CHAPTER 2:

TRAVERSING

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LIST OF ABBREVIATIONS

D-Card	Description Card
E	Easting
EDM	Electronic Distance Measurement
KUBH	Kathmandu University Boys Hostel
m	Meter
N	Northing
RL	Reduced Level
RO	Reference Origin

1. INTRODUCTION

1.1 Background

Traversing is a method in the field of surveying carried out to establish control networks. It is the technique of establishing horizontal control points in the dense and narrow area where second order triangulation is not possible. Traverse networks involve placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point.

Traversing has a wide application on various fields of geospatial survey procedure. Some of the main purpose of traversing incorporates determining existing boundary lines, calculation of area within the boundary, establishing control points for photogrammetric surveying and mapping, establishing control points for calculating earthwork quantities and so on (Punmia et al., 2005).

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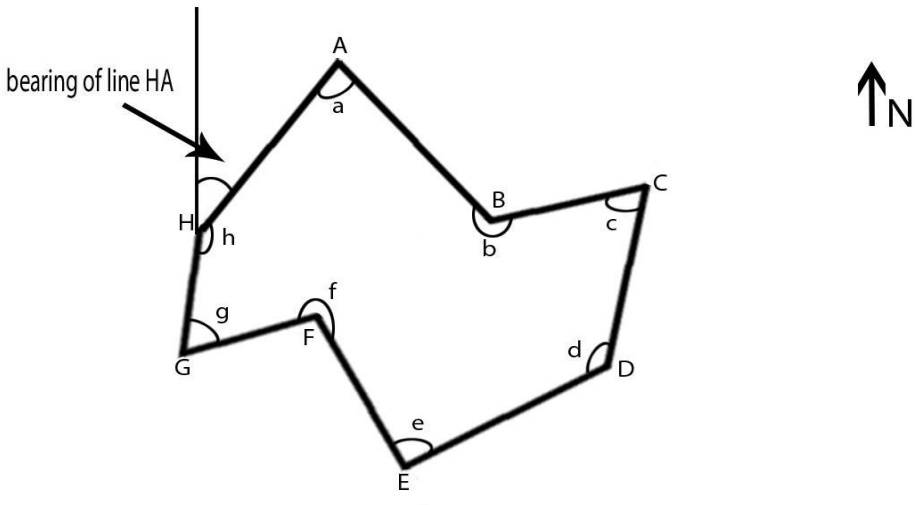

Figure 1. Traverse Loop

This project was carried out on the geographically diversified topographical land in the Kathmandu University premises, Dhulikhel, Kavre. A widely distributed seven number of closed loop traverse stations were carefully chosen whose geographical coordinates were established following the procedure of traverse. For a group of 5 members, we were provided with J2-2 Transit Theodolite for carrying out Theodolite Traverse. Linear

measurements were carried out using EDM under the supervision of faculties of the Department.

This project became a productive approach for us as the students of Geomatics Engineering as it helped us in broadening the practical understanding of Control Survey.

1.2 Objectives

The key objective of levelling was

- To establish control points for tacheometric surveying by the method of traverse.

The secondary objectives achieved during the accomplishment of traverse are pinpointed below:

- Determination of topographical diversification of area area.
- Performing trigonometric levelling in order to determine RL of stations.
- Setting up monuments and preparation of D-Cards of monuments.

1.3 Scope

The course of traverse was basically focused on establishing control points. It dealt with the scope of determining cultural features of the traverse stations (i.e. (x, y, z) coordinates). The monumentation used for stations were of temporary nature (wooden pegs were used). So, permanent monumentation of control point is not under the scope of the project. Furthermore, the preparation of D-Cards for the established monuments was incorporated under the scope of the project. And, the traverse was carried out following the fourth order specifications, so the accuracy greater than fourth order was not embraced under the scope of work.

2. METHODOLOGY

2.1 Theoretical Framework

Traversing is based on the principle that if the length and direction of a line is known then the coordinates of its head can be derived from the known coordinates of its tail.

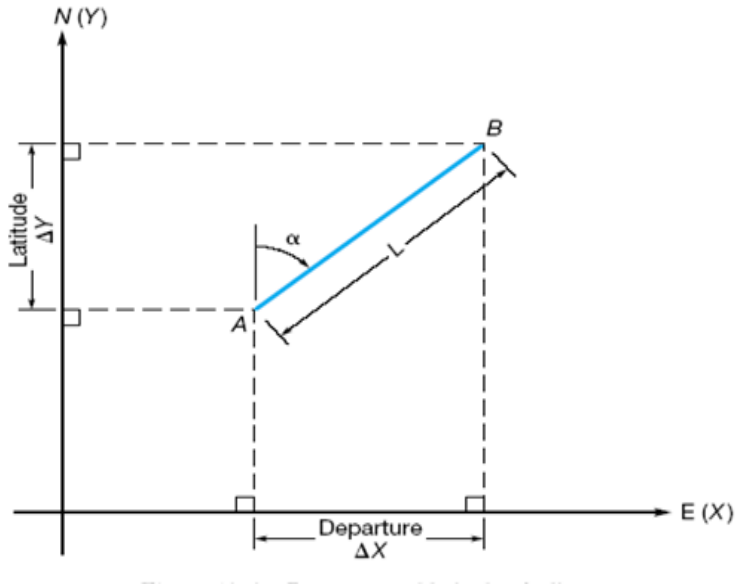

Figure 2. Departure and latitude of a line

Here,

Latitude is given by, Latitude(ΔN) = L cosα

and, Departure(ΔE) = L sinα

As according to the principle, if the coordinates of point A is known, i. e. A (E1, N1) then, the unknown coordinates of B (E2, N2) can be computed as;

E2 = E1+ ΔE and N2= N1+ ΔN.

On the basis of starting and ending points, traverse is classified into two sorts:

1) Closed Traverse: It starts either from known station and ends to same station or another known station. Closed traverse has more check and is accurate. It is itself linear and angular check.

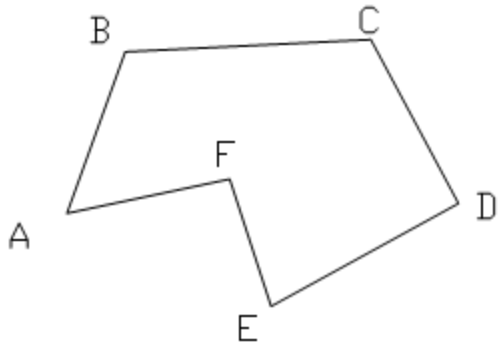

Figure 3. Closed Traverse

2) Open Traverse: It starts either from known or unknown station and ends to another unknown or known station. Checks are only possible by additional observation. It has no check itself.

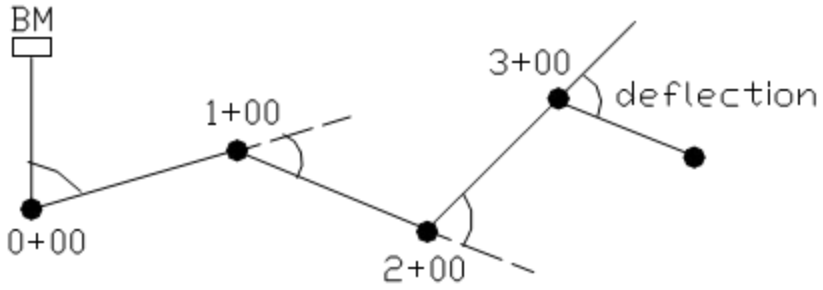

Figure 4. Open Traverse

Basic terms related to Traverse:

- Control Points: They are the points located on the ground by precise surveying that when identified on aerial photographs provides the control necessary for producing a photomap.
- Latitude: A latitude of a line is its projection in North-South Meridian.
- Departure: A departure of a line is its projection in East-West Line.
- Bearing: The bearing of a line is the horizontal angle which it makes with a reference meridian.
- Meridian: The fixed reference line about which bearing is measured is called meridian.

- Collimation Error: If the axis of telescope is not parallel to the line of collimation, the error introduced is called collimation error.
- Index error: When the telescope of the properly setup theodolite is exactly horizontal, the zenithal reading must read (90°00′00") in face left observation and (270°00′00") in face right observation and on summing them up, it must results 360°. If certain deviation is observed in this case, the discrepancy is called Index error.
- Closing Error: When first point of traverse doesn't coincide with last point then an error appears which is called closing error.

(Punmia et al., 2005) (Agor, 2018) (Duggal, 2013)

2.2 Study Area

Triangulation was carried out in Kathmandu University premises, Dhulikhel, Kavrepalanchowk District. A number of seven traverse stations were established in this geographically diversified premises.

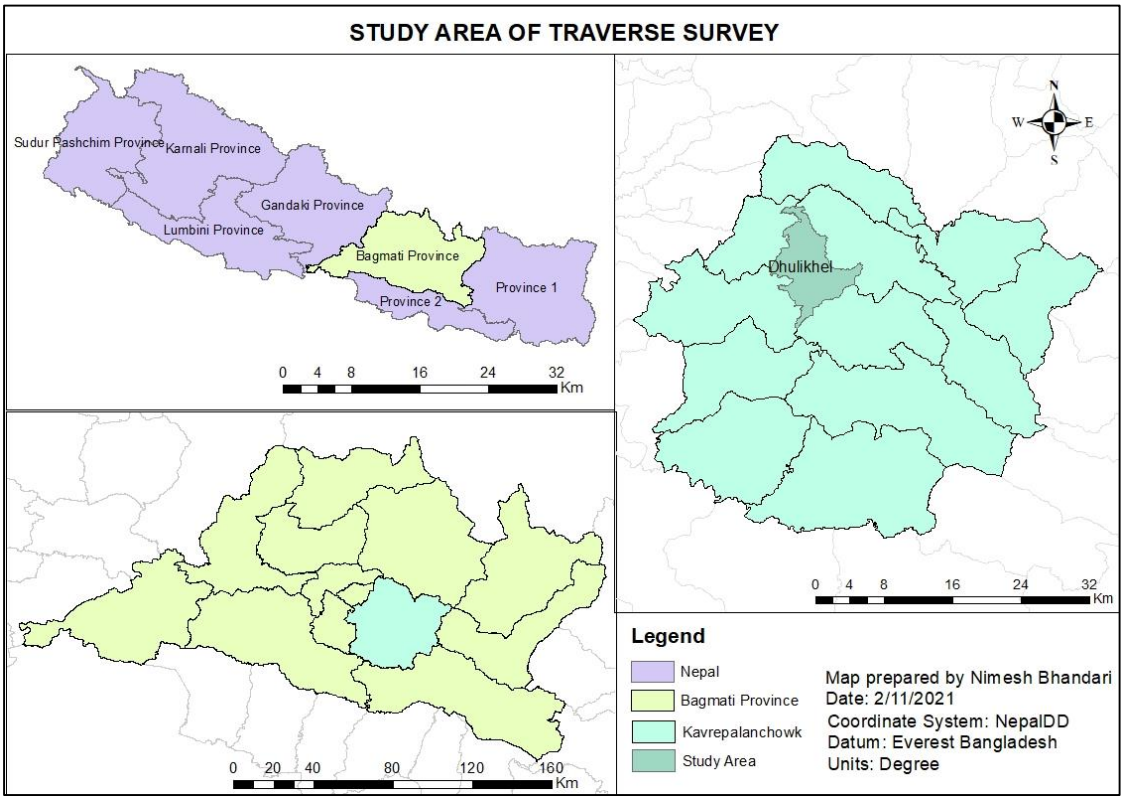

Figure 5. Study Area of Traverse

2.3 Specifications

i) Order of Work: Fourth order

ii) Method: Closed Traverse

iii) Numbering: 1001-1007

iv) Working hours: Whole day

v) Angular measurement direction: Clockwise

vi) Measurement Unit: Angular (Degree, minutes, seconds), Linear (Meters)

vi) Number of sets taken: 3

vii) Face to Face tolerance: 2 cg

viii) Set to Set tolerance: 60 ccg

ix) Index error: 5 cg

x) Angular Accuracy = $k\sqrt{n}$ (n=number of traverse station)

xi) Method of angular misclosure adjustment = Average Adjustment Method

xii) Method of linear misclosure adjustment = Bowditch rule

xiii) Method of vertical misclosure adjustment = Average Adjustment Method

2.4 Study Method and its Workflow

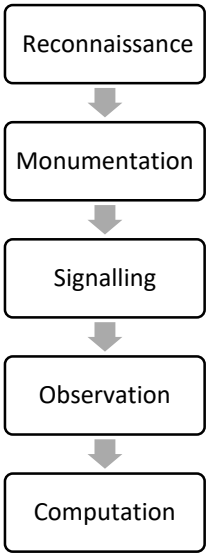

Figure 6. Methodological Flow Diagram

A) Reconnaissance

Reconnaissance is fundamentally the first field operation and prominent stage. In this phase, we fully inspected the field (KU Area) to be surveyed with the faculties of the department. We marked the position of stations on the ground. Similarly, minor bushes and branches were cut down for intervisibility of the marked stations.

B) Monumentation

We marked the selected stations on the ground with the wooden pegs around the permanent witness structure so that, they could be recovered at any time during the project period.

C) Signalling

Not all the monuments we've marked on the stations were visible from adjacent stations. For solving this deficiency, we used ranging rods erected vertically above the center of the stations as a signal during traverse.

D) Observation

Altogether, 7 stations were established in the project site initiating from 1001 and ending at 1007.

In each station, four different types of observation were made in theodolite traversing viz.

i) Horizontal Angle

ii) Vertical Angle

iii) Distance of leg

For the angular measurement, following procedures were followed:

- Setting up a tripod at a convenient height for observer.
- Setting up the theodolite followed by centering with optical plummet.
- Levelling up initially with circular bubble followed by levelling with plate level.
- Cross Hair Focusing.
- Image Focusing.
- Sighting towards the target.

i) Horizontal Angle

We carried out a tertiary traverse where three sets of horizontal angle reading were taken for each station. For the first set, the RO was set to 0°10'00". Similarly, for the second

and third set of reading, the RO was set to 60°10’00” and 120°10’60” respectively. Three different sets of reading were taken to eliminate graduation error. The permissible misclosure for set-set reading was 60ccg.

And, in each set, two face readings were taken; left face reading and right face reading. This was done by swinging the theodolite clockwise followed by transiting, to change the orientation of vertical circle in theodolite. Two faces reading was taken to eliminate the collimation error from theodolite. The permissible misclosure for face-face reading was 2cg.

ii) Vertical Angle

We actually observed the zenithal angle in the field using transit theodolite. Zenithal angle is preferred over vertical angle. Also, vertical angle is the compliment of zenithal angle and hence we can easily derive vertical angle. In the field, we had only taken a single set of reading and that set includes both left face and right face readings. Only single set of reading was taken. Vertical Angle is measured to determine the RL of traverse stations. The permissible misclosure for Index Error is 5cg.

iii) Distance

For the distance measurement, EDM was carried out used under the supervision of faculties.

Furthermore, we followed the anticlockwise path for taking observations in the closed loop of traverse stations.

E) Computation

i) Computation of (x, y) coordinates

In each station, the average of three horizontal angles obtained from three set of readings were calculated, which is the horizontal angle of those particular stations.

Having 7 stations in a closed traverse, the sum of traverse angles must have been

$$(2n-4) * \text{right angle} = ((2*7)-4) *90°$$

$$=900° \quad \text{where, n is the no. of stations}$$

However, due to existence of some systematic errors, natural errors and random errors, the sum of interior angles was found out to be 900°00’09”, with angular misclosure 000°00’09” which is within the permissible misclosure 0°0’10.51’” given by

$$C = k\sqrt{n} = 66\sqrt{7}$$

Where, n is the number of angles and k is a fraction of the least count of transit theodolite.

The misclosure was adjusted by the technique of *Average Adjustment* in each station angles.

Since, we were provided with the bearing of traverse leg 1001-1002 i.e. 260°00'00", we easily calculated the departure (ΔE) and latitude (ΔN) of each traverse legs. However, the angular error obtained in the latitude and departure was corrected by applying *Bowditch Method* in each legs.

For instance, the (ΔE, ΔN) (before adjustment) of leg 1002-1003 was (-46.118, 96.433). But we'd the angular error in departure and latitude, 0.294 and 0.005 respectively.

And perimeter of traverse was 687.017 m, having the length of leg 1002-1003, 106.893m.

According to Bowditch adjustment method, we proceed the adjustment as follows:

$$\text{Adjustment in Latitude of 1002} \frac{\text{Latitude misclosure} * \text{Length of } 1002 - 1003}{\text{Perimeter of Traverse}}$$

$$= \frac{0.005 * 106.893}{687.017} = 0.001$$

Therefore, the adjusted ΔN is 96.432.

Similarly,

$$\text{Adjustment in Departure of 1002}$$

$$= \frac{\text{Departure misclosure} * \text{Length of } 1002 - 1003}{\text{Perimeter of Traverse}}$$

$$= \frac{0.294 * 106.893}{687.017} = 0.046$$

Therefore, the adjusted ΔE is -46.164 and remaining values were adjusted similarly in succession.

Thus, we obtained corrected values of latitude and departure of each legs. Since, we were also provided with the coordinates of station 1001 (355787.71, 3055740.80), we derived the coordinates of station 1002 as:

$$E \text{ of } 1002 = E \text{ of } 1001 + \Delta E \text{ of } 1001\text{-}1002$$

N of 1002= N of 1001+ΔN of 1001-1002

And subsequently, we derived the coordinates of remaining stations

ii) Computation of RL Elevation

In each station, a single set of Zenithal Reading was taken. Both left and right face readings were taken at each of the adjacent target (staff) from the instrument station and the zenithal angle observed was recorded. For the staff at a station, the sum of zenithal angle observed from the instrument station for left face and right face reading must had been equal to 360°. But due to existence of some systematic errors, natural errors, and random errors, the sum in some cases fluctuated from 360°. But those within the permissible error i.e.5cg were adjusted by *Average Adjustment Method* and was reduced to 360°.

Since we had the zenithal angle of each stations and horizontal distance between two stations, we followed Trigonometric Levelling Procedure to determine RL of stations as shown in figure below.

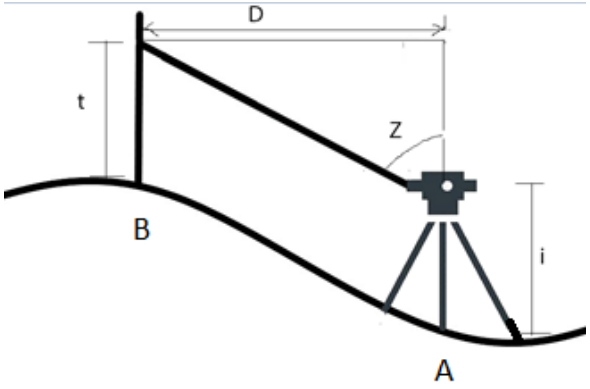

Figure 7. Trigonometric Levelling to Determine RL of a Station

As shown in figure above, the elevation of station B can be computed by using the relation;

$$\text{Elevation of B} = \text{Elevation of A} \pm (\text{D}\cot\text{Z} + \text{i} - \text{t})$$

Where, D = Distance between two stations

i = Instrument Height

t = Height of Target

This technique was implemented for determining RL of Traverse Stations.

2.4.1 Data Used

We've used the self-measured data collected in the field. However, the length of traverse legs, coordinates of station 1001 and bearing of leg 1001-1002 were provided by the faculties of the department.

2.4.2 Instruments Used

- Theodolite: A theodolite is a precision instrument for measuring angles in the horizontal and vertical planes. Horizontal between the stations and Zenithal angles were observed in the field using J2-2 Theodolite.
- Measuring Tape: A measuring tape is a flexible ruler used to measure size or distance and is a ubiquitous measuring tool. We used measuring tape to measure Instrument Height in the field.

2.5 Measures Adopted for Controlling Error during Traversing

i. Proper centering of the theodolite was done using optical plummet to eliminate the possible errors like deviated reading from actual horizontal reading caused by improper centering.

ii. Proper levelling of the instrument was done using circular bubble and plate bubble attached to the theodolite.

iii. Two face reading (face left and face right reading) was taken for each observed stations to eliminate the trouble that might be yield by collimation error. This also helps in diminishing the index error.

iv. Three sets of reading were taken setting RO as (000°10′00"), (060°10′00") and (120°10′00") and mean of the observed angles of each station were taken to minimize the possible errors of unequal graduations.

3. RESULTS

As per out objective, coordinates of the stations were furnished viz.

Table 1. Final Coordinates of Stations determined by Traverse Survey

Station	Easting	Northing	Elevation
1001	355787.710	3055740.80	1454.400
1002	355650.889	3055716.684	1436.818
1003	355604.725	3055813.116	1427.518
1004	355658.249	3055946.442	1432.054
1005	355741.179	3055918.194	1453.217
1006	355784.830	3055897.612	1462.553
1007	355767.511	3055801.382	1461.836

4. LIMITATIONS

Hence, traverse survey was carried out. Besides all the precautions adopted, there are some limitations of our project which are pinpointed below:

i. As the specifications for fourth order survey were implemented, it doesn't provide the accuracy of greater than fourth order.

ii. Due to site conditions, few of the traverse legs were not able to maintain the ratio of 2:1 for longest and shortest legs.

5. CONCLUSION AND RECOMMENDATIONS

Fourth order traverse survey was done for determining the cultural features (x, y, z) of the established stations. Multiple set and multiple face observations were adopted for diminishing probable errors and ensuring the precision of the observed data. From the bearing of a line and the coordinates of a station, coordinates of rest of the station were determined. As a recommendation, it is suggested that, it would have been better, if one or two more stations were established that would aid in taking more details of the topography without the use of offsets.

6. REFERENCES

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