LAB MANUALS
SURVEYING – II
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MGM'S
JAWAHARLAL NEHRU ENGINEERING COLLEGE
N-6, CIDCO, AURANGABAD

CIVIL ENGINEERING DEPARTMENT

LAB MANUALS
(Procedure for Conduct of Practicals/ Termwork)

Subject:- Surveying-II
Class:- (S.E Civil)

Prepared by

Revised and Approved by
Head of Department

Issued by
MR
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## PROJECT

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EXPERIMENT NO. 1

1) AIM: Setting of Curves by deflection distances (or offsets from the chords produced)

Definition: The method is very much useful for long curves and is generally used on highway curves when a theodolite is not available.

2) INSTRUMENTS USED: Theodolite, chain, Ranging rods, tape, Pegs, Hammer etc.

3) PROCEDURE:

Procedure for Setting Out the curve

1. Locate the tangent points \( T_1 \) and \( T_1 \) and find out their chainages as explained earlier. Calculate the length \( c \) of the first sub-chord so that the first peg is the full station.

2. With zero mark at \( T_1 \) spread the chain (or tape) along the first tangent to point \( A1 \) on it such that \( T_1A_1 = c \) = length of the first sub-chord.
**Procedure for Setting Out Curve**

1. Set the theodolite at the point of curve \((T_1)\). With both plates clamped to zero, direct the theodolite to bisect the point of intersection \((V)\). The line of sight is thus in the direction of the rear tangent.

2. Release the vernier plate and set angle \(V_1\) on the vernier. The line of sight is thus directed along chord \(T_1A\).

3. With the zero end of the tape pointed at \(T_1\) and an arrow held at a distance \(= T_1A = c\) along it, swing the tape around \(T_1\) till the arrow is bisected by the cross-hairs. Thus, the first point \(A\) is fixed.

4. Set the second deflection angle \(V_2\) on the venire so that the line of sight is directed along \(T_1B\).

5. With the zero end of the tape pinned, at \(A\), and an arrow held at distance \(AB = C\) along it, swing the tape around \(A\) till the arrow is bisected by the cross-hairs, thus fixing the point \(B\).

6. Repeat steps (4) and (5) till the last point \(T_2\) is reached.

Check: The last point so located must coincide with the point of tangency \((T_2)\) fixed independently by measurements from the point of intersection. If the discrepancy is small, last few pegs may be adjusted. If it is more, the whole curve should be reset.

In the case of the left hand curve, each of the calculated values of the deflection angle (i.e. \(V_1, V_2\) etc.), should be subtracted from \(360^0\). The angles so obtained are to be set on the vernier of theodolite for setting out the curve.
EXPERIMENT NO. 2

1) AIM: Setting of Curves by deflection Rankine's Method.

2) INSTRUMENTS USED: Theodolite, chain, Ranging rods, tape, Pegs, Hammer etc.

3) PROCEDURE:

RANINE'S METHOD OF TANGENTIAL (OR DEFLECTION) ANGLE

A deflection angle to any point on the curve is the angle of P.C. between the back tangment and the chord from P.C. to that point.

Rankine's method is based on the principle that the deflection angle to any point on a circular curve is measured by one-half the angle subtended by the arc from P.C. to that point, it is assumed that the length of the arc is approximately equal to its chord.
3. With \( T_1 \) as centre and \( T_1A_1 \) as radius, swing the chain such that the arc \( A_1A \) is calculated offset \( O_1 \). Fix the point \( A \) on the curve.

4. Spread the chain along \( T_1A \) and pull it straight in this direction to a point \( B_2 \) such that the zero of the chain is at \( A \) and the distance \( AB_2 = C \) = length of the normal chord.

5. With zero of the chain centred at \( A \) and \( AB_2 \) as radius, swing the chain to a point \( B \) such that \( B_2B_2 = 0_2 \) = length of the second offset. Fix the point \( B \) on the curve.

6. Spread the chain along \( AB \) and repeat the steps (4) and (5) till the point of tangency (\( T_2 \)) is reached. All intermediate offsets will be equal to \( \frac{C^2}{R} \), while the last offset will be equal to \( \frac{C}{2R} (C + C') \).

The last point so fixed must coincide with the point of tangency (\( T_2 \)) field originally by measurements from the vertex. If the discrepancy (sometimes called as the closing error) is more, the curve should be reset. If the error is less, it should be distributed to all the points by moving them sideways by an amount proportional to the square of their distance from the point \( T_1 \).

The method is mostly used in road surveys and is very satisfactory, specially when a theodolite is not available. However, it has a great defect in that the error in fixing a point is carried forward.
EXERCISE NO : 3

MEASUREMENT OF A BASE LINE

AIM : To measure the distance between two points on a base line by subtense bar method.

EQUIPMENTS : Subtense bar, transit theodolite with tripod, pegs, hammer metallic tape etc.

THEORY : Subtense bar is an instrument by which we can measure horizontal distance on a base line with better accuracy.

A subtense bar of fixed length usually 2m is stationed at one end of the base line to be measured and theodolite at the other end. The bar can be folded at the centre of the bar so as to set the subtense bar parallel to the line. The base is supported by a tripod and can be levelled accurately. The angle subtended by the bar at the instrument station called the parallactic angle is measured by the theodolite (i.e. hori. angle) between the triangular targets. The Vertical angle is also measured from this the horizontal distance between inst station & subtense bar station is calculated.

FIGURE :

![Figure 1](image1)

![Figure 2](image2)
\[ P = \text{Theodolite station} \]
\[ Q = \text{Substance bar station} \]
\[ \alpha = \text{Horizontal angle APB} \]
\[ \theta = \text{Vertical angle} = QPQ \]
\[ D = \text{Inclined distance between theodolite \& substance bar} \]

**OBSERVATIONS TABLE:**

<table>
<thead>
<tr>
<th>INST S</th>
<th>OBJECT SIGHTED</th>
<th>FACE</th>
<th>VER 'A' READING</th>
<th>VER 'B' READING</th>
<th>MEAN ANGLE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**OBSERVATIONS:**

1. Mean Horizontal angle (\( \alpha \)) =
2. Mean Vertical angle (\( \theta \)) =

**CALCULATIONS:**

From fig. (1)

\[
\tan \frac{\alpha}{2} = \frac{AQ}{2PO} = \frac{1}{d}
\]

\[
d = \sqrt{\tan \alpha / 2} = \frac{1}{\cot \frac{\alpha}{2}}
\]

\[
d = \frac{s}{\cot \frac{\alpha}{2}}
\]

(1) \( s \) is the stadia diff.

From Fig (2)

\[
\cos \theta = \frac{PQ}{D} = \frac{D}{PQ}
\]

\[
D = d \cos \theta - \text{II}
\]

RESULT: Horizontal distance between two points P & Q on a base line by substense bar method is \( \text{--- m} \).
EXERCISE NO. 4

SATELLITE STATION : REDUCTION TO CENTRE

In order to secure well conditioned triangle or better visibility objects such as church spires flag poles, towers etc are selected as the triangulation stations. When the observations are taken from such station it is impossible to set up an instrument over it. In such case a subsidiary station known as satellite station or eccentric station is selected as new to the main station as possible and observations are taken to the other triangulation stations. These angles are later corrected and reduced to what they would have been at the true station was occupied. This operation of applying the corrections due to eccentricity of the station is known as 'Reduction to centre'.

Let

- Let $A, B, C$ = Triangulation stations
- $S$ = Satellite Station for $B$.
- $d = BS$ = eccentric dist bet $B & S$.
- $\phi = ASC = \text{obs angle at } S$.
- $\alpha = \text{True angle at } B$.
- $Y = LCSB = \text{obs angle at } S$.
- $\beta_1 = SAB$.
- $\beta_2 = SCB$.
- $AC = d$, $AB = C \& BC = \alpha$.

1) Measure $AC & BS$.

$$BC = a = \frac{bsin CAB}{sin ABC}.$$  

$$AB = C = \frac{bsin ACB}{sin ABC}.$$  

Now $ABC = 180 - \angle BAC - \angle BCA$.

$$r = 180 - \angle A - \angle C.$$  

2) Knowing sides $AB & BC$ and eccentric distance $BS$, 'S ABS & CBS can be solved by sine rule, to get the values of $\beta_1$ & $\beta_2$ respectively.

- from ABS:
$$Sin \beta_1 = \frac{BS \sin ASE}{ABC} = \frac{d \sin (Q + Y)}{C}.$$  

- and from CBS:
$$Sin \beta_2 = \frac{BS \sin BSQ}{BC} = \frac{d \sin y}{a}.$$  

Since BS is very small in comparison to BA & BC the $\angle S \beta_1$ & $\beta_2$ are very small, we may write.
\[ B_1 \text{ (Seconds)} = \frac{\sin B}{\sin 1^\circ} \]
\[ = \frac{d \sin (Q + Y)}{c} \times 206265 \]

\[ B_2 \text{ (Seconds)} = \frac{\sin B}{\sin 1^\circ} \]
\[ = \frac{d \sin Y}{a \sin 1^\circ} = \frac{d \sin Y}{206265} \]

3) After having calculates the \( B_1 \) & \( B_2 \) the observed angle \( \theta \) at \( s \) is reduced to that at \( B \) as follow.

\[ \text{ABC} = \text{AOC} - \beta_2 \]
\[ = (\beta_1 + Q) - \frac{\pi}{2} \]
\[ = Q + B_1 + E \]

RESULT = ABC
**EXERCISE NO. 5**

**STUDY OF WILD T-2**

**AIM** : To study wild T-2 theodolite and measurement of horizontal & vertical angles by it.

**INSTRUMENTS** : WILD-T2 Theodolite with tripod, peg, hammer, ranging rods.

**THEORY** : Wild T2 is an universal instrument of 1" sec accuracy and used for different kinds of surveying.

- i) Triangulations survey
- ii) Astronomical surveying can be done accurately.
- iii) Extremely used in hydrographic surveying
- iv) In photogrammetry as a photo theodolite, the camera is fixed at upper part and photographs in required angles are taken.

**Parts of WILD - T2 Theodolite :**

- a) Optical Plummet used for accurate centering
- b) Selector Knob : For measurement of horizontal and vertical angle, the red line on selector knob is kept horizontal & vertical respectively.
- c) Circular Drive Knob : Used to adjust the initial reading, (generally 0° 0′ 0") on horizontal scale for measurement of angle.
- d) Horizontal drive knob : Used for bisection of object by horizontal direction.
- e) Vertical drive knob : Used for bisection of object by vertical direction.
- f) Micrometer Knob:

**OBSERVATION TABLE**

<table>
<thead>
<tr>
<th>Station</th>
<th>Object sighted</th>
<th>Face</th>
<th>Horizontal</th>
<th>Moni Angle</th>
<th>Vertical duke</th>
<th>Ver Angle</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Diff</td>
<td>Initial</td>
<td>Final</td>
</tr>
</tbody>
</table>

Diaphragm of wild T2

Scales of wild T2
DESCRIPTION OF THE INSTRUMENT WILD T2

1) Tribrach: The tribrach is the base of the inst, it has 3 foot square for setting the U.A. Vertical and an optical plummet for centering, it also has a circular level for leveling.

2) Lower Part: This campuses the centering flange, the standing ones system, the horizontal wide and associated parts. While using electric illumination, the mirror must be replaced by a plug in lamp. The socket to the left of the mirror must be connected to a battery box.

3) Alidade: The alidade is the upper part of the inst which rates around the standing axis. The telescope and reading micros are mounted. The plate level (21) is for levelling (up). The left standard with illuminating mirror (9) houses the vertical acre automatic indere. On the largest standard are the micrometer drive knob (15) and selector knob (20). If the red line on the selector knob is horizontal, the hole circle is seen the tricycles appears yellow the vertical white; The hori clamp & drive (5,22) & vertical clamp & drive (8,6) are used for setting the telescope to the largest, the press button checks the functioning of the automatic index.

4. Telescope: The telescope transet, at both ends the image is erect. The eyepieces is used for to cussing the cross hairs. The optical sights (7) are used for initially pointing to a largest.

USE OF THE INSTRUMENT

1) Centering & Leveling:

2) Focusing & Sightings: Pt telescope to sky or price of paper town eyepiece (19) until cross hairs are seen shop Target Image fours sing : Stacken horizontal & vertical clamps (5,8) point telescope to largest by means of
optical sight (7) tightens, the clamps, look through telescope eyepiece & turn focusing sleeve (screw) in till target is seem. Set cross hairs close to target by leveling the horizontal & vertical drives (6,22).

3] Circle Readings: For day light work is the elimination mirrors (3,9) are opened. The eyepiece (18) of the reading microscope is turned until the circle graduation lines (top window) are in focus.

In the top window of the reading microscope, image of graduation lines of diametrically opp. parts of the XXXX are seem. The two images appear to be separates by a fire line.

In the upper part of the central window all are seem the whole degree numbers. reach no has a triangular index beneath itBelow this indere is the row of numbers for tens of minutes.

In the bottom window is the micrometer scale. The value of one scale interval is 1".

4] setting the horizontal circle to Zero regained scales.

Assume that after pointing to the reference object it is regained to set 94°12'44". The 2'44" are set against the index of the micrometer scales by leavening the micrometer knob (15). the cover (23) is then opened and the circle drive to wined in till 94° appears & triangle is over no number.
1 Optical plummet
2 Tripod HDF22
3 Illumination mirror for horizontal circle
4 Lower part of T2
5 Horizontal clamp
6 Vertical drive screw
7 Optical sight, with point for centring under rod points
8 Vertical clamp
9 Illumination mirror for vertical circle
10 Telescope objective
11 Safety catch for carrying handle
12 Carrying handle
13 Locking screw for carrying handle
14 Lever for field of view (reticle) illumination. When using electric lighting, move lever towards objective until it reaches its stop.
15 Micrometer knob
16 Focusing sleeve
17 Bayonet ring, locks eyepiece in position
18 Eyepiece of reading microscope
19 Telescope eyepiece with dioptric scale
20 Selector knob for Hz and V reading
21 Plate level
22 Horizontal drive screw
23 Cover for circle drive knob
24 Circular bubble
25 Swivel locking knob. Arrow DOWN = locked. Arrow UP = unlocked. Knob is secured in arrow DOWN position by recessed screw when instrument leaves factory.
26 Foot screw
**PROJECT NO. 1**

**TACHEOMETRIC CONTOURING**

A tacheometer is a theodolite fitted with a sladia a diaphragm so that staff readings against all three hairs may be taken. In case of trilly terrain the tacheometric method can be used with advantage. The line of sight can make any inclination with the horizontal, thus increasing the range of instrumental observations. The horizontal distances need not to be measured, since the tacheometer provides both horizontal as well as vertical control.

A tacheometer is set on a pt. Where greater control is obtained. Radial lines can then be set making different angles with either the magnetic meridian or with the 1st radial line. On each radial line readings may be taken on leveling staff at different points. Thus on the same radial line the horizontal equivalent will be smaller for those two points the vertical difference in elevation of which is greater or vice-versa.

**Tacheometry Observations:**

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</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>
PROJECT NO. 2

SETTING OUT A RESIDENTIAL BUILDING

AIM: To set out a building Plan on ground.

EQUIPMENT:
Metallic tape (30m), pegs, hammed, cross staff etc.

THEORY: The object so setting out a building is to clearly define the outline of excavation on the ground for the guidance of contractor.

The site plan & detailed plan are studied Thoroughly. Then to set out a reference rectangle, outside, the limits of excavations, say, about 5m from the building line. So that the reference pts A,B,C,& D will not be disturbed during excavation & then to locate each corner by means of coordinates with reference to the sides of the rectangle.

PROCEDURE:

i) Two stakes A & B are accurately driven at the required distance.

ii) A cord is then stretched, the ends being secured to the wire nails drivers in the center of the stakes.

iii) At A set out a line ar to AB, The right angle being set out with the tape by 3-4-5 methods.

iv) On this line a stake is driven at D at a dist equal to the length of AD

v) The work is checked by measuring the diagonal BD & comparing it with calculated length, the error if any should be corrected.

vi) Similar procedure, is followed at B to set the stake at C.

vii) As a check, the diagonal AC is measured. The distance ED should now be exactly equal to dist AB.

viii) A cord is then passed round the periphery of the rectangle ABCD. Having set out the reference rectangle each corner is fixed by measuring. Its coordinates, from the sides of the reference rectangle & a stake is then driven to mark its exact position.

ix) When all the corners have been staked, a cord should be run round the periphery & the outline of the foundations marked with lime powder.

FIGURE:
4) FIGURE:
### Observation Table:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Page NO.</td>
<td>Chainage ft.</td>
<td>Chord Length ft. of Meters</td>
<td>Tangential Angle</td>
<td>Total Tangential or deflection angle</td>
<td>Actual Theodolite Reading</td>
<td>Offset Length</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
CED273 LAB VIII: SURVEYING – II

Teaching Scheme Examination Scheme
Practical: 2Hrs /week Term work: 25 marks

Oral Examination: 25 marks

**Term Work:** (A) The term work shall consist of Experiments given below (any seven)

1. Setting out simple circular curve by offset from long chord method.
2. Setting out simple circular curve by offset from chord Produced.
3. Setting out simple circular curve by Rankine’s method.
4. Measurements of base line by subtense bar method.
5. Satellite station and reduction to center
6. Study of one second Theodolite and measurement of horizontal angle by repetition method.
7. Study of Nautical sextant and measurement of angle by nautical sextant.
8. Determination of elevations and distances by Trignometrical observations

(B) Projects: - Any Two

1) Tachometric contouring.
2) Geodetic Quadrilateral Adjustments
3) Setting out building / culvert.

The assessment of term work shall be done on the basis of the following:

- Continuous Assessment
- Performing the experiment given in Laboratory

**Oral Examination**
The practical examination shall consists of performing an exercises based on the practical work done during the course. The record of the exercises submitted by the candidate and viva voce on the syllabus. The assessment will be based on

1) Performing an exercise
2) Record of exercise submitted by the candidate.
3) Viva – voce on the syllabus.

S. R. Shihab. A - Batch 1113
2/91
PROJECT NO.3

SETTING OUT A CULVERT

AIM: To set out a culvert on roads or railways & nullahs.

EQUIPMENTS: Chain, tapes, pegs, tress staff, hammer etc.

THEORY: The centre of the culvert is taken as the origin and the center lines of the roads, railway, etc and the nullahs are considered as the axes of coordinates. As in case of Buildings the foundations trench peon is proposed after the telans & estimates of the work are finalized and the chenille lines of the road or railway and the nullah are marled. The coordinates of all the crones are actually arced from the peon & the salutes are entered in a tabular form given below.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Point</th>
<th>Coordinates</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>(X, Y)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>(X, Y)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>(X, Y)</td>
<td></td>
</tr>
</tbody>
</table>

PROCEDURE:

i) To proceed with the setting out of work, centre O (See fig of the culvert is located on the ground, AB is the centre size of the road & CD the centre line of the nullah.)

ii) Set up a theodolite at point O and levelly et accurately

iii) Set out lines AB & CD at right angle to each other

v) Locate the corners L, M, N, etc along line AB and M2, R2 etc along line CD Drive pegs at these points & stretch cords.

vi) Fix up L, M, etc by means of distances L1L, L2L, M1M, M2M, etc from pts. L1, L2, M1, M2, etc measured from plan. secularly fix up other points also fix pegs at these points.

vii) Stretch a cord round the periphery LMNOPQRS.

viii) The outlines may be marked by line or by culling, a narrow trench along the cord.

The other abutment and the wing walls are also set out in the same manner & uneven ground levels may be taken at all the pegs to determine the correct depths of excavation & to calculate the quantities of east work.