Monday Batch - GROUP 10

Priyanshu Pandey (220829)

Priyanshu Gujraniya (220825)

Priyanshu (220824)

Priyadarshini Kumari (220820)

Prem Mundhra (220817)

Pulkit Dhayal (220834)

Group project Report

Objective

1. Establish control points and determine global coordinates for key features within the designated area.
2. Create a precise map of the area, representing all essential features and coordinates accurately using QGIS software.

Methodology

Week 1: Reconnaissance and Control Point Establishment:

1. **Survey Planning and Decision-Making**
   - Conduct a careful and detailed reconnaissance of the survey area to select appropriate methods, instrumentation, and strategies for achieving specified accuracy within time constraints.
2. **Control Point Definition**
   - A Control point is a precise location with known coordinates and elevation, serving as a reference for measurements and mapping in the survey area (in our case, we have to find the coordinates of our control points using different processes).
3. **Area Observation and Selection of Control Points**

- Conduct a thorough observation of the area's topography to identify potential control points. Selected control points should provide optimal visibility for feature mapping and survey accuracy.

4. **Precautions in Control Point Selection**
    - Ensure at least two points are visible from the sky for global coordinate determination.
    - Choose 4 to 6 intervisible points; each control point should be visible from the others without obstructions like trees or buildings.
    - Control points should be positioned to avoid obstructing traffic or public flow and should not be located on roads.
    - Position control points to allow maximum feature visibility for effective mapping.
5. **Final Control Point Selection**
    - Based on these considerations, four control points (P1 to P4) and a temporary point were established. Points were clearly marked with paint to prevent loss.

Week 2 Levelling:

1. **Levelling**
    - Levelling is the process of determining the relative heights (elevations) of points on the earth's surface, allowing surveyors to establish the difference in height between a reference point and other points. It is essential for creating accurate maps and topographical representations.
2. **Vertical Line and Level Surface**
    - A *vertical line* is a line that follows the local direction of gravity, as shown by a plumb line.
    - A *level surface* is a curved surface perpendicular to the local plumb line at every point, approximately spheroidal, reflecting the earth's curvature.
3. **Benchmark (BM)**
    - A *benchmark* is a permanent object (natural or artificial) with a marked point whose elevation above or below a reference datum is known or assumed. This provides a starting reference point for levelling.
4. **Levelling Loop**
    - A levelling loop involves moving between multiple points and returning to the starting benchmark to check for closure and eliminate any errors. It ensures that elevations calculated are consistent and accurate.

Equipment Used and Specifications

1. **Automatic Level**
   Automatically adjusts for small tilts (collimation errors) within ±20' using a compensator, maintaining accuracy without the need for centering, only requiring leveling.
   - Used to measure elevation differences accurately, with adjustments required for:
     - *Circular Bubble:* Ensures the telescope's line of collimation is horizontal when the bubble is centered.
     - *Two-Peg Test:* Detects collimation errors by verifying the level's accuracy over a set distance.
2. **Levelling Staff**
   - Made of wood, metal, or glass fiber and marked in meters and centimeters. Typically, alternating meter sections are colored in black and red on a white background, enhancing visibility for readings.
   - Marked in meters and centimeters with alternate black-red meter lengths on a white background; smallest graduation: 0.01 m; readings taken to the nearest millimeter for accuracy. Telescopic or socketed in 3-4 sections for portability.

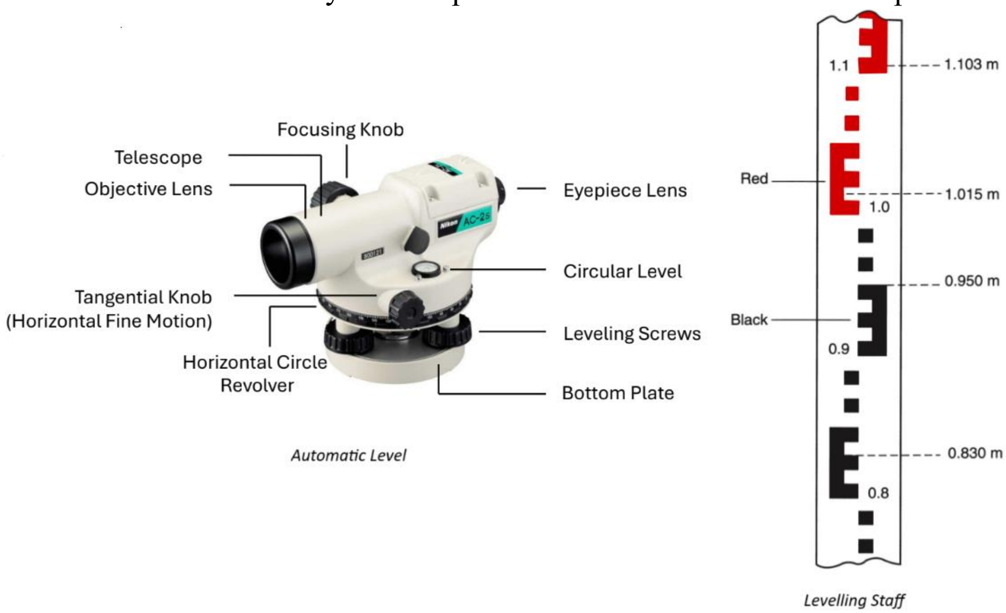

Figure 1 automatic level and levelling staff

Methodology and Procedure

1. Conducted levelling to determine reduced levels of control points P1, P2, etc., to create a closed level loop.
2. Starting from a benchmark (BM) near the geoinformatics lab (Western Labs) with an elevation of 128.409 m, the levelling process was carried out by transferring height to control points P1, P2, and others.
3. Used the *height of collimation* and *rise-and-fall* methods for transferring heights and returned to the starting benchmark to verify and calculate misclosure.

Precautions

1. Ensure control points are visible from at least two angles to determine global coordinates accurately.
2. Maintain intervisibility between control points; avoid locations with obstructions like buildings or trees.
3. Place tripods on firm ground, pressing legs securely into the soil to prevent sinking or movement.
4. Avoid touching or leaning on the tripod during observation to maintain stability.
5. Use a staff bubble and plumb-bob to keep the levelling staff strictly vertical.
6. Confirm all staff joints are properly secured, and staff faces are aligned for accurate readings.
7. Review and record readings carefully to prevent booking errors.

Sources of Error

1. **Observational Errors**
   - Staff reading errors due to tilting or inversion (when using a tilting level), inexperience, or poor sight conditions. Maintain sight distances within 25–30 m for accuracy.
2. **Instrumental Errors**
   - Misalignment of the circular bubble or residual compensator errors in the automatic level. Align the circular bubble carefully to minimize error.
3. **Natural Errors**
   - Curvature and refraction can impact readings. To minimize, ensure equal observation distances for backsight and foresight.
   - Wind may cause vibrations in the instrument or staff. In windy conditions, keep staff short and use a windbreak.
   - Heat shimmer in hot climates can distort staff readings; conducting levelling in the morning or evening is preferable.

By adhering to these procedures and precautions, we completed levelling for Week 2 to accurately determine the reduced levels for each control point.

Calculations:

Methods of Booking in Levelling

1. Rise-and-Fall Method:

- Start from a known Benchmark (BM).
- For each instrument setup, subtract *BS* from *FS* to find rises and falls.
- Calculate the reduced levels (RL) by subtracting FS from the previous BS.
  For first few readings from the below table
  RL of BM= 128.409m, Backsight reading (B.S)= 0.99m (using levelling staff)
  FS(by turning auto level from this change point A)= 1.32m
  RISE- if value decreases (BS-FS=negative) , Fall if value increases(BS-FS= positive)
  BS-FS= 0.33 fall
  RL of fore sight point A'= RL(at BS)- fall = 128.079m

  If Rise than value will be added

The data is tabulated below

- Perform checks:

$$Sum\ of\ RISE - \ Sum\ of\ FALL = 0.642 - 0.631 = 0.011$$

$$Last\ RL - First\ RL = 128.42 - 128.409$$

$$= 0.11$$

$$Sum\ of\ RISE - \ Sum\ of\ FALL = Last\ RL - First\ RL$$

Check is successful

2. Height of Collimation Method:

- Start from a known BM.
- Add *BS* to the instrument setup RL to find the *Height of Instrument (HPC)*.
- Subtract each *FS* from HI to find RLs.
- For first reading in the below table

  RL of BM= 128.409m, Backsight reading (B.S)= 0.99m (using levelling staff)
  HI= RL+BS= 128.409+0.99= 129.399m (Height of instrument at change point A)
  By turning auto level on the other side and take fore sight reading (say for point A')
  FS= 1.32m
  RL of foresight point (A') = HI- FS= 129.399-1.32= 128.079m

  Now remove instrument from here and move to change point B
  From here taking BS of point A' =1.32m
  HI= RL (of backsight point A') + BS= 129.399m
  FS (say for point B')= 1.357m
  RL of B'= HI of B- FS of B' = 129.399-1.357= 128.042m
  Follow this procedure for complete loop the table is given below

- Perform checks:

$$Sum\ of\ BS - \ Sum\ of\ FS = 10.27 - 10.259 = 0.011$$

$$Last\ RL - First\ RL = 128.42 - 128.409 = 0.011$$

$$Sum\ of\ BS - \ Sum\ of\ FS = Last\ RL - First\ RL = Sum\ of\ RISE - \ Sum\ of\ FALL$$

Check is correct

CP	Back Sight (B.S	Fore Sight (F.S.	I.S	HI	RL(m)	Upper stadia(US	LS	REMARKS	(US-LS)x100 (m	Rise (m)	Fall (m)	RL(m)
	0.99			129.399	128.409	1.14	0.843	Change point A	29.7			
		1.32			128.079	1.46	1.18		28		0.33	128.079
	1.32			129.399		1.41	1.27	Change point B	14			
RL of P1		1.357			128.042	1.415	1.297		11.8		0.037	128.042
	1.195			129.237		1.32	1.07	Change point C	25			
PL of P2		1.342			127.895	1.5	1.185		31.5		0.147	127.895
	1.371			129.266		1.511	1.231	Change point D	28			
		1.289			127.977	1.412	1.167		24.5	0.082		127.977
	1.284			129.261		1.357	1.212	Change point E	14.5			
RL of P3		1.305			127.956	1.383	1.228		15.5		0.021	127.956
	1.44			129.396		1.523	1.352	Change point F	17.1			
RL of P4		1.29			128.106	1.415	1.17		24.5	0.15		128.106
	1.15			129.256		1.24	0.981	Change point G	25.9			
		1.246			128.01	1.385	1.105		28		0.096	128.01
	1.52			129.53		1.664	1.39	Change point I	27.4			
		1.11			128.42	1.27	0.948		32.2	0.41		128.42
Sum (in m)	10.27	10.259							377.6	0.642	0.631	

Table 1 levelling calculations and data

Quality of Work:

Misclosure(M) = Computed RL of BM − Known RL of BM= 0.011m

• Distance Based
k = Distance levelled (in km)
c = Constant (2 to 12 mm, based on desired accuracy)
Tolerance mm = c k^(1/2)
k= 377.6m= 0.3776km

if we use c=18
then misclosure 11mm< c k^(1/2)= 11.06mm

thus **c=18** , which shows quality of work from the table between **Accurate to Ordinary**

Quality of Work

Misclosure Error	$\leq$	Closure Tolerance
$Misclosure = H_{BM} - BM$	$\leq$	$Tolerance\ (mm) = c\sqrt{k}$

Quality of Work	Purpose	c
Highest	Geodetic leveling, special surveys	1
Precise	Geodetic leveling, widely distributed benchmarks	4 (5)
Accurate	Principal benchmarks, extensive surveys	12 (10)
Ordinary	Construction, location surveys	24 (25)
Rough	Reconnaissance, preliminary surveys	100

Figure 2. levelling quality

Corrected Reduced level calculations:
We have RL of each point from the table we need to find corrected RL
Using Upper stadia and lower stadia values
How the closing error can be distributed/adjusted?
We need to find di for all P1-P4 for this add the (US-LS)x100 till each point, this will give cumulative di for each point

• Based on Distance
Distribute error correction based on distance leveled di
. $C = -\frac{d_i(M)}{\sum d_i}$

$\sum$di= 377.6m
M= 0.011m
d_1 for P1 (distance from BM to P1)= 29.7+28+14+11.8= 83.5m

$$\text{C(correction in P1 RL)} = \frac{83.5 \text{ x } 0.011}{377.6} = 0.002432\text{m}$$

Adjusted elevation at CP P1
$\overline{H_i}$
$= H_i + C_i$

RL of P1= 128.042
C_i should be negative as final RL(128.42m) is greater than actual BM (129.409m)
$\overline{H_1} = $ 128.042-0.002432 $=$ 128.0396m

d_2 for P2 (distance from BM to P2) = 29.7+28+14+11.8+25+31.5=140m

$$\text{C(correction in P1 RL)} = \frac{140 \text{ x } 0.011}{377.6} = 0.004078\text{m}$$

RL of P2= 127.8909m

The remaining RLs are shown in table

Point		RL in m	distance (di in m	correction	corrected RL in m
P1		128.042	83.5	0.00243246822	128.0395675
P2		127.895	140	0.004078389831	127.8909216
P3		127.956	222.5	0.006481726695	127.9495183
P4		128.106	264.1	0.007693591102	128.0983064
sum di	377.6m				
misclosure	0.011m				

Table 2: Corrected RL

Week 3,4 Traversing:

Traversing:

Traversing involves creating a network of connected lines by measuring angles and distances, forming a precise control framework.

Why Traversing?

Traversing is essential in surveying for creating accurate control points, which are crucial for map-making and other geospatial tasks.

Equipment

1. **Digital Theodolite (Total Station):** Measures horizontal and vertical angles.

Key Terms

- **Angle Measurement:** Determines internal/external angles of a polygon.
- **Whole Circle Bearing (WCB):** Angle measured clockwise from the North, ranging from 0° to 360°.
- **Reduced/Quadrantal Bearing (RB/QB):** Angle measured from North/South in a particular direction, limited to 0° to 90°.

Procedure for Traverse Establishment and Measurement

1. **Station Setup at P1:**
    - Set up the total station on a tripod at P1. Level and center the instrument by adjusting the bubble and aligning with P1 iteratively.

2. **Sighting and Measuring Distance to P2:**
   - Place a reflector prism at P2, set the total station's horizontal angle to 0°, and measure the distance from P1 to P2.
3. **Measuring Internal Angles:**
   - Move to P4, sight back on P1, and measure the horizontal angle to capture ∠P4P1P2. Repeat for all internal angles of the quadrilateral.
4. **Measuring Side Lengths:**
   - Measure the horizontal distances between each pair of stations (P1-P2, P2-P3, P3-P4, and P4-P1) to complete the quadrilateral measurements.

Internal angle correction and Misclosure-

Convert angles to degree

Internal angle at P1= 79° 54'01"= 79+ (53/60) +(01/3600)= 79.8836°

P2= 105.57944°

P3= 84.8061°

P4=89.73444°

Sum of internal angles= $\sum\theta_i$= 360.00358°

Angle misclosure(M)= $\sum\theta_i$- (n-2)x180°

= 360.00358°-360°= 0.00358 ° or 13"

$$\text{Correction}(C) = \left(\theta_{\mathrm{i}}/\sum\theta_{\mathrm{i}}\right) * M = \frac{\text{internal angle of station i}}{\text{sum of internal angles}}\text{x Misclosure}$$

Corrected angle= measured angle- correction

For P1

$\text{Correction}(C) = (79.8836/360.00358) * 0.00358$= 0.0007943901225 °

Corrected angle =79.8836 ° - 0.0007943901225°= 79.88280561 °

For P2, Corrected angle= 105.5783901 °

For P3

Corrected angle =84.80525666°

For P4, Corrected angle = 89.73354765°

For Whole circle bearing,

Choose P1P2 in N direction WCB P1P2= 0°

For P2P3=180°- angle P1= 74.42160992°

WCB P3P4= WCB_P2P3+ 180- angle P3= 169.6163533°

WCB_P4P1= WCB_P3P4 +180- angle P4= 259.8828056°

By this figure we can tabulate all WCB

We have length of all sides from traversing
Calculate Latitude and departure of each line
Latitude= Acos θ
Departure = Asin θ
θ = WCB of each line

For p1p2
θ = 0
A= 78.876m
Latitude= 78.876m
Departure = 0m

Traverse perimeter= 78.876m
Total latitude misclosure= $\sum$ L =-0.002300018164m
Total departure misclosure= $\sum$ D =-0.02754638825m

$$ClosingError = sqrt\left(\sum L^2 + \sum D^2\right) = 0.02764224284$$

Direction of closing error
$tan\theta = (\sum D \,/\, \sum L) = 11.97659596$

$$\text{Relative Precision} = \frac{\text{Closing error}}{\text{Traversing perimeter}} = \frac{0.02764224284}{258.131} = 0.0001070861029$$

		angle		correction	corrected angle			
P1		79.8836	0.000794390122	0.000794390122	79.88280561			
p2		105.57944	0.001049918435	0.001049918435	105.5783901			
p3		84.8061	0.000843341163	0.000843341163	84.80525666			
p4		89.73444	0.000892350279	0.000892350279	89.73354765			
sum		360.00358						
misclosure	0.00358							
	360.00358							
line	WCB	Length	latitude	correction	corrected	departure	correction	corrected
p1p2	0	78.876	78.876	-0.00070280684	78.87670281	0	-0.00841723357	0.008417233574
p2p3	74.42160992	41.779	11.22002331	-0.00037226237	11.22039557	40.24420353	-0.00445843604	40.24866197
p3p4	169.6163533	81.624	-80.28724001	-0.00072729227	-80.28651272	14.71177987	-0.00871048574	14.72049036
p4p1	259.8828056	55.852	-9.811083314	-0.00049765667	-9.810585657	-54.98352979	-0.00596023289	-54.97756956
Σ		258.131	-0.00230001816		0	-0.02754638825		0
tanθ	11.97659596							
closing error	0.02764224284							
relative precision	0.000107086102							
X	9338.279875							

Table 3: Gale’s table

Traverse Adjustment

Bowditch’s Rule

• Correction to Latitude of side i

$$C_i = \frac{S_i}{\sum S_i} \times \text{Total Latitude Misclosure}$$

Corrected Latitude = Measured Latitude – Correction

• Correction to Departure of side i

$$C_i = \frac{S_i}{\sum S_i} \times \text{Total Departure Misclosure}$$

Corrected Departure = Measured Departure – Correction

For P1P2

$$\text{C1} = \frac{78.876}{258.131} \text{x}(-0.002300018164) = -0.000702806841$$

Corrected Latitude = 78.876–(-0.000702806841)= 78.87670281m

Corrected departure= 0- (-0.008417233574) = 0.008417233574

Similar calculations for all lines are given in table 4

Quality of traverse

For angles

Angle Misclosure= 0.00358 °= 13’

n= no. of stations=4
Tolerance= 15x2=30"
13<30
C =15,
So the Quality between first and second order, close to **first order**

For distances

From previous calculations Relative precision= 0.0001070861029
writing in1/X form
Qualtity = 1/ 9338.279875

Quality is around 1/10000
Close to **second order**

Tolerance for angle misclosure,Tolerance (")=c√n

Tolerance for relative precision,Tolerance(e/p)=1:X

Quality of work	Permissible limit of closing error
First order	6 √n"
Second Order	11√n"
Third Order	30√n"

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

Figure 2: Quality of traverse standards

Finding Local coordinates:

We can assume coordinates of point P1 (100,100)
Now add latitude and departure value to find local coordinates of all points
For point P2
Latitude= 78.87615771(in y direction)
Departure= 0.008729171762
So coordinates of P2= (100+ 0.008729171762, 100+78.87615771)= (100.0087292, 178.8761577)

for all points calculations are given in table

		latitude	departure				
		78.87615771	0.008729171762				
		11.21323545	40.2507423				
		-80.28732384	14.71946496				
		-9.802069308	-54.97893643				
point		X(departure)	Y(latitude)			Global X	Global Y
P1		100	100				
P2		100.0087292	178.8761577			423540.153	2932776.431
P3		140.2594715	190.0893932			423581.772	2932773.667
p4		154.9789364	109.8020693				
p1		100	100				

Table 4: Local coordinates of each point

Transform Local coordinates to global coordinates :

Step 1: Define Known Points

Given:

1. Global Point 1 (for Control Point P1): (NG1,EG1)=(423540.153,2932776.431)
2. Global Point 2 (for Control Point P2): (NG2,EG2)=(423581.772,2932773.667)
3. Local Point 1 (for Control Point P1): (NL1,EL1)=(100,100)
4. Local Point 2 (for Control Point 2): (NL2,EL2)=(100.0087292,178.8761577))

Step 2: Set Up the Affine Transformation Equations

The affine transformation equations to convert local coordinates (NL,EL) to global coordinates (NG,EG)are:

$$N_G = S \cdot \sin(\theta) \cdot N_L + S \cdot \cos(\theta) \cdot E_L + T_N$$

$$E_G = S \cdot \cos(\theta) \cdot N_L - S \cdot \sin(\theta) \cdot E_L + T_E$$

Representing above equation in matrix form as A X =L

Representing above matrix in form $Ax = L$ — (1)

$$\underbrace{\begin{bmatrix} N_L & E_L & 1 & 0 \\ E_L & -N_L & 0 & 1 \end{bmatrix}}_{\substack{\text{Transformation matrix} \\ (A)}} \underbrace{\begin{bmatrix} S\cos\beta \\ S\sin\beta \\ T_N \\ T_E \end{bmatrix}}_{\substack{\text{unknowns} \\ (x)}} = \underbrace{\begin{bmatrix} N_G \\ E_G \end{bmatrix}}_{\substack{\text{Observations} \\ (L)}}$$

No. of unknowns $(x) = 4$

No. of equations from one point $= 2$

we need 2 points to get the solution

solution is given by $x = (A^TA)^{-1}A^TL$ — (2)

	Local coordinates	Global
P_1:	(100 , 100)	(unknown
P_2	(100.0087 , 178.87616)	(423540.153 2932776.431)
P_3	(140.2594715 , 190.0893932)	(423581.772 , 2932773.667)
P_4:	(154.9789364 , 109.8020693)	unknown

$$A = \begin{pmatrix} 178.8761577 & -100.0087292 & 1 & 0 \\ 100.0087292 & -178.8761577 & 0 & 1 \\ 190.0893932 & 140.2594715 & 1 & 0 \\ 140.2594715 & -190.0893932 & 0 & 1 \end{pmatrix}$$

$$L = \begin{pmatrix} 2932776.431 \\ 423540.153 \\ 2932773.667 \\ 423581.772 \end{pmatrix}$$

solving these using equation (2) in excel

gives $x = \begin{pmatrix} 0.941772 \\ -0.331033 \\ 2932641.076 \\ 423386.7536 \end{pmatrix}$

by putting this in eq (1) we can get for all points.

Figure 3: calculations for coordinate transformation

A		178.8761577	100.0087292	1	0	for point 2		L(4*1 matrix)	2932776.431		
		100.0087292	-178.8761577	0	1				423540.153		
		190.0893932	140.2594715	1	0				2932773.667		
		140.2594715	-190.0893932	0	1				423581.772		
A_T		178.8761577	100.0087292	190.0893932	140.2594715	for point 3					
		100.0087292	-178.8761577	140.2594715	-190.0893932						
		1	0	1	0						
		0	1	0	1						
A_T *A		97805.12244	0	368.9655509	240.2682006	inv(A_T *A)		0.001145567946	0	-0.2113375542	-0.1376217746
		0	97805.12244	240.2682006	-368.9655509			0	0.001145567946	-0.1376217746	0.2113375542
		368.9655509	240.2682006	2	0			-0.2113375542	-0.1376217746	56.02120662	0
		240.2682006	-368.9655509	0	2			-0.1376217746	0.2113375542	0	56.02120662
inv(A_T* A)*A_T		-0.00642276155	-0.02305498009	0.006422761552	0.02305498009	X		0.9417727036			
		-0.02305498009	0.006422761552	0.02305498009	-0.00642276155			-0.3310328781			
		4.454578169	3.481654035	-3.454578169	-3.481654035			2932641.076			
		-3.481654035	4.454578169	3.481654035	-3.454578169			423386.7536			
A forP1		100	100	1	0		L for P1		2932702.15		
		100	-100	0	1				423514.0342		
A for P2		178.8761577	100.0087292	1	0		L for P2		2932776.431		
		100.0087292	-178.8761577	0	1				423540.153		
A for P3		190.0893932	140.2594715	1	0		L for P3		2932773.667		
		140.2594715	-190.0893932	0	1				423581.772		
A for P4		109.8020693	154.9789364	1	0		L for P4		2932693.182		
		154.9789364	-109.8020693	0	1				423569.0566		

Table 5: Global coordinate transformation

Use code for confirming the coordinates

Colab link for code-
https://colab.research.google.com/drive/1YRUbS7WKW3MG3KNxRiGyEilzVWNfaYPS

Feature Mapping Process Using Total Station :

Step 1: Set Up the Total Station and Reflector

- **Positioning**: Mount the total station on a stable tripod at a known reference point (station point).
- **Leveling**: Align the total station horizontally using its built-in leveling tools.
- **Calibration and Coordinates**: Calibrate the total station by entering the known coordinates for the starting point or using a backsight for orientation.

Step 2: Prepare the Reflector and Assign Roles

- **Team Roles**: Assign one team member as the total station operator and another to handle the reflector or prism pole.
- **Place the Reflector**: Position the reflector at each feature to be mapped (e.g., building corners, tree locations, road edges).

Step 3: Use Autolock and Laser Functions on the Total Station

- **Activate Autolock**: Engage the autolock feature to ensure the total station continuously tracks the moving reflector.
- **Distance Measurement with Laser**: Use the laser tool to measure the distance to each feature point, ensuring high accuracy even over long distances or uneven terrain.
- **Record Data**: The total station captures horizontal and vertical angles, along with the distances to the reflector when the autolock function is active.

Step 4: Collect Data at Feature Points

- **Place the Reflector**: Position the reflector at each feature point.
- **Collect Coordinates**: The total station records the (x, y, z) coordinates of each feature point. Review measurements and recheck if necessary to confirm accuracy.

Step 5: Take Additional Measurements as Required

- **Manual and Laser Measurements**: For features with irregular shapes or uneven surfaces, use a laser distance meter or measuring tape to gather additional data on lengths, widths, or heights.
- **Record Additional Measurements**: Manually note any extra measurements for specific features that require them.

Step 6: Transfer Data for Lab Mapping

- **Data Transfer**: Move the recorded data to a pen drive and use Excel for further analysis and lab mapping.

Map making using QGIS (Quantum Geographic Information System) :

Step 1: Open QGIS and Create a New Project
Launch QGIS and create a new project by selecting **Project > New** from the menu.

Step 2: Import CSV Files
Navigate to **Layer > Add Layer > Add Delimited Text Layer** to import your CSV files for "all points" and "ground points." Choose the appropriate X and Y fields for each file, then click **Add** to display the points on your map.

Step 3: Customize the Map's Appearance (Symbology)
Right-click each layer, select **Properties**, and go to the **Symbology** tab to modify the appearance. You can choose different colors or symbols for each feature (e.g., roads, buildings, trees, and points). For contour lines, use **Raster > Extraction > Contour** if you have the necessary data.

Step 4: Add Labels
To label a layer (e.g., buildings), right-click the layer, go to **Properties > Labels**, and choose **Single Labels**. Select the field (e.g., feature name) to be displayed as a label, and adjust the font and color for clarity.

Step 5: Set Up the Map Layout
Select **Project > New Print Layout** to create a layout and give it a name. In the layout view, use **Add Map** to position your map, and then add additional elements such as a title, legend, north arrow, and scale bar.

Step 6: Export or Print the Map
Once your map layout is complete, go to **Layout > Export as PDF** or **Export as Image** to either print or save the final map for sharing.

This process will produce a finished map with points, labeled features, and contours, ready for printing or sharing.

Final map

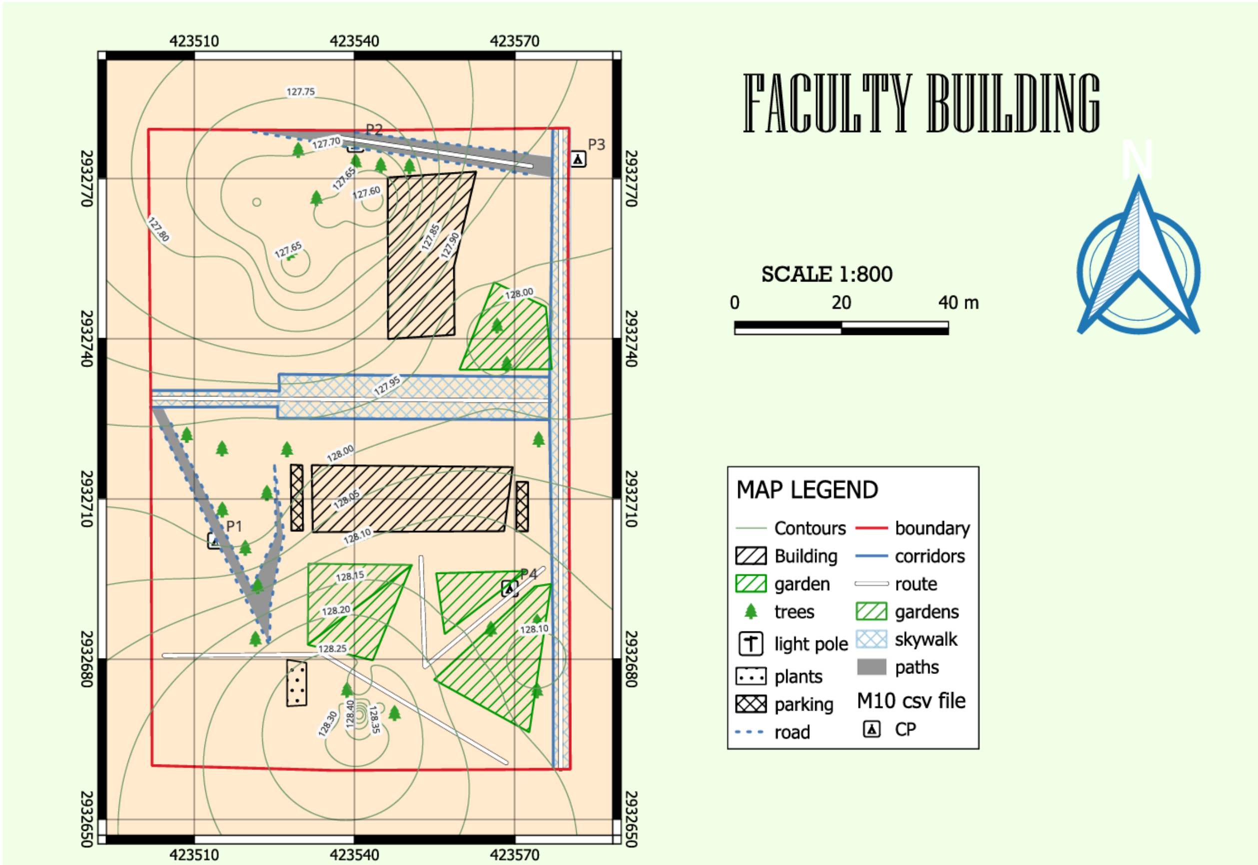

Figure 4: final map of area

Conclusions

The map-making and surveying process successfully established control points and accurately determined global coordinates using various techniques, including levelling and affine transformation. Feature mapping with a total station ensured precise data collection, while QGIS facilitated detailed map creation. The final map, incorporating labeled features and contours, serves as an accurate representation of the surveyed area for further analysis and presentation.

References

1.National Geospatial-Intelligence Agency. (2022). Map Numbering and Scale Systems. NGA Handbook, Chapter 3, pp. 45-50.
2. Engineering Surveying by W. Schofield and M. Breach, Elsevier/ButterworthHeinemann
3. Lab slides given by TAs
4. Wikipedia