Chharka Tangsong Rural Municipality

Office Of The Rural Municipal Executive

Kagkot, Dolpa

Chharka Road Construction Project

Chharka-1, Dolpa

Detailed Work Completion Report of Chharka Road

Ch.0+000 to Ch.76+000

Chharka - Dolpa

Auguest 2022

Prepared by:

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अमररांज सेजुवाल
प्रमुख प्रशासकीय अधिकृत

ACKNOWLEDGEMENTS

The Detailed engineering survey, Design, Cost estimate and Report preparation of Chharka Road Cosntruction Project under the Contract Agreement between Chharka Tangsong Municipality and Tripura Sundari Engineering Multipurpose Construction Pvt Ltd, Dolpa, we would like to convey our indebtedness to Chharka tansong Rural Municipality, kagkot Dolpa for entrusting us and giving the responsibility to carry out the above- mentioned task.

We would like to express our sincere gratitude to Chairperson Shenang Gurung, Vice Chairperson Karma Dundup Gurung, and Chief administrative Officer Amar Raj Sejuwal Er. Hira Bahadur Bohara and all other concerned staffs who helped with their valuable suggestions which help us to accomplish the agreed task. As per the responsibility assigned to us, we have completed the work complying best of our engineering practice.

We are also very thankful to all concerned local people for delivering kind information, co-operation and help during the field survey and collection of required data.

We wish that the Survey and Design proposed for Chharka Road Construction Project will be beneficial for inhabitants of Chharka Tangsong Rural Municipality and will serve as a milestone for the overall development process.

Tripura Sundari Engineering
Multipurpose Construction Pvt Ltd

LIST OF ACRONYMS

ADB : Asian Development Bank

ASTM: American Standard for Technical aterial

BS : British Standard

CAD : Computer Aided Design

CBR : California Bearing Ratio

CPM : Critical Path Method

DBST : Double Bituminous Surface Treatment

DOR : Department of Road

DRCN : District Road Core Network

EIA : Environmental Impact Assessment

EMP : Environmental Management Plan

GIS : Geo-graphical Information System

GON : Government of Nepal

GPS : Global Positioning System

IEE : Initial Environmental Examination

IoW : Inspector of Works

LCB : Local Competitive Bidding

MRE : Mountain Risk Engineering

PQ : Pre-qualification

PWD : Public Work Directive

RE : Resident Engineer RFP Request for Proposal

SRN: Strategic Road Network

ToR : Terms of Reference

TRL : Transport Research Laboratory

EXECUTIVE SUMMARY

Detailed engineering survey, Design and Cost Estimate was carried out for the Chharka Road Construction Project with appropriate structures. Final Report is submitted to the Chharka Tangsong Rural Municipality in accordance with the ToR. The Final Report is presented in following three volumes:

Volume I: Main Report

Volume II: Drawings

Volume III: Detail Estimate, Bill of Quantity and Rate Analysis

Detail engineering design was carried out in Auto CAD along with the help of Smart Project 2022 as it is able to design, produce all the required drawings (Plan, Profile and Cross Sections) in AutoCADandextractthequantitiesofEarthworksandRetainingStructureand other structure in Excel has been designed with minimum of 100 m super elevation and extra widening has been provided. After the completion of design, drawings were prepared for final alignment showing cutting, fillings and design profile with Cross-section of the Trench.

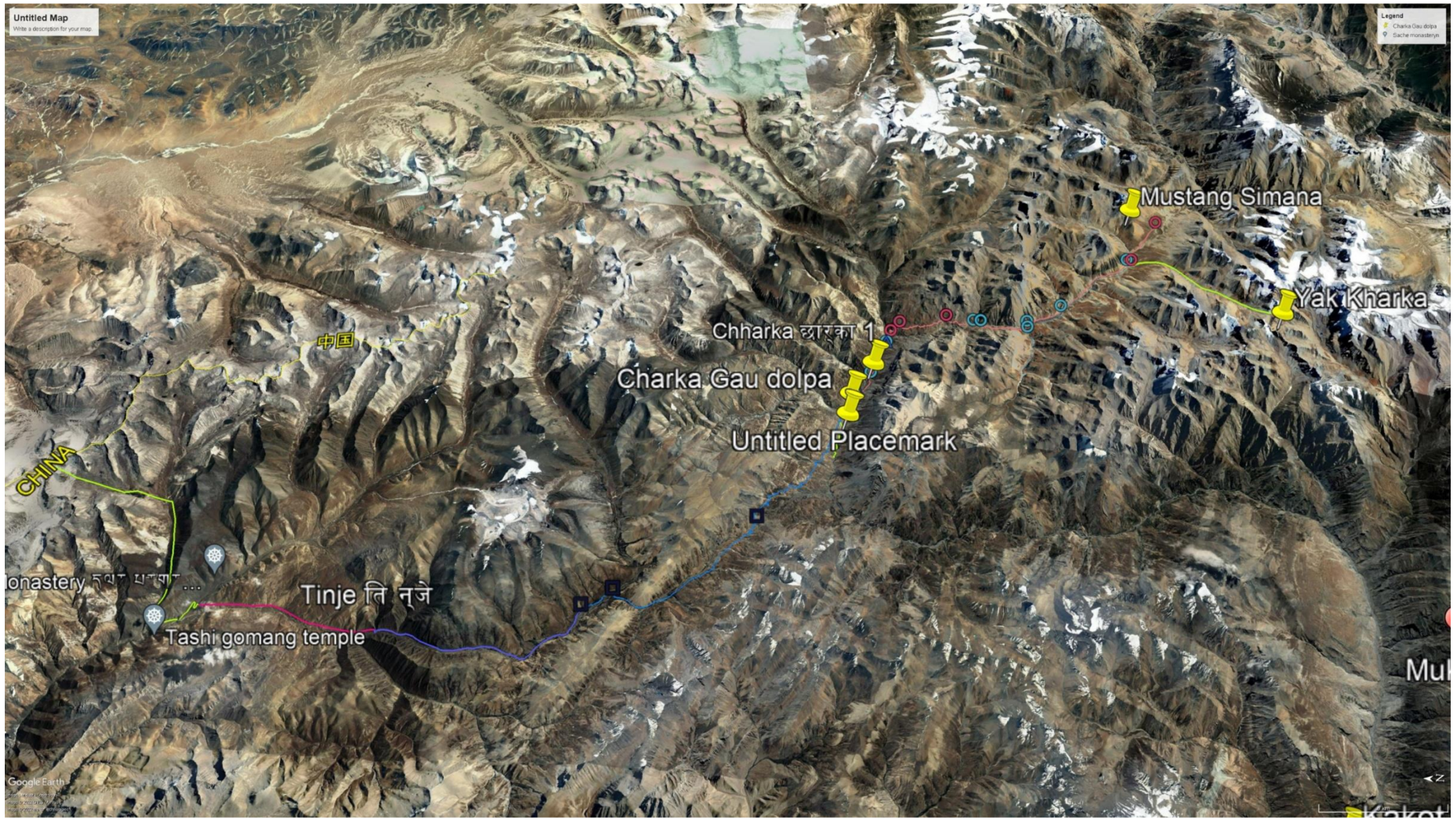
Table 1: Major Obligatory Points

S. N	Obligatory Points	Latitude (N)	Longitude (E)	Elevation	Remarks
1	Tinje Gaun	**29°22'28.21" N**	83°17'2.95"E	4175 m	
2	Chharka Gaun	29°5'21.11" N	83°25'1.41"E	4308 m	
3	Mustang Simana	28°55'40.08" N	83°33'0.40"E	5177m	
4	Yak Kharka	28°52'41.93" N	83°28'56.64"E	5700m	

SALIENT FEATURES

Features	Description
Name of the Road	Chharka Road
Scope	Road Appraise
Location	Chharka Tangsong Rural Municipality
Proveince:	Karnali
Zone:	Karnali
District:	Dolpa
Rural Municipality	Chharka Tangsong Rural Municipality
Major Settlements	Gurung, Lama,Vote, etc.
Length	76.000km
Starting Point	Tinje
End Point:	Yakkharka
Beneficiaries Population	About 1750
Geographical feature	
Terrain	Hill
Altitudinal Range	1500 m to 7700 m
Climate:	Upper-tropical and Sub-tropical
Geology:	Basically characterized by Phyllite and Quartzite and the common soil types include colluvial and residual soils
Meteorology:	Unevenly Distributed Precipitation Controlled by Monsoon
Design Standard	
Standard	NRRS 2055, 2nd Revision December 2014
Existing Surface:	Earthen road , track open
Geometrics	
Right of Way:	10 m on either sides (Center line)
Formation Width:	5.5 m (excluding drain)
Carriage Way Width:	3.75 m
Shoulder Width:	0.75 m on either side
Maximum Gradient	12%
Minimum Gradient	3%
Lane	Intermediate

Earth Work	
a) Excavation / Cutting	2291479.40m3
b) Embankment / Filling	323142.00 m3
Cost Estimate (NRs)	
Total Project Cost	Nrs. 615561906.52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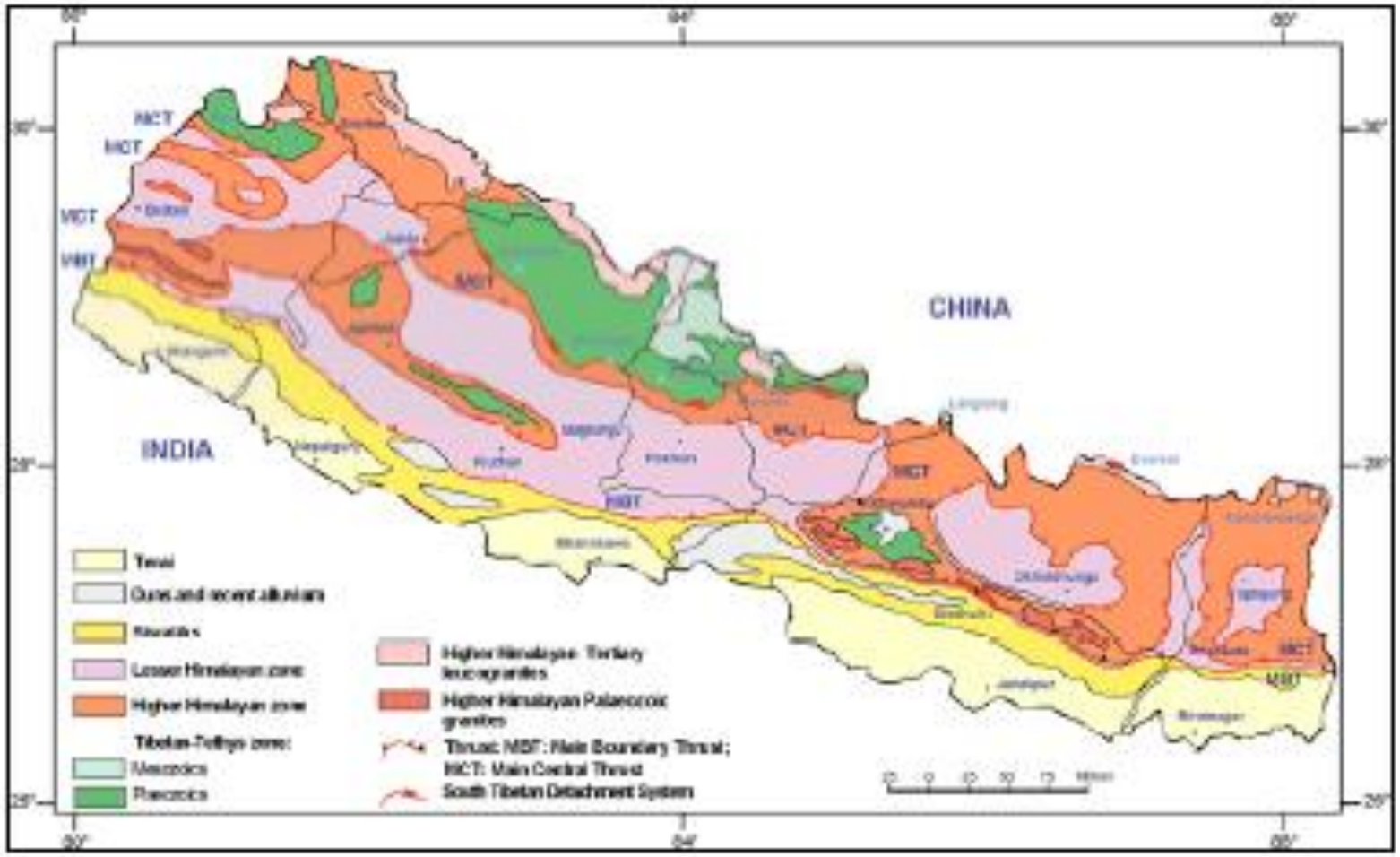

Figure 3.1: Regional Geology of the Nepal and Project Area

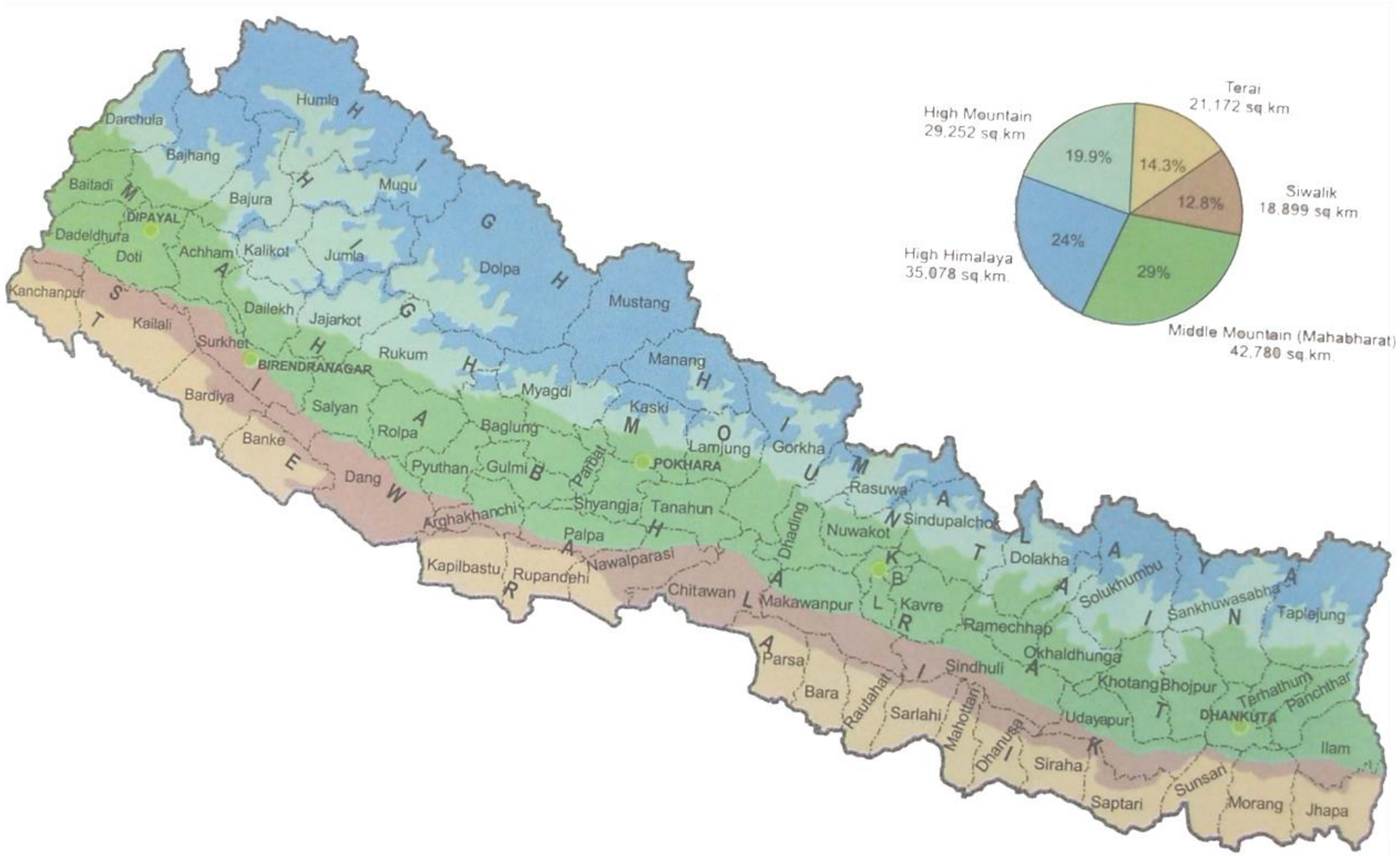

Figure 3.2: General Physiographic Map of Nepal and Project Area


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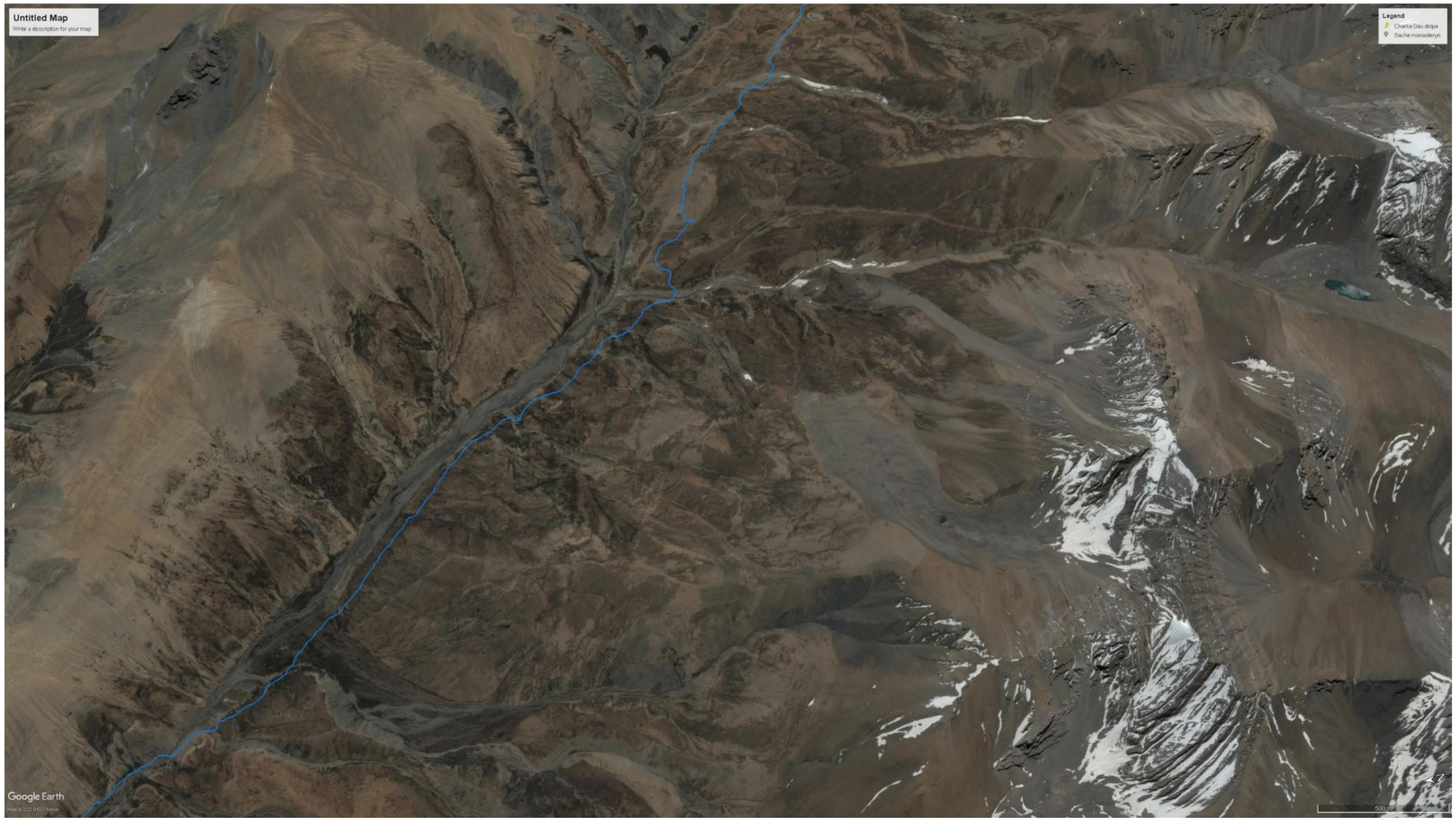
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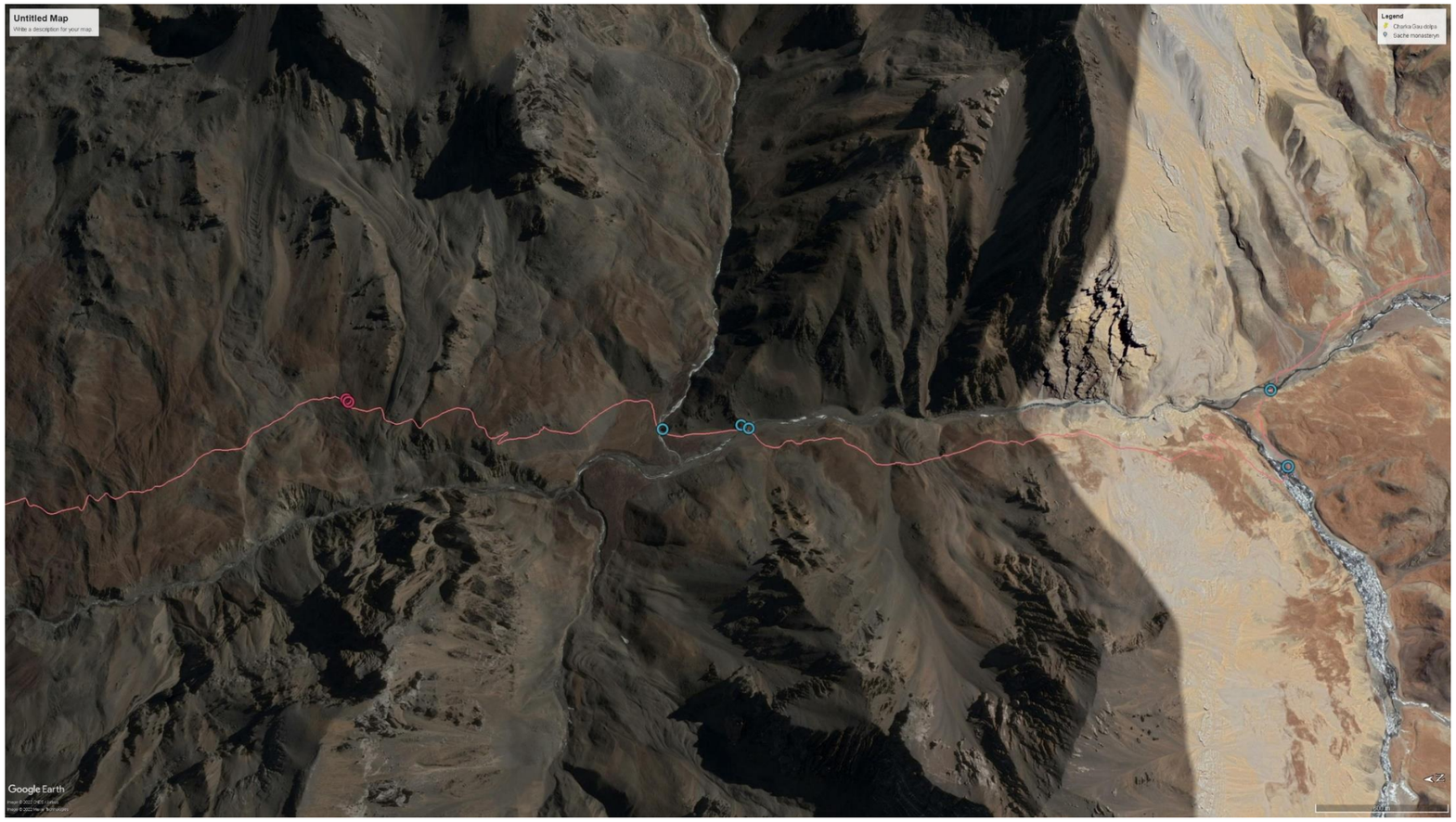
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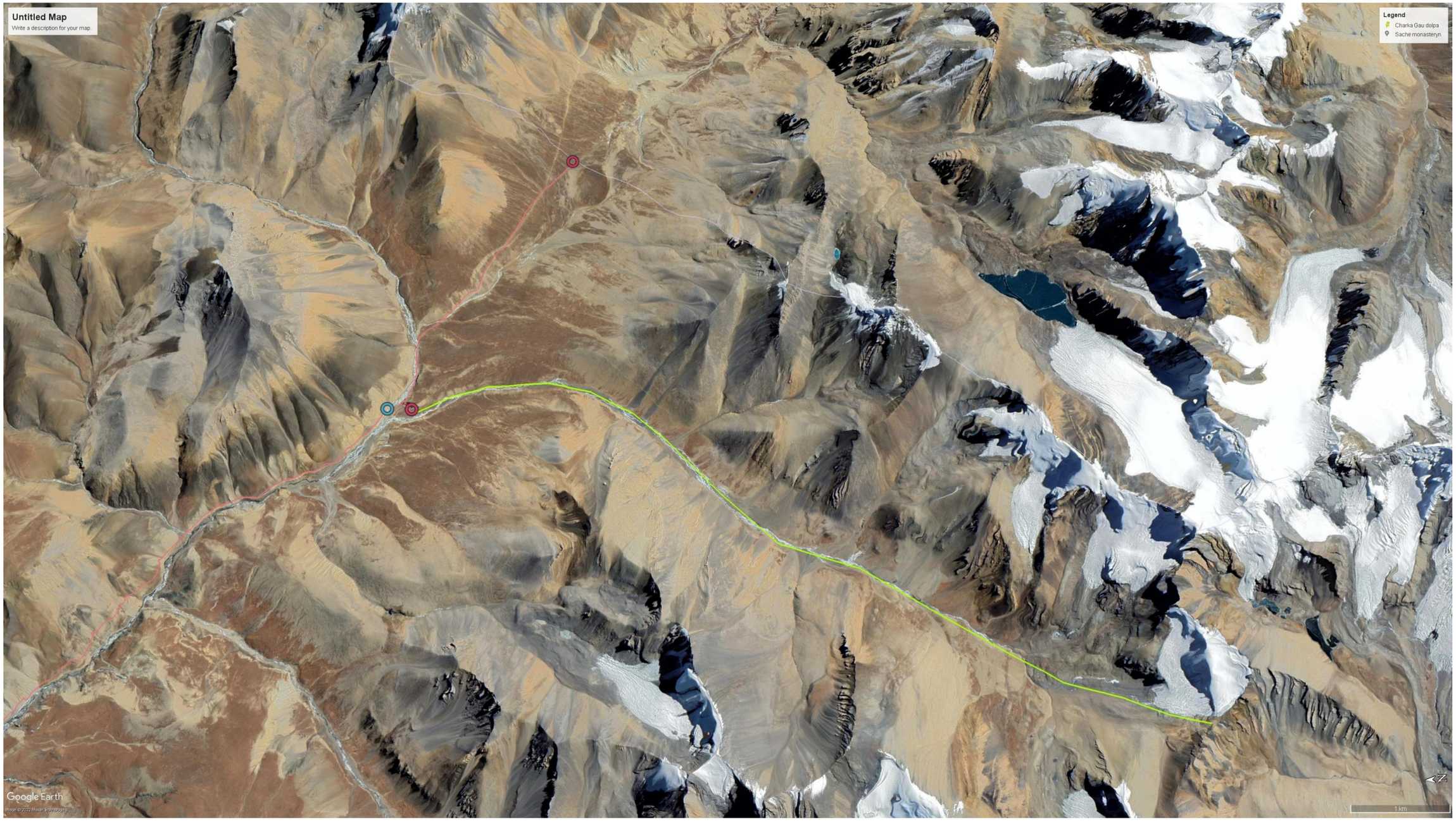
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1. INTRODUCTION

1.1 General

The overall development of a country is basically associated with the proper Road network planning in the country and it is one of the major infrastructures for the development. Economical and efficient road design and construction serves a great deal to the country for its rapid development. To reach light of development in the corners of rural areas of the country, it is necessary that the facility of transportation should reach in these areas.

1.2 Background

Dolpa District is one of the seventy-seven Districts of Nepal, and is located in the Karnali Province. It covers an area of 7889 km^2. Dolpa district lies in the mountain region of Nepal and Dunai as its district headquarter.

Transportation facility directly contributes to the development of agriculture, industry, Irrigation services and another productive sector. Inadequate transportation facility, especially in rural areas, has serious impacts on the lives and welfare of the majority of the population in under developed countries like Nepal where 83% of the population lives in rural areas (CBS, 2011). Accessibility to various basic services, e.g. markets, school and hospitals etc. Essential for economic survival and welfare of rural communities.

1.3 Location and Geographical Extent of ProjectArea

Chharka Tangsong Rural Municipality is located Northeast part of Dolpa district, which is the historical, cultural and religious center. Chharka Tangsong Rural Municipality is surrounded by Dolpo Buddha and Dolpo Buddha Rural Municipality.

Geographic Location:

Its geographic coordinates are

S. N	Obligatory Points	Latitude (N)	Longitude (E)	Elevation	Remarks
1	Chharka Gumba of Chharka Tangsong Rural Municipality Ward No. 1	28°53'16.04" N	81°44'46.39"	5230 m	
2	Chharka Bridge of Chharka Tangsong Rural MunicipalityWard No. 1	28°54'35.89" N	81°43'11.99"E	5225 m	

Objectives

According to ToR, the main objective of the consultancy services is to conduct a Detailed Engineering Survey of the proposed road, prepare detailed design and cost estimates for the construction of the road.

1.4 Understanding of Objectives

We understand the objectives as setting out the process required by project appropriate survey and design, preparation of Engineering Drawings and cost estimates. We feel it as very important to bring together, in a clear and structured manner, many aspects of the assignment in a way that ensures proper assessment of existing situation of the project roads with focus on adequacy of survey data acquisition. Proper analysis, identification of need-based following the design standards with consideration for innovation and appropriate technology and environment friendly design practices.

In overall perspective, the project will be contributing towards reducing poverty by improving rural connectivity of the project area. This will be in line to strategy of Government of Nepal for planned maintenance and management of the municipal roads.

The specific objectives are:

- Review of existing reports if any, and road networks
- Detailed engineering survey of the alignment of road
- Prepare topographical map of the road
- Conduct hydrological studies for cross drainage works and purpose the suitable cross drainage structures
- Choose economically feasible pavement type within the study area,
- Design of roads
- List out the trees, houses and other structures to be destroyed during the construction within road alignment
- Prepare working drawings

- Prepare survey and design report
- Prepare cost estimates with analysis of rates
- Detail Design and preparation of Report
  i. Detailed Engineering survey, pegging/marking of center lines and important bench marks and Design of Road and Other Structures
  ii. Preparation of cost estimate working drawings and Contract Package Document
  iii. Preparation of Detailed Project Report
- Explore and recommend sources of basic road construction materials
- Conduct and produce approved IEE report in all complete
- Preparation of Community Participation Plan(CPP)

1.5 Scope and Limitations

The principal services to be provided by the consultants to fulfill the objectives are given detailed below. However, these services are indicative of the overall tasks to be performed by the consultants. The consultant will be responsible for carrying out all necessary detail field survey works including topographical survey, design, cost estimate and completion and submission of report. The consultant will carry out the work in accordance with accepted professional standard, utilizing sound engineering and economic practices. Work activities are:

1.6 Engineering Details (Field Survey)

Accuracyandadequacyofdetailsdatacouldbeparamountforallsurveysandinvestigationcarried out for design of upgrading of road projects. Easy retrieval of survey references is required for proper construction use.

1.7 Engineering Design and Drawings

Determine extent and type of works for design of road improvement, rehabilitation and up-gradation works throughout the road length. Prepare detailed engineering design of road geometric, drainage, retaining and protection structures.

1.8 Environmental Consideration

Probable damages to environment by proposed works were identified and mitigation measures are proposed to minimize such damages by appropriate measures is included in design. During

time of design, safe tipping areas for spoil were identified, so that the nearby environmental condition remains intact.

1.9 Preparation of CostEstimates

Based on final design and drawings, the consultant has prepared Cost Estimates of the construction works using DoR Norms and standard specifications with sufficient accuracy with maximum deviation of +/- 10percent.

Estimation, the rate analysis and cost estimation has considered the following:

a) District approved rate for basic material
b) Government approval norms wherever applicable
c) Where the government approved norms are not available, develop norms followings standard practice
d) Standard Specification for Road and Bridge Works-2073 is the standard specification document in case it is not applicable other standards is to be used
e) Cost estimation will facilitate stage financing of the road improvement works.

1.10 Survey

Accuracy and adequacy of details is to be paramount for all surveys and investigation carried out for upgrading of project roads. Every retrieval of survey reference is required for proper construction use.

Adequate and accurate traverse lines was run along the road. The Road project is mostly within the existing earthen track, it is tried to adjust the alignment to match the existing earthen track. Sufficient corridor (more than 25m on each side) was surveyed to accommodate cut/fill and possible shift in the center line. Traverse survey was carried out by the use of **Total Station**.

1.11 Design

Effectiveness and reliability are two key attributes to refer to a good design. The effectiveness is judged on the basis of 'need' and 'cost', while 'reliability' is assessed on the ground of 'life' and 'serviceability. The road project requires upgrading to all weather serviceability. Considering low traffic volume in the road, it is understood that design was based on objective of cost-effective construction.

While the design was done based on District Standards of DoR, it considered certain deviation in geometry standards on economic ground.

1.12 Approach and Methodology

Alignment survey (Detail survey) was carried out by survey expert with the help of Total Station. All features are recorded during survey and geological study is carried out. All design is prepared using computer aided design and software Smart-Road version 2016 program. The Smart_ Road is a complete software solution for the road works which have been widely used by various projects. The drawing consists of:

Plan and Profile to scales of H 1:1000 and V 1:200respectively

Cross-sections to scale of1:200

Typical Drawings, Various Standard Scales

2. GEOMETRICDESIGN

2.1 Road Classification, Traffic and Loading

The objective of the consulting services is to assist the Chharka Tangsong Rural Municipality, Dolpa, Dolpa for design of **Chharka Road**, Dolpa . This road is designed in accordance with DOR Norms and standard specifications for District road.

For assigning various geometric and technical parameters for design, roads are categorized into classes as follows:

Table 2: Technical/Functional Classification of Roads

S.N	Class of Road	ADT	Time (in years)	Design speed adopted
1	I	ADT of 20,000 PCU or	20	120 km/hr
2	II	ADT of 5000-20000	20	100 km/hr
3	III	ADT of 2000-5000 PCU	20	80 km/hr
4	IV	ADT of less than 2000	20	60 km/hr

Table 3: Approximate Correlation between administrative and functional classification

	Plain and Rolling terrain	Mountainous and steep terrain
National Highway	I,II	II,III
Feeder Roads	II,III	III,IV

Source: NRS 2070

ADT is the average daily traffic that moves along the road section in both directions. Different vehicles with different shape, size and axle load ply along the road, and converting all of them to a single unit called Passenger Car Unit (PCU). For this equivalency factor is used to convert the vehiclesintoasingleunitwhichmakesthecalculationeasierforthedesignprocess.Theroadfalls in category IV referring table 2.2 as the road is District Road with hilly terrain type.

2.2 Design Speed

Class of the road is taken as the contributing factor for the design of a road section, and this is determined by the traffic volume on the road. Overall geometric design of a road is a function of design speed. Design speed is decided based on the importance of the road (road class) and the type of terrain. The design speed to be adopted for various classes of roads is given in Table 4.

Table 4: Design Speeds, km/h

Road Class	Hill	Terai
DRCN	Min-20, Ruling-25	Min-40, Ruling-50
Village Road (VR)	15	20

Source: NRRS 2055, second revision

As design speed is the guiding criterion for geometric design of the road, the road fall sunder class DRCN of Hill category. As a road is classified as Municipal with Hilly terrain the design speed adopted for the road section is 25kmph.

2.3 Traffic Characteristics

2.4 Vehicle Dimensions

The maximum dimensions of vehicles considered for design of roads in Nepal are as follows:

Maximum Width, 2.50 m

Maximum Height, 4.75 m

Maximum Length, 18.00 m

Maximum single axle load, 100 KN

Source: NRS 2070

2.5 Equivalency Factor

In Nepal, the traffic volume is calculated for the perspective period of 20 years, due to which a road shall be designed with a capacity sufficient to cater for the estimated traffic volume for 20 years after the date of completion of the works. Different types of vehicles with different axle loads ply on this road section, for which a single equivalent factor is required to bring all the vehicles into one single unit called Passenger Car Unit.

It is the factor adopted to bring all the vehicles that ply on the road section to one standard traffic unit (PCU) to which other types of vehicles may be related. For geometric design of roads this standard is the 'Passenger Car Unit (PCU)' which is that of a normal car (passenger car), light van

or pick-up. Other types of vehicles are taken into account by multiplying by the following equivalency factors

Table 5: Vehicle types, Equivalency Factors

S.N	Vehicle Type	Equivalency
1	Bicycle, Motorcycle	0.5
2	Car, Auto Rickshaw, SUV, Light Van and Pick Up	1.0
3	Light (Mini) Truck, Tractor, Rickshaw	1.5
4	Truck, Bus, Minibus, Tractor with trailer	3.0
5	Non-motorized carts	6

Source: NRS 2070

2.6 Capacity and Level of Service

Level of service (LOS) is a qualitative measured to relate the quality of traffic service. LOS is used to analyze highways by categorizing traffic flow and assigning quality levels of traffic based on performance measure like speed, density, volume.

Among six Level of Services (LOS), from A to F, NRS 2070 recommends to adopt a LOS B for the design capacity of a road. While adopting this LOS, the design road has to experience congestion and face inconvenience during some peak hours, this is acceptable to some extent. As per the traffic volumes, the number of lanes is determined for the carriageway in design phase. At the level of service B, volume of traffic will be around 45 percent of maximum capacity under mixed traffic condition. At the end of design life, design traffic volume should be taken as the volume that flow in the road section, for this equivalency factor is considered as shown in Table 5. Recommended design service volumes for single lane, intermediate lane, two lanes and multi-lane roads are presented in Table6.

Table 6: Capacity of Roads, PCU/day

S.N	Category	Plain		Rolling		Mountainous & Steep	
1	Single Lane Road (3.75 m) with good quality shoulders at least 1.0m wide	2000	1900	1800	1700	1600	1400

S.N	Category	Plain		Rolling		Mountainous & Steep	
2	Intermediate lane Road (5.5m) with good quality shoulders at least 1.0mwide	6000	5800	5700	5600	5200	4500
3	Double lane Road(7.0m) with good quality shoulders atleast 1.0m wide	15000	12500	11000	10000	7000	5000
4	Four lane road with a minimum 3 m widemedian	40000	35000	32500	30000	25000	20000

Source: NRS 2070

At the time of design, Double lane road of 7.0 m width is considered. For the District Road, categorized as class III with ADT of 2000-5000 PCU.

2.7 Sight distance

For safety it is necessary that sight distance of adequate length should be available to permit drivers enough time and distance to control their vehicles. Sight distances are usually governed by the distance required for stopping (stopping distance) and overtaking (overtaking distance).

2.8 Stopping distance

It is the distance ahead needed by a driver to bring his vehicle to a complete stop before meeting a stationary object in his path. The minimum stopping distance (Roads, 2070) shall be 80m, whereas maximum distance is 260 m. The SSD adopted for design is 30m.

2.9 Overtaking distance

It is the minimum distance that should be available to the driver to overtake another vehicle safely. The minimum overtaking distance (Roads, 2070) shall be 300 m, whereas maximum distance is 880m.

2.10 Lateral and verticalclearance

2.11 Lateral clearance

As per NRS 2070, for a single carriageway road that goes through an underpass, whole width of the roadway (carriage way plus shoulder widths) should be cleared in lateral direction. If foot paths are provided minimum lateral clearance should be width of footpath plus 1m.

2.12 Vertical clearance

As per NRS 2070, a vertical clearance of 5 m measured from the crown of the road surface is to be provided for whole roadway width on all roads. No obstructions shall be made on this space.

2.13 Horizontal Curves

2.14 Minimum Radius of Horizontal Curve

Minimum recommended values of radius of horizontal curves for various design speeds are given below. However as far as site conditions permit largest possible values of radius should be used.

Table 7: Minimum radius of horizontal curves

Road Class	Design Speed, km/h	Minimum Recommended Radius, m		
		When no super elevation provided (2.5% camber)	When maximum super elevation provided (10% provided)	From the comfort criteria of passengers
I	120	1730	600	760
II	100	870	370	530
III	80	440	210	340
IV	60	200	110	190
	40	70	40	90
	30	30	20	50
	20	20	10	30

Source: NRS 2070

2.15 Transition Curves

Transition curves are necessary to allow a vehicle smoothly enter the circular curve from straight section and vice versa. All horizontal curves with radius less than1000 m should be provided with transition curves. Minimum length of transition curves that should be provided is shown in Table 8.

Table 8: Length of Transition Curves

Radius, m	20	30	50	60	80	100	150	200	250	300	400	500	1000
Length of transition curve,m	20	30	35	40	45	50	60	70	80	90	100	110	120

Source: NRS 2070

2.16 Extra Widening

When a vehicle negotiates a horizontal curve, the wheels do not exactly follow the path of the front wheels. Their path is shifted towards the center of the curve in relation to the front wheels' path. In curves the drivers of the vehicles have a tendency to keep a greater clearance between them as compared to the straight sections of the road. For the reasons mentioned above the width of carriageway of roads at the curves is made wider than on the straight sections. Value of extra widening is adopted as shown below in Table9.

Table 9: Extra-widening

Radius of Curve		20	20-40	40-60	60-100	100-300	>300
Extra Width, m	Single Lane Road	0.9	0.6	0.6	Nil	Nil	Nil
	Double Lane Road	1.5	1.5	1.2	0.9	0.6	Nil
	Multi-Lane (N lane Road)	0.75 n	0.75 n	0.6 n	0.45 n	0.3 n	Nil

Source: NRS 2070

2.17 Set-Back Distance at HorizontalCurves

Adequate sight distance should be available across the inside of horizontal curves. Distance from the road center line within which the obstructions should be cleared to ensure the needed visibility I.e. the "set-back distance", can be calculated from geometrical considerations (NRS 2070).

2.18 Vertical Curve

The vertical alignment of the road should provide for a smooth longitudinal profile without any kinks and visual discontinuities in the profile. Grade changes in vertical alignments should be as less frequent as possible

2.19 Gradients

Vehicle operation cost is directly related with the longitudinal gradients, and so it is recommended to adopt their values as small as possible. Right from the early stage of alignment fixing, it should be born in mind that it becomes very difficult to flatten the gradient at later stage. Maximum gradient depends on the dynamic characteristics of commercial trucks, design speed and maximum allowable reduction in speed during climbing up the gradient. Considering these factors (weight to power ratio of trucks-120kg/kW, with a maximum reduction of speed by 25 km/hr. below the design speed) maximum gradients for various design speeds shall be as follows:

Table 10: Maximum gradients

Design Speed, km/h	20	30	40	60	80	100	120
Maximum Gradient,%	12	10	9	7	6	5	4

Source: NRS 2070

2.20 Right of way

As per NRS 2070, Right of Way for District road is 20 m, which has been shown in plan with 15 m on either side. The adopted Right of Way for the proposed road is 20 m (10 m each side).

2.21 Sign Posts

All traffic signs and road markings is considered as per the Traffic Signs Manuals Vol-I and Vol II published by the DOR with amendments made thereafter. Road safety notes published by the DOR shall be consulted.

3. SURVEY FOR EXISTING ROADCONDITION

3.1 Survey Procedure

Survey of the existing road was carried out as follow to determine the present condition of the road.

3.2 Reconnaissance

The team of topographical survey experts visited entire project road site and made enquiries regarding the general features of the surrounding and noted down the same. The survey team specially observed the construction material area, problematic area, permanent bench mark and other control points based on which temporary bench mark and new control points were to be established along the project road.

3.3 Base Line Survey

Several base lines were established along the road corridor considering inter visibility of the end points of baseline. Chaining work was carried out along the baseline to find the length of the road project. The end of the base line was marked properly by driving temporary wooded peg so that concrete pillars can be caste over the peg position later on. All details of the road corridor were observed with reference to the base line (BL). Points were mark as BL1 BL2…., BM1, BM2…. And TP1, TP2…. located in the drawing.

3.4 Existing Road Condition

The Road project starts from Tinje of Dolpo Buddha Rural Municipality Ward (Ch. 0+000km) alignment passes through open track and finally ends at Yakkharka of Chharka Tangsong Rural Municipality Ward No. 1 (Ch. 76+000km).

3.5 Control Points

All the Base line stations (BL Stations) and benchmark Stations (BM Stations) are shown on the topographical plan of the engineering drawing. Benchmarks were selected for the survey, and those points are shown in tabular from with all details (i.e. BM/BL numbers, elevation, northing and easting) at the end of Volume III (Drawings).

3.6 Material Survey

Quality of any construction works depends largely on standard of construction materials used in the work. Good quality work cannot be expected from sub-standard construction material, due to

which various sites have been selected for different materials to be used during construction stage. For Aggregate, gravel and sand, nearest river from the site issued.

3.7 Detail Topographic Survey

Total Station was used to collect all the required data used for an extension of existing road surface. Details of cross drainage structures, private houses lying within the Right of Way that are to be partly removed later on for road extension have also been observed and marked in the drawing. On the basis of the acquired field data digital topographic map were prepared and printed to scale and other detail were incorporated as shown in the drawing.

4. ENGINEERINGDESIGN

All drawings (horizontal alignment, vertical alignment and Cross-Sections) were prepared and designed by the use of computer aided design (CAD) and software Smart-Road version 2016 Program. The Smart Road is a complete software solution for the road works which have been widely used by various projects.

4.1 Horizontal Alignment

Design of the horizontal alignment has been carried out using Smart road (Smart Road 2016). Extensive field checks to verify the feasibility of the proposed alignment have been carried out and suitable modifications to the alignment have been done wherever considered essential to safeguard sensitive elements. Base plan of the existing road corridor showing all natural and manmade features have been prepared using the topographical survey data. All the features within a band width have been captured with a unique description code during the survey along with the details of existing carriageway centerline, edge of pavement, edge of shoulder, toe line of the embankment etc. This data has been extracted into the highway design software to prepare the base plans. Geometric design of the project corridor has been conceptualized for a design speed of 40 kmph.

4.2 Extra Widening

As recommended by Indian Road Congress and using formula given above, the inner edge of carriageway has been widened on horizontal curves to facilitate safe passing of vehicles.

While travelling under open highway conditions along the rural road, most drivers gravitate towards a more or less uniform speed. In the event that the road is not designed properly, a vehicle must be driven at a reduced speed for safety as well as comfort of the passengers when moving from a tangent section to a curved section of the highway. This is because a centrifugal force is acting on the vehicle that tends to cause an outward skidding away from the center of the curve.

Table 11: Extra Widening

SN	Radius (m)		Extra Widening (m)
	From	To	
	0	8	2.95
2	8	10	2.6
3	10	12.5	2.3
4	12.5	15	1.9

SN	Radius (m)		Extra Widening (m)
	From	To	
5	15	20	1.6
6	20	30	1.2
7	30	40	0.9
8	40	50	0.8
9	50	60	0.6
10	60	70	0.55
11	70	80	0.5
12	80	90	0.45

SN	Radius (m)		Extra Widening (m)
	From	To	
13	90	100	0.4
14	100	110	0.35
15	110	120	0.34
16	120	130	0.32
17	130	140	0.3
18	140	150	0.29
19	150	1000	0

4.3 Super Elevation

Super-elevation is defined as the raising of the outer edge of the road or track along curves. It will reduce effect of radial force on the vehicle.

As a vehicle of mass M at speed V moves about a carriage way curve of radius R that is at an angle α with the horizontal, it is subject to a reactive force = MV2/R, called the centrifugal force, which causes it to slide outward, away from the center of curvature.

Finally the formula comes to $V2/gR = \tan\alpha+\mu + (\mu\ V2/gR) \tan\alpha$

Where μ is the coefficient of lateral friction or side friction factor, g is the acceleration due to gravity, M is the mass of the vehicle. The quantity $(\mu V2/gR) \tan\alpha$ is so small that it can be neglected. If $\tan\alpha$ is expressed in terms of super-elevation, e, then,

$$V\ 2/R = (e + \mu)/g$$

Where: V 2/R is the centrifugal acceleration. If V m/s is replaced by V km/h and g= 9.81m/s2, then we get

$$V\ 2/127R = e+\mu \quad (4.1)$$

This is known as minimum radius equation. If design speed and super-elevation are known, it enables the minimum radius to be determined for an acceptable level of side friction (and ofdrive comfort).

The maximum super-elevation is obtained without taking into account the coefficient of lateral friction (μ = O)

$$V\ 2/127R=e \text{ ---------- } (4.2)$$

In this case, the driver does not require to adjust the steering wheel.

The minimum super-elevation is obtained in the case if taking into account the full value of the coefficient of lateral friction.

$$e = V\ 2/127R– \mu \quad (4.3)$$

In some countries super-elevation are normally provided only for balance about 45 percent of radial force in order to give the driver comfort and from the recognition that a stationary or slow-moving vehicle tends to slide toward the inside of the curve in abnormal coldish conditions.

When a vehicle traverses a horizontal curve, the centrifugal force act as horizontal out ward through the center of gravity of the vehicle. The centrifugal force developed depends on the radius of the horizontal curves. The super-elevation that is provided should not be less than the camber from the surface because of the drainage point of view hence a minimum super-elevation of 3% is adopted for black topped road.

The change over from normal section to super-elevation section should be achieved gradually over the full length the transition curves so that the design elevation is available at the starting point to the circular curve. The super-elevation is obtained in tangent and balanced on the circular curve. The super-elevation is introduced by raising the outer edge or the pavement at a specified rate by rotation the pavement about center line. As the traffic was observed as mixed so for this condition 75% of design speed is taken and the friction is neglected. Then the formula for super-elevation has reduced,

$$e+\mu=V2/gR \quad \text{.....(4.4)}$$

Where, μ = Coefficient of lateral friction taken as 0.15 for these roads.

V= Design speed in m/sec.

g= 9.81 m/sec2

The adopted Super Elevation are Tabulated as below:

Table 12: Super Elevation

Radius (m)		Super Elevation (%)
From	To	
0	15	7
15	20	7
20	25	7
25	50	6
50	60	5
60	100	4

Radius (m)		Super Elevation (%)
From	To	
100	100000	3
100000	1500000	0

4.4 Super Elevation Minimum Radius of Curvature

For the section of the road where difficult site conditions are in predominance, the minimum radius of horizontal curves adopted are 15 m and absolute minimum radius of 15 m is provided. In order to have clear vision range in the curves the setback distance have to be adopted ranging from 0.8 m for curve radius 150 m to 4.5 for curve having radius up to 15m.

Minimum radius of curvature (due to narrow landscape insistent to pass road through buildings constraint) adopted in the proposed road is 15 m. Most of the curves are designed for radius more than 15m and large radius to avoid huge amount of earthwork and protection works. Attempt has been made to increase radius as far as practicable considering the comfort of driver and passengers as well as serviceability of road.

$T = R\tan\Delta/2$ ..... (4.5)

$E = R(\sec\Delta/2 - 1)$ ..... (4.6)

$L = \pi R\Delta/180$ ..... (4.7)

Where,
- T = Tangentl ength
- E = Apex distance
- L = Length of curve
- R = Radius of curve in meter
- Δ = Deflection angle in degree

4.5 Widening on Curves

Widening includes mechanical and psychological widening. To facilitate safe passing of vehicles on curves having radius less than 60 (as recommendation by IRC m) the inner edge of carriageway will be widened. The widening is done according to the following formula

$We = (nL^2/2R) + V/(9.5\sqrt{R})$ ..... (4.8)

Where,
- We = extra widening
- N = number of traffic lanes
- L = length of wheel base (6.1 m)
- V = design speed (20km/h)
- R = radius ofcurve

Since in the proposed road no transition curve is provided two third of the extra width should be achieved on the tangent portion before the start of the circular curve and one third on the circular curve. Road is located in the hilly terrain; the entire widening should be done inside of the curve. Due to drainage consideration and other constrains, it is necessary to provide widening equally both sides of the road.

4.6 Vertical Alignment

The vertical alignment includes selection of gradient and design of summit and valley curves. The maximum gradient adopted is 10%, which is permitted by NRS. For smooth changes from one gradient to another, gradual vertical parabolic curves were provided.

Y = Ax2/200Lwhere,
A= Deviation of grades in percent
L = length of curve
X = horizontal distance

The length of both summit and valley surveys are calculated as per the equation discussed above. The recommended gradient for highway in mountainous/steep terrain is listed in Table 13below.

Table 13: Standard Gradient

S. No.	Design standard	Value
1	Maximum gradient	6%
2	Average gradient	4%
3	Minimum longitudinal gradients	0.5%
4	Limitation of Maximum Gradient length of above average gradient	150m
5	Mountainous/Steep Terrain (Percent cross slope>25<60)	150m
6	Rolling Terrain (Percent cross slope>10<25)	210m
7	Maximum Recovery Gradient to be applied after gradient in excess of average grade for the minimum recovery length of:	
a	150m in mountainous/ Steep terrain	3%
b	210m in rolling terrain	4%

4.7 Summit Curve

The criteria to be adopted is that the minimum sight distance shall be equal to the stopping sight distance and for rural road, the sight distance is 30m at design speed of 25 km/h.

The length of vertical summit curve is given by:

L = As2/200 when S is less than L..... (3.9)

And, L = (2S – 200/N), when S is greater than L .....(4.10)

Where L = Length of curve in m

S = Sight distance in m

A = Algebraic difference of approach grades in percent and

Height of eye = 1.0meter

Height of lowest objective visible = 0.10 meter

4.8 Valley Curve

The criteria to be adopted are that the headlight sight distance shall be equal to stopping sight distance and that centrifugal acceleration is limited to 0.30 m/sec^2 and it is given by,

L = As2/(200+3.5S) whenS<L ..... (4.11)
L =2S-(200+3.5S)/A whenS>L ..... (4.12)
Where the centripetal acceleration rules,
L = A V 2 / 395 where V is in km/h..... (4.13)

5. SOCIAL ECONOMIC STATUS OF INFLUENCE AREA

A general study of social aspect of the project area has been carried out. The study analyzed the aspects during and after construction phases. The main focus of study was towards the socio-economic status of the people including indigenous people and their improvement in living standard.

5.1 Demographic Profile

5.2 Demography of Study Area

Dolpa District is one of the seventy-seven Districts of Nepal, and is located in the Karnali Province. Chharka Tangsong Rural Municipality covers an area of 7789 km^2 and has a population (2020) of 17500. Chharka Tangsong Rural lies in the hilly region of Nepal and Dolpa as its district headquarter.

5.3 Nature of Migration and Outside Influx

Migration is the movement by people from one place to another with the intentions of settling temporarily or permanently in the new location. The movement is often over long distances and from one country to another, but internal migration is also possible; indeed, this is the dominant form globally. Migration may be individuals, family units or in large groups. In this project area migration to tarai region is of concern of local leaders as people are migrating outward in search of better opportunity for employment, education, health and livelihood.

5.4 Initial Road

The Consultant collected and studied all relevant data, review of all available reports, topographic maps and images from Google earth of the area along the existing road alignment and conducted the walkover survey to find the different alternative alignments and thorough investigations to finalize the appropriate alignment. While finalizing the alignment different aspects of the road project were studied such as Geology, Environment, Social impacts, Hydrology and meteorology, Geotechnical, Economy, Engineering and other relevant aspects.

5.5 Description of Road Alignment

The project (Tinje-chharka-mustang-yakkharka Road Section) lies in Chharka Tangsong Rural Municipality. Starting point of the road project is Tinje of Dolpo Buddha Rural Municipality, Almost all of the stretches of the alignment follow the, Hilly terrain. The road traverses through various villages and places of Chharka Tangsong Rural Municipality, Ward and the Road project

finally ends at Yakkharka of Chharka Tangsong Rural Municipality Ward No. 1. Total length of the road is 76km.

Table 15: Alignment Details

Chainage	Places	Remarks
00+000	Tinje Dolpo Buddha Rural Municipality.	Start Point
76+000	Chharka Tangsong Rural Municipality Ward No.1 Mustang-Yakkharka	End point

5.6 Study of Existing Alignment Inventory Survey

5.7 General

The consultant studied the condition of existing Chharka Road Section. An inventory survey of the proposed road has been carried out to assess the extent of rehabilitation and upgrading works required to upgrade the road to Highway standard.

5.8 Road Inventory

The Road inventory contains amongst others the details on the following parameter of road:

- Road Geometry
  - Cross Sectional elements
  - Intersection Location
- Side Drainage
  - Longitudinal side drain
  - Miter Drains
  - Turn Out
  - Cut-off Drains
- Cross Drainage Pipe Culverts
  - Slab Culverts
  - Causeways
  - Bridges
- Pavement
  - Carriageway
  - Shoulder
- Retaining Structures
- Road Furniture
  - Road Signs
  - Road Markings
  - Guard Rails
- Terrain
  - Soil Type
  - Topography
  - Land use Pattern

The location of the structures has been accessed during detailed engineering survey. The condition of existing structures was assessed by visual observation and measurement of structural dimension was made. It has been found that most of the existing structure in the good condition but the

dimension is not compatible for the proposed upgrading to Highway standard.

5.9 Existing Condition of Road Structures

Existing Road	Chainage	Length (Km)
Earthen Road	0+000 – 76+000	76km
Total Length		**76km**

5.10 Cross DrainageRequirement

Table 17: Estimate of Cross Drain Structures

Ch	Proposed					
	Humepipe	Pipe Culvert	Slab Culvert	Causeway	Box Culvert	Bridge
0+180.00		0.600				
0+370.00		0.600				
0+485.00		0.600				
0+535.00		0.600				
0+810.00		0.600				
0+970.00		0.600				
1+070.00		0.600				
1+334.00		0.600				
1+480.00		0.600				
1+560.00		0.600				
1+710.00		0.600				
2+520.00		0.900				
2+710.00		0.600				
2+820.00		0.600				
2+950.00		0.600				
3+220.00		0.600				
3+640.00		0.600				
3+772.00		0.600				
3+940.00		0.600				
4+090.00		0.600				
4+260.00		0.600				
4+375.00		0.600				
4+640.00		0.600				
5+020.00		0.900				
1+280.00				10		

5.11

5.12 Detailed Engineering Survey

5.13 Baseline Survey

The base line stations from where all the intersection points and most of the center line can be

located were fixed with the help of Differential Global Positioning System (DGPS). Most of the baseline stations were monumental permanently using concrete pegs. These stations were close data certain interval. The closing errors found within the permissible limit were adjusted.

5.14 Establishment of Bench Marks

Prior to initiate the engineering survey permanent survey monuments were established along the road. The intersection points (IP) and center line were set out with proper establishment of Bench marks. Bench Marks of size10cmx10cmx50cm were established with concrete having nail at center. The benchmarks were established so that detail topographic feature of the proposed area can be taken. The Bench Mark survey was done by fly leveling using Auto Level. For the future reference description cards (D-Cards) of all bench marks have been prepared which are presented in the appendix of this report. The bench mark survey was done with tolerable error not more than square root of distance in Km.

5.15 Traverse Survey

After the bench mark survey, traverse survey of the road alignment was carried out using Total Station. The survey was done applying standard practices. The distances were measured with the accuracy 4mm+4ppm * base line length. The errors were distributed based on the lengths of respective lines.

5.16 Topographical Survey

For existing road section, Consultant performed the task as below, but not limited to the following:

- Fixing road alignment by setting out intersection point (IP) and intermediate points
- Establishing Bench Mark (BM) and other reference points
- Taking longitudinal section (LS) and cross-section (CS) using step method
- Taking cross section taken at LS 15-25 m interval depending upon terrain and 2.5m interval across the alignment, minimum 15m both side from the centerline.
- Fixing the road alignment by setting out IP and intermediate point

Topographical survey of road in minimum 30m wide strip on either side of centerline.

6. Geological & Geo-Technical Study

6.1 General Geology

The Dolpa District is one of the seventy-seven Districts of Nepal, and is located in theKarnali

Province.

Highest temperature at the lowest elevation of Dolpa rises up to about 25 degrees Celsius in summer and the lowest temperature falls up to about -10 degrees Celsius in winter.The elevation of Chharka Tangsong Rural Municipality varies from about 4300 meters to about 6000 meters.

6.2 Regional Geology

The Nepal Himalaya has been divided into the Indo-Gangetic Plain, Sub-Himalaya (Siwalik Group), Lesser Himalaya, Higher Himalaya and Tibetan-Tethys Himalaya from south to north (Fig 6 and 7). The different major geological units are separated by almost east-west running thrust systems that pass through the entire Himalayan region. These thrusts are Indus-Tsangpo Suture, South Tibetan Detachment System, Main Central Thrust, Main Boundary Thrust and Main Frontal Thrust, from north to south. The General subdivision of the Himalaya is as follows:

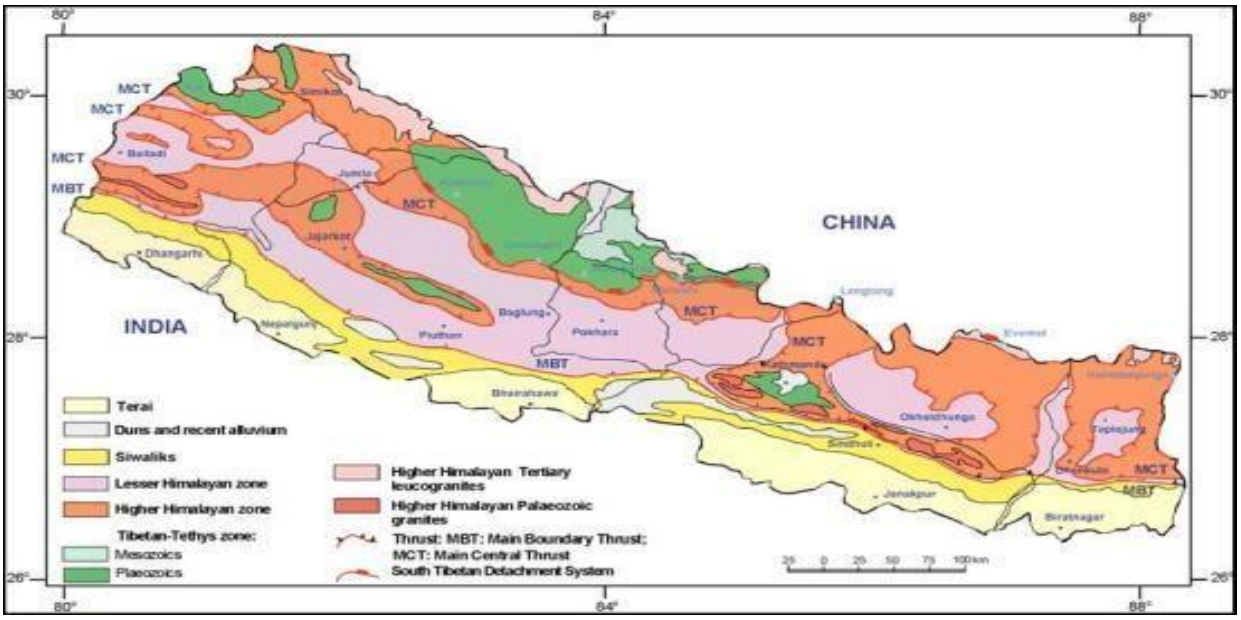


Figure 1: Geological Subdivision of Nepal Himalaya

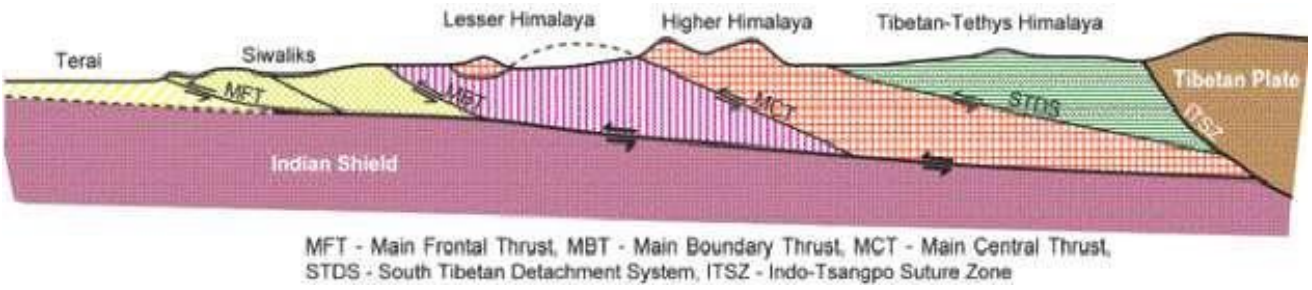


Figure 2: Generalized cross section of Himalaya (Dahal 2006)

6.3 Indo-Gangetic Plain or Terai Plain

The Indo-Gangetic Plainor Terai forms the southernmost tectonic unit of the Nepal Himalaya, having elevation from 100 to 200 m from mean sea level and covering alluvial deposits of Pleistocene to recent in age. The average thickness of the deposits is about 1,500m.

6.4 Sub-Himalaya (Siwalik Group)

The Siwalik Group is delimited by the Main Boundary Thrust (MBT)to the north and the Main Frontal Thrust (MFT) to the south and lying between the Lesser Himalaya andIndo-Gangetic Plain. About 6,000 m thick Neogene molasses type sediments were accumulated into the foreland basin during middle Miocene to lower Pleistocene in age. The sediment comprises mudstone, sandstone and conglomerate.

6.5 Lesser Himalaya

The Lesser Himalaya lies between the Siwalik Group to the south and the Higher Himalaya to the north. Both the southern and the northern limits of the Lesser Himalaya is represented by the thrust fault; the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT), to the southandnorth,respectively.Itisrepresentedbythickpilesofthesedimentaryrocksandlow- grade metamorphic rocks, ranging from the Pre-Cambrian to Tertiary in age. Total thickness of the Lesser Himalayan rocks is exposed more than 14 km. Nappe, Klippe and Schuppenlike tectonic structures have made complexity in the Lesser Himalayan geology.

6.6 Higher Himalaya

The Higher Himalaya is occupied by the high mountains and lies between the Lesser Himalaya tosouthandtheTibetan-Tethys Himalaya to the north, which is separated by the Main Central Thrust (MCT) in the south and north by the South Tibetan Detachment System (STDS). The Higher Himalaya is comprised of high-grade metamorphic rocks of schist with granite bodies, politics gneisses and migmatites and attains 6 to 12 km in thickness.

6.7 Tibetan-Tethys Himalaya

The Tibetan thesis Himalaya is northern part of the territory. The northern border of the Tethys Himalaya is represented by a fault called as the South Tibetan Detachment System (STDS). About 10 km thick shallow marine sedimentary rocks were deposited from Cambrian to Cretaceous image.

6.8 Physiographic Subdivision of Nepal

Physiography of the region governs the geological and engineering geological condition of the terrain and hence is an important factor to be considered during the road construction. The physiographic subdivision of the Nepalese Himalaya (Fig 8) is briefly described below:

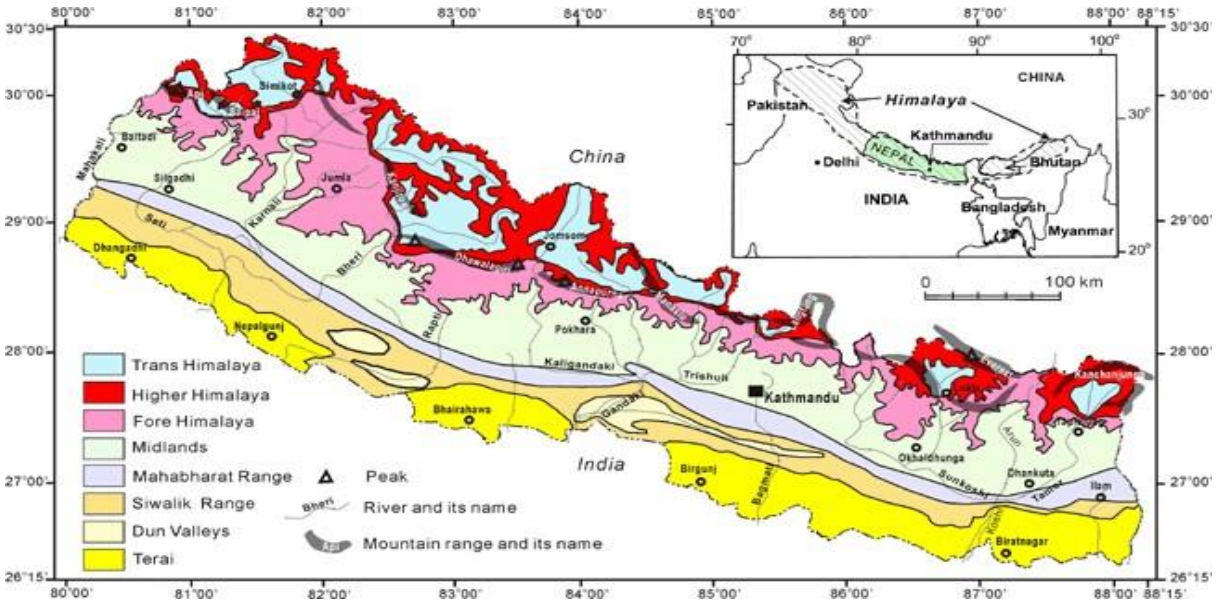


Figure 3: Physiographic Map of Nepal (Upreti, 1999)

6.9 Terai Plain and Dun Valleys

The Terai Plain and Dun Valleys comprises of the Quaternary (Recent) sediments deposited from the surrounding mountains through the rivers traversing from the mountainous parts. In addition, there are colluvial deposits at the foothill regions. The Terai Plain (Indo-Gangetic Plain) lies south of the Siwalik while the Dun valleys are more or less plain region surrounded by the Siwalik Range. The elevation of this zone ranges from 100 m - 200 m above sea level.

6.10 Churia Range

The Churia Range (Siwaliks) comprises the mountains lying north of the Terai Plain and the elevation ranges from 200 m -700 m above sea level. This range is consisting of sedimentary rocks, mainly mudstone, sandstone and conglomerates.

6.11 Mahabharata Range

North of the Siwalik range, the abruptly rising hills belong to the Mahabharata Range. The altitude of this region ranges from 1000 m - 2500 m above sea level.

6.12 Midlands

The Midland zone lie north of the Mahabharata Range, the altitude ranges from 300 m – 2000 m above sea level. This is the most inhibited region in the Nepalese mountains due to the presence of fertile valleys and slope cultivation is dominant.

6.13 Fore-Himalaya

This region lies at the higher elevation range (2000 m - 4500 m) than the Midland zone. It is the transition between the lesser Himalaya and Higher Himalayan region.

6.14 Higher Himalaya

The higher Himalayan region lies above 4000m elevation and is relatively inaccessible region, consisting of snowy mountain peaks.

6.15 Inner Valleys

The inner valleys are the regions surrounded by the higher Himalayas. The elevation ranges between 2500m and 4000m above sea level. These valleys are situated mostly along the major river traversing the higher Himalayan range.

6.16 Geology and Geomorphology of the site

6.17 Surface Geology

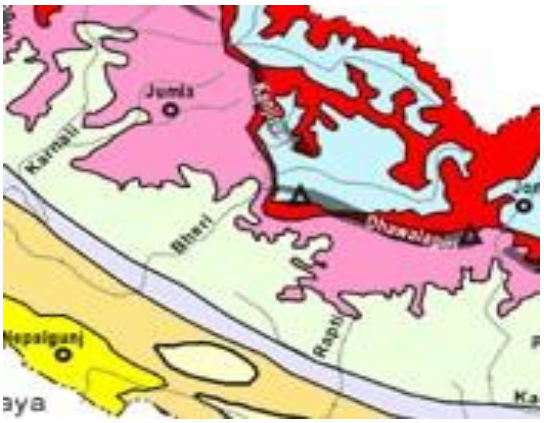


Figure 4: Geological Map of the Area

Geologically, the road alignment passes through the zone of High Hill region. The subgrade soil type is mainly sandy silt/ clay.

6.18 Seismicity

Due to Tectonic Forces, Himalayan zones and the neighboring areas are seismically very active. Most of epicenters of earthquakes are found to be located in the unstable zones. The frequency and intensity of earthquakes are found at the weakness of the crust such as major faults, major bends or major acres. Location of Nepal in the Himalaya along with major tectonic boundary and various longitudinal zones of the Himalaya are shown in Fig 6

Seismic hazard map of Nepal is also shown in Fig 7. Figure 7 shows that earthquake with a peak acceleration of 0.3 - 0.5 g may occur in 50 years, making the country very vulnerable to earthquake. A recent earthquake on April 25, 2015 of magnitude 7.8 whose epicenter was in Gorkha also proves that the country is very vulnerable to earthquake.

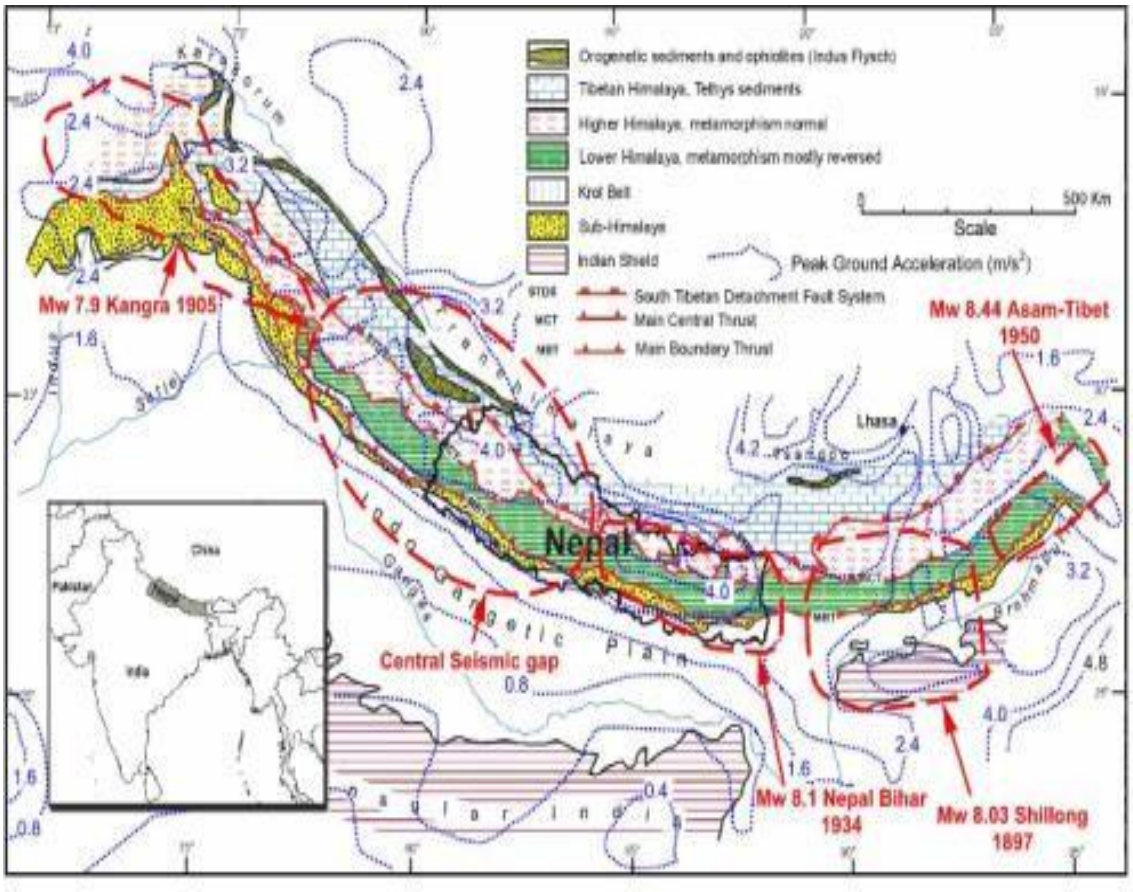


Figure 5: Location of Nepal in the Himalaya along with major tectonic boundary and various longitudinal zones of the Himalaya (Bhandary et al.2013)

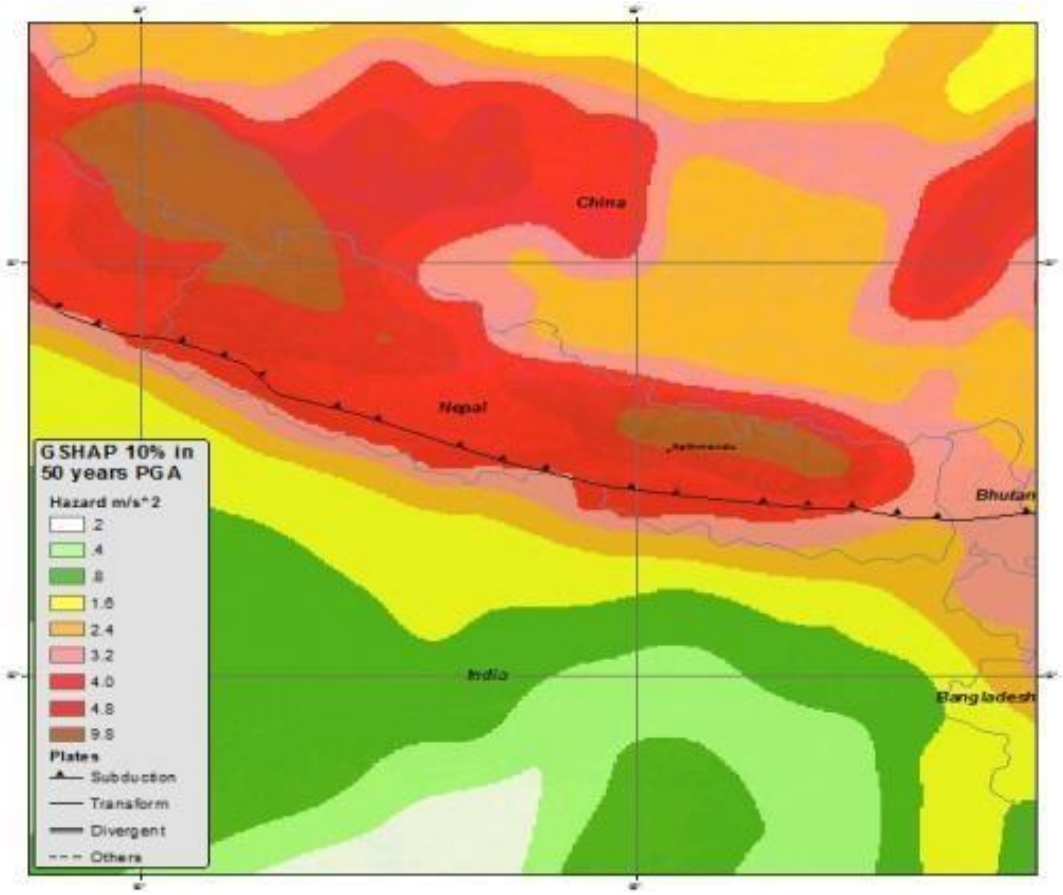


Figure 6: Seismic Hazard Map of Nepal (source: USGS)

Considering the cut and fill during road extension, the following soil type can be approximately used.

Table 18: Soil Type along the Alignment

Soil type	Percentage
Ordinary soil (gravel, sand, silt, clay)	70%
Hard Soil	10%
Soft Rock	10%
Hard Rock	10%

7. Traffic Survey, Studies and Pavement Design

7.1 Introduction

As the Proposed Road is in operation in dry season and hence the traffic study has been carried. The daily traffic count has been carried out for three days period. And the growth rate was calculated comparing with past data. As the opportunity of tourism, trade and agricultural development exists, population centers have been growing rapidly. A huge number of induced traffic is expected to grow in this road.

It is usual to consider following four categories of traffic when making forecasts of future traffic, because the benefits occurring to each category are different:

Normal Traffic – traffic that would use the road if no construction or improvement of the road section were made;

Diverted Traffic – traffic that changes from another route or mode of transport as a result of the construction or improvement of the road, because the study road is now part of a faster or lower cost route;

Generated Traffic – travel that is associated with journeys that will only be made in response to travel cost and time savings obtained as a result of the construction or improvement of the road; and

Induced Traffic – traffic that arises because of local development that occurs only as a result of the road construction or improvement.

7.2 Traffic Estimation

Normal Traffic

ADT estimated for 2022 is considered as normal traffic that is expected to grow over the service life at an estimated growth rate per annum. The following sections address the estimation of growth rate.

Traffic Growth Rate

Growth rate for the normal traffic is estimated based on the following:

Transport Sector Growth

Socio-Economic Parameters

Similar Project Findings

The mathematical model used for forecasting the growth rates from time series data is:

$$\text{Log}P\underline{N} = N \times \text{Log}\,(1+r) + \log P\underline{0}$$

Where,

P_0/P_N = Number of Vehicles in base year / n^{th} year

N = Number of Years,

R = Annual Growth Rate of Traffic

Transport Sector Growth

Transport sector in Nepal is dominated by road transport with limited contribution of rail / waterway-based transportation and aviation sectors. In absence of time series statistics on motor vehicle registration, overall transport sector growth is considered to represent growth in road transport and demand thereof for the project road.

Average annual growth of 4.9% is observed during the period of 1997-98 to 2004-05. A close look reveals that the sector has grown at 6.7% per annum till 2000-01 and slowed down since then to an average rate of 5.0%.

Socio-economic Parameters

Growth in relevant socio-economic parameters is also analyzed following the same principle for the period 1997-98 to 2013-14-time series data on constant price. Observed annual growth rates are:

Gross Domestic Product 5.48%

Real Per Capita Income 1.04%

Population in Nepal, as per 2011 Census has grown up by 2.27% per annum. During past decades, the population and growth rate are as given below:

Table 19: Population Growth Rate

Year	Population (million)	Annual Growth Rate (%)
1961	9.71	
1971	11.81	2.16
1981	14.72	2.46
1991	18.57	2.61
2001	23.66	2.74
2011	27.16	1.48

7.3 Growth Rate

Socio-Economic Data

Major socio-economic parameters that influence traffic growth estimation are State income (GDP), population and per capita share. As, Nepal's economy is mainly dominated by the

primary sector, growth in GDP is considered to be single most influencing indicator of the transport demand. Growth in population and per capita income have most influence on passenger travel demand, however, combined effect of population and per capita income growth nearly equates to the growth in GDP.

Past analysis of GDP shows a growth of 3.42% over the period of 1997-98 to 2004-05. Split analysis shows that it has grown at a healthy rate of 5.5% till 2000-01 and tumbled after following political disturbances in the recent past. Now following, political reorganization toward a stable democratic government, it can very well be anticipated that economy of Nepal would bounce back to the path of high sustainable growth. Hence an average annual Growth of 5% is considered during the project life.

Population growth rate over last three decades varies between 2.1 to 2.74% per annum. During last decade, it was 1.48% but for the coming decade, population growth can very well be interpreted in the range closer to 2.3% to 2.4% per annum.

In view of the above analysis, discussions on economic parameters and conclusion on thereof, traffic growth rates can be established as:

For two/three-Wheeler	7.5%
For Car	7.0%
For Passenger vehicles	8.0%
For Freight vehicles	7.0%

Adopted Growth Rate

The growth rates worked out from socio-economic parameters have been compared with that from Departmental Policy Document of Nepal to arrive at rational traffic projections. Adopted growth rate for various traffic is presented below.

Table 20: Vehicle Growth Rate

S. N.	Description	Vehicle Growth (%), per Annum			
		2/3 Wheeler	Car	Bus	Truck
1	Socio-Economic Data	7.5	7.0	8	7
2	Nepal Departmental Policy Document	6.0	6.0	6.0	6.0
Adopted Growth		7.0	7.0	7.0	7.0

Higher population growth would call for higher passenger movement demand than in average sector demand. On account of low per capita income, thrust of passenger demand shall be towards low-cost option like bus and low-cost vehicle option of two/three-wheeler. Little higher freight transport demand is considered on account of increase in cross border movement. From the above table, vehicle growth rate can be taken as 7.0% for all vehicles.

7.4 Base Year Traffic Flow (Normal Traffic)

The base year traffic flow is estimated by Average Daily Traffic (ADT) currently using the proposed route, classified into the vehicle categories of truck, bus, tractor, car, motorcycle, etc. Traffic Count 2021 is assumed as latest traffic count of that section. Construction period is taken as 3 years i.e. Project is assumed to be completed by 2024.Traffic growth is taken as 7% and projected for 2024. Traffic Data of 2024 is taken as base year traffic flow for traffic forecast. The ADT is defined as the average number of traffic summed for both directions. Further ADT is multiplied by the seasonal factors 0.91 to convert it into Average Annual Daily Traffic (AADT). Base year traffic flow can be expressed by using a single number i.e. Passenger Car Unit and Traffic Forecast is done for 20Years.

Table 21: Traffic Flow Analysis along the project road

Type	2021 Traffic Count (Both Direction)	Growth Rate 7%	2024 Traffic Forecast with 7% GrowthRate	AADT 2024 with seasonal factor 0.91	PCU	AADT in PCU in2021	AADT in PCU in2024
Multi-Axle	6	0.07	7	6.37	3	18	19
Heavy	6	0.07	7	6.37	3	18	19
Light	10	0.07	12	10.92	1.5	15	16
Big	10	0.07	12	10.92	3	30	32
Mini	6	0.07	7	6.37	1.5	9	9
Micro	10	0.07	12	10.92	1.5	15	16
Tractors	10	0.07	12	10.92	1.5	15	16
						120	127

Traffic Forecast in AADT in PCU for 20 Years

Table 22: Traffic forecast for 20 years

Vehicle	Type	2021 Traffic Count (Both Direction)	Growth Rate 7%	AADT 2024 with seasonal factor 0.91	AADT 2044 with seasonal factor 0.91	PCU	AADT in PCU in2021	AADT in PCU in2024	AADT in PCU in2044
Truck	Multi-Axle	6	0.07	6.37	24.57	3	18	19	73
	Heavy	6	0.07	6.37	24.57	3	18	19	73
	Light	10	0.07	10.92	41.86	1.5	15	16	62
Bus	Big	10	0.07	10.92	41.86	3	30	32	125
	Mini	6	0.07	6.37	24.57	1.5	9	9	36
	Micro	10	0.07	10.92	41.86	1.5	15	16	62
Tractors	Tractors	10	0.07	10.92	41.86	1.5	15	16	62
							120	127	493

Diverted and Generated Traffic

It is assumed that 7% growth rate in normal traffic will accommodate for diverted and induced traffic, no any separate calculation is made for diverted and induced traffic.

As traffic forecast is made for 20 years after completion of road construction with 7% annual growth rate. As 7% growth rate in normal traffic will accommodate for diverted and induced traffic, no any separatee calculation is made for diverted and induced traffic. AADT in PCU for 20 years forecast is calculated as 493 which is greater than 400 so, studied road is classified as DRCN.

7.5 Construction Materials Survey

Confirming to the grading and physical requirement for sub-base and base courses of highway, potential material sites are located nearby as local quarry sites, streams and rivers. The materials were generally chosen from the prospective quarries. Following considerations has been given for the selection of quarry site.

- Good quality
- Easily accessible
- Easy acquisition
- No determent effect on the environment

7.6 Geo technical Investigation

7.7 Construction Materials Investigation

This chapter deals with the materials that are needed for gravel wearing course, granular sub-base, crushed stone base for pavement, boulder stone and sand for the construction of masonry walls as shown in Table 36. The materials investigations were carried out in accordance to the Standard Specifications for Road and Bridge Works, DOR.

Table 23: Sources of Construction Material

S. No.	Description of Source	Type of Material	Estimated Quantity in m3	Suitability for Works	Remarks
1	Material available within 5 km	Alluvial deposits, comprising of boulders, cobbles, gravels and sands			Good
2	Kaen Khola	Boulders, gravels and sands			Excellent
3	Minor Streams	Boulders and gravels			Fair to good

Note: SB = Sub-Base, B = Base (obtained by crushing).

The information given in Table 34 above is indicative only. The contractor should satisfy himself of the availability, suitability and quantities of materials prior to bidding. The contractor should also confirm that the extraction of materials at these sources will be environmentally acceptable.

The quality and quantity availability of materials such as gravel, sand and stones were found to be satisfactory and can be obtained using proper extraction methodology. Masonry stone can be obtained from the rock bed at the quarry sites. The extraction of stone should be done in an environmentally safe way with the approval of the Engineer.

7.8 Source Identification

In order to identify the source of gravel material for the wearing course as well as sub-base and base course, various materials sources have been identified. Major gravel source is identified from river namely Veri Khola which are situated along the project road. In addition to the river sources, the team also investigated the quarry sites as well as small rivers along the road corridor. These also contain significant to little amount of desired construction materials. Mainly nyalgun Khola is the major sites for construction materials. Similarly base layer materials could be transported from Dolpa.

7.9 Field Investigation

Investigation of Potential Sources

7.10 Pavement Design

Pavement is most important component of highway section. An overall functioning of highway system greatly depends on the performance of its pavement. Furthermore, vehicle operating cost and entire highway economics and life cycle are interrelated to the pavement design practice.The design procedure of flexible pavement involves the interplay of several variables such as the wheel loads, traffic, climate, terrain and sub-grade soil conditions. Depending upon specific regional or nationwide characteristics, most of the countries are practicing some empirical and experience base methods for the design of flexible pavements. Therefore, pavement design is done by following three methods as perToR.

1. **DoR Pavement Design Guideline Method (Flexible Pavement)**
2. **IRC Method for Flexible Pavement**

7.11 DoR Pavement Design Guideline Method (Flexible Pavement)

General

Road pavement failure is mainly due to the traffic movement from both the magnitude of the individual wheel loads and the number of times these loads are applied. The total number of vehicles as well as wheel loads (axle load) should be considered for pavement design. The load imposed by passenger cars does not contribute significantly to the structural damage of the pavement. Therefore, cars and similar sized vehicles can be ignored for the structural design of pavement. Only the total number and the axle loading of the commercial vehicles (heavy vehicles) that will use the road during its design life need to be considered. In this context, heavy vehicles are defined as those having an unladen weight of 3000 kg or more. In some circumstances, particularly for low volume roads, construction traffic can be a significant component of overall traffic loading and the designs should take this into account. The total number of anticipated commercial vehicles during the design life is covered in to the cumulative equivalent standard axle of 8160kg.

Design life

In the context pavement, design life does not mean that at the end of the period the pavement will be completely worn out and in need of reconstruction. It means that towards the end of the period the pavement will need to be strengthened so that it can continue to carry traffic satisfactorily for a further period. Condition surveys of bituminous pavements are used to determine not only the maintenance requirements but also the nature and rate of change of condition to help to identify if and when the pavement is likely to need strengthening. The design life for the pavement is considered as cumulative number of standard axles that can be carried before strengthening of pavement is necessary. It is recommended that Feeder Road should be designed for a life of 15 Years. Express ways and urban roads may be designed longer life for 20 Years. For other categories of roads, a design life of 10 to 15 years may be taken. For this studied road project, a design life of 15years is taken after completion of construction.

Traffic Estimation

Base Year Traffic Flow

For the determination of the total traffic over the design life of the road, the first step is to estimate base year traffic flows. An estimate should be the Average Daily Traffic (ADT) currently using the route, classified into the vehicle categories of cars, light goods vehicles, trucks (heavy good vehicles) and buses. ADT is defined as number of traffic summed for both directions. Further ADT is multiplied by the seasonal factors to convert it into Average Annual Daily Traffic (AADT). Base year traffic flow can be expressed by using a single number i.e., Passenger Car Unit. It is recommended that traffic count for the purpose of pavement design is conducted for 24 hours and 7Days.

Traffic Forecasting

An extent of future traffic depends on many factors such as economic, land-use and demographic factors. Therefore, traffic forecasting is an uncertain process. In a developing economy the problem becomes more difficult because such economies are of ten very sensitive to the world prices of just one or two commodities. In order to forecast traffic growth, it is necessary to separate traffic into the following three categories.

Normal Traffic

Traffic which will pass along the existing road or track even if no any new pavement is provided. The commonest method of forecasting normal traffic is to extrapolate time series

data on traffic levels and assume that growth will either remain constant in absolute terms i.e.

a fixed number of vehicles per year (a linear extrapolation), or constant in relative terms i.e., a fixed percentage increase.

Diverted Traffic

Traffic that changes from another route (or mode of transport) to the project road because of the improved pavement, but still travels between the same origin and destination. Where parallel routes exist, traffic will usually travel on the quickest route although this may not necessarily be the shortest. Thus, surfacing an existing road may divert traffic from a parallel and shorter route because higher speeds are possible on the surface road. Origin and destination surveys should be carried out to provide data on the traffic diversions likely to arise. Diverted traffic is normally assumed to grow at the same rate as traffic on the road from it is diverted.

Generated Traffic

Additional traffic which occurs in response to the provision or improvement of the road. Generated traffic arises it her because a journey becomes more attractive by virtue of a cost or time reduction or because of the increased developments that is brought about by the road investment. Generated traffic is difficult to forecast accurately and can be easily overestimated. It is only likely to be significant in those cases where the road investment brings about large reductions in transport costs. For example, in the case of a small improvement within an already developed highway system, generated traffic will be small and can normally be ignored. However, in the case of a new road allowing access to an undeveloped area, there could be large reductions in transport costs as a result of changing mode from, for example, animal- based transport to motor vehicle transport. In such a case, generated traffic could be the main component of future traffic flow.

Axle loading

An accurate estimate of the current traffic loading is essential for an appropriate pavement design. Traffic volumes can be determined by traffic counts, but for current vehicle loads can be found by an axle load survey. It is no tractional to design pavement layer on the basis of legal axle load limits because of the widespread problem of overloading, in addition to this, the proportion of vehicles with partially loaded is unknown. In these circumstances of axle loading, pavement design across the world is accepted to design on the basis of Standard Axle i.e.,8.16 tones (80 KN). In Nepal, the legal axle load limit is 10.2 tones. Axle load surveys have been carried out as per procedure described in the TRL Overseas Road Note 31

for calculation of

traffic load for pavement design in terms of cumulative equivalent standard axle loads. The data collected from these surveys are used to calculate the mean number of equivalent standard axles for a typical vehicle in each class. These values are then used in conjunction with traffic forecasts to determine the predicted cumulative equivalent standard axles that the road will carry over its design life.

Equivalence factor

The damage that vehicles due to a road pavement depends very strongly on the axle loads of the vehicles. For pavement design purposes the damaging power of axles is related to a 'standard' axle of 8.16 tones (80 km) using equivalence factors which have been derived from empirical studies. In order to determine the cumulative axle load damage that a pavement will sustain during its design life, it is necessary to express the total number of heavy vehicles that will use the road over this period in terms of the cumulative number of equivalent standard axles(sea). Axle load surveys must be carried out to determine the axle load distribution of a sample of the heavy vehicles using the road. Data collected from these surveys are used to calculate the mean number of equivalent standard axles for a typical vehicle in each class. These values are then used in conjunction with traffic forecasts to determine the predicted cumulative equivalent standard axles that the road will carry over its design life. Equivalence factor is calculated by using the following relationships:

Front steering wheel (single wheel) axle $EF = \left| \frac{(Axle\ load,\ kgf)}{5410\ kgf\ (53kN)} \right|^4$

Single axle dual wheel $EF = \left| \frac{(Axle\ load,\ kgf)}{8160\ kgf\ (80kN)} \right|^4$

Tandem axle dual wheel $EF = \left| \frac{(Axle\ load, kgf)}{14968 kgf\ (146.8kN)} \right|^4$

Vehicle Damage Factor (VDF)

Where sufficient information on axle load is not available and project size does not warrant conducting an axle load survey, the indicative values of Vehicle damage factor (VDF) may be used as given in the table below. The Vehicle Damage factor (VDF)is the multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axles per

commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, and terrain type and from region to region. The VDF is arrived at axle load surveys on typical sections so as to cover various influencing factors, such as traffic mix, mode of transportation, commodities carried, time of the year, terrain, road conditions and degree of enforcement.

Table 24: Vehicle Damage Factor

S.N.	Vehicle Type	VDF
1	Heavy truck (three axle or more)	6.50
2	Heavy two axle	4.75
3	Mini truck/tractor	1.0
4	Large bus	0.50
5	Bus	0.35
6	Tractors	1.0

Distribution of commercial traffic over the carriageway

Total traffic AADT (both way) is distributed over the whole carriageway for design of pavement. During the calculation of design traffic (total equivalent standard axle) realistic study should be done for the directional distribution of total traffic. In the absence of adequate and conclusive data for particular project, it is recommended that following distribution may be assumed for design.

a) **Single lane roads:** Traffic tends to be more channelized on single lane roads than two- lane roads and to allow for this concentration of wheel load repetitions, the design should be based on total number of commercial vehicles in both directions.

b) **Two-lane single carriage roads/ Intermediate Lane roads:** The design should be based on 75 percent of the total number of commercial vehicles in both directions.

c) **Four-lane single carriageway roads:** The design should be based on 40 percent of the total number of commercial vehicles in both directions.

d) **Dual carriageway roads:** The design of dual two lane carriageway roads should be based on 75 percent of the number of commercial vehicles in each direction. For dual three-lane carriageway and dual four lane carriageway, the distribution factor will be 60 percent and 45 percent respectively.

The traffic in each direction may be assumed to be half of the sum in both directions when the latter only is known. Where significant difference between the two streams can occur, condition in the more heavily trafficked lane should be considered for design.

Where, the distribution of traffic between the carriageway lanes and axle loads spectrum for the carriage way lanes are available, the design should be based on the traffic in the most heavily trafficked lane and the same design will normally be applied for the whole carriage way width.

Computation of Design Traffic

The design traffic is considered in terms of cumulative number of standard axles (in the particular lane carrying maximum traffic) to be carried during the design life of the pavement. This can be computed as:

$$N = \frac{365*[(1+r)^n - 1]}{r} * A*D*F$$

Where,

N = Cumulative number of standard axles to be catered for the design in terms of msa
A = Initial traffic in the year of completion of construction in terms of CVPD
D = Lane distribution factor =0.75
F = Vehicle damage factor (as shown above VDF table)
n = Design life in years = 15years
r = annual growth rate of commercial vehicle (7% i.e.0.07)

The traffic in the year of completion is estimated using the following formula:

$A = P*(1+r)^n$

Where,

A = Initial traffic in the year of completion of construction in terms of number CVPD
P = Number of commercial vehicles per day as per last count
r = Annual growth rate of commercial vehicle (7% i.e.0.07)
n = No. of years between the last count and year of completion of construction (3years)

Detail Design Calculation as per DoR Pavement Design Guideline Method (Flexible Pavement)

Table 25 Calculation of Cumulative Number of Standard Axles by DoR Method.

Initial traffic CVPD	2023 Traffic Count (Both Direction)	VDF	ELSA	Traffic growth rate	Lane distribution factor	cumulative number of standard axles(N)	
Heavy truck three axle	7	6.5	45	0.07	0.75	464,668.28	
heavy truck two axle	7	4.75	33	0.07	0.75	339,565.28	
mini truck	12	1	12	0.07	0.75	122,549.87	
large bus	12	0.5	6	0.07	0.75	61,274.94	
bus	7	0.35	2	0.07	0.75	25,020.60	
Micro	12	0.35	4	0.07	0.75	42,892.46	
Tractor	12	1	12	0.07	0.75	122,549.87	
sub total CVPD	69		cumulative standard Axle			1,178,521.30	esa
			cumulative standard Axle			1.18	msa

Cumulative number of standard axles for design period is taken as1.18m sa which lies between 1 to 10 msa and CBR value is assumed to 5%. Pavement design for this project according to DoR pavement design guidelines is Plate I is used. According to the plate I, the total thickness of pavement is 450mm with granular subbase 280mm, granular base 150mm with bituminous surfacing (50 mm DBM and 20mm premix carpet as wearing course).

Sub grade

The sub-grade in cut and fill should be well compacted to utilize its full strength and to economize on the overall thickness of the pavement required. The general requirements for the construction detail of sub-grade should be referred to the Section 1000 of Standard Specifications for Road and Bridge Works.

Sub-Base Coarse

Sub-base construction material requirements and construction procedure shall be followed the standard Specification for Road and Bridge Works (Clause1201). From drainage consideration the granular sub-base should extended over the entire formation width. The thickness of the granular sub-base layer is 280mm. In the areas affected by frost, care should be taken to avoid using frost susceptible materials in the sub-base.

Base Course

Unbound granular bases which comprise conventional Graded Crushed Stone and Water

Bound Macadam (WBM) base shall be provided as per the Standard Specification (Clause 1203and1204). Materials used in the base must satisfy the grading and physical requirements in the Standard Specification. The thickness of granular base is 150mm.

Bituminous Surfacing

Bituminous surfacing shall consist of either a wearing course or a binder course with a wearing course depending upon the traffic to be carried. Bituminous Surfacing 70mm (20mm Premix carpet and 50 mm Dense Bituminous Macadam (section 1300)) is calculated as per DoR

Pavement Design Catalogue
Plate I - Recommended Design for Traffic Range 1 - 10 msa

CBR 5%					
Cumulative Traffic, msa	Total Pavement Thickness, mm	Pavement Composition			
		Bituminous Surfacing		Granular Base, mm	Granular Sub-base, mm
		Wearing Course, mm	Binder Course, mm		
1	430	20 PC		150	280
2	480	20 PC	50 DBM	150	280
3	510	20 PC	50 DBM	150	310
5	580	50 AC	50 DBM	150	330
10	660	50 AC	50 DBM	200	360

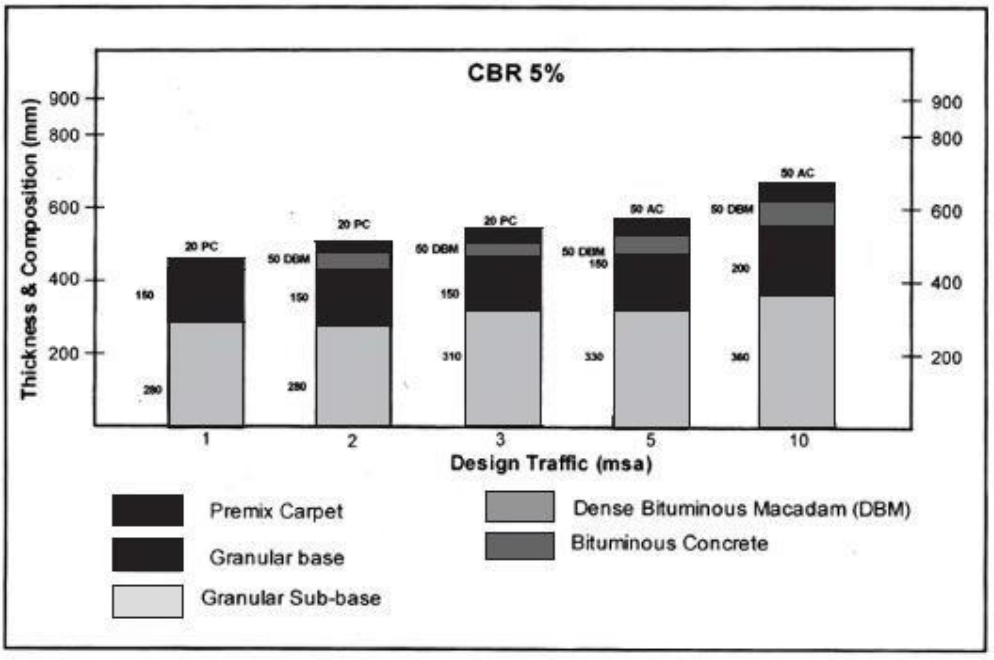


Figure 7: Pavement Design Chart For 1-10 MSA

7.12 IRC Method for Design of Flexible Pavement

General

Indian Roads Congress (IRC) has specified the design procedures for flexible pavements based on CBR Value and cumulative number of standard axles to be catered for design in terms of million standard axle (msa). This guideline follows analytical designs and developed set of designs up to 150 msa in IRC:37-2001

Design Procedure

1. Design is based on the performance of existing designs and using analytical approach, simple design charts and a catalogue of pavement designs added in the code.
2. The pavement designs are given for subgrade CBR values ranging from 2% to 10% and design traffic ranging from 1 msa to 150msa,
3. Using the following simple input parameters, appropriate designs could be chosen for the given traffic and soil strength.

- Design Traffic in terms of cumulative number of standard axles.
- CBR value of subgrade

Design Traffic

The method considers traffic in terms of the cumulative number of standard axles (8160kg) to be carried by the pavement during the design life. This requires the following information:

- Initial traffic in terms of Commercial Vehicles per Day (CVPD)
- Traffic growth rate during the design life
- Design life in number of years
- Vehicle Damage Factor(VDF)
- Distribution of commercial traffic over the carriageway

Initial Traffic in terms of CVPD

Initial traffic is determined in terms of commercial vehicles per day (CVPD). For the structural design of the pavement only commercial vehicles are considered assuming loaded weight of three tone or more and their axle loading will be considered. Estimate of the initial daily average traffic flow for any road should normally be based on 3-day 24 hour classified traffic counts (ADT). In case of new roads, traffic estimates can be made on the basis of potential land use and traffic on existing routes in the area.

Design Life

For purpose of the pavement design, the design life is defined in terms of the cumulative number of standard axles that can be carried before strengthening of the pavement is necessary. It is recommended that pavements for highways roads should be designed for 15 years and other categories of roads for 10 to 15years.

Traffic Growth Rate

Traffic growth rates can be estimated by:

- By studying the past trends of traffic growth
- By establishing econometric models

If adequate data is not available, it is recommended that an average annual growth rate of 7% may be adopted.

Vehicle Damage Factor

The vehicle damage factor (VDF) is a multiplier for converting the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle-load repetitions. It is defined as equivalent number of standard axles per commercial vehicle. The axle load equivalency factors are used to convert different axle load repetitions into equivalent standard axle load repetitions. The axle load equivalency factors recommended in the AASHTO guide are given in table below. They are used for converting different axle load repetitions into equivalent standard axle load repetitions.

Table 26: Axle Load Equivalency Factors as recommended by AASHTO Guide

S.N.	Gross Axle Weight (Kg)	Load Equivalency Factors		Remarks
		Single Axle	Tandem Axle	
1	900	0.0002	0.0000	
2	1810	0.0020	0.0002	
3	2720	0.0090	0.0010	
4	3630	0.0310	0.0030	
5	4540	0.0800	0.0060	
6	5440	0.1760	0.0130	
7	6350	0.3500	0.0240	
8	7260	0.6100	0.0430	
9	8160	1.0000	0.0700	
10	9070	1.5500	0.1100	
11	9980	2.3000	0.1660	
12	10890	3.2700	0.2420	

S.N.	Gross Axle Weight (Kg)	Load Equivalency Factors		Remarks
		Single Axle	Tandem Axle	
13	11790	4.4800	0.3420	
14	12700	5.9800	0.4700	
15	13610	7.8000	0.6330	
16	14520	10.0000	0.8340	
17	15420	12.5000	1.0800	
18	16320	15.5000	1.3800	
19	17230	19.0000	1.7300	
20	18140	23.0000	2.1400	
21	19051	27.7000	2.6100	
22	19958	33.0000	3.1600	
23	20865	39.3000	3.7900	
24	21772	46.5000	4.4900	
25	22680	55.0000	5.2800	
26	23587	-	6.1700	
27	24494	-	7.1500	
28	25401	-	8.2000	
29	26308	-	9.4000	
30	27216	-	10.7000	
31	28123	-	12.1000	
32	29030	-	13.7000	
33	29937	-	15.4000	
34	30844	-	17.2000	
35	31752	-	19.2000	
36	32660	-	21.3000	
37	33566	-	23.6000	
38	34473	-	26.1000	
39	35380	-	28.8000	
40	36288	-	31.7000	

When sufficient information on axle loads is not available and the project size does not warrant conducting an axle load survey, the indicative values of vehicle damage factor as given in table below may be used.

Table 27: Vehicle Damage Factor According to Terrain

S.N.	Initial Traffic Volume in terms of CVPD	Terrain		Remarks
		Plain	Rolling	
1	0-150	2.5	1.5	
2	150-1500	5.5	3.5	
3	More than 1500	6.5	4.5	

Where sufficient information on axle load is not available and project size does not warrant conducting an axle load survey, the indicative values of Vehicle damage factor (VDF) may be used as given in the table below. The Vehicle Damage factor (VDF) is the multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axle per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, and terrain type and from region to region. The VDF is arrived at axle load surveys on typical sections so as to cover various influencing factors, such as traffic mix, mode of transportation, commodities carried, time of the year, terrain, road conditions and degree of enforcement.

Table 28: Vehicle Damage Factor

S.N.	Vehicle Type	VDF
1	Heavy truck (three axle or more)	6.50
2	Heavy two axle	4.75
3	Mini truck/tractor	1.0
4	Large bus	0.50
5	Bus	0.35
6	Tractors	1.0

In case the class mark of the axle load survey does not match with the above axle loads, 4th PowerLawmaybeusedforconvertingaxleloadsintoequivalentstandardaxleloadsusingthe following formula.

Single Axle Load

Equivalency Factor = (axle load in

4kg/8160)^{423} Tandem Axle Load

Equivalency Factor = (axle load in kg/14968)^{4}

Vehicle Distribution

A realistic assessment of distribution of commercial traffic by direction and by lane is necessary as it directly affects the total equivalent standard axle load application used in the design. Until reliable data is available, the following distribution may be assumed.

a) **Single lane roads:** Traffic tends to be more channelized on single lane roads than two- lane roads and to allow for this concentration of wheel load repetitions, the design should be based on total number of commercial vehicles in both directions.
b) **Two-lane single carriage roads/ Intermediate Lane roads:** The design should be based on 75 percent of the total number of commercial vehicles in both directions.

c) **Four-lane single carriage way roads:** The design should be based on 40 percent of the total number of commercial vehicles in both directions.

d) **Dual carriageway roads:** The design of dual two-lane carriageway roads should be based on 75 percent of the number of commercial vehicles in each direction. For dual three-lane carriageway and dual four lane carriageway, the distribution factor will be 60 percent and 45 percent respectively.

Computation of Design Traffic

The design traffic is considered in terms of cumulative number of standard axles (in the particular lane carrying maximum traffic) to be carried during the design life of the pavement. This can be computed as:

$$N = \frac{365*[(1+r)^n - 1]}{r} * A*D*F$$

Where,

N = The cumulative number of standard axles to be catered for design in terms of msa

A = Initial traffic in the year of completion of construction in terms of number CVPD

D = Lane distribution factor =0.75

F = Vehicle damage factor (taken as shown in above table)

n = Design life in years = 15years

r = Annual growth rate of commercial vehicle (7% i.e0.07)

The traffic in the year of completion is estimated using the following formula:

$A = P*(1+r)^n$

Where,

A = Initial traffic in the year of completion of construction in terms of number CVPD

P = Number of commercial vehicles per day as per last count

r = Annual growth rate of commercial vehicle

n = Number of years between the last count and the year of completion of construction

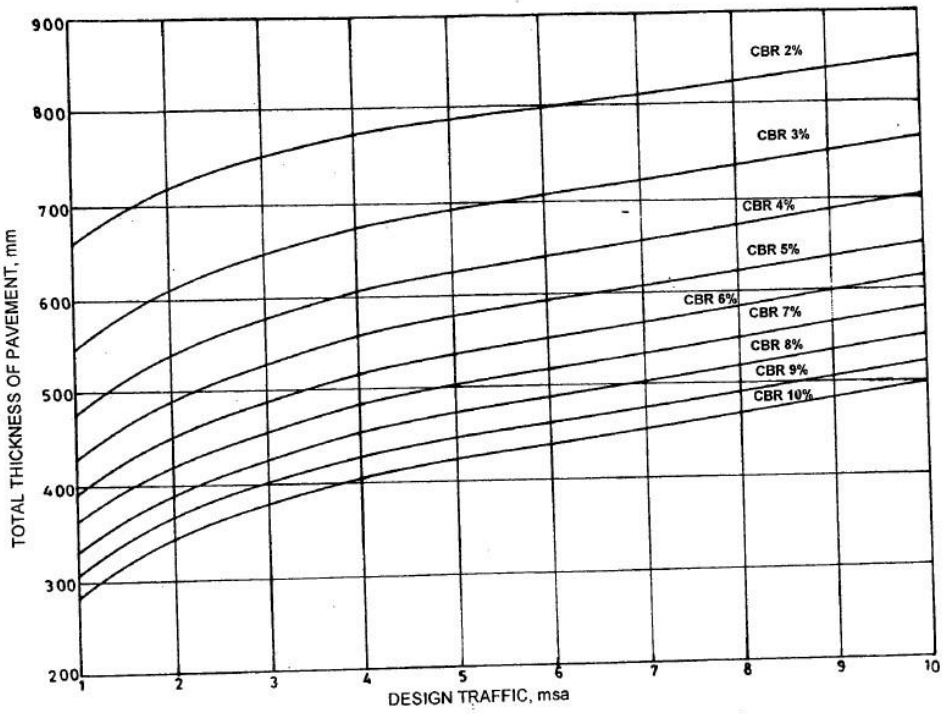


Fig. 1. Pavement Thickness Design Chart for Traffic 1-10 msa

Figure 8: Pavement thickness design chart

Design Calculation of Design Traffic and Cumulative Number of Standard Axles as per IRC Method

Table 29: Calculation of Cumulative Number of Standard Axles by IRC Method

S.N.	Vehicle	Type	2021 Traffic Count (Both Direction)	Growth Rate 7%	2023 Traffic Forecast with 7% Growth Rate	2043 Traffic Forecast with 7% Growth Rate	**AADT 2033 (A) with seasonal factor 0.87**	**VDF (F)**	**A*F**	**Lane Distribution Factor (D)**	**A*F*D**	**Cumulative Number of Standard Axles (N)**	**Remarks**
1	Truck	Multi-Axle	6	0.07	7	27	6.09	6.5	39.585	0.75	29.69	444,243.30	
2		Heavy	6	0.07	7	27	6.09	4.75	28.9275	0.75	21.70	324,639.33	
3		Light	10	0.07	12	46	10.44	1	10.44	0.75	7.83	117,163.07	
4	Bus	Big	10	0.07	12	46	10.44	0.5	5.22	0.75	3.92	58,581.53	
5		Mini	6	0.07	7	27	6.09	0.35	2.1315	0.75	1.60	23,920.79	
6		Micro	10	0.07	12	46	10.44	0.35	3.654	0.75	2.74	41,007.07	
7	Tractors	Tractors	10	0.07	12	46	10.44	1	10.44	0.75	7.83	117,163.07	
	Total								100.40		**75.30**	**1,126,718.16**	
Cumulative Number of Standard Axles for design period (N)												**1,126,718.16**	**esa**
Cumulative Number of Standard Axles for design period (N)												**1.13**	**msa**

Cumulative Number of Standard Axles for design period is taken as **1.13 msa** which lies between 1 to 10 msa and CBR value is assumed as 5%.

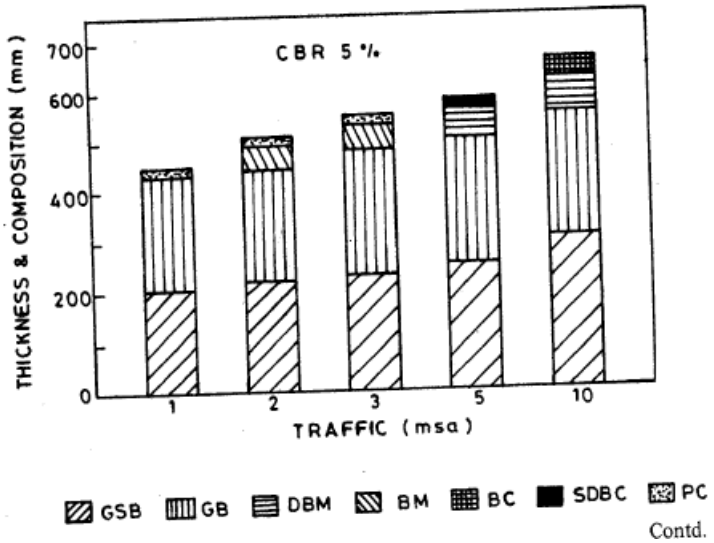
Pavement design for this project according to IRC method of pavement design guidelines is plate I recommended design for traffic range 1-10 msa for CBR value of 5%. According to that plate I, the total pavement thickness is 430 mm with 150 mm thick granular subbase, 200 mm thick granular base and 20mm thick premix carpet as wearing course.

IRC:37-2001

PAVEMENT DESIGN CATALOGUE

PLATE 1 – RECOMMENDED DESIGNS FOR TRAFFIC RANGE 1-10 msa

CBR 5%					
Cumulative Traffic (msa)	Total Pavement Thickness (mm)	PAVEMENT COMPOSITION			
		Bituminous Surfacing		Granular Base (mm)	Granular Sub-base (mm)
		Wearing Course (mm)	Binder Course (mm)		
1	430	20 PC		225	205
2	490	20 PC	50 BM	225	215
3	530	20 PC	50 BM	250	230
5	580	25 SDBC	55 DBM	250	250
10	660	40 BC	70 DBM	250	300



Contd.

Figure 9: Pavement composition and thickness IRC

Pavement Thickness and Composition

Pavement design for this project according to IRC Method of Pavement Design Guideline is Plate I – Recommended Design for Traffic Range less than 1 msa for CBR Value 5%. According to that Plate I, the total pavement thickness is 300 mm with Bituminous Surfacing 20 mm premix carpet, Granular Base 150mm and Granular Sub-base150mm

Among the above two methods, IRC method seems more optimum.

8. Miscellaneous

8.1 Retaining Structures

Retaining walls are structures to support back fill and surcharge load from the fill section of the road. Normally, it is constructed to support heavy backfill along roads.

Retaining and breast walls are not normally intended to stabilize slope failures but are meant to support active or passive earth pressure from the assumed failure wedge above the base of the wall.

Generally, retaining and breast structures are constructed for the following purposes:

- To support the road for high embankment, fill near large structures like bridge, culverts etc.
- To support the road completely or partially infill
- To support the toe of a weak slope

8.2 Gabion Structures

One of the most important advantages of gabion structures is that they act in a homogeneous way and possess higher flexibility. Gabion structures are capable of deforming themselves without loss in structural strength, and are able to accommodate settlement without rupture. They are highly permeable and allow free drainage through the wall. Therefore, gabion structures are favored under the following conditions:

As a retaining and support structure in weak foundation conditions, wet soils, high groundwater, high seepage pressure areas etc.

- To retain the road completely or partially in fill when the height of fill exceeds 3.5m.
- To strengthen and regulate natural slope drainage systems, water flow areas etc as protection works around drainage outlets

The general principles adopted in design and construction:

All wires used in gabion boxes should have heavy galvanized zinc coating

To achieve monolithic design and strength, all gabions should be firmly wired together with continuous lacing at the edges, with double loops at each binding place. This is done mostly before the filling.

Erection of gabion walls should start only after inspection and acceptance of the foundation. Permanent dampness must be avoided during the construction period, as well as thereafter.

Use of larger size, hammer dressed, tabular stones, staggered joints, proper bonding and interlocking between the stones must be ensured.

During the filling of the stones, bracing wires should be fixed at one-third and two-third height in the box.

The rear of gabions should be provided with a filter bed with well-compacted smaller stones to facilitate water flow.

When gabion structures are used in wet and weak soil, the rear face should be curtained with geo-textile fabric to retain the fine particles allowing the water to percolate.

The stone masonry structures are suggested as retaining as well as breast walls in difficult points where gabion and dry masonry walls are not possible to construct.

8.3 Roadside Development

The roadside development includes plantation of trees and shrubs and providing signposts required for safe, efficient and comfortable driving. For this road design post sand kilometer posts have to be installed. And for protection of cut and fills slopes vegetation measures such as bioengineering measures are applied and are advised, as a part of road project. The cost of bio- engineering is included in the cost estimate.

8.4 Relocation of Utility Services

The location of all access Paths, Watercourses, Irrigation Channels, Sewers, Drains, Water Pipes, Electricity and Telecommunication Cables, Structures and other Services, which may be encountered during the execution of the works are as curtained, then all such services should be reinstated as necessary. Reinstatement of services is considered while designing the road and related cost are included in the detail cost estimate.

8.5 Cross Drainage Structures

Based on the site survey, the Consultants calculated the type, size and location of all drainage structures. These structures will include a mixture of Bridge, Slab culvert, and pipe culvert. All the information about the cross drainages has been presented in the "VOLUME – I: Detailed Survey and Design Report Part: Engineers Estimate" in a tabular format.

The following considerations were taken into account when selecting cross drainage structures:

The minimum culvert size proposed is 900 mm diameter. The minimum size was selected to lessen the risk of the blockage and make it easier to clear blockages once they occur. The maximum size was selected in consideration of the difficulties of handling and transporting larger size pipes during construction.

Slab culverts will be preferred for cases where the topography would make construction of a floodway difficult.

The typical drawing for all the structures has been included in the design report.

8.6 Drainage Design / Water Management

Provision of adequate drainage structures is considered critical for long-term viability of road being constructed. The monsoonal rain in Nepal are very heavy and the hill roads that are constructed on a very steep mountain slopes, with large exposed batters, steep gradients and gravel or earth pavements are very susceptible to erosion, scour and slope instability.

Conservation of natural drainage patterns along the road alignment is one of the major considerations that should be made during the design and construction of the draining structure.

A fundamental technique applied in water management is to ensure that rain water is evenly distributed off the road surface, towards the valley side. This has been achieved by providing the road surface with an outward cross slope there by preventing rainwater to accumulate of the road surface as shown in the typical drawings. Drains have been proposed along hillside sections.

8.7 Cross Falls

The road surface is generally provided with 3% outward cross slope to allow the surface runoff to disperse gently toward valley and hill side, along the complete length of the road thereby reducing the possibility of erosion. The super-elevations are provided according to the requirement of curves and drains are provided according to the slopes of the road section if necessary.

8.8 Sub-surface Drains

The sub-surface drain (50cmx50cm) consists of filter material (40mm single size aggregate) enclosed by geo-textile fabric. The water from the sub-surface drain is discharged at intervals of 30 m along the length of the road.

8.9 Cross Drainage Structures

The most of the existing cross drainage structures have an average width of 7.5m. The project road has to be upgraded up to a width 7.5m cross drainage structures are recommended to dismantle and proposed for a new structure. The selection of the type of cross-drainage structures depends on the flow characteristics (discharge, sediment load etc), local topography, access to the site and availability of materials.

8.10 Irrigation Water Crossings

These are minor structures used to discharge irrigation water from one side of the road to the other. However, such crossings also come in use while discharging small quantities of rain water where required.

8.11 Safety Barriers

Both safety barriers and safety fences are devices which physically prevent vehicles from running off the roadway. However, there exist satiny functional difference between the barriers and the fences: the former do not get deformed in the process, whereas, the latter are designed to absorb some of the kinetic energy by getting deformed. Both types a in to prevent the striking vehicle from gyrating or overturning and, within a narrow angle, redirect it along the direction of traffic movement. For simplicity, the term safety barrier is used to denote both the barriers and fences throughout this technical note. This technical note will help to determine the necessity of safety barrier along roads and top lane appropriate and cost-effective safety barriers as dictated by site conditions.

The different systems of safety barriers can use:

Semi-rigid systems

- Steel beam barrier
- Gabion barrier

Rigid systems

- Random-rubble masonry barrier,
- Plum-concrete barrier,
- R. C. C. barrier.

Barrier Recommended Use

Steel beam barrier	: High speed roads where space is limited
Gabion barrier	: General use but not in towns
Random rubble masonry barrier	: Alternate to other barriers on bridge approaches

Plum concrete barrier : Alternate to gabion barrier where a more permanent looking structure is required slower speeds
R.C.C barrier : Narrow medians; where space is limited. where it is essential that the vehicles to stopped

Gabion Barrier is recommended forth is road section because Gabion barriers are very effective and at the same time are economic, easy to construct and maintain. However, they do not look neat and modem like other types. Gabion safety barriers are useful against all run-off-road type accidents. They have proved to be effective in stopping large vehicles, including loaded trucks. However, as they only 'give' on impact but do not redirect the impacting vehicle, there can be a lot of damage to the vehicle and occupants if it is traveling very fast.

8.12 Cut / Fill Batter Slopes

Cut/fill slope designs are normally based on geo-technical parameters, such as soil and rock properties, terrain slope, water tables and height of cut slope.

8.13 Design Considerations

The slope gradient and length of cut slope should be determined on the basis of the geological, hydro geological conditions, and soil parameters. The cut slope gradient should be between1:0.3 (V: H) and 1:1.5 depending on subsurface conditions and other characteristics. Berms of 1 to 4 m width should be constructed at interval of 5 to 10 m in the vertical direction (height). Attention shall be paid to the geological condition of the slope prior to cutting of the slope. The gradient of the cut slope should be based on the results of the investigation and as approved by the engineer. In designing a cut slope, the following geological conditions should be considered with the utmost care.

a) Colluvial Deposit Slope

Colluviums such as talus and debris flow deposits, being poorly consolidated, usually form a slope with a critical angle of stability. When excavated, the cut slope formed will become unstable. Therefore, a wide berm near the boundary between the bedrock and the upper colluvial deposit should be designed.

b) Erosive Sandy Soil

Sandy soils, such as decomposed granite, pits and or terrace gravel are easily eroded by surface water, which may result shallow collapse.

c) Erodible Soft Rocks

Cut slopes in soft rocks such as mudstone and tuff with low degree of solidification becomes unstable after the completion of cutting because of the weak internal shear strength of the rock and stress release.

d) Fissured Rock Slope

The stability of fissured rock slopes is governed by the degree of fissure development and their distribution.

As a rule, cutting and removal of soil mass should be performed from upper to lower portion to maintain the slope stability. Cutting work should be carried out during dry season. The final cut slopes should be treated with adequate drainages, slope protection works and/or bioengineering works to increase stability against effects of rainfall and infiltration of water.

Protection of the cut slope and its foot should be considered in order to prevent erosion and instabilities. Slopes must be protected by means of walls and resisting structures if it is unavoidable to implement steeper slope gradient than the standard gradient. Proper cutting work is effective to safeguard the probable cut slope failures.

8.14 Delineation

Delineation is always helpful, but it is particularly important at bends. Road accident records have shown that more accidents happen on bends than on straight sections. Good delineation of a road serves the following purposes:

- it shows the safe limits of the road,
- it helps drivers to control approach speed on bends,
- it improves lane discipline.
- it aids in identifying potentially hazardous situations such as sharp bend sand
- obstacles, and
- it helps to prevent crumbling of road edge and deterioration of shoulders.

Delineating devices will not make our roads completely safe. Nevertheless, studies elsewhere show that an intelligent mix of some of the delineating devices can reduce accidents by as much as 60 percent.

Types of delineating devices

In some respect delineators do warn of an impending hazard situation. In strict sense, however, only road indicators can be considered as delineating devices.

- Center and edge lines
- Post delineators
- Confidence blocks
- Earth-filled bitumen drums
- Chevron signs
- Reflective studs

Recommended Delineating Devices

- Post Delineator

As the posts stand out prominently, they provide very good delineation even when the road is impounded with flood. The posts enable the driver to plan forward route, and thus need to be consistent. The addition of a small reflector would make the delineator much more visible at night when good delineation is especially important. The additional cost would only be about Rs 100.

- Standard to be adopted

The length of the concrete posts to be used as post delineator should be 1500 mm or more, so that 1000 mm should be above road level after erection. No concrete foundation block shall be used for erection of a post delineator. Post delineators are especially desirable in the following situations:

- on both sides along horizontal curves
- along summit curves when the sight distance is inadequate
- on straight sections where the visibility is poor due to climatic conditions
- along temporary road diversions
- along flood ways
- at the approaches to important intersections
- valley side of hill roads
- road embankments exceeding 3m,

where the road narrows suddenly, for example, on the approaches to a narrow bridge.

The use of post delineator is recommended to be limited to sub-urban and rural areas. On the delineator posts with reflective plates, the red reflectors shall face the oncoming traffic on the same lane and the white- reflectors shall face the oncoming traffic on the opposite lane. Experiments are underway to find a cheap, effective, vandal-proof reflector. The use of recessed galvanized iron plates is currently favored. These are fixed into the post during casting. Adhesive-backed retro-reflective sheeting (3M's Scotch lite or similar) is applied to the plate once the concrete has cured. Post delineators are erected at 600 mm from the outer edge of the shoulder. On hill, roads along the stretches with big drops the delineators may be placed on the top of the retaining walls. Post delineators are redundant when crash barriers are provided. They may, however, be used in combination with chevron signs.

8.15 Retaining / Protection Structures

The retaining walls are designed to retain filling materials in road section. The retaining structures are cement sand mortared stone masonry and gabion masonry according to the site condition. A number of protection structures are found to be also necessary for inlet and outlets of cross drainage works.

8.16 Bio-Engineering Works

The slope protection works shall be done following the manuals published by the Department of Roads, Geo-Environmental and Social Unit (GESU). The following manuals shall be used for bio-engineering works.

- Road–Side Bio-engineering Site- Hand Book,1999
- Road-Side Bioengineering Reference Manual, DoR,1999
- Vegetation Structures for Stabilizing Highway Slope, A Manual for Nepal, DoR assisted by ODA, U.K. March1991.

Since this project road passes through the flat terrain, there are no possibilities of Landslide as in hill roads. Some stretches of the road have high embankment, in such location suitable bio-engineering slope protection measures have been recommended. It also includes the water management considering both sub-surface drainage and surface water management.

8.17 Road Safety Works

Proper traffic signs and signals are to be used during construction and after construction as per requirement of the project road following the DoR standards and specification published by Traffic Engineering and Safety Unit (TESU). Safety barriers, delineators and safety parapets

etc. make the road safer for road users. Similarly, road markings and painting help ply the traffic safely on the roads. These measures are given due attention during the design of the project road and costs are included in the detailed cost.

9.0 Quantity Survey and Cost Estimate

9.1 Rate Analysis

9.2 Basic District Rates

The items rates for cost estimation are based on the district rates approved by the District Administration Offices of the Dolpa district. In case of the items for which the rates are not approved by the District Administration Offices, market or approved rates of adjoining districts or the road/rail head are taken after adding the approved transportation charges of Transportation Management Organization of the respective district was added. For locally available materials such as water, firewood etc., the local rates of such items is used in the estimation.

9.3 Unit Rate Analysis

The unit rates of items are based on the approved norms of Department of Roads, Government of Nepal 2075. The norms for items which are not included in the approved norms are as per the norms adopted in the previous project of DoR. The Unit rates include three major components, which are labor, materials and the equipment involved in the works. Cost of materials at site always includes transportation cost.

9.4 Cost Estimate

Based on these quantities, unit rate items (including Contractor's overhead and profit) and adding value added tax (VAT) cost estimates has been prepared for all above mentioned contract packages and shall be submitted to the DoR. The details of the Engineer's Estimate for all contract packages have been presented in the separate Volume.

S.N.	Description of works	Amount (NRs)	Remarks
A	General Item	6,273,437.81	1.65%
B	Site Clearance and Earthworks	-	
C	Earthwork	61,725,710.17	16.27%
D	Pavement Works	120,085,251.94	31.65%
E	Structural/ Side Drain/ Cross Drainage Works	186,471,054.97	49.15%
F	Bio-engineering works	632,661.00	0.17%
G	Road Furnishing and Miscellaneous Work	4,128,135.32	1.09%
H	Day Works	113,260.00	0.03%
	Base Cost (A+B+C+D+E+F+G+H)	**379,429,511.21**	100%(I)
	VAT @13% of Base Cost	49,325,836.45	II=13% of I
	Contingency @ 4% of Base Cost	15,177,180.44	III=4% 0f I
	Total Cost including VAT & Contingency	**443,932,528.10**	IV=I+II+III
	Price adjustment Contingency @ 10% of Base Cost	37,942,951.12	V

Physical Contingency @ 10% of Base cost	37,942,951.12	VI
Grand Total Cost	**519,818,430.34**	VII=IV+V+VI
Cost Per Km of the road inclusive of VAT and contingency at Base Cost	66,450,001.96	IX=III/5.71

9. Conclusion and Recommendation

10.1 Conclusion

The main beneficiaries of improvement of Tinje-chharka-mustang-yakkharka Road Section, Chharka Tangsong Rural Municipality include export/import operators, the business community in the region and communities in the zones of influence of the roads. The communities in the project zones of influence will benefit from improved road safety, attaining high level of service free from congestion along with increase in land value of the concerned area and its buffer area. The project will create job opportunities during the construction phase which will benefit the communities through direct employment and supply of goods and services to the roads and related works.

The project will support economic and social development programs of the project site through efficient and cost-effective movement of passengers and freight transport, in line with the objectives of the transport policy. The roads proposed for construction will provide access to the communities in the zones of influence, to better markets and social services, contribute to reduction of poverty and improve cross-border trade with neighboring countries, like China at the same time enhance tourism and regional integration.

10.2 Recommendation

Besides the above-mentioned benefits, there are some factors which are to be kept in mind before commencement of the work. First of all, it is recommended that standard of the road should be followed throughout the length of upgrading road. Utmost care is required to construct in the given standards, especially at junctions where safety is one of the prominent factors to be considered during construction phase.

At some sections of the road, land have to be acquired in the upgrading process as it falls under Right of Way (RoW) and due attention should be given for acquiring the required land with proper planning within the existing policy of the government. Furthermore, there should be coordination among various stakeholders, such that the desired goals are achieved without interruption and foray. Government has to take initiatives before the inception of work, so that in future problems might not arise, and for the sake of that a high-level committee representing the concerned agencies, their line agencies and stakeholders need to be formed in accordance.

10. References

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