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LAB REPORT:

SURVEYING INSTRUMENTES

For the partial fulfilment of the module submission requirement of

“OPTICAL INSTRUMENTS”

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INTRODUCTION

Surveying instruments are instruments that are used in mapping and construction to measure heights, angles, and distances on the surface of the ground. Tachymeters, levels, total stations, and theodolites are typical examples used for this purpose. In this experiment we are using Tachymeters to measure the distances, angles and height of the surface. A tachymeter, also called a tacheometer, is a kind of theodolite that is perfect instrument which can measure distances rapidly. Tachymeters measure angles and distances quickly, while theodolites offer great accuracy in angular measurements. For accurate and effective measurements, both tools are essential in industries including land surveying, civil engineering, and building. The main aim of the experiment is to understand the working principle of surveying instruments and how to handle them. The experiment is divided into two parts,

1. To calculate the Room's floor area.

2. To determine the Radius of curvature for the room's curved Ceiling.

THEORY

The main principle for measurement in EDMI (Electro Optical Distance Measurement Instruments) is based on the measurement of the parallactic angle (δ) and of the length (b), which is opposite to the instruments location in the distance (d).

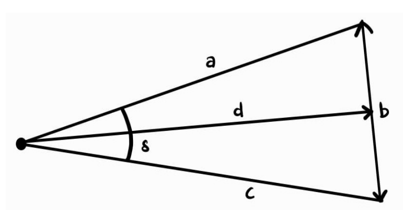


Figure 1: Measurement principle of EDM Instruments

For these calculations, we use Law of cosines which is given as

$$\boldsymbol{b^2 = a^2 + c^2 - 2.a.c.Cos(\delta)}$$

For calculating Radius of curvature, we use

$$\boldsymbol{r = \frac{s}{2.Sin(\varphi)}}$$

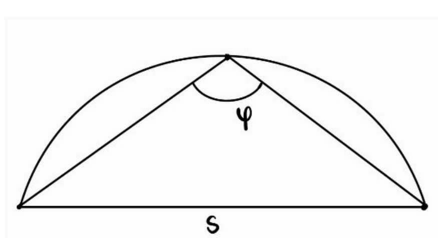
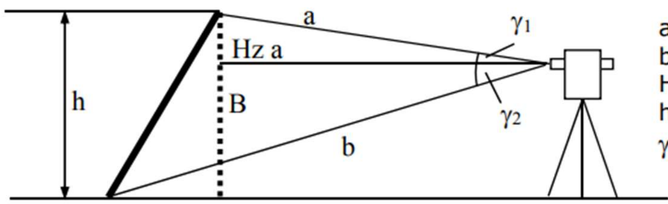


Figure 2: Measurement principle for finding Radius of Curvature

PREPARATION_TASKS

3.1. Calculate the required height h of a supporting bar B by using the known values a, b, $\gamma 1$ and $\gamma 2$. Please note, that you're able to reduce an angular distance to the appropriate horizontal distance. (See sketch below).



a - upper angular distance
b - lower angular distance
Hz a - horizontal distance to a
h - height of the bar B
γ_1, γ_2 - angels relative to Hz a

Answer:

Case 1: Consider

From Trigonometry,

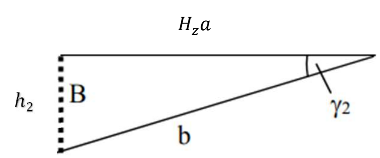
$$\sin\theta = \frac{Opposite\ Side}{Hypotenuse}$$

So,

$$\sin\gamma_1 = \frac{h_1}{a}\ ,$$

$$h_1 = a\sin\gamma_1$$

Case 2: Consider



Here,

$$\sin\gamma_2 = \frac{h_2}{b}\ ,$$

$$h_2 = b\sin\gamma_2$$

Total Horizontal height of Bar B

$$\mathrm{h} = h_1 + h_2$$

$$\mathrm{h} = a\sin\gamma_1 + \ b\sin\gamma_2$$

3.2. What are differences between levelling instruments, tachymeters and theodolites?

Answer:

1) <u>Levelling Instruments:</u>

- Tools used in surveying and construction to determine the height of point from reference level.

Figure 3: Levelling Instrument for Surveying

2) <u>Tachymeters (Tachometer):</u>

- Instrument used for quick measurement for quick measurement distance, height, and angles while surveying.
- It is Combination of Theodolite and an EDM device.

Figure 4: Tachymeter / Tacheometer

3) <u>Theodolite:</u>

- Instrument used to measure horizontal and vertical angles.
- Theodolite is mainly categorized into two types:
    1. Optical – Old/Traditional
    2. Electronic – Modern with display & electronic angle measurements

Figure 5: Theodolite

3.3. Explain the principle of electro optical distance measurement.

Answer:

Basic Principle of Electro Optical Distance Measurement:

- EDM mainly uses electromagnetic energy to determine the length of the line.
- This method includes the EDM device at the source which produces electromagnetic wave which propagates in a sinusoidal from and return to the source after hitting the reflector.

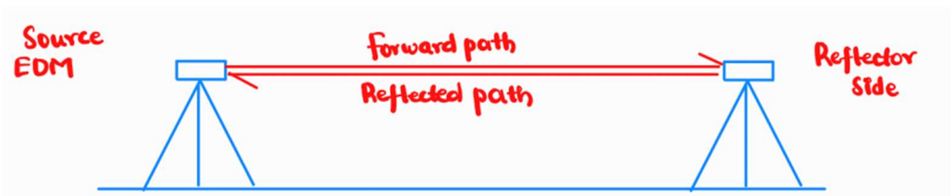
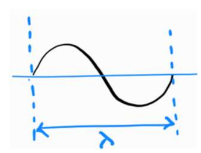


Figure 6: Conceptual sketch of EDM principle

Wavelength,

$$\lambda = \frac{c}{f}$$

where,



C = Speed of light = $3 * 10^8$m/sec
f = Frequency of wave

- For shorter distances, Light itself acts as the carrier and will be modulated by at least two different frequencies.
- From the phase shift between the outgoing and incoming light the distance can be calculated.
- The second frequency is to distinguish between phase shift larger than 2π.

TASK 1: FINDING THE AREA OF THE FLOOR

PROCEDURE

- The M3 Total Station is initially positioned in the centre of the floor area that needs to be measured, using a tripod. It is kept in such a way that majority of the room's corners can be easily reached by the equipment to get the readings.
- We level the instrument by using the levelling stencil. By setting the dials accordingly, we can make the levelling instrument bubble into the centre such that the telescope of the instrument is at an exact vertical angle with respect to the room's walls and floor.
- The telescope must be focused on a selected spot on the walls or corners of the room after the M3 Total Station has been set up. For accurate measuring of angles and pen marked is made on the corners for ease in focusing. With the telescope's focus dials, the focus can be changed.
- After focusing the telescope on a single wall corner, the device's readout is reset to zero. Once the corner of the wall is in focus, the "DR" mode on the instrument helps to automatically compute the horizontal distance, vertical distance and the angle between the two corners.
- To ensure correct focus and measurement, repeat the process for each corner in the room, if necessary, move the device but then ensure that the device's readout is reset to zero again. With this procedure note down all the measurements.
- The floor's area is finally computed as we now know the lengths of each of its sides.

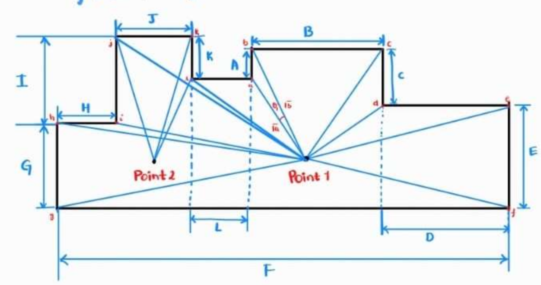
OBSERVATIONS

S No.	Vertical Angle	Horizontal Angle	Distance (in mts)
1	88˚ 17' 18''	0˚	3.065
2	90˚ 38' 58''	1˚36 '18''	3.559
3	84˚ 45' 57''	11˚00 '18''	8.215
4	88˚ 22' 24''	87˚09 '58''	7.644
5	89˚ 20' 07''	89˚33 '17''	9.043
6	81˚ 20' 23''	116˚58 '41''	9.119
7	89˚ 49' 12''	265˚36 '10''	6.042
8	89˚ 04' 29''	292˚40 '31''	5.536
9	89˚23' 24''	295˚43 '50''	4.226
10	83˚30 '13''	329˚50 '53''	6.116
11	83˚02 '14''	356˚45 '56''	5.108
12 (1)	88˚44 '14''	333˚32 '45''	3.846
12 (2)	90˚03 '53''	0˚	3.603

Table 1: Observations for calculating Area of Room

CALCULATIONS

→ From Observations and readings from the labsession,
Rough Sketch of the floor,



by using Law of cosines,

$$\text{Distance } A = \sqrt{(l_a)^2+(l_b)^2-2(l_a)(l_b)\cos\theta_1}$$

$$= \sqrt{(3.068)^2+(3.559)^2-2(3.068)(3.559)\cos(1.605^\circ)}$$

$$= 0.4996 \text{ mts} \approx 0.5 \text{ mts}$$

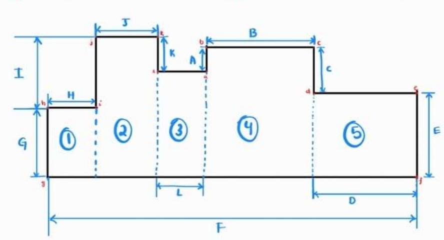
Similarly,

Distances w.r.t point 1 , Distances w.r.t point 2

B = 8.00619 mts
C = 1.4762 mts
D = 1.44134 mts
E = 4.30517 mts
F = 14.6201 mts
G = 2.75497 mts
H = 1.33506 mts
I = 2.6408 mts
L = 3.846 mts

J = 2.789 mts
K = 1.524 mts

for calculating Area, lets divide the figure into 5 Rectangles as shown below.



Area of 1 ⇒ G×H
⇒ 2.7549 × 1.335 = 3.68 sq.mts

Area of 2 ⇒ J×(G+I)
⇒ 2.789 ×(2.7549+2.6408) = 15.05 sq.mts

Area of 3 ⇒ L×(G+I−K)
⇒ 3.846 × (2.75497 + 2.6408 − 1.524) = 14.89 sq.mts

Area of 4 ⇒ B×(C+E)
⇒ 8.00619 × (1.4762 + 4.30517) = 46.29 sq.mts

Area of 5 ⇒ E×D
⇒ 4.30517 × 1.44134 = 6.21 sq.mts

Total Area = 3.68 + 15.05 + 14.89 + 46.29 + 6.21

$\boxed{\text{Total Area} = 86.12 \text{ sq.mts.}}$

TASK 2: FINDING RADIUS OF CURVATURE OF CEILING

PROCEDURE

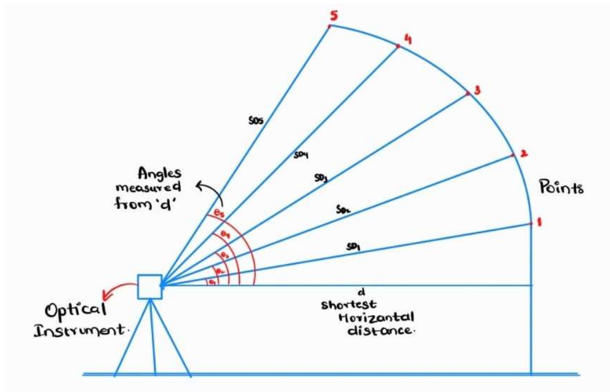
- The M3 Total Station is initially positioned in the centre of the floor area that needs to be measured, using a tripod. It is kept in such a way that majority of the room's ceiling area can be reached by the equipment to get the readings.
- We level the instrument by using the levelling stencil. By setting the dials accordingly, we can make the levelling instrument bubble into the centre such that the telescope of the instrument is at an exact vertical angle with respect to the room's walls and floor.
- For calculating the radius of curvature of the curvature, the **Shortest horizontal distance(d) from the equipment** is to be calculated.
- For calculating the shortest distance, the SDs of the walls under the ceiling are found out by using the procedure of the Task1.
- The width of the wall is calculated as **1.7721mts.**
- From the above obtained length and one of the SDs from the wall, the angle between SD and wall under the ceiling is found which is **77.09°** in our experiment.
- After the above step, the Equipment is moved **12.91°** (90°-77.09°) inwards to the centre of the width from the SD (which we took for reference) to obtain the Shortest horizontal distance(d).
- Keeping 'd' as the reference, 5 readings of the ceiling curve is taken and noted in the observation table below.
- After noting the readings, the radius of the curvature is calculated for two parts of the noting's and similar procedure is carried out until last piece of the arc.
- The Final Radius of curvatures is obtained by calculating average of the radii from the different sections of the Arc.

OBSERVATIONS

Points	SD in mts.	Vertical Angle	Angle from d
1	4.24	53° 42' 50"	36° 18' 10"
2	4.032	39° 15' 27"	50° 45' 33"
3	4	35° 29' 40"	54° 31' 20"
4	3.983	32° 49' 10"	57° 11' 50"
5	3.993	15° 18' 29"	74° 48' 31"

Table 2: Observations for calculating Radius of curvature of the ceiling.

CALCULATIONS



Case 1: Consider sector with Points 1,2 and 3.

by using law of cosines,

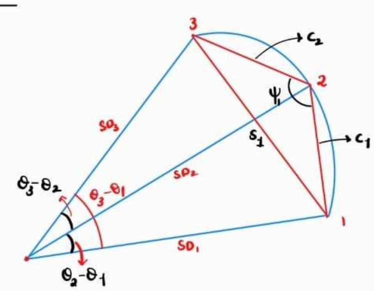
$$\boxed{C_1 = \sqrt{SD_1^2 + SD_2^2 - 2 \cdot SD_1 \cdot SD_2 \cdot \cos(\theta_2 - \theta_1)}}$$

from Observations,

$SD_1 = 4.24$ mts
$SD_2 = 4.032$ mts
$\theta_2 - \theta_1 = 14.46^\circ$

$$\therefore C_1 = \sqrt{4.24^2 + 4.032^2 - 2 \times 4.24 \times 4.032 \times \cos(14.46^\circ)}$$

$$\boxed{C_1 = 1.061 \text{ mts}}$$



$$\boxed{C_2 = \sqrt{SD_2^2 + SD_3^2 - 2 \cdot SD_2 \cdot SD_3 \cdot \cos(\theta_3 - \theta_2)}}$$

from Observations,

$SD_2 = 4.032$ mts
$SD_3 = 4$ mts
$\theta_3 - \theta_2 = 54.52^\circ - 50.76^\circ = 3.76^\circ$

$$\therefore C_2 = \sqrt{4.032^2 + 4^2 - 2 \times 4.032 \times 4 \times \cos(3.76)}$$

$$\boxed{C_2 = 0.265 \text{ mts}}$$

$$\boxed{S_1 = \sqrt{SD_1^2 + SD_3^2 - 2 \cdot SD_1 \cdot SD_3 \cdot \cos(\theta_3 - \theta_1)}}$$

from observations

$SD_1 = 4.24$ mts
$SD_3 = 4$ mts
$\theta_3 = 54.52^\circ - 36.30^\circ = 18.22^\circ$

$$\therefore S_1 = \sqrt{4.24^2 + 4^2 - 2 \times 4.24 \times 4 \times \cos(18.22^\circ)}$$

$$\boxed{S_1 = 1.326 \text{ mts}}$$

from law of cosines the ψ_1 ($\angle 321$) can be given as

$$\boxed{S_1^2 = C_1^2 + C_2^2 - 2C_1C_2\cos\psi}$$

$$\boxed{\psi = \cos^{-1}\left(\frac{S_1^2 - C_1^2 - C_2^2}{-2C_1C_2}\right)}$$

by substituting values we got

$$\boxed{\psi = 179^\circ}$$

The radius of curvature of the curve (r) is given by

$$\boxed{r = \frac{S_1}{2\sin(\psi)}}$$

by substituting values we get,

$$r = \frac{1.326}{2 \times \sin(179^\circ)}$$

$$r_1 = 37.99\text{m}$$

Case 2: Sector with points 2,3 and 4

from case 1 we know,

$\boxed{C_2 = 0.265 \text{ mts}}$

by using cosine law as case 1, we get

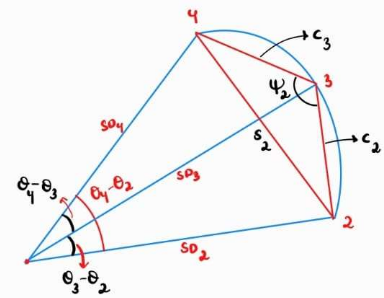
$\boxed{C_3 = 0.187 \text{ mts}}$

$\boxed{S_2 = 0.45 \text{ mts}}$

from above values

$\boxed{\Psi_2 = 169.05^\circ}$

The radius of curvature $r_2 = 1.185 \text{ m}$



Case 3: Sector with points 3,4 and 5

from case 2 we know,

$\boxed{C_3 = 0.187 \text{ mts}}$

by using cosine law as case 1, we get

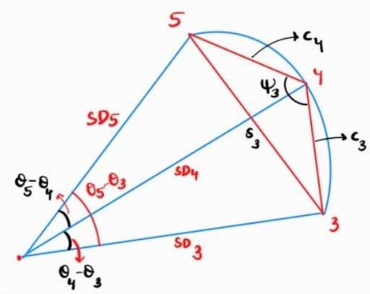
$\boxed{C_4 = 1.22 \text{ mts}}$

$\boxed{S_3 = 1.40 \text{ mts}}$

from above values

$\boxed{\Psi_3 = 163.12^\circ}$

The radius of curvature $r_3 = 2.411 \text{ m}$



Calculating Final radius of curvature:

→ For calculating final radius of curvature we have to calculate the average of individual sectors, which is given as

$$\boxed{r = \frac{r_1 + r_2 + r_3}{3}}$$

$$\text{So, } r = \frac{37.99 + 1.185 + 2.411}{3}$$

$$r = 13.86 \text{ m}$$

CONCLUSION

The experiment was successfully carried out with the help of surveying Instruments to calculate the Area of the room's floor and to determine the Radius of curvature of the curved surface. In conclusion,

- The Area of the Floor is **86.12 square meters.**
- The Radius of Curvature of the Ceiling is **13.86 meters**.