Chapter 1

INTRODUCTION

Surveying is an art of determining the relative positions of point on above or beneath the surface of the earth by means of angular and linear measurements. The main objective of surveying is to prepare plans and maps of areas. Thus the subject emerges out to be the most important before and during all engineering works like civil engineering works such as designing and construction of highways, water supply systems, irrigation projects, buildings etc.

The B.E. Survey Camp 2073, Kirtipur organized by the Survey Instruction Committee, I.O.E, Pulchowk Campus is a part of the four-year Bachelor's degree in Civil Engineering course, third year first semester, carrying a total of 100 marks. The total duration of the survey camp was 10 days, from 11th of Baisakh to 20th Baisakh, 2073.

This is a detailed report of the works performed by group no. 4 during the camp period. It briefly explains the working procedures and technique along with the observations, calculations, and methods of adjustment of error. In addition, it also contain the main problem faced during work and their solution, results of all calculations.

The work done during the camp duration can be categorized into:

1. **Topographical survey**
2. **Bridge site survey**
3. **Road alignment survey**

1.1 Objectives of Survey Camp:

The main objectives of the survey camp are as follows:

- Horizontal control and vertical control survey practices with respect to National grid system and produces topographic map in coordinate system.
- Linear segment survey practice through Road Alignment Survey.
- Practices of horizontal control and vertical control survey surrounding the cross drainage through bridge site survey.
- Analytical resection intersection for the transfer of coordinates through National grid system.

1.2 Location Map:

(See Appendix)

1.3 Project Area:

Tribhuvan University, Kirtipur.

1.4 Location and Accessibility:

Kirtipur is about 12km southern west part from Kathmandu. Iswari Rajmarg and Viswa Vidhyalaya marg links Kirtipur with Kathmandu. Kirtipur was also called Padma Kshetrapuri at ancient time. Kirtipur is assumed to be earth quake resistant area. The area to be surveyed is area under Tribhuvan University. There are regular buses running to and from Kirtipur. Moreover, the Central Campus, Pulchowk has made bus available for various routes. Thus, our project area was quite suitable and easily accessible. The journey from Kathmandu to Kirtipur takes about 20 minutes by bus.

- **Country:** Nepal
- **Development Region:** Central
- **Zone:** Bagmati
- **District:** Kathmandu
- **Municipality:** Kritipur
- **Ward No.:** 3
- **Location:** Tribhuvan University, Kirtipur Campus

1.5 Topography and Geology:

Kirtipur has gently steep topography. The area contains ground features ranging from step slopes to almost flat grounds.

Latitude: 29° 22’ 06” N

Longitude: 84° 55’ 00” E

Kirtipur is situated southern western part of Kathmandu valley and just below the Chandragiri Mountain. The average height of kirtipur is 1414m above the mean sea level; area of kirtipur is about 1400 hectares.

Geology plays a vital role for the construction maintenance and rehabilitation of any type of structure. For our concern, the job site falls in “Lesser Himalaya Zone”.

1.6 Temperature, Climate and Vegetation:

According to Central Bureau of Statistics, the annual temperature variation and rainfall was as follows:

Temperature: Max. 28°C to Min.16°C in summer

Max. 17°C to Min.2°C in winter

Rainfall: 90 inches in summer and slight drizzle in winter.

Major Crops grown: Paddy, wheat, etc.

Types of vegetation found: Herbs, Shrubs and tall trees.

Peepal, Sirish, Bamboo.

The temperature during the camp period was about 26°C. The days were hotter whereas in the evening, wind blew throughout the camp period making the evening pleasant.

1.7 Others:

Kirtipur is an ancient city with its unique history and pleasant environment. It has a number of places which are important from viewpoint of history, mythology and tourism. Kirtipur is one of the oldest settlements in the Kathmandu valley and its history goes back to ancient times. According to the bamsawali of Nepalmandal, Kirtipur was the hometown of the earliest Gopalbamshi kings of the valley.

In the Malla period, the people of Kirtipur were known for their skill in building. Kirtipur stone carvers and wood carvers were employed in constructing the monumental structures of the valley. Umamaheswor and BaghBhairav temples are the historic and religious places of Kirtipur. Panga and Chovar are the neighboring villages.

Tribhuvan University area lies at the center of the Kirtipur Municipality. It is oldest university of Nepal and biggest one from all. The campus is also important because it carries international cricket ground in its premises. The project area was divided into different parts for individual group. The main area of traversing includes almost all types of the land features like sloppy, dense forest, hedges, plain areas etc.

The whole area was sub-divided into various parts where the almost area covers educational buildings. The main buildings are Faculty of Education, Faculty of Humanities, Gandhi Bhawan, Library, SHEDA building, Student’s Club, Physical Science, Chemistry, Earth Science, Botany, Mathematics etc. and Coronation Park.

Chapter 2

TOPOGRAPHICAL SURVEY

Topographical surveying is the process of determining the positions of existing features of the locality by means of conventional signs on a topographical map. They are carried out to depict the topography of the mountainous terrain, rivers, water bodies, wooded areas and other cultural details as roads, railways, townships, etc. Topographic surveys are three-dimensional. They provide the techniques of plane surveying and other special techniques to establish both horizontal and vertical control.

2.1 Objectives:

- To prepare the topographic map of the given area with horizontal and vertical control at required accuracy.

2.2 Brief Description of the Area:

The area through which the major traverse was run was a small portion of the whole Tribhuvan University premises. Along with the preparation of the topographical map of the major traverse, detailed topographical map of the small area with contours was also prepared. The area on which detailed topographical survey was performed includes: Central Department of Botany, Central Department of Zoology, Central Department of Microbiology, Central Department of Mathematics and Statistics and other nearby small buildings.

2.3 Technical Specifications (Norms):

- Conduct reconnaissance survey of the given area. Form a close traverse (major and minor) around the perimeter of the area by making traverse stations. In the selection of the traverse station, make sure that the stations are inter-visible and maintain the ratio of maximum traverse leg to minimum traverse leg 3:1 for minor traverse and 1:2 in the case of major traverse.
- Measure the traverse legs in the forward and reverse directions by means of a tape calibrated against the standard length provided in the field, note that discrepancy between forward and backward measurements should be better than 1:2000.
- In case of distance measurement by total station in both forward and backward direction the precision of 1:5000 in case of major traverse and 1:3000 in case of minor traverse should be maintained.
- Measure traverse angle on two sets of reading by total station. Note the difference between the mean angles of two sets reading should be within 20 seconds.
- Carry out fly leveling from the given arbitrary T.B.M.1 (near Global IME Bank) to T.B.M. 2 (near Cricket Stadium) Perform two-peg test before the start of fly leveling. Note that collimation error should be less than 1:10000. Maintain equal fore sight and back sight distances to eliminate collimation error. Permissible error for fly leveling is $\pm 25\sqrt{k}$ mm, where k is the distance in kilometer.
- R.L. of TBM1 = 1286.698m
- R.L. of TBM2 = 1309.606m
- Balance the traverse. The permissible angular error for the sum of interior angles of the traverse should be less than $\pm 30''\sqrt{n}$ and $\pm 1'\sqrt{n}$ for major and minor traverse respectively. The sum of interior/exterior angles in a closed traverse should be equal to $(2N \pm 4) * 90^o$ where, N is the total number of stations. For major and minor traverse, the relative closing error should be less than 1:5000 and 1:3000 respectively.

- Plot the major and minor traverse stations by coordinate method in appropriate scale (1:1000 and 1:500 respectively).
- Carry out the detail survey of the given sub area by total station and tachometric surveying with reference to the major and minor traverse, which have been already plotted. Use conventional symbols for plotting.

2.4 Equipment and Accessories:

- Total station
- Theodolite
- Leveling staffs (5m)
- Ranging Rods
- Measuring Tapes (30m & 5m)
- Leveling instrument
- Hammer
- Nails & pegs
- Plumb bob
- Compass
- Prism
- Prism holder

2.5 Methodology:

The methodology of surveying is based on the principle of surveying. They are as follows:

i. Working from whole to a part.
ii. Independent check.
iii. Consistency of work.
iv. Accuracy required

The different methodologies were used in surveying to solve the problems arise in the field. These methodologies are as follows:

2.5.1 Reconnaissance:

Reconnaissance (Recce) means the preliminary inspection of the area before commencing the actual detail survey, for the purpose of fixing the survey stations and forming a general plan for the network of the chain lines. For this purpose the detailed inspection of the given area of Tribhuvan University was carried out by reconnaissance survey.

During reconnaissance the major and minor traverse control points to form a closed traverse around the perimeter of the area was found out. While selecting the major and minor control points following points should be considered:

i. The adjacent stations should be clearly inter-visible and cover the whole area with least number of stations as far as possible. The traverse station should maintain the ratio of maximum traverse leg to minimum traverse leg less than 2:1.
ii. The steep slopes and badly broken ground should be avoided as for as possible, which may cause inaccuracy in tapping.
iii. The stations should provide minimum level surface required to set up the tripod of the instrument.
iv. The traverse line of sight should not be near the ground level to avoid the refraction.
v. If possible well-conditioned triangles should be formed to give good graphical intersection during plotting.

2.5.2 Major traverse:

The skeleton of lines joining those control points, which covers the whole entire area, is called Major Traverse. Two-set of readings are taken for Major Traverse as the work done on major traverse need to be precise. For convenience, the readings are taken by setting the total station at 0°0’0” for one set and 90°00’00” for another.

The major traverse had 16 control stations including two given control points. The control stations were named as 4M1, 4M2,…., 4M14 and two control points as CP_1 and CP_2 respectively. The leg ratio of maximum traverse leg to minimum traverse leg was maintained within 2:1. The precision in length between the forward measurements and the backward measurements of all the traverse legs was within 1:5000 when measured through total station. The difference between the mean angles of two sets of readings was within a minute for all the angles whereas for two face reading was within 20’’ for all the measured angles.

Computation of Co-ordinates:

The length of the traverse is measured by total station. The traverse angles are measured with a total station by setting up the instrument at each station. The bearing of the any one of the traverse leg measured and the entire traverse angle measured, the bearing of all the legs can be calculated by:

Bearing of a line = (bearing of previous line +included angle) $\pm$ (180) or (540)

If θ is the bearing of line (c.p, A say), and l be the length of the line and provided that co-ordinate of the control point (c.p) is known then the co-ordinate of the point ‘A’ can be calculated as follows:

X-coordinate of A=x-coordinate of control point (c.p) +L*sinθ

Y-coordinate of A=y-coordinate of control point (c.p) +L*cosθ

R.L or z-coordinate of A=R.L of point (c.p) +H.I $\pm$ V-Height of signal.

Where, H.I=Height of instrument

V=vertical distance

2.5.3 Minor traverse:

For the detailed topographical survey, the detail points may not be sufficiently obtained from the control stations of the major traverse. For this minor traverse need to be laid. Minor traverse is that one which runs through the area to make detailing easy. Minor Traverse covers only small area. Less precise work than that of major traverse is acceptable so that single set reading is sufficient. The minor traverse had 9 control stations. The minor traverse enclosed Central Department of Botany, Central Department of Zoology, Central Department of Microbiology, Central Department of Mathematics and Statistics as well as the nearby buildings. The stations were named as 4m1, 4m2,…..,4m6. The leg ratio of maximum traverse leg to minimum traverse leg was maintained within 3:1. The precision in length between the forward measurements and the backward measurements of all the traverse legs was within 1:3000.

2.5.4 Leveling:

Leveling is an art of determining relative altitudes of points on the surface of the earth or beneath the surface of the earth. It is used to find the elevation of given points with respect to a given or assumed datum and to establish points at a given elevation or at different elevations with respect to a given or assumed datum. Leveling deals with measurements in a vertical plane. Finding out elevation is necessary to enable the work and establishing points are necessary in the setting out of works.

- Simple Levelling:

  The operation of levelling for determining the difference in elevation, if not too great, between two points visible from a single position of the level, is known as simple levelling.

- Differential Levelling:

  The method of levelling for determining the difference in elevation of two points either too far or obstructed by an intervening ground, is known as differential levelling. The level is set up at number of points and the difference in elevation of successive points, is determined in this method.

- Check Levelling:

  After the completion of fly levelling, level lines are run to check the accuracy of the bench marks previously fixed which is called check levelling.

- Profile Levelling:

  The operation of levelling carried out to determine the elevations of the points at known distances apart, and also salient features, along a given straight line is called profile levelling. It is also known as longitudinal levelling.

- Cross-section levelling:

  The operation of levelling which is carried out to provide levels on either side of the main line at right angles, in order to determine the vertical section of the earth surface on the ground is called cross section levelling.

- Reciprocal levelling:

  When the level is not possible to be set up between two points due to an intervening obstruction as large water bodies, reciprocal levelling is carried out. The two sets of reciprocal levelling is done to find out the difference in elevation between two points accurately.

Temporary adjustments of Level:

The temporary adjustments for a level consist of the following:

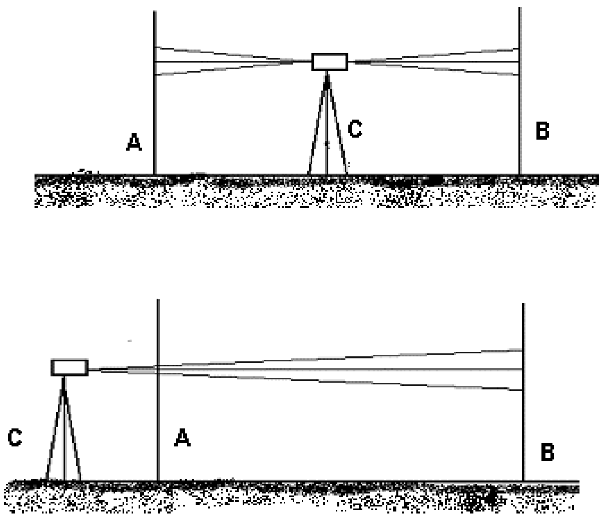
a) Setting up the level: The operation of setting up includes fixing the instrument on the stand and leveling the instrument approximately.

b) Leveling up: Accurate leveling is done with the help of foot screws and with reference to the plate levels. The purpose of leveling is to make the vertical axis truly vertical. It is done by adjusting the screws.

c) Removal of parallax: Parallax is a condition when the image formed by the objective is not in the plane of the cross hairs. Parallax is eliminated by focusing the eye-piece for distinct vision of the cross hairs and by focusing the objective to bring the image of the object in the plane of cross hairs.

Permanent adjustments of Level:

To check for the permanent adjustments of level two-peg test method should be performed. Two staffs were placed at A and B of known length (about 50 m). First the instrument was setup on the line near B and both staff readings (Top, Middle, and Bottom) were taken. Then, the instrument was setup at the middle C on the line and again both staff readings on A and B was taken. Then computation was done in order to check whether the adjustment was within the required accuracy or not.



Two peg test arrangement

Booking of reducing levels:

There are two methods of booking and reducing the elevation of points from the observed staff reading:

1. Height of the Instrument method
   Arithmetic Check:

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

2. Rise and Fall method
   Arithmetic Check:

   $$\sum B.S. - \sum F.S. = \sum Rise - \sum Fall = \text{Last R.L.} - \text{First R.L.}$$

Among the two methods, Rise and Fall method was widely used.

Fly Leveling:

The fly levelling was carried out between TBM 1 and TBM 2 and check levelling was performed to check the results.

Level transfer to the major and minor traverse stations:

The R. L of the temporary benchmark was then transferred to the control stations of the major and minor traverse. The closing error was found to be within the permissible limits. The misclosure was adjusted in each leg of the leveling path by using the following formula:

Permissible error = $\pm 25\sqrt{k}$ mm.

Where k is the total perimeter in Km

Actual Error (e) = $\sum$BS – $\sum$F.S. = Last R.L. – First R.L.

Correction i^{th} leg=-(e x ($L_1 + L_2 + \ldots + L_i$)/P

Where L_1, L_2, L_i Length of 1^{st} 2^{nd}, ….. i^{th} leg.

P is perimeter

Relative Precision= 1/(p/e)

2.5.5 Detailing:

Detailing means locating and plotting relief in a topographic map. Detailing can be done by either plane table surveying or tachometric surveying or by total station. We performed detailing by total station, detailing by tachometry and tangential method while taking details during the camp.

Total Station:

Total station was used to get the horizontal angle, horizontal distance and vertical height of different points when it was sighted to the prism with poles on those points.

Tacheometry:

It is the branch of surveying in which both the horizontal and vertical distances between stations are determined by making instrumental observations. Tacheometry is used in the preparation of contour maps and they also provides a good check on distances measured with tape or chain.

Principle of tacheometry:

In isosceles triangles, the ratio of the perpendiculars from the vertex on their bases is constant.

The formula for the horizontal distance is

$$H=k*s\cos^2\theta$$

The formula for the vertical distance is

$V = (k*s \sin 2\theta)/2$

Where, s = staff intercept ; θ = Vertical Angle

Detailing by trigonometric levelling:

In this method we have to take two middle staff reading, with 2 different vert. angle along with horizontal angle with any traverse leg. We use the formula:

S=difference in staff reading

$H = S / (\tan(90-\theta_1)-\tan(90-\theta_2))$

$V = H \tan(90-\theta_2)$

where, θ_1 is smaller zenithal angle and

θ_2 is bigger zenithal angle.

Contouring:

A contour is defined as an imaginary line passing through the points of equal elevation. Thus contour lines on a plan illustrates the configuration of the ground. The method of representing the relief of the ground by the help of contour is called contouring. The vertical distance between two consecutive contours is called contour interval. Every 5^{th} contour which is 5 times of the contour interval is the index contour which is generally darkened in the contour and is known as Index Contour. The least horizontal distance between two consecutive contours is called the horizontal equivalent.

Methods of contouring:

There are two ways of contouring. They are namely:

1. The Direct method
2. The Indirect method

1. The direct method:

In this direct method, the equal elevated points are joined. For this, firstly the points with the same elevations are found out by setting out the instrument at a point and by hit and trial method of searching the points which gives the same required staff reading.

2. The indirect method:

In this method, some suitable guide points are selected and surveyed, the guide points need not necessarily be on the contours. There are some of the indirect methods of locating the ground points:

a. By squares
b. By cross-sections
c. By tachometric method

Contour Interpolation:

The process of drawing contours proportionately between the plotted ground points or in between the plotted contours is called interpolation of the contours. Interpolation of contours between points is done assuming that the slope of ground between two points is uniform. It may be done by anyone of following methods:

* Estimation
* Arithmetic calculation
* Graphical method

Contour Characteristics:

- Two contour lines do not intersect each other except in the case of overhanging cliff.
- A contour line must close onto itself not necessarily within the limits of a map.
- Contours of different elevations do not unite to form one contour except in the case of a vertical cliff.
- Two contour lines do not unite to form a single one except in the case of perpendicular cliff.
- Contours drawn closer depict a steep slope and if drawn apart, represent a gentle slope.
- Contours equally spaced depict a uniform slope. When contours are parallel, equidistant and straight, these represent an inclined plane surface.
- A set ring contours with higher values inside depict a hill whereas a set of ring contours with lower values inside depict a pond or a depression without an outlet.
- When contours cross a ridge or V-shaped valley, they form sharp V-shapes across them. Contours represent a ridge line, if the concavity of higher value contour lies towards the next lower value contour and on the other hand these represent a valley if the concavity of the lower value contour, lies toward the higher value contours.
- The same contour must appear on both the sides of a ridge or a valley.
- Contours do not have sharp turnings.

Balancing of Traverse:

There are two methods of balancing of traverse: -

1. Bowditch's method
2. Transit method

1. Bowditch's method:

In this method, the total error in the latitude and departure is distributed in proportion to the lengths of the sides. It is mostly used to balance a traverse where linear and angular measurements are of equal precision. This rule says:

Correction to latitude (or departure) of any side

$$= \frac{\text{Total error in latitude (or departure)} \times \text{length of that side}}{\text{Perimeter of traverse}}$$

2. Transit method:

In this method, the total error in latitude & departure is distributed in proportion to the latitude & departure of its side. This rule is adopted when angular measurements are precise rather than linear measurements. This role provides correction to latitude & departure of any side.

Correction in Latitude (or Departure) of any side

$$= \frac{\text{Total error in latitude or departure * latitude (or departure) of that line}}{\text{Arithmetic sum of latitude (or departure)}}$$

2.5.6 Computation and plotting:

For the calculations as well as plotting, we applied the coordinate method (latitude and departure method). In this method, two terms latitude and departure are used for calculation. Latitude of a survey line may be defined as its coordinate lengths measured parallel to an assumed meridian direction. The latitude (L) of a line is positive when measured towards north, and termed Northing and it is negative when measured towards south, and termed Southing. The departure (D) of a line is positive when measured towards east, and termed Easting and it is negative when measured towards south, and termed Westing. The latitude and departures of each control station can be calculated using the relation:

Latitude = L Cosθ

Departure = L Sinθ

Where, L=distance of the traverse legs

θ=*Reduced* bearing

If a closed traverse is plotted according to the field measurements, the end of the traverse will not coincide exactly with the starting point. Such and error is known as closing error.

Mathematically,

Closing error (e) = $\sqrt{\{(\Sigma L)^2 + (\Sigma D)^2\}}$

The relative error of closure = e / p

The error (e) in a closed traverse due to bearing may be determined by comparing the two bearings of the last line as observed at the first and last stations of traverse.

Plotting of Major and Minor traverse:

After computing the co-ordinate of each of the control points, they were plotted in A1 size grid paper. Both major and minor traverses were plotted to **1:500** scales. The plotted traverse was made at the center of the sheet with the help of least co-ordinates and highest co-ordinates. Minor Traverse was plotted in similar way to scale **1:500** over which later detailing was done.

2.6 Resection:

Resection is the process used for determining the position of unknown point with the help of already defined known coordinated points. The readings are taken from the unknown points. Either two point resection or three point resection can be performed. We performed three point resection in the field.

2.7 Intersection

A minimum of two control stations is required for this operation, with the unknown point visible from each of them. It is not essential that the control stations are inter-visible, but it makes it easier if they are.

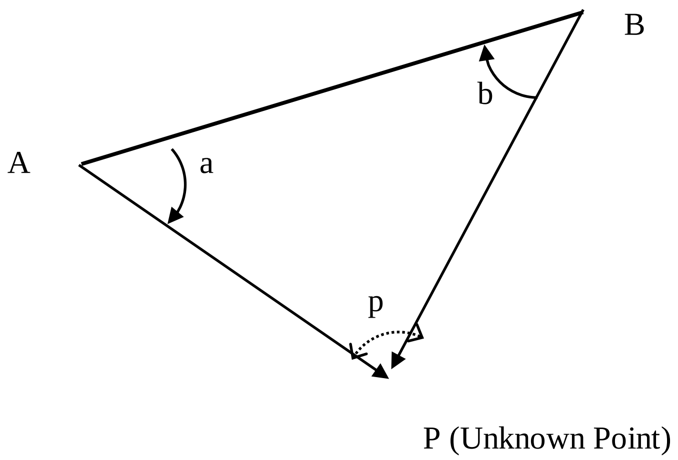


Figure 1. Sightings and angles measured for intersection.

The theodolite is set up at each of the stations (control points) A and B in turn. At station A, the telescope is first sighted on B and then transited round to P, measuring the angle a. Similarly, at B the angle b between line BA and line BP.

- surveying points high up on buildings, perhaps for later use as reference objects
- measurement of the deflection of large structures (e.g. dams, bridges)
- Setting out of curves.

Because we know the co-ordinates of stations A and B, and because we know that the sum of the internal angles in the triangle must equal 180°, we can calculate the following:

Length of line AB = $\sqrt{(\Delta E^2 + \Delta N^2)}$

Bearing of line AB = $\tan^{-1} (\Delta E / \Delta N)$

Angle p = 180° - a – b

Further calculation allows us to find the length and bearing of each of the lines AP and BP:

Sine Rule: $\frac{AB}{SinP} = \frac{AP}{Sin\ b} = \frac{BP}{Sin\ a}$

Bearing of AP = bearing AB + a

Bearing of BP = bearing BA – b

Note that angle b is anticlockwise from BA to BP, hence the negative sign in the above equation.

Once we have the bearing and length of lines AP and BP then the co-ordinates of P can be calculated from each line. These two sets of co-ordinates should correspond within the expected degree of accuracy.

2.7 Comments and Conclusion:

The site for the survey camp was suitable for us to practice the theoretically acquired knowledge in the field. Laying control stations, carrying out level works and angular measurement became difficult while laying stations on jungle side. The obstructions due to trees created problem. The work was slowed down as some of the instruments provided were with errors. However, the work was completed within the allocated time.

Chapter 3

BRIDGE SITE SURVEY

Bridges are the structures that are constructed with the purpose of connecting two places separated by deep valleys or gorges or rivers and streams. Bridges are usually the cross drainage and hence a part of roads making them shorter and hence economical. For places, where the ground is uneven and undulated and where the number of rivers is large, bridges are the most economic and efficient way. It is a very convenient way.

3.1 Objectives:

- To select the possible bridge site and axis for the construction of bridge.
- To collect the preliminary data i.e. normal water flow level, high flood level.
- To study about the geological features of the ground.
- To carry out surveying for topographical mapping, longitudinal and cross sections at both the upstream and downstream side of the river.

3.2Brief description of the site:

The bridge site was surrounded by trees and bushes. There were no rocks. The ground was damp and swampy. The soil was soft and clayey. It was brown in color. The hill slopes on both sides were not very steep and are thus geologically stable. There is not much water to be found on the bridge site. The only water is collected from rain and other sources.

3.3 Hydrology, Geology & Soil:

The site is surrounded with steep hill, which is covered with densely planted shrubs. The width of stream is not so big but high flood level covers large area. Water scoured marks on the sideshow that the highest flood level.

3.4Technical Specifications(Norms):

The following norms were followed while performing the bridge site survey in the field:

1. Control point fixing as well as determining the length of the bridge axis had to be done by the method of triangulation. While forming triangles, proper care had to be taken such that the triangles were well conditioned, i.e. none of the angles of the triangle were **greater than 120° or less than 30°.**
2. In triangulation, distance of Base Line must be measured in an accuracy of 1:2000.
3. The triangulation angle had to be measured on two sets of readings by Theodolite and the difference between the mean angles of two sets of readings had to be within a minute. Angular misclosure for base triangle should be 30” √N and other triangle 1’√N
4. Carry out reciprocal levelling to transfer level from one bank to other bank of the river within a precision of ±25√k mm Determine the RL of the other triangulation stations by fly levelling from the end point of bridge axis.
5. Plot a topographic map indicating contour lines at suitable interval (contour interval = 1m).
6. The scale for plotting the topographical map was given to **be 1:500**

7. In order to plot the longitudinal section of the river, data had to be taken along the riverbed **150 m upstream** and at least **50 m downstream**. The plot for the longitudinal section along the flow line had to be done in a scale of **1:50 for vertical and 1:500 for horizontal, for cross-section v=H=1:50 or 100.**

3.5Equipment & Accessories:

The equipment used in the survey during the preparation of topographic map in bridge site are as follows:

1.Theodolite
2.Total Station
3.Ranging Rods
4.Measuring Tapes
5.Leveling Staffs
6.Plumb Bob
7.Pegs & Arrows
8.Marker Pen
9.Compass
10. Prism & Prism Holder

3.6Methodology:

The various methods performed during the bridge site survey were site selection, triangulation, leveling (fly levelling and reciprocal levelling), detailing by total station, cross section, and L-section. The brief descriptions of these methodologies are given below:

3.6.1 Site Selection:

Site selection is the first and foremost step for the construction of bridge. Several governing factors are there for the site selection of the bridge. Geological condition, socio-economic and ecological aspect etc. guides the way of selection of bridge site. Therefore, the site was chosen such that it is laid on the very stable rocks at the bed of river as far as possible and not affect the ecological balance of the flora and fauna of the site area. The location of the bridge was selected in such a way that the heights of the roads joined by the proposed bridge were almost the same. This prevented a lot of cutting and filling to maintain a gentle gradient. The bridge site was chosen in such a way that the bridge axis was perpendicular to the flow direction and was also shorter in span so as to make the construction economical. The starting point of bridge axis was not laid on the curve of the road.

3.6.2 Topographic Survey:

For the topographic survey of bridge site, triangulation was done. Triangulation is the process of measuring the angles of a chain or a network. The main purpose of the triangulation was to determine the length of the bridge axis. The triangulation also serves the control points for detailing. The bridge axis was set and horizontal control stations were fixed on either side. Distances between stations on the same sides of river i.e. base lines were measured with tape precisely. Then the interconnecting triangles were formed and angles were measured with the theodolite with two sets of observations. The bridge axis length or span was calculated by solving the triangles using the sine rule. For vertical control, the level was transferred from the arbitrary benchmark and RL was transferred to the stations on the next bank by reciprocal leveling while direct level transfer method was used or the same bank.

3.6.3 L-Section & Cross Section:

For gaining an idea about bed slope, nature of the riverbed, and the variation in the elevations of the different points along the length of the river, L-section is carried out. Keeping the instrument at the control (traverse) stations on the river banks, the staff readings were taken at different points along the center line of the river up to a 150 meters upstream and 50 m downstream. The R.Ls of the traverse stations being known previously, the levels of the different points on the river were calculated. Then the L-Section of the riverbed was plotted on a graph paper on scale for vertical and horizontal.

Cross-section of a river at a particular point is the profile of the lateral sides from the centerline of the river cut transverse to the L-Section at that point. The cross section can be used to calculate the volume and discharge of water at the particular section if the velocity at the cross section is known. Cross sections were taken at an interval of about 25 m extending 150 m upstream and 50 m downstream of the river. Staff readings of points along a line perpendicular to the flow of river were taken from the stations points and the elevations of the points were calculated using tachometric methods.

3.6.4 Leveling:

Transferring R.L. from B.M. to control points:

The benchmark was on the manhole near the cricket ground. R.L. was transferred to the triangular station from the B.M. by fly leveling by taking the back sight-reading to the bench mark which should be within the given accuracy. The R.L. was transferred to the opposite bank of the river by reciprocal leveling.

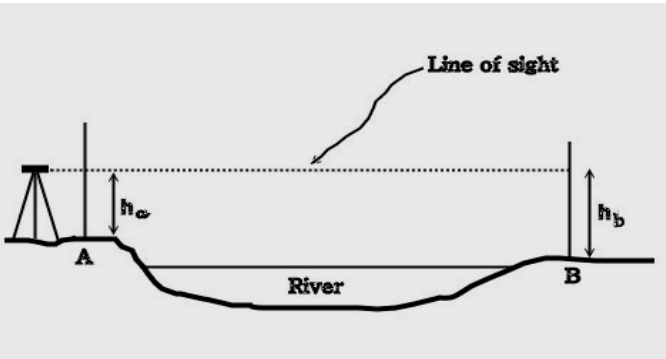
Reciprocal Leveling:

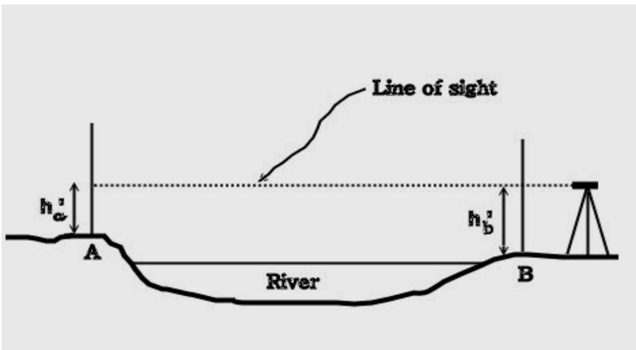
This method is applicable when taping is obstructed but not the vision. For transferring the RL across the bridge reciprocal leveling was performed. This method eliminates the error due to focusing, collimation, earth’s curvature and refraction of atmosphere etc.

True difference in elevation between A and B = H = h_a- (h_b-e)

Also the true difference in elevation = H = (h_a '- e)-h_b'

Taking the average of the two differences we get the difference in elevation between A and B.





3.6.5 Detailing:

Total station was used for detailing of the entire bridge site. The reading was taken from the different station set up. The detailing was done with respect to the skeleton formed by triangulation. The vertices of triangles serve as a control point. The details were booked, up to 150m upstream and 50m downstream. The data and the calculations have been tabulated in a systematic way.

3.6.6 Computation & Plotting:

The use of total station makes the detailing process easy and fast. The total station gives the direct vales of the horizontal distances and vertical height difference between the station point and the detailing point. The RLs of the points can be calculated by using following formula.

$$\text{RL of detail} = \text{RL of station} + \text{HI} \pm \text{V-Target Height}$$

The topographic map, the longitudinal section and the cross section were plotted on the respective scales after the completion of calculations. By taking an A1 grid sheet, control stations were plotted accurately. Then all hard details as well as contours were plotted with reference to the control stations by the method of angle and distances.

3.6.7 Comments and Conclusion:

Economy and durability determines the way how a bridge is designed. The bridge axis should be designed such that the span length should be minimum and the location is safe. The bridge axis should not be below the highest flood level. The bridge span was found out to be 64 meters. The cross-section was taken at the banks of river and at the middle of the river to get the profile of the flowing river. Also, we marked the high flood level and low flood level. Change due to erosion of the bank is not so significant.

Chapter 4

ROAD ALIGNMENT

A road is an identifiable route, way or path between two or more places. Roads are typically smoothed, paved, or otherwise prepared to allow easy travel; though they need not be, and historically many roads were simply recognizable routes without any formal construction or maintenance. The road need to pass through positive obligatory points. Positive obligatory points include cities, schools, markets and negative obligatory points include temples, national parks and wild life conservation areas. Road must not pass through such negative obligatory points.

Before the construction of the road, preliminary survey is done. Road alignment is the preliminary stage of road construction. Selection of Intersection Points (IP) is the foundation of construction of the road. After that cross section, longitudinal section and formation level are required.

4.1 Brief description of the project area:

Road alignment and bridge site survey goes side by side to run a road between two terminals and to carry a survey for the bridge construction along the route. This specific job is essential for an engineer combating with the mountainous topography of Nepal.

4.2 Geology Hydrology & Soil:

The land was undulated with no large boulders or rocks of any kind along the proposed site. There are several places where culvert or cause way can exist. The soil is uniform throughout the whole length of the road. Although the road alignment has certain up and downs. Finally the starting and ending point of the road has no significant level differences. Soft clayey soil were found along the road course.

4.3 Technical Specifications (Norms):

Reece alignment selection was carried out of the road corridor considering permissible gradient, obligatory points, bridge site and geometry of tentative horizontal and vertical curves. The road setting horizontal curve, cross sectional detail in 15m interval and longitudinal profile were prepared.

The topographic map (scale 1:1000) of road corridor was prepared. Geometric curves, road formation width, right of way, crossings and other details were shown in the map.

While performing the road alignment survey, the following norms were strictly followed:

- Carry out reconnaissance survey and alignment selection of a road corridor about 700m or more.
- If the external deflection angle at the I.P. of the road is less than 3°, curves need not be fitted.
- Simple horizontal curves had to be laid out where the road changed its direction, determining and pegging three points on the curve - the beginning of the curve, the middle point of the curve and the end of the curve along the centerline of the road.
- The radius of the curve had to be chosen such that it was convenient and safe. The radius of the curve should not be less than 12m. The radius must be within the multiple of 5 or 10.
- The gradient of the road had to be maintained below 12 %.

- Subsequent reverse curves in road alignment should be avoided.
- The deflection angle should not be greater than 90^o.
- Two successive curves must not be overlapped.
- Carry out levelling survey for longitudinal section along the centre line at 15m interval, at abrupt change point and at all the curve point BC, MC and EC. Close the levelling survey and check the RL at job site immediately. Permissible error of closure for levelling must not be greater than $\pm 25\sqrt{k}$ mm.
- Cross sections had to be taken at 15 m intervals and at the beginning, middle and end of the curve, along the centerline of the road - observations being taken for at least 10 m on either side of the centerline.
- Plan of the road had to be prepared on a scale of 1:500
- L-Section of the road had to be plotted on a scale of 1:1000 horizontally and 1:100 vertically.
- The cross section of the road had to be plotted on a scale of 1:100 (both vertical and horizontal).
- The amount of cutting and filling required for the road construction had to be determined from the L-Section and the cross sections. However, the volume of cutting had to be roughly equal to the volume of filling.

4.4 Equipment & Accessories:

The following are the instruments used during the road alignment survey in the field:

- Theodolite
- Tripod Stand
- Plumb Bob
- Leveling Instrument
- Leveling Staffs
- Ranging Rods
- Measuring Tape
- Pegs and Arrows
- Marker Pen

4.5 Methodology:

The alignment of road includes several ways and procedures that need to be carried out. Following are the listed methodology:

4.5.1 Reconnaissance:

The reconnaissance survey was performed along the given route. Tentative estimation were done for the intersection points, where the direction had to be changed. While returning back the route, the IPs was fixed. For this the inter-visibility of the stations was checked and gradient between the two IPs was adjusted such that it does not exceed 12%, using the abney level. Meanwhile the pegs with IP no. were driven at these points.

4.5.2 Horizontal Alignment:

Horizontal alignment is done for fixing the road direction in horizontal plane. For this, the bearing of initial line connecting two initial stations was measured using compass. The interior angles were observed using theodolite at each IP and then deflection angles were calculated.

Deflection angle = 180^0- observed angle

If the deflection angle is positive the deflection is towards right and if the deflection angle is negative the deflection is towards the left. The radius was assumed according to the deflection angle. Then the tangent length, Beginning of the Curve (BC), End of the Curve (EC), apex distance along with their chainage were found by using the following formulae,

Tangent length (T) = R x Tan (Δ/2)

Length of curve (L.C) = Π x R x Δ/180

Apex distance = R x(1/(Cos (Δ/2)-1)

Chainage of BC = Chainage of IP – T

Chainage of MC = Chainage of BC +LC/2

Chainage of EC = Chainage of MC + LC/2

= Chainage of BC + LC

The BC and EC points were located along the line by measuring the tangent length from the apex and the points were marked distinctly. The radius was chosen such that the tangent does not overlap. The apex was fixed at the length of apex distance from IP along the line bisecting the interior angle.

4.5.3 Vertical Alignment:

Vertical profile of the Road alignment is known by the vertical alignment. In the L-section of the Road alignment, vertical alignment was plotted with maximum gradient of 12 %. According to Nepal Road Standard, Gradient of the Road cannot be taken more than 12 %. In the vertical alignment, we set the vertical curve with proper design. Vertical curve may be either summit curve or valley curve. While setting the vertical alignment, it should keep in mind whether cutting and filling were balanced or not.

4.5.4 Leveling:

The method of fly leveling was applied in transferring the level from the given B.M. to all the I.Ps, beginnings, mid points and ends of the curves as well as to the points along the center line of the road where the cross sections were taken. After completing the work of one way fly leveling on the entire length of the road, check leveling was continued back to the B.M. making a closed loop for check and adjustment. The difference in the R.L. of the B.M. before and after forming the loops should be less than 25$\sqrt{}$ k mm, where k is the loop distance in km.

4.5.5 L-section & Cross Section:

Nature of the ground, the variation in the elevations of the different points along the length of road need to be known for the construction of the road. For this L-Section of the road is required. In order to obtain the data for L-Section, staff readings were taken at points at 15m intervals along the centerline of the road with the help of a level by the method of fly leveling. Thus after performing the necessary calculations, the level was transferred to all those points with respect to the R.L. of the given B.M. Then finally the L-Section of the road was plotted on a graph paper on a vertical scale of 1:100 and a horizontal scale of **1:1000**. The staff readings at BC, EC and apex were also taken. The RL of each point were calculated.

Cross sections at different points are drawn perpendicular to the longitudinal section of the road on either side of its centerline in order to present the lateral outline of the ground. Cross sections are also equally useful in determining the amount of cut and fill required for the road construction. Cross sections were taken at 15m intervals along the centerline of the road and at points where there was a sharp change in the elevation. While doing so, the horizontal distances of the different points from the centerline were measured with the help of a tape and the vertical heights with a measuring staff. The R.L. was transferred to all the points by performing the necessary calculations and finally, the cross sections at different sections were plotted on a graph paper on a scale of **both vertical and 1:100 - horizontal.**

4.6 Curve Setting:

A regular curved path followed by highway or railway alignment is curve. It is introduced wherever it is necessary to change the direction of motion due to the nature of terrain. A curve may be circular, parabola or spiral and is always tangential to two straight directions.

There may be different types of curves:

Simple curve, Compound curve, Reverse curve, Transition curve.

Simple Circular Curve:

A simple circular curve is the curve, which consists of a single arc of a circle. It is tangential to both the straight lines.

Setting Out OF Simple Circular Curves:

1. Linear method: - In this method, only a chain or tape is used. Linear methods are used when a high degree of accuracy is not required and the curve is short.

E.g: Offsets from Long Chord

Offsets form Tangents

Successive bisection of Chords

Offsets from Chords produced

2. Angular method: - In this method, an instrument like theodolite is used with or without chain or tape.

E.g.: Rankine's Method of Tangential Deflection Angles

Two Theodolite Method

- **Offset from Long Cord Method:**

Mid-ordinate can be determined by the relation

$$O_o = R - \sqrt{[R2 - (L/2)^2]}$$

The Ordinate at a distance 'x' is given by,

$$O_x = \sqrt{[(R^2 - X^2) - (R - O_o)]}$$

Where,

O_o = mid-ordinate

O_x = ordinate at distance x from the mid point of the chord

L = length of the long chord
R = Radius of the curve

- **Rankine's Method:**

In Rankine's method, it's assumed that the length of the curve and the chord length are equal (case for larger radius). The deflection angle to any point on the curve is an angle at the point of contact between the back tangent and the chord joining the point of contact and that point.
The angle subtended by first sub-chord is given by,

$\delta_1 = 1718.9\ C_1/R$ minutes

The angle subtended by each normal chord is given by the formula,
$\delta = 1718.9\ C/R$ minutes

If δ_1, δ_2..., δ_n are the tangential angles made by successive chords with their tangents and Δ_1, Δ_2........Δ_n are the total deflection angles, then
$\Delta_1 = \delta_1$
$\Delta_2 = \Delta_1 + \delta_1 = \delta_1 + \delta_2$
……………………
………………………………
Similarly,
$\Delta_n = \Delta_{n-1} + \delta_n = \delta_1 + \delta_2 + \delta_3 + \ldots\ldots\ldots + \delta_n = \Delta/2$

Field Procedure:

1. The instrument is set at T_1 and zero is set along P.I..
2. Then the theodolite is set to read an angle of $\delta_1 (=\Delta_1)$.
3. With T_1 as center and C_1 as radius, the tape is swung and arrow was marked at intersection of the tape with crosshairs.
4. Then angle Δ_2 was set on the theodolite and with length of normal chord as radius, the next point on the curve was marked at the point of intersection.

This procedure is continued till the point of tangency is located.

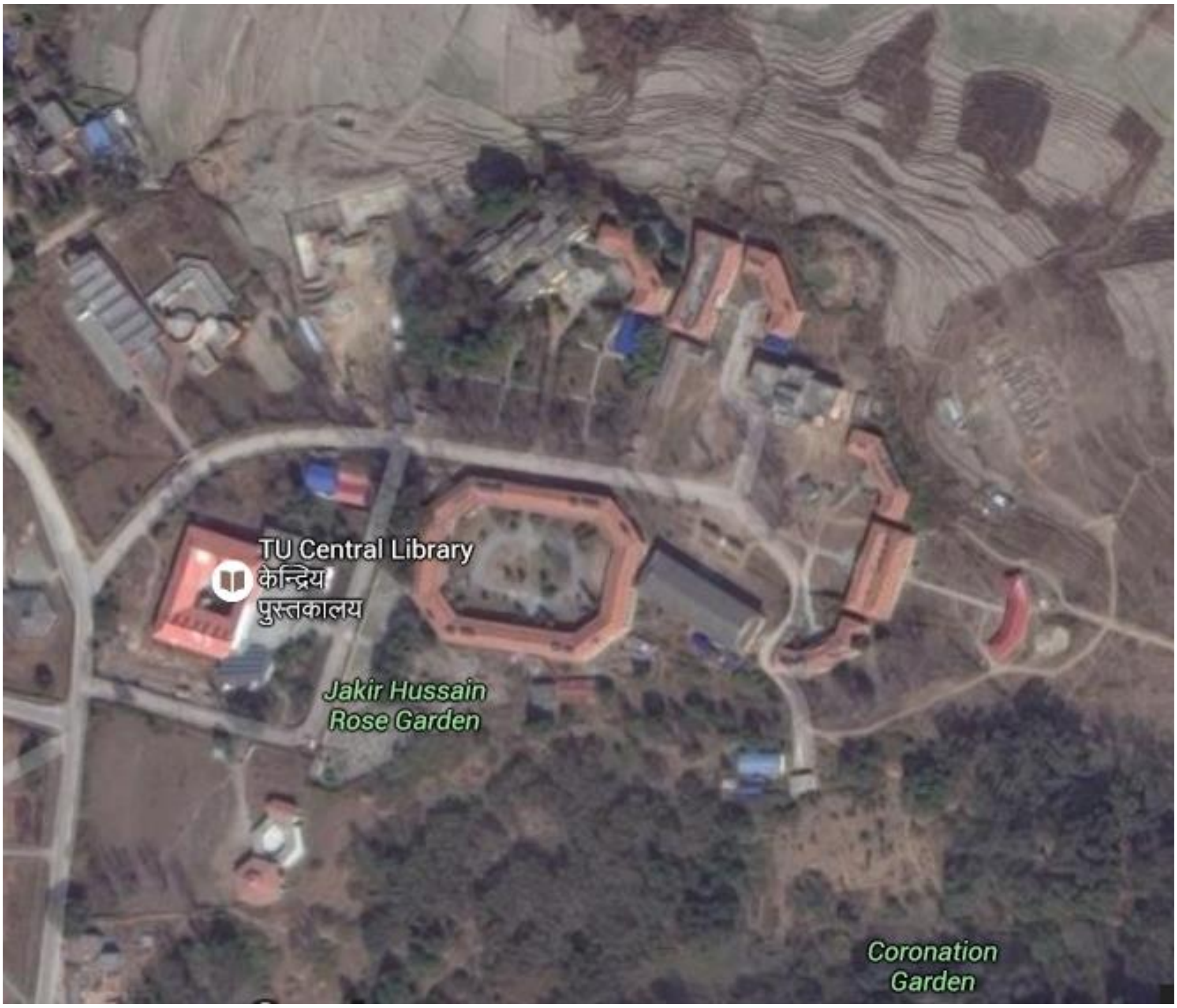
4.7 Comments and Conclusion:

Survey of the road alignment is done to make safe, easy, short and economical road. Geological stability and soil stability are also taken into account. Vertical and horizontal curves are set according to Road Design Standards for comfort and other factors.

While setting the road alignment, it should be kept in mind that the minimum IP points should be taken as far as possible and deflection angles should be minimal as far as possible.

APPENDIX

Location Map:



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