CE332A Survey Camp (UGP-1) Project Report

AAROGYADHAM, CHITRAKOOT
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INTRODUCTION

This project report is based on the Geoinformatics Survey Camp (CE332A), which took place at Arogyadham, Chitrakoot, from 27 November to 6 December 2022. It was an extraordinary and beautiful experience for me to take part in the survey camp. I am extremely grateful for the guidance and affection of Professor Onkar Dixit, Sheetla sir, Hari Babu sir, and Vipul sir, as well as the other supporting staff and mentors Rohit & Prashant. For the vast amount of practical knowledge and skills I gained at the survey camp, I will always be indebted to them.

Aarogyadham is a scenic and tranquil campus situated in the hilly terrains of Chitrakoot, and it houses a variety of ayurvedic facilities, including a Medicine Laboratory, Gaushala, and Hospitals. Additionally, 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.

At the survey camp, we mapped the area around the DRI Canteen, the Gaushala, and the Cottages at the Aarogyadham in Chitrakoot. To create a comprehensive topographic map of the entire allotted area utilizing ArcGIS software, our team established 12 control points, measured internal angles for the closed traverse with the Total Station, determined elevation for the control points, utilised GNSS to determine global coordinates of the control points, and mapped the area's features. Using Juno, we created a line map and an area map while walking over 16 kilometers around Kamadgiri Hill. In addition, we did road profiling of the main road on the Arogyadham Campus. Using a GIS software, all of the data was processed and a map was created. This report attempts to summarise our activities during the survey camp and presents the results in a coherent manner.

At the heart of it Surveying is collection of data or information. The major principles of Surveying are:

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

For the mapping exercise following things are performed:

1. Reconnaissance Survey (Recy Survey)
2. Establishment of Control Network
3. ETS Traversing
4. Levelling using Auto Level
5. Measuring Global Coordinates of the Control Points using GNSS
6. Taking offsets (features) using Total Station and storing information in computer
7. Processing all the data collected to make a topographic map of the area

OBJECTIVE

The Objective of the survey camp was following:

1. Get hands on experience of Total Station survey and get familiarity with the surveying instruments like Total Station, GNSS, AutoLevel, etc.
2. To make a topographic map of the area of Aarogyadham.
3. To make use of a GIS Software like ArcGIS, QGIS, etc to process the data and fabricate a map.
4. 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.
5. To understand how to do reconnaissance of an area to setup control points and take various features (geospatial data) in that area with minimum no. of control points and maximum area covered.
6. To do road profiling of the 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.

RECONNAISSANCE SURVEY (RECY SURVEY)

A detailed study of the area before conducting land survey.

Reconnaissance 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.

Control point marking:

- Open to sky (if later ECEF coordinates are also required on the same points).
- Maximum area is covering.
- Stable surface is required.
- Minimum number of control points.
- Intervisibility between the two consecutive control points.

If reconnaissance reveals that any of the preliminary station placements identified are inadequate, their positions should be modified. The purpose of reconnaissance is to eliminate those control points which are impractical or unfeasible and to identify the more promising control points and maintain the inter visibility.

Methodology for Reconnaissance:

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 two- or 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.

No. of Control Networks Identified = 3

No. of Control Points in the Best Control Network = 12

A diagram of the final traverse network as well as other 2 discarded control network have been shown in Figure 1 to 3.

Control Network 1 was disregarded because of two independent loops.

Control Network 2 and Control Network 3 have same no. of control points but the latter covers more area and hence it was given priority over the other.

Figure 1: 1st Control Network of the points

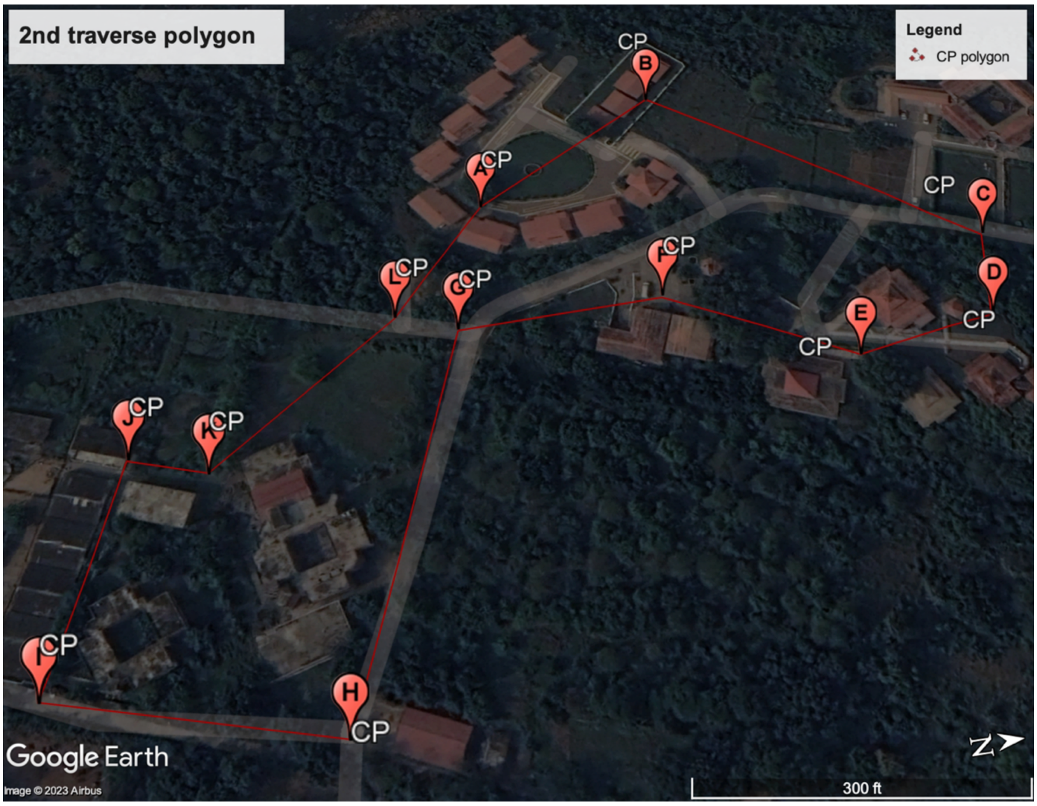


Figure 2: 2nd Control Network of the Points

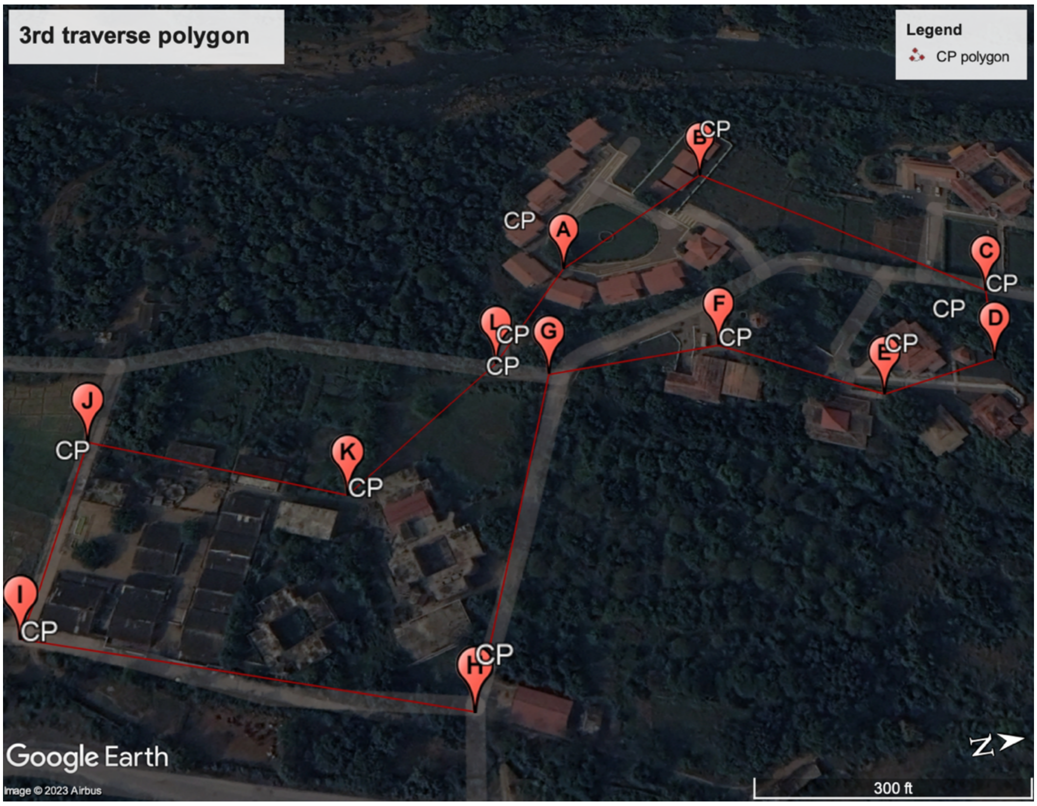


Figure 3: 3rd Control Network of the Points which was the final control network we chose for our survey of the area from whole to part

TOPOGRAPHIC MAPPING

Electronic Total Station (ETS) Traversing

Traversing

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
- GPS Satellites

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

Figure 4 illustrates the method of traversing to locate the control points A to L.

The field data comprises all the angles as shown plus the horizontal distances AB, BC, CD, DE, … KL, and LA.

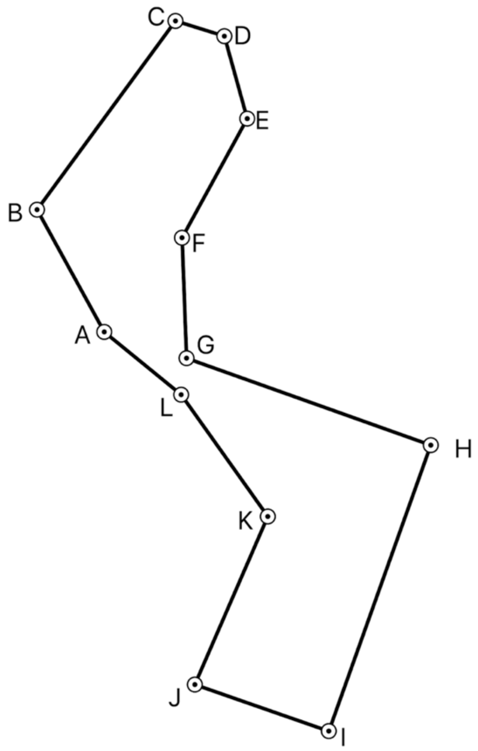


Figure 4: Traverse Network A to L

In traversing to gain overall project efficiency and improve angle accuracy, it is always preferable to have long sight distances. Also, to avoid mistakes it is advisable to avoid having nearly “flat” angles (values near 180°) whenever possible. To accomplish this, presurvey reconnaissance is recommended.

There are two types of traverses:

1. Open Traverse: When the lines form a circuit ends elsewhere except starting point, it is said to be an open traverse.
2. Closed Traverse: When the lines form a circuit which ends at the starting point, it is known as a closed traverse.

Closed traverse is always better than Open Traverse because it has the provision to apply checks in it using the sum of interior / exterior angles in a polygon property.

Steps to make a traverse:

- Reconnaissance
- Electronic total station (ETS) setup
- Traverse making
- Traverse adjustment
- Closed traverse with coordinates

<u>Total Station (Trimble S5 Total Station)</u>

A total station is an electronic / optical instrument used in modern surveying to measure horizontal and zenith (or altitude) angles, as well as distances, and transmit the results in real time to a built-in computer. The horizontal and zenith (or altitude) angle and slope distance can be displayed, and then upon keyboard commands, horizontal and vertical distance components can be instantaneously computed from these data and displayed.

If the instrument is oriented in direction, and the coordinates of the occupied station are input to the system, the coordinates of any point sighted can be immediately obtained. These data can all be stored within the instrument, or in a data collector, thereby eliminating manual recording. Data collected from total station can be downloaded into computer/laptops for further processing of information. It is a vital instrument used for surveying without which surveying can't be imagined. The survey that is carried out with Total Station is called Total Station Survey.

Total stations are mainly used by land surveyors and civil engineers, either to record features as in topographic surveying or to set out features (such as roads, houses or boundaries). They are also used by archaeologists to record excavations and by police, crime scene investigators, private accident reconstructionist and insurance companies to take measurements of scenes.

Figure 5: A man using Trimble S5 Total Station

Principle of Total Station

Distances are observed electronically by determining the number of full and partial waves of transmitted electromagnetic energy that are required in traveling the distance between the two ends of a line. In other words, this process involves determining the number of wavelengths in an unknown distance. Then, knowing the precise length of the wave, the distance can be determined.

The procedure of measuring a distance electronically is depicted in Figure 6.

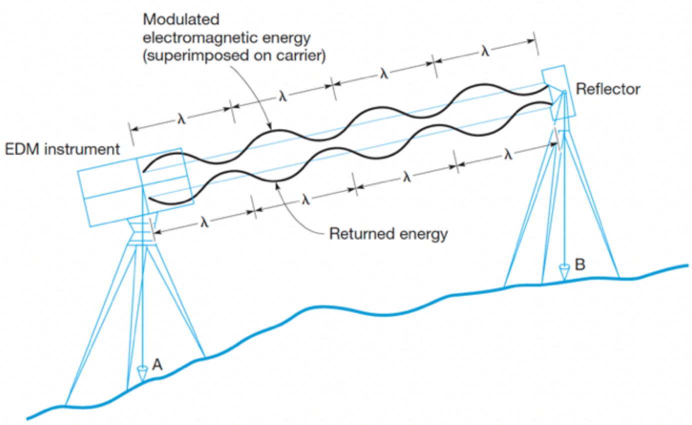


Figure 6: Generalized EDM Procedure (Image from Charles D. Ghilani)

Prism (Retroreflector)

Survey prisms are retro-reflectors or, more precisely, corner reflectors that are used to reflect the signal from Electronic Distance Measurement devices like Total Stations. In surveying, prism assemblies are often referred to as "targets."

Prisms reflect the infrared beam emitted by a Total Station back to its source, allowing precise distance and angle calculations. In surveying applications, a prism is designed to reduce the scatter of an EDM signal, allowing for more accurate and long-range electronic measurements.

Trimble Traversing Target, Tiltable

It is used with a rod & a bipod. A prism (retro-reflector) is fitted in it to serve as a target for total station survey.

Figure 7: A man holding target

Trimble Tripod

A surveyor's tripod is a device used to support surveying instrument, such as theodolites, total stations, auto-levels, etc.

Figure 8: A Tripod (with Total Station)

Trimble Bipod

A Bipod is a portable two-legged frame, used as a platform for supporting the weight and maintaining the stability some surveying object, such as GNSS, Reflector, etc. It provides stability against downward forces and horizontal forces and movements about horizontal axes.

Figure 9: A Bipod (with Prism)

Peg

Pegs are driven in the ground with the help of a hammer and kept about 4 cm projection above the ground. They are used to locate the control points at places where marking point via paint doesn't work like ground, field, farm, etc.

Measuring Tape

Tapes are used in surveying for measuring instrument height. It is also used for measuring horizontal, vertical or slope distances and other distances.

Methodology for Traversing:

1. Setup Total Station on a control point by centering and levelling. (say A).
2. Make a reference plane by placing a target at backside control point (say L).
3. Measure Internal angle and length.
4. After the measurements move total station and place it to the next control point (say B).
5. Repeat the same procedure up to the last control point i.e. A to L.
6. In case of lengths take two readings and average them out. The value then obtained will be more precise and reliable.
7. Apply the check: $Sum\ of\ External\ Angles\ of\ a\ Polygon\ =\ (n+2)*180.$
8. If the results differ, make adjustments.
9. $\xi =\ required\ sum -\ total\ observed\ angles\ of\ traverse$
   Where, ξ is correction to be applied in the internal angles
10. Divide the ξ by the number of sides and distribute the same value to each of the external angles.
11. The external angles of the polygon are adjusted.
12. Now, the lengths are not adjusted, there may be case of overshoot or undershoot.
13. The length of each arm of the polygon should be adjusted.
14. Calculate Whole Circle Bearing (WCB) at each control point.
15. Calculate Latitude and Departure of each control point i.e.
$$Latitude\ \ \Delta E = dSin\varphi$$
$$Departure\ \ \Delta N = dCos\varphi$$
16. Apply correction to the latitude and departure using Bowditch Rule.
$$\Delta E_{correction} = \frac{total\ correction\ (\sum \Delta E)}{perimeter\ of\ the\ traverse} \times segment\ length$$
$$\Delta N_{correction} = \frac{total\ correction\ (\sum \Delta N)}{perimeter\ of\ the\ traverse} \times segment\ length$$
17. After getting corrected latitude and longitude, find the local coordinates of the control points.
18. Assume initial coordinate at first point and adding the same in other control point's coordinates find the local coordinates of all the control points.

Observation Table (observed angles and distances):

Table 1: Observation Table for Traversing

	length			external angle			
station	1st	2nd	average length	degree	minute	sec	angle in degree
A							
	72.769	72.769	72.769	245	1	23	245.0230556
B							
	122.141	122.141	122.141	251	6	32	251.1088889
C							
	26.669	26.665	26.667	237	6	9	237.1025
D							
	44.63	44.631	44.6305	224	14	19	224.2386111
E							
	70.891	70.89	70.8905	149	8	43	149.1452778
F							
	62.899	62.899	62.899	111	46	41	111.7780556
G							

	135.218	135.217	135.2175	270	0	6	270.0016667
H							
	158.421	-	158.421	269	32	53	269.5480556
I							
	73.93	73.935	73.9325	275	31	0	275.5166667
J							
	94.394	94.384	94.389	119	54	47	119.9130556
K							
	80.384	80.384	80.384	164	38	15	164.6375
L							
	51.81	51.81	51.81	201	59	17	201.9880556
A							

Arithmetic Check:

- Sum of external angles = $(n + 2) * 180$
- Sum of internal angles = $(n - 2) * 180$
- Sum of latitudes = 0
- Sum of departures = 0

Closing Error:

- Closing Error in distances = $0.01105\ m\ or\ 11.05\ mm$
- Closing Error in angles = 5″

Quality of the survey work:

Quality of the traversed network

Quality	Permissible limit of closing error
First order	$6''\sqrt{N}$
Second order	$15''\sqrt{N}$
Third order	$30''\sqrt{N}$

N is the number of sides in the traverse.

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

e/p is reported in 1: X format.

- Distances = 1:89960.2
  Permissible Limit = 1:25000 => **1st Order**
- Angles = 5″
  Permissible Limit = $6\sqrt{12} = 20.78''$ => **1st Order**

Result Table (including adjustments and coordinates of control points referring to a local datum):

Table 2: Result Table for Traversing

	length			external angle				corrected angle	WCB	latitude (ΔE)	departure (ΔN)	corrected latitude	corrected departure	northing in topocentric coordinate	easting in topocentric coordinate
station	1st	2nd	average length	degree	minute	sec	angle in degree			dSinΦ	dCosΦ				
A														-72.76857704	-0.00046226
	72.769	72.769	72.769	245	1	23	245.0230556	245.0229398	180	-72.769	0	-72.76844117	-0.000584837		
B														-124.3423315	-110.7194414
	122.141	122.141	122.141	251	6	32	251.1088889	251.1087731	245.0229398	-51.57469249	-110.7179975	-51.57375451	-110.7189792		
C														-105.1169585	-129.1999641
	26.669	26.665	26.667	237	6	9	237.1025	237.1023843	316.131713	19.22516821	-18.48030834	19.225373	-18.48052266		
D														-61.67137528	-118.9830528
	44.63	44.631	44.6305	224	14	19	224.2386111	224.2384954	13.23409722	43.44524053	10.21726996	43.44558327	10.21691127		
E														-23.55279757	-59.21340816

	70.891	70.89	70.8905	149	8	43	149.1452778	149.145162	57.47259259	38.1180333	59.77021439	38.1185777	59.76964465		
F														32.68036286	-31.03288825
	62.899	62.899	62.899	111	46	41	111.7780556	111.7779398	26.61775463	56.2326774	28.18102542	56.23316043	28.18051991		
G														133.7900431	-120.8160158
	135.218	135.217	135.2175	270	0	6	270.0016667	270.0015509	318.3956944	101.1086418	-89.78204083	101.1096802	-89.78312756		
H														238.9768097	-2.355424641
	158.421	_	158.421	269	32	53	269.5480556	269.5479398	48.39724537	105.18555	118.4618644	105.1867666	118.4605912		
I														184.0821761	47.16702057
	73.93	73.935	73.9325	275	31	0	275.5166667	275.5165509	137.9451852	-54.8952013	49.52303939	-54.89463353	49.52244521		
J														127.8875137	-28.67147115
	94.394	94.384	94.389	119	54	47	119.9130556	119.9129398	233.4617361	-56.19538732	-75.83773312	-56.19466246	-75.83849171		
K														48.04094598	-19.39771684
	80.384	80.384	80.384	164	38	15	164.6375	164.6373843	173.3746759	-79.84718501	9.274400345	-79.8465677	9.273754308		
L														-0.000135854	0.000122556
	51.81	51.81	51.81	201	59	17	201.9880556	201.9879398	158.0120602	-48.04147971	19.39825579	-48.04108183	19.3978394		
A															
Total			994.151	2515	295	305	2520.001389	2520	1908.065694	-0.007634589	0.007989864	1.91988E-08	-2.00922E-08		

Quality of survey work:

closing error (angles)	5
closing error (distances)	0.011051012
X = p/e	89960.17726
Quality = e/p = 1:X	1:X = 1: 89960.2
1st order	

Auto Level / Levelling

Levelling

Levelling is the general term applied to any of the various processes by which elevations of points or differences in elevation are determined. It's an essential process for developing the information required for cartography, engineering, and construction.

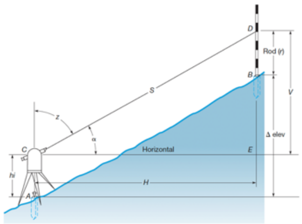
Steps to make a levelling network:

- Control point marking
- Auto level/Digital level setup
- Level network
- Network adjustment

There are two methods used for Levelling:

1. Rise and Fall Method
   The arithmetic check applied for this method is
   $$\sum B.S. - \sum F.S. = \ Last\ R.L. - First\ R.L$$
   $$\sum Rise\ - \sum Fall\ =\ First\ R.L. - Last\ R.L.$$
2. Height of the instrument Method
   The arithmetic check applied for this method is
   $$\sum B.S. - \sum F.S. = \ Last\ R.L. - First\ R.L$$

Trigonometric Levelling: The difference in elevation between two points can be determined by measuring (1) the inclined or horizontal distance between them and (2) the zenith angle or the altitude angle to one point from the other. The difference in elevation ($\Delta elev$) between points A and B in Figure 10 is given by



$$\Delta elev = h_i + V - r$$

Figure 10: Trigonometric Levelling

Auto Level (Nikon AC-2S)

Automatic Levels (Auto Levels) incorporate a self-leveling feature. Most of these instruments have a three-screw leveling head, which is used to quickly centre a bull's-eye bubble. After the bull's-eye bubble is centered manually, an automatic compensator takes over, levels the line of sight, and keeps it level.

Figure 10: A man using Auto Level

Level Staff (Double-faced leveling rod with metric graduations)

A Grade Rod or leveling rod, is a graduated rod used to determine differences in elevation. Rod graduations are accurately painted, alternate black and white spaces. When the high rod is required, it must be fully extended; else, a grave error will result from its reading. Graduations on the front faces of the two sections read continuously from zero at the base to 13 ft at the top for the high-rod setting.

Figure 11: A man holding Levelling Staff

Trimble's Tripod

A sturdy tripod in good condition is used to mount auto-levels and is essential to obtain accurate results.

Measuring Tape

Tape for measuring height of the instrument.

Methodology adopted for Levelling Survey:

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 upto last control point, i.e. A to L.
9. Apply arithmetic checks after completing the levelling network.
$$\sum B.S. - \sum F.S. = Last\ R.L. - First\ R.L$$
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.

Observation table (observed stadia and reduced level (RL) values of the control points):

Table 3.1: Observation Table for Levelling Loop 1

Back Sight			Fore Sight			HI	Comment
LS	MS	US	LS	MS	US		
0.402	0.48	0.557				100.48	BM
0.424	0.508	0.591	3.258	3.367	3.478	97.621	
2.387	2.458	2.528	1.8	1.879	1.958	98.2	
1.673	1.723	1.774	1.673	1.723	1.774	98.2	B
1.939	2.094	2.249	2.387	2.457	2.527	97.837	
1.562	1.682	1.802	1.79	1.96	2.13	97.559	A
0.445	0.51	0.578	0.329	0.475	0.621	97.594	L
1.667	1.8	1.932	2.522	2.61	2.699	96.784	
2.899	3.044	3.191	0.05	0.229	0.409	99.599	K
3.326	3.41	3.492	1.612	1.741	1.871	101.268	
1.549	1.742	1.929	0.56	0.699	0.838	102.311	J
0.922	1.11	1.292	0.519	0.7	0.822	102.721	I
0.812	0.968	1.122	1.868	2.061	2.259	101.628	
0.535	0.758	0.98	1.039	1.3	1.562	101.086	H
1.142	1.281	1.42	1.972	2.189	2.405	100.178	
2.086	2.215	2.345	1.101	1.201	1.302	101.192	G
			1.069	1.184	1.299	100.008	BM

Table 3.2: Observation Table for Levelling Loop 2

Back Sight			Fore Sight			HI	Comment
LS	MS	US	LS	MS	US		
0.481	0.544	0.606				100.544	BM

1.5	1.672	1.845	1.505	1.6	1.649	100.616	**F**
1.29	1.394	1.499	1.34	1.52	1.7	100.49	**E**
2.549	2.651	2.755	2.587	2.705	2.823	100.436	**D**
1.291	1.47	1.651	1.194	1.311	1.429	100.595	
1.534	1.592	1.649	1.488	1.656	1.823	100.531	**Near F**
				0.536	0.608	99.995	**BM**

Table 3.3: Observation Table for Levelling Loop 3

Back Sight			Fore Sight			HI	Comment
LS	MS	US	LS	MS	US		
0.228	0.293	0.359				100.293	BM
0.481	0.56	0.639	1.728	1.802	1.877	99.051	
-0.023	0.089	0.201	2.684	2.767	2.85	96.373	
-0.065	0.008	0.081	3.04	3.157	3.271	93.224	
2.97	3.064	3.158	2.97	3.064	3.158	93.224	C
2.578	2.66	2.743	0.003	0.107	0.182	95.777	
2.983	3.133	3.283	-0.024	0.043	0.11	98.867	
1.657	1.698	1.739	0.113	0.23	0.348	100.335	
			0.27	0.334	0.397	100.001	BM

Closing Error

Loop misclosure $= Closing\ RL\ of\ BM - RL\ of\ BM = Last\ RL - 100$

- Closing Error in Loop 1 $= 100.008 - 100 = +0.008$
- Closing Error in Loop 2 $= 99.995 - 100 = -0.005$
- Closing Error in Loop 3 $= 100.001 - 100 = +0.001$

Arithmetic Check

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

Quality of the survey work

METHOD 1: Using No. of Auto-Level Setups

Permissible Error in Levelling is given by $E = c\sqrt{n}$, where n = no. of setups of auto-level

- For Loop 1: $E = 5\sqrt{16} = 20\ mm$
  Misclosure error = 8 mm -> OK
- For Loop 2: $E = 5\sqrt{6} = 12.25\ mm$
  Misclosure error = 5 mm -> OK
- For Loop 3: $E = 5\sqrt{8} = 14.14\ mm$
  Misclosure error = 1 mm -> OK

METHOD 2: Using distance traversed in levelling operation

Error in mm is related to distance traversed in levelling operation $E = C\sqrt{K}$

Where E is error in mm, K distance in km C is constant as below:

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)

- For Loop 1: $E = 12\sqrt{0.8417} = 11.09\ mm$
  Misclosure error = 8 mm -> Accurate Work
- For Loop 2: $E = 12\sqrt{0.3278} = 6.87\ mm$
  Misclosure error = 5 mm -> Accurate Work
- For Loop 3: $E = 4\sqrt{0.2803} = 2.12\ mm$
  Misclosure error = 1 mm -> Precise Levelling Work

Adjusted Results

Table 4.1: Observation Table for Levelling Loop 1

Back Sight			Fore Sight							Comment	Distance	Cumulative Distance	Correct RL
LS	MS	US	LS	MS	US	HI	RL	D1	D2				
0.402	0.48	0.557				100.48	100			BM			
0.424	0.508	0.591	3.258	3.367	3.478	97.621	97.113	15.5	22		37.5	37.5	97.11264
2.387	2.458	2.528	1.8	1.879	1.958	98.2	95.742	16.7	15.8		32.5	70	95.74133
1.673	1.723	1.774	1.673	1.723	1.774	98.2	96.477	14.1	10.1	B	24.2	94.2	96.4761
1.939	2.094	2.249	2.387	2.457	2.527	97.837	95.743	10.1	14		24.1	118.3	95.74188
1.562	1.682	1.802	1.79	1.96	2.13	97.559	95.877	31	34	A	65	183.3	95.87526
0.445	0.51	0.578	0.329	0.475	0.621	97.594	97.084	24	29.2	L	53.2	236.5	97.08175
1.667	1.8	1.932	2.522	2.61	2.699	96.784	94.984	13.3	17.7		31	267.5	94.98146
2.899	3.044	3.191	0.05	0.229	0.409	99.599	96.555	26.5	35.9	K	62.4	329.9	96.55186
3.326	3.41	3.492	1.612	1.741	1.871	101.268	97.858	29.2	25.9		55.1	385	97.85434
1.549	1.742	1.929	0.56	0.699	0.838	102.311	100.569	16.6	27.8	J	44.4	429.4	100.5649
0.922	1.11	1.292	0.519	0.7	0.822	102.721	101.611	38	30.3	I	68.3	497.7	101.6063
0.812	0.968	1.122	1.868	2.061	2.259	101.628	100.66	37	39.1		76.1	573.8	100.6545
0.535	0.758	0.98	1.039	1.3	1.562	101.086	100.328	31	52.3	H	83.3	657.1	100.3218
1.142	1.281	1.42	1.972	2.189	2.405	100.178	98.897	44.5	43.3		87.8	744.9	98.88992
2.086	2.215	2.345	1.101	1.201	1.302	101.192	98.977	27.8	20.1	G	47.9	792.8	98.96946
			1.069	1.184	1.299	100.008	100.008	25.9	23	BM	48.9	841.7	100

Error in Loop 1 = + 0.008

Table 4.2: Observation Table for Levelling Loop 2

Back Sight			Fore Sight							Comment	Distance	Cumulative Distance	Correct RL
LS	MS	US	LS	MS	US	HI	RL	D1	D2				
0.481	0.544	0.606				100.544	100			BM			
1.5	1.672	1.845	1.505	1.6	1.649	100.616	98.944	12.5	14.4	F	26.9	26.9	98.94441

1.29	1.394	1.499	1.34	1.52	1.7	100.49	99.096	34.5	36	E	70.5	97.4	99.09749
2.549	2.651	2.755	2.587	2.705	2.823	100.436	97.785	20.9	23.6	D	44.5	141.9	97.78716
1.291	1.47	1.651	1.194	1.311	1.429	100.595	99.125	20.6	23.5		44.1	186	99.12784
1.534	1.592	1.649	1.488	1.656	1.823	100.531	98.939	36	33.5	Near F	69.5	255.5	98.9429
				0.536	0.608	99.995	99.995	11.5	60.8	BM	72.3	327.8	100

Error in Loop 2 = - 0.005

Table 4.3: Observation Table for Levelling Loop 3

Back Sight			Fore Sight							Comment	Distance	Cumulative Distance	Correct RL
LS	MS	US	LS	MS	US	HI	RL	D1	D2				
0.228	0.293	0.359				100.293	100			BM			
0.481	0.56	0.639	1.728	1.802	1.877	99.051	98.491	13.1	14.9		28	28	98.49090011
-0.023	0.089	0.201	2.684	2.767	2.85	96.373	96.284	15.8	16.6		32.4	60.4	96.28378452
-0.065	0.008	0.081	3.04	3.157	3.271	93.224	93.216	22.4	23.1		45.5	105.9	93.21562219
2.97	3.064	3.158	2.97	3.064	3.158	93.224	90.16	14.6	18.8	C	33.4	139.3	90.15950303
2.578	2.66	2.743	0.003	0.107	0.182	95.777	93.117	18.8	17.9		36.7	176	93.1163721
2.983	3.133	3.283	-0.024	0.043	0.11	98.867	95.734	16.5	13.4		29.9	205.9	95.73326543
1.657	1.698	1.739	0.113	0.23	0.348	100.335	98.637	30	23.5		53.5	259.4	98.63607456
			0.27	0.334	0.397	100.001	100.001	8.2	12.7	BM	20.9	280.3	100

Error in Loop 3 = +0.001

Global Navigation Satellite System (GNSS) Survey

GPS uses a network of satellites, which communicate with receivers on the ground. When a receiver requests data to calculate its location, four or more GPS satellites communicate with the receiver, sending the position of the satellite, the time the data was transmitted and the distance between the satellite and the receiver.

The information collected from these satellites then calculates the latitude, longitude and height of the receiver.

GNSS (Trimble R12 Integrated GNSS System)

Global Navigation Satellite System (GNSS) refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location accurately. GNSS provides global coverage.

The entire scope of satellite systems used in positioning is now referred to as global navigation satellite systems (GNSS). Receivers that use GPS satellites and another system such as GLONASS are known as GNSS receivers.

Figure 12: A man operating GNSS

GNSS Controller (Trimble TSC7 Controller)

Trimble TSC7 controller combines the power of a tablet, laptop and survey-rugged field controller in one device. GNSS Controller is used to connect to GNSS Receiver and collect and process geospatial data. It is a kind of laptop cum tablet and is used to control GNSS receiver.

Figure 13: A GNSS Controller

Bipod

A bipod is required to support GNSS and precisely locate a point in field whose coordinates are to be measured.

Methodology adopted for GNSS Survey

1. Setup the GNSS Receiver by a bipod at the control point.
2. Connect GNSS Controller to the Receiver.
3. Start collecting the coordinates of the point.
4. If the area is open to sky and the no. of satellites are good, then take about 20-25 minutes to collect data. If the area is not open to sky or no. of satellites available is less and some buildings, trees, etc. are nearby then take more time to collect data there, maybe 30-40 minutes.
5. Move to the next control point.
6. Repeat the procedure up to last control point i.e. A to L.
7. Take the data captured for processing.
8. Make use of Static GPS Baseline technique to determine accurate coordinates for survey points.
9. Process the data with the help of TBC (Trimble Business Center) Software to do Baseline Processing and generate a Baseline Processing Report.

Result Table

Coordinate System Name: Worldwide/UTM

Zone: 44 North

Datum: WGS 1984

ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
A	486211.503	2781778.83	86.454
B	486176.469	2781842.6	87.042
C	486248.62	2781941.07	80.787
D	486274.104	2781933.12	88.413
E	486286.031	2781890.1	89.661
F	486252.029	2781827.96	89.525
G	486254.395	2781765.14	89.546
H	486381.701	2781719.75	90.941
I	486328.531	2781570.59	92.193

J	486258.729	2781594.86	91.151
K	486296.744	2781682.54	86.3
L	486251.584	2781746.08	87.728

Precision of each control points

Point A		Point B	
Horizontal precision:	0.006 m	Horizontal precision:	0.002 m
Vertical precision:	0.010 m	Vertical precision:	0.003 m
Point C		Point D	
Horizontal precision:	0.024 m	Horizontal precision:	0.003 m
Vertical precision:	0.025 m	Vertical precision:	0.006 m
Point E		Point F	
Horizontal precision:	0.007 m	Horizontal precision:	0.002 m
Vertical precision:	0.013 m	Vertical precision:	0.004 m
Point G		Point H	
Horizontal precision:	0.006 m	Horizontal precision:	0.005 m
Vertical precision:	0.009 m	Vertical precision:	0.013 m
Point I		Point J	
Horizontal precision:	0.002 m	Horizontal precision:	0.002 m
Vertical precision:	0.004 m	Vertical precision:	0.004 m
Point L			
Horizontal precision:	0.002 m		
Vertical precision:	0.004 m		

Variance Covariance Matrices

Point A				Point B			
	X	Y	Z		X	Y	Z
X	0.0000055767	0.0000016154	0.0000020502	X	0.0000004277	0.0000002695	0.0000000812
Y	0.0000016154	0.0000206727	0.0000098364	Y	0.0000002695	0.0000022973	0.0000009309
Z	0.0000020502	0.0000100035	0.0000098364	Z	0.0000000812	0.0000008052	0.0000009309
Point C				Point D			
	X	Y	Z		X	Y	Z
X	0.0000573883	0.0000190587	-0.0000253374	X	0.0000011201	0.0000002670	0.0000000515
Y	0.0000190587	0.0001109727	0.0001080924	Y	0.0000002670	0.0000082789	0.0000021316
Z	-0.0000253374	0.0000632064	0.0001080924	Z	0.0000000515	0.0000027270	0.0000021316
Point E				Point F			
	X	Y	Z		X	Y	Z
X	0.0000089282	0.0000077364	0.0000038026	X	0.0000006902	0.0000010006	0.0000002691
Y	0.0000077364	0.0000335262	0.0000156294	Y	0.0000010006	0.0000047009	0.0000007841
Z	0.0000038026	0.0000146125	0.0000156294	Z	0.0000002691	0.0000013562	0.0000007841
Point G				Point H			
	X	Y	Z		X	Y	Z

X	0.0000050569	-0.0000017226	0.0000003167	X	0.0000052689	0.0000031691	0.0000014035
Y	-0.0000017226	0.0000210393	0.0000053449	Y	0.0000031691	0.0000336939	0.0000111647
Z	0.0000003167	0.0000073995	0.0000053449	Z	0.0000014035	0.0000144533	0.0000111647
Point I				**Point J**			
	X	Y	Z		X	Y	Z
X	0.0000005662	0.0000003622	0.0000002048	X	0.0000006003	0.0000003937	0.0000002339
Y	0.0000003622	0.0000031953	0.0000008163	Y	0.0000003937	0.0000034583	0.0000009006
Z	0.0000002048	0.0000011420	0.0000008163	Z	0.0000002339	0.0000012537	0.0000009006
Point L							
	X	Y	Z				
X	0.0000009465	0.0000002036	0.0000002282				
Y	0.0000002036	0.0000037880	0.0000014802				
Z	0.0000002282	0.0000014347	0.0000014802				

Baseline Processing Report

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.

Baseline Processing / Static Relative Positioning

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 of 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, varience-covarince matrix, etc.

Figure 14: Base Station Setup

<u>**Topographic Map**</u>

CE332A: SURVEY CAMP

Department of Civil Engineering, IIT Kanpur

AAROGYADHAM, CHITRAKOOT, MADHYA PRADESH

SCALE 1:1800

0 50 100 m

Contour Interval = 0.5 m

LEGEND

- Electric Pole
- CP
- Tree
- Petrol Pump
- Pond
- Building
- Wall
- Fencing
- Cement Road
- Park
- Road
- Raw Road
- Contours

GROUP 2

Instructor: Prof. Onkar Dikshit

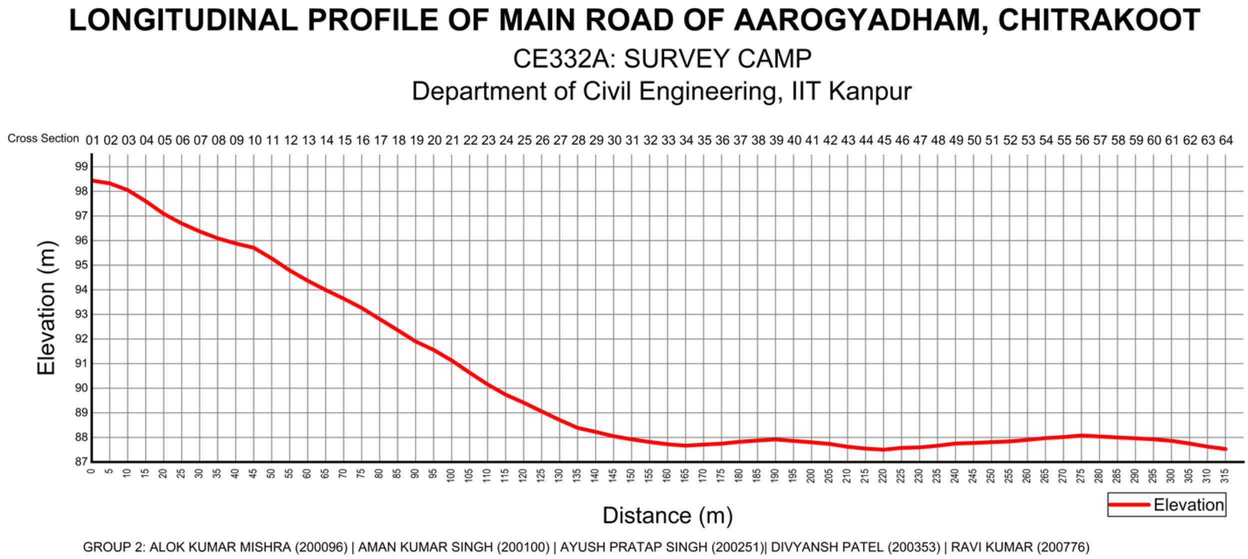
Group Members:
Alok Kumar Mishra (200096)
Aman Kumar Singh (200100)
Ayush Pratap Singh (200251)
Divyansh Patel (200353)
Ravi Kumar (200776)

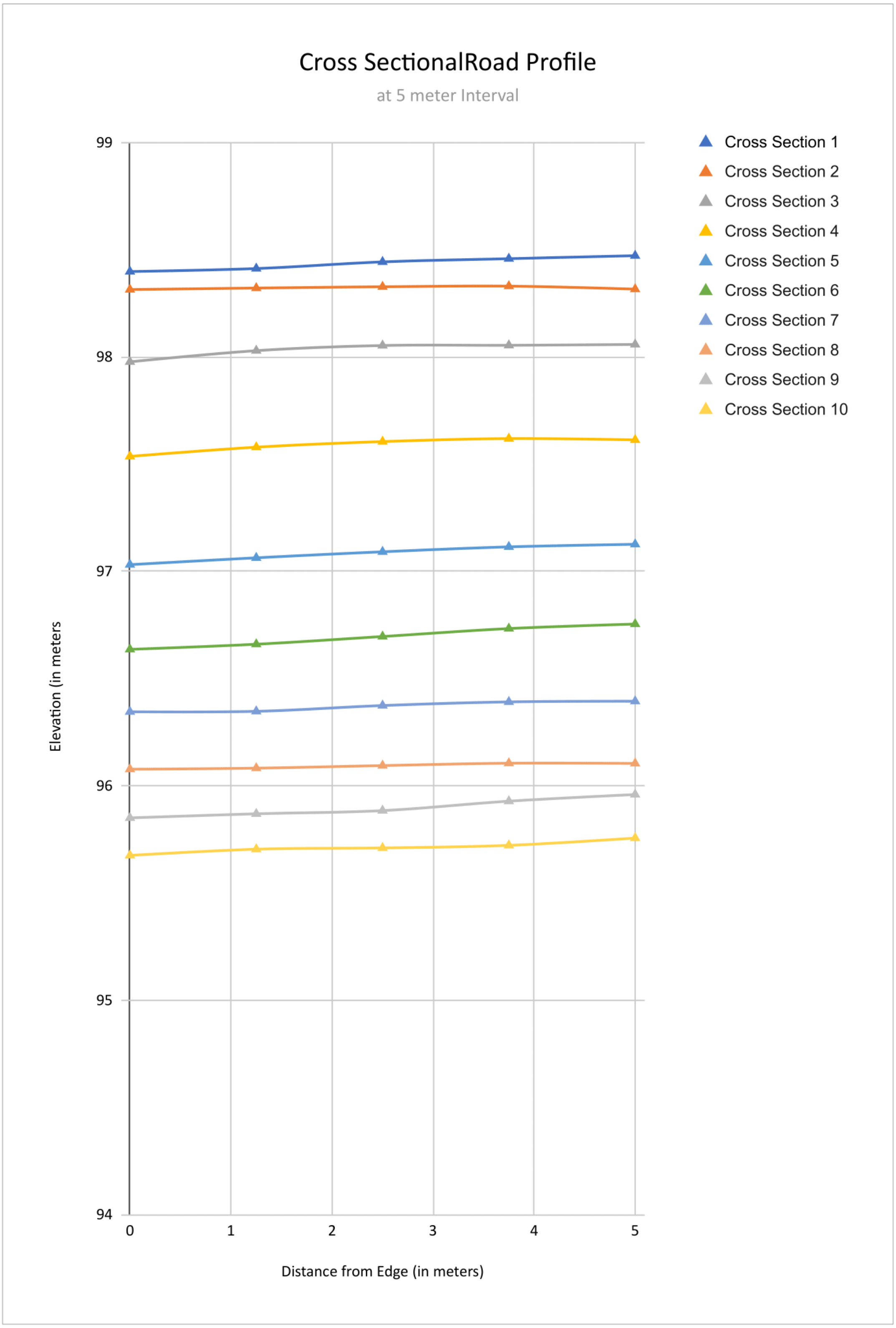
ROAD PROFILE

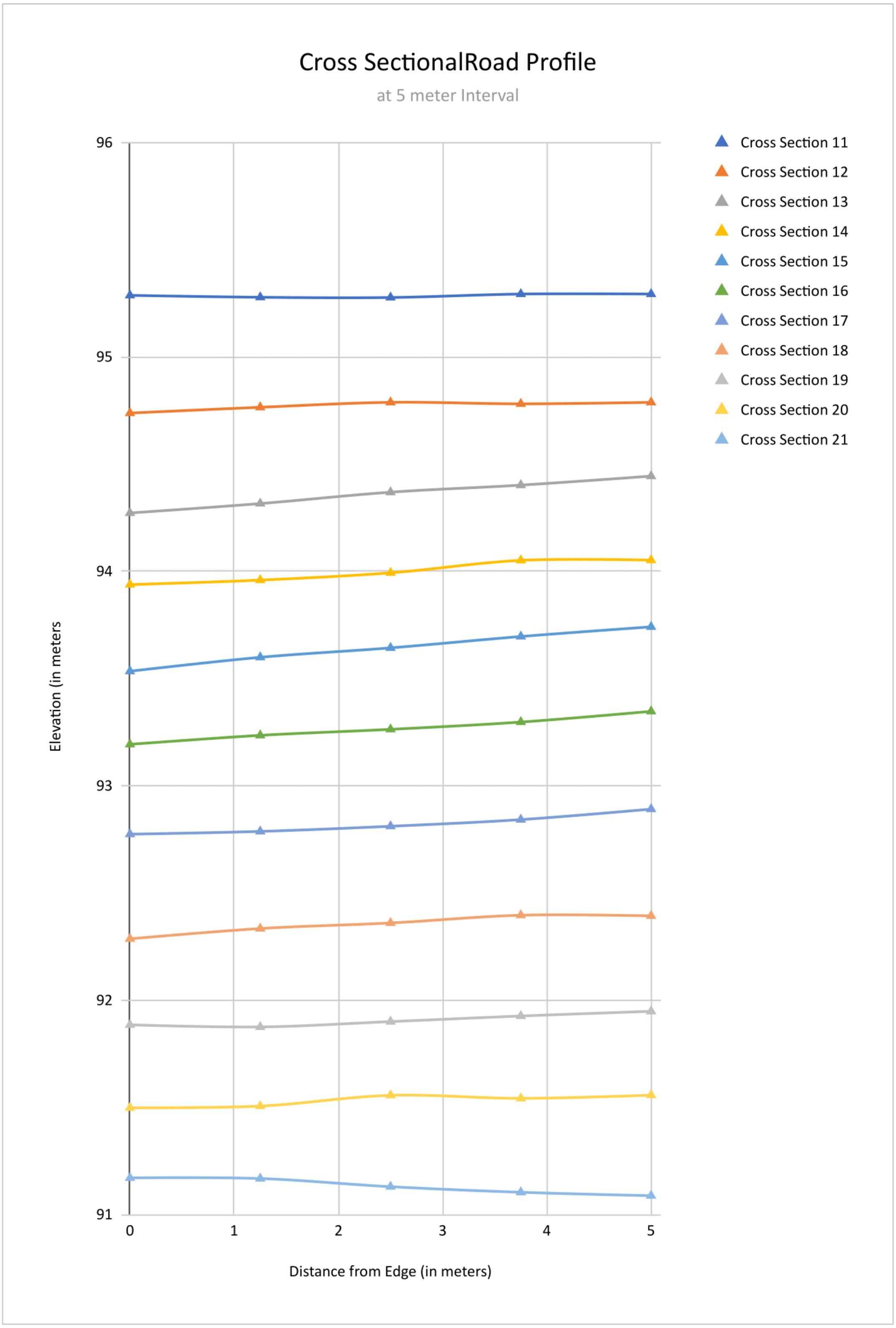
Methodology adopted for Road Profiling

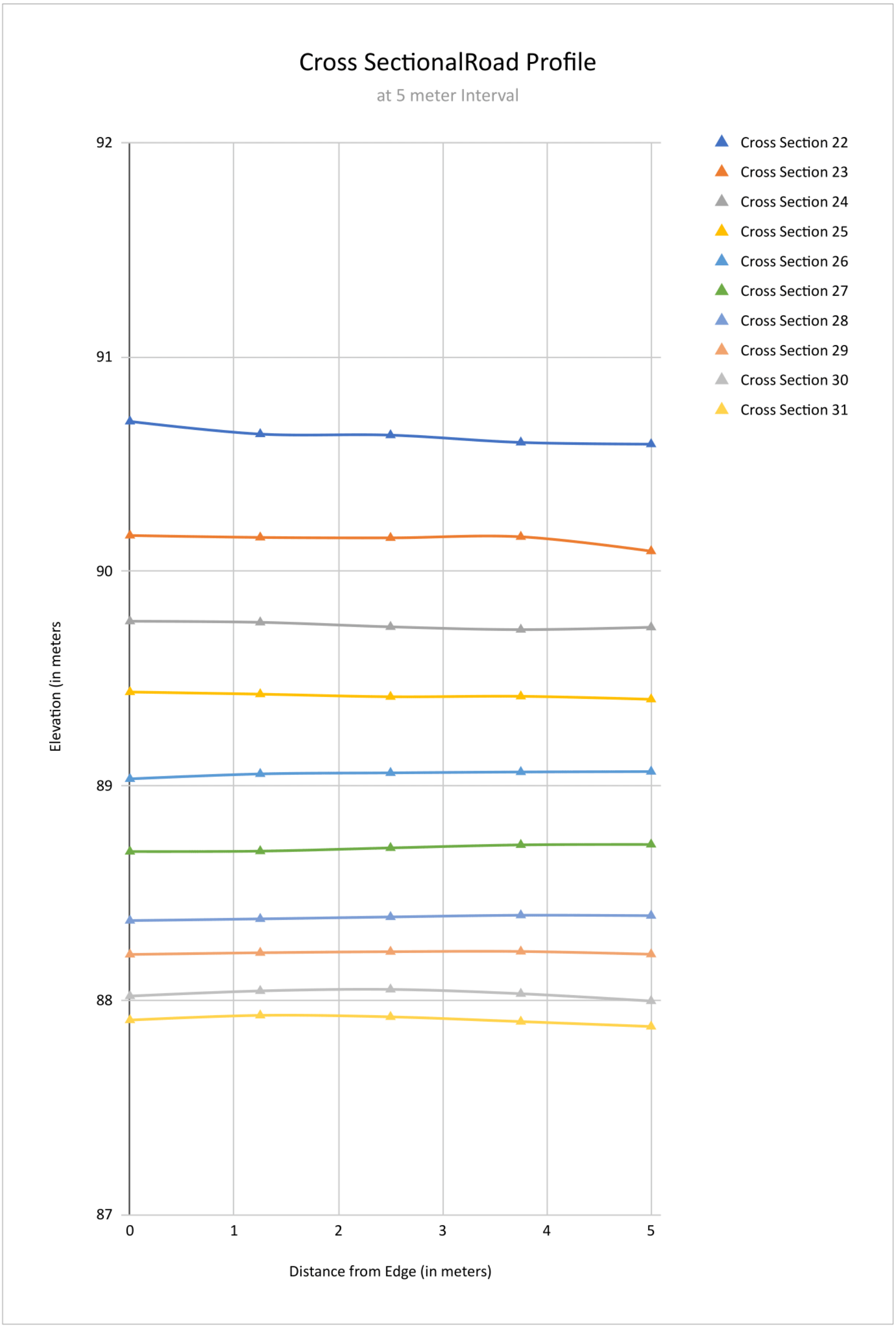
1. Draw straight lines on the road with the help of a chalk and make such lines on every 5 m distances up to where the road is to be profiled.
2. Setup total station on the control point.
3. Know the global coordinates of all the control points & Height of the instrument.
4. Set the target at 5 points on every cross section, one at middle and other two on both sides from the centre line of the cross section.
5. Measure the geospatial data of the points by targeting a reflector at those points.
6. This data contains coordinates, elevation, etc of the points.
7. Now move to the next control point and repeat the procedure until the data of entire road's cross sections is collected
8. Take the data from total station to your computer.
9. Plot the Elevation vs Distance graph for making the longitudinal profile of the road by making use of elevation values of mid points of each cross section.
10. Plot the Elevation vs Distance graph for each cross section using the elevation of all the 5 equidistant points.

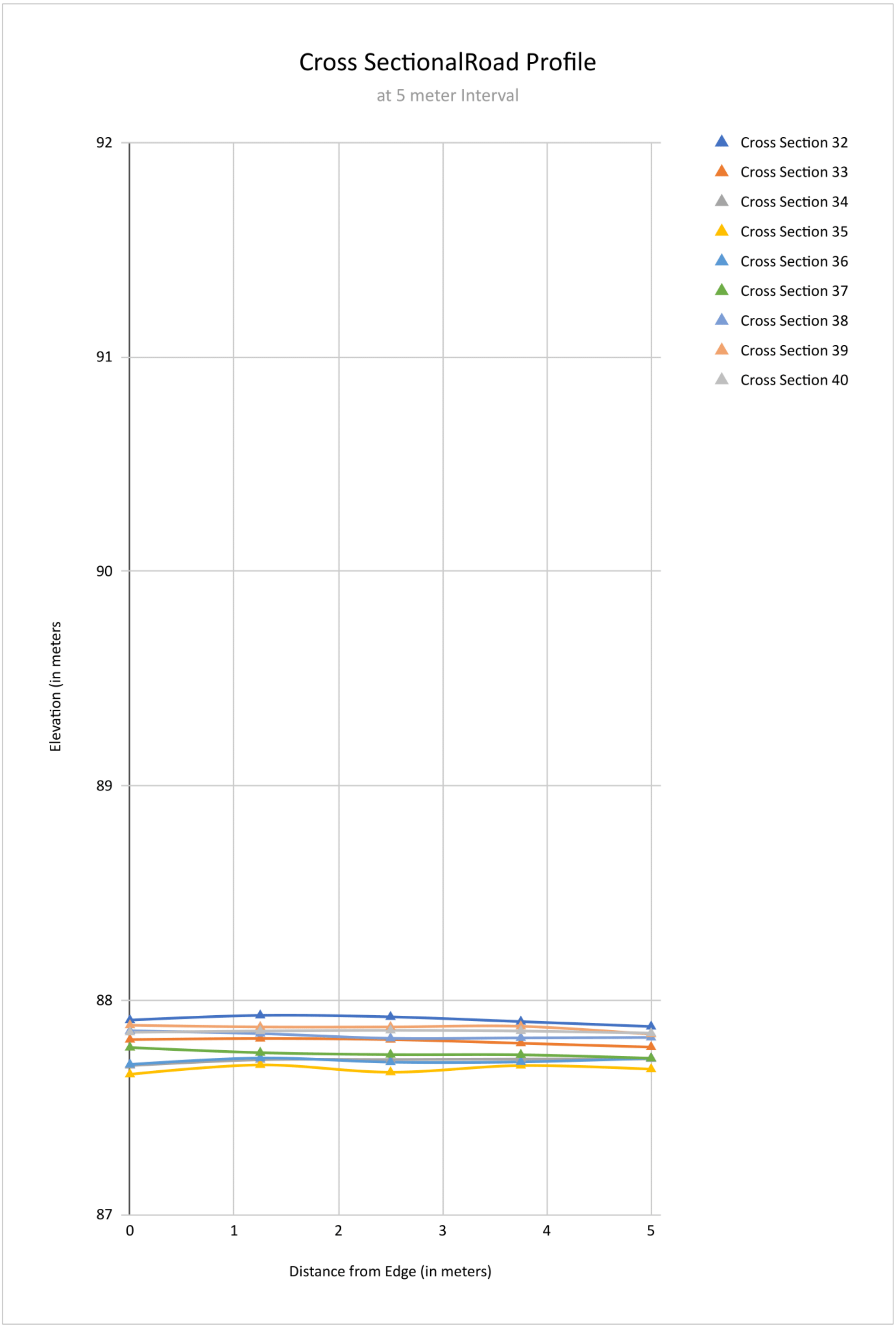
Results

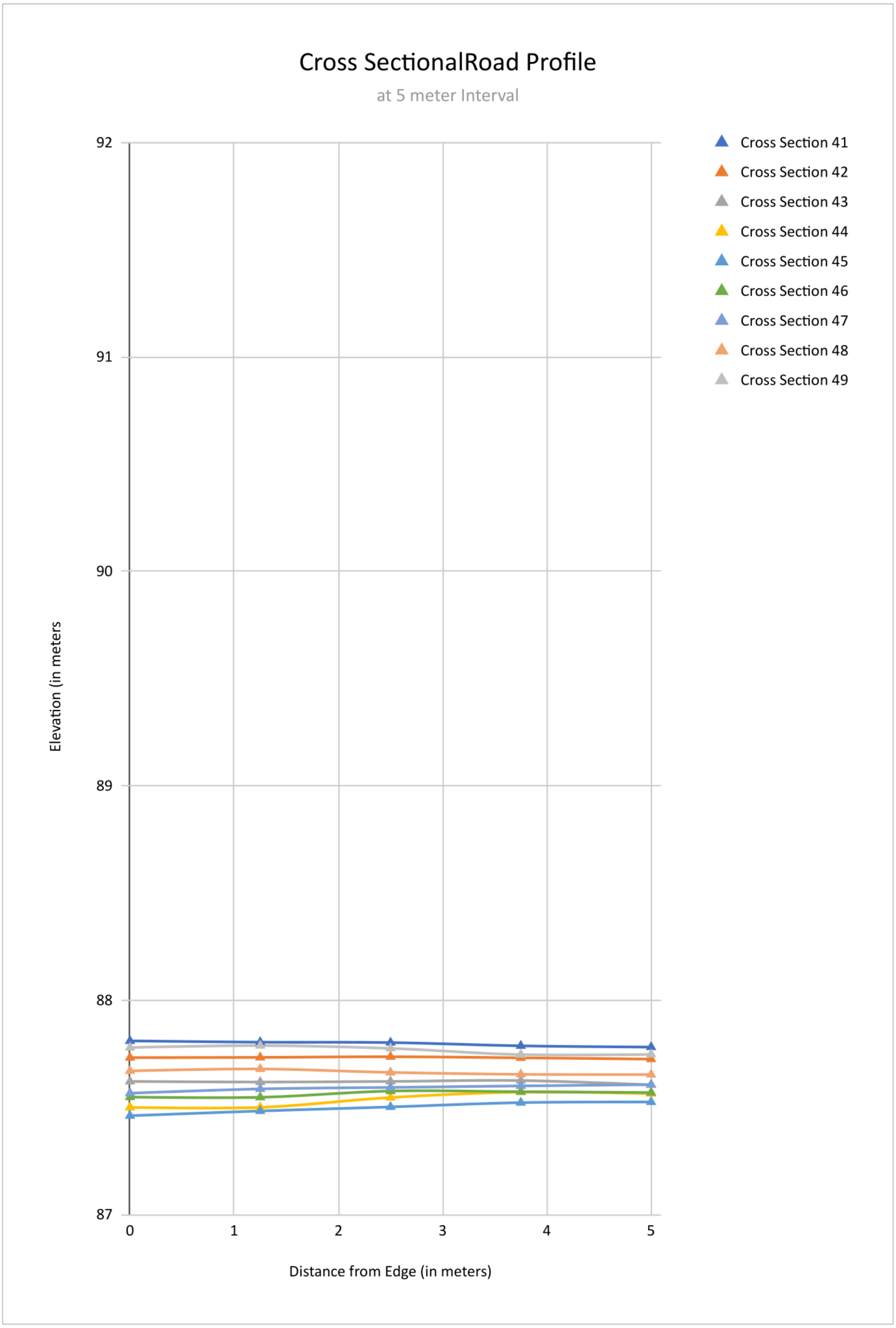


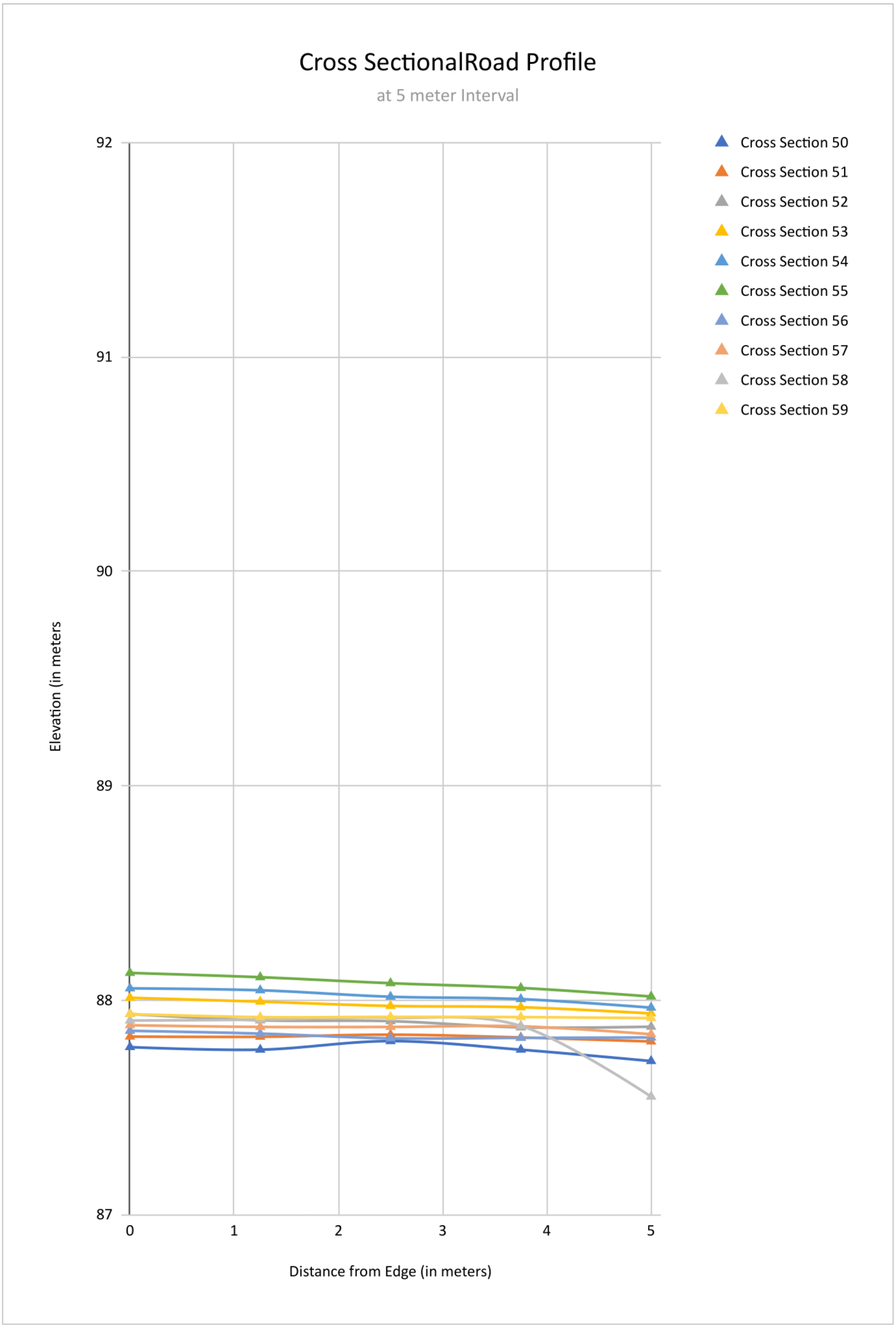

Cross SectionalRoad Profile
at 5 meter Interval
99
98
97
96
95
94
0
1
2
3
4
5
Elevation (in meters
Distance from Edge (in meters)
Cross Section 1
Cross Section 2
Cross Section 3
Cross Section 4
Cross Section 5
Cross Section 6
Cross Section 7
Cross Section 8
Cross Section 9
Cross Section 10

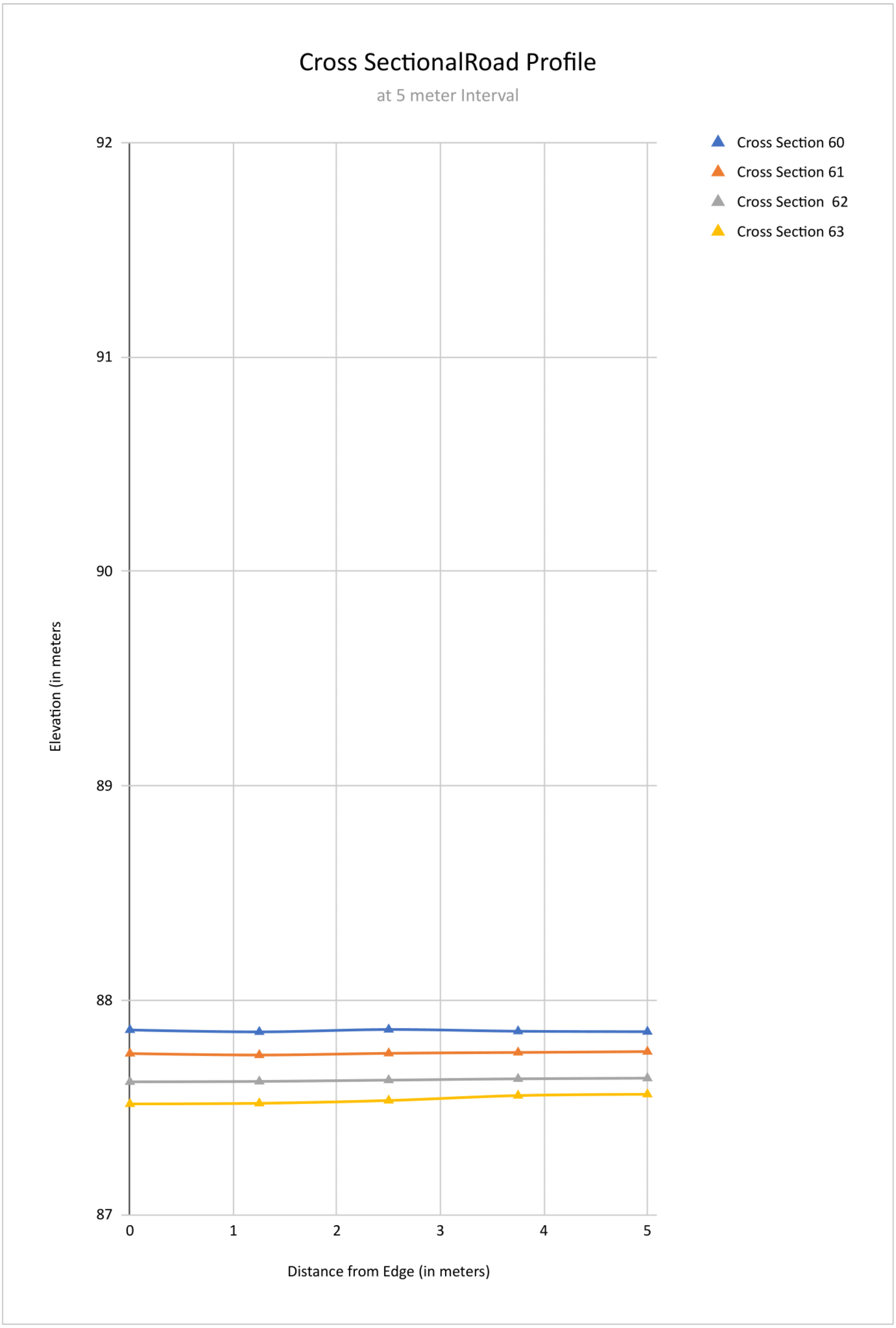

Cross SectionalRoad Profile
at 5 meter Interval
96
95
94
93
92
91
0
1
2
3
4
5
Elevation (in meters
Distance from Edge (in meters)
Cross Section 11
Cross Section 12
Cross Section 13
Cross Section 14
Cross Section 15
Cross Section 16
Cross Section 17
Cross Section 18
Cross Section 19
Cross Section 20
Cross Section 21


Cross SectionalRoad Profile
at 5 meter Interval
92
91
90
89
88
87
0
1
2
3
4
5
Elevation (in meters
Distance from Edge (in meters)
Cross Section 22
Cross Section 23
Cross Section 24
Cross Section 25
Cross Section 26
Cross Section 27
Cross Section 28
Cross Section 29
Cross Section 30
Cross Section 31


Cross SectionalRoad Profile
at 5 meter Interval
92
91
90
89
88
87
0
1
2
3
4
5
Elevation (in meters
Distance from Edge (in meters)
Cross Section 32
Cross Section 33
Cross Section 34
Cross Section 35
Cross Section 36
Cross Section 37
Cross Section 38
Cross Section 39
Cross Section 40


Cross SectionalRoad Profile
at 5 meter Interval
Elevation (in meters
92
91
90
89
88
87
0
1
2
3
4
5
Distance from Edge (in meters)
Cross Section 41
Cross Section 42
Cross Section 43
Cross Section 44
Cross Section 45
Cross Section 46
Cross Section 47
Cross Section 48
Cross Section 49


Cross SectionalRoad Profile
at 5 meter Interval
Elevation (in meters
Distance from Edge (in meters)
92
91
90
89
88
87
0
1
2
3
4
5
Cross Section 50
Cross Section 51
Cross Section 52
Cross Section 53
Cross Section 54
Cross Section 55
Cross Section 56
Cross Section 57
Cross Section 58
Cross Section 59



Cross SectionalRoad Profile
at 5 meter Interval
Elevation (in meters
92
91
90
89
88
87
0
1
2
3
4
5
Distance from Edge (in meters)
Cross Section 60
Cross Section 61
Cross Section 62
Cross Section 63

JUNO MAP

Trimble Juno 3B Handheld GPS

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

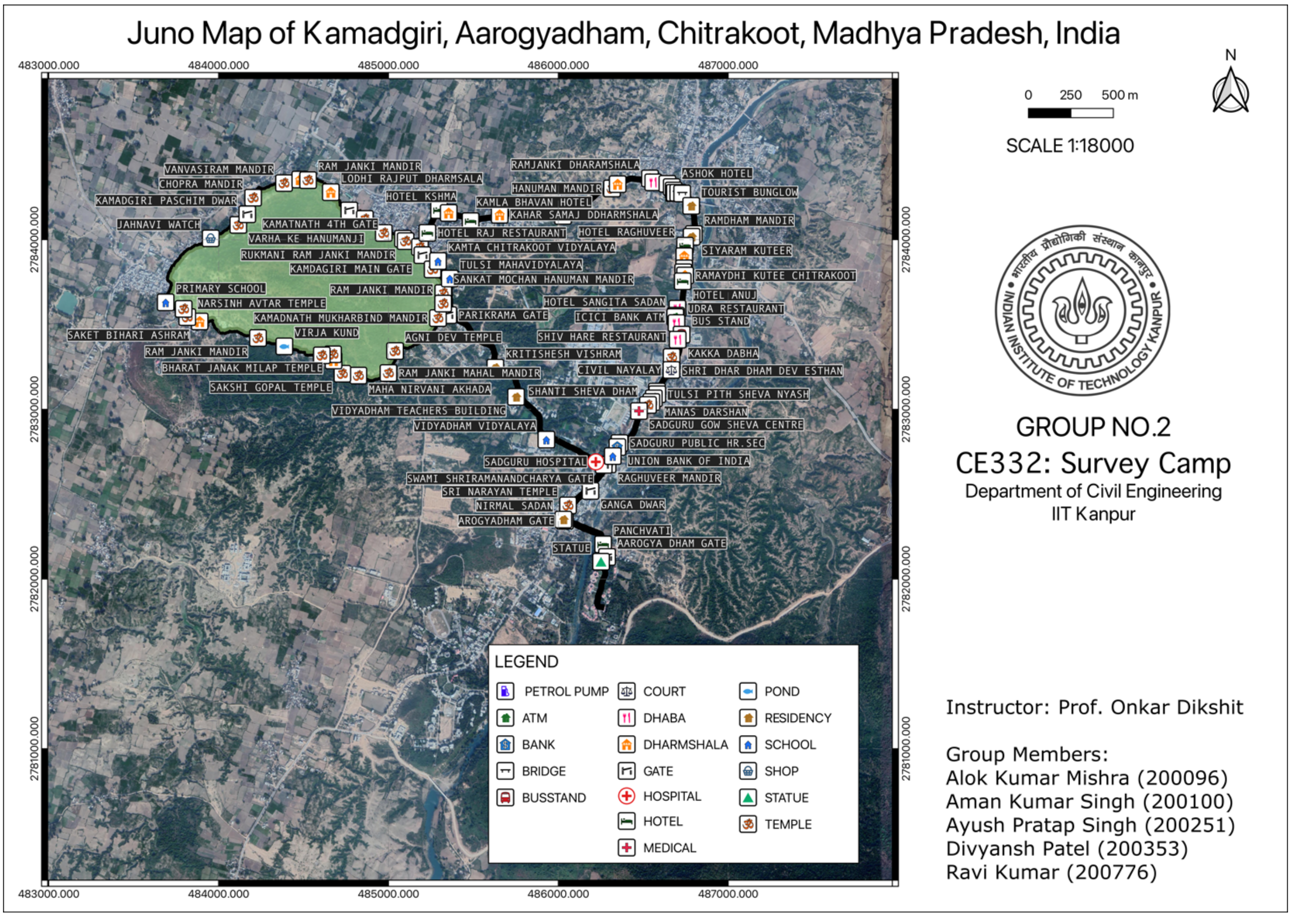
- Point-generic: Points like tree, poles, hospitals, buildings, etc.
- Line-generic: Multiline like roads, footpath, etc.
- Area-generic: Polygon like hill's boundary, etc.

Figure 15: A man using Juno 3B

Methodology adopted for Juno Mapping

1. Take two Junos. One Juno to collect line and area generic features while other to take point generic features.
2. Move along the roadmap and start collecting line generic area.
3. While moving on end the line-generic collection at point where area generic features are to be taken.
4. Start collecting area-generic features at Kamadgiri while doing a Parikrama of it.
5. End data collection at same point where the data collection was started.
6. Start collecting line generic feature collection.
7. Keep moving according to roadmap and end data collection on reaching the destination
8. While collecting line and area generic features, also take point generic features by stopping by at the places and collecting location data.
9. Either area/line data collection can be paused for that moment or other team member can take the data.
10. Processing of the data collected can be either by Pre-processing or Post-processing.
11. After data collection, now export those shapefiles .kmz or .kml format.
12. Open the .kmz or .kml file on Google Earth.
13. Overlay the data collected with Google Earth.
14. Comment on the accuracy of data collected.
15. Add the shape files to a GIS Software say QGIS and prepare a map of the proposed area.

Juno Map



CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

The survey camp was an enriching and educational experience. I gained a better understanding of surveying, acquired hands-on experience, and forged stronger bonds with my group members and colleagues.

I learned a lot of things through trial and error that cannot be learned from textbooks, including the importance of punctuality, teamwork, professionalism, and time management. I also learned new concepts such as baseline processing, the auto lock feature of the Trimble Total Station, laser surveying, Juno Survey, and road profiling. In addition to the educational benefits, I had a lot of fun during the survey exercises and our visits to different places such as Dharkundi, Gupt Godavari, and Sati Anushuiya, etc.

I would like to express my sincere gratitude to Prof. Onkar Dikshit for giving me the opportunity to participate in this wonderful camp. Sheetla Sir, Hari Babu Sir, Vipul Sir, Prashant Sir, Rohit Sir, all supporting staff, and my fellow batchmates all made this camp a success with their help, support, and guidance.

I believe that the survey camp is a valuable learning experience. It provides students with the opportunity to gain hands-on experience in surveying, learn new concepts, and develop teamwork and leadership skills. I highly recommend this camp to any student who is interested in pursuing a career in surveying.

Suggestion for future work: The duration of the camp could be extended allowing for more in-depth training and experience.