Instrumentation Laboratory and Field Practices for Geo- informatics

CE – 673

Survey Camp Report

Arogyadham (DRI), Chitrakoot, MP

(November 28th - Dec 3rd, 2023)

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1. Introduction

This survey project report is based on Geoinformatics Survey camp (CE-673) which was held at Arogy-dham, Chitrakoot in Madhya Pradesh state of India. This Arogyadham is also known as Deendayal Research Institute (DRI) which was been setup model for development such as providing services for health, hygiene, basic education, training for self employment etc. It have been developed to achieve overall socio-economic development and reconstruction of Indian Society. The DRI is a scenic campus situated in the hilly terrains of chitrakoot and it offers a variety of ayurvedic facilities including the Medical laboratory, Gaushala and Hospitals. Also there is a resort and residential area for the staff's families. There are tranquil ponds, beautiful flower gardens, and organic farms throughout the campus. A lush, verdant hillside borders the campus on one side, while the sparkling, icy waters of the Mandakini river border it on the other.

The camp was held from 27th of November to 5th of December 2023. It was a special experience as a student to be a part camp for me and my group. A I am extremely grateful for the guidance I received from Professor Onkar Dikshit and all the Geoinformatics laboratory staff throughout the camp, Sheetla Sir, Hari babu Prajapati Sir, Ram Keval Maurya sir, and all the TA's Rasmi Malik, Ratnesh Kushwaha, and Arnabh Laha throughout the Camp.

For the survey camp we started on the 27th of November Bus from IIT Kanpur campus to chitrakoot at 8:00 am via Bundelkhand Expressway. There we stayed at Panchwati guest house near DRI campus.

At the camp we mapped the area around the DRI canteen, to the area near Gaushala and the Guest cottages area, and also mapped the road profile from cottages to the main gate of Arogyadham. To create a topographic map of entire allotted area using GIS software first after reconnaissance survey we established the control point and then we measured their respective co-ordinates using Trimble R12 GNSS receiver. Using Juno 3B we created a line map and an area map while walking over 16 kilometers around Kamadgiri Hill. With help of Auto Level we performed levelling for measing elevations, Total Station Trimble S5 model was used for feature mapping.

1.1 Itinerary for the Camp

Day 1: November 28th, 2023

- **Activity:** Reconnaissance
- **Details:** Identified suitable locations for control points (CPs) based on predefined criteria. Marked 7 CPs ensuring maximum coverage and efficiency.

Day 2: November 29th, 2023

- **Activity:** GNSS Traversing
- **Details:** Used R10 receivers for GNSS traversing in static mode. Obtained precise coordinates of the CPs to establish geodetic control.

Day 3: November 30th, 2023

- **Activity:** Auto Level Levelling
- **Details:** Conducted Auto Level Levelling to determine orthometric heights. Obtained accurate elevation data for subsequent mapping tasks.

Day 4-5: December 1st-2nd, 2023

- **Activity:** Feature Mapping with Total Station
- **Details:** Employed Total Station for detailed feature mapping. Collected data on terrain, buildings, vegetation, etc., for topographic map creation.

Day 6: December 3rd, 2023

- **Activity:** Data Collection with Juno Receiver
- **Details:** Utilized Juno receivers for data collection. Gathered area generic, line generic, and point generic data to create navigational maps.

Additional Labs: IIT Kanpur Campus (April-2024)

- TS traversing
- EDM
- Chain and Compass Surveying

We utilized Total Station for field surveys and QGIS/ArcGIS Pro for spatial analysis and mapping in this survey. Various exercises demonstrate their combined functionality.

Surveying - Surveying is a process used in various fields such as construction, engineering, land mapping, and environmental assessment to measure and map the characteristics of a land area or structure. It involves using specialized instruments and techniques to determine distances, angles, elevations, and positions of points on the Earth's surface.

The principles of Surveying are:

- Work from whole to part.
- There must be adequate provisions for check.
- Choose the method of survey that is most suitable for the purpose.
- Record the field data carefully.

For Mapping exercise, we performed the following exercise:

1. Reconnaissance Survey
2. Establish Control Point
3. Traversing
4. Leavelling using Auto level
5. Control points co-ordinate measurement using GNSS
6. Use of Total station for feature mapping
7. Processing data collected and make topographic Map.

1.2 Objectives of Survey Camp

1. To learn how to survey an area efficiently, including placing control points and capturing geospatial data, while using the fewest control points possible and covering the largest possible area.
2. Get hands on experience of Total Station survey and get familiar with the surveying instruments like Total Station, GNSS, Auto-Level, Juno ,etc.
3. To make use of a GIS Software like ArcGIS, QGIS, etc to process the data and fabricate a map.
4. To learn to make a topographic map including contours by making map of the area of Aarogyadham.
5. To make use of a handled device Juno to create area generic, line generic and point generic geospatial data as one move along and make a map of it.
6. To perform road profiling of nearly 315 m long road of Aarogyadham, draw longitudinal profile of it as well as cross sectional profiles of each section at 5 m interval from the other.

2 Reconnaissance Survey

A reconnaissance survey is an initial, broad assessment of an area to gather preliminary information before conducting detailed surveying or other activities. It involves quickly scanning the area to identify key features, terrain characteristics, potential challenges, and suitable locations for establishing control points or conducting further surveys. Reconnaissance surveys help in planning and decision-making by providing an overview of the area's conditions and requirements.

It is the first and most important step in the surveying process. In the first instance, surveying requires management and decision-making in determining the appropriate methods and instrumentation required to complete the task satisfactorily with the required accuracy and within the available time constraints. This initial process can only be executed correctly after a meticulous and comprehensive reconnaissance of the area to be surveyed. Its purpose is to decide the best location for the control points through which we can take control of the entire area that is to be mapped working from whole to part.

We consider following factors while establishing control point:

- Point should be Open to Sky
- It should cover maximum area possible.
- Stable hard surface should be considered.
- Minimum number of Control points
- Other control points should be visible from the another.

Total 7 control points were identified for Traversing, It is suggested that minimum amount of control points should be setup but maximum area to be covered in order to reduce the accumulation of error. Reconnaissance aims to assess and, if necessary, adjust the initial station placements by eliminating impractical or unfeasible control points while identifying and preserving more viable ones, ensuring continued inter-visibility.

2.1 Methodology for Reconnaissance survey

1. Go to the area and have an idea of it.
2. **Walk around the area** Make a walk around the area of DRI Canteen, the Gaushala, and the Cottages at the Aarogyadham in Chitrakoot and identify possible station locations while having an idea of what features need to be collected as well.
3. **Establish Control Network / Control Points** The most fundamental operation in surveying areas of land is the establishment of twoor three-dimensional control networks. Control networks are made up of a series of points or positions (called control points) that are spatially located for the purpose of topographic surveying. In this process choose the control points after walking around the area.
4. **Paper Survey** After a casual walk around the area, take data from all possible sources and study. The sources comprise of any existing maps and plans, aerial photographs, etc. That’s called ‘paper survey’. Make use of web services such as GOOGLE EARTH to make early decisions regarding a site's potential for GNSS receiver occupancy and possibility for making it a control point. However, a site visit is always the only method to confirm its suitability. Make a rough sketch of where to setup the control points and locate all of them.
5. **Field Reconnaissance** After the paper survey, do a detailed field reconnaissance and locate all the control points in the area of interest. This time make a detailed walk and locate all the CPs in the paper survey at the actual area. Identify all the control networks during the reconnaissance that can serve the purpose of taking control over the area. Out of those all, choose the best control network that ensures clear, uninterrupted lines of sight, best observing angle, minimum control points and maximum area covered.
6. After making a rough sketch of the survey area, the discuss the strategy to be employed to make map of the area.

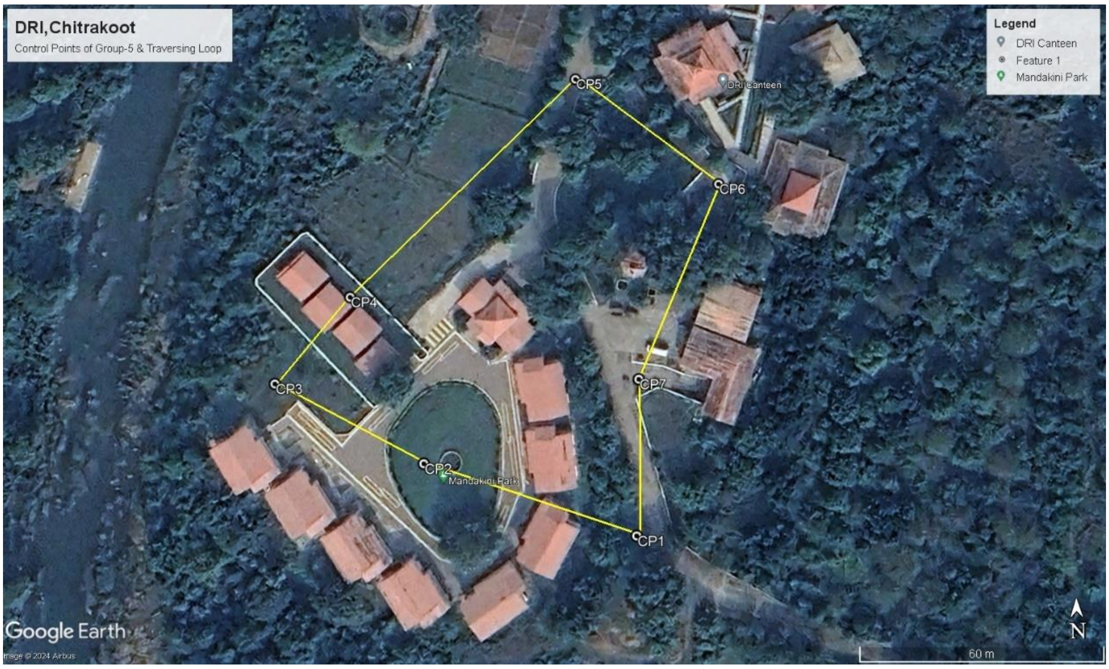


Figure 1: Traverse Loop with Control Points

3 GNSS Traversing

GPS relies on a constellation of satellites that communicate with ground receivers. When a receiver seeks location data, it connects with at least four GPS satellites. These satellites transmit their positions, the time of transmission, and the distance to the receiver. By processing this data, the receiver calculates its latitude, longitude, and altitude.

Equipment Used – Trimble R12 receiver, Bipod, GNSS controller, Receiver Rod.
Now as we have identified 7 Control points, we then setup GNSS receiver on each point and we here will use "static" method to conduct survey, As for this method for setting control point we need high accuracy and precise co-ordinate.

3.1 Trimble R10 Receiver and TSC7 controller

The Trimble R10 GNSS receiver incorporates a GNSS antenna, receiver, internal radio, and battery in a rugged light-weight unit that is ideally suited as an all-on the-pole RTK rover or quick setup/rapid mobilization base station. LEDs enable you to monitor satellite tracking, radio reception, data logging status, Wi-Fi status, and power. Bluetooth wireless technology provides cable-free communications between the receiver and controller. This is a dual frequency receiver.
R10 receiver antenna is a dual frequency receiver, and it is embedded in the receiver itself. The receiver is mounted on a bipod. R10 receiver is based on the principle of carrier phase frequency hence accuracy is in order of cm's depending on the data acquisition mode (static or kinematic).

Figure 2: Trimble R-10-2 GNSS Receiver

Figure 3: Buttons on R10-2 Receiver

3.1.1 Steps to take observations from Trimble R10-2 Receiver in Static Mode

a) Place the GNSS receiver in a location on the jobsite where equal range in all directions provides full coverage of the site. This is more important on larger jobsites, where the broadcast range of the base station radio may limit the operations of the system.

Place the GNSS antenna in a location that has a clear line of sight to the sky in all directions. Do not place the antenna near vertical obstructions such as buildings, deep cuttings, site vehicles, towers, or tree canopy.

Place the GNSS and radio antennas as high as practical. This minimizes multipath from the surrounding area and enables the radio to broadcast to the maximum distance Importance of cut-off angle in GNSS Mission planning.

b) Level the receiver with help of bubble level attached with the Tripod.

Figure 4:GNSS controller Trimble TSC7

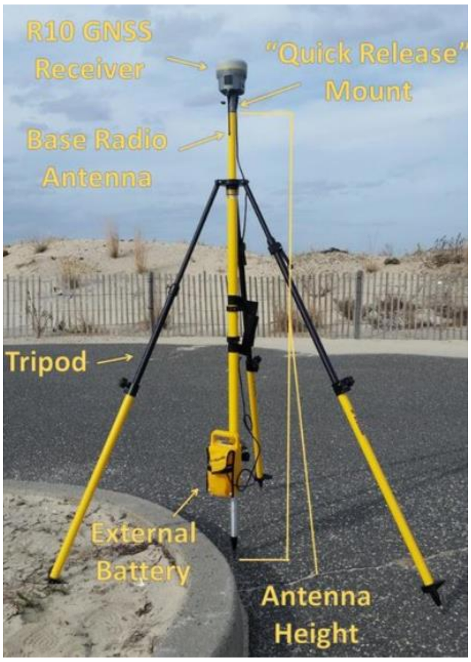


Figure 5: GNSS receiver with Tripod.

c) Turn on the receiver and TSC3 or Trimble Tablet. Run **Trimble Access**

d) In the General Survey menu: Tap Instrument

Figure 6: General Survey Menu interface in Trimble Access

e) On the receiver by pressing power button
f) Connect the TSC3 and R10 receiver and connect TSC3 to wi-fi.
g) On TSC 3 Click on "New Project" and Give Name for Our project file.
h) Give Job file Name and Set UTM 44 North Zone.
i) Set datum as WGS -84.
j) Set Project height as 0.
k) Set co-ordinates as Grid. And click on Store.
l) Now Go to Settings
m) Click on instrument > GNSS function > Connections > Bluetooth > connect to GNSS rover.

n) Now Go back and Select > Rover mode > click Accept.
o) Now again click on Menu> Settings > Survey style > select “static” and Go to Rover option
p) In rover option > select “Survey styles” > set antenna height of 2m & Elevation mask 10^o
q) In GNSS Signal tracking Options Select Satellites which we want data (GPS, GLONASS, Galileo, Bei Dou, etc) > click on “Store”
r) Go to main menu > Settings bar and click > Measure > static >Measure points.
s) Now In measure point , Give Point name, Code. Antenna height can be changes from here too.
t) Click on Options > In FastStatic times we can set time for taking single observation. So, we set here as 15 min in Open sky area and 20 min in dense area with some tree cover hindrances. >click Enter.
u) Now select measure to start measuring data of Point. And Reverse timer will start that our data capturing is started.
v) After Capturing data > click on “Store” to store observations.
w) Now we can capture other points too with same clicking on measure. No need to adjust settings again which we have setup for rover.

After we obtain the .csv files we then perform GNSS data Baseline processing on our co-ordinates using TBC software.

3.2 Baseline Processing

This GPS surveying technique is simple but extremely useful and accurate, especially when measuring long distances. The natural distortions that occur in GPS signals cancel each other out because the GPS data is collected over a long period of time and the observations are collected at the same time at each end of the baseline. This technique has a typical accuracy of 1 ppm.
GPS baseline uses two survey-quality GPS receivers, with one at each end of the line to be measured. They collect data from the same GPS satellites at the same time. The duration of these simultaneous observations varies with the length of the line and the accuracy needed but is typically half an hour or more.
In this procedure, two (or more) receivers are employed. The process begins with one receiver (called the base receiver) being located on an existing control station, while the remaining receivers (called the roving receivers) occupy stations with unknown coordinates. For the first observing session, simultaneous observations are made from all stations to four or more satellites for time period of an hour or more depending on the baseline length. (Longer baselines require greater observing times.) Except for one, all the receivers can be moved upon completion of the first session. The remaining receiver now serves as the base station for the next observation session. It can be selected from any of the receivers used in the first observation session. Upon completion of the second session, the process is repeated until all stations are occupied, and the observed baselines form geometrically closed figures.

A static GPS baseline is a technique for determining precise survey point coordinates. Baseline measurements accomplish this by continuously recording GPS observations and then processing that data to provide the most accurate result. The technique employs two GPS receivers. Then, at each survey point, collect data for 20 minutes using GPS receivers.

Once all the data has been collected, TBC (Trimble Business Center) software is used to for processing this data and it give the report of the Baseline Processing which contain all the relevant data and global coordinates, ellipsoidal height, precision, variance-covariance matrix, etc.

Figure 7: GNSS Base station setup near cottages in DRI, Chitrakoot.

A posteriori Variance- co-variance matrices generated during the baseline processing are:

Base	X	Y	Z
X	0.0000063079		
Y	0.0000157320	0.0001153779	
Z	0.0000095729	0.0000525222	0.0000319278

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

P1.1	X	Y	Z
X	0.0000029138		
Y	0.0000018566	0.0000200307	
Z	0.0000014823	0.0000080523	0.0000074154

3.3 Steps for GNSS Processing

a) Open a New Project in TBC software and select blank template.
b) Go to the project settings.
c) Go to coordinate System settings and set system as Worldwide/UTM projection.
d) Set the datum transformation as UTM 44 North and WGS 1984 as our horizontal datum and then choose no Geoid Model.
e) Go to baseline processing setting and click on satellite settings, then choose GNSS constellation.
f) Import baseline data of base stations and then right click on the base station and go to add coordinates.
g) Now, modify the Easting and northing and as we need more precise survey, for that select control quality from planar quality tag.
h) Then import the receiver's data for multiple stations and select those point IDs whose duration will be more than or nearby 15 minutes. Then click OK.
i) We can now see baseline has created from base station to the receiver station. Then select the baseline and right click on it. Go to the session editor where time edits can be done for improving the quality of data.
j) Select the baseline and right click on it then click on baseline processing.
k) We can see a tabular column showing observations, horizontal and vertical precision, RMS values and the length of the baseline. Then save it.
l) Generate the report of baseline processing and point wise processing.

Readings are taken in static mode by GNSS R10 receiver.

Applying transit rule for corrections:

In this method, the coordinate error is distributed in proportion to the amount that various coordinates change between points.

- Northing adjustment = Change in Northing for traverse line to point / Sum of absolute values of all changes in northing for all traverse lines × Northing closure error
- Easting adjustment = Change in Northing for traverse line to point / Sum of absolute values of all changes in northing for all traverse lines × Easting closure error

A series of GPS baselines forming a loop off a single point can be adjusted and assessed similarly to a conventional EDM traverse loop described above (Figure 11-1). The baseline vector components may be computed (accumulated) around the loop with a resultant three-dimensional misclosure back at the starting point. These misclosures (in X, Y, and Z) may be adjusted using either approximate or least-squares methods. The method by which the misclosure is distributed among the intermediate points in the traverse is a function of the adjustment weighting technique. (1) In the case of a simple EDM traverse adjustment, the observed distances (or position corrections) are weighted as a function of the segment length and the overall traverse length (Compass Rule), or to the overall sum of the latitudes/departures (Transit Rule).

For close loop error we have used closed Transit error to evenly distribute error. Which is,

$$\delta x_i = -dx\ [\Delta x_i \ / \ \Sigma \Delta x_i]$$

$$\delta y_i = -dy\ [\Delta y_i \ / \ \Sigma \Delta y_i]$$

$$\delta z_i = -dz\ [\Delta z_i \ / \ \Sigma \Delta z_i]$$

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**
P1.1	486247.492	2781780702	90.211
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**

Table 1 : Processed GNSS Survey Co-ordinates of Control points after Corrections.

Traverse misclosure:

ΔN = 486247.495 - 486247.492 = 0.003 m

ΔE = 2781780.715 - 2781780.702 = 0.013 m

$\Delta H_{\text{elevation}}$ = 90.214 - 90.211= 0.003 m

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:

- ∑ΔE = |-50.827| + |-53.081| + |-38.004| + |17.486| + |61.458| + |36.947| + |-23.217| + |-1.592| + |-50.824| = 332.446 m
- ∑ΔN = |-22.366| + |18.772| + |20.874| + |21.181| + |59.450| + |-30.441| + |-50.688| + |-39.161| + |22.379| = 100.252 m

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 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

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

Figure 8: Surveyor Operating GNSS Receiver

3.4 Quality assessment for GNSS Traversing:

- $\Delta N = 0.003m$
- $\Delta E = 0.013m$

Traverse perimeter (p) = Sum of the lengths of all traverse lines

First, we need to calculate the traverse perimeter (p). Since the traverse lines are not explicitly provided, we can approximate the perimeter by summing the distances between consecutive points:

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

Let's calculate the perimeter and closing error:

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

e/*p* ratio:
Assuming a linear approximation between points, we can calculate the distances between consecutive points:

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

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

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

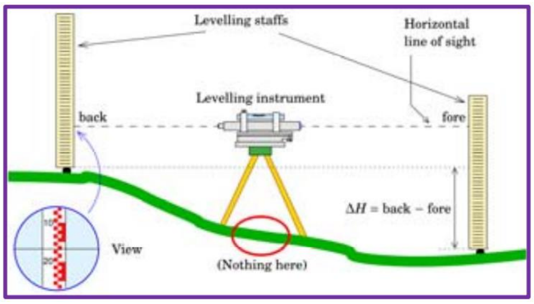
$$p \approx 2646.822m$$
$$e/p \approx 4.911\times10{-}6$$

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

Hence, the ratio falls in the category *first order surveying*.

4. Levelling using Auto-Level

Levelling is a Method of determining the Elevation difference or level of various points above datum.



Terminologies used in levelling:
Height of Instrument (HI): RL of line-of-sight Backsight (BS) or plus sight: Taken to get HI (RL of line of sight), by observing a point of known RL
Foresight (FS) or minus sight: Taken on last point or turning point (TP)
Turning point (TP): A foresight after which instrument is moved; point where both the foresight and backsight are made on a staff held at that point.
Intermediate sight (IS): All remaining FS which are neither TP or sights on the last point
Reduced Level (RL): Reduced level of a point is height relative to datum. It is calculated height above/below the point of datum. Also known as Datum.
Steps to make a levelling network:
• Control point marking
• Auto level/Digital level setup
• Level network
• Network adjustment

Principles of Levelling:
Height of Instrument: HI = RL + BS
Reduced Level: RL = HI – FS

Methods used for Levelling:
- Height of Instrument Method.
- The arithmetic check applied for this method is:

$$\sum B.\ S. - \sum F.\ S. = Last\ R.L - First\ R.L$$

Instruments for Levelling:

1. Auto Level (Nikon AC-2S)
2. Level Staff (Double-faced leveling rod with metric graduations)
3. Trimble's Tripod
4. Measuring Tape

Figure 10: Nikon Auto-level instrument.

Figure 9: Ranging staff for Observimg height.

Figure 11:Surveyor observing the Elevation from Auto-level.

Figure 12: Person holding the staff perfectly levelled.

4.1 Methodology for Levelling

1. Setup Auto Level on a control point.
2. Measure Back Sight and Fore Sight values (Mid stadia, upper stadia and lower stadia values).
3. The backsight and foresight distances should be almost equal from the control point. Counting the no of steps can be done to make sure the distances are equal.
4. Remember to take readings up to three decimal places for accuracy.
5. Rod should be held parallel, straight upright and a bit from upper half to reduce errors due to rod handling
6. Calculate height of the instrument using a measuring tape.
7. Move to the next control point.
8. Repeat the procedure up to last control point.
9. Apply arithmetic checks after completing the levelling network.
10. Check for the quality of levelling.

11. The no. of levelling networks can be increased to for better quality work as the levelling distance increase, chances of error also increase.

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		100.005	

Table 2: Readings Obtained from Levelling.

The methodology followed of surveying is Height of Instrument method.
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
  Therefore,
  C = 2.639, therefore the levelling is classified into *Precision levelling*.

Work	Purpose	C
Highest quality	Geodetic levelling and surveys for special purpose	1
Precise levelling	Geodetic levelling 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)

4.2 Correction for Leveling:

Loop closure: as function of distance

C=e/L

Example for few stations:

$Correction1 = \frac{0.005}{527.8}(50)$ = 0.000474

$Correction2 = \frac{0.005}{527.8}(29.2)$ = 0.000277

Station	RL	Cumulative distance	correction	Corrected RL
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	100.0051

Table 3: Correction applied to Auto-level.

5 Juno Survey

he Juno 3B is a handheld GNSS (Global Navigation Satellite System) receiver manufactured by Trimble. It is designed for field data collection, mapping, and navigation tasks, especially in outdoor environments where GPS/GNSS signals are available. The Juno 3B offers a range of features and capabilities, including:

1. **GNSS Support:** The Juno 3B supports multiple GNSS constellations, including GPS, GLONASS, and SBAS
2. **Data Collection:** It is for data collection, allowing users to capture various types of spatial data such as points, lines, polygons.
3. **Integrated Camera:** Some models of the Juno 3B come with an integrated 5 MP camera for capturing geotagged photos,
4. **Rugged Design:** The device is designed to withstand harsh environmental conditions, making it suitable for outdoor use.
5. **Connectivity:** Bluetooth and Wi-Fi and Cellular.

Figure 13: Surveyor holding Trimble Juno 3B.

Juno is device using which three types of geospatial data can be collected:

- Point-generic: Points like tree, poles, hospitals, buildings, etc.
- Line-generic: Multiline like roads, footpath, etc.
- Area-generic: Polygon like hill's boundary, etc

Considering that the data sheets for the Juno 3 series only claim an HRMS accuracy of 1-3m for postprocessed positions and a real time (SBAS) accuracy of 2-5m.

5.1 Methodology for Juno Survey

1. Utilize two Juno devices, with one dedicated to capturing line and area features, while the other focuses on gathering point features.

2. Begin by following the designated roadmap and commence collecting line-based generic features.

3. Terminate the collection of line-based features at locations where area-based generic features are to be recorded.

4. Initiate the collection of area-based generic features specifically at Kamadgiri, during a circumambulation.

5. Conclude data collection at the same starting point.

6. Resume collecting line-based generic features.

7. Continuously progress along the roadmap and conclude data collection upon reaching the destination.

8. Concurrently with line and area feature collection, capture point-based generic features by pausing at designated locations and recording their coordinates.

9. Either pause area/line data collection temporarily or delegate the task to another team member.

10. Data processing can occur either through pre-processing or post-processing methods.

11. Export the collected data into shapefiles in .kmz or .kml formats.

12. Open the exported .kmz or .kml file using Google Earth.

13. Overlay the collected data onto Google Earth for visualization.

14. Evaluate the accuracy of the collected data.

15. Integrate the shapefiles into GIS software such as QGIS and generate a map depicting the proposed area.

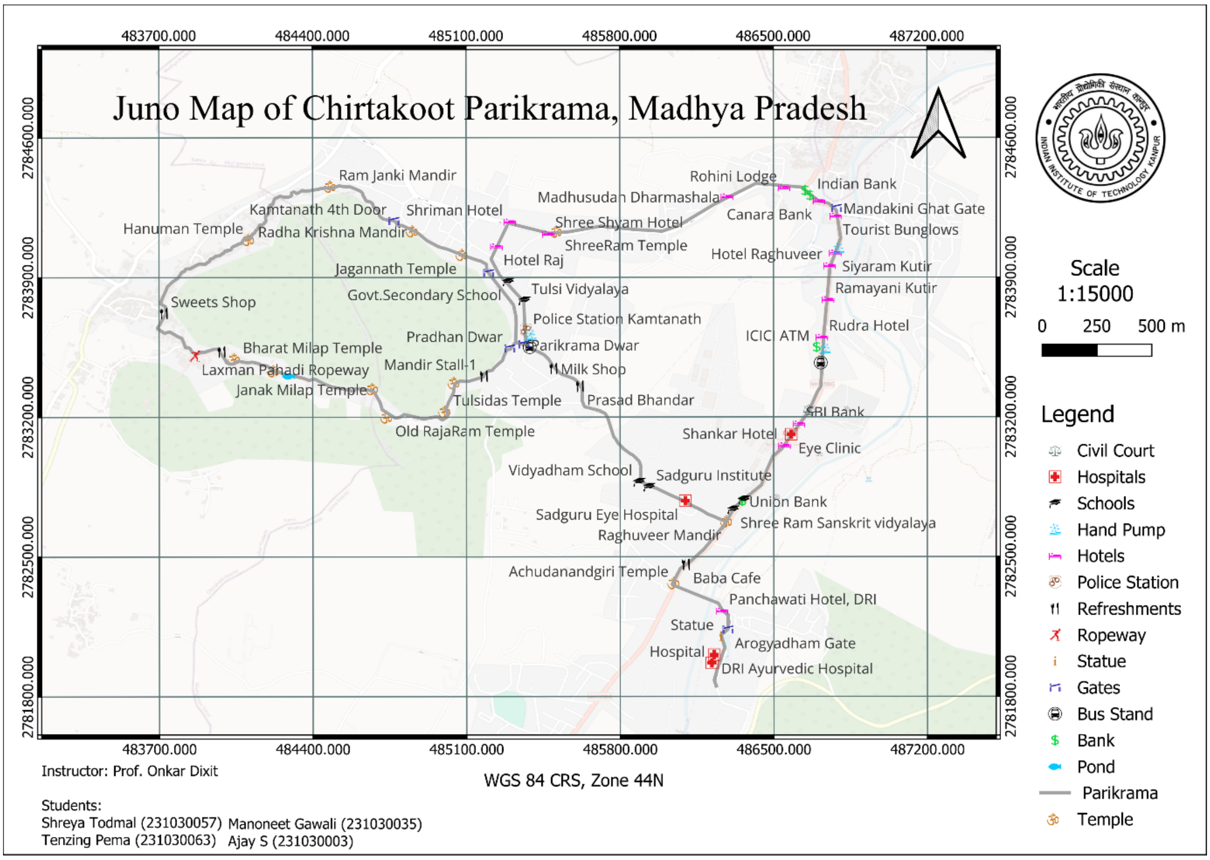


Figure 14: Juno Map generated using QGIS.

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
- Plottable error: 3.75m
- CRS: WGS 84

6 Topographical Survey using Total Station

After a control network is setup, it is required to obtain the coordinate positions of each point. This can be done using any of the following methods:

• Intersection or Resection

• Traversing • Networks

• GNSS Satellites

Traversing is probably the most favoured simple method of locating the relative coordinate positions of control points in engineering.

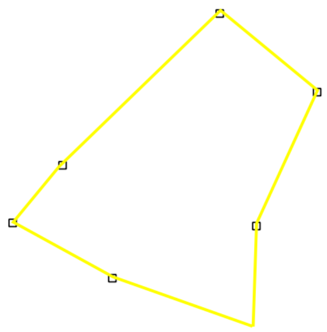


Figure 15: Traverse Loop followed, represented as shape shown above.

To enhance overall project efficiency and angle accuracy, it's advisable to prioritize long sight distances during traversing and avoid nearly flat angles (values close to 180°) whenever feasible. Presurvey reconnaissance is recommended for this purpose.

There are two traverse types:

1. Open Traverse: Lines form a circuit that ends elsewhere besides the starting point.

2. Closed Traverse: Lines form a circuit ending at the starting point.

Closed traverses are preferable over open traverses because they allow checks using the sum of interior or exterior angles in a polygon, improving accuracy and reliability.

1. **Reconnaissance survey**

- Conduct a thorough presurvey reconnaissance to familiarize yourself with the terrain, identify prominent landmarks, and plan the traverse route.
- Determine the starting point (origin) and the direction of the traverse.

2. **Setup Total Station Setup**

- Set up the electronic total station at the starting point, ensuring it is level and stable.
- Calibrate the ETS and input any necessary parameters such as instrument height and prism constant.

3. **Traverse Making**

- Measure the angles and distances between consecutive traverse points using the ETS.
- Record the observed angles and distances systematically in a field notebook or digital device.
- Proceed to the next traverse point, ensuring visibility and maintaining a clear line of sight.

4. **Adjustment of Traverse**

- After completing the traverse, perform a traverse adjustment to improve the accuracy of the measured data.
- Apply correction factors such as angular misclosure and linear misclosure to adjust the traverse measurements.

5. **Closed Traverse with Coordinates**

- Calculate the coordinates of each traverse point using trigonometric or geometric methods.
- Apply closure checks to verify the accuracy of the traverse, such as comparing the sum of interior angles with the expected value for a closed polygon.
- Adjust the coordinates if necessary to achieve closure and consistency within acceptable tolerances.

6.1 Trimble Total Station S5

The Trimble S5 Total Station is a high-precision instrument commonly used in surveying and construction applications.

6.1.1 Feature Mapping using Total station

A total station is a surveying instrument that combines various functionalities to measure angles and distances accurately, providing a comprehensive solution for land surveying and construction tasks.

We can measure following data using total station:
- Horizontal distance measurements
- Vertical distance measurements
- Elevation
- Vertical Angle
- Horizontal Angle
- Co-ordinate of point.

6.1.2 Steps for setting Instrument:

1) Set the instrument on the Tripod and power on.
2) Do the leveling of the instrument with the level bubble and also digital level available

on the provide total station for both Trunnion axis and vertical axis using the leveling screws, later on center the instrument with the help of telescope bubble on instrument.

3) Once the leveling and centering is done. Open the Trimble access software. Complete the electronic leveling and the angles in both the axis should be within 10 seconds.
4) In Trimble access go to: general survey > create a new job> set the coordinate system
5) 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.
6) Set the prism on the backsight point.
7) From main menu > measure > VX and S series > Station set up
8) Enter the point name, instrument height (2m in our case), check the coordinate details
9) Enter the backsight point details and the height., store the values; the station setup is completed.
10) In measure> measure topo > select target and its height (for prism = 1.5 m, target DR = 0m)
11) Now start taking readings by entering suitable codes for the features.

Figure 16: Person Holding reflector staff.

Figure 17: Surveyor using Trimble S5 Total Station.

6.1.3 Equipment's used for feature Mapping:

- Total Station (Trimble S5)
- Prism/ Retro Reflector
- Trimble Traversing Target
- Trimble Tripod
- Trimble Bipod
- Pegs
- Measuring Tape
- Generating Contour and map Feature using ArcGIS.

6.1.4 Contour Map: Digitization of point data to features

1. Digitizing point data in QGIS is a fundamental GIS task with diverse applications ranging from data visualization and analysis to field data collection and historical research. It is a powerful tool for understanding and exploring spatial relationships within a geographic context.

2. Add coordinate system to the map.

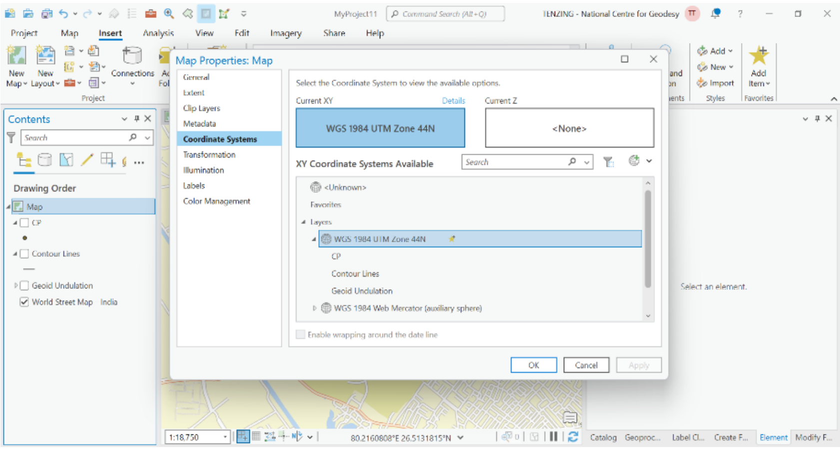


Figure 18: Adding the coordinate system

3. Add Delimited text file

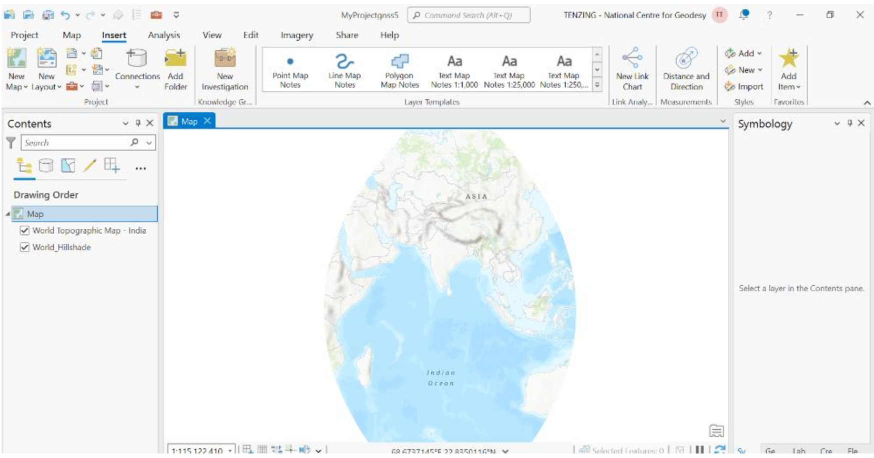


Figure 19: ArcGIS interface left side showing delimited text layer.

4. Add the.CSV file

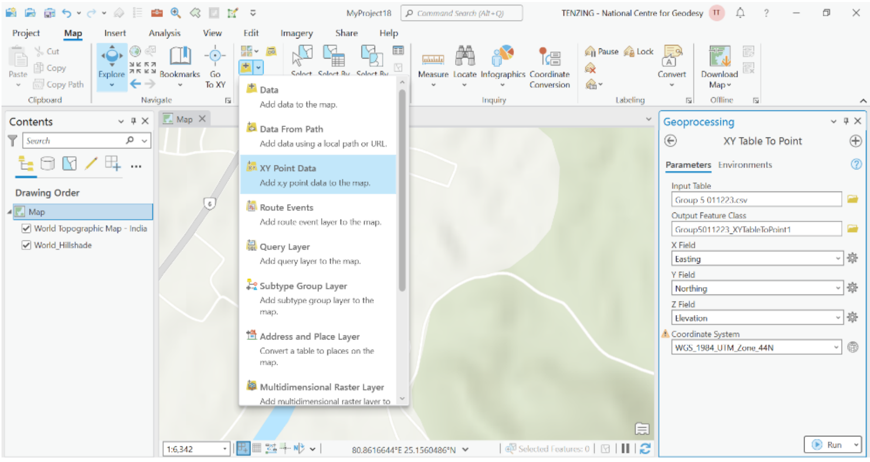


Figure 20:Adding XY point data

5. Check for correct geographical location

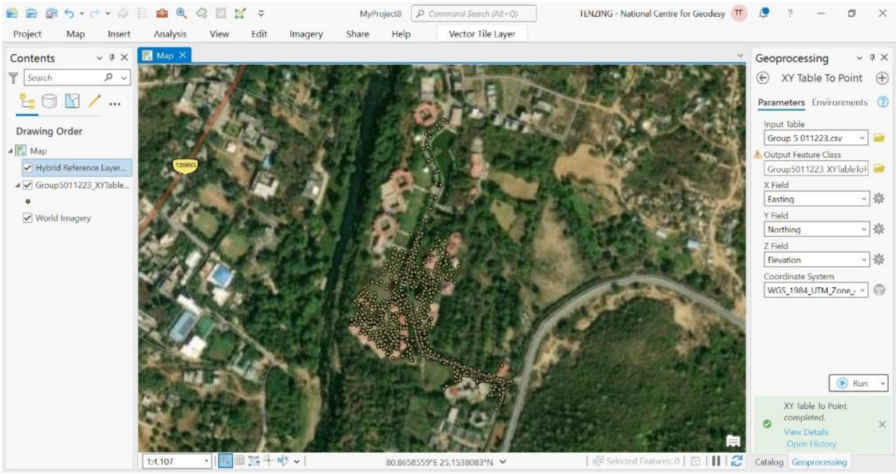


Figure 21: Adding Base Map satellite imagery

6. Interpolating topo. to raster to generate DEM:

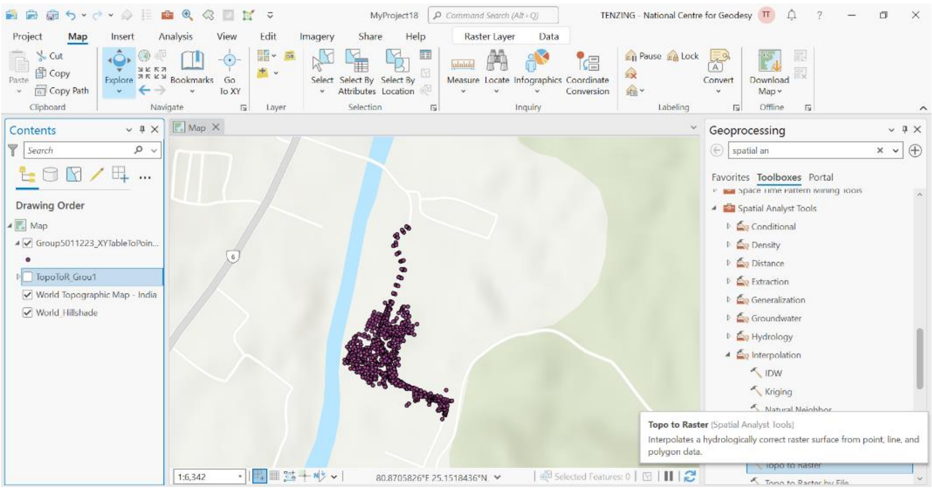


Figure 22:Topo to raster interpolation

7. Generate Contour Map

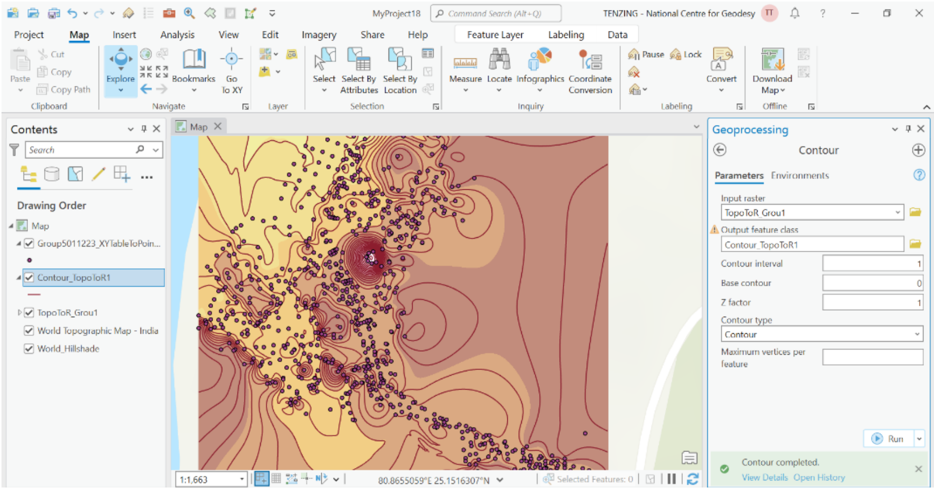


Figure 23:Contour Map generated at an interval of 1m

6.1.5 Feature Map

Creating various feature class like lines, polygons and point .shp files by Digitization. Digitization is the process of converting features into a digital format, it is one way to create data in GIS environment.

1. Once various points, lines, polygon .shp file. Start plotting the map.

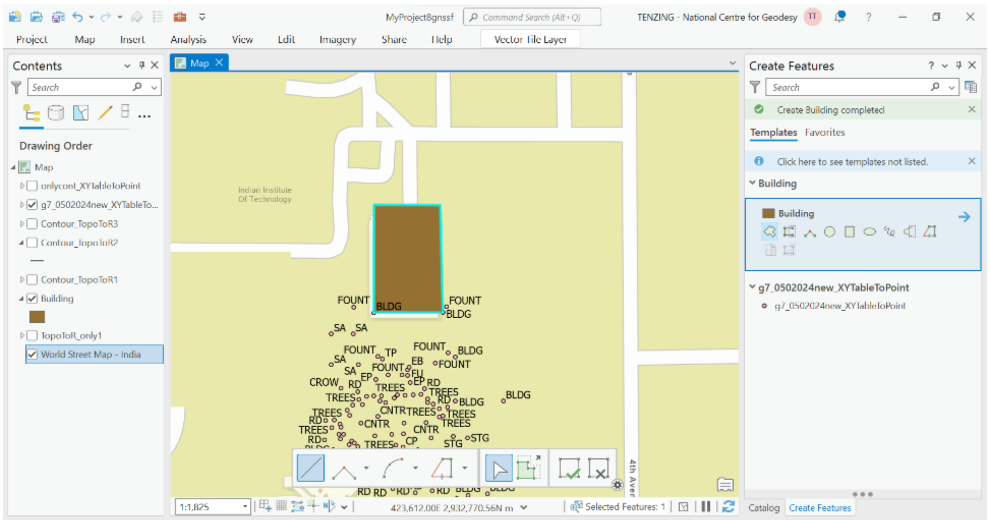


Figure 24:Mapping the area using the point data

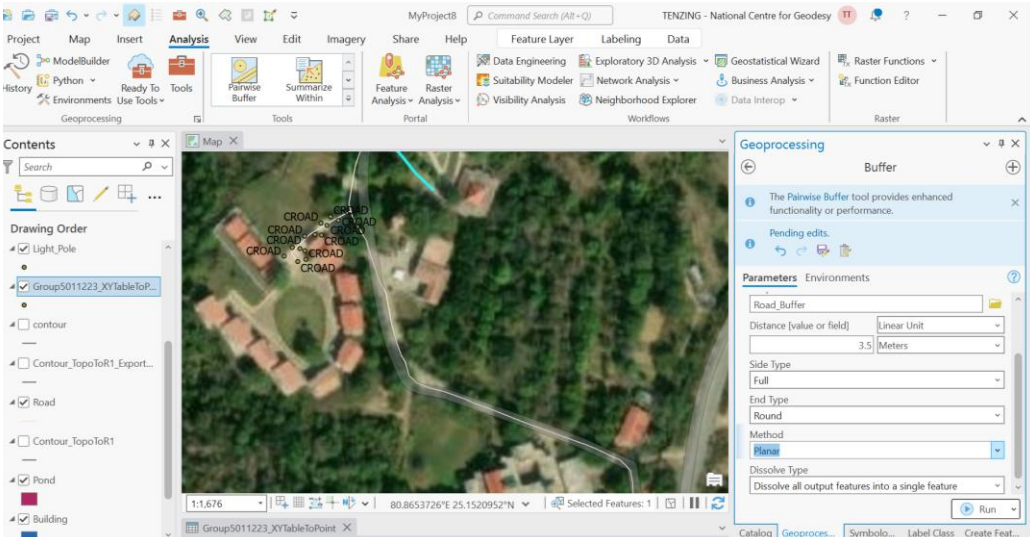


Figure 25:Creating Road as line feature.

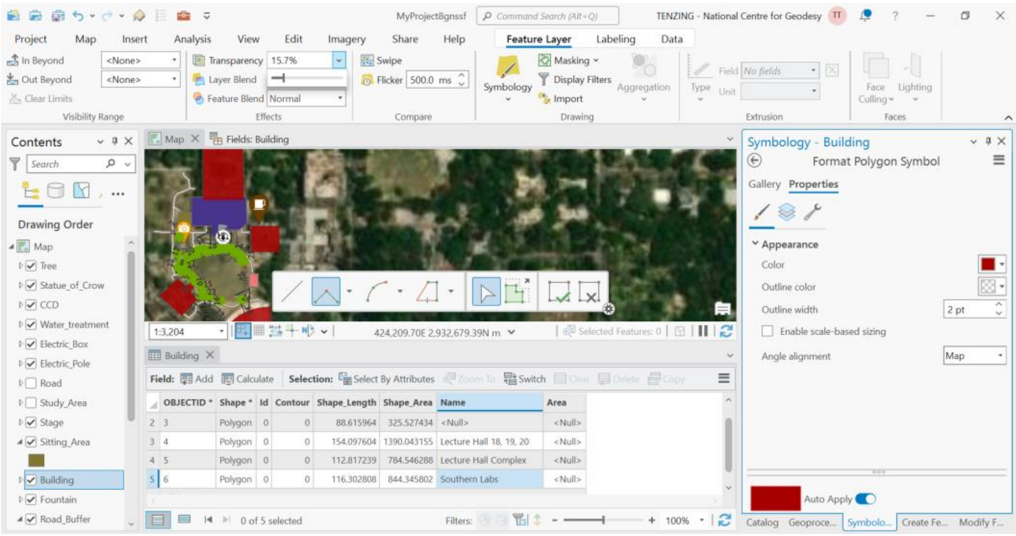


Figure 26:Add in various labels

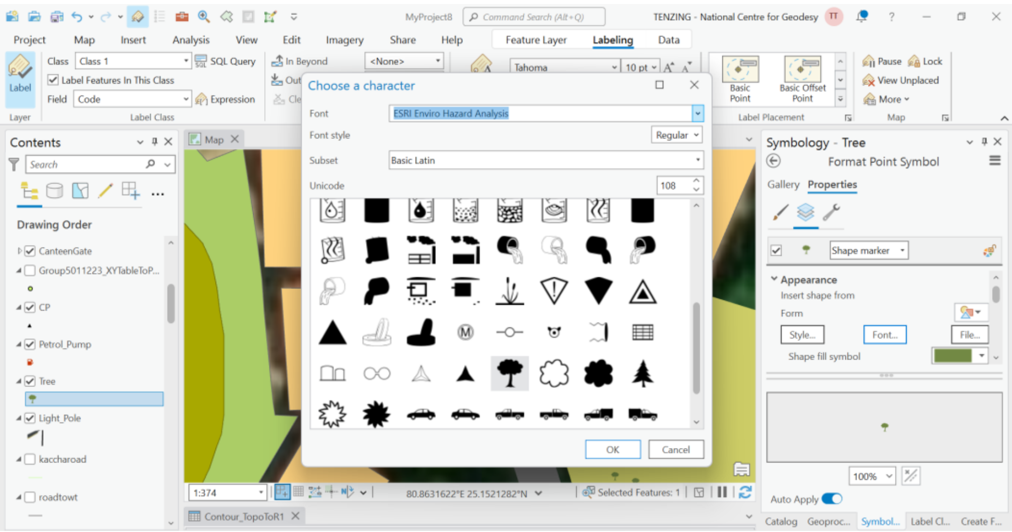


Figure 27: Usings symbology to modify the .shp files with different colours

6.1.6 Map Layout:

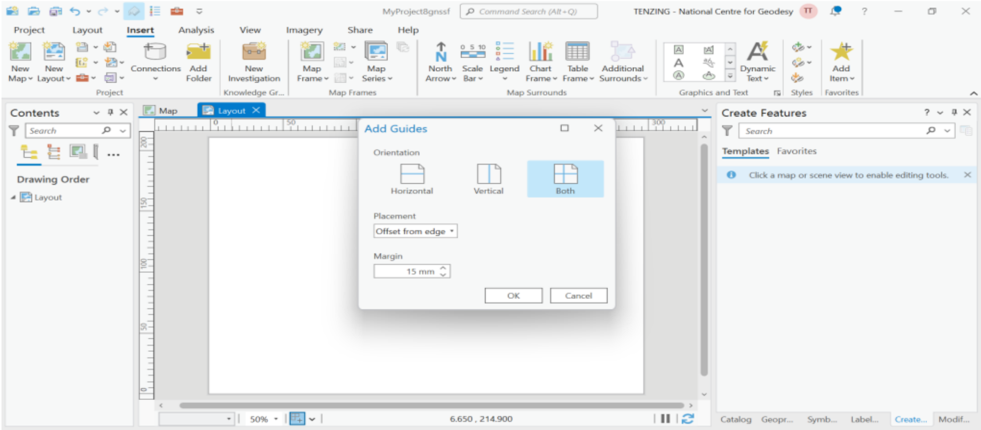


Figure 28:Add Grides

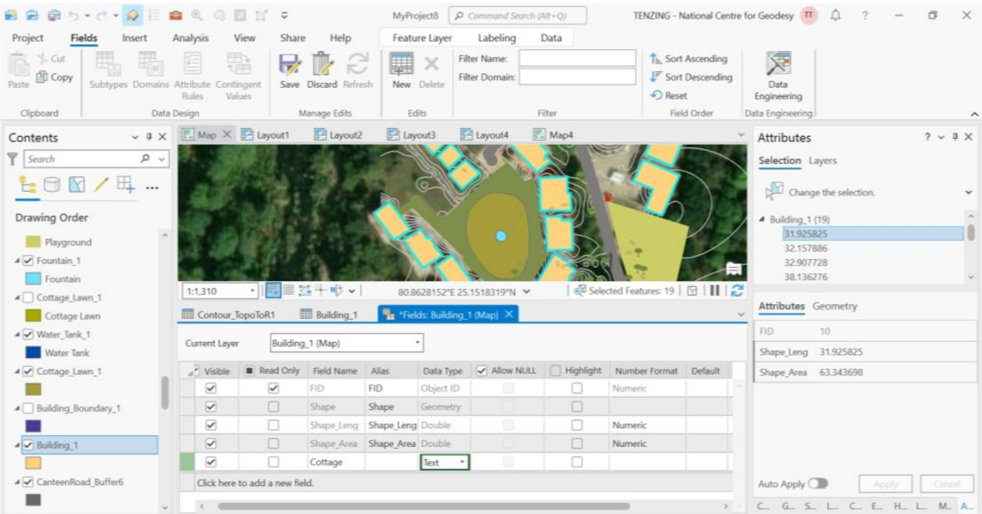


Figure 29:Adding building names by creating new field.

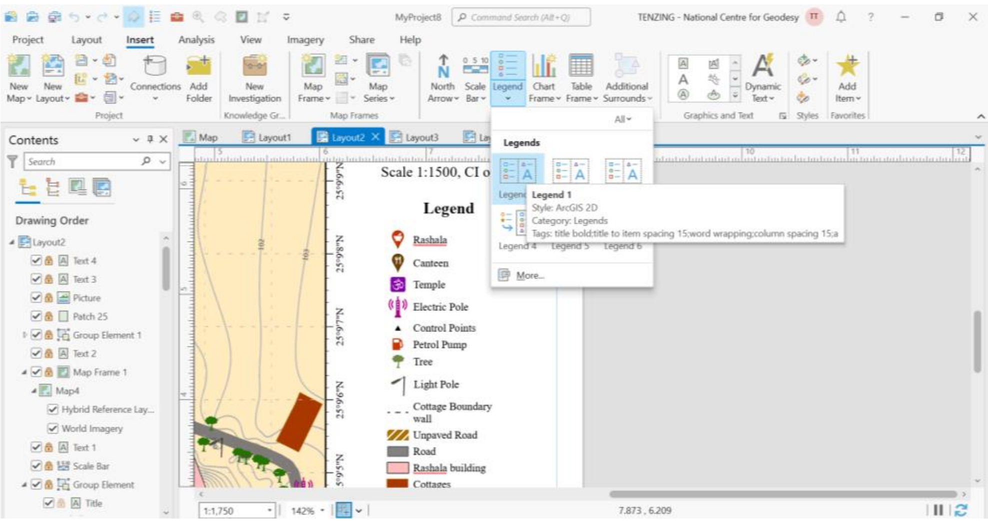


Figure 30:Adding the legends.

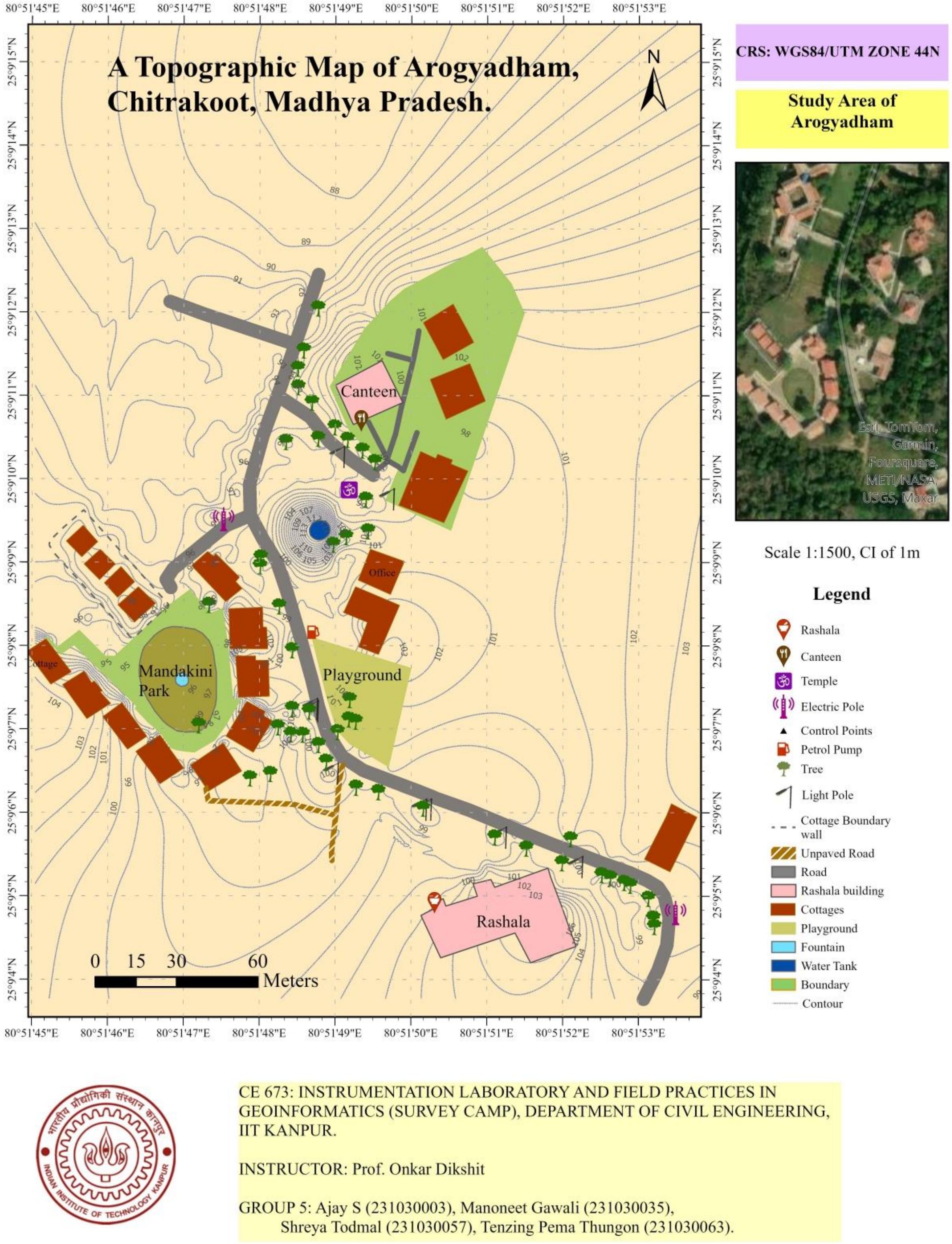


Figure 31: Topographic map generated using Arc-GIS Pro

7 Road Profile

- A road profile is a two-dimensional slice of the road surface, taken along an imaginary line.
- In the exercise, road profiling has been done for the main road connecting the main entrance of the place and the main office in Aarogyadham, Chitrakoot, Madhya Pradesh.
- For the road profiling, the Total Station is used.
- Initially different sections were marked on the road at 20 m interval from the control point were we set up the Total Station.
- 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 intervals into 4 sections of 0.9m width. The figure below shows the graphical representation of the division of each section of the road.

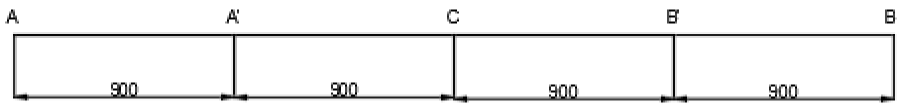


Figure 32: Division of Road Section.

- The total station is then used to take readings on the five points marked on all the sections of the road considered at 20 m interval from the control points by placing the reflector on the points taken on each section.
- The Total Station reading will give coordinates (Easting and Northing) and elevation of the points.
- The data thus collected is then used to plot the longitudinal and transverse section of the road.
- The longitudinal profile of the road is plotted by plotting the Elevation vs Distance (interval between the each section of the road) plot.
- The transverse section is plotted by plotting Elevation vs Distance from the edge of the road for each section.
- The road profile thus plotted is shown in the figure below:

.

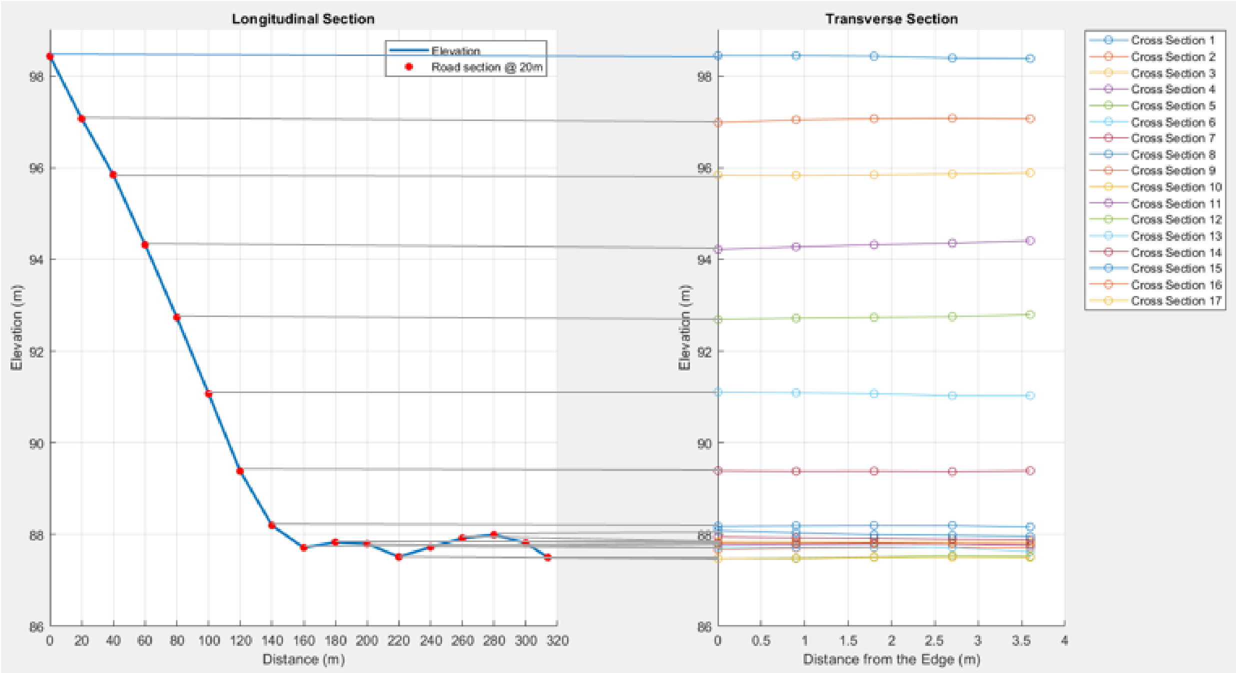


Figure 33: Side and Top view of road profile.

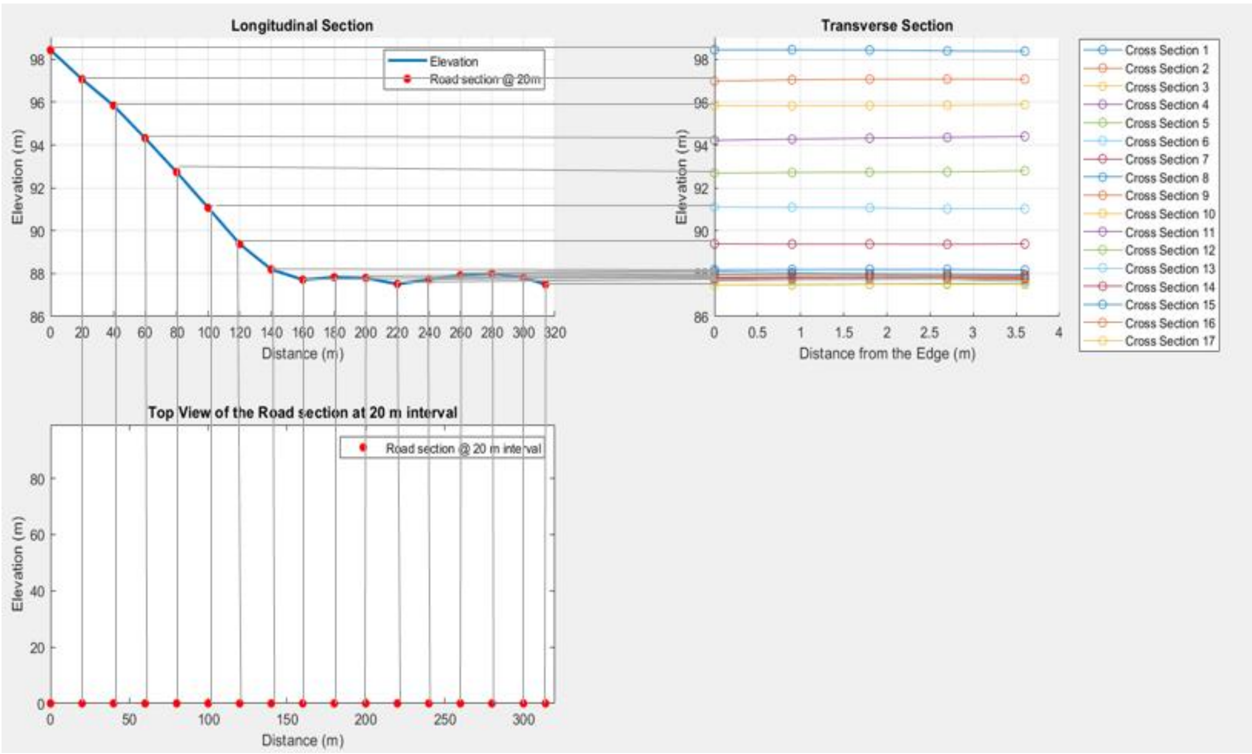


Figure 34: Longitudinal section, Traverse, and Top view of Road Profile.

8 Conclusion

The survey camp not only equipped us with practical skills in diverse surveying methodologies but also instilled a deeper understanding of their applications across various domains. The integration of modern technologies like GNSS, Juno surveying, and LiDAR showcased the evolution of surveying techniques towards precision, efficiency, and data richness, essential for contemporary geospatial projects.

The hands-on experiences, challenges faced, and successful outcomes achieved during the camp have significantly contributed to our knowledge and preparedness for future endeavors in the field of geospatial surveying and mapping.

9 Experience & Suggestion

- The survey camp was a valuable experience for Learning hands-on experience about the GNSS surveying in both Static and RTK mode, Leveling exercises provided understanding about height measurements and differential leveling techniques.
- Topography mapping taught you about capturing detailed surface features and creating comprehensive topographic maps.
- Juno surveying experiences likely emphasized efficient data collection and attribute recording.
- Road profiling activities enhanced your understanding of analysing elevation changes along road corridors using LiDAR and GPS technologies.
- More time should be engaged in camp for more practical experience.
- Before-head classes should be held regarding the technologies we will be using by instructor so that then we will be relating concepts taught previously.
- GNSS data post processing should be shown in survey camp.
- Transportation facility was not up-to the mark while returning from the camp, the bus was not in proper condition.
- This experience was a must have when someone is thinking to perceive career in surveying.
- The survey camp taught about Teamwork, professionalism, Management of time and punctuality, Trial and error made us to learn lot of many things which can't be learned from any other.
- I thank personally to instructor Dr.Onkar Dikshit for organising a wonderful learning experience and all the GI lab staff members for constantly being with us throughout the camp and answering all the queries faced, also I thank all the TA's which were with us, Also I thank my group members Shreya Todmal, Tensing Pema, Ajay S for their help and support and all my batchmates for making this camp Successful.

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Instrumentation Laboratory and Field Practices for Geo- informatics

CE – 673

Laboratory Report -1

Distance Measurement using Chain and Tape And Compass Surveying

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Course Instructor:

Dr. Onkar Dikshit

Civil Engineering Department
Geoinformatics
IIT kanpur

Objective

- To learn how to measure distance between two points using chain and Tape and compare these distances obtained.
- Enter details in field book for chain lines in the form of a suitable form(ABC). Plot details in the form of a map(feature such as tree, light pole,etc.) from the data recorded in the field book.
- To prepare a map using chain and compass survey

Equipment

7. Ranging rods.
8. Pegs
9. Ranging Pins
10. Tape
11. Chain
12. Cross staff
13. Optical square, etc
14. Prismatic Compass
15. Tripod
16. Ranging poles

Theory

By the various methods of determining distance the most accurate and common method is the method of measuring distance with a chain or tape is called chaining. For work of ordinary precision. a chain is used. But where great accuracy is required a steel tape is invariably used.

The term chaining was originally applied to measure Distance with a chain. The term chaining is used to denote measuring distance with either chain or tape, In the process of chaining, The survey party consists of a leader (the surveyor at the forward end of the chain) a follower (the surveyor at the rare end of the chain and an assistant to establish intermediate points) .The accuracy to which measurement can be made with chain and tape varies with the methods used and precautions exercised. The precision of chaining. For ordinary work, ranges from 1/1000 to 1/30,000 and precise measurement such as Baseline may be of the order of 1000000.

in diameter called links. The end of each link is bent into a loop and connected together by means of three oval rings which afford flexibility To the chain and make it less liable to become kinked. The ends of chain are provided with brass handles for dragging the chain on the ground, each with a swivel Joints so that the chain can be turned round without twisting. The length of the A link is the distance between the centres of the two consecutive middle rings. The end links include the handles metallic rings indicators of distinctive points of the Chain to facilitate quick reading of fractions of chain in surveying measurements.

The ranging rods are used for marking the positions of Stations conspicuously and for ranging the lines. Io order to make these visible at a distance, they are painted alternately black and white, or red and white or red, White and black successively. The adjustment of the chain should as far as possible be affected symmetrically on either side of the middle so as that the position of central tag remains unaltered. In measuring the length of survey line also called as chain line. It is necessary that the chain should be laid out on the ground in a straight line between the end stations.

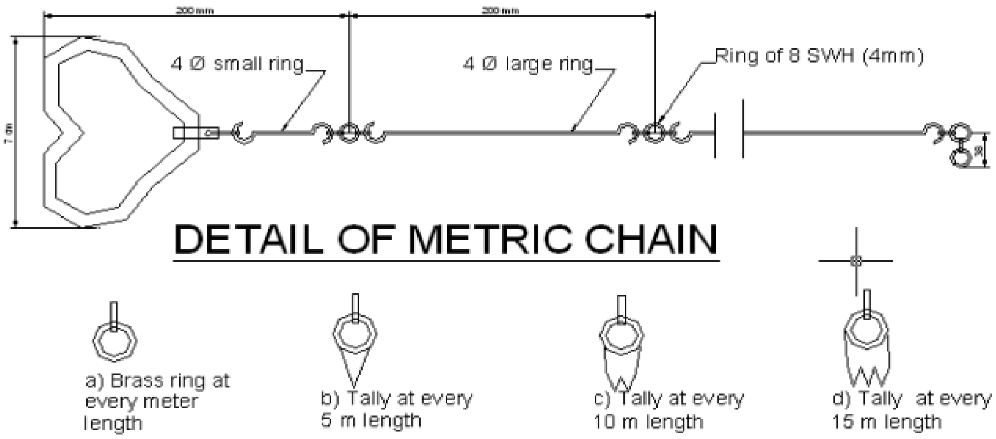

Figure 35: Details of Metric chain.

Important parts of compass are:

- A box with graduated circle
- A magnetic Needle
- A line of sight

When the line of sight is pointed to point, the magnetic needle of compass points towards north (Magnetic meridian). The angle which this line of sight makes with the magnetic meridian is read on graduated circle.it is known as magnetic bearing of the line.

Bearing of Lines: A bearing of a line is a horizontal angle made by the survey line with some reference direction or meridian. Meridian may be:

1) A true meridian - The true geographical meridian passing through a point is a line of intersection of earth's surface by a plane containing north south pole and given point. They are not parallel to each other at different places.

2) A magnetic meridian - the direction indicate by a free suspended and a properly balanced magnetic needle Free from all other attractive forces. The direction of magnetic meridian can be established with the help of Magnetic compass.

Measured clockwise from the north point of the reference meridian towards the line right round the circle. The angle thus measured between the reference meridian and the line is called Whole circle bearing of the line. Angles measured will have value between 0 to 360 degrees.

Conversion of WCB to RB:

Case	WCB between	R.B.	QUADRANT
1	0^0 TO90^0	WCB	N-E
2	90^0 TO -180^0	180-WCB	S-E
3	180^0 TO -270^0	WCB-180^0	S-W
4	270^0 TO 360^0	360-WCB	N-W

Reduced Bearing (RB) - In this system of bearing of a line is measured clockwise or anticlockwise from north or south direction whichever is nearer to the line towards east or west. The concept of reduced bearing facilitates computations in traverse surveying. The compass may be held in hand but for better results it should be fitted at the top of tripod having ball and socket arrangement.

Case	R.B in quadrant	Rule of W.C.B.	W.C.B between
1	N-E	WCB=R.B	0^0 TO90^0
2	S-E	WCB =180-R.B	90^0 TO -180^0
3	S-W	WCB =R.B+180	180^0 TO -270^0
4	N-W	WCB =360-R.B	270^0 TO 360^0

Procedure

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.

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.

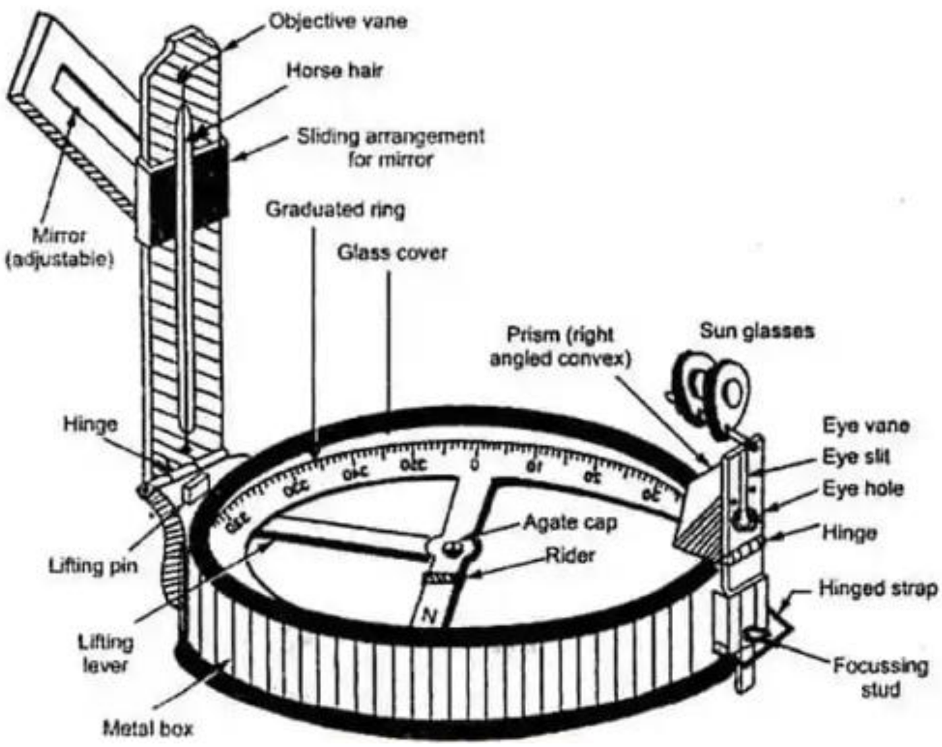

Figure 36: Prismatic Compass and its parts.

Graphical method correction using Bowditch's Rule

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 .

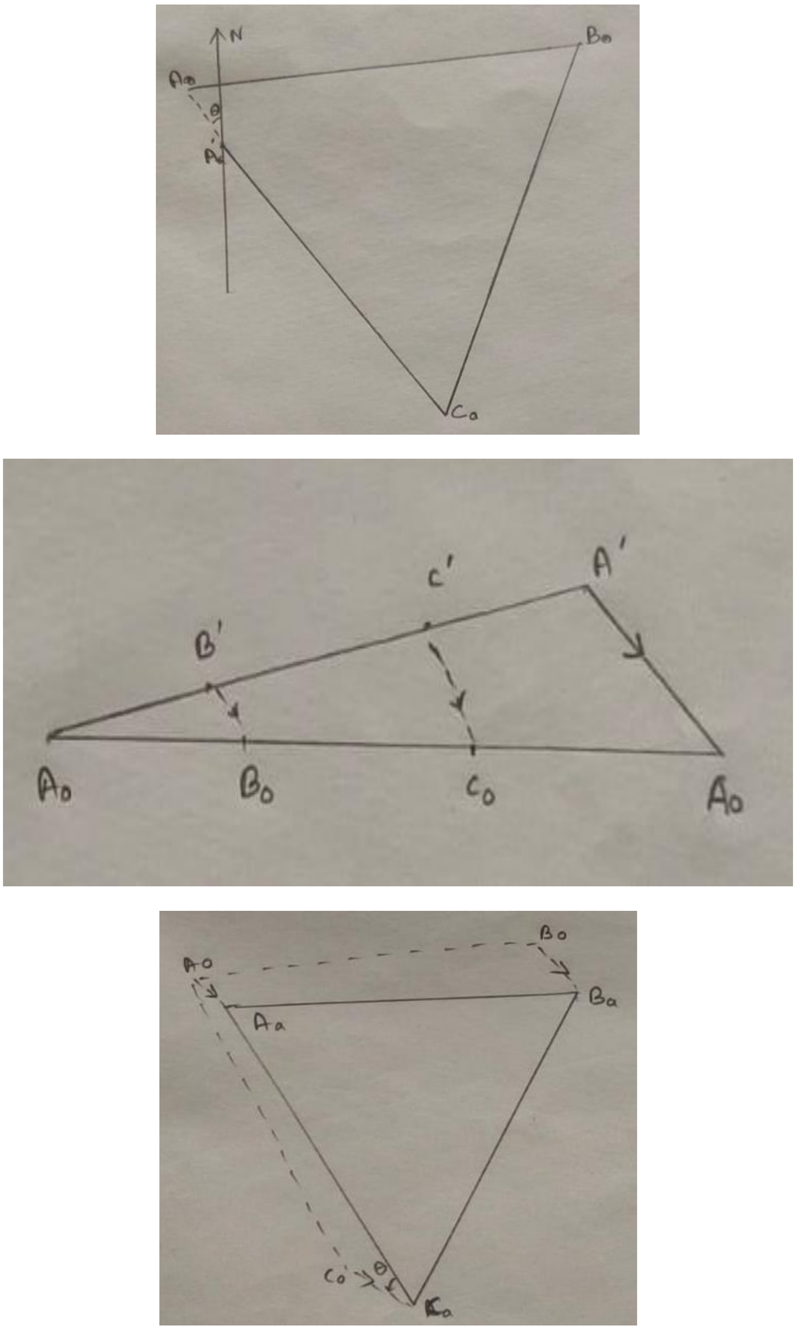

Figure 37: Graphical adjustement of traverse using Bowditch's Rule.

Observations

Chain Surveying map generated using AutoCAD.

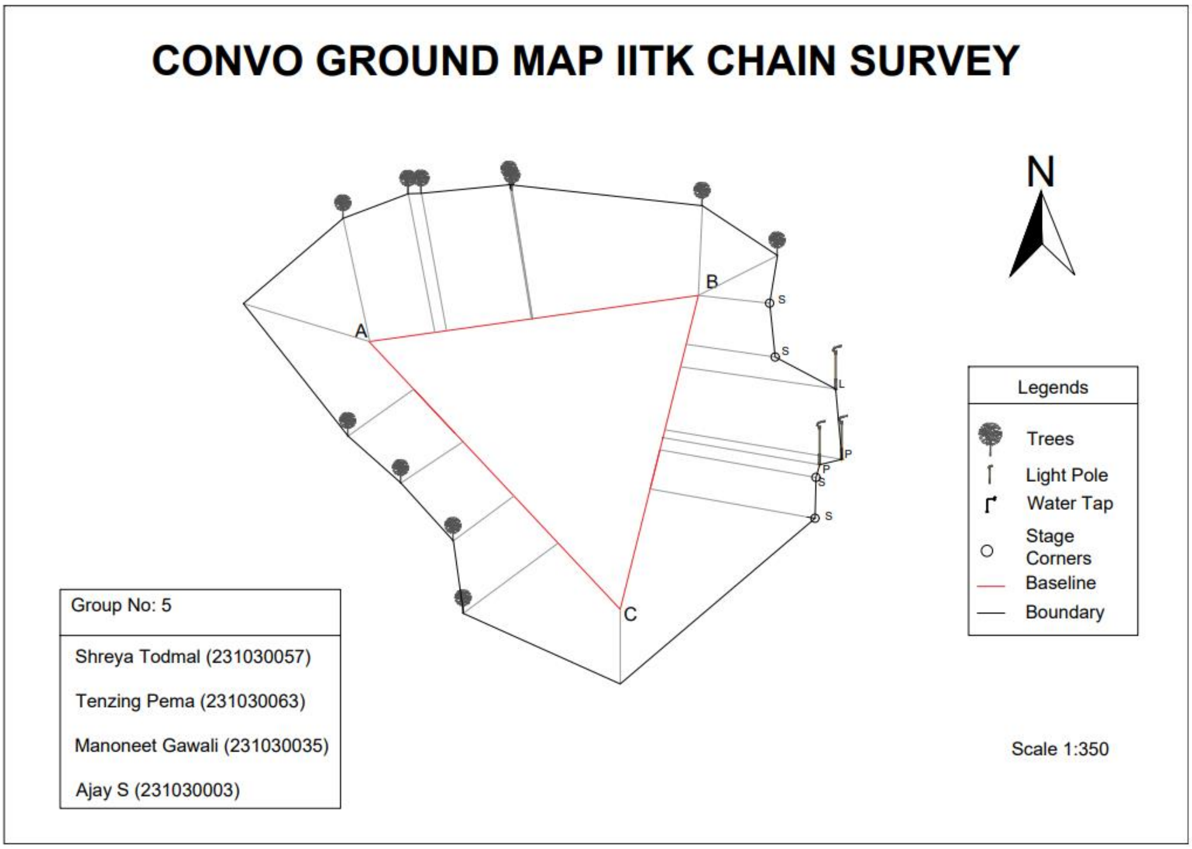

Figure 38: Feature mapping using chain surveying.

Compass Surveying

From	To	FB	BB	| FB-BB |
A	**B**	82°	263°	181°
B	**C**	194°	14°	180°
C	**A**	318°	137°	181°

References

[1] J. a. E. Mikhail, Surveying theory and Practise, Boston: McGraw WCB , 1998.

[2] D. O. Dikshit, *Lecture on Surveying and LEavelling for CE-673,* IIT Kanpur, 2024.

[3] C. D. G. a. P. R. Wolf, in *Elementary Surveying*, Prentice Hall, 2008 Edition 14th.

Field Book :

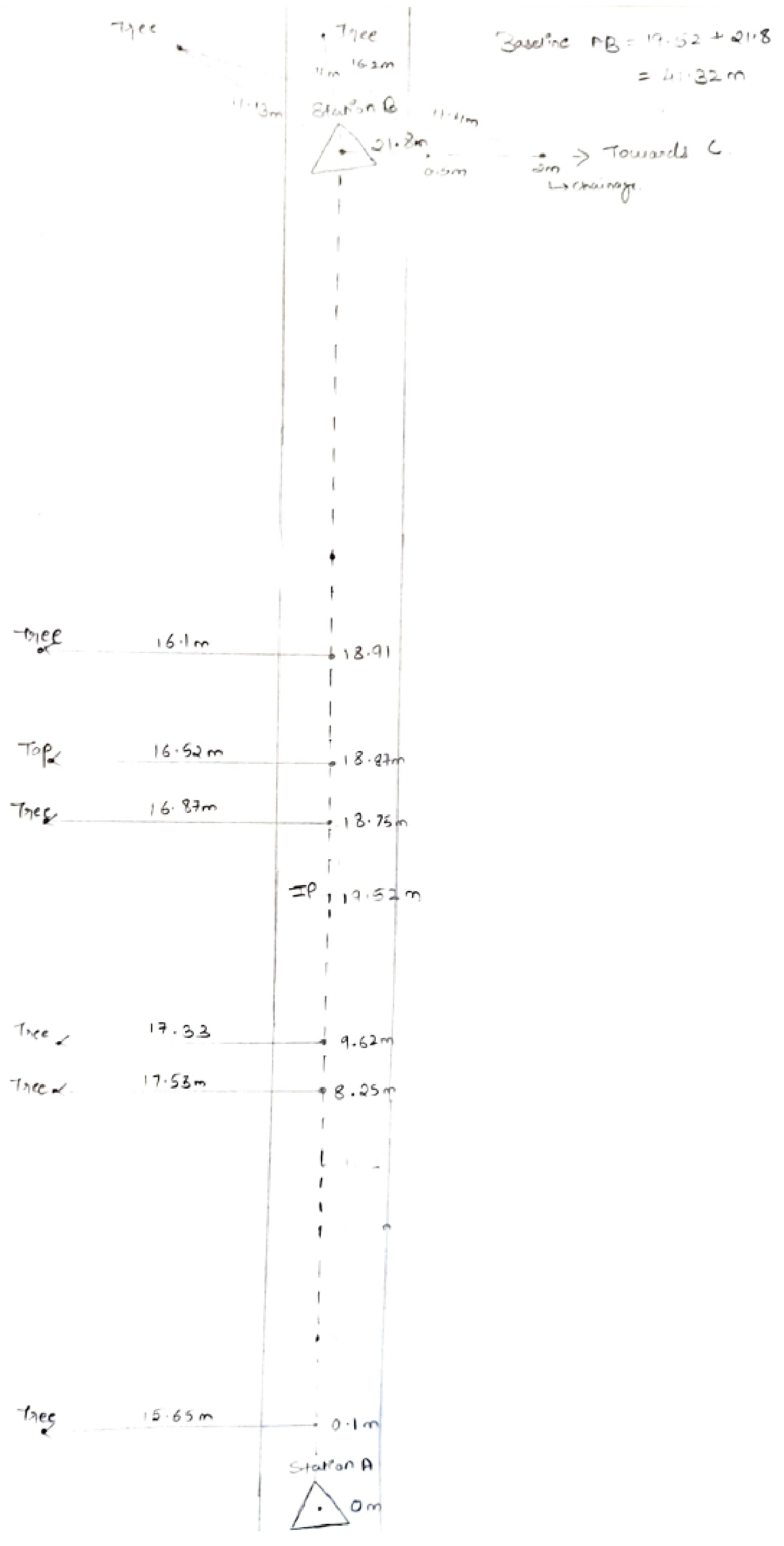

Figure 39:Field Book of feature mapping using chain and compass surveying

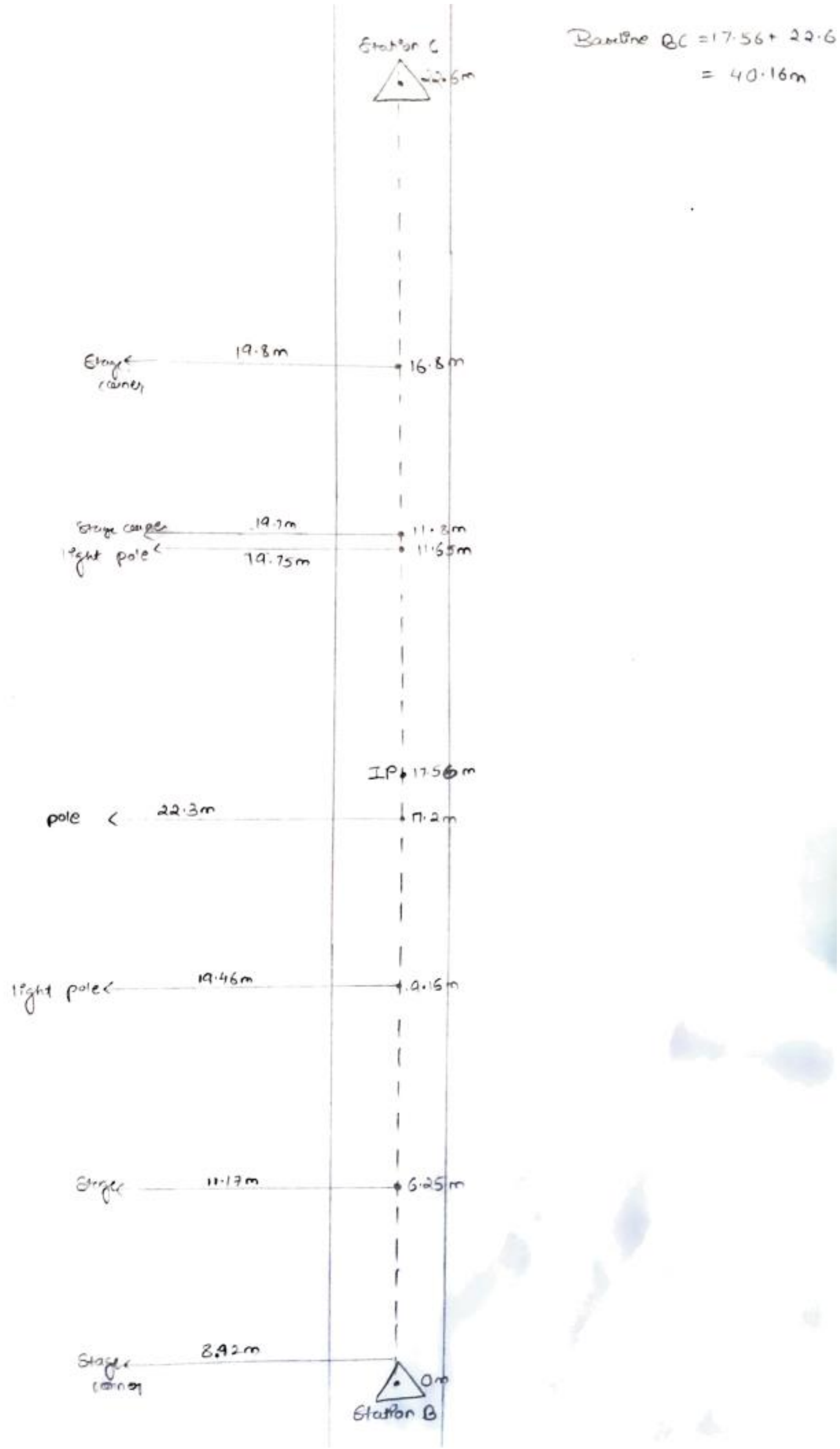

Figure 40: Field book station B of compass and chain survey

Figure 41: Field book for station C in chain and compass survey.

Instrumentation Laboratory and Field Practices for Geo- informatics

CE – 673

Laboratory Report -2

Calibration of EDMI

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Objective

To determine the cyclic error curve, reflector-instrument error and scale error for given EDMI

Equipment

1. EDMI
2. Tape
3. Reflector
4. Tripod
5. Staff

Procedure

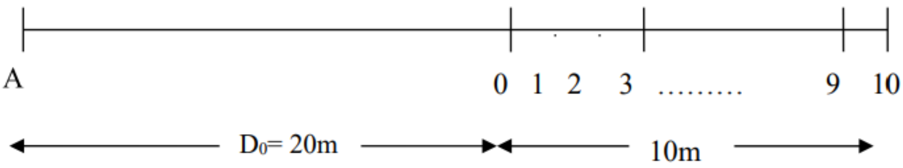
I. Setting up the instrument:

17. Mount the instrument over the tripod and approximately level the setup.
18. Carryout the levelling process as described below:
    a. Centre the circular bubble by using two levelling screws at a time. Both screws should be rotated either inwards or outwards at a time.
    b. Then keep the instrument approximately perpendicular to the previous position and use the other levelling screw to centre the bubble. Now the levelling operation is complete.
    c. Repeat operation (a) and (b), if required
19. Connect batteries to the instrument as instructed and press the POWER (PWR) switch on the instrument to start functioning.
20. Open Trimble Access and select General survey. Select Instruments and carry out finer levelling of the instrument with the help of electronic level appearing in computer display by using the principle of "three levelling screws".
21. Press Accept to initialize the instrument.
22. From the instrument menu select Survey Basic and enter some entries related to pressure, temperature, etc. as required. Enter appropriate values.
23. Sight the instrument approximately in North direction and enter the HA reference 0o 0' 0". Press ENTER.
24. Measure Instrument height with the help of measuring tape provided by Trimble and press F3. It will prompt to enter the instrument height (IH). Type the height, for example IH = 1.434 and press ENTER
25. Note the reflector height (SH) from graduations on it. Press F6; it will prompt for signal height (SH). Enter the signal height, for example SH = 1.50 and press ENTER.
26. Sight the target/reflector and by pressing Measure button, measure Horizontal distance (HD), Vertical distance (VD), Sloping distance (SD), Northing, Easting, etc. Ignore Northing, Easting for this experiment.

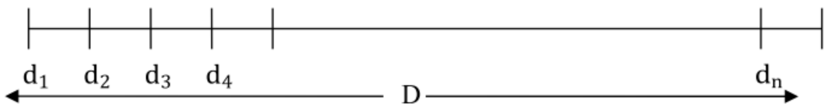
II. Principle of Error Determination

This will require accurate measurement of distances using tape on a flat ground and comparison of the same with EDMI measured distances. Using these, one can estimate various calibration errors/correction. The order of corrections is as follows: cyclic, reflector-instrument constant, scale.

1. Nonlinearity/Cyclic Error
   a. Assume the basic measuring unit as 10m (effective wavelength = λ/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.



2. Reflector-instrument constant
   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:
   $$K = \frac{D - \sum d_i}{n-1}$$



3. Scale error

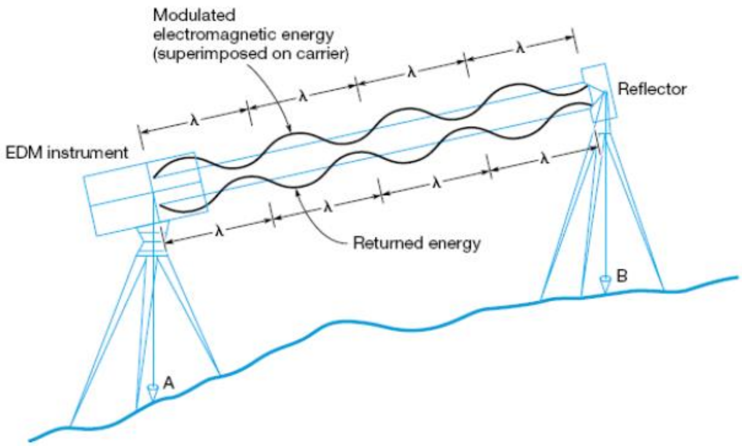
   If we know the length of a "calibrated line", scale error can be found out. If the known distance, Dk, is measured as Dm then the scale error can be calculated by the formula:

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

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

Theory

Principle of EDMI: A modulated EM beam from one transmitter at the master station sent to a reflector at the remote station and received back at the master station.



Instrument measures slope distance between transmitter and receiver by modulating the continuous carrier wave at different frequencies, and then measuring the phase difference at the master station between the outgoing and the incoming signals. Modulation is the process of superimposing one wave on the carrier so as to vary certain characteristics of carrier.

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

2D = Double distance

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

ϕ = measured phase difference

λ = modulation wavelength

K = constant

The Calibration results in:

- determination of instrument constants (IC) and associated precision
- baseline calibration (rigorous, mathematical) - errors computed simultaneously.
- field calibration (practical) - order of computations important
- An EDMI can be tested and calibrated for all errors one at time, or simultaneously using a baseline.
- 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)

Observations

1) Non-linearity/ cycle error

Station	Taped Distance d_i	EDMI distance Di	$D0 + \sum$ di	$ei = Di - (D0 + \sum di)$	$ci = -ei + \sum ei /10$
0	20	19.995	20	-0.005	0.0045
1	21	20.997	21	-0.003	0.0042
2	22	21.993	22	-0.007	0.0035
3	23	22.996	23	-0.004	0.0035
4	24	23.991	24	-0.009	0.0026
5	25	24.989	25	-0.011	0.0024
6	26	25.988	26	-0.012	0.0023
7	27	26.988	27	-0.012	0.0023
8	28	27.994	28	-0.006	0.0017
9	29	27.994	29	-1.006	-0.0983
10	30	29.993	30	-0.007	0.0016

2) Reflector-instrument constant:

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

Taped dist. d_i (m)	EDMI dist. D_i (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

Sum of Di = 10.108
D =10
n = 10

Reflector instrument constant,

$$K = -\ 0.012$$

3) Scale Error

D_k: known distance = 10 m
D_m: Measured distance = 10.108 m

$$Scale\ error(ppm) = \frac{Dk - Dm}{Dk} * 10^6 = -0.108$$

Taped dist. Di (m) or Initial	Corrected distance
20	19.77905
21	20.77023
22	21.75548
23	22.74764
24	23.7319
25	24.71912
26	25.70733
27	26.69653
28	27.69166
29	27.69166
30	29.66908

Conclusion

- Calibration verifies that the EDMI is providing accurate distance measurements. This is crucial in various applications such as land surveying, construction, and engineering, where precise measurements are required.
- Calibration helps detect and quantify any errors or inaccuracies in distance measurements. By comparing the EDMI's readings against known reference distances, calibration can identify and correct systematic errors or instrument drift.
- Regular calibration allows for monitoring the performance of the EDMI over time. It helps assess if the instrument is operating within acceptable limits and if adjustments or maintenance are needed to maintain accuracy.
- Calibration is part of quality assurance practices for instruments. It ensures that the EDMI meets performance standards and provides reliable data for decision-making and project planning.
- calibration of an Electronic Distance Measuring Instrument is crucial for verifying accuracy, meeting compliance requirements, detecting errors, monitoring performance, ensuring quality, and establishing traceability of measurements.
- Cyclic error, additive constant and scale error needs to be applied after calculating the measurements, so that the true and accurate values with no error will be generated and so is this lab was intended to fulfil this requirement of learning.

References

[1] J. a. E. Mikhail, Surveying theory and Practise, Boston: McGraw WCB , 1998.

[2] E. surveying, Engineering surveying, VI Edition, Oxford: Butterworth, 2007.

[3] A. J. a. P.J.Taetz, Elements of Plane Surveying, New York: McGrawHill, 1991.

[4] P. a. C.D.Ghilani, Elementary surveying, an introduction to Geomatics, Prentine Hall New Jersey: Weley, 2002.

[5] C. D. G. a. P. R. Wolf, in *Elementary Surveying*, Prentice Hall, 2008 Edition 14th.

Instrumentation Laboratory and Field Practices for Geo- informatics

CE – 673

Laboratory Report - 3

Traverse Adjustment by Total Station

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Objective

To establish a close traverse using Total Station and compare the results of adjustment using the Bowditch's rule and Least squares adjustment.

Introduction

1. Traversing is a form of a Control Survey that requires the estamblishment of series of stations that are linked together by angles and distances.
2. Angles and Distances are measured.
3. Use of traversing surveys is very fundamental and have become important method in geodesy.

Equipment

1. Total station
2. Leveling staff
3. Pegs
4. Tape
5. Compass

Procedure

1. 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.
2. Perform "Initial Settings" for the total station as given in the Instrument Manual
3. Carry out temporary adjustments for the equipment (i.e. centring and leveling, etc.).
4. Find out the length of each side using tape/tacheometry/EDMI
5. 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" or initial reading. You may use a sample Table
6. After taking readings at a station, move to the next station. DO NOT MOVE THE INSTRUMENT. Use the same instrument set up by the previous group. Repeat angle measurements.
7. Adjust closing error using Bowditch's rule. You may use sample Table 2
8. Keep these observations (angular) with you in an Excel file. Also, apply least squares adjustment
9. You may take the coordinates of one of the points as (10000, 10000) and the bearing of one line measured from the compass.

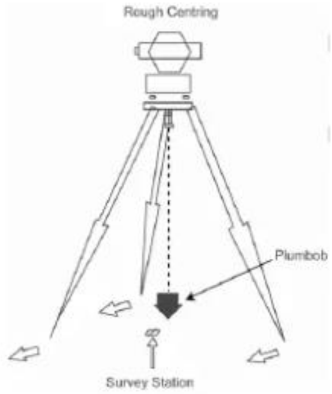
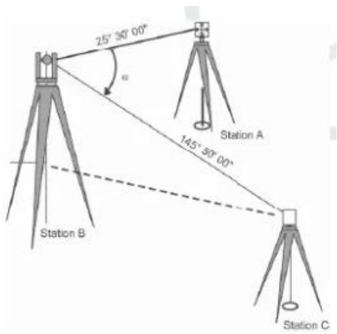


Figure 42: Setting up total station for Traversing.

Steps for Setting Up total station:

1. Roughly level instrument using legs of tripod- total station should stay almost on target.
2. Level with screws. Move instrument above target; repeat level and move until done.
3. Turn bubble parallel to two screws A and B to bring the horizontal bubble to tec enter.
4. Turn instrument through 90 degrees and bring the bubble to the centre by adjusting third screw of plate bubble.
5. If bubble is in center then it is adjusted.
6. If not, repeat the whole process.
7. Tie plum bob and the bob should be at perfectly at centre of peg.
8. Setup the station on station; Instrument has two faces; Face left and Face right.



9. Starting from face left, the telescope is pointed at station A. The horizontal reading is then noted.
10. The instrument is then turned in a clockwise direction to point C. again the horizontal reading is noted.
11. The horizontal angle can be calculated, by finding the differences between the two horizontal reading
12. The station is then turned the face of total station. While pointing at station C the horizontal reading is again recorded.
13. Turn the instrument in a clockwise manner and point at station A. Record the Horizontal reading.

14. Note that changing the face will change the reading by 180. This gives a check on observations and ensure that reading errors can be eliminated. If there is a great difference in two readings, the observations are then repeated until readings agree.
15. Compass Survey Bearing using Surveyor's compass we took a reading for single vertices of the plot. This is done because our network should be oriented to the North direction.

Figure 43 : Prismatic Compass for Orientation of Network.

Observations

A reconnaissance survey is an initial, broad assessment of an area to gather preliminary information before conducting detailed surveying or other activities. It involves quickly scanning the area to identify key features, terrain characteristics, potential challenges, and suitable locations for establishing control points or conducting further surveys. Reconnaissance surveys help in planning and decision-making by providing an overview of the area's conditions and requirements.

It is the first and most important step in the surveying process. In the first instance, surveying requires management and decision-making in determining the appropriate methods and instrumentation required to complete the task satisfactorily with the required accuracy and within the available time constraints. This initial process can only be executed correctly after a meticulous and comprehensive reconnaissance of the area to be surveyed. Its purpose is to decide the best location for the control points through which we can take control of the entire area that is to be mapped working from whole to part.

We consider following factors while establishing control point:

- Point should be Open to Sky
- It should cover maximum area possible.
- Stable hard surface should be considered.
- Minimum number of Control points
- Other control points should be visible from the another.

Sl No.	Station Observed	Face (L/R)	Horizontal Angle				Succesive difference	Adjusted angle
			Reading (Degrees)	Mean of interior angle	Multiples of average corrections	Correction rounded		
	A		0					
	D	L	144.1572					
	A'		0.0025					
1	Error		-0.0025	144.086235	0.012	0.0125	0.0125	144 5' 55''
	A		180					
	D	R	324.01527					
	A'		179.9991					
	Error		0.0009					
	B		0					
	A	L	94.17805					
	B'		0.0011					
2	Error		-0.0011	94.177625	0.249	0.025	0.0125	94 11' 24''
	B		180					
	A	R	274.1772					
	B'		180.01694					
	Error		-0.01694					
	C		0					
	B	L	72.47777					
	C'		0.0025					
3	Error		-0.0025	72.479995	0.0374	0.0375	0.0125	72 29' 33''
	C		180					
	B	R	252.48222					
	C'		180.00111					
	Error		0.00111					
	C		0					
	D	L	49.16694					
	C'		0.003888					
4	Error		0.003888	49.206385	0.0499	0.05	0.0125	49 13' 8''
	C		180					
	D	R	229.24583					
	C'		180.03888					
	Error		0.03888					
							0.05	360 0' 0''

Total Interior Angle = 359.95024°

Error = 0.0496°

Error Distribution = 0.01244°

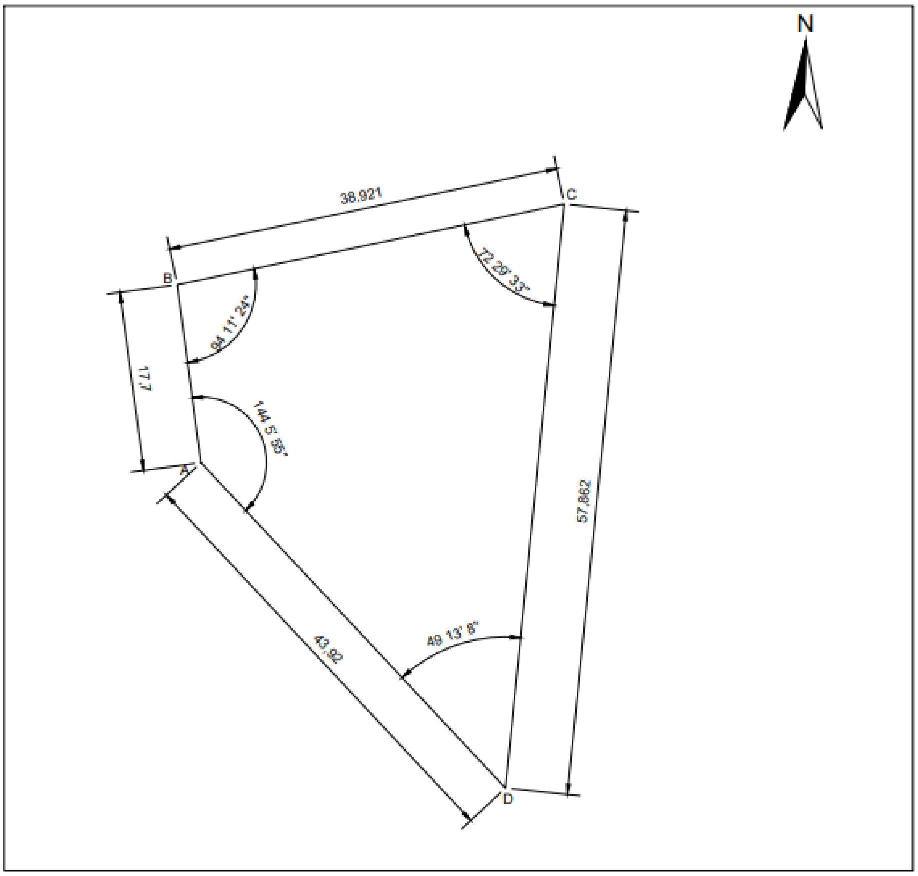


Figure 44: Traverse Adjustment loop generated using AutoCAD

Conclusion

The lab gives the insights about the concepts of Traverse network adjustment. Traverse adjustment is a fundamental concept in surveying used to improve the accuracy of measured traverses or networks of connected survey lines. It involves adjusting the measured angles and distances within the traverse to minimize errors and satisfy closure requirements. There are different methods for traverse adjustment, including the Compass Rule, Transit Rule, Bowditch Rule, and Crandall's Rule. Each method has its advantages and limitations, and the choice of method depends on factors such as the type of traverse, accuracy requirements, and available software/tools.

References

[1] C. D. G. a. P. R. Wolf, in *Elementary Surveying*, Prentice Hall, 2008 Edition 14th.

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[3] A. J. a. P.J.Taetz, Elements of Plane Surveying, New York: McGrawHill, 1991.