear method and checking it by an angular method.

Theory:
Curves are generally used on highways and railways where it is necessary to change the direction of motion. A curve may be circular, parabolic or spiral and is always tangential to the two straight directions. There are three types of circular curves:
(i) Simple Curve, (ii) Compound Curve and (iii) Reverse Curve.

Simple Curve: A simple curve is the one that consists of a single arc of a circle.



T_1 = Point of Curve (P.C.)

T_2 = Point of Tangency (P.T.)

V = Point of Intersection (P.I.)

Δ = Deflection Angle

D = Degree of Curvature

Radius of Curvature, $R \cong 5730/D$

Length of Curve, $l = 100\ \Delta/D$

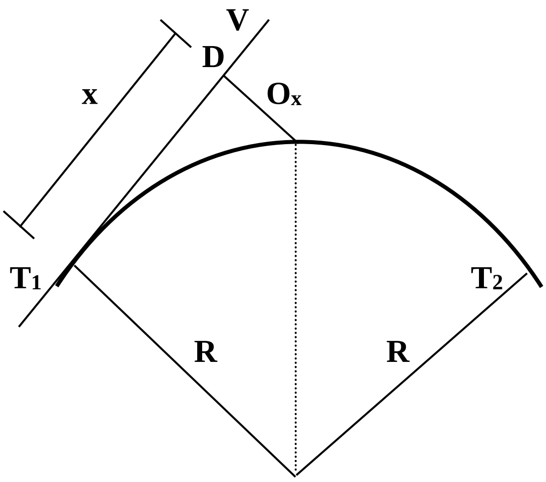
Super-Elevation, $e = B\,(s - f)/(1 + s\,f)$

where $s = v^2/gR$, f = Friction Factor, v = Maximum speed of vehicle, g = Acceleration due to gravity

Figure 6.1: Elements of Simple Circular Curve

Depending on the instruments used, there are two main methods for setting out of Simple Curves; i.e., (i) Linear methods and (ii) Angular methods.

One of the linear methods is by **Perpendicular Offsets from Tangents**



Perpendicular Offset, $O_x = R - \sqrt{(R^2 - x^2)}$

x = Distance along the tangent from P.C.

R = Radius of Curvature

$T_1V = R \tan(\Delta/2)$

$T_1T_2 = 2R \sin(\Delta/2)$

Figure 6.2: Linear Method by Perpendicular Offsets from Tangents

One of the angular methods is **Rankine's Method of Tangential (or Deflection) Angle**.

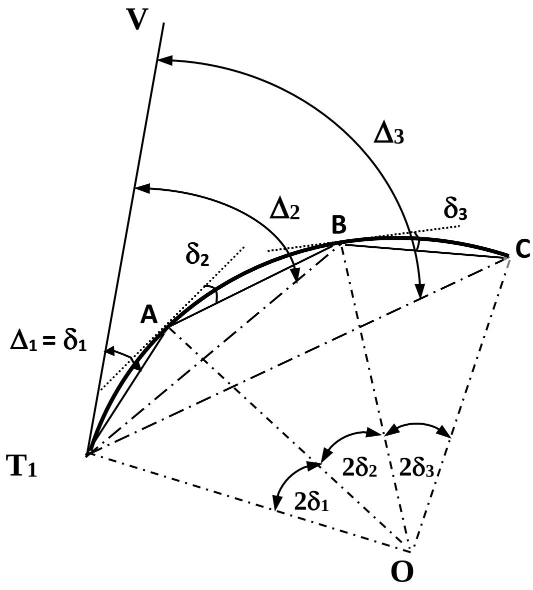


Figure 6.3: Angular (Rankine's)

T_1V = Rear Tangent
δ_1, δ_2, δ_3 …..= The Deflection angles or the angles which each of the successive cords T_1A, AB, BC….. make with the respective tangents to curve at T_1, A, B, C…...
Δ_1, Δ_2, Δ_3….. = Total tangential angles or the deflection angles to points A, B, C…...
C_1, C_2, C_3 …..= Lengths of the cord T_1A, AB, BC….…..

$\delta_1 = 1718.9\ C_1/R$ (mins), $\delta_2 = 1718.9\ C_2/R$ (mins), $\delta_3 = 1718.9\ C_3/R$ (mins) …...

$\Delta_1 = \delta_1$, $\Delta_2 = \Delta_1 + \delta_2$, $\Delta_3 = \Delta_2 + \delta_3$ ………………….. $\Delta_n = \Delta_{n-1} + \delta_n$

Significance:

After participating in this fieldwork, students will learn how to mark areas of the ground and in what proportions for setting out circular curve using data from 2 intersecting straight portions of different roads. Students will set the curve and check it following engineering principles. In particular they will set the curve using Perpendicular Offset Method and check for accuracy of points set using Rankine's Method.

Instruments:
Theodolite, Rope, Pegs (e.g., bamboo, steel), Tape.

Procedure:
Method of Perpendicular Offsets from Tangents
(i) Measure distances x_1, x_2, x_3 …..…… from the first tangent point T_1 along the tangent
(ii) Set perpendicular offsets O_x at the corresponding point.
(iii) Set the Super-elevation along the road width.

Check by Rankine's Method of Tangential Angle
(iv) Set the theodolite at T_1 along the back tangent VT_1

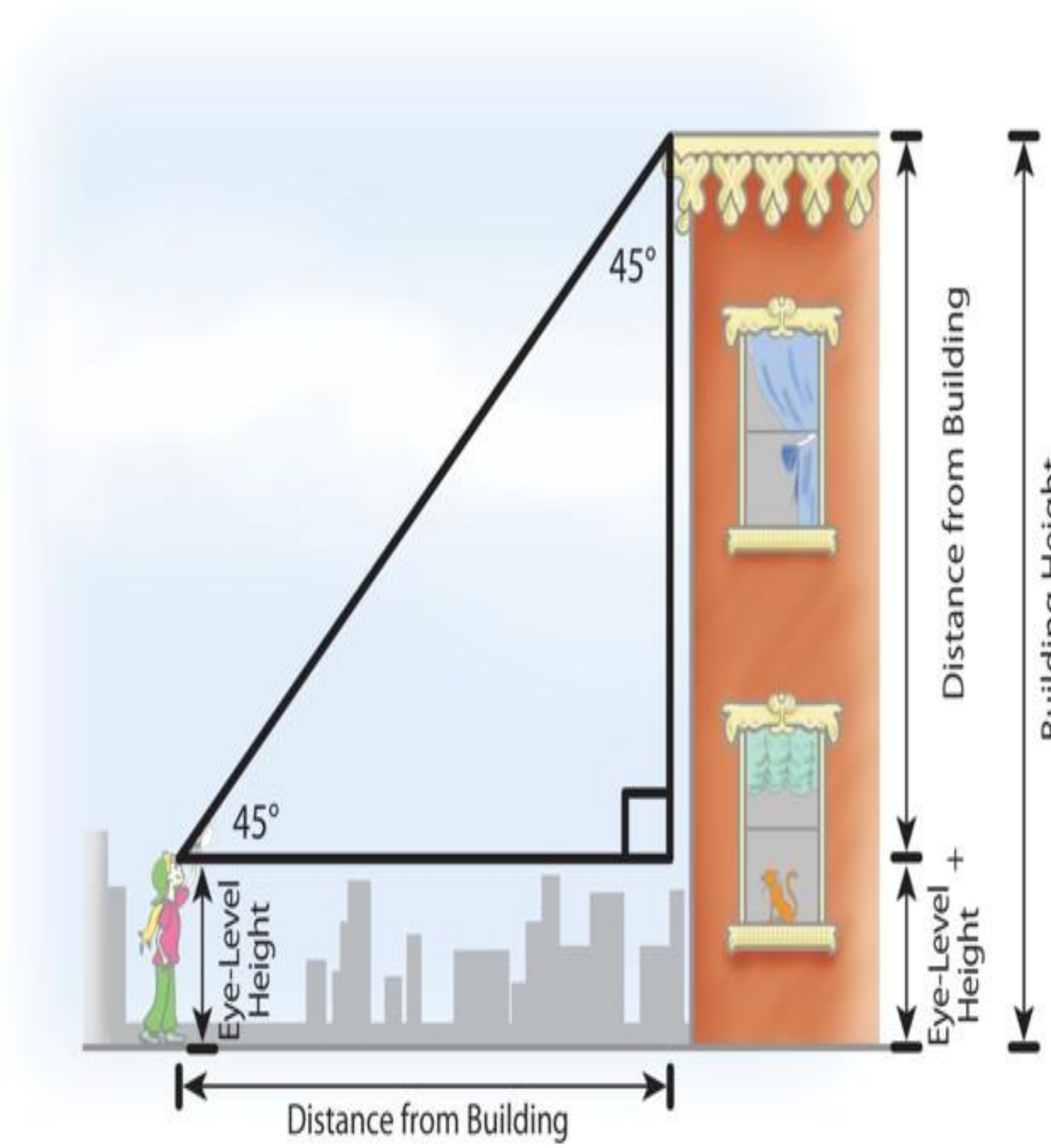
(v) Rotate it to the pegs at A, B, C……, measure the successive cord distances C_1, C_2, C_3 ……… and deflection angles Δ_1, Δ_2, Δ_3 ……..
(vi) Compare the deflection angles with the calculated deflection angles.

Data: Deflection angle, Degree of curvature, Cord interval for circular curve, Super-elevation, Road width, Maximum speed of vehicle.

Submission:
Detailed calculation for necessary data and drawing using
(i) Perpendicular offsets from tangents, (ii) Rankine's Method

Fieldwork No. 7

HEIGHT MEASUREMENT



Objective: To determine the height of a tower by Trigonometric Leveling.

Instrument:

1. Theodolite
2. Staff
3. Measuring Tape
4. Arrow/ peg
5. Ranging rod

Base of the object inaccessible: Instrument stations in the same vertical plane as the elevated object

If the horizontal distance between the instrument and the object can be measured due to obstacles etc., two Instrument stations are used so that they are in the same vertical plane as the elevated object.

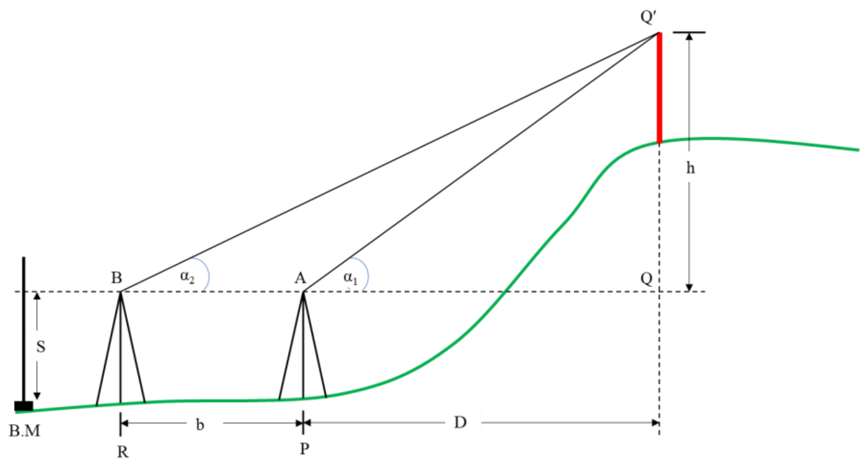


Figure 7.1: Instrument axes at the same level

Procedure:

1. Set up the theodolite at P and level it accurately with respect to the altitude bubble.

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 second instrument station R on the ground. Measure the distance RP accurately.

Repeat steps (2) and (3) for both face observations. The mean values should be adopted.

4. With the vertical vernier set to zero reading, and the altitude bubble in the centre of its run, take the reading on the staff kept at the nearby B.M.

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. With the vertical vernier set to zero reading, and the altitude bubble in the centre of its run, take the reading on the staff kept at the nearby B.M.

In order to calculate the R.L of Q′, there can be three cases:

(a) When the instrument axes at A and B are at the same level.

(b) When they are at different levels but the difference is small, and

(c) When they are at very different levels.

Case (a); i.e., Instrument axes at the same level (Fig. 7.1)

Let h = QQ′

α_1= Angle of elevation from A to Q′

α_2 = Angle of elevation from B to Q′

S =staff reading on B.M., taken from both A and B, the reading being the same in both the cases.

b = horizontal distance between the instrument stations.

D = horizontal distance between P and Q

From triangle AQQ′, h= D tan α_1 ………..(9.1)

From triangle BQQ′, h= (b + D) tan α_2 ………..(9.2)

Equating (9.1) and (9.2) $\Rightarrow$ D tan α_1 = (b + D) tan α_2

$\Rightarrow$ D = b tan α_2/(tan α_1– tan α_2) ………..(9.3)

$\therefore$ h = D tan α_1 = b tan α_1 tan α_2/(tan α_1– tan α_2) ………..(9.4)

R.L. of Q′ = R.L. of B.M. + S + h

Case (b); i.e., Instrument axes at the different level (Fig. 7.2)

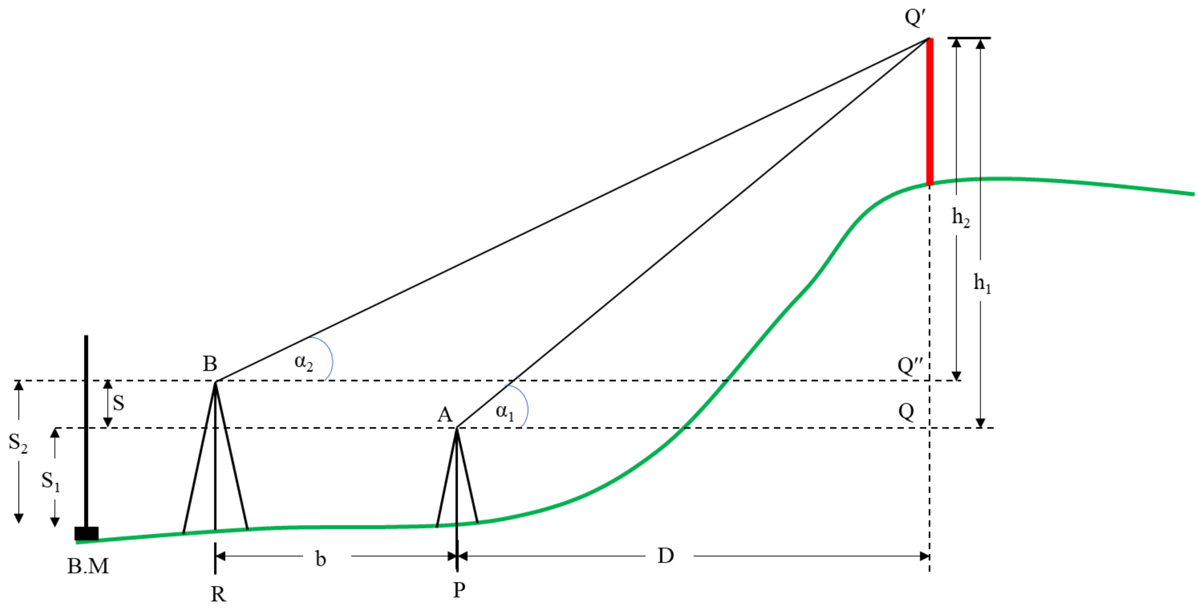


Figure 7.2: Instrument axes at the different levels

Let $h_1 = QQ'$

α_1= Angle of elevation from A to Q′

α_2 = Angle of elevation from B to Q′

S = Difference of staff readings on B.M., taken from both A and B

b = horizontal distance between the instrument stations.

D = horizontal distance between P and Q

$$\boldsymbol{D = \frac{s + b\, tan\alpha_2}{tan\alpha_1 - tan\alpha_2}} \qquad \text{..........(9.5)}$$

$$h_1 = D\, \boldsymbol{tan1} \qquad \text{..........(9.6)}$$

$$\therefore \boldsymbol{h_1 = \frac{s\, tan\alpha_1 + b\, tan\alpha_1 tan\alpha_2}{tan\alpha_1 - tan\alpha_2}} \qquad \text{..........(9.7)}$$

R.L. of Q′ = R.L. of B.M. + S_1 + h_1

Data Sheet:

Reduced level of bench mark: 0.00 m

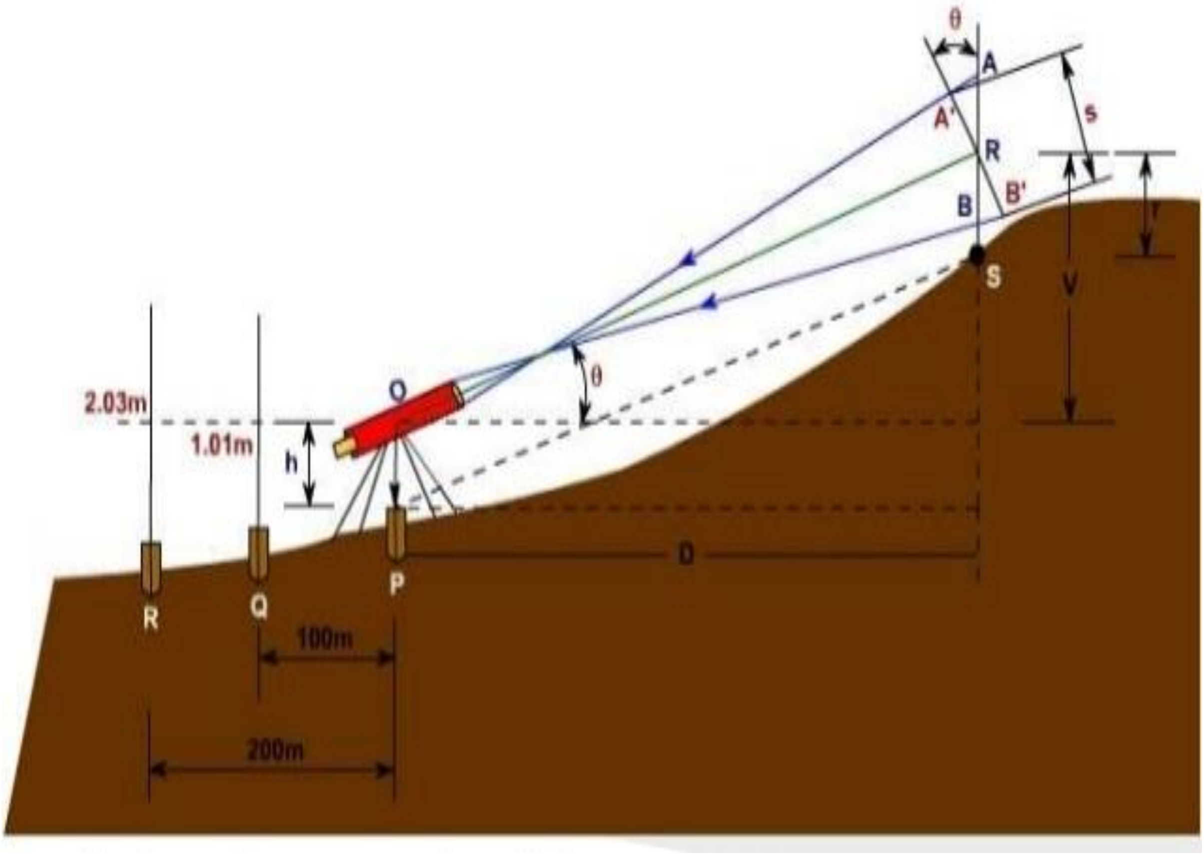
Sl. No	Parameters	Value
01		
02		
03		
04		
05		
06		

Assignments:

1. Height of the building.
2. Height of the flagpole.
3. Compare your result with the actual values.
4. Write some benefits of this method

Fieldwork No. 8

STADIA SURVEY/ TACHEOMETRY



Tacheometry is the type of surveying in which vertical and horizontal distances are computed from stadia readings without using chain or tape. This is done by the help of a special type of transit theodolite known as tacheometer and a staff known as stadia rod.

Stadia:
The stadia diaphragm essentially consists of one stadia hair above and the other an equal distance below the horizontal cross-hair, the stadia hairs being mounted in the ring and on the same vertical plane as the horizontal and vertical cross-hairs.

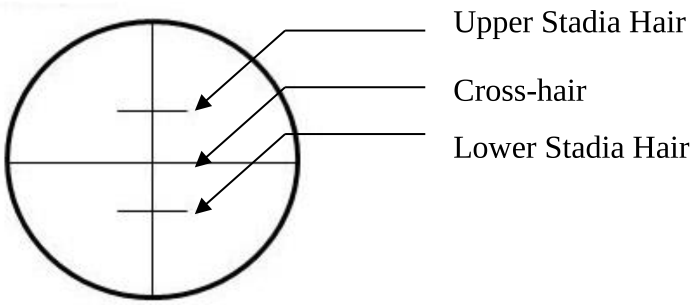


Figure 8.1: Stadia Diaphragm

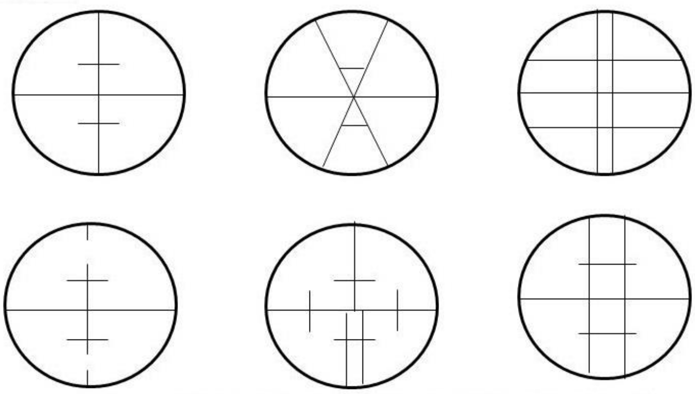


Figure 8.2: Different forms of stadia commonly used

Principle of Tacheometry:
In stadia tacheometry, the line of sight of the tacheometer may be kept horizontal or inclined depending upon the field conditions. In the case of horizontal line of sight, the horizontal distance between the instrument at A and the staff at B is

$$D = (f/i)S + (f+d)$$
$$D = K\,S + C$$

The value of (f + d) is called the additive constan, i.e. C; while (f/i) is called the multiplying constant, i.e. K.

Tacheometry can be used on horizontal or inclined sights. This lecture focuses on horizontal sights.
Tacheometric Equation for Horizontal Sights:
$D = KS + C$
S= Staff intercept = $S_T - S_B$, where S_T and S_B are the top hair and bottom hair readings respectively.
K = Multiplying constant of the tacheometer.
C = Additive constant of the tacheometer
D = horizontal distance between the instrument at A and the staff at B

Operating principle of a tacheometer:
In a theodolite, if two additional wires are placed symmetrically on either side of the horizontal cross-hair, the horizontal distance and vertical difference in height from the centre of the instrument to the staff point can be found out without actually measuring it. Such a diaphragm with additional horizontal wires is called a stadia diaphragm. The constant of the instrument depends upon the stadia interval, i.e. the interval between the two stadia wires. Normally, there are two constants.

i. The multiplying constant (K), normally kept at 100 or 150.
ii. The additive constant (C), the value of which varies from 20 to 30 cm. This value is grater in external focusing telescopes and smaller in internal focusing telescopes, and sometime quite negligible. By imposing an additional lens in the telescope, the additive constants can be reduced to zero. Such a lens is called an anallactic lens.

By observing the vertical angels, if any, from the instrument to the staff point, the horizontal distances and vertical height can be computed by applying proper equations.

Significance:
Through this fieldwork, students will learn about indirect measurement of horizontal or inclined distances. It is particularly useful where it is difficult to pass a measurement instrument along the terrain to the target place up to which the distance is to be measured**.**

Determination of Tacheometric Constants:
Set up the instrument on fairly level ground giving horizontal sights to a series of pegs at known distances, D, from the instrument. Now, using the equation D = KS + C.

For example,

Distance measured (ft)	Stadia Readings (cm)
50	135.5, 128, 120.5
75	140.5, 129, 118

For the 1st observation, distance measured, D_1 = 50 ft = 1524 cm & staff intercept (difference in readings between upper and lower stadia hair), S_1 = 135.5 – 120.5 cm = 15 cm.
$D_1 = KS_1 + C$ >>1524 = K (15) + C…………(i)

For the 2nd observation, distance measured,
$D_2 = KS_2 + C$ >>2286 = K (22.5) + C …………….(ii)

Solving the above two equations gives K = 101.6 and C = 0

So, **D = 101.6 * S**

Anallactic lens: Am additional lens is sometimes placed between the object glass and the eye piece of the telescope on order to eliminate the additive constant (f+d). This is done to make the expression for the distance D between instrument station and staff position more simplified. The anallactic lens is provided only in an external focusing telescope, but not in the internal focusing one, which is virtually anallactic since the value of (f+d) is very small. This arrangement simplifies the calculation of heights and distances from field book, specially for inclined sights. But the drawback is that it reduces the brilliance/ refulgence of the image due to absorption of light.

Problem sums:

Problem (1): Calculate the tacheometric constants from the following observations:

Distance measured (ft)	Staff Intercepts
200	1.988
300	2.991

Answer: 100 and 1

Problem (2): A tacheometer was placed with its axis horizontal 5.10 ft above a station A whose RL is 320 ft. staff was held at b vertically and the stadia readings were 4.50, 6.50 and 8.50. Calculate the distance between A and B and the R.L. of B. Given, f/i = 100 and f + d = 1.

Answer: 401 ft; 318.60 ft.

Problem (3): Calculate the tacheometric constants from the following observations:

Distance measured (ft)	Staff Intercepts
400	3.98, 5.975, 7.97
600	5.76, 8.755, 11.75

Answer: 100 and 1

Problem (4): A tacheometer was placed over a station whose reduced R.L. is 100.00, stadia readings were taken on another point with the staff vertical and the telescope horizontal. The readings were 4.28, 5.88 and 7.48. The height of the instrument axis over the station was 5.30 ft and the values of 9F+d) and F/I were 1 and 100 respectively. Calculate the R.L. of the staff station and the distance between the staff position and the instrument station.

Answer: 99.42 ft; 321 ft.

Fieldwork No. 9

CONTOURING

Objective: To draw a contour map

Methodology: Square or Grid System

Instruments:
1. Level
2. Leveling Staff
3. Arrows
4. Tape

Definitions:
(a) Contours: Contours are imaginary lines joining points of equal altitudes upon the earth's surface with reference to a fixed datum.

(b) Contouring: The process by which a contour map is prepared is known as contouring.

(c) Contour map/topographic map: The map showing the altitudes of all these points is called contour map or topographic map.

Procedure:

(a) Select any suitable place for setting up the instrument. Place the instrument and try to adjust it. Adjustment procedure should be consist of the followings,
(i) Setting up the level (ii) Leveling up (iii) Elimination of parallax

(b) Mark an area of 100 m^2; i.e., length 10 m and width 10m.

(c) Take staff reading at every station at an interval of 2.5 m. (e.g. 2.5 m × 2.5 m grid). The grid points are determined using tape, and marked using arrows.

(d) Take the elevation of top left corner as 7.00 m (A-1) which may be considered as bench mark.

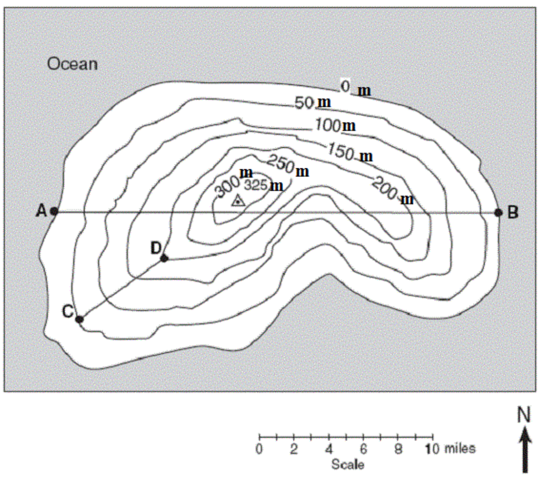


Figure 9.1: Typical Contour Diagram

Significance:

Contouring helps in studying the general character of the tract of the country without visiting the ground. With the knowledge of characteristics of contours, it is easy to visualize whether country is flat, undulating or mountainous. Contouring can assist in deciding the sites for engineering works such as reservoirs, canals, roads and railways etc. on the basis of the economy. Contouring is used to determine the catchment area of the drainage basin and hence capacity of the proposed reservoir. It is useful in computing the earth work required for filling or cutting along the linear alignment of the projects such as canals, roads, etc. In addition the height of earth retaining structures (e.g. retaining walls) can be easily estimated. Contouring is also used to find out the inter-visibility of the points and to trace out a contour gradient for road alignments. Besides, we can draw longitudinal and cross- sections to ascertain nature of the ground. Through this fieldwork students will learn about procedures of collecting data for contour maps, using level and tape. Students will also learn about the procedures to draw contour maps.

Data Sheet:

Station	Distance (m)	Staff Reading at station			H. I.	Difference		Reduced Level (m)	Remarks
		Back (m)	Inter (m)	Fore (m)		Rise (m)	Fall (m)		
A1									B.M.
A2									
A3									
A4									
A5									
B1									
B2									
B3									
B4									
B5									
C1									
C2									
C3									
C4									
C5									
D1									
D2									
D3									
D4									
D5									
E1									
E2									
E3									
E4									
E5									

Contour Map:

Assignments:

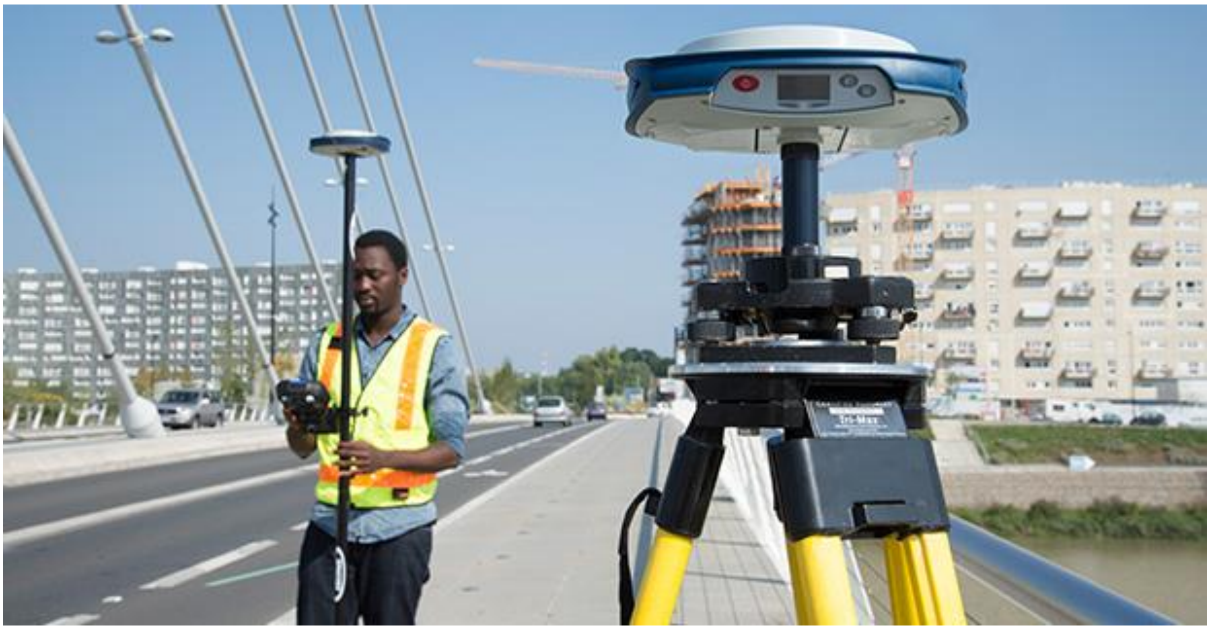
(a) Find out the reduced levels of each points by any methods

(b) Draw contour lines of 0.1 m interval

(c) Draw the contour map using EXCEL

(d) Viva –voce

Fieldwork No. 10
GLOBAL POSITIONING SYSTEM (GPS)



Objective: To plot a small area using GPS measurements.

Theory:

The Global Positioning System (GPS) is a satellite-based navigation and surveying system for determination of precise position and time, using radio signals from the satellites, in real time or in post-processing mode. The NAVSTAR Global Positioning System is a satellite based navigation system being developed and maintained by the DoD since 1972, for providing extremely accurate 3-D position fixes and UTC information to properly equipped users anywhere on or near the Earth, at any time, regardless of weather conditions. The system consists of three segments: Space Segment, Control Segment and User Segment. The satellites continuously transmit dual frequency navigation signals consisting of information of satellites position with time tag, along with other data, which is periodically uploaded in satellite memory from the Control Segment. The User Segment receives navigation signals from at least 4 satellites, available any time globally, allowing the user to simultaneously solve 4 independent range-difference equations to yield his position - latitude, longitude and height and also the time.

GPS Segments: The Global Positioning System basically consists of three segments: the Space Segment, The Control Segment and the User Segment.

1. Space Segment

The Space Segment contains 24 satellites, in 12-hour near-circular orbits at altitude of about 20000 km, with inclination of orbit 55°. The constellation ensures at least 4 satellites in view from any point on the earth at any time for 3-D positioning and navigation on world-wide basis. The three-axis controlled, earth-pointing satellites continuously transmit navigation and system data comprising predicted satellite ephemeris, clock error etc., on dual frequency L1 and L2 bands (see Figs. 1 & 2).

2. Control Segment

This has a Master Control Station (MCS), few Monitor Stations (MSs) and an Up Load Station (ULS). The MSs are transportable shelters with receivers and computers; all located in U.S.A., which passively track satellites, accumulating ranging data from navigation signals. This is transferred to MCS for processing by computer, to provide best estimates of satellite position, velocity and clock drift relative to system time. The data thus processed generates refined information of gravity field influencing the satellite motion, solar pressure parameters, position, clock bias and electronic delay characteristics of ground stations and other observable system influences. Future navigation messages are generated from this and loaded into satellite memory once a day via ULS which has a parabolic antenna, a transmitter and a computer. Thus, role of Control Segment is: - To estimate satellite [space vehicle (SV)] ephemerides and atomic clock behaviour. - To predict SV positions and clock drifts. - To upload this data to SVs.

3. User Segment

The user equipment consists of an antenna, a receiver, a data-processor with software and a control/display unit. The GPS receiver measures the pseudo range, phase and other data using navigation signals from minimum 4 satellites and computes the 3-D position, velocity and system time. The position is in geocentric coordinates in the basic reference coordinate system: World Geodetic reference System 1984 (WGS 84), which are converted and displayed as geographic, UTM, grid, or any other type of coordinates. Corrections like delay due to ionospheric and tropospheric refraction, clock errors, etc. are also computed and applied by the user equipment / processing software.

Significance:

Through this fieldwork, students will learn about taking data using a GPS receiver and using that data to plot surveyed areas as well as make other calculations including area of that place. Surveying Surveyors are responsible for mapping and measuring features on the earth's surface and under water with high accuracy. This includes things like determining land boundaries, monitoring changes in the shape of structures or mapping the sea floor. Surveyors have historically required line-of-sight between their instruments in order to undertake such work, but the availability of high accuracy GPS receivers has reduced the need for this. GPS can either be setup over a single point to establish a reference marker, or it can be used in a moving configuration to map out the boundaries of various features. This data can then be transferred into mapping software to create very quick and detailed maps for customers.

Instruments:

1. Antenna and cables
2. Batteries and power cables
3. Tripods, tribrachs and adapters
4. Tape measures
5. Flashlights
6. Radios
7. Station log sheets
8. Writing apparatus (pens)

9. Station descriptions
10. Observing schedule and station lists
11. Special equipment required
12. Traffic cones, safety equipment
13. Maps, keys, lock combinations.

Procedure:

1. Reconnaissance for a GPS Survey.
2. Antenna is set up. Check that tripod is stable. Weights, such as sand bags, must be used to stabilize legs on hard paving surfaces. Check that antenna/tribrach is level.
3. Keep signal path clear; heads, trucks, etc. Check for reflective objects (e.g. any nearby vehicles).
4. Orient the phase center offset.
5. Follow the manufacturer's recommended procedure for determining the antenna height. Make at least two antenna height measurements per session. Verify the height at the end of station occupation. Measure the antenna height in meters and preferably in feet as well.
6. Operate the receiver following the instructions of the instructor.
7. Initialize the session according to the requirements of the survey method utilized.
8. Key in all necessary station and session related information.
9. Coordinate the length of the session with other stations.
10. If other stations are not ready, you may start observing early.
11. Check receiver and antenna frequently during observations. Check for power loss, tripod movement, etc. Record weather data and note any drastic changes during sessions. Monitor data logs and note unusual occurrences during sessions.

Reconnaissance for a GPS Survey:

Reconnaissance is one of the most important parts of a GPS survey. For the actual collection of GPS data, the observing station must have a clear view of the sky when satellites are passing over the job site. Steps involved in a typical GPS reconnaissance include:

a. Mark the general area where GPS control points are to be located on maps or aerial photographs.
b. Visit the job site and select the best location for the control point.

c. Using a "Station Visibility Diagram," locate and record all obstructions exceeding 20 degrees above the horizon, as well as any radio frequency (RF) sources. Ideal tools for this are a compass and an Abney level.
d. Using the station visibility diagrams and a skyplot of visible satellites at the time the GPS survey is to take place, the proper observing session can be planned for each station.

Methodology – Point positioning:

In point positioning, coordinates of the antenna position at an unknown point are sought with respect to the WGS84 reference frame. In this method, the known positions of the tracked GPS satellites (the position of a satellite can be computed from ephemerides) are being used to determine the position of unknown point using single GPS receiver by a method similar to the method of resection used in plane table surveying (Fig. 10.1).

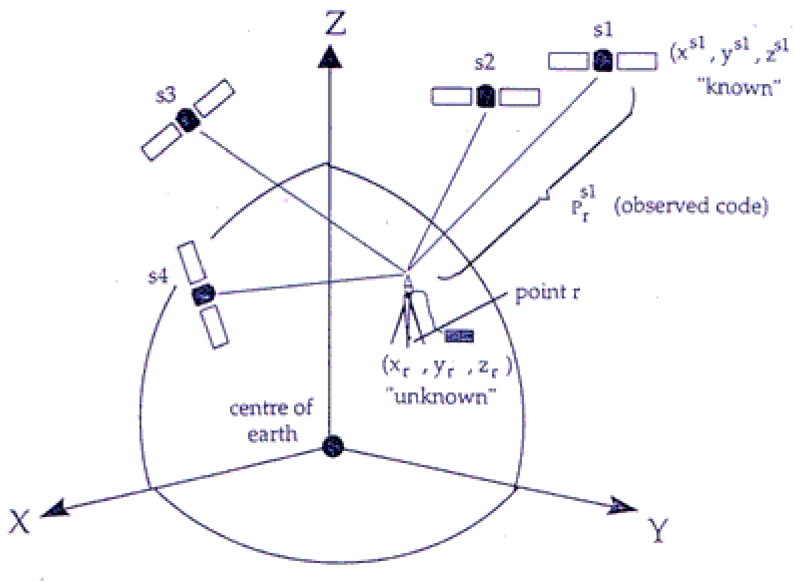


Figure 10.1: Point Positioning of GPS receiver

In this figure, s1, s2, s3 and s4 represent four different satellites (least required) being tracked. The positions of these satellites are referenced to the centre of the earth in the X, Y, Z coordinate frame. The coordinates for s1 are shown as (xs1, ys1, zs1). The coordinates of r, the unknown point, as referenced to the centre of the earth, are assumed to be (xr, yr, zr). The observed code, Prs1, relates the known coordinates of satellite 1 with the unknown coordinates of the receiver using the equation for a line in three-dimensional space. That is,

Prs1 = Ö [(Xs1 – Xr)2 + (Ys1 – Yr)2 + (Zs1 – Zr)2] + error

Thus, from four satellites, four distance equation can be formed leading to computation of the four unknowns (xr, yr, zr and clock bias) can be computed.

Control Point:

Land surveyors measure horizontal positions in geographic or plane coordinate systems relative to previously surveyed positions called **control points**. Control points are those whose position and coordinates are already known before start of survey. A geodetic control network consists of stable, identifiable points with published datum values derived from observations that tie the points together. The control point is used to enable to plot a map based on GPS data. Good site characteristics of a control point for GPS observation include:

- A clear view of the sky;
- No obstructions above the cut-off angle (say 15°);
- No reflecting surfaces that could cause multi-path;
- Safe, away from traffic and passers-by;
- Possibility to leave the receiver unattended;
- No powerful transmitters (radio, TV antennas etc.) in the vicinity

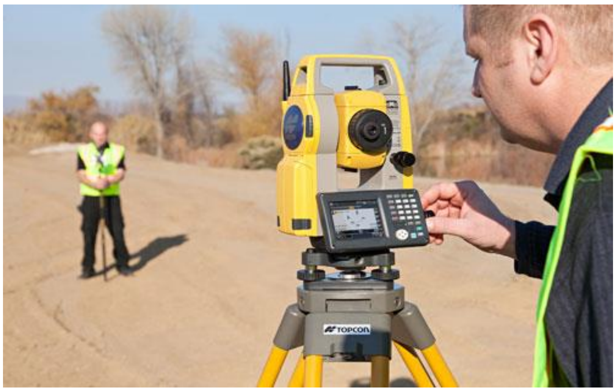
Assignments:

Plot the interior details of the area surveyed in a drawing sheet. Find the area of the plot. Compare it with manual measurements taken with a tape/chain.

Instruction: Drawing has to be submitted individually.

Fieldwork No. 11

TOTAL STATION (TS)



Objective: To plot a small area using measurements taken from a Total Station.

Theory:

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

Total stations with different accuracy, in angle measurement and different range of measurements are available in the market. Figure 1 shows one such instrument manufactured by SOKKIA Co. Ltd. Tokyo, Japan.

Important Operations of Total Station:

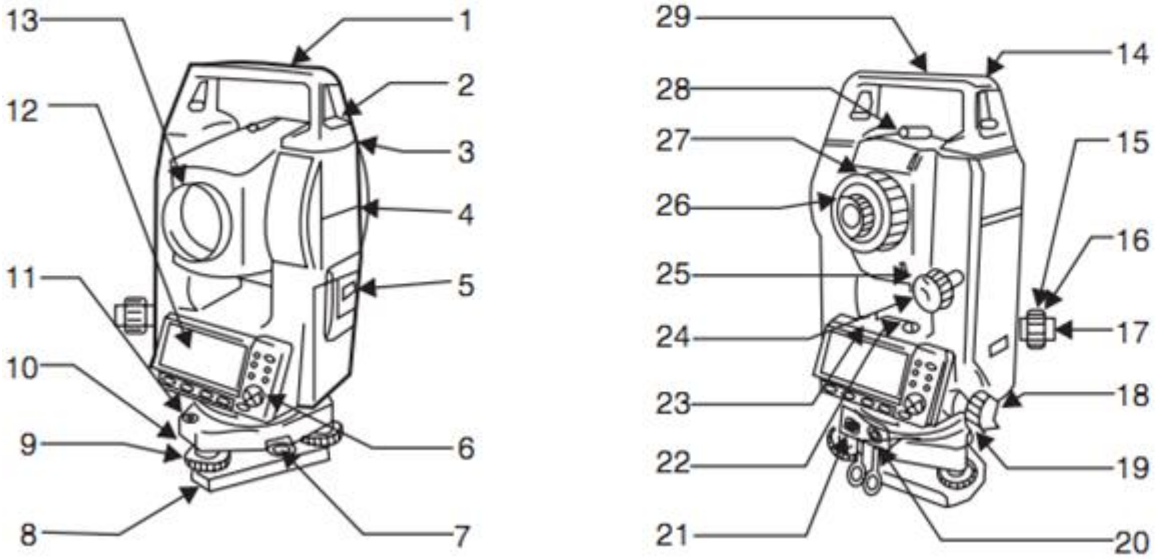
1. **Distance Measurement:** Electronic distance measuring (EDM) instrument is a major part of total station. Its range varies from 2.8 km to 4.2 km. The accuracy of measurement varies from 5 mm to 10 mm per km measurement. They are used with automatic target recognizer. The distance measured is always sloping distance from instrument to the object.
2. **Angle Measurements:** The electronic theodolite part of total station is used for measuring vertical and horizontal angle. For measurement of horizontal angles any convenient direction may be taken as reference direction. For vertical angle measurement vertical upward (zenith) direction is taken as reference direction. The accuracy of angle measurement varies from 2 to 6 seconds.
3. **Data Processing:** The instrument is provided with an inbuilt microprocessor. The microprocessor averages multiple observations. With the help of slope distance and vertical and horizontal angles measured, when height of axis of instrument and targets are supplied, the microprocessor computes the horizontal distance and X, Y, Z coordinates. The processor is capable of applying temperature and pressure corrections to the measurements, if atmospheric temperature and pressures are supplied.

Significance:

Through this fieldwork, students will learn the operation of and data usage from total station to plot a surveyed area. Total Station is used in Mine Survey, Cadastral Survey, Engineering Survey, Large Scale Survey, Road / Rail / Canal Survey, etc. It is particularly useful in Remote Distance Measurement (RDM) and Missing Line Measurement (MLM).

Instruments:

1. Total Station
2. Tripods
3. Batteries and Chargers
4. Data and Power cables
5. Prisms
6. Prism Poles
7. Tribraches



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

Figure 11.1: Point Positioning of GPS receiver
(https://theconstructor.org)

Figure 11.2: Accessories Used with Total Station

(http://www.gisresources.com)

Procedure:

1. The total station instrument is mounted on a tripod and is levelled by operating levelling screws. Within a small range instrument is capable of adjusting itself to the level position. Then vertical and horizontal reference directions are indexed using onboard keys.
2. It is possible to set required units for distance, temperature and pressure (FPS or SI). Surveyor can select measurement mode like fine, coarse, single or repeated.
3. When target is sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriate keys they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information about the point and displays on screen.
4. This information is also stored in the electronic notebook. At the end of the day or whenever electronic note book is full, the information stored is downloaded to computers.
5. The point data downloaded to the computer can be used for further processing. There are software like auto civil and auto plotter clubbed with AutoCad which can be used for plotting contours at any specified interval and for plotting cross-section along any specified line.

Advantages of Using Total Stations

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

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

However, surveyor should check the working condition of the instruments before using. For these standard points may be located near survey office and before taking out instrument for field work, its working is checked by observing those standard points from the specified instrument station.

Assignments:

Plot the interior details of the area surveyed in a drawing sheet and also in AutoCAD.

Find the area of the plot from AutoCAD and directly from Total Station. Finally, compare the results with the actual area obtained from manual measurements taken with a tape/chain in the field.

Instruction: Drawing has to be submitted individually.

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