Batch: Thursday Group: 3

Project Report

Introduction

This report covers the procedures and findings of a Geoinformatics lab project that aimed to construct a detailed map of the **area covering the L20 Ground and Lecture Hall 20 at IIT Kanpur**. Over a **six-week period**, various geospatial techniques, including GNSS surveying, levelling, and total station mapping, were employed to accurately map the area.

Objective

The primary objectives were:

1. Establish a closed traverse ensuring visibility between each point and its adjacent points.
2. Determine the elevation of control points through levelling.
3. Calculate local coordinates of each control point using distance and angle measurements.
4. Transfer global coordinates to local coordinates using GNSS and Coordinate Transformation.
5. Map features near each control point using a total station.
6. Prepare a detailed map using QGIS.

Instruments Used

- Paint
- Auto leveller
- Staff
- Total Station
- Target/Reflector
- Tripod
- Measuring Tape

Figure 1: Figure illustrating Total Station.

Methodology

Week 1: Reconnaissance Survey

- The reconnaissance survey involved examining the area and selecting the optimal control points based on visibility and coverage. This initial survey ensured a clear view between each point, essential for accurate subsequent measurements.

- **Eight Control points** were setup, selecting the most accessible with maximum coverage.

Figure 2: Figure illustrating the images of the Control Points.

Week 2: Levelling

- Levelling was conducted to determine the reduced levels (RLs) of each control point. We used the Rise and Fall method and the Height of Collimation method, recording data in separate tables to ensure accuracy.
- Tables for Levelling:
    - **Height of Collimation Table (for Loop 1 (points 1 to 7)):**

Station	BS			FS			Distance	HI	RL	Cumulative Distance	Corrected RL
	US	MS	LS	US	MS	LS					
BM	1.13	1.01	0.889				24.1	129.046	**128.036**	24.1	**128.036**
3	1.267	1.13	0.99	1.193	1.095	1	47	129.081	127.951	71.1	127.9511493
5	1.3	1.194	1.087	1.24	1.01	0.78	67.3	129.265	128.071	138.4	128.0712906
6	1.285	1.048	0.811	1.347	1.231	1.115	70.6	129.082	128.034	209	128.0344388
2	1.383	1.229	1.074	1.288	1.11	0.931	66.6	129.201	127.972	275.6	127.9725786
1	1.394	1.241	1.088	1.442	1.29	1.138	61	129.152	127.911	336.6	127.9117067
7	1.182	1.079	0.972	1.345	1.201	1.058	49.7	129.03	127.951	386.3	127.951811
4	1.381	1.221	1.061	1.287	1.162	1.039	56.8	129.089	127.868	443.1	127.8689303
BM				1.22	1.054	0.888	33.2		**128.035**	476.3	**128.036**
∑		**9.152**			**9.153**		**476.3**				

Check:

- Sum of Back Sights (B.S.) = 9.152
- Sum of Fore Sights (F.S.) = 9.153
- **Difference (L.H.S.) = ∑BS - ∑FS = -0.001**
- First Reduced Level (R.L.) = 128.036
- Last Reduced Level (R.L.) = 128.035
- **Difference (R.H.S.) = Last RL – First RL = -0.001**
- **Thus, L.H.S. = R.H.S. = -0.001**
- **Total Distance (TD)= BS + FS**
- Total Distance Travelled (m) = **∑(US - LS)*100 of BS and FS = d1+d2 = 476.3 m**

This shows the table prepared is **Consistent**.

The table also contains the adjustments in the Reduced Level by **Distance based Approach:**

- Error Correction Distribution: Based on distance levelled (d).
  $$\mathbf{Ci = -d_i\ M\ /\ Sum(d_i)}.$$
- Adjusted Elevation at CP:
  $$\mathbf{H_i = H_i + C_i}.$$
- Adjusted Elevation at BM:
  $$\mathbf{H_{BM} = H_{BM} + C_i = BM}.$$

Quality Assessment: We can measure the quality of the work done as follows

- **Misclosure Difference: |128.305 – 128.306| m = 0.001 m = 0.1 cm = 1 mm**
- **Total Distance Travelled (km) (k)** = ∑ (US - LS) *100 for BS and FS = **0.4763 km**
- Putting in the inequality to calculate the value of c:
  Misclosure Error <= Closure Error
  c >= Misclosure error(mm)/ $k^{1/2}$
  c >= $1/(0.4763)^{0.5}$
  c >= 1.4489710525
- **Quality of Work**: Since c is 1.44897, the quality of work is considered in range of **Highest to Precise**.

For **Second Loop** (from 1 to 8 to 7)

Station	BS			FS			Distance	HI	RL	Cumulative Distance	Corrected RL
	US	MS	LS	US	MS	LS					
1	1.459	1.404	1.348				11.1	129.316	127.912	11.1	127.9117067
8	1.217	1.121	1.022	1.289	1.247	1.201	28.3	129.19	128.069	39.4	128.0706408
7				1.381	1.241	1.1	28.1		127.949	67.5	127.951811
∑		**2.525**			**2.488**		**67.5**				

Check:

- **Misclosure** = RL of 7 from loop 2 – RL of 7 from loop 1 = **-0.00281104346**
- **∑BS - ∑FS = 0.037**
- **Last RL (of point 7) – First RL (of Point 1) =127.949 -127.912 = 0.037**
- **Thus, the table is consistent.**

The Adjusted RL for 1,8 and 7 are listed above in the table.

Week 3 to 4: Traversing

- Traversing was performed by setting up the Total Station at each control point. This enabled us to record internal angles, distances, and coordinates (northing and

easting) at each point. The data collected in this step formed the basis for converting local coordinates to global coordinates.

Station	Point Observed	Horizontal Angle		Distance	Adjustments	
		Angle	Corrected Angle		Correction	Adjusted Angle
3	5	0°0'1"	141°57'13''	72.46	0°0'4''	141°57'17''
	4	141°57'17"		57.434		
	5	0°0'5"		72.46		
5	6	0°0'1"	103°7'59''	44.627	0°0'3''	103°8'2''
	3	103°8'54"		72.465		
	6	0°0'56"		44.626		
6	2	0°0'0"	92°42'20''	82.641	0°0'3''	92°42'23''
	5	92°41'53"		44.627		
	2	359°59'33"		82.642		
2	1	0°0'0"	219°45'19''	61.53	0°0'7''	219°45'26''
	6	219°45'24"		82.633		
	1	0°0'5"		61.529		
1	8	0°0'5"	131°55'12''	20.166	0°0'4''	131°55'16''
	2	131°53'34"		61.526		
	8	359°58'27"		20.17		
8	7	0°0'1"	102°45'50''	47.762	0°0'3''	102°45'53''
	1	102°46'6"		20.17		
	7	0°0'17"		47.775		
7	4	0°0'0"	129°23'25''	45.439	0°0'4''	129°23'29''
	8	129°23'25"		47.777		
	4	0°0'0"		45.442		
4	3	0°0'0"	158°22'9''	57.431	0°0'5''	158°22'14''
	7	158°22'51"		45.435		
	3	0°0'42"		57.43		
∑			**1079°59'27''**			

Below is the table of for the Gales Tables for Correction and Computations:

Stations	Distance	WCB	ΔL	ΔD	correction in ΔL	correction in ΔD	corrected ΔL	corrected ΔD
4-3	57.43166667	64.1596535	25.03245208	51.68919306	0.001709515107	-0.00588539346	25.03074257	51.69507845
3-5	72.4625	102.2049306	-15.31921795	70.8246812	0.002156923969	-0.007425699938	-15.32137488	70.8321069
5-6	44.62666667	179.0710417	-44.62080121	0.7235174472	0.001328360559	-0.004573182486	-44.62212957	0.7280906297
6-2	82.63866667	266.3646528	-5.239805083	-82.47238126	0.002459828475	-0.008468517398	-5.242264911	-82.46391275
2-1	61.52833333	226.6074306	-42.26955133	-44.7104108	0.00183145678	-0.006305205327	-42.27138278	-44.70410559
1-8	20.16866667	274.6863194	1.647790911	-20.10124126	0.0006003419776	-0.002066813411	1.647190569	-20.09917445
8-7	47.77133333	351.9215972	47.29728401	-6.713211851	0.001421964932	-0.00489543677	47.29586205	-6.708316414
7-4	45.43866667	42.53020833	33.48470948	30.71557682	0.001352530609	-0.004656393366	33.48335695	30.72023321
Σ	432.0665		0.01286092241	-0.04427664216			0	0

The misclosure in the distance and the relative precision is listed below:

misclosure distance =	0.04610666292
relative precision =	0.0001067119597

relative precision (1:X) =	9371.020859

- **Misclosure Calculation and Correction:**

Below are the steps to find, calculate and correct due to **misclosure in angles**:

- The sum of the internal angles of a closed polygon should be:
  $$(n-2) \times 180° = (8-2) \times 180° = 1080° \; 0$$
- Due to random errors, the actual sum deviates from this theoretical value.
  Misclosure = Measured sum of angles - Theoretical sum
  = 1079°59'27" - 1080°00'00''
  = -0°0'33"
- Bowditch's Rule for Correction: The correction for each internal angle (Ci) is given by:
  $$Ci = (\theta_i / \Sigma\theta_i) \times Misclosure$$
- Corrected angle = Measured angle - Correction

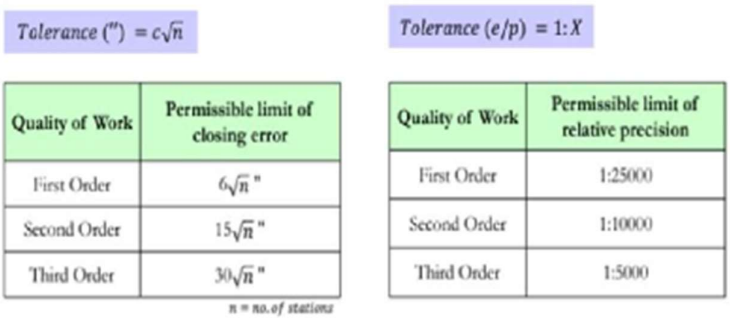
Below are the steps to find, calculate and correction in **latitude and departure**:

- **Latitude and Departure Corrections**: Corrections for latitude and departure are calculated for each side of the traverse based on their lengths and measured angles. Latitude(L) or Northing(N) = S cos(θ) Departure(D) or Easting(E) = S sin(θ)
- **Final Adjusted Traverse**: After applying these corrections, the traverse is adjusted to close properly. Thus,
  - Total Latitude Misclosure = ∑L = 0.01286092241
  - Total Departure Misclosure = ∑D = -0.04427664216
  - Ideally both are zero (i.e. ∑L = 0 and ∑D = 0)
- **Closing Error** = $(\sum L^2 + \sum D^2)^{1/2}$
  $= ((0.01286092241)^2 + (-0.04427664216)^2)^{1/2}$
  = 0.04610666292
- **Direction of Closing Error = tan(θ) = ∑D/ ∑L**
  = (-0.04427664216)/(0.01286092241)
  = -3.442726793
- **Relative Precision = Closing Error / Traverse Perimeter**
  = 0.04610666292/432.0665
  = 0.0001067119597

Quality Assessment: Evaluation of traverse closure and correction using the Bowditch method, ensuring all angle and distance measurements met the required accuracy:

- **n = 8** (Total no. of Stations)
- **Closing Error: 33"**
- **Tolerance = 15 * $(n)^{0.5}$ = 42.43''**

- **Quality**: Based on the closing error value and the Tolerance value, from the given below chart, we can conclude that the quality of the traverse is classified as **Second Order**.
- Based on our above calculations for **Relative precision = 1: 9371.02** (> 1:5000, for Third order and < (less than) 1: 10000 for Second Order), from the given below chart we can conclude that quality of work is **Second Order**.



Tolerance (″) = $c\sqrt{n}$

Quality of Work	Permissible limit of closing error
First Order	$6\sqrt{n}$ ″
Second Order	$15\sqrt{n}$ ″
Third Order	$30\sqrt{n}$ ″

n = no.of stations

Tolerance (e/p) = 1:X

Quality of Work	Permissible limit of relative precision
First Order	1:25000
Second Order	1:10000
Third Order	1:5000

Figure 3: Figure illustrating various tolerance values for Calculating the Quality of work.

Week 4 to 6: Mapping

- Mapping involved using the Total Station setup at various control points to capture the maximum number of features with precision. Ensuring the highest level of detail, each feature within the selected area was documented, including buildings of the Lecture Hall, pathways, skywalk, vegetation, electric poles and other landmarks.
- This would first involve getting the Global coordinates of two control points and then transforming all Local coordinate to Global Coordinates using Coordinate Transformation.
- The list of local coordinates is given below:

Point. no.	L	D
4	1000	1000
3	1025.030743	1051.695078
5	1009.709368	1122.527185
6	965.0872381	1123.255276
2	959.8449732	1040.791363
1	917.5735904	996.0872576
8	919.220781	975.9880832
7	966.516643	969.2797668
4	1000	1000

- The list of Transformed Global Coordinates with 3 and 4 (known precisely) are:

Northing	Easting	Point. no.
2932550.429	423598.233	**4**
2932575.457	423649.913	**3**
2932560.145	423720.728	**5**
2932515.534	423721.4591	**6**
2932510.287	423639.0167	**2**
2932468.024	423594.3272	**1**
2932469.669	423574.233	**8**

2932516.952	423567.5231	**7**

- The list of the Parameters in the Global Coordinate transformation involved are:

S cos a	S sin a	Tn	Te
0.9997429104	0.00007142155682	2931550.615	422598.5615

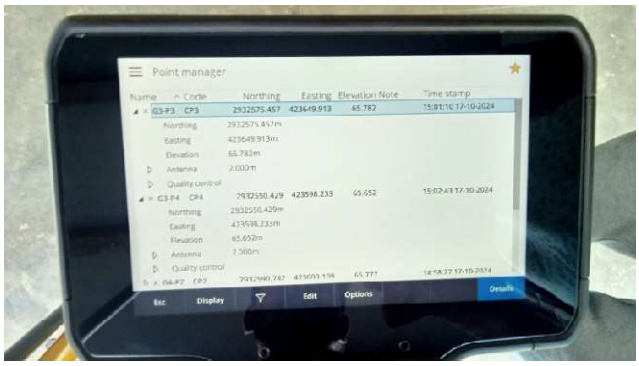


Figure 4: Figure illustrating the image of the Global Coordinates of the Control Point 3 and 4.

Map Creation in QGIS:

- All collected data was processed in QGIS to create a detailed map, which included key features, contours, and a scaled representation of the area around the Lecture Hall Complex. Global coordinates were converted from local coordinates to ensure alignment with satellite imagery.
- Satellite view of Map including Various Points Recorded is shown below:

Figure 5: Figure illustrating the image of Satellite View of Map including Various Features recorded using Total Station.

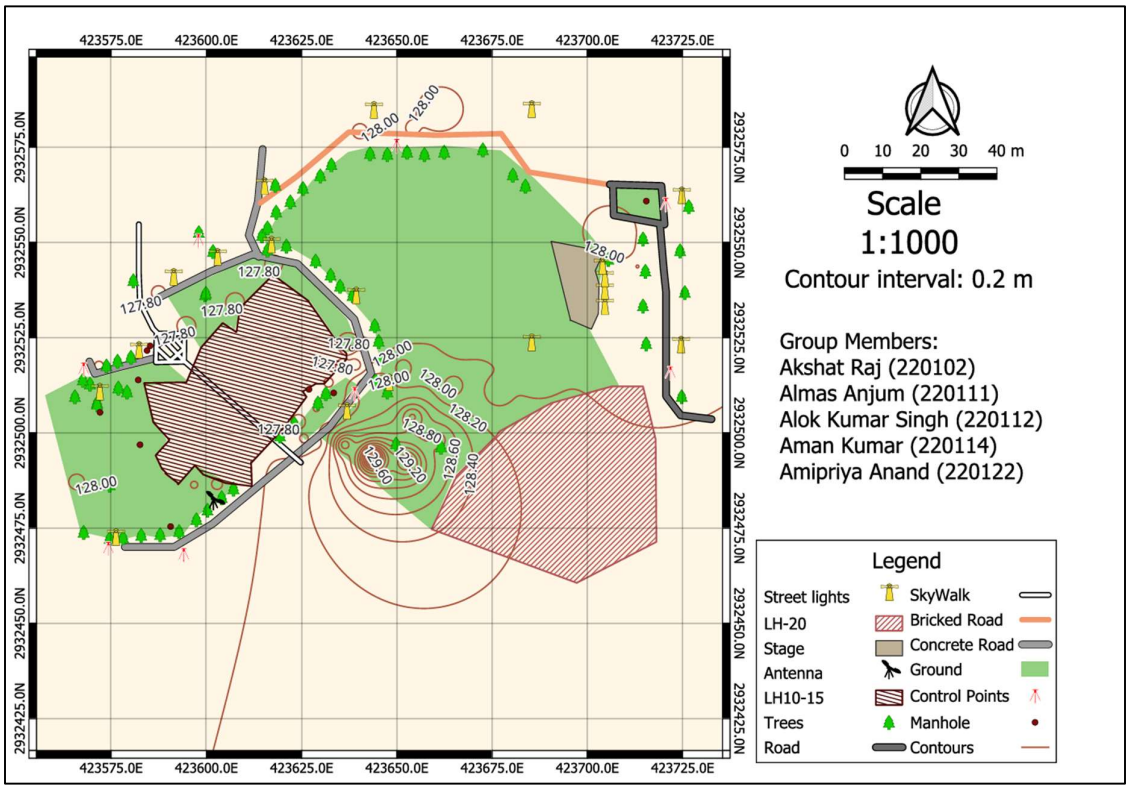


Figure 6: Figure illustrating Map Formed at end of the Project.

Results and Discussion

The data collected during the traversing and levelling was analysed to calculate control point heights and coordinates. Angle corrections using the Bowditch method were applied where necessary to maintain accuracy across the traverse.

Conclusions

Through this project, we gained experience in:

1. Conducting reconnaissance and establishing control points.
2. Using levelling techniques and Total Station for accurate surveying.
3. Adjusting data for common errors.
4. Mapping and spatial analysis using QGIS.
5. Collaborating effectively in a team to manage data and achieve project goals.

Comments and Feedback

Through this project, we gained experience in:

- **What is your feedback for this lab experiment?**
  This lab experiment provided valuable hands-on experience with a range of geospatial tools and techniques, particularly in conducting traversing and mapping with a Total

Station and GNSS. It allowed us to apply theoretical knowledge in a practical setting and gain proficiency in data collection, handling, and analysis.

- **What kind of problems did you encounter during this lab experiment?**
  One of the main challenges we faced was the need to include an additional control point (Point 8), which required adjusting our original traverse path. This change added complexity to the setup and required us to reconfigure the total station setup multiple times.
- **How did you handle them?**
  We addressed this by adding a new path from Point 1 to Point 8 and then connecting to Point 7 to ensure complete coverage. Additionally, managing eight control points required setting up the Total Station eight times, but we coordinated our work efficiently to minimize time spent on each setup.

References

Figures and Tables used in the preparation of this Project report are used from:

- Lecture and Pre lab Lecture Notes were used for various charts and images.
- Figures 1 was directly taken from the Pre-Lab lecture notes shared via mail.
- Figure 2 and 4 are clicked by the students involved in the Project during Lab Hours.
- Figure 5, generated from the QGIS software while making the map.
- Mapping software used for mapping of these points is **QGIS**.
- **Geospatial PDF of Map** is directly attached with this PDF in the zipped file.
- All Pre Lab-Lecture Notes Link: CE331 Lab Handouts - Google Drive
- Link for the Original Tables: https://docs.google.com/spreadsheets/d/1X-zWFsItyViMhkNmb0LPzHIbBM7q1-JntgzIRMBxZNA/edit?usp=sharing