Acknowledgement

We would like to express our sincere gratitude to all those who contributed to the successful completion of our Engineering project **(Detailed survey Design and Estimating of Rural Road).**

First and foremost, we extend our heartfelt thanks to our project supervisor **Er. Om Prakash Giri** for their invaluable guidance throughout the duration of the project.

We also thank the faculty and staff of School of Engineering Department of Science and technology, Pokhara University Lekhnath Kaski for providing the resources, facilities and a conducive environment that enabled us to carry out our research and implementation effectively.

We are grateful to our teammates for their dedication, collaboration and mutual support during this project. Each member's unique contribution to the project success.

Team Members

Deepshikha Aryal (22040166)

Jyoti Adhikari (22040173)

Nirmala Lamichhane (22040179)

Sunita Neupane (22040221)

Abstract

The development of rural roads plays a vital role in enhancing connectivity, promoting economic growth, and improving access to essential services in remote and underdeveloped areas. This study focuses on the comprehensive process of detailed engineering survey, geometric and pavement design, and cost estimation for a rural road project, aimed at delivering a technically sound and cost-effective solution tailored to local terrain, traffic demands, and environmental conditions.

A detailed topographic and geotechnical survey was conducted using modern instruments and field investigations to gather accurate data on elevation, soil properties, hydrology, and existing infrastructure. Based on this data, the geometric design was carried out in accordance with relevant standards (such as IRC SP-20 and Nepal Rural Road Standards), addressing elements like horizontal and vertical alignment, road width, camber, super-elevation, and drainage structures. The pavement design was determined through soil strength analysis (CBR tests) and expected traffic loading, ensuring durability and performance under rural operating conditions.

Further, a comprehensive quantity take-off and cost estimation was performed, including preparation of the Bill of Quantities (BOQ), rate analysis, and total project cost calculation with consideration for labor, material, equipment, and contingencies. This holistic approach ensures the road design is not only technically viable but also economically justified and environmentally responsible.

In conclusion, the study provides a replicable framework for rural road development projects, supporting sustainable infrastructure planning and contributing to regional development and improved rural livelihoods.

Keywords: Road alignment, Pavement design, Bill of quantities (BOQ), Geometric design, cost estimation cut and fill calculation

Table of Contents

List of Figures

List of Tables

Abbreviations

LRN	Long Range Navigator
VDC	Village Development Committee Headquarters
DTMP	District transport master plans
NRS	Nepal road standard
RRCES	Rural road cost estimation software
IRC	Indian road congress
WBM	Water Bound Mecadam
RRCES	Rural road cost estimation software
CBR	California bearing ratio

1. Introduction

1.1 Background

A road is a route, way or path between two or more places. Roads are typically smoothed, paved or otherwise prepared to allow easy travel. Although in Nepal being landlocked country, road transportation is the best form of transportation as air transportation is very risky and uneconomical and other means of transportation are not suitable as per the geological condition of Nepal.

Hill road is defined as the one which passes through the terrain with a cross slope of 25% or more. A hill road is characterized by wide differing elevation, steep slope, deep Georges and a great number of watercourses. Due to this, the route length must be ineffectively increased. Nepal is a mountainous country and other means of transportation viz. railway, waterway, ropeway, and airways are less visible and costlier. The road transportation in Nepal is best suited for the rural linkage and overall development of any area, for the fulfillment of the basic needs of the people, upliftment in the level of thinking and sustainable development of nation. Road has become the main infrastructure for the other infrastructural development work and is in the top priority of nation planning commission of Nepal.

In the past two years there has also been a significant change in LRN policy including the revision of the district transport master plans (DTMP) to link district to VDC HQ_s by means of all – weather district road core network and a shift of priority from new construction to upgrading, maintenance and joining river crossing with bridges. This in turn prompted the revision of the 1999 rural road standards in January 2013 and provided DOLIDAR with the opportunity to make changes designed to tackle issues relating to cater present increasing scope of LRN, road safety, climate change and disaster risk reduction.

Road Network Planning is one of the major infrastructures essential for development. Economical and efficient road construction greatly contributes to the rapid development of a country. To bring the benefits of development to the remote corners of rural areas, it is necessary that transportation facilities reach every part of the valley. Our country is largely covered by mountainous regions where transportation facilities are minimal. People often must walk for days to reach these rural areas. As a result, the people living in such areas are deprived of development opportunities. According to the current national policy of the country, the priority is assigned to the development of district headquarter link roads. As per the Nepal Road Standard (NRS) 2071, roads in our country are classified as follows:

- National Highway.
- Feeder Roads.
- District Roads.
- City Roads.
- Village Roads (According to revised NRS)

Site location:

The proposed road located in Pokhara Metropolitan City Ward no 32. The road that is to be surveyed starts from Ghimirethar to Aapukhola. In this package of the road, the total length is of 3km.

Geographical Feature:

Terrain	: Rolling and Hilly
Climate	: Sub-tropical with average rainfall
Geology	: Common ordinary soil
Latitude	: 28.1552°N
Longitude	: 84.1302°E

Figure 1.1 Location of site

- stimulating local economies.
- Enable all-weather mobility for villagers.
- Reduce accident risks by optimizing curvature, gradients, and road width.
- Identify potential routes considering terrain, settlements, and environmental constraints.

2. Significance of this Research (Work)

The main aim of this project as mentioned above is to survey, design and estimation of the link road for better flow of traffic. The proposed project is necessary:

- To prepare geometric design of road including alignment plan, cross section and typical drawing.
- To be familiar with technique and equipment for hill road construction.
- To prepare detailed cost estimate.
- Ensure road geometry complies with standards (e.g., Nepal Rural Road Standards), directly reducing accident risk.
- Boost agricultural access to markets, education, and health services—quantifiable through comparative network accessibility models
- To provide reliable all-weather access to essential services such as healthcare, education, and markets.
- Improved rural roads facilitate the movement of goods and people, thereby stimulating local economies.
- Enable all-weather mobility for villagers.
- Reduce accident risks by optimizing curvature, gradients, and road width.
- Identify potential routes considering terrain, settlements, and environmental constraints.

3. Literature Review

Nepal is a small and among the least developed countries situated roughly in east-west direction. Over 75% of its landmass is in hilly and mountainous ranges that spread North-south within a small horizontal distance of 195km between 50m to over 8880 meters above sea level and expanding about 900km from East to West. The Himalayans of Nepal provides an extraordinary refuse to an extremely rich and unique biological as well as ethnic and religious cultural diversity. Nepal is a mountainous country where majority of rural population does not have road links from the cities to their village. Local transportation depends on foot trails and mule track. The Department Of Road (DOR) under government constructs the road in the country, but the pace of the construction is very slow as compared to the national need. Nepal Road Standard 2071 classifies 4 types of roads in the country as:

- National Highway (NH)
- Feeder Road (FR)
- District Road (DR)
- Urban Road (UR)

3.1 Surveying Instrument

In ancient times, road surveying instrument included chains, compass, solar compass, theodolite, dioptra, odometer and many more. Chains with equal size links were used to measure distance between two required points. A compass was used to measure the direction of line that was being surveyed. A solar compass used to measure horizontal angle and the “true north” of a particular place. A metallic measuring tape was used to measure shorter distance.

As technology gradually advanced with time, instrument used for road surveying also improved. Horizontal and vertical angles were measured using a simple theodolite whereas different heights were measured by a basic level. Measuring wheels were also initially used by surveyors to measure long distances in short duration of time. Measuring wheels came in two types: mechanical and electrical, and both worked on the same principle of rolling the wheel from the start to the endpoint.

3.1.1 Some Old Surveying Instruments

- **Diopter**

A diopter is a classical surveying instrument, dating from the 3rd century BC. The diopter was a sighting tube attached to a stand. It could be used to measure angles.

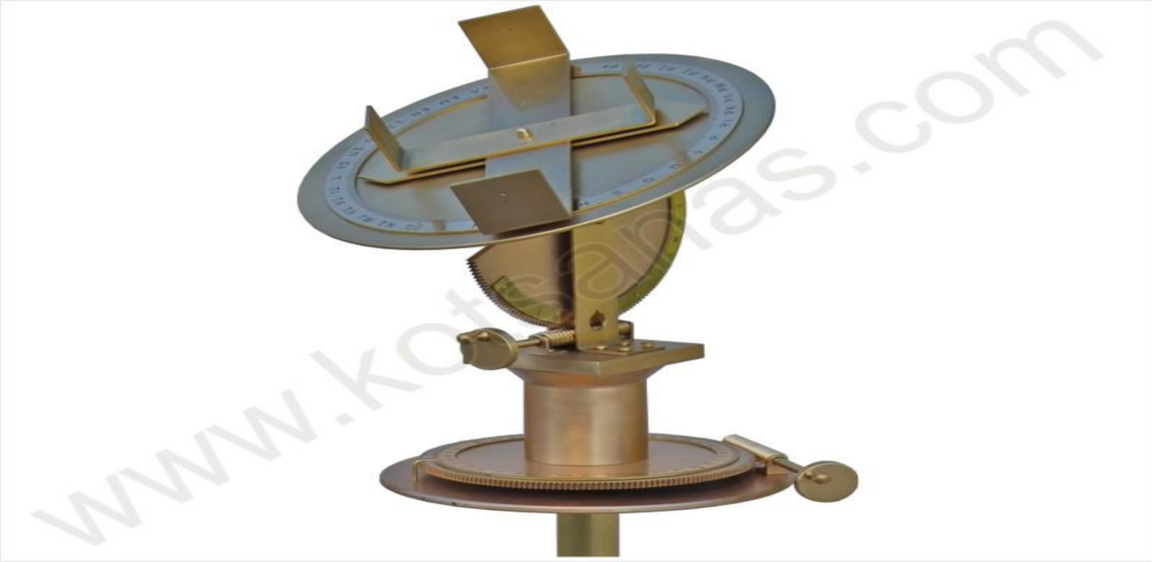

Figure 3.1.1.1 Diopter

- **Road counter “Odometer”**

It is a measuring instrument, tools and machine used in ancient Greeks. It is used to measure accurate distance of road. It consisted of a box with co-operating screws and gearwheels attached to a moving vehicle. In a variation of the device one calibrated disc had radial holes with balls that when one of them was aligned with a corresponding hole of the box the ball fell into a metal vessel offering easy measurement of device.

Figure 3.1.1.2 Road Counter Odometer

- **Surveyor’s wheel:**

A surveyor’s wheel, also called a clickwheel, hodometer, waywiser, trundle wheel, measuring wheel is a device for measuring distance. Each revolution of wheel measure a specific distance, such as yard, meter or half rod. Thus counting revolution with a mechanical device attached to the wheel measures the distance directly. The surveyor’s wheel measures the distance along a surface, distance between points are usually measured horizontally with vertical measurement indicated indifference in elevation.

Figure 3.1.1.3 Surveyor's wheel

- **Solar Compass**

The solar compass, a surveying instrument that makes use of the sun’s direction, was first invented and made by William Austin Burt. The solar compass is useful for navigation in the high latitude, especially near the poles, where compass become unreliable. It is used to measure horizontal angle and the “true north” of a particular place.

Figure 3.1.1.4 Solar Compass

- **Theodolite**

A theodolite is a precision optical instrument for measuring angles between designated visible points in the horizontal and vertical planes. It consists of a moveable telescope mounted so it can rotate around horizontal and vertical axes and provide angular readouts. In a transit theodolite, theodolite, the telescope is short enough to rotate through the zenith, otherwise for non-transit instruments vertical (or altitude), rotation is restricted to a limited arc.

Figure 3.1.1.5 Theodolite

3.1.2 Some Modern Surveying Instruments

- **Total Station**

A total station (TS) or total station theodolite (TST) is an electronic/optical instrument used for surveying and building construction. It is an electronic transit theodolite integrated with electronic distance measurement (EDM) to measure both vertical and horizontal angles and the slope distance from the instrument to a particular point, and an on-board computer to collect data and perform triangulation calculations.[1]

Robotic or motorized total stations allow the operator to control the instrument from a distance via remote control. This eliminates the need for an assistant staff member as the operator holds the retroreflector and controls the total station from the observed point. These motorized total stations can also be used in automated setups knows as Automated Motorized Total Station (AMTS).

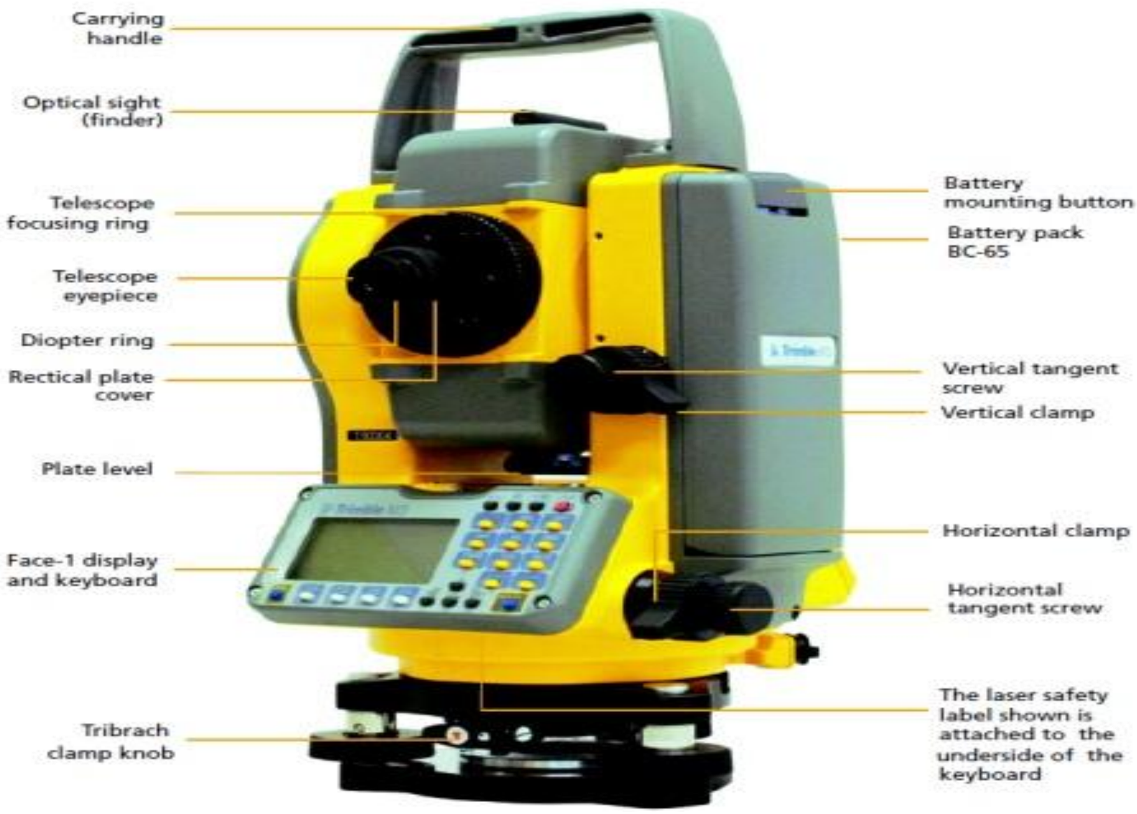

Figure 3.1.2.6 Total Station

- **Total Station**

Today, GPS is a vital part of surveying and mapping activities around the world. When used by skilled professionals, GPS provides surveying and mapping data of the highest accuracy. GPS is especially useful in surveying coasts and waterways, where there are few land-based reference points. Moreover, with the introduction of global positioning system, the methods of surveying have totally changed. GPS has not only made surveying faster but has increased the accuracy to amazing heights. GPS work with help of satellite system which provide accuracy data directly on the computer screen. Various type of GPS equipment is available, form basic to highly advanced. Some GPS equipment even have night vision which facilitates at night time. However, it is said that though GPS helps in acquiring the exact position of the land; it does not provide good results in dense forest areas or concrete. For this reason, total station is used along with the GPS.

Figure 3.1.2.7 GPS

3.2 Highway Geometric Design

The geometric design of road deals with the dimension and layout of visible features of highway. The geometry of the road should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost. The safe efficient and economic operation of a highway is governed to a large extent by the care with which the geometric design has been worked out.

3.2.1 Factors Controlling Geometric Design

- **Design Speed**

The design speed is the important consideration in geometric design. The design speed is the maximum permissible safe speed of a vehicle on a given road considered for a design of road elements. It is the speed which may be adopted by a majority of skilled drivers when there are no secondary hindrances on road. NRS 2071 has recommended the following standard.

Road categories	Hills		Terai	
	Ruling	Minimum	Ruling	Minimum
District Road	25	20	50	40

Village Road	15	30

Table 3.2.1 Design Speed

- **Topography, physical and madman features**

The topography of the land plays a significant role as well—flat terrains allow for straighter alignments and higher speeds, while hilly or mountainous areas may require tighter curves, steeper gradient.

- **Traffic Factors**

The factors associated with the traffic that affects geometric design of roads are the vehicular characteristics and human characteristics of the road users.

- **Traffic Volume Study**

Traffic volume is the number of vehicles crossing a section of road per unit time at any selected period. Traffic volume is used as quantity measure of flow; the commonly used units are vehicles per day and vehicles per hour. The object and the uses of traffic volume studies are given below:

a) Traffic volume study is used in planning and designing the new road and the planning, traffic operation and control of existing facilities.
b) Classified volume study is useful in structural design of pavements, in geometric design and in computing roadway capacity.
c) This study is used in analysis of traffic patterns and trends.

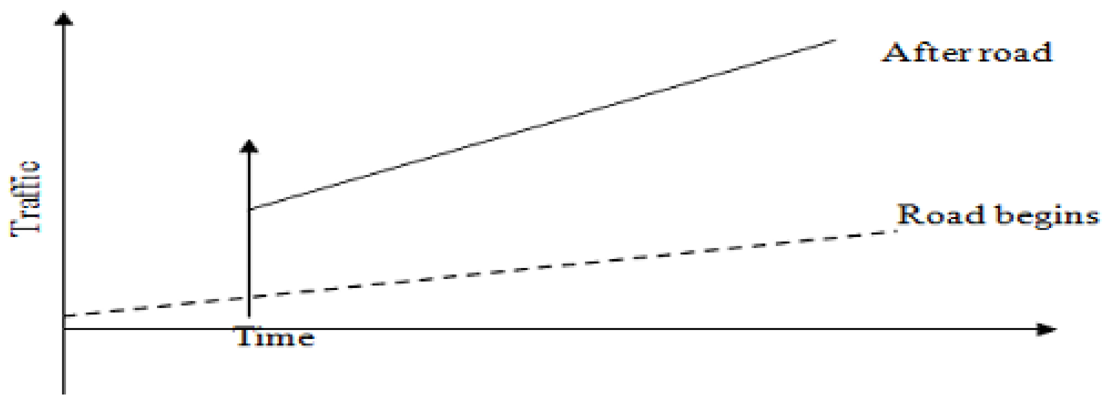

Figure 3.2.1.1 Traffic Generation Curve

For the different purposes of planning and design of traffic characteristics of roads, traffic volume study is important both in the existing and new roads. The traffic volume data is presented in Annual Average Daily Traffic (AADT) which is useful for future extension and design. This helps in deciding the relative importance of the route and in phasing the road development program in order to convert the different vehicle classes to one class such as passenger car, conversion factors known as Passenger Car Units (PCU) is used.

- **Design Hourly Volume and Capacity**

The traffic flow or volume keeps fluctuating with time, from a low value during off peak hours to the highest value during the peak hours. It will be uneconomical to design the roadway facilities for the peak traffic flow or the highest hourly traffic volume. Therefore, a reasonable value of traffic volume is decided for the design and this is called the design hourly volume. The ratio of volume to capacity affects the level of service of the road.

- **Environmental and Other Factors**

The environmental factors such as aesthetics , landscaping , air pollution , noise pollution and other local conditions should be given due considerations in the design on road geometrics.

3.3 Design of Horizontal Alignment

Design of Horizontal Alignment involves determining the layout of a road or railway in the horizontal plane. It includes selecting curves, tangents, and transitions to ensure smooth and safe vehicle movement. Proper alignment enhances comfort, visibility, and operational efficiency.

3.3.1 Horizontal Curves

A horizontal highway curve is a curve in plan to provide change in direction to the central line of road. They are generally used on the highways where it is necessary to change the direction of motion. The horizontal curves, which are generally used in highways, are circular.

Elements of Horizontal Curves are:

I. Tangent Length(T)
II. Length of Curve(L)
III. Length of Chord(I)
IV. Deflection Angle (Δ)
V. Radius of Curve(R)
VI. Apex Distance(E)

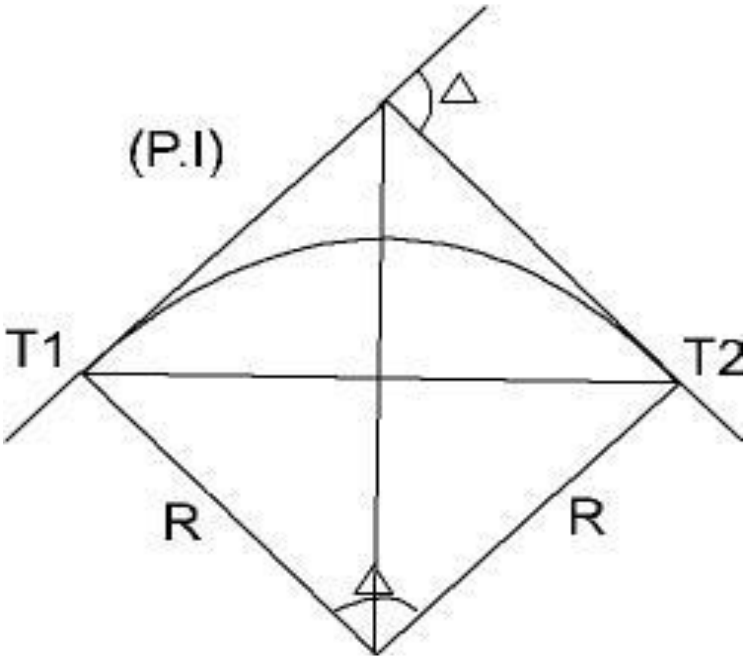

Figure 3.3.1.1 Horizontal Curves

3.3.2 Widening of Pavement on Horizontal Curve

Especially on horizontally curves, when they are not of very large radii, it is common to widen the pavement slightly more than the normal width. The widening introduce gradually, starting from the beginning of the transition curve or the tangent point progressively increased at the uniform rate, till the full value of designed widening, 'We' is reached at the end of transition curve where full values of super-elevation is provided.

3.3.3 Super Elevation

Super elevation is defined as one sided slope obtained by raising the outer edge of the pavement with respect to inner one along a curved path in order to counteract the effect of centrifugal force and reduce the tendency of the vehicle to overturn or skid. The NRS recommendation for the super elevation where ice condition does not exist is 0.12, the maximum of 0.12 values has been adopted for designed purpose. The minimum super elevation to be provided on horizontal curve may be limited to the camber of the surface.

3.3.4 Transition Curve

A non- circular curve introduced between a straight and a circular curve, is known as transition curve. The curvature of such curves varies from zero as its beginning to a definite value at its junction with the circular curve.

The function of transition curves in the horizontal alignment of the highway may be summed up into the following points:

- To introduce gradually the centrifugal force between the tangent point and the beginning of the circular curve, avoiding a sudden jerk on the vehicle.
- To enable the driver, turn the steering gradually for his own comfort and security.
- To enable gradual introduction of the designed super-elevation and extra widening of pavement at the start of the circular curve.

- To improve the aesthetic appearance of the road.

3.4 Design of Vertical Curve

It is necessary to introduce vertical curve at the intersection of different grades to smoothen out the vertical profile because of changes in grade in the vertical alignment of highway and thus ease off the changes in gradients for the fast-moving vehicles. If not so, the drastic change in the rate of grade may subject a vehicle passing over it to an impact, which would be dangerous leading to the loss of property and lives. Hence, the vertical curve contributes to safety, comfort and appearance.

Types of Vertical Curve

- Submit Curve
- Valley Curve

3.5 Gradient

Gradient is the rate of rise or fall along the length of the road with respect to the horizontal. It is expressed as a ratio of 1 in x. Sometimes it is also expressed as a percentage, n i.e., n in100.

Gradients are divided into the following categories:

- Ruling gradient
- Limiting gradient
- Exceptional gradient
- Minimum gradient

Grade Compensation on Horizontal Curves

When a sharp horizontal curve is to be introduced in a certain section of the road, which has already maximum permissible gradient, then the longitudinal gradient should be corrected and reduced to compensate for the loss of reactive effort due to various reasons. Some of them are given below:

- Increased rolling resistance.
- Increased grade resistance
- Increased air resistance

3.6 Highway Drainage

Highway drainage is the process of removing and controlling excess surface and soil water within the right of way. This includes interception and diversion of water from the road surface and sub-grade. Highway drainage is achieved by two methods as given below.

I. Surface Drainage
II. Sub Surface Drainage

6.6.1 Importance of Highway Drainage

1. Prevents Structural Damage

- Water accumulation weakens the road foundation (subgrade and base layers).
- Reduces bearing capacity of soil, leading to settlement, rutting, or collapse.
- Avoid potholes and cracks that arise from water infiltration.

2. Enhances Road Safety

- Prevents water logging onto the surface which can lead to:
- Hydroplaning (loss of vehicle traction on wet surfaces).
- Reduced visibility and control for drivers.
- Eliminates hazardous conditions, especially in curves and slopes.

3. Prolongs Pavement Life

- Efficient drainage reduces moisture content in pavement layers.
- Help in preserving the pavement integrity by avoiding freeze-thaw cycles and erosion.
- Reduces maintenance costs and frequency of major repairs.

4. Protects Surrounding Environment

- Proper drainage systems prevent soil erosion and flooding of adjacent lands.
- Helps manage storm water and avoids water contamination in nearby fields or rivers.

5. Improves Load-Bearing Capacity

- Dry pavement layers perform better under vehicle loads.
- Prevents premature failure of flexible or rigid pavements due to weakened support layers.

6. Maintains Traffic Flow

- Prevents waterlogging that could obstruct traffic or require emergency closures.
- Supports uninterrupted transportation, which is especially critical for emergency services and commerce.

7. Required by Design Standards

IRC (India), AASHTO (USA), and other design codes emphasize the need for:

- Longitudinal drains
- Cross drains (culverts)
- Side drains
- Catch basins and slope protection.

4. Objectives

The following are the major objectives of our project:

- To prepare geometric design of road including alignment plan, cross section and typical drawing.
- To be familiar with technique and equipment for hill road construction.
- To prepare detailed cost estimate.
- Ensure road geometry complies with standards (e.g., Nepal Rural Road Standards), directly reducing accident risk.

5. Scope and Limitation

5.1 Scope of the study

To study and recommend appropriate solution stabilization through civil engineering structures and bioengineering works.

- To give preventive measures and appropriate solutions for critical sections.
- To be familiar with the methodology behind the construction of low-cost rural road.
- To carry out the quantity estimates of the whole project.

5.2 Limitations of the study

- CBR test is not conducted due to time limit
- Culvert is not design
- Retaining wall is not design

6. Methodology

- First, group discussion will be carried out to select the desired topic.
- After the selection of topic, desk study will be done to locate the site through articles, maps, paragraphs
- After desk study a site will be selected
- Feasibility of site will be checked out and studied properly
- If the feasibility of the site is ok, then detailed survey will be carried out
- Finally, data collection and report submission will be done
- A brief presentation on our topic will be given

Figure 6.1 Methodology

7. Expected Result (Result and Discussion)

It is expected that the adoption of modern and traditional tools in surveying will help in detail study of topographic maps, contour lines, lamd features and existing infrastructure. It will help for finalization of horizontal and vertical alignment that will balance cost, saftey, terrain and environmental concerns and will also minimize earthwork and avoids hazardous or unstable areas. It will also helps in preparing tender documents and procurement planning. Planning of budget will helps in detail estimation of cost on materials, overhead, labor, taxes etc. We are also expecting that after fulfillment of this project there will be improved access to markets, schools, hospitals and government services. The travel time and transportation costs will reduced. Enhancement in mobility for women, children, farmers and business and facilitation of rural urban linkages and poverty reduction. The expected results of the "Detailed Survey, Design and Estimating of a Rural Road" project go far beyond technical drawings and cost sheets. This phase will lay the foundation for a resilient cost effective, environmentally sound and socially beneficial road infrastructure. When done thoroughly it ensures that the road not only gets built-but delivers long lasting impact in improving rural livelihoods and connectivity

8. Significant of Expected Result (Significant of Result)

The main aim of this project as mentioned above is to survey, design and estimation of the link road for better flow of traffic. The proposed project is necessary :

- To reduce the time travel of road users from origin to destination.
- To help with the transportation of local agricultural products in nearby markets.
- To make the use of locally available resources
- To create the opportunity of job for the youngster.

The site is located in the rural area of Kaski district and follows a hilly terrain so, earth retaining structures seems to be needed at many places in order to maintain the standard road geometry proposed by NRS 2055. Longitudinal side drains are needed in the side of road alignment and is used in almost at all the parts of road.

9. Expected Budget

The proposed project will be completed in the following budget if no problems arise during the project.

S. N	Category	Budget (NRS)
1.	Field Visit	15,000
2.	Transportation	5,000
3.	Stationary	3,500
4.	Miscellaneous	10,000
5.	**Total**	**33,500**

Table 9.1 Expected Budget

Budget in words: Thirty-three thousand and five hundred only.

10. Schedule

Weeks Activity	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Group discussion and topic selection																
Literature Review																
Site Selection																
Fundamental Planning																
Preliminary Design																
Proposal Presentation																
Survey																
Design																
Final Report Preparation																
Final Presentation																

Table 10.1 Schedule

11. Conclusions

By the end of the project, we will have the skills to operate equipment such as Total Station and GPS. We will also be proficient in using various road-related software like DTM, Road Smart, AutoCAD, etc. Additionally, we will be capable of performing geometric design for both rural and plain roads, as well as preparing road cost estimates accurately. The survey work will be conducted with the required precision.

Furthermore, providing transportation access to productive rural areas along the proposed road alignment will significantly contribute to improving living standards, enhancing quality of life, and reducing rural poverty.

12. Further Research/ Work

- Route selection and reconnaissance
- Soil investigation and testing
- Traffic survey
- Material survey and source identification
- Use of technology and software
- Geometric and pavement design

13. References

1. Shrestha D.K, Maraseni A, Transportation Engineering, 2016, Heritage Publishers and Distributors Pvt. Ltd. Bhotahity, Kathmandu, Nepal.
2. Justo C.E.G, Khanna S.K, Highway Engineering, Khanna Publications, New Delhi, India.
3. Punmia B.C, Jain A.K, Jain A.K, Surveying, 2005, Laxmi Publications (P) Ltd. New Delhi, India.
4. Nepal Road Standard-2070 (NRS-2070)
5. Nepal Rural Road Standard-2071 (NRSS-2071)