**DETAILED SURVEY, DESIGN AND COST ESTIMATION OF DISTRICT ROAD FROM BHUMESWOR MAHADEV MANDIR TO MICROSTAND (near *nec*)**

***Submitted by***

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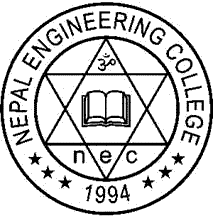
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**A Project report submitted in partial fulfillment of the**

**Requirements of Pokhara University for the Degree of Bachelor of Civil Engineering**

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CHANGUNARAYAN, BHAKTAPUR, NEPAL

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**CERTIFICATE**

This is to certify that the project entitled **“DETAILED SURVEY, DESIGN AND COST ESTIMATION OF DISTRICT ROAD FROM BHUMESWOR MAHADEV MANDIR TO MICROSTAND (near *nec*)”** submitted by (*Hari Lal Chaudhary (017-072), Jagat Bista (017-051), Jeeban Bomjan (017-071), Prabesh Ojha (017-069), Pratik Tiwari (017-070)*) have been examined by us and is accepted for the award of the degree of the **Bachelor of Civil Engineering by Pokhara University**.

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# ABSTRACT

The Detailed,survey, design and cost estimation of district road from Bhumeswor Mahadev mandir to microstand (near *nec*) was carried out for the project work. This proposed road was studied with various aspects such as technical, social, environmental and economical aspects and the technical standards and the guidelines of NRRS 2071 are followed for the road selection, feasibility study, detail survey, geometric design, drawing and pavement design of the road using plastic wastes.

Everyone is aware of the fact that humans are the most innovative creature. Their creativity and greed of getting more and more have helped them achieve the standard of life which they are living with. Development of the society they are living in is significantly dependent upon the word “Transportation”. Good transportation facilities itself plays the vital role for the overall development of the nation by raising the economic status of the people and development of a civilized society. The proposed road is 1.9080 km in length.

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# SALIENT FEATURES OF THE PROJECT

1. **Name of the project:**

Detailed survey, design and cost estimation of district road from Bhumeswor Mahadev mandir to microstand (near *nec*) Changunarayan, Bhaktapur

**2. Project location:**

**2.1. Geographic location**:

**a. Province** : Bagmati Province

**b. District** : Bhaktapur

**c. Municipality** : Changunarayan Rural Municipality

**2.2. Geographical Features:**

**a. Climate** : Subtropical

**b. Soil Type** : Ordinary soil

**c. Hydrology** : Precipitation controlled by monsoon

**d. Meteorology** : Unevenly distributed precipitation controlled by monsoon

**e. Terrain** : Hill

**2.3. Classification:**

**a. Classification** : District Road

**3. Length of road:**

**a. Length** : 1+908 km

**b. Starting Point** : 0+000 Bhumeswor Mahadev Mandir

**c. Ending Point** : 1+908 Microstand (near *nec*)

**4. Geometrics:**

**a. Right of way** : 10 m either side of the road (20 meter)

**b. Drain** : Trapezoidal drain as per site condition

**c. Carriage way width:** 3.75 m

**d. Design speed** : 25 kmph

**e. Shoulder width** : 0.75 m

**f. Super elevation** : Maximum 10%

**g. Camber** : 2.5%

**h. Gradient** : 0.5(minimum) to 12(maximum)

**i. Radius** : Minimum 22 m

**j. Stopping Sight Distance:** 48 m

**5. Earthwork:**

**a. Earth work in Cutting** : 3635.905 m3

**b. Earthwork in Filling :**3927.485 m3

**6.Project Cost:**

**a. Total Cost** : NRs 526,24,312.02

**b. Cost per Km** : NRs 275,74,372.93

# 

# ABBREVIATIONS USED

B Breadth

BM Bench Mark

BMS Boulder Mixed Soil

CBR California Bearing Ratio

CH Chainage

CL Centre Line

Cum Cubic meter

Cvpd Commercial Vehicles per day

DoLIDAR Department of Local Infrastructure and Development of

DoR Department of Road

H Height

IP Intersection Point

IRC Indian Road Congress

Kmph Kilometer per hour

L Length

L-Section Longitudinal Section

NRRS Nepal Rural Road Standard

OSD Overtaking Sight Distance

PCE Passenger Car Equivalent

PCU Passenger Car Unit

RL Reduced Level

RoW Right of Way

Sqm. Square meter

SSD Stopping Sight Distance

TBM Temporary Bench Mark

VAT Value Added Tax

X-Section Cross-section

VDC Village Development Committee

SRN Strategic Road Network

# CHAPTER 1

**INTRODUCTION**

## **Background of Nepal**

Nepal is a landlocked country with mountainous regions and lies between India and China. Due to the rugged topography, the various means of transportation in our country such as railways, waterways, ropeways and airways are less suitable. The country lacks adequate transportation facilities and thus road transportation is best suited for the rural connectivity as well as overall development of most of the area in Nepal. While transport facilities do not create development, they are essential for development to start. The overarching goal of road development is to reduce the pervasive poverty. In a country like Nepal, where most of the population is living in rural area, road transportation plays a vital role. Market access of the agricultural products from rural areas, in time supply of medicine and daily required commodities, improvement of employment opportunities etc. are advantages of efficient transportation facilities. The poor condition of the road network affects the country’s economic development. Therefore, it is crucial to maintain the rural road network, sustain its quality to contribute to development in major economic sectors, to ensure better living condition for the majority of national population.

In 2069 there were 6,683 rural roads with total length of 5,0943.647 km out of which 1,575.434 Km had been blacktopped, 14,601.921 Km had been graveled, 3,4766.293 had been earthen. The density of the road was 34.61 Km/sq.Km. The population influenced with the stated road connectivity was 1.91Km/1000 persons. (DoLI, 2069)

The History of Road development in Nepal is not very long. The Government of Nepal (GoN) has been giving high priority to the development of roads since the beginning of planned development programmed in 1956. With continued effort, the road length of the country which was only 376 Km in the 1950’s is currently above 24,000 Km including District and Urban Roads. The length of road is also an indicator of development, industrialization and economic prosperity of a country. Over the last two decades, therefore, increasing emphasis is being accorded to the development of rural roads in the country. The local authorities, the DDCs in particular, are becoming more and more responsible for planning, development and management of rural roads. NGOs, INGOs and donor agencies are increasingly collaborating with the DDCs. From the government side DoLIDAR coordinates, facilitates, regulates and monitors the rural road development activities in the country simultaneously providing technical assistance to the DDCs.

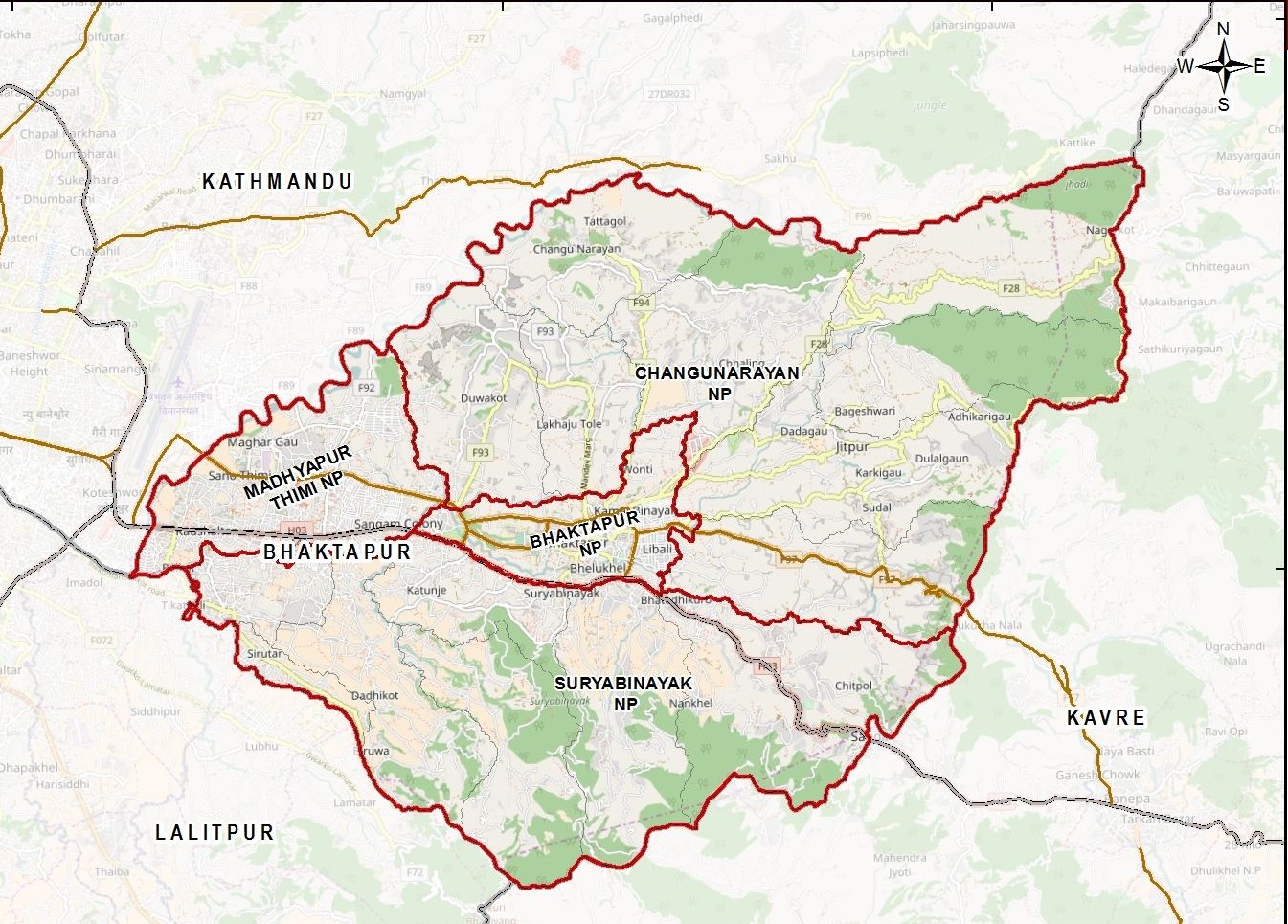
## **The Project Background**

The proposed road from Bhumeswor mandir to microstand (near *nec*), Changunarayan Bhaktapur was taken as project for the detail study and design. There is already existing earthen road for more than 70% of the total chainage and a small foot track in the remaining part, it needs greater improvement. This road is just about enough for medium sized vehicles. The Geometric design as well as gradient of the existing road is improper and much of the portion is not serviceable during heavy monsoon due to the presence of numerous cross flowing streams. Thus, construction of road with proper gradient and Geometric design has been found quite essential. Also paving of the road is also necessary because of the presence of numerous inhabitants and high flow of traffic. For the design of the proposed road project, Nepal Rural Road Standard (NRRS 2071 2nd revision 2071) has been used.

## **Study Area**

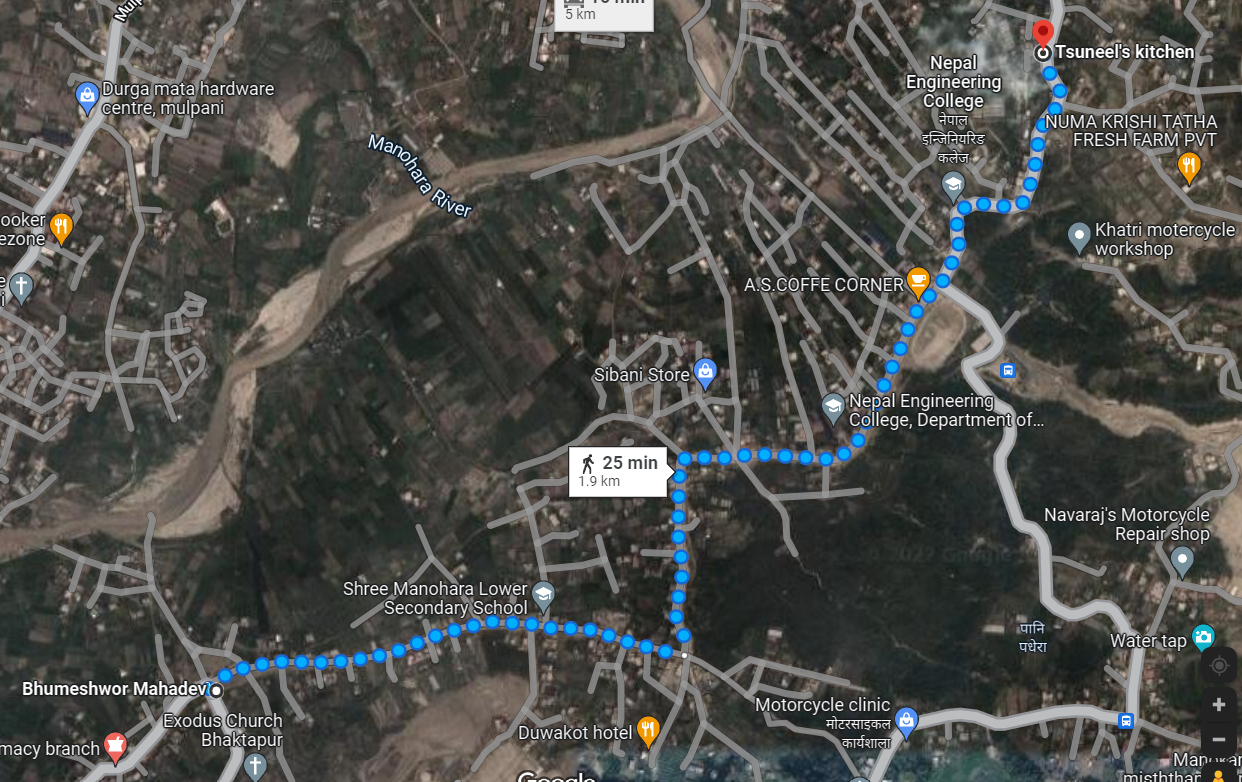
### **1.3.1** **Project Location**

The project area is located in Changunarayan VDC which is situated to the North – West direction from Bhaktapur city. The proposed road connects Duwakot and Mulpani, Bhaktapur. The alignment runs through the Changunarayan based community.



**Figure 1: Map of Bhaktapur District**

(Source: Google Map)



**Figure 2: Road Alignment**

(Source: Google Map)

### **1.3.2** **Climate and Hydrology**

The temperature of Changunarayan VDC is moderate. During summer, the maximum temperature ranges from 20 oC to 32 oC and during winter the minimum temperature ranges from 0oC to 2oC.

### **1.3.3 Physical Infrastructure and Economy**

Major income source of people in this area is agricultural products which are mushroom, cabbage, potato, tomato, maize etc. The area has gained importance for commercial vegetable cultivation in recent times. People are also involved in government and private services. There is absence of industrial infrastructures however educational institutions are present.

## **1.4 Statement of Problem**

From the study of project area, the problems faced by the society can be listed as below

* Lack of transportation facilities to the rural people.
* Difficulties for export of crash crop and rural product to the market.
* Problem for higher education and health treatment due to lack of motor access.

## **1.5 Objective**

The general objective of this project is to contribute for the development of Changunarayan VDC by connecting road network. The specific objective of project is:

* To carry out detail survey, design and cost-estimate of paved road from Bhumeswor Mahadev Mandir to microstand (near *nec*), Changunarayan Bhaktapur.

## **1.6 Significance of Study**

The proposed road alignment has a total length of 1.850 Km. The project site can be accessed from Duwakot. Due to the present landscape of the area, it is required to have several earth retaining structures, pipe culverts, causeways etc. to maintain the standard road geometry as given by the Nepal Rural Road Standard (NRRS) 2071.The construction of this proposed road help to increase volume of trade and business at the proposed site by market access of the agricultural products and also supply of needed agricultural inputs. Simultaneously, increase in economical standard due to improvement in employment opportunities will create positive impact on the society.

The various significance of this project is:

* Road linking from Bhumeswor Mahadev Mandir to microstand (near *nec*) Changunarayan Bhaktapur with motor-able service.
* Explore the opportunities for tourism enhancement in the area.
* Enhance the use of locally available resources in terms of labor, materials, finance and improve access to services, market and trading centers.
* Generate direct and indirect employment opportunities in order to uplift the living standard of people.

## **1.7 Scope of the Work**

The following are taken in the scope of work of proposed road project.

* Prepare the topographical map of the road corridor
* Detailed engineering survey of the alignment and its corridor
* Conduct hydrological studies for cross – drainage works and purpose the suitable cross drainage structures
* Choose economically feasible pavement type within the study corridor
* List the trees, house and other structures to be destroyed during the construction within road alignment
* Preparation of working drawings
* Prepare quantity and cost estimates
* Explore and recommend sources of basic construction materials.

## **1.8 Geology**

Geology deals with the study of earth. Geomorphology is one of the branches of geology which deals with the characteristics of land and earth’s surface phenomenon. The engineering geological study covers areas such as,

* Drainage flow and study
* Minor land slide areas
* Debris/mudflow sites
* Areas with high cuts and fill

# CHAPTER 2

**LITERATURE REVIEW**

## **2.1** **Importance of Road in Rural Development**

A country cannot progress unless it has a good road network. It improves market intelligence while encouraging price equalization among different transport regions of the country. Since Nepal’s economy is agrarian in character and the settlement pattern is rural oriented, rural roads constitute a critical element of the transport infrastructure. Road sector plays an important role in socio-economic development and regional integration in Nepal. The rural roads are essential to connect the rural areas with the cities or market centers. People in the rural areas need to travel long distances on a daily basis to access goods and services for domestic requirements and livelihoods. Thus, the absence of a proper means of transporting produces hindrance to district trades and economic development. The economic development is only possible when the rural economy gets developed. This is only possible when the rural people are able to access the daily requirements at cheaper cost and on timely basis. The specific importance of rural road is:

1. **National Integration:**

Better roads contribute to the reduction of regional differences and to the building of national unity through integration, resulting from enhanced transport services.

1. **Economic Growth:**

Better road connectivity stimulates economic growth by reducing transportation costs and providing access to markets, thus facilitating agricultural growth by ensuring reliable delivery of inputs and timely marketing of production at reasonable cost.

1. **Strategic Asset:**

Better roads bolster Nepal’s strategic geographical position as an essential transit corridor for its landlocked neighbors, facilitating their access to international markets.

1. **Poverty Reduction and Social Development:**

Roads provide access to VDC office, administrative and social support services, employment opportunities, schools, health care facilities and other social services.

## **2.2 Road classification**

According to Nepal rural road standard -2071(2nd Revision) roads in our country are classified as follows:

**District Road (Core Network)** – An important road joining a VDC, HQ’s office or nearest economic center to the district headquarter, via through either a neighboring district headquarter or Strategic Road Network.

**District Road**- Smaller roads not falling under District Road (Core Network) category are District Roads, including other Agriculture Road.

### **2.2.1 Road Standards**

In context of Nepal, road is designed according to following standard:

1. Nepal Road Standards

Nepal Road Standard was introduced in 2027 B.S. (2nd Revised 2070 BS). It is used to design Strategic Road Network (SRN). National Highways and Feeder Roads come under SRN. It is followed by Department of Road.

1. Nepal Rural Road Standards

The Nepal Rural Road Standards were introduced in 2055 B.S. and revised (second) in 2071 BS. It is used to design local level of Road Network. It is usually followed by user communities, DoLIDAR and its development partners. Since, the survey road falls under rural hill road, Nepal Rural Road Standard is used for literature purpose.

## **2.3 Hill Road**

A hill road is one which passes through a terrain with a cross slope of 25% or more. A hilly or mountainous area is characterized by highly broken relief with widely differing elevations, steep slopes, deep gorges and great number of water courses. The geometric design of the highway deals with the dimensions and layout of visible features of the highway such as alignment, sight distance and intersections. The geometric of highway should be designed to provide optimum efficiency on traffic operations with reasonable cost. Selection of a suitable alignment in hilly region is a complex job when the valley pattern takes a radial form and where the valley converges into a knot of mountains due to the meeting of several mountains. A thorough knowledge of the geological formation of the area is essential to decide the road alignment as the process of road construction in mountains disturbs the natural stability conditions. Prevention of soil erosion and stabilization of hill slope has been major problem in the maintenance of hill road.

## **Design Consideration of Rural Road**

### **2.4.1 Design Considerations**

The design consideration of roads is based on many factors including design speed, functional classification, vehicular volume, types of vehicles, existing terrain and natural features, community impacts, environmental effects, cost considerations and the right of way needed for road development. Road design is accomplished with the consideration of following design criteria and guidelines:

1. **Design Capacity**: Design capacity shall provide the basis for determining the class of the rural road. For example, a road classified as ‘B’ on the basis of connectivity might be changed into a class ‘A’ road, if the volume of traffic is found to be higher.
2. **Design Speed**: When the design speed is higher, the design standards should be of higher order which ensures the road safety, capacity, and comfort and decreases the user’s operational expenditure but the choice of design speed is influenced by the class of road, traffic volume, available budget and the terrain.
3. **Terrain**: The terrain through which the rural transport linkage passes directly influences the selection of geometric standards such as formation width, carriageway width, right of way, free board, radius of horizontal curves, gradient and intervals of passing zones.
4. **Environment:** The factors such as aesthetics, landscaping, air pollution, noise pollution and other local conditions should be given due consideration in the design on road geometrics.

### **2.4.2 Socio-economic and Technical Consideration in Rural Roads**

Improvement of “FWR-Fair Weather Road” to “AWR-All Weather Road” generally requires to be justified on socio-economic grounds. For this actually served population /households per kilometer must not be less than the threshold criteria. For AWRs proposed to be blacktopped (or bituminous seal coated) there must exist minimum of 50 vehicles per day as Annual Average Daily Traffic. Sustainability of rural roads may be assured only when local authorities take full responsibility of their development and maintenance. While designing different components of road, the design should be simple and low cost rather than complicated and costly design. More over the design should be based on availability of local materials and investment should remain within the reach of the local economy.

### **2.4.3 Environmental and Social Consideration in Rural Roads**

1. **Environmental Considerations**

The basic intention of environmental consideration is to develop the best possible rural road in the given environmental settings by the use of environmentally sound and appropriate approaches, methods, standards and techniques maintaining environmental quality. Main environmental factors that need to be considered are forest and protected areas, landslides and erosion prone areas, flood and drainage problems, sites of historic, cultural, religious or archaeological significance, population centers and valued environmental features like wet land, lakes, drinking water source need to be protected while planning and developing the road network.

1. **Social Considerations**

The social consideration in road development is associated with promoting broader social development benefits and to discourage any social harms and dis-benefits from the road. Emphasized care should be given for not harming the poor, landless and vulnerable groups. Compensation should be provided for the loss of livelihood assets and employment opportunities.

## **2.5 Highway Alignment**

The highway alignment may be defined as the position occupied by the center line of the road on the ground. The horizontal alignment includes the straight path, the horizontal deviations and curves. Changes in gradient and vertical curves are covered under vertical alignments of road. To determine the precise position of the layout of the road centerline from the design and drawing on ground during construction, it is essential to determine three coordinates of all points of the center line. Thus, highway alignment is located on the ground with the help of its two components. A new road should be aligned very carefully, as improper alignment will result in one or more of the following disadvantages:

1. Increase in construction cost

2. Increase in vehicle operation cost

3. Increase in maintenance cost

4. Increase in accident rates

5. When Road is constructed, it will be uneconomical to redesign and to realign the existing road and hence the road should be aligned carefully as far as possible.

### **2.5.1 Basic requirements of highway alignment**

**Short**: It is desirable to have a shortest alignment between two terminal stations. Its shortest path due to obligatory points, such as gradient, mountain pass, structures, ditches, intermediate towns etc. So, obligatory points describe points through which the alignment should pass and should not pass.

**Easy**: The alignment should be such that it is easy to construct and maintain easy with minimum problems. In addition, the alignment should pass and should not pass.

**Safe**: The alignment should be safe enough for construction and maintenance from the viewpoint of stability of natural hill slopes, embankment and cut slopes and foundation of embankments. It should be safe for the traffic operation with safe geometric features.

**Economical**: If the total cost including initial cost, maintenance cost and vehicle operation cost is low the road alignment could be considered economical. The alignment should be such that it would offer maximum utility by serving maximum population and products is considered in selecting the alignment.

### **2.5.2 Factors Controlling Highway Alignment**

While designing road alignment, the distance between two terminals should be straight and short as far as possible. However, it is not possible due to various reasons such as due to the physical and geometric conditions of the site. Similarly, there may be construction and maintenance problems along a route, which may otherwise be short and easy. A road, which is economical in the initial construction cost, need not necessarily be the most economical in the maintenance or in cost of vehicle operation.

The various factors which control the highway alignment are listed as:

1. Obligatory points
2. Traffic
3. Geometric design
4. Economics
5. Other considerations
6. **Obligatory points**
   1. Points through which the alignment should pass
   2. Bridge site
   3. Industrial area
   4. Hill pass
   5. Intermediate town
   6. Points through which the alignment should not pass
   7. Waterlogged area
   8. Historical or archeological site
   9. Restricted zone for defense / national security
   10. Densely populated area
   11. Very costly structures
7. **Traffic** 
   1. The alignment should suit traffic requirements. Origin and destination study should be carried out in the Area.
8. **Geometric design** 
   1. The geometric design of a highway deals with the dimensions and layout of visible features of the Highway such as such as gradients, radius of curve, sight distance, and super elevation etc. While aligning a new road, the gradient should be flat and less than design gradient.
9. **Economy** 
   1. The alignment should also be economical.
10. **Others**

* Various other factors such as drainage, hydrological factors, political considerations, monotony, Subsurface Water level, seepage flow and high flood level are to be keeping in view.
* Alignment along a hill side pass
* Connecting intermediate town
* Alignment avoiding an intermediate area
* Alignment to suit proper location of bridge
* For Hill Road special consideration needs, be given to such concerns as:

Stability

Drainage

Geometric standards of hill roads

Composition of traffic

## **2.6 Engineering Survey and its Stages**

The engineering surveys are to be carried out before a Road alignment is finalized in Road project. The Surveys are completed in four stages, first three stages consider all possible alternate alignments keeping in view of the various requirement of road alignment. The fourth stage is meant for the detailed survey of the selected alignment.

The four stages of the engineering surveys are:

1. **Map Study**

By analyzing the topographical map of the area, we first extract several alternative routes of the road, so that further details of these may be studied later at the site. Usually, the topographical map of scale of 1:25000 provided by Department of Survey, Government of Nepal (GoN) is preferred in highway planning but for small stretch, such large-scale maps are not preferable.

1. **Reconnaissance**

It is the second stage of surveying deciding the road location. The field survey parties inclusive of an advisor inspect a broad stretch of land along the proposed alternative routes of map in the field. All relevant details not available in the map were collected and noted down. Some of the details collected during reconnaissance are mentioned as follows:

* Ponds, marshy land, ridge, hills, permanent structures and other obstruction along the route, which are not available in the map study.
* Number and types of cross drainage structures, maximum flood level and natural ground water level along the probable routes.
* Soil type along the routes from field identification tests and observation of geological features.
* Sources of construction materials, water and location of stone quarries.

1. **Preliminary Survey**

During Preliminary survey following tasks are performed:

* The Survey of the various alternate alignments proposed after the reconnaissance and to collect all necessary details of topography, drainage and soil.
* Comparison of different proposals in view of the requirements of a good alignment.
* Selected the best alignment from all considerations.

1. **Final Location and Detailed Survey**

The alignment finalized after the preliminary surveys is first located on the field by establishing the centerline. Next detailed survey is carried out collecting the data necessary for the preparation of plans and construction details for the road Project. The key terms used in the course of detailed survey are as stated hereunder:

1. **Plan**

It is top view of project in a map. It consists of

1. Northing
2. Location of IPs and BMs with reference
3. The road centerline, formation width, side drain and right of way
4. **Benchmark**

It is a permanent point of reference whose elevations w.r.t some assumed datum is known.

1. **Leveling**

The objective of leveling is to find the elevations of given points w.r.t a given elevations or at a different elevations w.r.t a given or assumed datum. Leveling deals with measurements in a vertical plane. For the purpose of road construction, the profile leveling is carried out to determine the R.L of the centerline located with driven pegs. The leveling determines the alignment of the road. The leveling is taken at suitable intervals according to the site.

1. **Composition of Traffic**

The alignment of road passing from the shortest route is deviated due to the volume and composition of traffic. For road with intensive heavy vehicles and high volume of traffic alignment yielding minimum length of steep ascend/descend is much desirable than the shortest route distance.

Similarly, a road leading to a recreation spot, or tourist spot that might have predominant by light passenger car and a few buses, alignment may be chosen with higher slope. In addition, the origin and destination study should be carried out in the area and the desire lines be drawn showing the trend of traffic flow. The alignment should be chosen based on origin and destination study, traffic desire lines, flow pattern, future trends etc.

1. **Geometric Features**

Geometric design factors such as permissible limit of descending or ascending slopes, sight distance requirements, degree of curvature and bends, slope of camber, super elevation, and width of the road, extra widening and many other dimensional features of the road may also govern the final alignment of the road.

1. **Economy**

The appropriate alignment should also be economical. The economic analysis is done taking into account all the possible costs which includes construction cost, maintenance cost, vehicle operation cost, accident cost, travel time cost etc. The analysis should also include cost of environmental and social mitigation measures, land acquisition for construction and development of road. For road alignment to be economical, the sum of all road components should be as less as possible. The initial construction cost seems to be more initially but in reality, the vehicle operation cost and road user travel time cost is more. However, due to budget constraint sometimes – initial construction cost might be the governing factor and alignment selected accordingly even if the road yields highest maintenance cost and vehicle operation cost. The Initial cost of construction can be decreased if high embankments and deep cuttings are avoided and the alignment is chosen in a manner to balance the cutting and filling.

## **2.7 Geometric Design of Road**

Geometric design of road deals with the dimensions and layout of visible features of road such as alignment, cross slope or camber, gradient, sight distance considerations, horizontal and vertical alignment details, intersection elements, width, turning radius, carriage way, kerb and road margins. The geometry of the road should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost and also should be consistent with its economy. Therefore, it is important to plan and design the geometric features of the road during the initial alignment itself taking into consideration the future growth of the traffic flow as well as the possibility of the road being upgraded to a higher category or to a higher design speed standard at a later stage.

### **2.7.1 Elements of Geometric Design**

Geometric design of Road deals with following elements:

* Cross section elements
* Sight distance considerations
* Horizontal alignment details
* Vertical alignments details
* Intersection elements

### **2.7.2 Highway Cross-Section Elements**

Cross-sections are run along transverse direction to the longitudinal profile and on other side for the purpose of lateral outline of the ground surface. They provide the data for estimating quantities of earthwork and for other purposes. The scale selected for plotting is equal on both the axes. Cross-sections are plotted for each element of curves. The cross-section consists of the following:

* Pavement surface
* Cross slope or camber
* Width of pavement or carriageway
* Kerbs
* Road margins
* Width of roadway
* Right of Way
* Formation width

A description of these cross-section elements is provided hereunder:

1. **Pavement Surface**

The pavement surface depends on the pavement type which is decided based on the availability of materials and funds, volume and composition of traffic, sub grade and climate conditions, constructions facilities and cost considerations. The important surface characteristics of the pavement are friction, pavement unevenness, Light reflecting characteristics and drainage of surface water.

1. **Cross Slope or Camber**

Cross slope or camber is the slope provided to the road surface in transverse directions to drain off the rain water from the road surface. The required camber of a pavement depends on the type of pavement surface and the amount of rainfall. Too steep cross slope is not desirable because of tilting of vehicles and discomfort in driving.

Types of camber are

1. Straight
2. Parabolic
3. Combined

The NRRS2071 has recommended of camber for the bitumen rural area to be 3%. The recommended values of camber in different types of roads are provided in table 2. In designing the proposed road, the standard value has been considered.

**Table 1: Values of camber in different types of road surface (NRRS2071)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Camber** | **Types of road surface** | **District Road Core Network** | | **District Road** | |
| **Hill** | **Terai** | **Hill** | **Terai** |
| Carriageway slope (%) | Earthen(existing) | 5 | 5 | 5 | 5 |
| Gravel | 4 | 4 | 4 | 4 |
| Bituminous Seal Coat | 3 | 3 | - | - |

1. **Width of Pavement or Carriageway**

The pavement or carriageway width depends on the width of traffic lane and number of lanes. The carriageway intended for one line of traffic movements may be called a traffic lane. The lane width is determined on the basis of the width of vehicle and the minimum side clearance which may be provided for safety.

**Table 2: Width of carriageway for various classes of roads (NRRS2071)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **carriageway width (m)** | **Shoulder**  **width (m)** | **Roadway**  **width (m)** |
| District Road Core Network | Hill | 5.5 (if traffic> 400 vpd) | 0.75 | 7 |
| 3.75 (if traffic > 100 vpd) | 0.75 | 5.25 |
| 3 (if traffic < 100 vpd) | 0.75 | 4.5 |
| Terai | 5.5 (if traffic> 400 vpd) | 1 | 7.5 |
| 3.75 (if traffic > 100 vpd) | 1.5 | 6.75 |
| 3 (if traffic < 100 vpd) | 1.5 | 6 |
| District Road | Hill | 3 | 0.5 | 4 |
| Terai | 3 | 0.75 | 4.5 |

1. **Kerbs**

Kerb indicates the boundary between the pavement and shoulder or sometimes islands or foot path or kerb parking space. Kerbs provide lateral confinement and stability to the granular base course and flexible pavements. Kerbs may be mainly divided into three groups based on their functions:

1. Low or mountable type kerb
2. Semi-barrier type kerb
3. Barrier type kerb
4. **Road Margins**

The various elements included in the road margins are shoulder, parking lane, frontage road, driveway, cycle track, footpath, guard rail and embankment slope as shown in fig no.1.

**Roadway width**

**BUILDING LINE**

**BUILDING LINE**

**CONTROL LINE**

**RIGHT OF WAY**

**Shoulder**

**Carriage way**

**Formation width**

**Road margin**

**CONTROL LINE**

**Figure 3: Road Margin in Embankment**

1. **Width of Roadway**

Width of roadway is the sum of widths of pavements or carriageway including separators, if any, and the shoulder excluding side drains.

1. **Right of Way**

Right of way is the area of land acquired for the road, along its alignment. The width of this acquired land is known as land width and it depends on the importance of the road and possible future development. The NRRS2071 recommendation on the right of way for the different types of roads is provided in Table 4.

**Table4: Right of Way (NRRS2071)**

|  |  |  |
| --- | --- | --- |
| **Types of Roads** | **RoW** | **Comment** |
| District Road (Core Network) | 20 | 10m RoW on either side from center line |
| District Road | 15 | 7.5m RoW on either side from road center line |

**Formation width**

It is finished width of earthwork in fill or cut.

### **2.7.3 Horizontal Alignment Details**

Following elements are to be considered while the design of horizontal alignment:

1. **Design Speed**

It is the maximum speed allowed for the vehicles to move on the road. The design speed is the most important factor controlling the geometric design elements such as requirements of pavement surface characteristics, cross section elements of road, elements of horizontal alignment and element of vertical alignments. The NRRS 2071 recommendation for the design of district road is 20 Kmph. The adopted design speed is 20 Kmph for this project.

1. **Horizontal Curve**

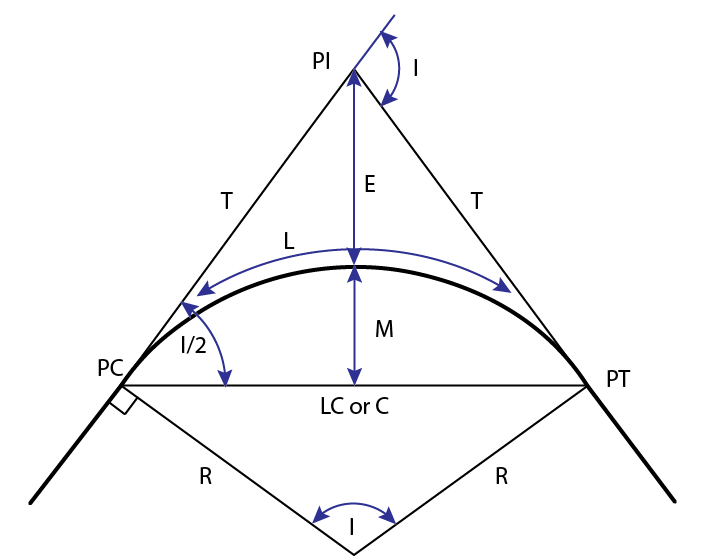
A horizontal curve is a curve in plan to provide change in direction to the central line of road. They are generally used on the highways where it is necessary to change the direction of motion. The simplest form of horizontal curve for roads is an arc of a circle, whose radius is chosen to suite the speed of traffic using the road or to fit geometrical constraints such as missing fixed objects or passing through a certain point.

**Elements of horizontal curves are as follows:**

* **Tangent Length (T):** The length between the beginning of the curve or end of the curve and the point of intersection is called the tangent length. It depends on the deflection angle and radius of the curve given by the relation T=R tan (Δ/2).
* **Length of Curve (L):** The length of curve from the point of commencement to the point of tangency is called length of the curve. If the curve is designated by its degree of curvature, the length of the curve will depend upon the criteria used for the definition of the degree of curve given by relation L= π RΔ/180.
* **Length of Chord (l):** It is the chord joining the point of curve with the point of tangent or point of curve itself.
* **Deflection Angle (**Δ**):** The angle between which a survey line makes with the prolongation of the proceeding line is called deflection angle. It is measured to the clockwise or anticlockwise from the prolongation of the previous line. Its value ranges from 0o-180o.
* **Radius of Curve(R):** For the certain speed of vehicle, the centrifugal force is dependent on the radius of the horizontal curve. To keep the centrifugal ratio within

low limit the radius of the curve should be kept correspondingly high. According to the NRRS 2071, the minimum radius to be adopted is 15 m.

* **Apex Distance (E):** It is the distance between the points of intersection to the middle of curve length. It also depends in the deflection angle and radius of the curve.



**Figure 4: Horizontal Curve**

* **Bearing of Line:** The bearing of line is the angle made by that line with respect to the magnetic north direction. It is also known as whole circle bearing (WCB).

**Radius of Horizontal Curve**

For the certain speed of vehicle, the centrifugal force is dependent on the radius of the horizontal curves. To keep the centrifugal ratio within a low limit, the radius of the curve should be kept correspondingly high. The centrifugal force which is counteracted by the super elevation and lateral friction is given by the relation,



 (Where e = 0.07 maximum allowable super elevation rate)

 (f = 0.15 design coefficient of lateral friction)

If the design speed is decided for a highway, the minimum radius to be adopted can be found from the above relationship. Thus, the ruling minimum radius of the curve for ruling design speed v m/sec or V, Kmph is given by:



Also, 

where, v and V = ruling design speeds in m/sec and Kmph respectively

e = rate of super-elevation

f = design value of transverse skid resistance or coefficient of friction taken as 0.15

g = acceleration due to gravity = 9.8 m/sec2

**a) 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 introduces 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 is reached. Total widening 'We' is reached at the end of transition curve where full values of super elevation is provided.

Mechanical widening 

Psychological widening 

Hence Total widening (We) = Mechanical widening + Psychological widening.

= W*m* + W*ps*

Where, n = number of traffic lanes.

l = Length of wheelbase of longest vehicle, m. The value of 1 is normally taken as 6.1 m or 6.0 m for commercial vehicle.

V = design speed, Kmph.

R = radius of horizontal curves.

Psychological widening is not considered for rural road.

b) **Super elevation**

To counteract the effect of centrifugal force and to reduce the tendency of the vehicle to overturn or skid, the outer edge of the pavement is raised with respect to the inner edge thus providing a transverse slope throughout the length of the curve. This transverse inclination to the pavement surface is known as super elevation or banking. Introducing super elevation permits a vehicle to travel through a curve more safely and at a higher speed than possible with a normal crown section. The NRRS 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. There are two ways of attainment of super elevation which are:

* 1. Elimination of crown of the cambered section
  2. Rotation of pavement to attain full super elevation.

**Design criteria of super-elevation**

Various steps in the design of the super elevation in practical are summarized as given below:

1. The super elevation for 75% of design speed (V Kmph) is calculated neglecting the friction.





1. If the calculated value of e is less than 1/15 or 0.07, then the value so obtained is provided.

If the value of e exceeds 1/15 or 0.07 then provide the maximum super elevation equal to 1/15 and proceed with steps given below.

1. Check the coefficient of the friction developed for the maximum value of e = 0.07 at the full value of the design speed.





If the value of  thus calculated is less than 0.15, the super elevation is safe for the design speed. If not, calculate the restricted speed from the above step.

As an alternative to step 3, the allowable speed (, Kmph) at the curve is calculated by considering the design coefficient of lateral friction and the maximum super elevation

e + f = 0.067 + 0.15 = 0.217 = 

Calculate the safe allowable speed.

, m/sec.

, Kmph.

If the allowable speed as calculate above higher than the design speed, then the designs is adequate and then provides a super elevation of 'e' equal to 0.07. If the allowable speed is less than the design speed then the speed is limited to the allowable speed Kmph calculated above.

**a) Transition Curve**

Anon- 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:

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

**Calculation of the length of transition curve**

The length of transition curve is designed to fulfill following three conditions

1. Rate of the change of centrifugal acceleration to be developed gradually.
2. Rate of the introduction of the designed super-elevation to be at reasonable rate.
3. Minimum length by IRC empirical formula.

**Rate of the change of centrifugal acceleration (C)**

 (m/sec3)

The length of transition curve Ls



Were,

Ls = length of transition curve, m

R = radius of the circular curve, m

C = allowable rate of change of centrifugal acceleration m / sec3

m/sec3 [0.5 < C < 0.08]

**Rate of introduction of super elevation**

 ; If outer edge is rotated about center line.

Ls= EN = eN (W +We); If pavement is rotated about the inner edge.

Where, Ls= Length of transition curve, m

e = rate of super elevation in %

E = e (W+W*e*)

W*e* = extra widening provided at the circular curve

N = 150 in plain rolling terrain

= 60 in hilly terrain

**By empirical formula:**

1. for plain and rolling terrain:



V = Velocity in Kmph

1. for hilly and steep terrains



V = Velocity in Kmph

**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 the loss of tractive effort due to various reasons. Some of them are:

1. Increased rolling resistance.
2. Increased grade resistance
3. Increased air resistance

Due to the turning angle of vehicles, the curves resistance is developed at the horizontal curves. When there are horizontal curves in addition to the gradient, there will be increased resistance to traction due to both gradient and curves; it is necessary that in such cases, the total resistance due to grade and curve should not exceed the resistance due to the maximum value of gradient specified. For design purpose, this maximum value may be taken as the ruling gradient and in some special cases as limiting gradient for the terrain. When the sharp horizontal curve is to be introduced on a road, which has already the maximum permissible gradient, the gradient should be decreased to compensate for the loss of tractive effort due to the curves.

This reduction in gradient at the horizontal curve is called grade compensation. This is calculated from the relation:

Grade compensation % =  , subject to a maximum value of 

Were,

R = Radius of circular curve, m

The grade compensation is not required for the curves flatter than 4% gradients.

### **2.7.4 Sight Distance**

The clear distance visible ahead of a driver at horizontal and vertical curves and at intersections governs the safe movements of vehicles.

Three sight distance situations are considered in the design:

1. Stopping sight distance
2. Safe overtaking or passing sight distance
3. Safe sight distance for entering into controlled intersection

The standards for sight distance should satisfy the following three conditions:

* Driver travelling at the design speed has sufficient sight distance or length of road visible ahead to stop the vehicle, in case of any obstruction on the road ahead, without causing collision.
* Driver travelling at the design speed should be able to safely overtake the slower vehicles without causing obstruction or hazard to traffic from opposite direction at a certain interval.
* Driver entering an uncontrolled intersection has sufficient visibility to enable him/her to take control of his/her vehicle and to avoid collision with another vehicle.

1. **Stopping Sight Distance (SSD)**

The minimum sight distance available on a highway at any spot should be of sufficient length to stop a vehicle travelling at design speed safely without collision with any other obstruction.

The sight distance available on a road to a driver at any instance depends on

* Features of the road ahead
* Height of the driver’s eye above the road surface
* Height of the object above the road surface.

Stopping distance = Lag distance + Braking distance

SD = vt +

Where, v = speed of vehicle, m/s

f = design coefficient of friction (0.4-0.35 from 30-80 Kmph)

t = total reaction time of the driver in seconds

1. **Overtaking Sight Distance (OSD)**

The minimum distance open to the vision of the driver of a vehicle intending to overtake slow vehicle ahead with safety against opposite direction vehicles is known as the overtaking sight distance or the safe passing sight distance available.

Some of the important factors on which the minimum overtaking sight distance required for the safe overtaking maneuver depends are:

* Speed of (a) overtaking vehicle (b) overtaken vehicles (c) the vehicle coming from opposite direction, if any.
* Distance between the overtaking and overtaken vehicles. The minimum spacing required depends on the speed.
* Skill and reaction time of the driver.
* Rate of acceleration of overtaking vehicle.
* Gradient of the road.

### **2.7.5 Vertical Alignment Details**

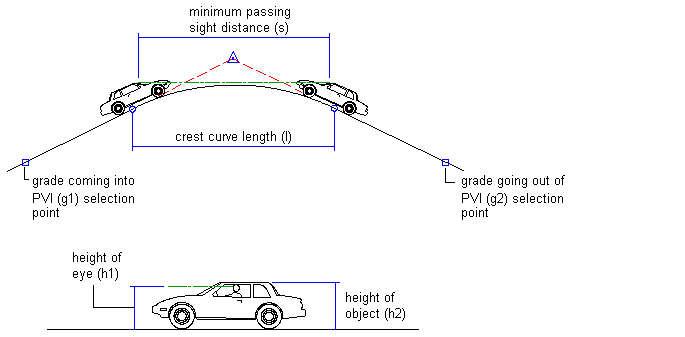
While aligning a highway it must follow the general topography of the land. But the natural ground may be level only at some places and otherwise the ground may have slopes of varying magnitudes. Hence, the vertical profile of a road would have level stretches as well slopes or grades. In order to have smooth vehicle movements on the roads, the change in the grade should be smoothened by the vertical curves. Followings are important to be considered in vertical alignment:

1. **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 the safety, comfort and appearance.

1. **Types of Vertical Curve**
2. Summit curve
3. Valley curve
4. **Summit curve**

The summit curve is introduced when an ascending gradient meets with descending gradient in the alignment. The maximum permissible gradient is taken as 12% and maximum average gradient is 8 % (NRRS2071). During the design, the minimum value of stopping sight distance is considered as 20m for the design speed 20 Km/hr. according to NRRS2071.



**Figure 5: Summit Curve**

**a) When L> SSD**



Height of driver's eye (H) = 1.2m (above the pavement surface)

Height of object above the pavement surface (h)=0.15m

S = Stopping sight distance, (SSD), m

N = Algebraic difference of grade

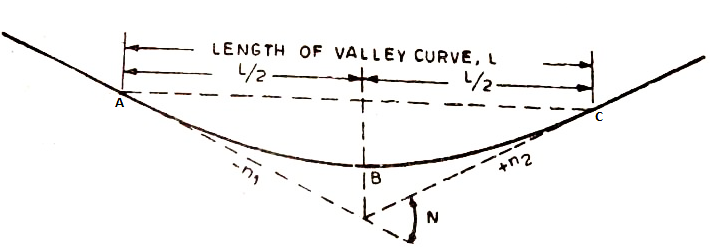
**b) When L < SSD**



1. **Valley curve**

In the alignment, the valley curve is introduced when descending gradient meets with an ascending gradient. The length of valley transition curve is designed based on the two criteria: (i) the allowable rate of change of centrifugal acceleration (ii) the head light sight distance, and the higher of the two values is adopted. Usually, the second criterion of head light sight distance is higher and therefore governs the design. During design, sight distance is considered and according to NRRS2071, which consist that the headlight sight distance will be the stopping sight distance, minimum value of stopping sight distance is 20mand that the centrifugal acceleration will be of 0.6m/sec2.

1. **The length of transition curve Ls for comfort condition is given by equation,**

****

**Figure 6: Valley curve**

The valley curve is made fully transitional by providing two similar transition curves of equal length. Refer figure 3 where ABC is the valley curve of total length L and AB and BC are two equal transition curves each of length Ls=L/2, having minimum radius R at the common point B.

Length of valley curve L = 2Ls = 2

N = deviation angle

L = Total length of valley curve

= speed in m/s

= allowable rate of change of centrifugal acceleration

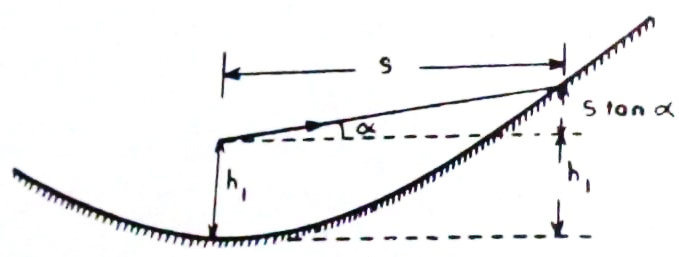
V Kmph = m/s

L = 2

L = 0.38

Minimum radius of valley curve for cubic parabola is given by R = =

1. **Length of valley curve for headlight sight distance.**
2. **L > SSD**

****

**Figure 7: Head light sight distance when L>S**

L = 

Where, L = length of summit curve,

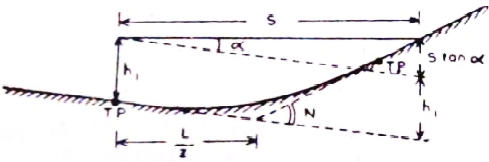
S = stopping sight distance, (SSD), m

N = deviation angle

h1 =Average height of head light = 0.75 m

= Beam angle = 1o

1. **L < SSD**



**Figure 8: Head light sight distance when L < S**

L = 2S - 

Substituting h=0.75 m and =10when L<S

L = 2S - 

1. **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 following categories:

1. Ruling gradient
2. Limiting gradient
3. Exceptional gradient
4. Minimum gradient

### **2.7.6 Intersection Elements**

Design of road intersection with facilities for safe and efficient traffic movement needs adequate knowledge of traffic engineering.

## **2.8 Highway Drainage**

### **2.8.1 Introduction**

Highway drainage is the process of removing and controlling excess surface and sub-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.

1. **Surface drainage.**

The surface water is to be collected and disposed of. The water is first collected in longitudinal drains, generally side drains and then the water is disposed of at the nearest stream, valley or water course. Cross drainage structures like culverts and small bridges may be necessary for the disposal of surface water from the road side drains.

1. **Sub surface drainage.**

Sub-surface drainage involves removal of excess water from the sub soil. The aims of sub surface drainage are:

* 1. Lowering of water table.
  2. Control of seepage flow.
  3. Control of capillary rise.
  4. Drainage of infiltration water.

### **2.8.2 Importance of Highway Drainage**

Followings are the importance of highway drainage:

1. It maintains the bearing capacity of soil.
2. It removes water from flowing or standing on the carriageway.
3. It prevents from failure of pavement.
4. It reduces necessity of maintenance cost.
5. It provides safety travel in place of freezing temperature.
6. It prevents mud pumping pavement failure.

### **2.8.3 Side Drains**

Side drains are meant for the drainage of the surface water these are provided on the both side of the road to drain off the surface water from the carriageway. The longitudinal slope

of drain is made parallel to the longitudinal slope of the alignment.

### **2.8.4 Design of Surface Drainage System**

Design of surface drainage system involves:

1. Hydrologic analysis
2. Hydraulic analysis
3. **Hydrologic Analysis**

The peak runoff is calculated by rational formula:

Q=CIA/360

Where, Q= Runoff in m3/s

A= Area of catchment in hectare

C=Runoff coefficient

I= Rainfall intensity, mm/hr.

1. **Hydraulic Analysis**

Once the design discharge is determined the hydraulic analysis is done. The side drains are designed based on principle of open channel flow. Longitudinal slope of channels, which is parallel to the road profile, is selected. The type of lining from which value of ‘n’ and permissible ‘V ‘is obtained is selected.

Then,

Q=A x V

Q=A x (R2/3 x S1/2)/n (1)

For the rectangular section, select economical section as,

R=D/2, B=2 x D

Solve equation (1) to get B and D

Calculate V by

V= (R2/3 x S1/2)/n for the design section which should be within the permissible limit otherwise change lining material and redesign the section.

Where,

V=velocity of flow, m/sec

N= Manning’s roughness coefficient

A=Area, m2

P=wetted perimeter, m

R=Hydraulic radius =A/P, m

S=Longitudinal bed slope of channel

### **2.8.5 Cross-Drainage Structure**

There are number of cross drainage structure is to be constructed in order to drain off the water from the side drain.one of the important cross drainage structure in the road aliment is culvert.

### **2.8.5.1 Culvert**

A culvert is a closed conduit placed under the embankment to carry water across the roadway. Culvert is preferred than a minor bridge because it is hydraulically more efficient. According to Nepal Road Standard 2027; bridge structure of span less than 6 m is termed as culverts.

Followings are important types of culverts:

**Slab Culvert**: A slab is placed over abutments made of masonry, sometimes called box culverts if the span is below two meters.

**Pipe Culvert:** Pipe of minimum diameter 60 cm and made of steel or pre-cast RCC is used when the discharge is low. But, pipe culverts of diameter 75 cm, 90 cm, 120 cm are available in the market.

**Causeway**

These are structures provided with hill road which allows to drain off water flowing over the road surface to the lower level safely. Generally, for stability and durability consideration RCC cause ways are used rather than dry stone cause ways.

## **2.9 Retaining Structure**

### **2.9.1 Introduction**

Retaining wall is that type of wall, which is used to retain the vertical mass of soil. The primary function of retaining wall is to resist the lateral thrust of a mass of earth on one side and sometime the pressure of subsoil, water and in many cases the wall may also be required to support vertical loads form a structure above call surcharge.

**Functional Requirements of Retaining Structures:**

Retaining structures must specially satisfy the important requirements as below:

1. Strength and stability
2. Durability

The retaining structures must not

1. Slide
2. Overturn
3. Overstress the materials of which the structures are constructed
4. Overstress the soils in which the wall rest

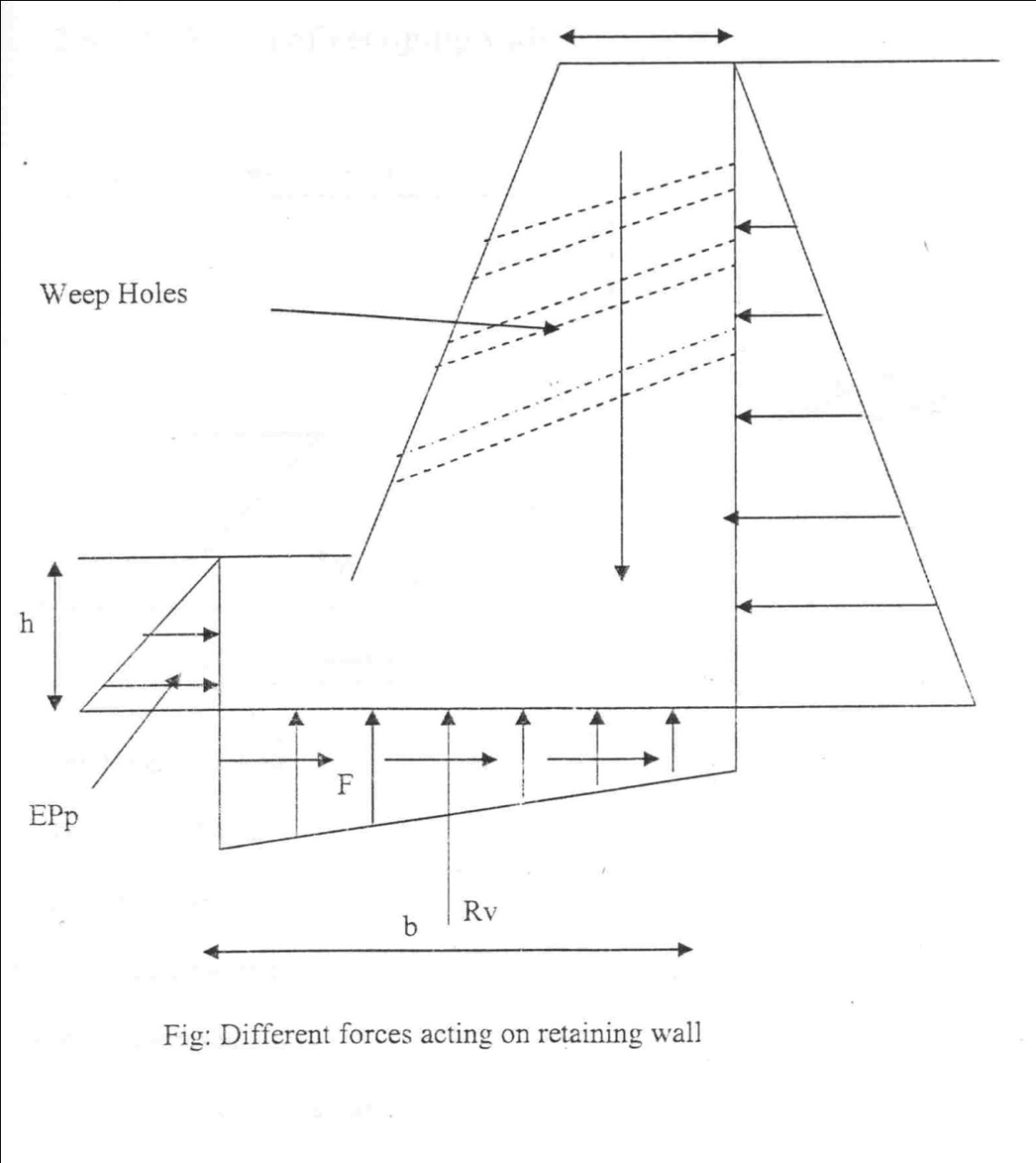
### **2.9.2 Types of Retaining Walls**

i. Cantilever retaining walls

ii. Mass retaining walls (Gravity retaining walls)

Considerations of following elements are important in the design of retaining wall:

1. **Active Earth Pressure:** Lateral pressure, which tends to move or overturn the wall at all, times and this is result of the earth wedge being retained together with any hydrostatic pressure caused by the pressure of ground water.
2. **Passive Earth Pressure:** Reactionary pressure that builds up to resist any forward movement will comprise the soil in front and relation to counteract this movement.
3. **Angle of Repose:** It is the natural slope taken by any soil and it is given in terms of the angle to the horizontal base line. Angle of repose varies from 45 degree to 0 degree for wet clay but for most of soil angle of repose is nearly about 30 degrees.
4. **Wedge of Soil:** It is the mass of soil resting on the upper plane of the angle of repose.
5. **Surcharge Load:** The part of the material or load supported by a retaining wall at a level above the top level of the wall may be by virtue of its nature of position



**Figure 9: Different Forces acting on Retaining Wall**

### **2.9.3 Survey Information and Design Consideration for Retaining Walls**

Retaining walls help to support mountainside slopes, or support the road or slope segments from the valley side. They are designed to stop an active earth pressure. Toe walls are normally considered to be a type of retaining wall found are the base of a slope or segment of slope which have the outer slope 1 in 10 and bed slope is 1 in 4.

Practical Features:

* Use dry masonry in every case where it is applicable (see special features of dry masonry walls below). Only use other types of walls when you are certain you need greater strength and can justify the additional cost.
* The top width of the retaining wall should not be less that 60cm for stone masonry
* The back should be left rough or built-in steps to increase friction between the wall and the backing.
* The backfill should be deposited in 10 cm to 15 cm layers with moderate compaction sloping downward from the wall to reduce lateral pressure, after the wall has attained sufficient strength.
* The foundation should be taken deep enough to safeguard against weather and should be at least h/10 +30 cm below the ground level.
* The projection of any footing course should not exceed half the depth of course
* Careful design and supervision of foundations are of paramount importance
* While excavating foundations, remove debris to a safe location. Do not allow to be thrown down the slope.
* In most locations, solving the drainage problem is a major difficulty. Therefore, consideration should always be given to using the best drained of structures. Once the construction is complete ensure that the slopes around the structure are tidied up and treated using appropriate bioengineering measure. All surplus debris must be removed, or it will encourage the development of erosion.

# CHAPTER 3

**METHODOLOGY**

The typical flowchart diagram of the methodology which will be carried out are as follows.

**Data Collection & Map Study**

* + 1. **Field visit and Walkover survey**
    2. **Feasibility/Environmental/Socio-economic Study**

**Alignment Selection**

**Literature Review**

**Supervisor**

**Consultation**

**Detail Survey**

**Design and Estimation**

**Complete Design and Estimation**

### **3.1. Data Collection**

### **3.1.1. Desk study**

Documents, drawing maps, design standard for the detail design of the road were collected. Following activities were carried out during desk study.

a. Map and the paper document related with the site were studied.

b. The design standards, norms were collected during the desk study.

c. NRRS 2nd revision 2071 has been studied and referred for adoption of design standard and specification.

### **3.1.2. Identification and selection of road**

After thorough review of the different site by field visit, Bhumeswor Mandir to Microstand, Manohara road was selected as final project site. The route was selected because we found this site as best possible site to learn hill road survey and design.

### **3.2. Design and Survey works**

### **3.2.1. Field survey**

The survey included survey throughout the road alignment, hydrological study geological study as well as structure that must be constructed along the road alignment. The major works on the field's survey are:

1. **Reconnaissance**

It was the first stage of the survey for the road alignment. During reconnaissance we proposed

1. The type of the cross drainage and their location.
2. Location of the Gabion retaining wall, retaining structures along the road.
3. Bio-engineering methods application area.
4. **Detail survey**

The list of equipment’s that were used in surveying work can be mentioned as follows:

* Total station
* Measuring tape
* Plumb bob
* Level
* Staff
* Ranging rods and arrows
* Hammer
* Wooden pegs
* GPS device
* Compass

First of all, we fixed the station point at the ground. Then total station was placed on the station point and the coordinate of Northing (N), Easting (E) and Elevation (Z) was set. For the Horizontal angle in Total Station the North point was set as zero. And reading was taken on the center line of the road at the interval of 20m.The ground points data were also recorded. A Gabion retaining wall, Hume pipe were proposed in different locations which are shown in ANNEX- DETAILED ESTIMATE. These various structures are shown on the detailed drawings. The soil type was identified on the field by the quantity of gravel present in the soil and the soil was mixed with boulders so the soil is boulder mixed soil (BMS). Detailed survey was done with the rough drawing and recording the required data throughout the road alignment.

### **3.3 Engineering Design**

The geometric parameters were adopted following the NRRS (2071) guidelines and chosen on the basis of comfort, safety and minimal construction and maintenance cost after finalizing the road classification. The vertical alignment was designed to obtain an optimum balance of cut and fill (earth work) while minimizing the optimum embankment filling in the plain and rolling terrain insuring its stability. The locations of key points of vertical alignment such as beginning of curve, middle of curve, and end of curve, highest and lowest points was fully defined with respect to the designed points of vertical intersection. Cross-sectional parameters such as extra widening, super-elevation, and camber was provided according to NRRS (2071). Adequate provisions for retaining wall, gabion wall, cross and side drains was made to ensure safety of road.

Road Design Software (Smart-Road) was used for the computation of field data which also facilitate in the preparation of various drawings and design such as:

* + Plan of Survey alignment showing the key structures within road corridor.
  + Horizontal and Vertical alignments showing all design parameters with the conformity of road design standards.
  + Cross-sections at given interval including retaining structures, drainage type as recommended.
  + Computation of cut-fill quantity to access the estimation of earth work.

### **3.4 Engineering Drawings**

The drawings were prepared using AutoCAD and Road Design Software. For the implementation of detail design works of the project following drawings are produced:

* Plan in 1:1000 scale containing alignment, curve data and indicating surrounding features in the Road corridor.
* Profile at 1:200 scale indicating existing ground situations, proposed designs and indicating length and type of drains.
* Cross-sections incorporating structures at 1:200 scale at all centerline pegs with existing ground situations, proposed designs and data such as existing ground level, area of cut, area of fill, soil type and drain type etc.

### **3.5 Software used**

Smart Road software is one of the best tools for plotting the cross-section at required intervals, plan and profile of the proposed alignment of the road. This software is very easy for operation. Output of this software is obtained in auto CAD. It is very popular software for designing the roads.

The data obtained from surveying by Total station used in the Smart Road software. Then, this software gives the output for the longitudinal profile of existing ground and from this profile, alignment can be fixed with respect to the average maximum gradient considering the balance of cut/fill volume.

After entering co-ordinates, type of drain, side slope of drain, right of way, shoulder width, carriageway width, type of soil, cross-section interval, scale of drawing, the output can be achieved in required format of cross section, plan and profile in auto CAD. This software gives the quantities required for various structures like gabion retaining wall, gabion breast wall. It also gives the data for horizontal curve and vertical curve in excel sheets. Cross section, plan and profile of road alignment from auto CAD can be plotted easily.

## 

## **3.6 Report**

Final report and drawings including salient features and all findings from detailed design and survey was prepared.

# CHAPTER 4

**DESIGN AND CALCULATIONS**

# Geometric Design

### **Horizontal Curve**

For minimum radius of horizontal curve, we have the formula,

R = V2 / (127(e + f))

Where,

e= super elevation=0.07

f=lateral coefficient of friction between the road surface and tires=0.15 V=speed of vehicles in Kmph=25 Kmph

This gives R=22m From NRRS 2071,

Minimum radius of horizontal curve(R) =12.5m

So, we provide minimum radius of horizontal curve (R) =22m

Curve Design at IP2:

∆ = 78.150

R =25 m

Tangent length = R\*tan (∆/2)

= 25\*tan(78.15/2)

=20.29 m

Length of curve (L) = *R*

=3.14\*25\*78.15/180

=34.m

Vertical curve design at IP8 :

SSD = 48 m

n1 = 3.03 %

n2 = -3.06 %

Then

N = 3.03 –(-3.06)

= 6.09 %

Assume L<S, L= 2S-4.4/N

=2\*48- 4.4/6.09

= 23.75 m <SSD (OK)

### **Super elevation Design**

The super elevation for 75 percent of design may be calculated by neglecting the friction. From NRRS 2071,

e=super elevation =0.07

f=lateral coefficient of friction between the road and tires=0.15 For checking super elevation,

e= (0.75v2)/ (127R)

e= (0.75\*25)2 / (127\*25)

e=0.11>0.07

So f= v2/127R-e

f=0.12<0.15(safe)

So, we provide maximum super elevation (e) =7% and lateral coefficient of friction =0.12

### **Extra Widening of curves**

For single lane road, psychological widening is not provided and the space required for mechanical widening is fulfilled by shoulder

Total extra widening =nL2/2R

Where, L=length of wheel base=6.1 V=design speed (Kmph) =25 Kmph n=number of lanes=1

𝑅=design radius in meters=22m

Therefore, extra widening of curves=0.84m

### **Stopping sight distance**

S=reaction distance + braking distance

SSD = 0.278vt + v2 /(254f)

v=design speed in Kmph=25kmph t=reaction time of driver in sec=2.5sec

f=coefficient of friction between tire and road surface=0.4 Above values give SSD=24m

Provide SSD= 48m

# Hydraulic Design

### **Design of Side Drain**

The peak run off is calculated by rational formula in which, Q = CIA / 360

Where,

Q = Runoff in m3/s

A = Area of the catchment = 75 ha (from Google earth)

C= Impermeability factor = 0.45

I = Rainfall intensity = 5 mm/hr.

Thus

Q= (0.45\*5\*75)/360=0.468 m3

Now,

V = Permissible velocity of flow=1.5m/s

n = manning’s roughness coefficient = 0.015

A = area of drain

P = wetted perimeter

R = hydraulic radius =A/P

Now

A = 𝑄

𝑉

= 0.468

1.5

= 0.312 𝑚2

Assume B= 0.6 m Solving,

A= (B×D) + 1 × 𝐷 × mD

2

0.312 = BD +1/2\*D2\*0.2 (assume m=0.2)

Or, D = 0.486 m

Adopt, D = 0.5 m

Slope of Drain

S1/2= v\*n / R2/3

A/P = (0.312/(0.5+0.6+0.51) = 0.194 m

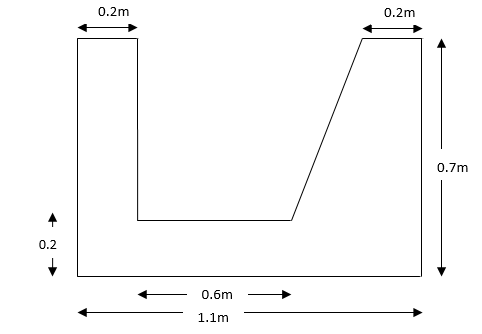
Or, S1/2 = 1.5 ×0.015

(0.194)2/3

Or, S = 4.5 × 10−3

= 1 in 222.22

Therefore, Longitudinal Slope, S = 1 in 225 is provided.



### **Figure 10: Typical Drawing of Drain**

### **Design of Hume Pipe**

For Small seasonal stream pipe culvert of sufficient dia. To be provided for safe crossing. The design of the pipe culvert, s=7%

Manning’s Coefficient is assumed

Q=A×V

Velocity (V) = 1R2/3 S1/2

𝑛

2

Q=𝜋𝑑 × 1R2/3 S1/2

4 𝑛

For most economical section R=0.29D

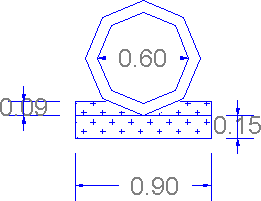
Where, Q=discharge=0.2029m3/s

(For, A'=31.32 ha)

A=area of pipe

Diameter is calculated on the basis of trial and error method. Check for velocity,

If calculated velocity<permissible velocity, velocity is adopted for calculation. Hume pipe of dia. 0.6m is adopted.



### **Figure 12: Hume Pipe**

### **Causeway Design**

Since the design discharge for Causeway design is very low i.e. Q= 0.08 m3 /s (For A=10hac, C=0.55), a simple type of causeway is provided having base slab 3m, and side slab of 3m span at slope 1:10 on both sides. Slab thickness is adopted as 25cm (250mm). Longitudinal slope of Causeway is 7%.

# Retaining Wall Design

Sample calculation,

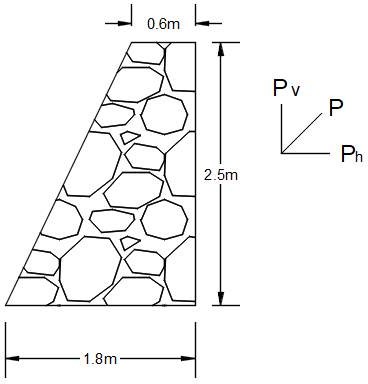
Since the back of the wall is inclined, Rankine's equation for determining the active pressure will have to be used. Hence, use equation

Ka=cosβ((cosβ−√(cosβ)2−(𝑐𝑜𝑠∅)2)/(cosβ−√(cosβ)2−(𝑐𝑜𝑠∅)2))

Here,

β = Angle of backfill slope

Ø = Angle of shearing resistance of the soil



### **Figure 13: Retaining Wall**

Here,

Back fill provided is 2.5:1 (H:V)

Therefore, β= tan-1( 1 )=21.80

2.5

Assume the coefficient of friction at the base of the wall is 0.6 Angle of shearing resistance of soil for clay is (25-30) Therefore, take Ø=280

From above equation we get, Ka=0.489

Now, using equation, we get active pressure

Pa=1Ka ΓH2= 1(0.489×20×2.52)=30.56KN/m

2 2

The total pressure acts inclined to the normal.

Horizontal Components of pressure

Ph=Pacos 25.64°

=30.56×cos 25.64

=27.55KN/m

Vertical component, Pv =Pasin 25.64°

=30.56×sin 25.64°

=13.22KN/m

### **Table 4: Computation of Forces and Moment**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sn | Description | Forces(Kn/M) | | Lever Arm | Moments About Toe (KnM/M) | |
|  |  | Vertical | Horizontal |  | Clockwise | Anticlockwise |
| 1 | W1=0.6×2.5×24 | 36 |  | 1.5 | 54 |  |
| 2 | W2=0.5×1.2×2.5×24 | 36 |  | 0.8 | 28.8 |  |
| 3 | 𝑃𝑣 | 13.22 |  | 0.8 | 10.576 |  |
| 4 | Ph |  | 27.55 | 0.833 |  | 22.94 |
|  | **∑** | **85.22** | **27.55** |  | **93.376** | **22.94** |

i) FOS against sliding = 𝑅𝑒𝑠𝑖𝑠𝑡𝑖𝑛𝑔 𝐹𝑜𝑟𝑐𝑒𝑠

𝑆𝑙𝑖𝑑𝑖𝑛𝑔 𝐹𝑜𝑟𝑐𝑒𝑠

=𝛍 ∑ 𝑽

∑ 𝐻

=0.6×85.22

27.55

=1.85>1.5 (Safe)

ii) FOS against overturning = 𝑅𝑒𝑠𝑖𝑠𝑡𝑖𝑛𝑔 𝑀𝑜𝑚𝑒𝑛𝑡

𝑂𝑣𝑒𝑡𝑢𝑟𝑛𝑖𝑛𝑔 𝑀𝑜𝑚𝑒𝑛𝑡

= ∑ 𝑀𝑟

𝑀𝑜

= 93.376

22.94

= 4.04>2 (Safe)

# Traffic Volume Study

Location: Near to Electrical Block (*nec*) Observed Month= March

Time: 10:30 AM to 11:30 AM

### **Table 5: Traffic volume data**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of vehicle | No. of vehicle per hour(a) | No. of projected vehicle per day(a\*10) | Equivalency factor | Converted no. of vehicle or PCU |
| Motorcycle | 90 | 900 | 0.5 | 450 |
| Bus | 5 | 50 | 3 | 150 |
| Car | 8 | 80 | 1 | 80 |
| Truck (Mini) | 4 | 40 | 1.5 | 60 |
| Van | 3 | 30 | 1 | 30 |
| **Total** |  | **1100** |  | **770** |

Note: As the data was only taken for sample observation, peak hour was chosen and due to unavailability of sufficient time to take full day data. So this peak data is projected to get daily traffic data for design basis. In order to get vehicle per day (full day data) 10 hour is assumed for projection.

# CBR Test:

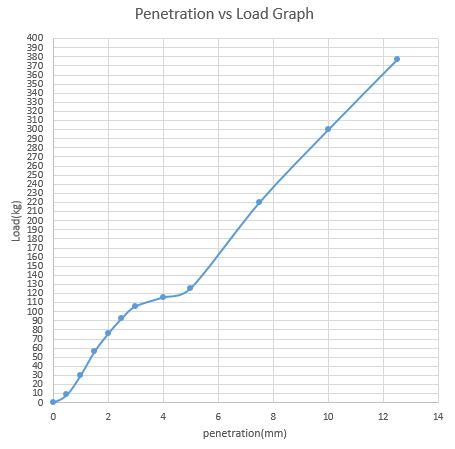
* CBR test is used to evaluate the subgrade strength of road and pavements.
* It is used to determine thickness of pavement.

### **Table 6: CBR test(sample 1)**

|  |  |  |
| --- | --- | --- |
| **Penetration** | **Reading** | **Loading** |
| **(mm)** | **Division** | **Kg** |
| 0 | 0 | 0 |
| 0.5 | 25 | 8.5 |
| 1 | 88 | 29.92 |
| 1.5 | 164 | 55.76 |
| 2 | 223 | 75.82 |
| 2.5 | 273 | 92.82 |
| 3 | 312 | 106.08 |
| 4 | 341 | 115.94 |
| 5 | 370 | 125.80 |
| 7.5 | 647 | 219.98 |
| 10 | 882 | 299.88 |
| 12.5 | 110 | 376.72 |

Standard values on crushed stone aggregates for specified penetration values:-

|  |  |
| --- | --- |
| Penetration, mm | Standard load, Kg |
| 2.5 | 1370 |
| 5 | 2055 |



[Graph 1: Load-Penetration Curve in CBR Test (Sample 1)](#_Toc76821174)

Sample 1,

CBR at 2.5 mm = 𝐿𝑜𝑎𝑑 𝑟𝑒𝑞𝑢𝑖𝑟𝑒𝑑 𝑡𝑜 𝑝𝑒𝑛𝑒𝑡𝑟𝑎𝑡𝑒 2.5 𝑚𝑚 𝑓𝑜𝑟 𝑔𝑖𝑣𝑒𝑛 𝑠𝑝𝑒𝑐𝑖𝑚𝑒𝑛

𝐿𝑜𝑎𝑑 𝐶𝑎𝑟𝑟𝑖𝑒𝑑 𝑏𝑦 𝑠𝑡𝑎𝑛𝑑𝑎𝑟𝑑 𝑠𝑝𝑒𝑐𝑖𝑚𝑒𝑛 𝑓𝑜𝑟 2.5 𝑚𝑚 𝑝𝑒𝑛𝑒𝑡𝑟𝑎𝑡𝑖𝑜𝑛

= 𝐿𝑜𝑎𝑑 𝑎𝑡 2.5 𝑚𝑚 \* 100

1370

\* 100

= 92.82

1370

∗ 100

= 6.775 %

CBR at 5 mm = 𝐿𝑜𝑎𝑑 𝑎𝑡 5 𝑚𝑚 ∗ 100%

2055

= 125.8

2055

∗ 100% = 6.2%

# Pavement Design

Subgrade CBR obtained from lab = 6.77% So, Adopting, subgrade CBR as 6%.

PCU = 770 PCU

n =10

Traffic growth rate = 8%

N =365\*((1+r)n-1)/r)\*VDF\*LDF

=365\*770((1+0.08)10-1)/r)\*1.5\*1

=6.10\*106 esal

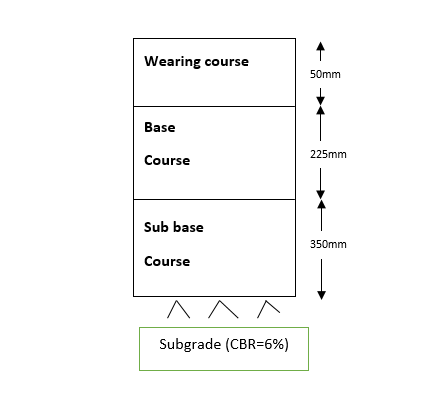
Here Traffic class is T6 and subgrade strength class is S3.

From chart,

Thickness of surface course = 50 mm

Thickness of base course = 225 mm

Thickness of sub-base course = 350 mm



**Figure 15: Pavement Structure**

# CHAPTER 5

# BIOENGINEERING

A detailed environmental assessment of the project area was undertaken comprising of the physical, cultural and ecological environment. In this context, the physical environment refers to meteorological elements, topography, soil, geology, land use pattern along the corridor, surface water resources and ground water resources, ambient air quality and noise. The cultural environment comprises schools, colleges, temples etc. Forests and the associated wildlife along with the trees along the corridor constitute the ecological environment. The findings are outlined in the ensuing section.

# Bioengineering works

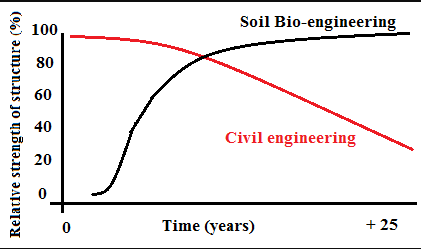
### **Introduction**

Bioengineering systems work by fulfilling the engineering functions required for the protection and stabilization of slopes. It is not a substitute for civil engineering even though it offers a set of tools to complement those already available in solving a range of shallow slope problems. Bioengineering plays one or more roles of catching debris, armoring the surface, reinforcing the soil, anchoring the surface layer, supporting the slope or draining the material. Bioengineering serves two distinct roles providing additional techniques for stabilizing shallow failures and controlling erosion and enhancing civil engineering structures by protecting them and maximizing their effectiveness.

In the context of Nepal, Bioengineering plays an important role because of the conditions like the active geomorphology, steep slopes in mountains, intense rainfall, restricted economy, etc. So, Bio-engineering should be used more widely in Nepal on account of the extreme terrain conditions and the need for extensive low-cost techniques for protecting slopes and stabilizing shallow-seated failures.

### **Combined Effect of Civil and Bio-Engineering Structures**

Due to integration of bioengineering with the road construction projects it stabilize the slope with minimum number of structure and small size of them which ultimately minimizing the cost of construction.



### **Figure 16: Life span of small civil engineering and vegetative structures**

### **Importance of Bio-Engineering**

Without the knowledge of bioengineering, a road engineer cannot be perfect. Every road engineer must have to knowledge about slope stabilization, choice of suitable plants according to altitude and environmental condition for plantation on both sides of road and idea makes the road beautiful. Bioengineering Works as Road Side Development

Roadside development deals with the development of aesthetic and other amenities of road and the right of way. Proper planning is needed for roadside development right from the stage of survey and during construction. For this, we propose following points.

* Wide right of way
* Consistent alignment
* Flint side slope in embankment and cutting
* Planting of trees along the roadside and proper maintenance
* Turfing on side slopes

Afforestation along the roadside or the arboriculture is one of the very important aspects in roadside development. Trees are proposed to plant on both sides of the road to enhance road in the following ways.

* It helps to improve road landscape from aesthetic point of view. Greenery along the road apparently makes the road beautiful and attractive.
* It provides shade and a highly cool feeling
* It intercepts the annoying sound of vehicles.

Both forest resources and land for agriculture become economically important with access. Under such conditions threat of extinction of vegetation become imminent. Roadside land provides an excellent habitat for the conservation of such species. The management or the conservation of plantations on the roadside is relatively easy and more effective to control. Representative of all the endangered or threatened life forms such as trees shrubs and herbs can be conserved in this fashion. In this process priority should be given to those plants that are most need. Roadside plantation can also enhance the scope of bee keeping and increase the possibility of farmers to earn additional income from honey. This also increases the crop production through pollination.

Proper planning in plantation would avoid wastage due to deterioration trees. It is necessary to frame a plan where trees are carefully examined and dead trees are discarded. Additional trees are planted as part of renovation. Trees are planted at an interval of 12m longitudinally. List of species to be used are proposed as follows.

### Trees

* 1. Bamboo
  2. Khannue

### Shrubs

* 1. Nigalo
  2. Assuro

### **Grass**

* 1. Amliso
  2. Khar
  3. Narkat
  4. Babiyo

# Environmental Impact Assessment Observation

Any development activities have its own advantages and disadvantages. The major activity in road construction is cutting of stabilized land slope. Earthwork excavation through blasting can disturb the stabilized mass. Balance volume of soil, which is supported by itself under gravity. Hence, the major environmental impact of road construction is destabilization of stable slope in general following is the main environmental effect may result during the construction of road.

1. Deforestation
2. Air pollution
3. Mass movement of Soil

For prevention on the environmental impact following measures will be adopted during construction.

1. While selecting road alignment selection in such a way that uncultivated land was used by road.
2. Cut/fill volume should be minimum to reduce erosion soil dump area requirement and changed in landscape protection the susceptible surface affected by erosion at construction side.
3. Implementation forestry conservation and development program
4. Limitation on use of fuel wood and prohibition of unauthorized falling of trees and use of open fire during construction
5. In the entire cut slope major, minor, good water management is required, which is the main cause of land unsuitability of the region.

The alignment mostly following the existing track so the environmental impact is within the manageable limit.

# CHAPTER 6

# PROJECT COST

# Cost Estimation

### **Project Cost**

Project cost was obtained based on Rate Analysis norms and basic district rate of Bhaktapur district. The project cost has been classified as

1. Net project Cost
2. Gross project cost

Net project cost includes the contractor’s overhead and contract tax whereas the gross project

cost is inclusive of provisional sum @4%, contingencies @ 5% and VAT@13%.

Basic unit rates of labor, material and equipment are adopted as per district rate of Bhaktapur.

# Details of Measurements

### **Earth Work**

The earthwork in cutting and filling was derived in cubic meters from average area method. This is given by the combine computation of design line, summit curve and valley curve.

### **Side Drainage and Cross Drainage**

The quantity of side drain was determined by taking sectional area for each type of side drain and multiplying it by the length of the corresponding side drain.

### **Retaining Structures Earthwork**

Earthwork in retaining structure is computed from the cross-section diagram. Cross-section diagram shows depth of earth work required for the structures.

# Analysis of rate

### **Quantity Estimate**

Quantity estimate of different items are provided in Appendix-1 which provides the estimate quantities of different items of work for the road alignment.

### **Manpower Estimate**

The necessary number of skilled and unskilled manpower is estimated for different kinds of road construction jobs according to norms and quality of works included in rate analysis.

### **Availability of Materials**

Besides the locally available construction materials, other imported materials are also necessary for other jobs like slope protection works, cross-drainage structures.

### **Availability of Manpower**

It has been realized that the skilled and unskilled manpower is adequately available in Bhaktapur district.

# CHAPTER 7

# CONCLUSIONAND RECOMMENDATION

# Conclusion

This report contains all the technical and theoretical aspects and the geometric standards that are required for the construction and that follow the standard norms of Nepal of the before mentioned road. Observing the current road construction, it has various problems for the vehicle due to the construction in the road. The various problems are due to the excessive gradient, inadequate geometric standards, improper drainage structures and the lack of retaining structures.

The maximum gradient was fixed up to 12%due to the topography of the location and due to the social constraints of the locality and in this project exceptional gradient was avoided while selecting road alignment.

The total volume of cutting is 3635.905 m3 and total volume of filling is 3927.485 m3. The total cost of the project having a length of 1+908 Km is estimated to be NRs. 526,24,312.02. The total cost per Km is NRs. 2,7574372.93.

# Recommendation

* + - Due considerations should be taken during the construction phase in order to minimize disturbances to the naturally stable slopes.
    - Introduction of small scale Civil Engineering structure with conjunction of bio engineering should be preferred and land preparation for this purpose should be done from the very beginning of the project i.e. from the first phase of the project.
    - Due to variance in cutting and filling volume, two optimum sites for the deposition of the soil must be explored within the area by visiting the site of the road construction and thus deposition of the soil must be done.
    - For quality and long life of road, it is strongly recommended that the road should be frequently maintained after construction. This will not only maintain the beauty, quality and life of road, but also the economy.

**Limitations**

* + - This report covers survey and design work of rural hill road only.
    - Design of pavement in the road is not carried out due to limited scope of our project.
    - The maintenance works are not included in this report.
    - Designing on retaining wall is based on simple considerations.
    - Rainfall intensity is assumed while calculating drainage discharge due to lack of availability exact data for project area.

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ANNEXES

ANNEX 1

SURVEY DATA

**SURVEY DATA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.N. | Easting | Northing | RL | Remarks |
| 1 | 342806.8 | 3065542.377 | 1285.786 | IS1 |
| 2 | 342806.8 | 3065545.377 | 1285.786 | BS1 |
| 3 | 342810.5 | 3065541.043 | 1285.675 | RRC |
| 4 | 342816.2 | 3065542.039 | 1285.85 | RRC |
| 5 | 342824.1 | 3065543.427 | 1286.027 | RRC |
| 6 | 342833.1 | 3065545.08 | 1286.221 | RRC |
| 7 | 342840.7 | 3065544.761 | 1286.315 | RRC |
| 8 | 342850.2 | 3065543.9 | 1286.53 | RRC |
| 9 | 342857.5 | 3065543.096 | 1286.704 | RRC |
| 10 | 342866.7 | 3065543.141 | 1286.804 | RRC |
| 11 | 342874 | 3065543.229 | 1286.812 | RRC |
| 12 | 342886.5 | 3065543.458 | 1287.008 | RRC |
| 13 | 342894 | 3065543.362 | 1287.138 | RRC |
| 14 | 342903 | 3065544.088 | 1287.294 | RRC |
| 15 | 342911.5 | 3065544.13 | 1287.318 | RRC |
| 16 | 342921.9 | 3065545.291 | 1287.509 | RRC |
| 17 | 342932.1 | 3065545.982 | 1287.655 | RRC |
| 18 | 342942.4 | 3065547.031 | 1287.662 | RRC |
| 19 | 342950.1 | 3065547.838 | 1287.995 | RRC |
| 20 | 342959.9 | 3065549.481 | 1288.189 | RRC |
| 21 | 342969 | 3065550.242 | 1288.373 | RRC |
| 22 | 342980.3 | 3065551.776 | 1288.499 | RRC |
| 23 | 342989.5 | 3065551.073 | 1289.062 | RRD |
| 24 | 342941.5 | 3065544.216 | 1288.01 | RRD |
| 25 | 342945.2 | 3065544.54 | 1288.09 | RRD |
| 26 | 342936.8 | 3065543.511 | 1287.869 | RRD |
| 27 | 342929.5 | 3065542.836 | 1287.702 | RRD |
| 28 | 342911.6 | 3065541.968 | 1287.46 | RRD |
| 29 | 342904.4 | 3065542.229 | 1287.381 | RRD |
| 30 | 342891.2 | 3065542.149 | 1287.17 | RRD |
| 31 | 342873.5 | 3065541.398 | 1287.101 | RRD |
| 32 | 342861.4 | 3065540.7 | 1287.003 | RRD |
| 33 | 342859 | 3065540.812 | 1286.944 | RRD |
| 34 | 342855.3 | 3065541.286 | 1286.87 | RRD |
| 35 | 342847.7 | 3065542.108 | 1286.708 | RRD |
| 36 | 342839.6 | 3065542.736 | 1286.521 | RRD |
| 37 | 342833.4 | 3065542.808 | 1286.397 | RRD |
| 38 | 342823.8 | 3065541.344 | 1286.216 | RRD |
| 39 | 342817.7 | 3065540.14 | 1286.145 | RRD |
| 40 | 342814.2 | 3065539.455 | 1286.034 | RRD |
| 41 | 342808.8 | 3065538.494 | 1285.973 | RRD |
| 42 | 342806.3 | 3065548.64 | 1285.81 | CL |
| 43 | 342814.7 | 3065549.629 | 1285.9 | CL |
| 44 | 342824.9 | 3065549.994 | 1286.063 | CL |
| 45 | 342839.1 | 3065550.801 | 1286.217 | CL |
| 46 | 342848.7 | 3065549.999 | 1286.376 | CL |
| 47 | 342864.5 | 3065548.028 | 1286.642 | CL |
| 48 | 342872.3 | 3065547.874 | 1286.839 | CL |
| 49 | 342864.5 | 3065548.038 | 1286.647 | CL |
| 50 | 342872.4 | 3065547.799 | 1286.855 | CL |
| 51 | 342886.4 | 3065547.403 | 1286.887 | CL |
| 52 | 342897.6 | 3065548.678 | 1287.186 | CL |
| 53 | 342911.1 | 3065551.303 | 1287.4 | CL |
| 54 | 342929.1 | 3065552.997 | 1287.705 | CL |
| 55 | 342945.7 | 3065553.353 | 1287.987 | CL |
| 56 | 342965.2 | 3065554.937 | 1288.364 | CL |
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| 58 | 342858.4 | 3065555.902 | 1286.35 | LRC |
| 59 | 342847.4 | 3065555.701 | 1286.4 | LRC |
| 60 | 342836.9 | 3065555.434 | 1286.245 | LRC |
| 61 | 342828.4 | 3065555.283 | 1286.19 | LRC |
| 62 | 342821.4 | 3065555.221 | 1286.065 | LRC |
| 63 | 342814.7 | 3065554.473 | 1285.991 | LRC |
| 64 | 342807.4 | 3065554.428 | 1285.783 | LRC |
| 65 | 342975.4 | 3065559.322 | 1288.513 | IS2 |
| 66 | 342963.6 | 3065560.512 | 1288.019 | LRC |
| 67 | 342955.6 | 3065560.096 | 1287.82 | LRC |
| 68 | 342891.7 | 3065555.976 | 1286.779 | LRC |
| 69 | 342944.5 | 3065559.413 | 1287.561 | LRC |
| 70 | 342904.3 | 3065556.327 | 1286.84 | LRC |
| 71 | 342930.5 | 3065559.29 | 1287.377 | LRC |
| 72 | 342915.5 | 3065557.2 | 1287.064 | LRC |
| 73 | 342922.3 | 3065559.107 | 1287.275 | LRC |
| 74 | 342977 | 3065562.046 | 1288.354 | LRC |
| 75 | 342984.5 | 3065564.204 | 1288.352 | LRC |
| 76 | 342993.9 | 3065567.324 | 1288.62 | LRC |
| 77 | 343001.3 | 3065569.485 | 1288.708 | LRC |
| 78 | 343015 | 3065573.192 | 1289.009 | LRC |
| 79 | 343024.5 | 3065575.59 | 1289.074 | LRC |
| 80 | 343037 | 3065579.193 | 1289.137 | LRC |
| 81 | 343045.8 | 3065582.052 | 1289.159 | LRC |
| 82 | 343060 | 3065585.855 | 1289.463 | LRC |
| 83 | 343068.9 | 3065587.566 | 1289.628 | LRC |
| 84 | 343077.7 | 3065589.112 | 1289.806 | LRC |
| 85 | 343087.6 | 3065590.779 | 1289.893 | LRC |
| 86 | 343095.8 | 3065592.51 | 1289.836 | LRC |
| 87 | 343104.6 | 3065593.192 | 1290.063 | LRC |
| 88 | 343115.1 | 3065594.28 | 1290.312 | LRC |
| 89 | 343122.4 | 3065594.55 | 1290.425 | LRC |
| 90 | 343130.2 | 3065594.2 | 1290.405 | LRC |
| 91 | 343138.7 | 3065594.028 | 1290.564 | LRC |
| 92 | 343148.8 | 3065593.198 | 1290.712 | LRC |
| 93 | 343157.6 | 3065592.132 | 1290.864 | LRC |
| 94 | 343139.5 | 3065588.675 | 1290.482 | CL |
| 95 | 343131.2 | 3065589.381 | 1290.433 | CL |
| 96 | 343119.2 | 3065588.287 | 1290.428 | CL |
| 97 | 343110.1 | 3065587.951 | 1290.216 | CL |
| 98 | 343100.6 | 3065586.398 | 1290.131 | CL |
| 99 | 343088.9 | 3065585.018 | 1289.977 | CL |
| 100 | 343083.2 | 3065583.914 | 1289.917 | CL |
| 101 | 343073.4 | 3065581.922 | 1289.75 | CL |
| 102 | 343066.3 | 3065580.678 | 1289.601 | CL |
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| 104 | 343029 | 3065570.208 | 1288.998 | CL |
| 105 | 343013.7 | 3065566.121 | 1288.811 | CL |
| 106 | 342997.2 | 3065561.507 | 1288.552 | CL |
| 107 | 342982.4 | 3065557.133 | 1288.23 | CL |
| 108 | 342974.6 | 3065555.311 | 1288.103 | CL |
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| 114 | 343049.7 | 3065571.431 | 1289.225 | RRC |
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| 118 | 343096.5 | 3065580.866 | 1289.845 | RRC |
| 119 | 343108.1 | 3065580.996 | 1290.046 | RRC |
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| 123 | 343060.1 | 3065571.156 | 1289.423 | RDC |
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| 125 | 343020.2 | 3065560.15 | 1289.199 | RDC |
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| 129 | 343021.3 | 3065554.612 | 1289.786 | HC |
| 130 | 343023.5 | 3065556.483 | 1289.465 | HC |
| 131 | 343033.9 | 3065559.513 | 1289.488 | HC |
| 132 | 343163.4 | 3065589.559 | 1290.75 | IS3 |
| 133 | 343131.3 | 3065581.784 | 1290.3 | RRC |
| 134 | 343141.8 | 3065581.468 | 1290.348 | RRC |
| 135 | 343149.4 | 3065580.828 | 1290.434 | RRC |
| 136 | 343155 | 3065579.969 | 1290.547 | RRC |
| 137 | 343163.3 | 3065577.612 | 1290.745 | RRC |
| 138 | 343172.4 | 3065574.878 | 1290.946 | RRC |
| 139 | 343181.1 | 3065572.799 | 1291.073 | RRC |
| 140 | 343187.6 | 3065572.139 | 1291.222 | RRC |
| 141 | 343195.6 | 3065571.644 | 1291.996 | RRC |
| 142 | 343214.7 | 3065571.129 | 1291.738 | RRC |
| 143 | 343228.6 | 3065566.221 | 1292.19 | RRC |
| 144 | 343236.7 | 3065563.103 | 1292.385 | RRC |
| 145 | 343245.4 | 3065561.979 | 1292.673 | RRC |
| 146 | 343256 | 3065560.559 | 1293.193 | RRC |
| 147 | 343266.6 | 3065561.008 | 1293.163 | RRC |
| 148 | 343270.4 | 3065561.01 | 1293.576 | RRC |
| 149 | 343278.1 | 3065560.956 | 1293.755 | RRC |
| 150 | 343284.9 | 3065560.015 | 1293.904 | RRC |
| 151 | 343290.7 | 3065557.851 | 1294.036 | RRC |
| 152 | 343300.1 | 3065554.776 | 1293.989 | RRC |
| 153 | 343283.6 | 3065558.158 | 1294.067 | RDC |
| 154 | 343273.6 | 3065558.82 | 1293.701 | RDC |
| 155 | 343266.5 | 3065558.577 | 1293.458 | RDC |
| 156 | 343252.7 | 3065558.83 | 1293.081 | RDC |
| 157 | 343245.2 | 3065559.813 | 1292.927 | RDC |
| 158 | 343233.5 | 3065560.224 | 1293.109 | RDC |
| 159 | 343195.2 | 3065568.612 | 1292.569 | RDC |
| 160 | 343188.1 | 3065567.558 | 1291.526 | RDC |
| 161 | 343182.4 | 3065569.675 | 1291.283 | RDC |
| 162 | 343171.4 | 3065572.649 | 1290.943 | RDC |
| 163 | 343159.3 | 3065576.213 | 1290.861 | RDC |
| 164 | 343148.8 | 3065578.746 | 1290.368 | RDC |
| 165 | 343140.3 | 3065579.364 | 1290.3 | RDC |
| 166 | 343129 | 3065579.766 | 1290.251 | RDC |
| 167 | 343121.2 | 3065579.497 | 1290.203 | RDC |
| 168 | 343188.9 | 3065571.791 | 1291.908 | CUL |
| 169 | 343195 | 3065571.298 | 1292.062 | CUL |
| 170 | 343194.7 | 3065566.627 | 1292.287 | CUL |
| 171 | 343188.6 | 3065567.717 | 1292.028 | CUL |
| 172 | 343186.1 | 3065565.307 | 1292.818 | HC |
| 173 | 343179.4 | 3065565.732 | 1292.522 | HC |
| 174 | 343179.1 | 3065590.85 | 1290.988 | HC |
| 175 | 343168.5 | 3065592.186 | 1290.831 | HC |
| 176 | 343139.5 | 3065594.048 | 1290.574 | LRC |
| 177 | 343154.8 | 3065592.426 | 1290.815 | LRC |
| 178 | 343171.4 | 3065589.096 | 1291.012 | LRC |
| 179 | 343179.6 | 3065586.4 | 1291.108 | LRC |
| 180 | 343191.8 | 3065584.053 | 1291.125 | LRC |
| 181 | 343202 | 3065582.497 | 1291.314 | LRC |
| 182 | 343218.3 | 3065578.954 | 1291.508 | LRC |
| 183 | 343227.7 | 3065577.298 | 1291.839 | LRC |
| 184 | 343239.9 | 3065574.859 | 1292.453 | LRC |
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| 186 | 343228.1 | 3065571.82 | 1292.008 | CL |
| 187 | 343213 | 3065575.64 | 1291.581 | CL |
| 188 | 343199.6 | 3065578.135 | 1291.352 | CL |
| 189 | 343179.1 | 3065579.753 | 1291.008 | CL |
| 190 | 343163.4 | 3065584.441 | 1290.641 | CL |
| 191 | 343151 | 3065587.02 | 1290.547 | CL |
| 192 | 343140.1 | 3065588.752 | 1290.459 | CL |
| 193 | 343260.4 | 3065568.331 | 1293.279 | CL |
| 194 | 343269.6 | 3065567.408 | 1293.494 | CL |
| 195 | 343280.6 | 3065565.248 | 1293.537 | CL |
| 196 | 343290.1 | 3065562.366 | 1293.734 | CL |
| 197 | 343302.8 | 3065556.757 | 1294.102 | CL |
| 198 | 343313.4 | 3065552.274 | 1294.34 | CL |
| 199 | 343329 | 3065550.482 | 1294.785 | IS4 |
| 200 | 343314.1 | 3065560.449 | 1294.295 | LRC |
| 201 | 343307 | 3065563.268 | 1294.191 | LRC |
| 202 | 343300.9 | 3065566.788 | 1294.173 | LRC |
| 203 | 343300.9 | 3065566.802 | 1294.17 | LRC |
| 204 | 343300.9 | 3065566.79 | 1294.17 | LRC |
| 205 | 343293.5 | 3065569.478 | 1294.143 | LRC |
| 206 | 343286.2 | 3065571.575 | 1293.973 | LRC |
| 207 | 343279.2 | 3065573.312 | 1293.781 | LRC |
| 208 | 343271.7 | 3065574.05 | 1293.47 | LRC |
| 209 | 343261.9 | 3065575.05 | 1293.331 | LRC |
| 210 | 343254.3 | 3065575.752 | 1293.025 | LRC |
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| 212 | 343235.7 | 3065576.683 | 1292.377 | LRC |
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| 215 | 343337.4 | 3065537.409 | 1295.211 | RRC |
| 216 | 343342.9 | 3065534.916 | 1295.437 | RRC |
| 217 | 343352.1 | 3065532.914 | 1295.372 | RRC |
| 218 | 343358.8 | 3065532.023 | 1295.648 | RRC |
| 219 | 343369.5 | 3065529.145 | 1295.958 | RRC |
| 220 | 343375.7 | 3065526.468 | 1296.314 | RRC |
| 221 | 343386.7 | 3065521.393 | 1296.788 | RRC |
| 222 | 343394.1 | 3065518.331 | 1297.496 | RRC |
| 223 | 343402.2 | 3065516.294 | 1297.541 | RRC |
| 224 | 343405.9 | 3065515.422 | 1298.047 | RRC |
| 225 | 343410.6 | 3065514.638 | 1298.027 | RRC |
| 226 | 343413.9 | 3065514.838 | 1298.115 | RRC |
| 227 | 343416.9 | 3065522.887 | 1298.216 | RRC |
| 228 | 343415.7 | 3065518.379 | 1298.44 | RRC |
| 229 | 343417.8 | 3065521.23 | 1298.24 | RRC |
| 230 | 343417 | 3065525.768 | 1297.973 | RRC |
| 231 | 343417.2 | 3065535.018 | 1297.301 | RRC |
| 232 | 343416.6 | 3065528.152 | 1297.602 | RRC |
| 233 | 343417.1 | 3065544.176 | 1297.04 | RRC |
| 234 | 343409.9 | 3065545.732 | 1297.056 | LRC |
| 235 | 343409.7 | 3065540.408 | 1297.135 | LRC |
| 236 | 343409.1 | 3065536.708 | 1297.259 | LRC |
| 237 | 343407.5 | 3065529.414 | 1297.505 | LRC |
| 238 | 343407.3 | 3065528.287 | 1297.552 | LRC |
| 239 | 343406.7 | 3065526.844 | 1297.622 | LRC |
| 240 | 343406.2 | 3065526.087 | 1297.676 | LRC |
| 241 | 343403.2 | 3065525.457 | 1297.533 | LRC |
| 242 | 343399.7 | 3065526.675 | 1297.399 | LRC |
| 243 | 343391 | 3065530.095 | 1296.863 | LRC |
| 244 | 343377.9 | 3065535.751 | 1296.3 | LRC |
| 245 | 343362.4 | 3065540.441 | 1295.621 | LRC |
| 246 | 343351.6 | 3065544.433 | 1295.465 | LRC |
| 247 | 343341.7 | 3065547.269 | 1295.255 | LRC |
| 248 | 343331.5 | 3065551.066 | 1294.909 | LRC |
| 249 | 343288.8 | 3065557.307 | 1294.039 | RDC |
| 250 | 343296.4 | 3065553.227 | 1294.279 | RDC |
| 251 | 343301.7 | 3065550.431 | 1294.276 | RDC |
| 252 | 343306.6 | 3065547.461 | 1294.41 | RDC |
| 253 | 343325.5 | 3065538.649 | 1295.166 | RDC |
| 254 | 343330.3 | 3065537.357 | 1295.251 | RDC |
| 255 | 343334.8 | 3065536.328 | 1295.205 | RDC |
| 256 | 343341.2 | 3065533.555 | 1295.391 | RDC |
| 257 | 343346.7 | 3065532.064 | 1295.417 | RDC |
| 258 | 343352.4 | 3065530.966 | 1295.558 | RDC |
| 259 | 343361.4 | 3065530.431 | 1295.819 | RDC |
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| 261 | 343379.8 | 3065522.755 | 1296.693 | RDC |
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| 264 | 343398.8 | 3065514.945 | 1297.604 | RDC |
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| 274 | 343404.7 | 3065520.821 | 1297.767 | CL |
| 275 | 343398.7 | 3065521.445 | 1297.39 | CL |
| 276 | 343391.7 | 3065524.046 | 1296.983 | CL |
| 277 | 343385.8 | 3065527.237 | 1296.635 | CL |
| 278 | 343372.3 | 3065532.396 | 1296.056 | CL |
| 279 | 343360.2 | 3065536.43 | 1295.626 | CL |
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| 613 | 343689.2 | 3065808.511 | 1288.504 | RRC |
| 614 | 343692.6 | 3065816.03 | 1288.345 | RRC |
| 615 | 343697.8 | 3065827.083 | 1288.169 | RRC |
| 616 | 343703.8 | 3065836.625 | 1288.258 | RRC |
| 617 | 343709.2 | 3065846.145 | 1288.232 | RRC |
| 618 | 343715.8 | 3065858.419 | 1288.337 | RRC |
| 619 | 343719.9 | 3065865.722 | 1288.37 | RRC |
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| 622 | 343735.9 | 3065899.653 | 1288.084 | RRC |
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| 624 | 343749.4 | 3065927.841 | 1288.185 | RRC |
| 625 | 343752.7 | 3065937.102 | 1288.097 | RRC |
| 626 | 343756.9 | 3065946.381 | 1288.009 | RRC |
| 627 | 343762 | 3065957.276 | 1288.141 | RRC |
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| 629 | 343770.7 | 3065970.898 | 1288.013 | RRC |
| 630 | 343774.1 | 3065976.342 | 1287.897 | RRC |
| 631 | 343780.1 | 3065986.595 | 1287.904 | RRC |
| 632 | 343784 | 3065993.984 | 1287.962 | RRC |
| 633 | 343765.4 | 3065961.099 | 1289.036 | RDC |
| 634 | 343761.6 | 3065954.562 | 1289.049 | RDC |
| 635 | 343759.5 | 3065947.669 | 1288.961 | RDC |
| 636 | 343755.9 | 3065941.215 | 1288.99 | RDC |
| 637 | 343752.1 | 3065930.199 | 1289.113 | RDC |
| 638 | 343749.3 | 3065923.08 | 1289.137 | RDC |
| 639 | 343743.8 | 3065912.917 | 1289.129 | RDC |
| 640 | 343741.8 | 3065905.284 | 1289.315 | RDC |
| 641 | 343737.6 | 3065898.284 | 1288.444 | RDC |
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| 645 | 343715.4 | 3065854.655 | 1288.593 | RDC |
| 646 | 343703.3 | 3065833.59 | 1288.538 | RDC |
| 647 | 343697.7 | 3065824.084 | 1288.864 | RDC |
| 648 | 343693.4 | 3065814.682 | 1289.073 | RDC |
| 649 | 343691.1 | 3065809.605 | 1289.081 | RDC |
| 650 | 343688.7 | 3065804.719 | 1289.228 | RDC |
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| 652 | 343681.3 | 3065796.14 | 1289.377 | RDC |
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| 654 | 343669.5 | 3065787.357 | 1289.324 | RDC |
| 655 | 343659.1 | 3065780.761 | 1289.306 | RDC |
| 656 | 343651.5 | 3065775.857 | 1289.273 | RDC |
| 657 | 343641 | 3065772.747 | 1289.29 | RDC |
| 658 | 343629 | 3065773.655 | 1289.297 | RDC |
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| 661 | 343605.3 | 3065778.789 | 1288.794 | RDC |
| 662 | 343593 | 3065781.382 | 1288.737 | RDC |
| 663 | 343612.3 | 3065770.945 | 1289.611 | HC |
| 664 | 343623.3 | 3065771.1 | 1289.633 | HC |
| 665 | 343658.2 | 3065798.221 | 1288.296 | GT |
| 666 | 343661.2 | 3065799.817 | 1287.934 | GT |
| 667 | 343662.1 | 3065800.842 | 1287.918 | GT |
| 668 | 343647.7 | 3065794.246 | 1289.525 | HC |
| 669 | 343642.6 | 3065792.166 | 1289.456 | HC |
| 670 | 343687.4 | 3065801.111 | 1289.481 | HC |
| 671 | 343690.6 | 3065808.469 | 1289.135 | HC |
| 672 | 343794.5 | 3066019.702 | 1287.897 | IS8 |
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| 692 | 343837 | 3066068.699 | 1288.624 | RRC |
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| 904 | 343952.2 | 3066169.185 | 1294.879 | RRC |
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| 906 | 343945.9 | 3066153.605 | 1293.743 | RRC |
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| 927 | 343952.7 | 3066167.123 | 1294.829 | RDC |
| 928 | 343950 | 3066160.925 | 1294.246 | RDC |
| 929 | 343945.3 | 3066150.167 | 1293.768 | RDC |
| 930 | 343941.3 | 3066140.882 | 1293.358 | RDC |
| 931 | 343935.4 | 3066129.655 | 1293.125 | RDC |
| 932 | 343931.5 | 3066121.118 | 1292.47 | RDC |
| 933 | 343929 | 3066121.812 | 1292.328 | CUL |
| 934 | 343927.1 | 3066118.635 | 1292.319 | CUL |
| 935 | 343921.6 | 3066122.533 | 1292.043 | CUL |
| 936 | 343924.3 | 3066125.848 | 1292.128 | CUL |
| 937 | 343921.7 | 3066134.69 | 1293.805 | HC |
| 938 | 343926.7 | 3066147.477 | 1293.767 | HC |
| 939 | 343968.1 | 3066233.425 | 1296.765 | IS12 |
| 940 | 343951.5 | 3066181.969 | 1295.541 | LRC |
| 941 | 343951.9 | 3066184.819 | 1295.688 | LRC |
| 942 | 343952.5 | 3066191.575 | 1295.905 | LRC |
| 943 | 343953.1 | 3066195.648 | 1295.923 | LRC |
| 944 | 343953.5 | 3066200.033 | 1296.035 | LRC |
| 945 | 343953.7 | 3066203.068 | 1296.084 | LRC |
| 946 | 343954.1 | 3066205.988 | 1296.117 | LRC |
| 947 | 343955.3 | 3066210.697 | 1296.121 | LRC |
| 948 | 343956.8 | 3066214.726 | 1296.196 | LRC |
| 949 | 343958.6 | 3066218.508 | 1296.224 | LRC |
| 950 | 343963.2 | 3066227.004 | 1296.395 | LRC |
| 951 | 343966 | 3066230.897 | 1296.515 | LRC |
| 952 | 343972.8 | 3066237.726 | 1296.984 | LRC |
| 953 | 343979.8 | 3066243.109 | 1297.396 | LRC |
| 954 | 343982.8 | 3066246.005 | 1297.403 | LRC |
| 955 | 343993 | 3066254.396 | 1297.14 | CL |
| 956 | 343991.4 | 3066251.681 | 1297.188 | CL |
| 957 | 343989.7 | 3066249.074 | 1297.242 | CL |
| 958 | 343988.2 | 3066247.629 | 1297.235 | CL |
| 959 | 343986.6 | 3066245.942 | 1297.233 | CL |
| 960 | 343980.6 | 3066241.724 | 1297.319 | CL |
| 961 | 343975.9 | 3066237.638 | 1297.043 | CL |
| 962 | 343971.8 | 3066234.064 | 1296.742 | CL |
| 963 | 343967.2 | 3066228.279 | 1296.383 | CL |
| 964 | 343963 | 3066221.235 | 1296.22 | CL |
| 965 | 343960 | 3066215.593 | 1296.111 | CL |
| 966 | 343957.6 | 3066207.623 | 1295.912 | CL |
| 967 | 343955.9 | 3066202.114 | 1295.979 | CL |
| 968 | 343955.2 | 3066196.047 | 1295.864 | CL |
| 969 | 343954.7 | 3066190.776 | 1295.791 | CL |
| 970 | 343963.5 | 3066215.548 | 1296.152 | RRC |
| 971 | 343966.1 | 3066220.411 | 1296.235 | RRC |
| 972 | 343968.3 | 3066225.578 | 1296.382 | RRC |
| 973 | 343970.2 | 3066228.905 | 1296.486 | RRC |
| 974 | 343971.8 | 3066230.928 | 1296.608 | RRC |
| 975 | 343974 | 3066232.949 | 1296.766 | RRC |
| 976 | 343978.9 | 3066237.618 | 1297.201 | RRC |
| 977 | 343985 | 3066242.019 | 1297.4 | RRC |
| 978 | 343992 | 3066244.649 | 1297.455 | RRC |
| 979 | 343997.5 | 3066246.769 | 1297.653 | RRC |
| 980 | 344001.7 | 3066249.795 | 1298.122 | RRC |
| 981 | 343997.3 | 3066250.269 | 1297.505 | IS13 |
| 982 | 344002.1 | 3066254.486 | 1298.302 | RRC |
| 983 | 344000.9 | 3066258.745 | 1297.926 | RRC |
| 984 | 343983.8 | 3066238.026 | 1298.339 | HC |
| 985 | 343977 | 3066229.387 | 1298.161 | HC |
| 986 | 343983.8 | 3066247.458 | 1297.36 | LRC |
| 987 | 343985.4 | 3066249.632 | 1297.265 | LRC |
| 988 | 343987.3 | 3066252.164 | 1297.292 | LRC |
| 989 | 343988.5 | 3066254.56 | 1297.284 | LRC |
| 990 | 343989.3 | 3066256.92 | 1297.225 | LRC |
| 991 | 343990.1 | 3066259.823 | 1297.078 | LRC |
| 992 | 343990.5 | 3066263.293 | 1296.952 | LRC |
| 993 | 343989.1 | 3066270.012 | 1296.744 | LRC |
| 994 | 343985.4 | 3066279.41 | 1296.503 | LRC |
| 995 | 343981.6 | 3066287.152 | 1296.313 | LRC |
| 996 | 343978.1 | 3066294.853 | 1296.197 | LRC |
| 997 | 343975.9 | 3066300.888 | 1296.003 | LRC |
| 998 | 343974.9 | 3066305.921 | 1295.76 | LRC |
| 999 | 343974 | 3066310.964 | 1295.642 | LRC |
| 1000 | 343973.8 | 3066317.155 | 1295.461 | LRC |
| 1001 | 343974.5 | 3066324.281 | 1295.301 | LRC |
| 1002 | 343974.6 | 3066328.672 | 1295.21 | LRC |
| 1003 | 343975.9 | 3066317.825 | 1295.194 | CL |
| 1004 | 343976.4 | 3066309.825 | 1295.51 | CL |
| 1005 | 343977.5 | 3066304.875 | 1295.62 | CL |
| 1006 | 343979.7 | 3066296.526 | 1295.968 | CL |
| 1007 | 343982.1 | 3066292.466 | 1296.111 | CL |
| 1008 | 343985.4 | 3066285.472 | 1296.224 | CL |
| 1009 | 343987.8 | 3066280.021 | 1296.374 | CL |
| 1010 | 343990.4 | 3066272.873 | 1296.514 | CL |
| 1011 | 343993.1 | 3066266.855 | 1296.688 | CL |
| 1012 | 343994 | 3066262.537 | 1296.895 | CL |
| 1013 | 343995 | 3066257.666 | 1297.135 | CL |
| 1014 | 343994.7 | 3066255.39 | 1297.202 | CL |
| 1015 | 344000.7 | 3066261.503 | 1297.474 | RRC |
| 1016 | 343999.8 | 3066263.491 | 1297.471 | RRC |
| 1017 | 343998.5 | 3066266.308 | 1297.24 | RRC |
| 1018 | 343997.1 | 3066269.047 | 1297.037 | RRC |
| 1019 | 343994.2 | 3066276.589 | 1296.453 | RRC |
| 1020 | 343987.2 | 3066288.649 | 1296.076 | RRC |
| 1021 | 343985.3 | 3066293.293 | 1296.032 | RRC |
| 1022 | 343983.2 | 3066296.366 | 1295.819 | RRC |
| 1023 | 343981.1 | 3066301.945 | 1295.718 | RRC |
| 1024 | 343980.5 | 3066304.604 | 1295.629 | RRC |
| 1025 | 343979.1 | 3066308.153 | 1295.268 | RRC |
| 1026 | 343978.5 | 3066312.079 | 1295.065 | RRC |
| 1027 | 343978.4 | 3066314.462 | 1295.311 | RRC |
| 1028 | 343979.5 | 3066311.75 | 1295.508 | RRC |
| 1029 | 343981 | 3066305.973 | 1295.586 | RDC |
| 1030 | 343982 | 3066303.033 | 1295.851 | RDC |
| 1031 | 343982.9 | 3066299.901 | 1295.775 | RDC |
| 1032 | 343985.1 | 3066295.029 | 1295.993 | RDC |
| 1033 | 343986.3 | 3066292.709 | 1295.924 | RDC |
| 1034 | 343993.8 | 3066280.887 | 1296.478 | RDC |
| 1035 | 343996.4 | 3066274.651 | 1296.465 | RDC |
| 1036 | 343998 | 3066270.962 | 1296.462 | RDC |
| 1037 | 344004.9 | 3066259.678 | 1298.317 | RDC |
| 1038 | 344003.9 | 3066251.397 | 1298.593 | RP |
| 1039 | 344006.5 | 3066251.603 | 1298.484 | RP |
| 1040 | 344010.5 | 3066249.415 | 1299.342 | RP |
| 1041 | 344004.5 | 3066258.002 | 1298.44 | RP |
| 1042 | 344010.5 | 3066255.786 | 1299.217 | RP |
| 1043 | 343999.6 | 3066271.926 | 1296.769 | HC |
| 1044 | 343995.9 | 3066279.368 | 1296.835 | HC |
| 1045 | 343986.3 | 3066263.783 | 1296.956 | HC |
| 1046 | 343985.7 | 3066269.934 | 1296.976 | HC |
| 1047 | 343974.9 | 3066327.341 | 1295.34 | IS14 |
| 1048 | 343978.7 | 3066318.978 | 1295.215 | RRC |
| 1049 | 343979.6 | 3066324.652 | 1294.892 | RRC |
| 1050 | 343980.2 | 3066329.526 | 1295.03 | RRC |
| 1051 | 343982.3 | 3066336.143 | 1294.943 | RRC |
| 1052 | 343985.6 | 3066345.432 | 1294.617 | RRC |
| 1053 | 343988.4 | 3066351.823 | 1294.475 | RRC |
| 1054 | 343993.4 | 3066361.791 | 1294.13 | RRC |
| 1055 | 343997 | 3066370.955 | 1294.001 | RRC |
| 1056 | 343999.1 | 3066379.041 | 1293.862 | RRC |
| 1057 | 344000.5 | 3066387.896 | 1293.569 | RRC |
| 1058 | 344000 | 3066396.608 | 1293.294 | RRC |
| 1059 | 343999 | 3066405.399 | 1292.98 | RRC |
| 1060 | 343997.7 | 3066394.552 | 1293.148 | CL |
| 1061 | 343997.2 | 3066388.354 | 1293.37 | CL |
| 1062 | 343996.9 | 3066384.204 | 1293.594 | CL |
| 1063 | 343996.3 | 3066379.814 | 1293.773 | CL |
| 1064 | 343995.1 | 3066374.589 | 1293.968 | CL |
| 1065 | 343993.7 | 3066369.567 | 1294.117 | CL |
| 1066 | 343991.4 | 3066364.21 | 1294.243 | CL |
| 1067 | 343989.3 | 3066359.98 | 1294.286 | CL |
| 1068 | 343986.1 | 3066353.854 | 1294.437 | CL |
| 1069 | 343983.8 | 3066348.9 | 1294.596 | CL |
| 1070 | 343982.2 | 3066344.597 | 1294.636 | CL |
| 1071 | 343980.5 | 3066339.754 | 1294.756 | CL |
| 1072 | 343979.3 | 3066335.47 | 1294.845 | CL |
| 1073 | 343978.1 | 3066331.27 | 1294.892 | CL |
| 1074 | 343977.4 | 3066328.046 | 1294.943 | CL |
| 1075 | 343976.7 | 3066324.677 | 1295.024 | CL |
| 1076 | 343975.9 | 3066331.858 | 1294.914 | LRC |
| 1077 | 343976.6 | 3066337.664 | 1294.832 | LRC |
| 1078 | 343978.9 | 3066346.039 | 1294.826 | LRC |
| 1079 | 343983.7 | 3066355.588 | 1294.691 | LRC |
| 1080 | 343988 | 3066362.77 | 1294.457 | LRC |
| 1081 | 343990.7 | 3066368.812 | 1294.364 | LRC |
| 1082 | 343992.3 | 3066373.516 | 1294.223 | LRC |
| 1083 | 343993.5 | 3066378.513 | 1294.004 | LRC |
| 1084 | 343994.1 | 3066383.483 | 1293.868 | LRC |
| 1085 | 343994.6 | 3066388.781 | 1293.588 | LRC |
| 1086 | 343994.9 | 3066392.309 | 1293.312 | LRC |
| 1087 | 344001.5 | 3066394.342 | 1293.365 | RDC |
| 1088 | 344001.8 | 3066390.533 | 1293.638 | RDC |
| 1089 | 344001.8 | 3066386.664 | 1293.62 | RDC |
| 1090 | 344000 | 3066378.895 | 1294.008 | RDC |
| 1091 | 343998.8 | 3066373.66 | 1294.383 | RDC |
| 1092 | 343997.9 | 3066370.164 | 1294.164 | RDC |
| 1093 | 343994.1 | 3066360.364 | 1294.217 | RDC |
| 1094 | 343991.8 | 3066355.695 | 1294.333 | RDC |
| 1095 | 343988.6 | 3066348.956 | 1294.491 | RDC |
| 1096 | 343986.4 | 3066344.179 | 1294.579 | RDC |
| 1097 | 343985.3 | 3066340.928 | 1294.753 | RDC |
| 1098 | 343984.4 | 3066337.925 | 1294.946 | RDC |
| 1099 | 343982.2 | 3066331.067 | 1295.406 | RDC |
| 1100 | 343980.8 | 3066326.11 | 1294.94 | RDC |
| 1101 | 343980.2 | 3066322.142 | 1295.147 | RDC |
| 1102 | 343979.7 | 3066318.186 | 1295.325 | RDC |
| 1103 | 343979.3 | 3066314.961 | 1295.297 | RDC |
| 1104 | 343973.2 | 3066333.657 | 1295.332 | HC |
| 1105 | 343975.5 | 3066346.812 | 1295.403 | HC |
| 1106 | 344005.7 | 3066414.708 | 1293.785 | HC |

ANNEX 2

QUANTITY AND COST

ANNEX 3

DRAWING