CE673A Instrumentation Laboratory and field practices in Geoinformatics

Project Report

Aarogyadham Chitrakoot, Madhye Pradesh

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Introduction

Figure 1 Aarogyadham survey camp glimpse

The CE673A Instrumentation Laboratory and field practices in Geoinformatics project encapsulated an immersive one-week expedition into the heart of Aarogydham Chitrakoot area, Madhya Pradesh, commencing on November 28th, 2023. Led by a dedicated team of professionals and faculty members, this endeavor aimed at learning practical skills in Geoinformatics, instrumental surveying techniques, and spatial analysis. Over the course of six intensive days, a comprehensive spectrum of activities was undertaken, ranging from reconnaissance to detailed feature mapping, with the aim of creating navigational aids. This report serves as a documentation of my journey, delving into the intricacies of each activity, the methodologies employed, and the insights gained. Additionally, I extend my heartfelt gratitude to Professor Onkar Dixit, Hari Babu Sir, Maurya Sir, Shitla Sir, and the entire GI lab staff for their unwavering guidance and support throughout this experience.

In essence, this report not only covers our expedition but also stands as a testament to the invaluable knowledge imparted and the skills acquired during our time in the field. Through the meticulous execution of various surveying techniques and the application of tools such as Total Station, GNSS receivers, and Juno receivers, we navigated the complexities of geospatial data collection and analysis with precision. Moreover, the utilization of QGIS/ArcGIS Pro software for spatial analysis and mapping further enriched our understanding of Geoinformatics principles and their real-world applications.

Objective

The following are the objectives:

- Documenting the process and outcomes of field surveys and Geoinformatics practices in Aarogyadham Chitrakoot, Madhya Pradesh.
- Understanding the working procedure of various instruments like GNSS R10 receiver, JUNO receiver, Auto level, Total station in application of feature mapping.
- Generate topographic map of Aarogyadham.
- Generate navigational map by JUNO for Chitrakoot.
- To create a road profile.
- To make a map by chain and compass surveying.
- To understand the calibration of EDMI
- To establish a close traverse by Total Station.

Principles and outline of work

The following are the principles of surveying:

- Working from whole to part
- Location of a point by measurement from two points of reference

The following is the outline of day-wise activity of camp along with lab work:

Day	**Date**	**Activity**	**Details**
Day 1	November 28th, 2023	Reconnaissance	Identified suitable locations for control points (CPs) based on predefined criteria. Marked 7 CPs ensuring maximum coverage and efficiency.
Day 2	November 29th, 2023	GNSS Traversing	Used R10 receivers for GNSS traversing in static mode. Obtained precise coordinates of the CPs to establish geodetic control.
Day 3	November 30th, 2023	Auto Level-Levelling	Conducted Auto Level Levelling to determine orthometric heights. Obtained accurate elevation data for subsequent mapping tasks.
Day 4-5	December 1st-2nd, 2023	Feature Mapping with Total Station	Employed Total Station for detailed feature mapping. Collected data on terrain, buildings, vegetation, etc., for topographic map creation.
Day 6	December 3rd, 2023	Data Collection with Juno Receiver	Utilized Juno receivers for data collection. Gathered area generic, line generic, and point generic data to create navigational maps.
Additional Labs	April-2024	TS traversing, EDM, Chain and Compass Surveying	Conducted additional labs at IIT Kanpur Campus, including TS traversing, EDM, and Chain and Compass Surveying.

Reconnaissance survey

Instruments

The following instruments are used for reconnaissance survey:

- Satellite imagery of the area
- Paints and chalk
- Notepads

Methodology

Preparation:

- Studied satellite imagery of the survey area to familiarize with the terrain and key features.

Field Visit:

- Conducted a physical inspection of the survey area to assess its suitability for control point (CP) placement and subsequent survey activities. The walk was conducted around the campus of Aarogyadham for placement of possible CPs.

Criteria Identification:

- The preferred locations for selecting suitable locations for CPs, considering factors such as accessibility, visibility, and coverage area.
- The locations need to have inter-visibility among adjacent CPs for orientation of TS for further activities.
- The location needs to be open to sky for later taking R10 receiver readings for determining the coordinates of the CP.

Control Point Selection:

- Identify potential locations within the survey area that meet the predefined criteria.
- Marked those points with paints and pegs. Fig (2)

Data Collection:

- Rough sketch is created for the loop traverse, highlighting the control points and major nearby features.

Result

Number of control points identified are: 7

P1: This point is at higher elevation which gives more coverage for the major part of the road.

P2: This point is at the center of the cottage area, where all the features can be mapped.

P3: This point act as a link for inter-visibility between P4 and P2

P4: This point connects back to main road and covers more of the lawn area for contours.

P5: This point covers major part of road on the lower side.

P6: It gives a connection for having an extension point for the canteen area.

P7: This point covers the office and petrol pump area, connect backs to P1.

Figure 2 Loop traverse

GNSS Traversing

Instruments

- GNSS R10 receiver and antenna
- Height extension pole with measurement level
- Base station radio and antenna

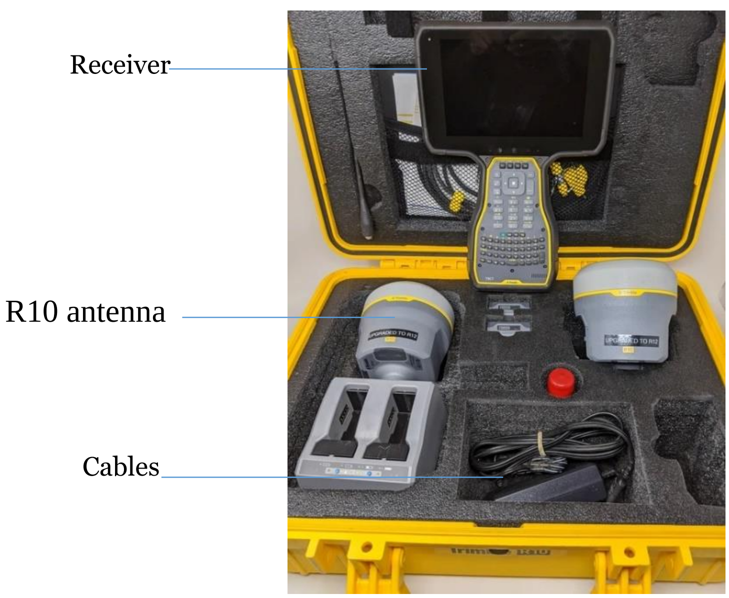


Figure 3 GNSS R10 receiver kit

Methodology

A. Computing Coordinates

Detail procedure for coordinate data collection:

Step1: Set up the R10 antenna on the point where coordinates are to be recorded, arrange the bubble in the center position for proper leveling.
Step 2: Switch on the antenna as well as it's Bluetooth. Keep the antenna height as needed, generally it is kept as 2m.
Step 3: Switch on the receiver, open Trimble access, create a new job file.
Step 4: Edit the coordinate system to WGS 84 UTM coordinates, zone 44N.
Step 5: Connect it to antenna; settings-surveying styles-static-rover option
Step 6: To collect data in Static mode; Measure-static-measure points
Step 7: Enter the details like point name, point code, antenna height (2m), time for data recording (15mins), cutoff angle (15^0)
Step 8: To collect the data click on measure, after the timer is over click on store.
Step 9: This data can be collected from the rover for further processing.

The Coordinates are collected, to generate coordinates with more precision, R10 receiver is setup as a base station, a base station consists of a receiver that is placed at a known (and fixed) position. The receiver tracks the same satellites that are being tracked by the rover receiver, at the same time that the rover is tracking them. Errors in the GNSS system are monitored at the fixed (and known) base station, and a series of position corrections are computed. Mostly for recording data it takes 22-24hrs of time period. The baseline processing is done in TBC on the basis of base station data.

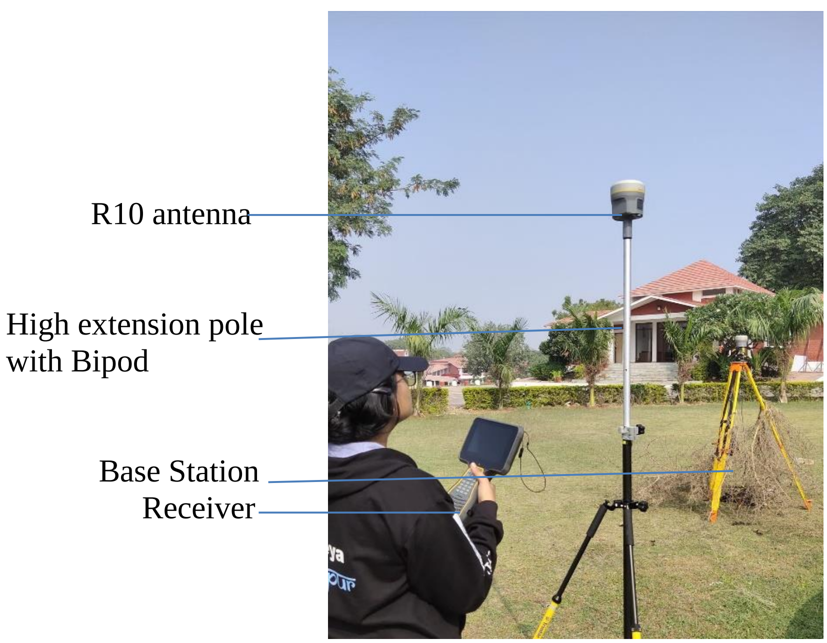


Figure 4 GNSS Setup

B. TBC processing

One of the most powerful tools for processing raw Global Navigation Satellite System (GNSS) data is Trimble Business Center. Trimble Business Center goes beyond basic data processing with its robust outlier detection mechanisms, enhancing the reliability of the final results. The software streamlines the data acquisition process by providing the facility to automatically or manually download International GNSS Service (IGS) data and ephemeris for single or multiple GNSS constellations. This feature ensures that the raw data is consistently up-to-date, contributing to the generation of high-accuracy GNSS data. The software's support for various raw data formats, including .dat, .T0?, RT17, RT27, .cap, and rinex (v2.10, v2.11, v3.02, v3.03, and v3.04).

The data obtained from the GNSS receiver is in.T0 format which is in terms of global coordinates, it has to be converted to local coordinates i.e. wrt to base station data, as well as some error are to be accounted. For this, Trimble Business Centre is used for Base line Processing of Data.

C. Traversing

Traversing for the loop is done by GNSS traversing, the coordinates obtained after TBC processing were then processed for loop closure by transit rule.
The following is the methodology for application of transit rule:

Readings obtained after TBC processing:

ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
base02 29112023	486196.668	2781803.081	86.516
IITK	423495.479	2933660.080	70.242
p1	**486247.495**	**2781780.715**	**90.214**
p2	486194.414	2781799.487	86.332
p3	486156.410	2781820.361	85.100
p4	486173.896	2781841.542	87.198
p5	486235.354	2781900.992	84.555
p6	486272.301	2781870.551	89.658
p7	486249.084	2781819.863	89.999
P1	**486247.492**	**2781780.702**	**90.211**

Traverse misclosure:

ΔN = 486247.495-486247.492 = 0.003m

ΔE = 2781780.715-2781780.702 = 0.013m

$\Delta elevation$ =90.214-90.211=0.003m

Calculate the Northing and Easting adjustments for each point using the Transit Rule:

*Northing adjustment for each point = (ΔN for traverse line to point / ∑ΔN) * Northing closure error*

*Easting adjustment for each point = (ΔE for traverse line to point / ∑ΔE) * Easting closure error*

Calculating the change in northings and eastings for each traverse line to point:

From Point	To Point	ΔE (m)	ΔN (m)
base02	p1	486247.495 - 486196.668 = 50.827	2781780.715 - 2781803.081 = -22.366
p1	p2	486194.414 - 486247.495 = -53.081	2781799.487 - 2781780.715 = 18.772
p2	p3	486156.410 - 486194.414 = -38.004	2781820.361 - 2781799.487 = 20.874
p3	p4	486173.896 - 486156.410 = 17.486	2781841.542 - 2781820.361 = 21.181
p4	p5	486235.354 - 486173.896 = 61.458	2781900.992 - 2781841.542 = 59.450
p5	p6	486272.301 - 486235.354 = 36.947	2781870.551 - 2781900.992 = -30.441
p6	p7	486249.084 - 486272.301 = -23.217	2781819.863 - 2781870.551 = -50.688
p7	P1	486247.492 - 486249.084 = -1.592	2781780.702 - 2781819.863 = -39.161
P1	base02	486196.668 - 486247.492 = -50.824	2781803.081 - 2781780.702 = 22.379

The sum of absolute values of all changes in Northing and Easting for all traverse lines:

$$\sum \Delta E = |-50.827| + |-53.081| + |-38.004| + |17.486| + |61.458| + |36.947| + |-23.217| + |-1.592| + |-50.824| = 332.446m$$

$$\sum \Delta N = |-22.366| + |18.772| + |20.874| + |21.181| + |59.450| + |-30.441| + |-50.688| + |-39.161| + |22.379| = 100.252m$$

Calculating the adjustments:

Point	Northing Adjustment (m)	Easting Adjustment (m)
p1	(-22.366 / 100.252) * 0.003 = -0.000671m	(-50.827 / 332.446) * 0.013 = -0.001986m
p2	(18.772 / 100.252) * 0.003 = 0.000564m	(-53.081 / 332.446) * 0.013 = -0.002073m
p3	(20.874 / 100.252) * 0.003 = 0.000626m	(-38.004 / 332.446) * 0.013 = -0.001488m
p4	(21.181 / 100.252) * 0.003 = 0.000634m	(17.486 / 332.446) * 0.013 = 0.000687m
p5	(59.450 / 100.252) * 0.003 = 0.001783m	(61.458 / 332.446) * 0.013 = 0.002389m
p6	(-30.441 / 100.252) * 0.003 = -0.000912m	(36.947 / 332.446) * 0.013 = 0.001446m
p7	(-50.688 / 100.252) * 0.003 = -0.001520m	(-23.217 / 332.446) * 0.013 = -0.000909m
P1	(-39.161 / 100.252) * 0.003 = -0.001488m	(-1.592 / 332.446) * 0.013 = -0.000062m

Adjusting the coordinates:

Point	Original Easting (m)	Original Northing (m)	Original Elevation (m)	Northing Adjustment (m)	Easting Adjustment (m)	Corrected Easting (m)	Corrected Northing (m)	Corrected Elevation (m)
base02	486196.7	2781803	86.516	-	-	486196.7	2781803	86.516
p1	486247.5	2781781	90.214	-0.00067	-0.00199	486246.8	2781781	90.214
p2	486194.4	2781799	86.332	0.000564	-0.00207	486195	2781799	86.332
p3	486156.4	2781820	85.1	0.000626	-0.00149	486157	2781820	85.1
p4	486173.9	2781842	87.198	0.000634	0.000687	486174.5	2781842	87.198
p5	486235.4	2781901	84.555	0.001783	0.002389	486237.1	2781901	84.555
p6	486272.3	2781871	89.658	-0.00091	0.001446	486271.4	2781871	89.658
p7	486249.1	2781820	89.999	-0.00152	-0.00091	486247.6	2781820	89.999
P1	486247.5	2781781	90.211	-0.00149	-6.2E-05	486246	2781781	90.211

Quality Assessment

e/*p*: ratio

Where, $p = \sum\sqrt{(\Delta Ei)^2 + (\Delta Ni)^2}$

$e = \sqrt{(\Delta E)^2 + (\Delta N)^2}$

Calculating for the values of e and p as,

Assuming a linear approximation between points, we can calculate the distances between consecutive points:

$P = (\sqrt{(\Delta E1)^2 + (\Delta N1)^2}) + \sqrt{(\Delta E2)^2 + (\Delta N2)^2} + ... + \sqrt{(\Delta E\mathrm{n})^2 + (\Delta Nn)^2}$

given the changes in Easting (ΔE) and Northing (ΔN) for each traverse line to point

$p \approx 2646.822m$

$e = (0.013)^2 + (0.003)^2 = 0.000169 + 0.000009 \approx 0.000178 \approx 0.013m$

Therefore, $e/p \approx 4.911 \times 10{-}6$

$e/p \approx 1{:}203563$

Quality	Permissible limit of closing error
First order	1: 25000
Second order	1: 10000
Third order	1: 5000

The ratio falls in first order surveying; hence the traverse is of **first order** surveying.

Result

The coordinates after correction along with their precision values are:

Point	Corrected Easting (m)	Corrected Northing (m)	Corrected Elevation (m)	Vertical Precision (m)	Horizontal Precision (m)
p1	486246.8	2781781	90.214	0.008	0.004
p2	486195	2781799	86.332	0.004	0.002
p3	486157	2781820	85.1	0.005	0.003
p4	486174.5	2781842	87.198	0.004	0.002
p5	486237.1	2781901	84.555	0.012	0.005
p6	486271.4	2781871	89.658	0.008	0.004
p7	486247.6	2781820	89.999	0.006	0.002

Horizontal Precision (m):

- This value indicates the degree of accuracy in the easting and northing coordinates (X and Y directions) of each point.
- A lower horizontal precision value signifies higher accuracy in determining the position of the point on the horizontal plane.

Vertical Precision (m):

- This value indicates the degree of accuracy in the elevation (Z direction) of each point.
- A lower vertical precision value signifies higher accuracy in determining the elevation of the point.

Aposteriori reference covariance (m^2):

P1	X	Y	Z
X	0.0000033395		
Y	0.0000028819	0.0000143831	
Z	0.0000019061	0.0000058374	0.0000043408
P2	X	Y	Z
X	0.0000009106		
Y	0.0000004302	0.0000040431	
Z	0.0000002798	0.0000015764	0.0000012293
P3	X	Y	Z
X	0.0000013662		
Y	0.0000003264	0.0000057905	
Z	0.0000002532	0.0000027491	0.0000024929

P4	X	Y	Z
X	0.0000007506		
Y	0.0000001691	0.0000030093	
Z	0.0000001779	0.0000013100	0.0000013062
P5	X	Y	Z
X	0.0000042703		
Y	0.0000030480	0.0000295595	
Z	0.0000024125	0.0000155626	0.0000139574
P6	X	Y	Z
X	0.0000021908		
Y	0.0000005567	0.0000143782	
Z	0.0000008435	0.0000058199	0.0000046602
P7	X	Y	Z
X	0.0000008756		
Y	0.0000003343	0.0000070004	
Z	0.0000002669	0.0000027123	0.0000020560

X and Y Coordinates (Horizontal):

- The a-posteriori reference variance for X and Y coordinates indicates the spread or variability of the adjusted positions of the points in the easting and northing directions.
- A lower value for the a-posteriori reference variance in X and Y suggests that the adjusted coordinates are tightly clustered around the mean, indicating high precision in determining the horizontal positions of the points.

Z Coordinate (Vertical):

- The a-posteriori reference variance for the Z coordinate indicates the spread or variability of the adjusted elevations of the points.
- A lower value for the a-posteriori reference variance in Z suggests that the adjusted elevations are tightly clustered around the mean, indicating high precision in determining the vertical positions of the points.

Levelling

Instruments
Auto level, Tripod, Levelling Staff

Methodology

In the leveling survey conducted using an auto level, control point served as a loop to determine orthometric heights for various points, including temporary ones. The height of the instrument method was employed, with the reduced level of point near petrol station was assumed to be 100m and designated as the Benchmark (BM). The leveling process involved establishing a closed loop with control point, allowing for the precise determination of orthometric heights by accounting for changes in elevation. Temporary points, integral to the survey, were also included in the calculations. The height of instrument method provided an efficient means of obtaining accurate height measurements, ensuring that the survey outcomes were consistent and reliable. By utilizing a known benchmark as the reference point and conducting a closed-loop leveling survey, this approach facilitated the establishment of a robust vertical control network for the surveyed area.

Procedure to set up auto level:
1. Setup your tripod as level as possible, step on tripod legs to drive into the ground.
2. Attach auto level to the tripod with the leveling screws. *Fig (6)*
3. Adjust level so bubble is centered in vial. *Fig (5)*
4. Keep the staff completely vertical on the point where RL is to be measured.
5. Adjust recital until cross-hairs are clear.
6. Adjust the objective lens until object you are sighting on is clear. *Fig (7)*

Figure 5 Leveling bubble

Figure 6 Target sighting

Figure 7 Leveling Screw

Method for leveling: **<u>Height of Instrument Method</u>**

- Sight with a level from LS at the levelling staff on point A. The point where the line of sight meets the levelling staff is point X. Measure AX. This is called a backsight (BS).

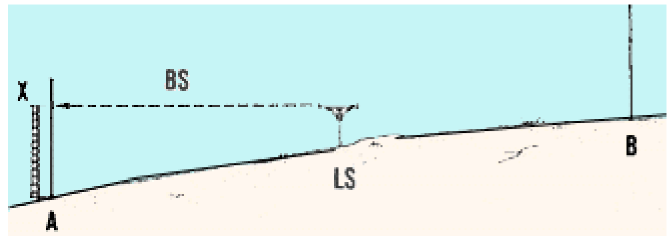


Figure 8 Back sight reading for pt A

- Turn around and sight from LS at the levelling staff on point B. The point where the line of sight meets the levelling staff is point Y. Measure BY. This is called a foresight (FS).

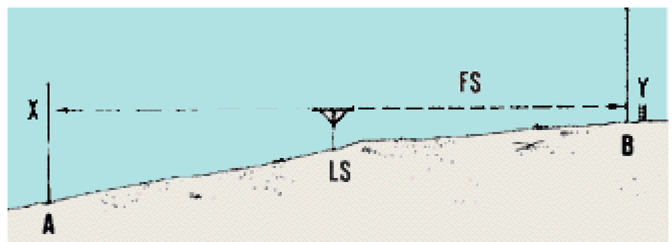


Figure 9 Foresight Reading for pt B

- The difference in elevation between point A and point B equals BC or (AX-BY) or (backsight BS - foresight FS).

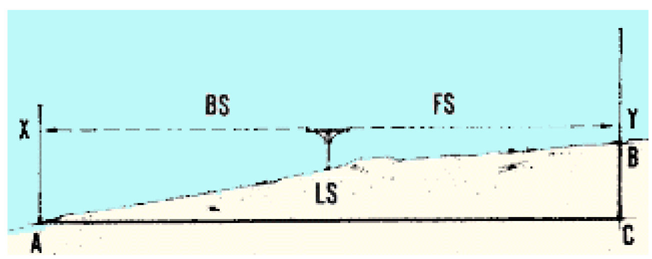


Figure 10 Elevation difference in A and B

Height of instrument: $HI = BS + RL$

Reduced Level: $RL = HI - FS$

Result

Auto level readings:

BS	FS	HI	RL	Remark
0.975		100.975	100	BM
0.54	1.335	100.18	99.64	CP1
0.76	2.875	98.065	97.305	
1.22	2.16	97.125	95.905	CP2
0.81	1.39	96.545	95.735	
2.83	1.65	97.725	94.895	CP3
1.71	1.085	98.35	96.64	CP4
3.765	4.38	97.735	93.97	CP5
2.665	0.955	99.445	96.78	
1.325	0.365	100.405	99.08	CP6
1.285	1.385	100.305	99.02	CP7
1.305	0.88	100.73	99.45	
	0.725		100.00	

Arithmetic checks for HI method:

$\sum BS - \sum FS = Last\ RL - First\ RL$

$\sum BS - \sum FS$ = 19.19 – 19.185 = 0.005
$Last\ RL - First\ RL$ =100.005-100= 0.005

Classification of work:
By $E = C\sqrt{K}$:

$E = 5\ mm$
$K = 0.5278\ km$
Therefore,
$C = 2.639$, therefore the levelling is classified into **precision levelling**.

Work	Purpose	*C*
Highest quality	Geodetic leveling and surveys for special purpose	1
Precise leveling	Geodetic leveling and benchmarks of widely distributed points	4 (5)
Accurate	Principal benchmarks and extensive surveys	12 (10)
Ordinary	Location and construction survey	24 (25)
Rough	Reconnaissance and preliminary surveys	100 (100)

Corrections:

Loop closure: as function of distance
C = e/L

Example for few station:

$$Correction\ 1 = \frac{0.005}{527.8}(50) = 0.000474$$

$$Correction\ 2 = \frac{0.005}{527.8}(29.2) = 0.000277$$

Station	RL (m)	Cumulative distance (m)	correction	Corrected RL (m)
BM	100	50	0.000474	100.0005
CP1	99.64	29.2	0.000277	99.64028
	97.305	25.2	0.000239	97.30524
CP2	95.905	59.5	0.000564	95.90556
	95.735	47.9	0.000454	95.73545
CP3	94.895	51	0.000483	94.89548
CP4	96.64	58	0.000549	96.64055
CP5	93.97	76	0.00072	93.97072
	96.78	28.5	0.00027	96.78027
CP6	99.08	48	0.000455	99.08045
CP7	99.02	25.5	0.000242	99.02024
	99.45	20.5	0.000194	99.45019
	100.005	8.5	8.05E-05	100.0000

Thus we have orthometric heights for all the control points.

Feature Mapping by Total Station

Instruments

Total station, Tripod, Target staff-prism, tripod, bipod, tape.

Methodology

A. Total Station Feature mapping

Total stations are commonly used in surveying and feature mapping due to their precision and efficiency. A total station is an optical instrument used in surveying and construction that combines the functions of a theodolite and distance meter. It is often employed for various applications, including topographic mapping, construction layout, and land surveying.

The following readings can be taken from total station:

Horizontal Distance, Vertical Distance, Horizontal Angle, Vertical Angle, Slope distance, Elevation, Coordinates

Steps to set up total station:

1) Set the tribarc above the point and approximately do the leveling fig (11)
2) Set the instrument on the tribarc and power it on
3) Do the leveling of the instrument with the level bubble using the leveling screws, later on center the instrument with the help of telescope bubble. Fig (13)
4) Once the leveling and centering is done fig (14), go to trimble access software. Complete the electronic leveling and the angles in both the axis should be within $10''$
5) In Trimble access go to general survey > create a new job> set the coordinate system
6) Now go back to main menu > key in > enter the coordinates of the point along with orthometric height > store that point; follow the same procedure for storing the backsight point details
7) Set the prism on the backsight point
8) From main menu > measure > VX and S series > Station set up
9) Enter the point name, instrument height, check the coordinate details
10) Enter the backsight point details and the height., store the values; the station setup is completed.
11) In measure> measure topo > select target and its height (for prism = 1.5 m, target DR =0m)
12) Now start taking readings by entering suitable codes for the features.

Figure 11 TS on point

Figure 12 Leveling Screw

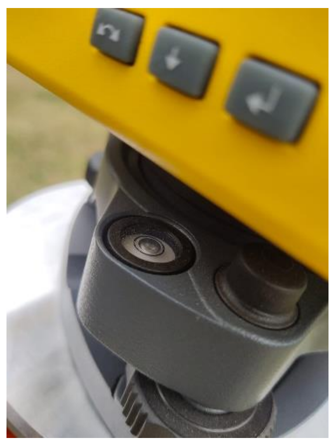


Figure 13 Leveling bubble

Figure 14 Centering

Figure 15 Contour data record by TS

B. Arc GIS digitization

The following are the steps of feature mapping in Arc GIS pro:

Create a New Map Project:

- Open ArcGIS Pro and create a new project.
- Set the coordinate system as UTM WGS 84 and map template.

Add Scanned Survey Sheets to the Map:

- In the Contents pane, right-click on "Maps" and choose "Add Data" > "Add Data."
- Navigate to the folder containing your scanned survey sheets and add them to the map.

Georeference the Survey Sheets:

- Use the Georeferencing toolbar to georeference each survey sheet to its correct location on the map.
- Identify common features between the survey sheet and the basemap to align the sheet spatially.
- Add control points and enter known coordinates to warp the survey sheet to the correct position.

Digitize Features:

- Once the survey sheets are georeferenced, activate the Editing toolbar.
- Create a new feature layer for the features you want to digitize (e.g., contour lines, roads, buildings).
- Select the feature type you want to digitize (e.g., "Line" for contour lines, "Polygon" for buildings).
- Begin digitizing by tracing the features from the scanned survey sheets using the editing tools.

Attribute Data:

- As you digitize features, add attribute information such as elevation for contour lines, building names, road types, etc.
- Use the Attribute Table to manage and edit attribute data for the features.

Quality Assurance:

- Regularly review your digitized features to ensure accuracy and completeness.
- Compare the digitized features with the original survey sheets to catch any discrepancies.

Save and Export:

- Save your project frequently to avoid data loss.
- Once digitization is complete, save the feature layers and project.
- Export the final feature map in a desired format (e.g., PDF, shapefile) for sharing or further analysis.

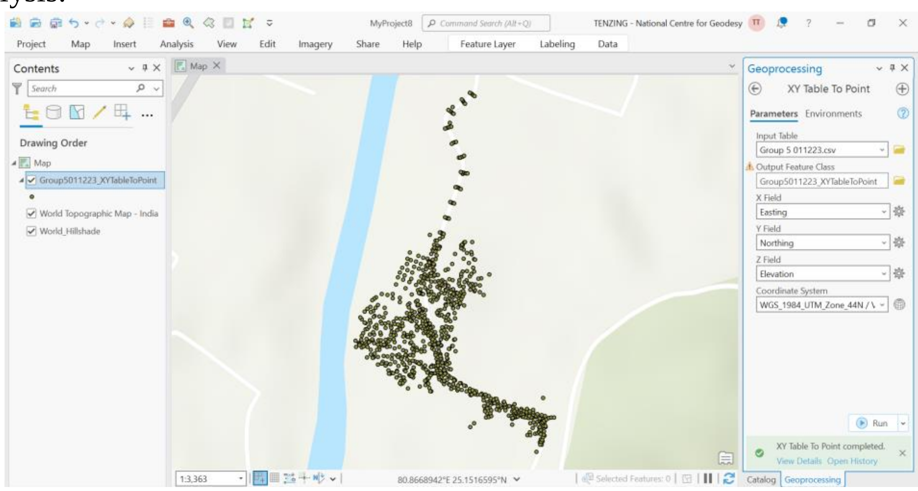


Figure 16 Point data in Arc GIS

a) Contours

The following are the steps for contour generation:

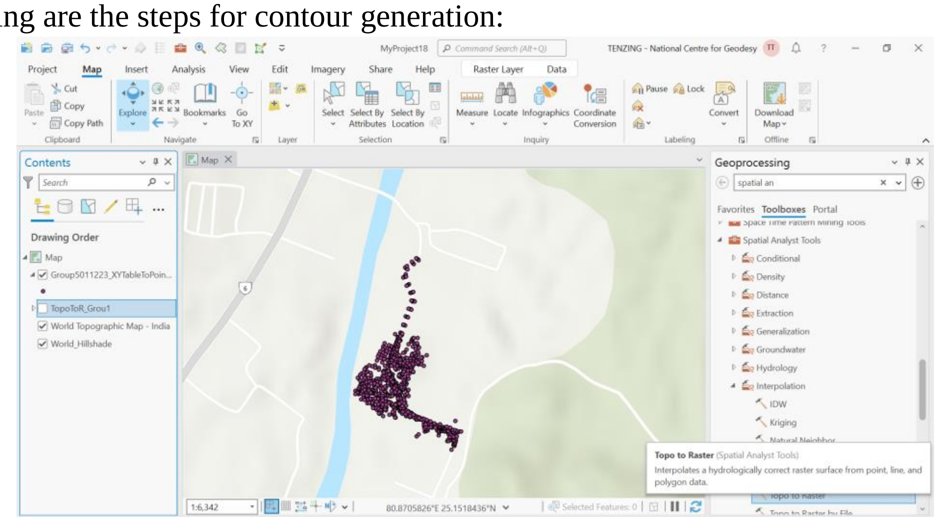


Figure 17 topo to raster generation

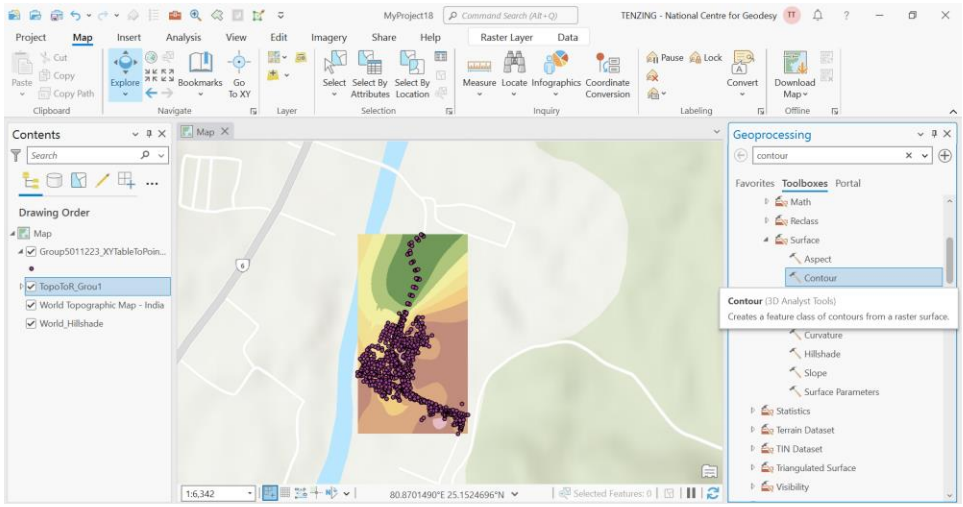


Figure 18 Displaying DEM

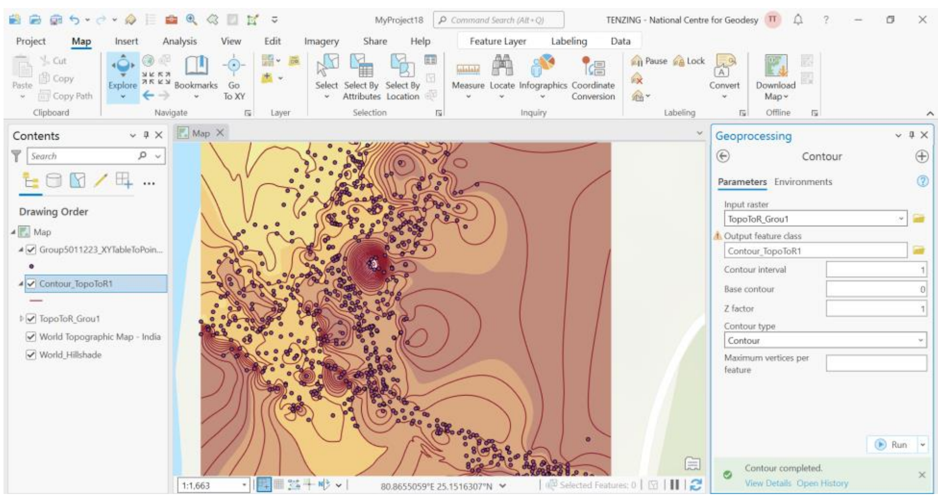


Figure 19 Generation of contour map at 1m interval

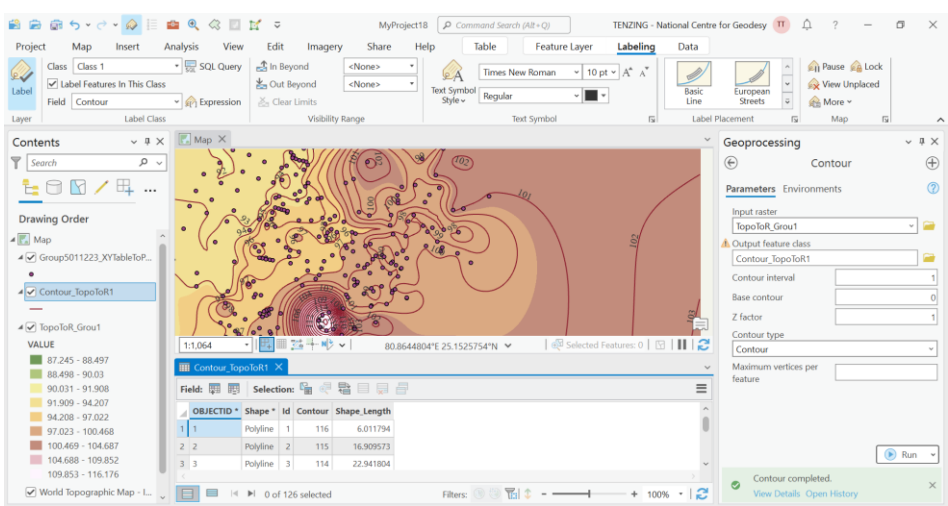


Figure 10 Labelling the generated Contour

Scale of the map: 1: 1500 (Large scale map)

The terrain is rolling terrain hence contour interval of 1m is adopted.

On basis of scale of map, the plotable error on map is 37.5 mm

b) Feature Map

The following are the steps for Feature map generation:

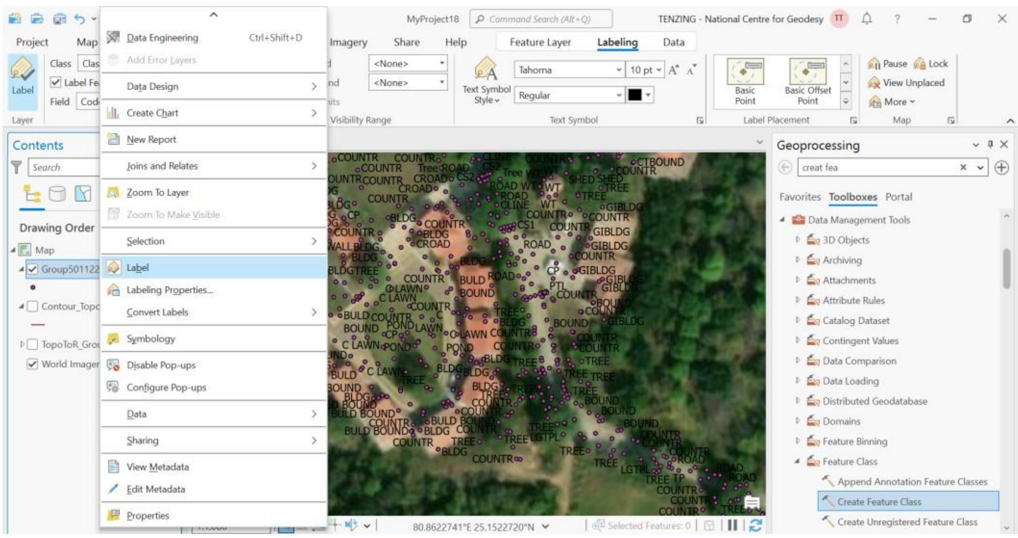


Figure 11 Displaying labels

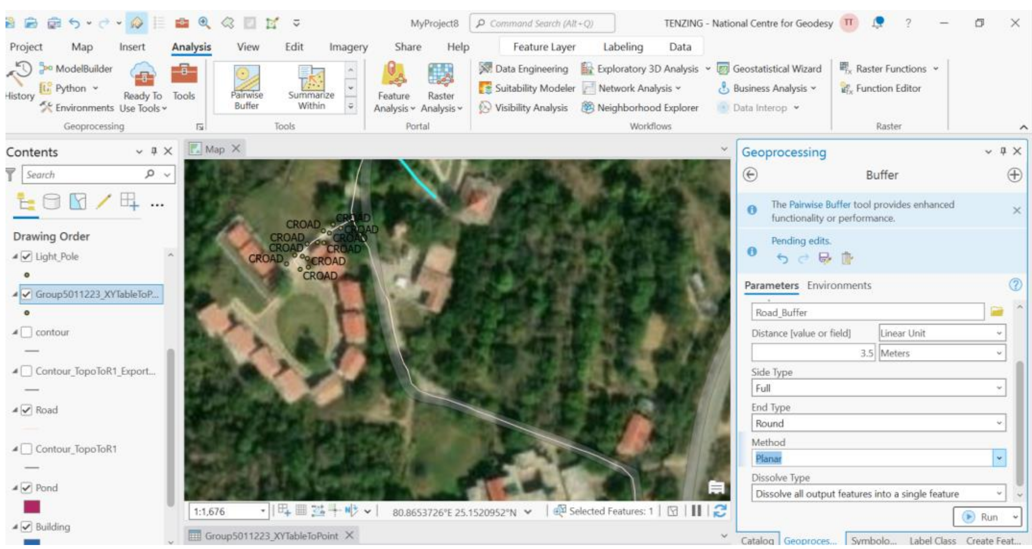


Figure 12 Line feature generation as road

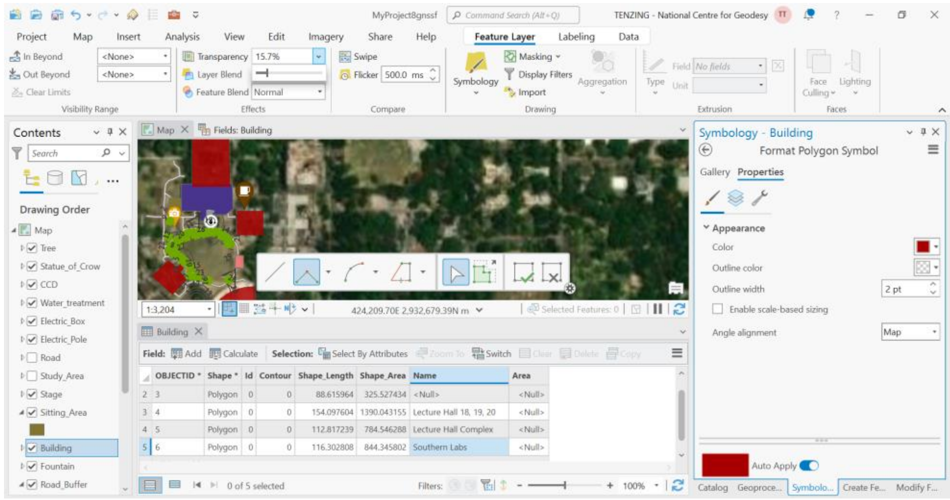


Figure13 Polygon feature generation for houses

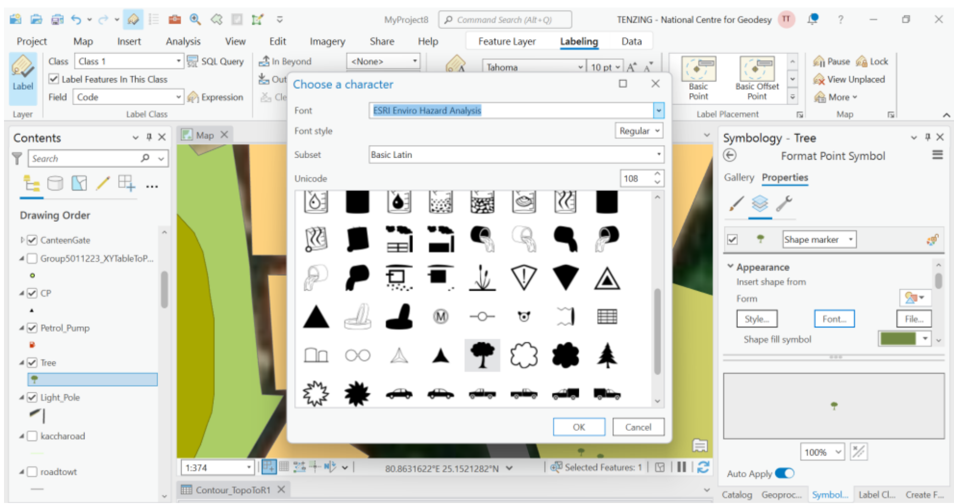


Figure 14 Point feature generation and adding symbology

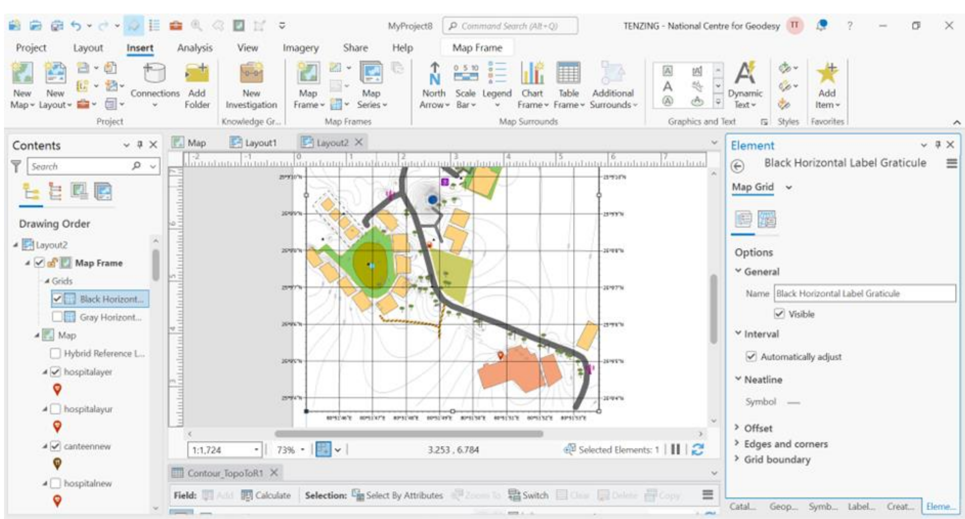


Figure 15 Map in final layout

Result

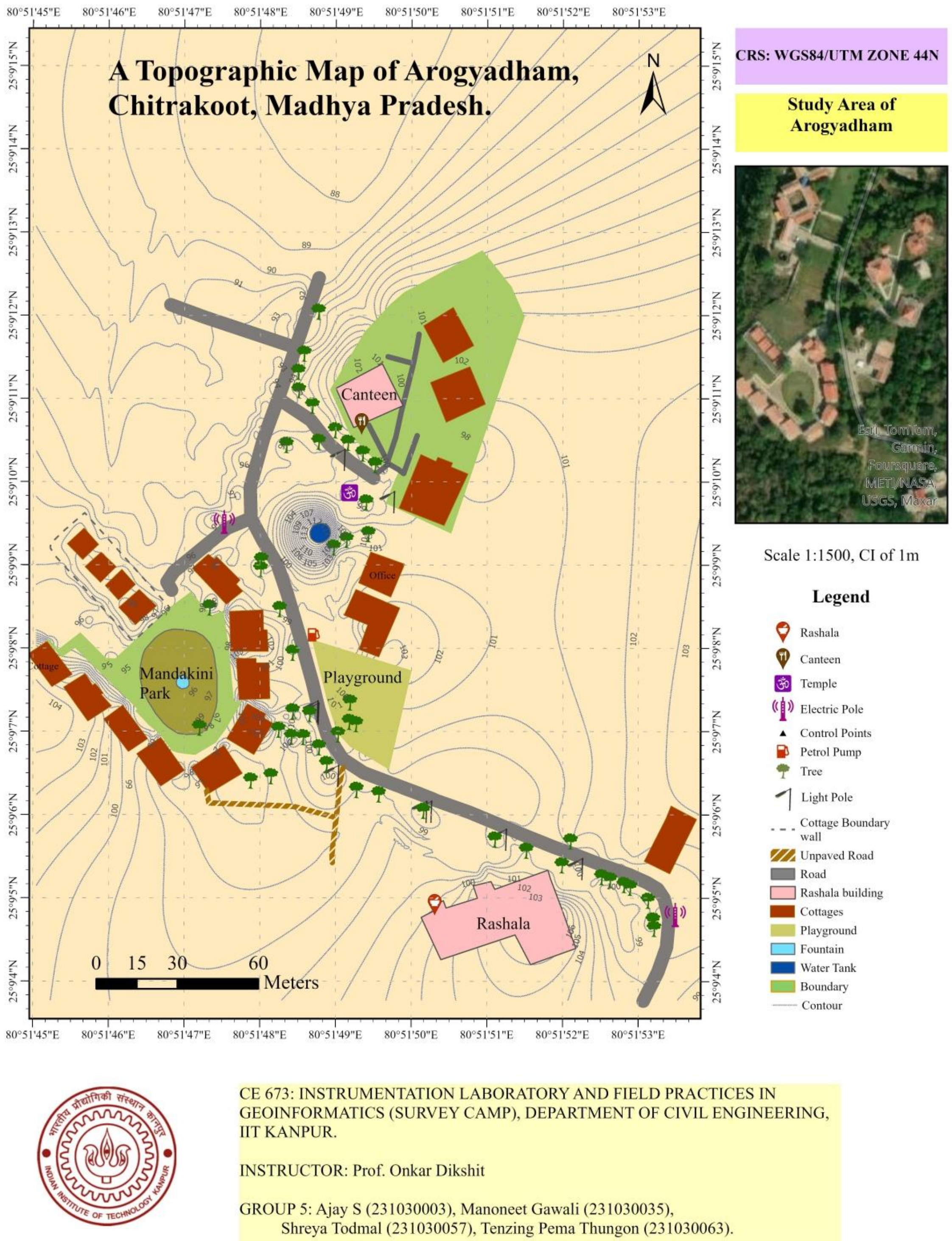


Figure 16 Topographic map generated

Juno Map

Instruments
Juno 3B

Methodology

The Juno 3B is a single frequency, rugged handheld GPS device manufactured by Trimble. It's designed for field data collection and mapping applications. It provides accuracy around 3-5m. Various features like point, line and area features can be plotted. The integrated GNSS receiver provides accurate positioning information within 3 meters when using postprocessed or 5 meters with real-time differential corrections. For accuracy it works in two mode: 1) if terra sync software is used post processing of the data is needed, 2) Use a real-time differential GNSS (DGNSS) source to collect data in realtime.

The following is the methodology for Juno data collection:

Equipment Setup:
- Equip one Juno device for collecting point and area generic features and another for collecting line generic features.
- Ensure both devices are configured with TerraSync software for data collection.

Data Collection Setup:
- For data collection the complete road map was studied and the survey was accordingly planned.

Line Generic Feature Collection:
- Start moving along the roadmap with the Juno device assigned for line generic feature collection.
- Begin collecting line generic features as per the roadmap.
- While moving, use the Juno device to collect the line generic features like road.

Point Generic Feature Collection:
- Collect point generic features by stopping at designated locations, majority of the features collected are Temples, ATM, hospitals, government organization, etc
- Use the Juno device assigned for point feature collection to capture location data at these points, enter the names of the features in the IDs.

Data Collection Completion:
- End data collection at the same point where it was started.
- The receiver collecting the line feature, i.e. road, must continuously keep moving, if a break has to be taken the feature recording must be paused.

Data Processing:

- Process the collected data either through pre-processing or post-processing methods.
- In postprocessed DGNSS, the collected GNSS data is transferred to an office computer, and measurements from the base station are downloaded. You can postprocess GNSS data collected with Trimble GNSS field software using: 1) The GPS Pathfinder Office software
  2)The Trimble GPS .Factors that affect the accuracy of postprocessed DGNSS include the type of receiver and antenna used at the base station, the distance between the base station and the location where the rover data was collected, the accuracy of the base station position, and the logging interval at the base station.

Export Data:

- Export the collected data as shapefiles or in .kmz or .kml format suitable for viewing in Google Earth.

Google Earth Integration:

- Open the exported .kmz or .kml file in Google Earth to overlay the collected data onto the map.

GIS Software Integration:

- Add the exported shapefiles to a GIS software, QGIS to prepare a map of the proposed area.
- Use appropriate symbology and labeling to visualize the collected features effectively.

Figure 26 feature types in juno

Figure 27 Juno survey

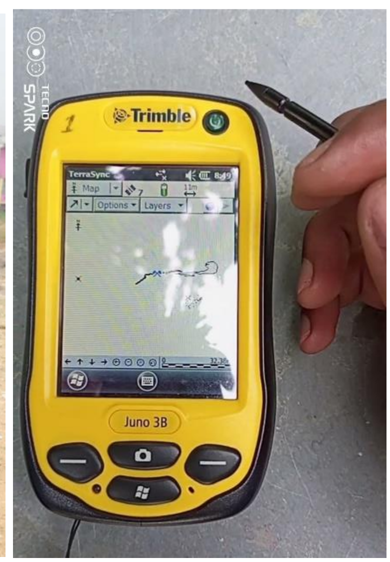


Figure 28 Line feature plotted

The steps for digitizing the features are:

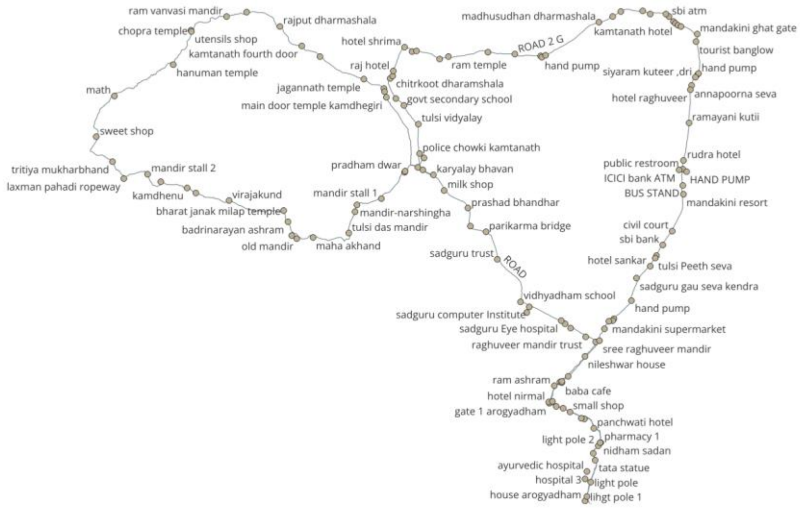


Figure 27 adding Juno data to Qgis

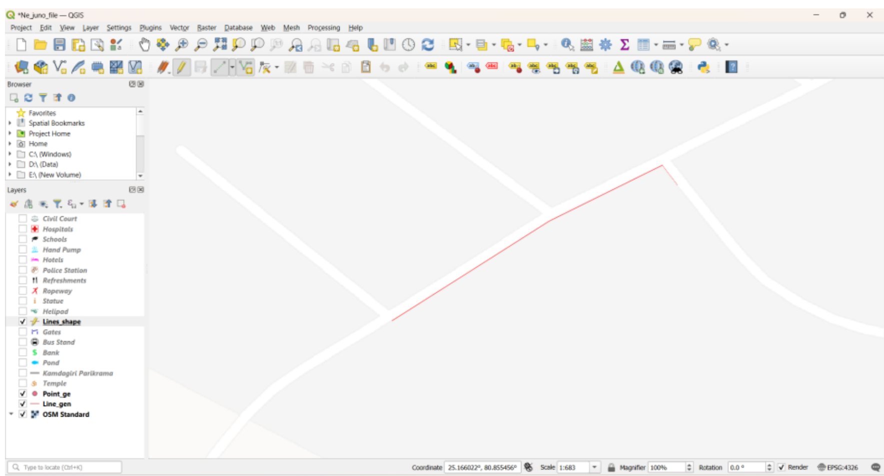


Figure 28 digitizing line feature

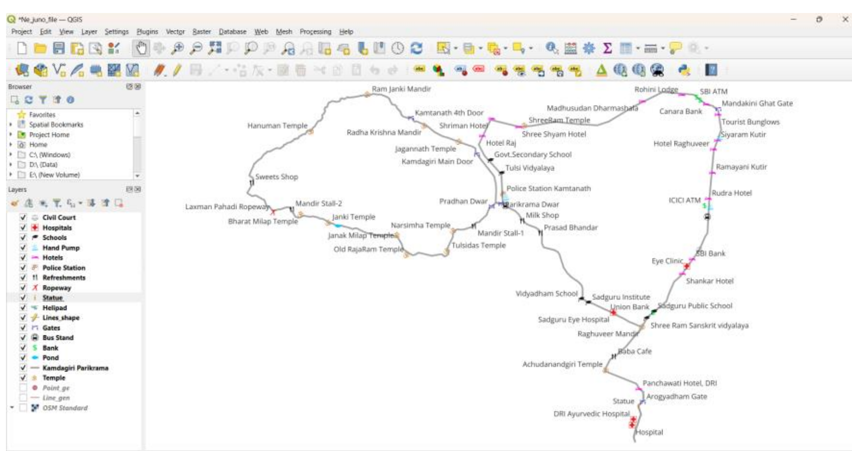


Figure 179 Digitizing point feature

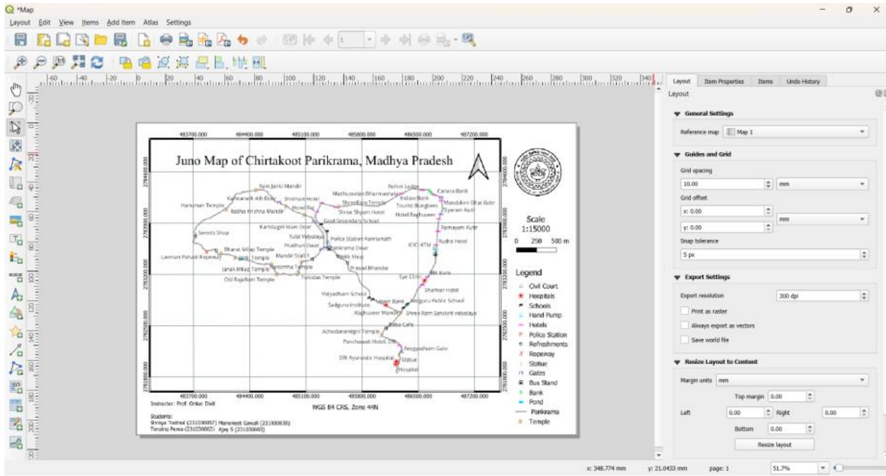


Figure 180 Generating print layout

Result

Navigational Map by Juno:

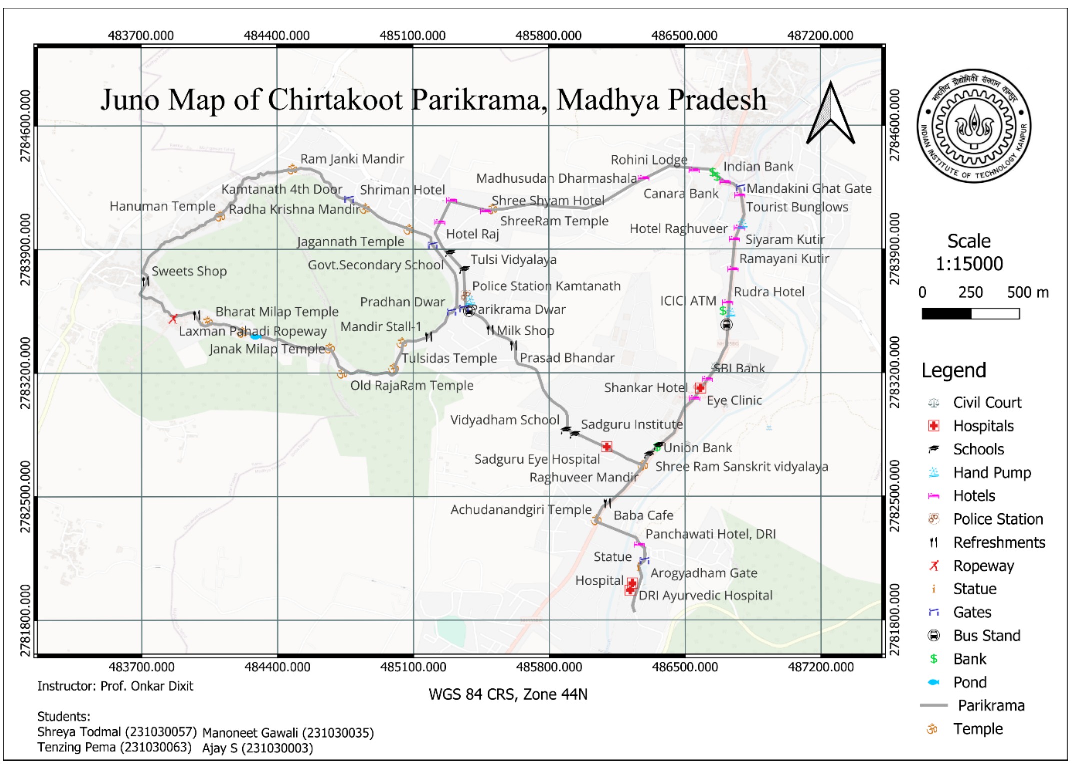


Figure 31 Navigational Map of Chitrakoot parikrama

Here the data is added to Q Gis. The line and point features are properly digitized. Appropriate labels are used for features, later on print layout is generated for the map and exported.
Scale of the map: 1: 15000
Plotable error: 3.75m
CRS: WGS 84

Road Profile by Total Station

Instruments
Total station, tripod, bipod, target prism, tape, chalk.

Methodology

Prepare the Road:

- Use chalk to draw straight lines on the road at 20-meter intervals along the length of the road segment to be profiled. These lines will serve as reference points for data collection. Mark the center of the road, along with center mark a line across the road and divide it in equal parts such that there are two points on both right and left each.

Setup Total Station:

- Set up the Total Station at a control point near the starting point of the road segment. Ensure that it has a clear line of sight to the chalked lines on the road.

Target Placement:

- Place reflective targets at 5 points on every cross-section along the road: one at the middle and two on each side of the centerline. Ensure that the targets are positioned accurately.
- Total 17 sections were considered in the total distance of 314m.
- The road is of width 3.6 m. Therefore, we divided each section at 20 m interval into 4 sections of 0.9m width. The fig() shows the graphical representation of the division of each section of the road.

Longitudinal Profile:

- Plot the Elevation vs Distance graph for the longitudinal profile of the road using the elevation values of the midpoints of each cross-section.
- Organize the data to represent the elevation at regular intervals along the length of the road.

Cross-Section Profile:

- Plot the Elevation vs Distance graph for each cross-section using the elevation values of all 5 equidistant points.
- Organize the data to represent the elevation at each point along the cross-sections.

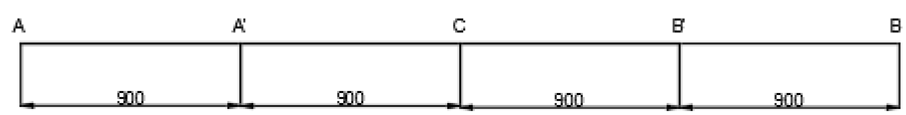


Figure 32 marking on road cross section

Result

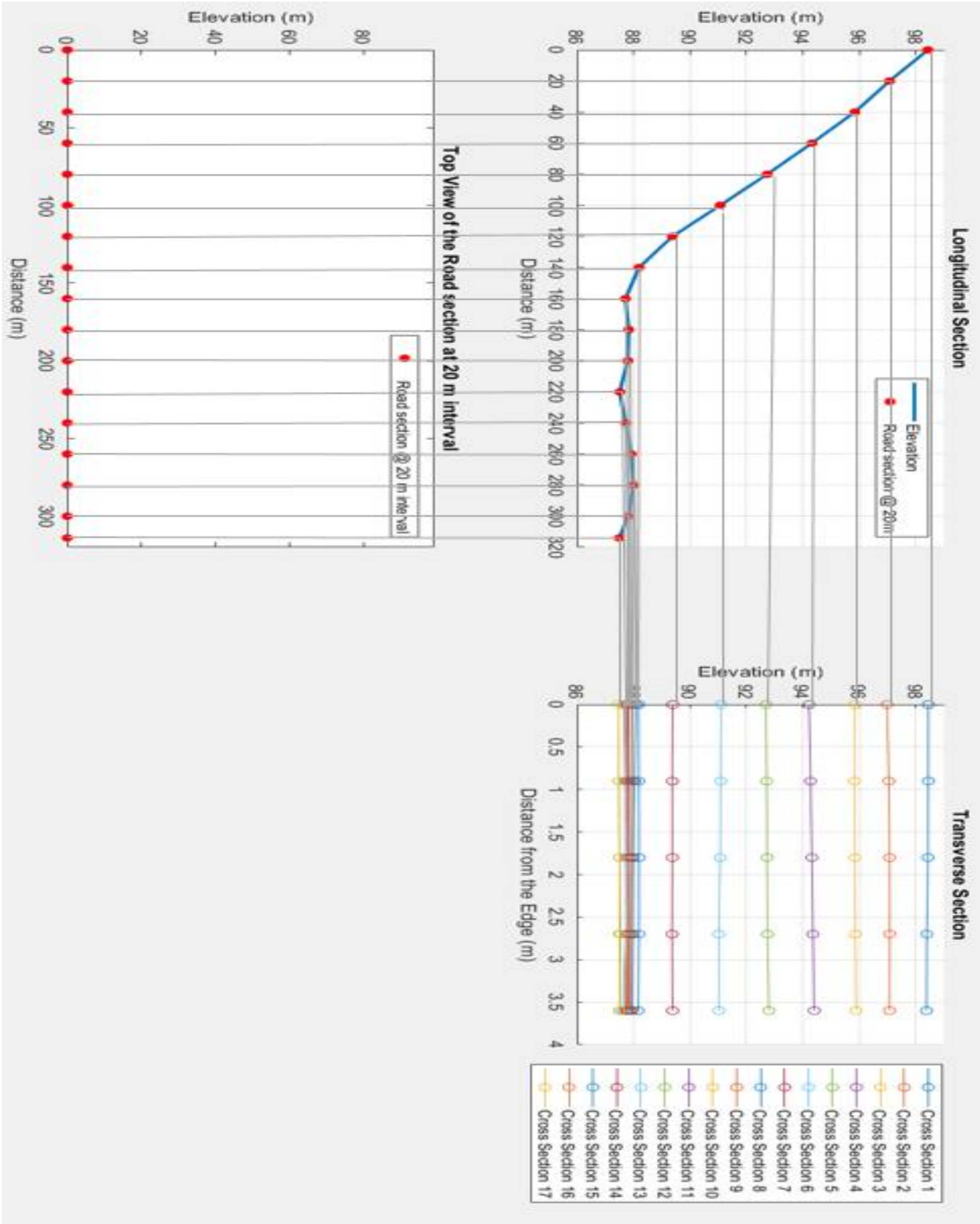


Figure 33 Road profile sheet

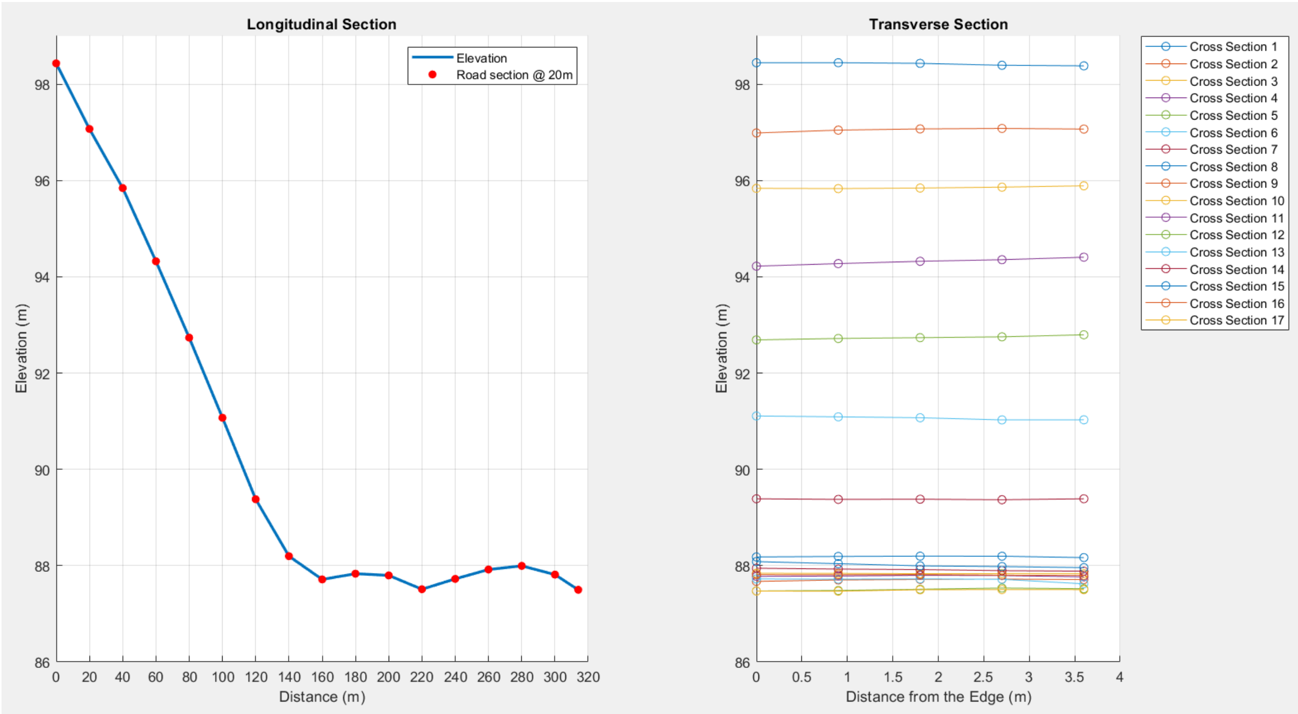


Figure 34 Longitude and transverse section of road

Analysis:

- The longitudinal section gives insight about the change in elevation w.r.t. length of the road.
- It also reveals the slope of the road or grade of road, as the road has steep grade it may affect vehicle traction and braking but in this case as the road is not a very busy road, this factor can be ignored.
- The road drainage system can be studied, which states clear that the drainage is good on major parts of the road, only at the distance of 200m on elevation graph there might be problem of water stagnation which can be overcome by the cross fall.

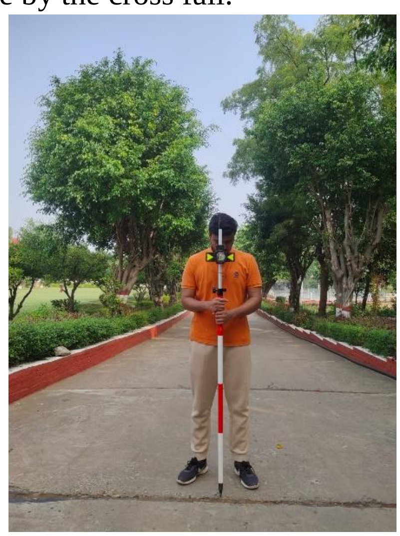


Figure 35 Marking center line of road

Chain and Compass Surveying

Instruments

1. Ranging rods, Pegs, Ranging Pins, Tape, Chain, Cross staff, Optical square, Prismatic Compass, Tripod, Ranging poles

Methodology

A. Chain and Tape Surveying

1. Select relatively flat ground. Mark two points on the ground at a distance of about 2-3 chain lengths using ranging operation.
2. Suppose A and B are the two points whose distance is to be calculated using a chain and tape.
3. If the distance to be measured is more than one chain or tape length, then it would be difficult to know whether the distance calculated is in a straight line or not.
4. To ensure that the distance measured is in a straight line, ranging is to be done.
5. First select a point in between the two selected points which is approximately 1/3rd of the distance of the total chain length. Let this point be C.
6. Ranging rods are placed at all three points A, B and C
7. Then the person at station A aligns the ranging rod at C by waving his hands, such that the ranging rods at A, B and C are in a straight line.
8. Further select a point D in between the stations C and B and repeat the same procedure to align all the points such that they coincide.
9. Spread the chain or tape to measure the distance.
10. Use principle of chaining to record data (as explained in the class) in the field book.
11. From the field book prepare the map.

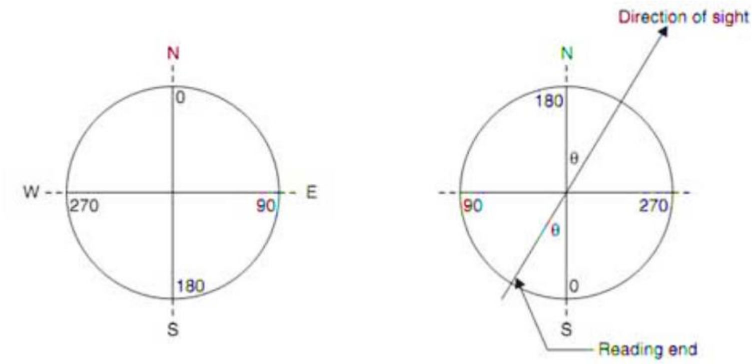
Figure 36 Offsets with tape

Figure 37 Orienting the traverse

Figure 19 Prismatic compass

B. Compass Surveying

1. Establish a triangle using tape and compass, such that each side is of length between 50 to 60 m.
2. Record FB/BB of line AB, BC, CA and apply checks.
3. Compute internal angles and apply checks.
4. Plot a few details (tree, building, pole etc.,) by measuring angles (Intersection method).
5. Adjust the traverse by graphical method.



The reflecting prism and the sight vane are placed exactly, opposite to each other. When the magnetic needle points north direction, the reading under the prism should be zero. As the zero graduation is at the south end of the needle, and the sight and eye vanes are exactly opposite, when the north end is at the sight vane, the south end will be at the eye vane, i.e., under the prism and, therefore, zero reading is obtained. Thus the bearings of lines are obtained in a clockwise direction from the north.

Compass Surveying**:** Readings taken

From	**To**	**FB**	**BB**
A	B	82^o	263^o
B	C	194^o	14^o
C	A	318^o	137^o

Errors due to:

- Faulty linear measurements
- Local attraction

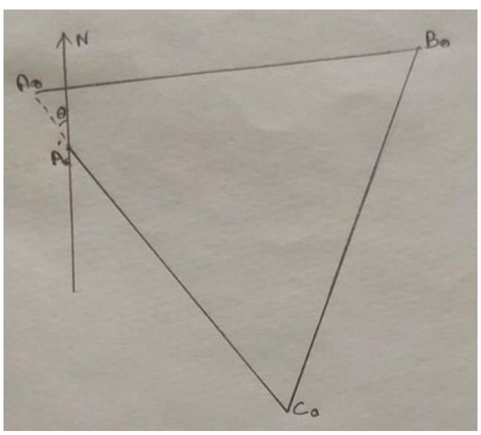
Correction for Local Attraction: done using included angles method

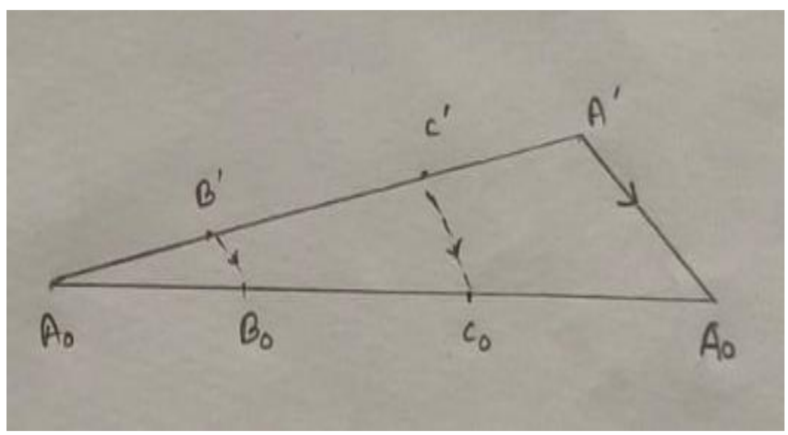
From	To	FB & BB	FB-BB	LA	Error	Correction	Corrected Bearings
A B	B A	82^o 263^o	181^o	Y	1^o	-1^o 0^o	83^o 263^o
B C	C B	194^o 14^o	180^o	N	0^o	0^o 0^o	194^o 14^o
C A	A C	318^o 137^o	181^o	Y	1^o	0^o -1^o	318^o 138^o

BC has no local attraction (LA), LA was found in station A.

Graphical method correction

For rough surveys or small area traverses, graphical adjustment methods are often utilized. In this technique, adjustments are made directly to the locations and coordinates of the stations, with corrections proportional to their distances from the initial station. Suppose A B C A' represents the graphical plot of a closed-loop traverse ABC. If the observed lengths and directions of traverse sides result in an unbalanced plot, depicted by a shift A A', the closing error of the traverse is A A' To distribute this error evenly among all sides and ensure closure, stations' positions are shifted graphically. Initially, a line is drawn at scale to represent the perimeter of the plotted traverse; in this case, a horizontal line A A' is drawn Traverse stations such as B, C, are marked on this line, with their distances representing the lengths of the traverse sides. Parallel to the closure correction, a line A' Aa is drawn from A'. Joining A to Aa and drawing lines parallel to A' Aa at B, C, gives the length and direction of errors at these stations. Corrections equal to these lengths and in the same direction are then applied to stations B, C providing their adjusted positions as Aa, Ba, Ca. Connecting these adjusted positions yields the corrected traverse Aa Bb Cc .





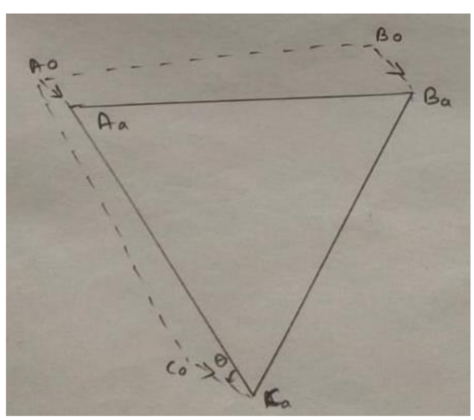


Figure 39 Graphical method adjustment of traverse by Bowditch rule

Field book

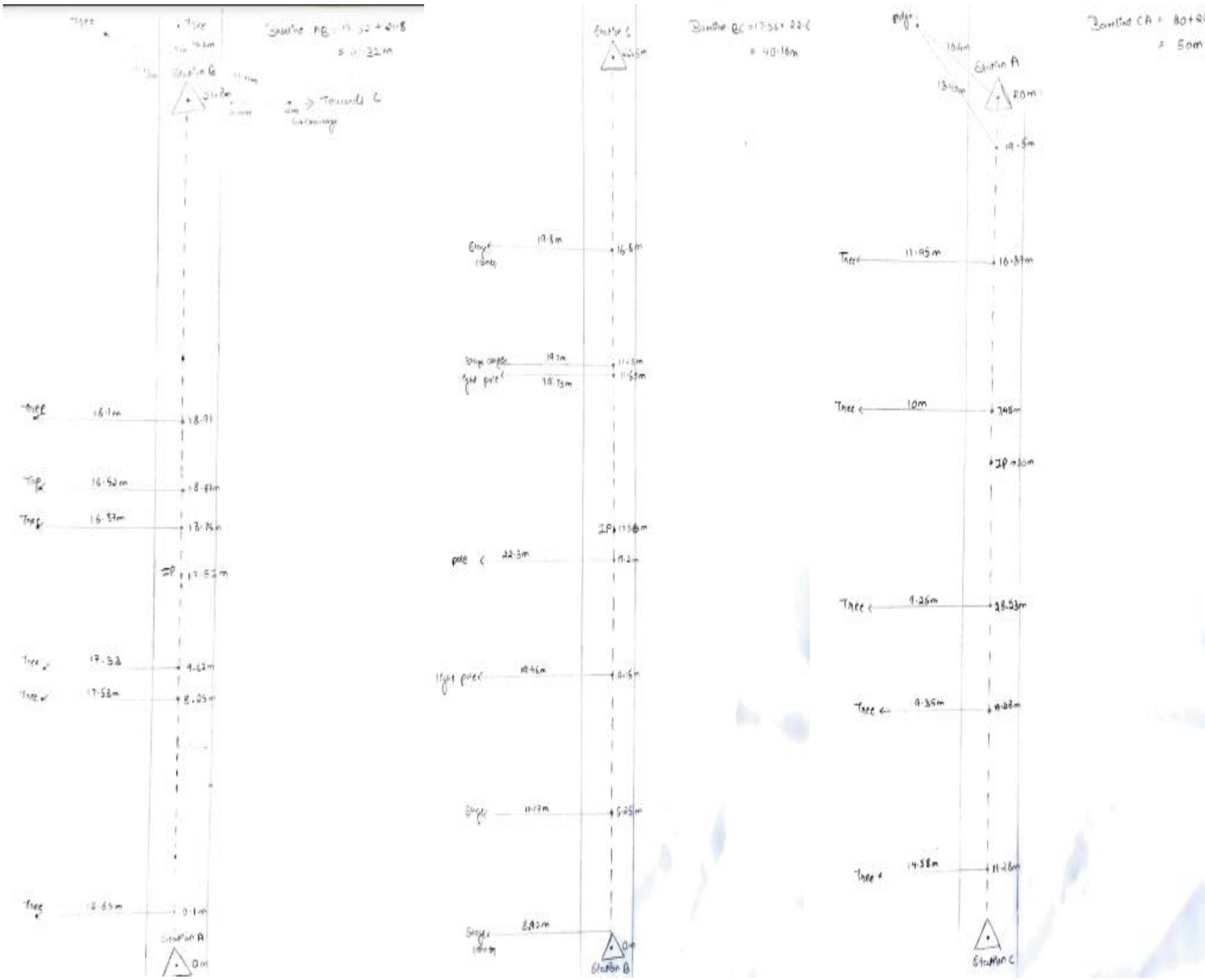


Figure 39 Field book foe each baseline

Result

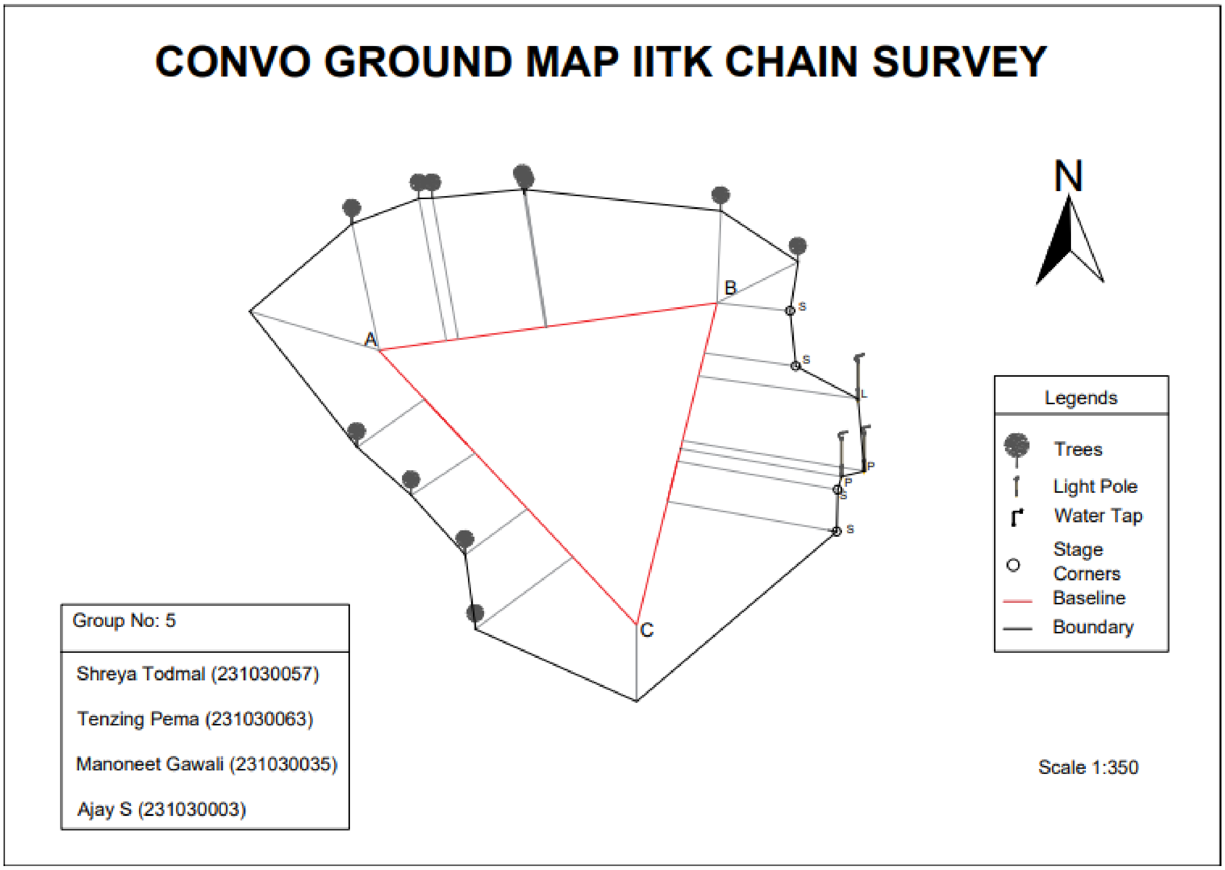


Figure 20 Traverse map by chain and compass survey

EDMI Calibration

Instruments

Total station, tripod, prism, bipod, tape.

Methodology

EDMI distance is calculated by the following equation:

$$2D = m\lambda + \frac{\phi}{2\pi}\lambda + k$$

2D: 2 x distance

m: unknown number of complete wavelengths (ambiguity) contained within double distance

ϕ: measured phase difference

λ: modulation wavelength

K: constant

An easy method is to determine each error by a series of tests which should be performed in the following order:

- Determine the degree of cyclic error (K3)
- Determine the value of the additive constant (K2)
- Measure known distances to find the scale error (K1)

A. Non linearity/cycle error

The precision of an EDM instrument is dependent on the precision of the internal phase measurement. Unwanted interference either through electronic/optical cross talk or multi-path effects of the transmitted signal onto the received signal causes cyclic error. The major form of the cyclic error is sinusoidal with a wavelength equal to the unit length of the instrument.

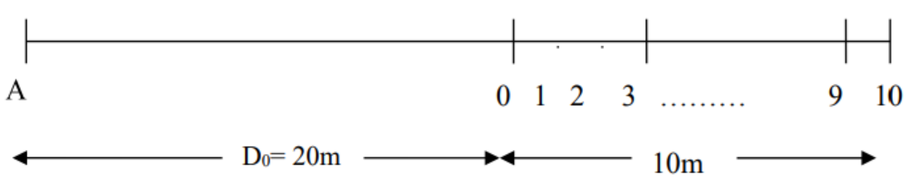
a. Assume the basic measuring unit as 10m (effective wavelength = $\lambda/2$)
b. Set up instrument at A.
c. Divide the 30m line from A into 2 segments of 20m and 10
d. Divide the last 10 m into 10 parts each of 1 m. Measure each part carefully using the tape (di) as well as the EDMI (Di). Note that Di is to be measured from EDMI position (A).
e. Carefully measure $D0$ with EDM (say 20.000 m).
f. The error correction is given by the formula:

$$e_i = D_i - (D_0 + \sum d_i)$$

g. The correction is given by

$$c_i = -e_i + \sum \frac{e_i}{10};$$

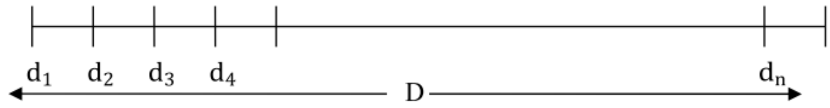
ei/10 indicates average error.



B. Reflector instrument check

a. Divide suitable distance D into n number of segments.
b. Use the same set of EDMI & reflector set for entire set of measurements.
c. Measure length of line (D) using EDMI and length of each of n segments (d1, d2, d3, d4….)
d. Reflector constant can be calculated by the formula:

$$K = \frac{D - \sum d_i}{n-1}$$



C. Scale error

Scale error is proportional to the length of the line measured and is caused by: internal frequency errors, including those caused by external temperature and instrument "warm up" effects; errors of measured temperature, pressure and humidity which affect the velocity of the signal; and non-homogeneous emissions/reception patterns from the emitting and receiving diodes (phase in-homogeneities).

If we know the length of a “calibrated line”, scale error can be found out. If the known distance, Dk, is measured as Dm then the scale error can be calculated by the formula:

$$Scale\ Error(ppm) = \left(\frac{D_k - D_m}{D_k}\right) * 10^6 = n\ ppm$$

$$Corrected\ Distance = D_m + n * D_m$$

Result

A. Non linearity/cycle error

Taped dist di(m)	taped distance	EDMI dist, Di (m)	Do + Sd (m)	Di-(D0+sum(d)) (m)	Correction (m)
20	0	19.995	20	-0.005	0.0045
21	1	20.997	21	-0.003	0.0042
22	2	21.993	22	-0.007	0.0035
23	3	22.996	23	-0.004	0.0035
24	4	23.991	24	-0.009	0.0026
25	5	24.989	25	-0.011	0.0024
26	6	25.988	26	-0.012	0.0023
27	7	26.988	27	-0.012	0.0023
28	8	27.994	28	-0.006	0.0017
29	9	27.994	29	-1.006	-0.0083
30	10	29.993	30	-0.007	0.0016

B. Reflector instrument check

Taped dist di(m)	EDMI dist, Di (m)	each segment length
20	3.024	0
21	4.01	1.01
22	5.01	1.01
23	6.015	1.015
24	7.013	1.013
25	8.019	1.019
26	9.009	1.009
27	10.005	1.005
28	11.005	1.005
29	12.009	1.009
30	13.013	1.013

$$K = \frac{D - \sum di}{n - 1}$$

$\sum di$ = 10.108
D =10, n = 10   Therefore K= -0.012

C. Scale error

Dk : known distance = 10 m

Dm: Measured distance = 10.108 m

$$Scale\ error(ppm) = \frac{Dk - Dm}{Dk} * 10^6 = 10.18ppm$$

$$corrected\ distance = scale\ error(ppm)\frac{Measured\ distance}{1000}$$

Corrected distance:

EDMI dist, Di (m)	Corrected distance
19.995	19.77905
20.997	20.77023
21.993	21.75548
22.996	22.74764
23.991	23.7319
24.989	24.71912
25.988	25.70733
26.988	26.69653
27.994	27.69166
27.994	27.69166
29.993	29.66908

Close loop traverse by Total station

Instruments

Total station, levelling staff, peg, tape, compass

Methodology

a) Keep number of stations equal to the number of groups forming a closed figure of side 40-50 m long. Each group will be setting up the instrument at only one station.

b) Perform “Initial Settings” for the total station as given in the Instrument Manual.

c) Carry out temporary adjustments for the equipment (i.e. centring and leveling, etc.).

d) Find out the length of each side using tape and EDMI.

e) After setting the instrument at each station, record all horizontal angles. Each individual from every group has to record both face-right and face-left observations. While recording the angles, please close the horizon and apply station adjustment if required. Each student should observe the horizontal angle with a different zero. You may use a sample Table.

f) After taking readings at a station, move to the next station. Use the same instrument set up by the previous group. Repeat angle measurements.

g) Adjust closing error using Bowditch’s rule.

h) Keep these observations (angular) with you in an Excel file. Also, apply least squares adjustment

i) Assume the coordinates of one of the points as (10000, 10000) and the bearing of one line measured from the compass.

Result

Station Observed	Face L/R	Horizontal Angle				Succesive difference	Adjusted angle
		Reading (Degrees)	Mean of interior angle	Multiples of average corrections	Correction rounded		
A	L	0	144.086235	0.012	0.0125	0.0125	144 5' 55"
D		144.1572					
A'		0.0025					
Error		-0.0025					
A	R	180					
D		324.01527					
A'		179.9991					
Error		0.0009					
B	L	0	94.177625	0.249	0.025	0.0125	94 11' 24"
A		94.17805					
B'		0.0011					
Error		-0.0011					
B	R	180					
A		274.1772					
B'		180.01694					
Error		-0.01694					
C	L	0	72.479995	0.0374	0.0375	0.0125	72 29' 33"
B		72.47777					
C'		0.0025					
Error		-0.0025					
C	R	180					
B		252.48222					
C'		180.00111					
Error		0.00111					
C	L	0	49.206385	0.0499	0.05	0.0125	49 13' 8"
D		49.16694					
C'		0.003888					
Error		0.003888					
C	R	180					
D		229.24583					
C'		180.03888					
Error		0.03888					
						0.05	360 0' 0"

Total interior angle	359.95024
Error	0.04976
Distribution of the error	0.01244

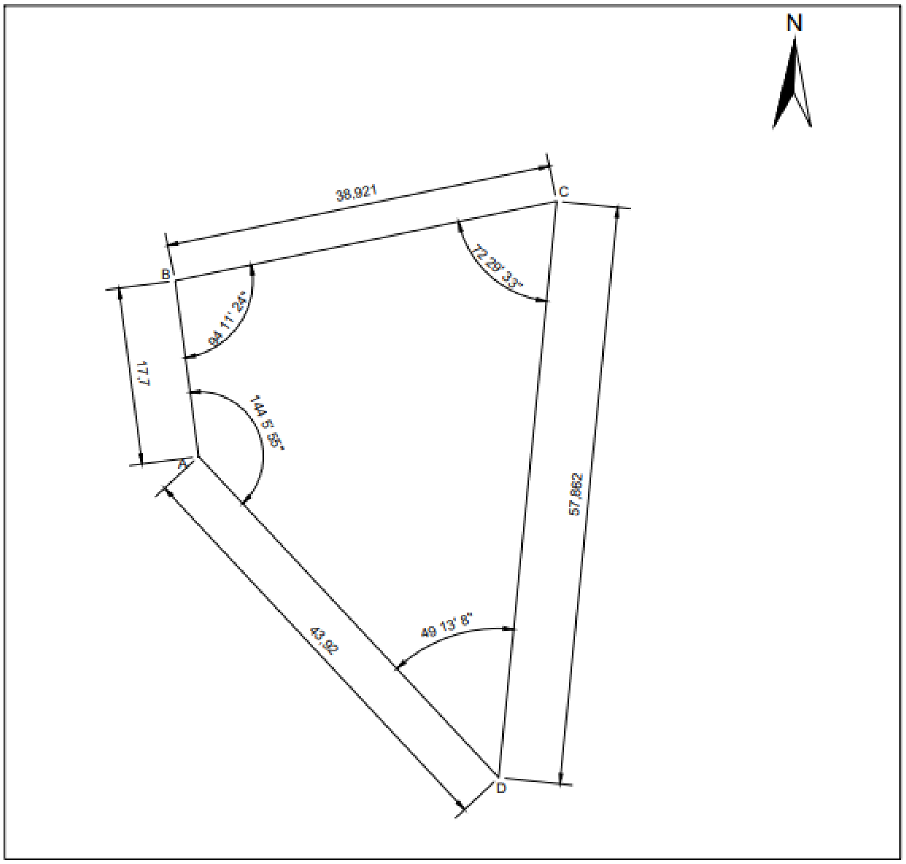


Figure 21 Map of traversing by total station

Conclusion

The culmination of various surveying methodologies, including reconnaissance, GNSS traversing, Total Station surveying, auto-leveling, feature mapping by Total Station, Juno survey, road profiling, chain and compass survey, and EDM calibration, has provided a holistic understanding of the terrain in Aarogydham Chitrakoot. This comprehensive approach enabled precise positioning, accurate measurement of coordinates, establishment of elevation benchmarks, detailed mapping of features, and assessment of road networks. The integration of modern technology alongside traditional methods ensured thorough coverage of the area, resulting in a robust dataset essential for map preparation. The calibrated instruments guaranteed the reliability of distance measurements, crucial for constructing an accurate map.

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