ACKNOWLEDGEMENT

The Detailed Project Report of Drabya Shah Road -DRCN Code No: 36A006R (Luitel - Aappipal - Harmibhanjyang - Thalajung – Bhachek road) Rehabilitation & Reconstruction Road Project - **Package No. 2 : Chitre Pokhari-Bhachek (Ch. 17+600 to Ch. 30+575)** , Gorkha district under ADB funded Earthquake Emergency Assistance Project (ADB Loan No. 3260 – NEP), which aims to accelerate the recovery and reconstruction of the rural roads damaged by earthquake. This main report is part of the assignment as per contract between Central Implementation Support Consultants, DRILP-AF, Lalitpur, Nepal as the Client and JV of BEAM/CEMECA/ Digicon, Kathmandu as consultant. We take this opportunity to express our gratitude to MOFALD,EEAP, the Central Level Project Implementation Unit, Lalitpur, Nepal and officials of DoLIDAR, DDC and DTO.

We are also very much grateful to the contribution of all the individuals who were directly or indirectly involved in this project works for their kind co-operation and help at every step in the process for the completing the assignment.

JV of
BEAM Consultants Pvt. Ltd.,
Cemeca Consultant Pvt. Ltd.
Digicon Engineering Consult Pvt.Ltd
Kathmandu, Nepal

EXECUTIVE SUMMARY

The detailed engineering survey, design and cost estimate for rehabilitation and reconstruction of Darby Shah Road -DRCN Code No: 36A006R- (Luitel - Aappipal - Harmibhanjyang - Thalajung – Bhachek Road) Rehabilitation & Reconstruction Road Project -**Package No. 2 : Chitre Pokhari – Bhachek (Ch. 17+600 to Ch. 30+575)** , Gorkha district, Nepal has been prepared for ADB funded Emergency Earthquake Assistance Project (ADB Loan 3260-NEP). The road length is 12.975 km. The road alignment starts from Chitre Pokhari of Chhoprak VDC and ends at Bhachek of Hansapur VDC. It passes through through Chhoprak, Shreenathkot, Jaubari and Hansapur VDCs.

Design of the road was carried out by SW_ROAD 2006 and SW_DTM 2006 computer software developed by SOFTWEL (P) Ltd, Nepal. Design was carried out using strip survey method, so that alignment could be optimized as per requirement.

Nepal Rural Road Standard (2055) with 2nd Revision, DoLIDAR is followed to design the road. The road falls under the category of District Road Core Network as per NRRS as such the relevant accordingly design parameters and standards are adopted for the road design. The Roadway width is 5.25 m which includes 3.75 m wide carriageway and formation width including drain is 6.25m.

DoLIDAR and DoR Guidelines is adopted to design the retaining structures as appropriate. The retaining structures include gabion retaining wall, stone masonry retaining wall, Stone masonry Breast Wall and Stone Masonry Revetment Wall.

The existing width of the road varies from 8 m to 10 m. Though the right of way is 10 m on either side from road centerline it is proposed to acquire only 5m on both side from the centre of the road for the carriageway, shoulder, side drains and passing bays. However, in the built up area even this may not be feasible accordingly in such areas only minimum required land has been proposed for acquisition. It is proposed to acquire additional 0.5 m to 2 m width of the road to avoid the demolition of RCC buildings, temples and schools. The total area of land to be acquired is 2.26 Hectare.

The road alignment passes through colluvial soil, residual soil and alluvial soil.A few cut slope failures were observed along the road alignment. There is a landslide prone section from Chainage 21+680 to 21+730. In this section, bioengineering works have been proposed along with retaining wall to stabilize the area. The total cost of bioengineering works is estimated to be NRs. 406,097.00

The pavement design for bituminous road is based on *Overseas Road Note 31 (Fourth Edition)*. The DCP tests were undertaken for pavement design this together with traffic volume estimates the CBR Value 7% and traffic loading 1.76 MSA have been computed. The adopted total

thickness of the pavement is 420 mm [Sub base—200 mm,Base—200 mm & Bituminous Surface as Premix Carpeting—20 mm].

Stone and aggregates required for road works can be procured from quarry sites located along the road alignment at Ch. 19+800, Ch. 21+250, Ch. 21+500, Ch. 21+680 and Ch. 27+624. . Other construction materials such as GI wire, cement, reinforcement, hume pipes can be procured from Gorkha Bazar, which about 20 km far from the starting point of proposed road.

The cost estimates are based on applicable DoLIDAR norms. In cases where DoLIDAR norms are not available, DOR norms have been used. The unit item rates for each item have been calculated on the basis of approved district rate for fiscal year 2073/074. While calculating item rates, it is assumed that a qualified contractor will undertake construction following mechanized approach for road works. It is envisaged that a construction period of 18 months will be appropriate giving due consideration to the volume of works.

The base cost of civil works has been estimated to be NRs. 230,918,402.00. The total cost for rehabilitation and reconstruction of the road project (Package 2) Ch:17+600 to 30+57 Km is NRs. 290,957,187.6 .This total cost includes work charge staff & Miscellaneous Expenses,Physical contingencies & VAT as per GON rules. The cost of per construction of works is NRs 20,110,595.00 per Km inclusive of VAT to Base Cost . It is envisaged that the construction works can be completed within 18 months from award of contract and estimates are based on it. For budgetary purpose to take account of change in scope in accordance with GON financial rules a provision of 10% of the base cost estimate has been indicated in the budgetary cost estimate.

Table of Contents

APPENDICES

List of Figures

List of Tables

SALIENT FEATURES

Features	Description
Name of the Road	Darby Shah Road (Luitel - Aappipal - Harmibhanjyang - Thalajung – Bhachek Road)
DRCN Road Code No	36A006R
Package No.	2(Chitre Pokhari – Bhachek)
Scope	Reconstruction and Rehabilitation
Location	
Region:	Western Development
Zone:	Gandaki
District:	Gorkha
VDC/Municipality along the corridor	Chhoprak, Shreenathkot, Jaubari and Hansapur
Major Settlements	Bhachek
Length	12.975 Km
Starting Point	Chitre Pokhari of Chhoprak VDC
End Point	Bhachek of Hansapur VDC
Beneficiaries Population in ZOI	Households - 3966, No of Male - 6982, No of Female - 8703,Total Population - 15685
Geographical feature	
Terrain	Rolling
Altitudinal Range	836 to 1161 masl
Climate:	Sub-tropical
Geology:	Higher Himalayan (Alluvial, colluvial soil and residual soil)
Meteorology:	Unevenly Distributed Precipitation Controlled by Monsoon
Design Standard	
Standard	NRRS 2055, 2nd Revision December 2014
Existing Surface:	Earthen
Proposed Pavement:	Bituminous(Premix Carpeting)
Geometrics	
Right Of Way:	10 m on either sides (Center line)
Formation Width:	6.25 m (includes 1m drainage & 0.75 m Shoulder)
Carriage Way Width:	3.75 m
Shoulder Width:	0.75 m on either side
Maximum Gradient	11%
Minimum Gradient	0.5%

Features	Description
Lane	Single
Structures (Qty/No.)	
Drainage Structures	
a) Side Drain	- Covered Trapezoidal -Open Trapezoidal - Open Cascade - Closed Cascade
b) Pipe Culvert	1 Nos. (0.9 m dia), 27 Nos. (0.6 m dia)& 3 Nos.(0.3 m dia)
c) Irrigation Crossing	10 Nos. (Pipe Culvert of 0.3 m dia)
Retaining Structures	
a) Stone masonry Wall	7,339.32 cum
b) Gabion Retaining and Breast Walls	4,146.50 cum
Earth Work	
a) Excavation/Cutting	1,24,538.07 cum
b) Embankment/Filling	30,204.05 cum
Pavement	
a) Gravel(Sub-base)	12,124.51 cum
b) Base	12,124.51 cum
c) Premix Carpet	1,212.45 cum
Cost Estimate (Rs)	
a) Civil Works (Base cost)	NRs. 230,918,402.89
b) VAT @13%	NRs. 30,019,392.38
c) Total Cost	NRs. 260,937,795.26
d) Cost Per Kilometer of construction works including Base Cost and VAT	NRs. 20,110,595.74
e) Work Charge Staff & Miscellaneous Expenses @ 3%	NRs. 6,927,552.09
f) Physical contingency @ 10 %	NRs. 27,076,575.00
g) Grand Total	NRs. 290,957,187.64

ACRONYMS

AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
CBR	California Bearing Ratio
CUM	Cubic Metre
DCP	Dynamic Cone Penetrometer
DDC	District Development Committee
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DoR	Department of Roads
DPR	Detail Project Report
DRCN	District Road Core Network
DTMP	District Transport Master Plan
DTO	District Technical Office
EEAP	Earthquake Emergency Assistance Project
EMP	Environment Management Plan
FGD	Focus Group Discussion
GoN	Government of Nepal
IEE	Intial Environmental Examination
M/m	Metre
MM/mm	Milimetre
NRRS	Nepal Rural Road Standard
PC	Pipe Culvert
PCU	Passenger Car Unit
RoW	Right of Way
SDC	Swiss Agency for Development and Cooperation
Sqm	Square metre
ToR	Terms of Reference
VDC	Village Development Committee
VPD	Vehicle per Day
ZoI	Zone of Influence

1 INTRODUCTION

1.1 GENERAL

This report has been prepared as per the Contract between Central Implementation Support Consultants, DRILP-AF, Lalitpur, Nepal as the Client and JV of BEAM/CEMECA/ Digicon, Kathmandu as the Consultant, made on January 2016for preparation of Detailed Project Report for rehabilitation and reconstruction of selected road subprojects in Cluster 4 districts of Gorkha and Lamjung for ADB funded Emergency Earthquake Assistance Project (ADB Loan 3260-NEP).

1.2 PROJECT BACKGROUND

The rehabilitation and reconstruction of the local road network damaged due to devastating earthquake of April 25, 2015 and the major aftershock of May 12, 2015 has high priority for the Government of Nepal (GoN). The Asian Development Bank (ADB) funds Earthquake Emergency Assistance Project (EEAP) through (ADB Loan No. 3260 – NEP) is aimed to accelerated the recovery and reconstruction of about 385 km of rural roads damaged by the earthquake and landslides in 10 of the earthquake hit districts (Dolakha, Kavrepalanchok, Lalitpur, Chitwan, Sindhuli, Solukhumbu, Okhaldunga, Ramechhap, Gorkha and Lamjung). In this backdrop, ***Drabya Shah Road***-DRCN Code No: 36A006R- ***[Luitel - Aappipal - Harmibhanjyang - Thalajung–Bhachek road) Rehabilitation & Reconstruction Road Project ,Package No. 2: Chitre Pokhari –Bhachek (17+600 -30+575)]***", Gorkha district has been selected as one of the roads for reconstruction.

1.3 GENERAL FEATURES OF THE DISTRICT AND SUB PROJECT AREA

The project area is located in Gorkha District is located in the Gandaki Zone in the Western Development Region of Nepal. It lies within latitude 27°15' to 28°45' and longitude 84°27' to 84°58'. Its elevation ranges from 488 to 8156m. Ecologically, it lies in the hilly region bordering Tibet (China) in the north, Dhading& Tibet (China) in the east, Lamjung, Chitwan, Tanahun & Dhading in the south and Tanahun, Lamjung, Manang, Chitwan& Tibet (China) in the west.

A total population in the district is 271,061living in 66,506 households with male population – 121,041 and female – 150,020. The district has an average population density of around 75 people per square km. The average literacy rate is about 66.3%. Different castes living there and are Gurung, Brahmin, Chhetri, Damai, Tamang, Baram, Sarki, Magar and others.

Darby Shah Road (Chitre Pokhari–Bhachek road) starts from Chitre Pokhari of Chhoprak VDC and ends at Bhachek of Hansapur VDC.

1.4 SCOPE OF THE WORK

For the preparation of the detailed engineering design and cost estimate for the rehabilitation and reconstruction of the road the scope of work covers:

a. Detailed engineering survey of the road including fixing of centerline,
b. Detailed design of the road to DoLIDAR's NRRS 2055, 2nd Revision, December 2014,
c. Preparation of engineering drawings including alignment plan, design profile, design cross section and typical drawings,
d. Preparation of detailed cost estimate, and
e. Preparation of technical study reports

To fulfill the above scope of services under the assignment as part of the preparation of the Detailed Project Report (DPR), the consultant carried out the following activities:

- Discussions and meetings with the Client and stakeholders
- Collection and review of concerned documents, report, manual, guidelines, specifications, norms and others
- Preparation for field survey
- Reconnaissance survey, Monumentation, Traversing and Chainage Marking
- Detailed engineering survey of the existing road alignment and its corridor (topographical survey, geological observation, hydrological study slope patterns, drainages patterns, Cross-drainage and others)
- Material and labour availability survey
- Collection of district rates (labour, material and transportation)
- Detail designs as per the DoLIDAR’s Rural Road Design Standards.
- Drawings preparation
- Quantity estimation, rate analysis and cost estimates.
- Preparation of reports

2 ENGINEERING SURVEY AND STUDY

2.1 DESK STUDY

The Consultant collected documents, drawings, study reports, maps, walkover survey report and existing DTMP to acquire and extract key information to carry of the study. The Consultant collected and reviewed the following documents to field survey:

- Maps and previous reports
- Relevant guidelines, norms, handout, specification and maps
- Nepal Rural Road Standard (NRSS 2055) 2nd Revision and DoLIDAR Norms & Specification
- District Transport Master Plan (DTMP) of district
- Geological map to acquire geological/geotechnical feature of road alignment.

After the desk study, the field survey was carried out by the Consultants' team and during the field survey; the major following activities performed are discussed herewith:

2.2 WORKING TEAM

The working team has included the following members:

• Highway or Transport Engineer(Team Leader)	Mr. Hare Krishna Shrestha
• Environmental expert	Mr. Madhav Giri
• Resettlement Specialist	Mr. Chinta Mani Sharma
• GESI Specialist	Mr. Pradip Parajuli
• Civil engineer	Mr. Surya Chaudhary
• Surveyor	Mr. Om Yadav

2.3 PRE – SURVEY ACTIVITIES

Before the field visit, the team made meetings and discussions with the concerned site office and stakeholder. The team also made public consultation with local community for the purpose of engineering survey as well as to get their support for the completion of the assignment.

2.4 TOPOGRAPHICAL SURVEY

Road strip survey method was used in the field which included fixing of the base stations and taking details 10m either side for preparing a topographic map of the road corridor. Topography survey was carried out in adequate details and accuracy to prepare DTM of the road alignment in 1:1000 scales. Horizontal and vertical control points were established by monument of concrete pillar at an interval of 500m.

Initially traverse survey was carried out with high accuracy (1:70,000 to 1:148,000.)to establish traverse station and other permanent control points. Topographical details were carried out from these traverse station to attain accuracy at higher level. Close traverse method was applied for horizontal traversing.

Establishment of Control Points / Benchmarks

Permanent monuments were installed as benchmarks (approx. size 15 cm x 15 cm x 60 cm) with 1:2:4 cement concrete nails embedded as per the DoLIDAR standards and / or nailed in the permanent structure at intervalof 500 m and or less than that according to site condition.

Traverse and Fly Leveling

The coordinates of Bench Mark is presented in NEZD (Northing, Easting, Elevation and Description) format along with point number and remark. Closed traverse survey was carried out to confirm the control point coordinates. All traverse angles and distances were double checked with reciprocal observations. Traverse and level were calculated at the site itself for accuracy and quality control as well as data validation.

Centerline and Cross Section Survey

- Centerline of road was marked using Abney level by the method of chaining and pegging which then followed by Total station survey.
- Cross sections survey carried out at intervals of 10 m and where topographic features such as ridges and valleys were encountered, additional cross sections taken.
- Cross sections - 15 m either side of road centerline and also extended further whenever site demands
- Enough points taken at each cross-section or for each string to cover full width of the road including roadside feature, side drain, toe of cut/fill slope retaining wall, cross drainage structure etc.
- Topographical survey also included individual building, utilities (water supply, electricity, telephone poles etc.), landslides, canals, footpaths, temples, *Kosmas*, drainages, cross structures, retaining structures, land use patterns and other information such as fences etc.
- At bridge side, the bank lines lowest water level, HFL, direction and distribution of flow taken.

2.5 GEOLOGICAL OBSERVATION

The project area is located in Higher Himalaya Zone of Western Nepal as shown in the figure given below. The Higher Himalaya is occupied by the high mountains, and lies between the Lesser Himalaya to south and the Tibetan-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, politic gneisses and migmatites, and attains 6 to 12 km in thickness.

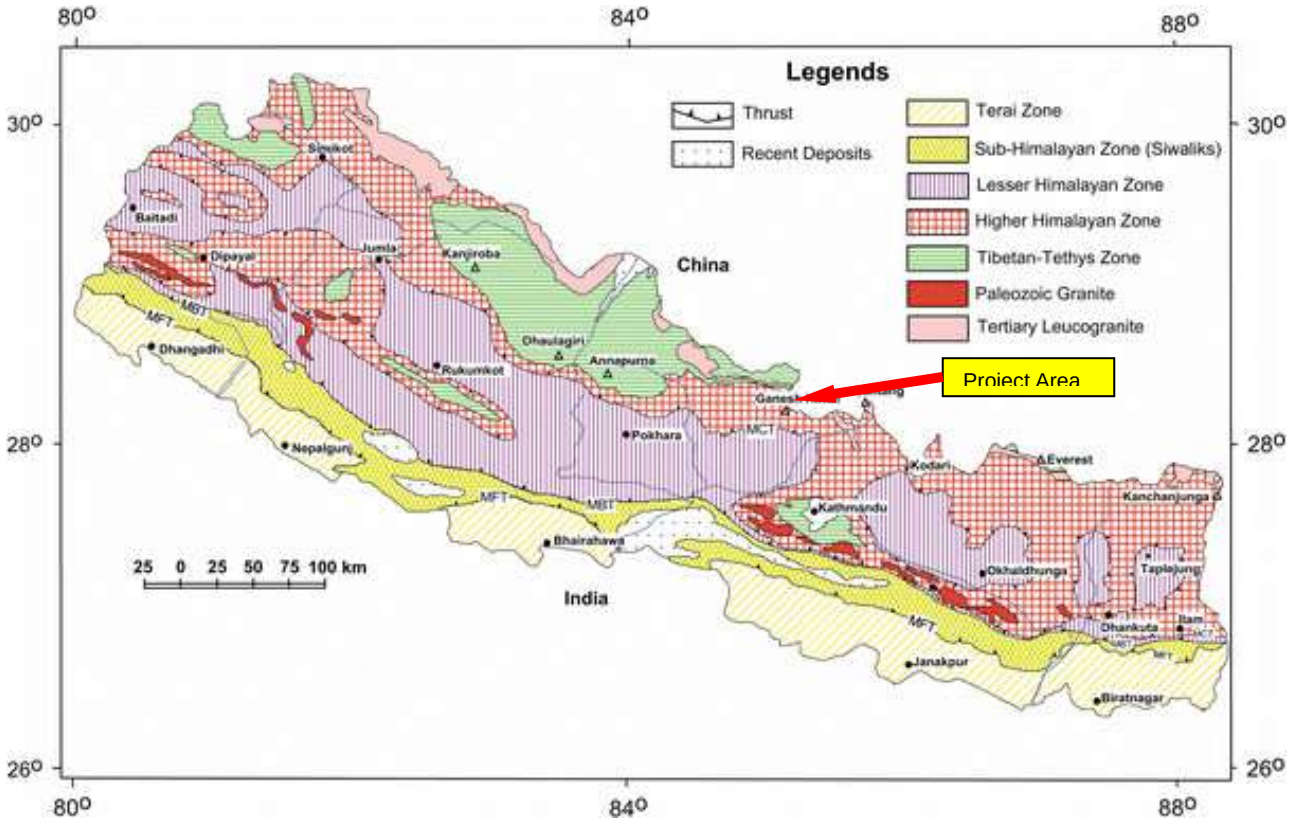
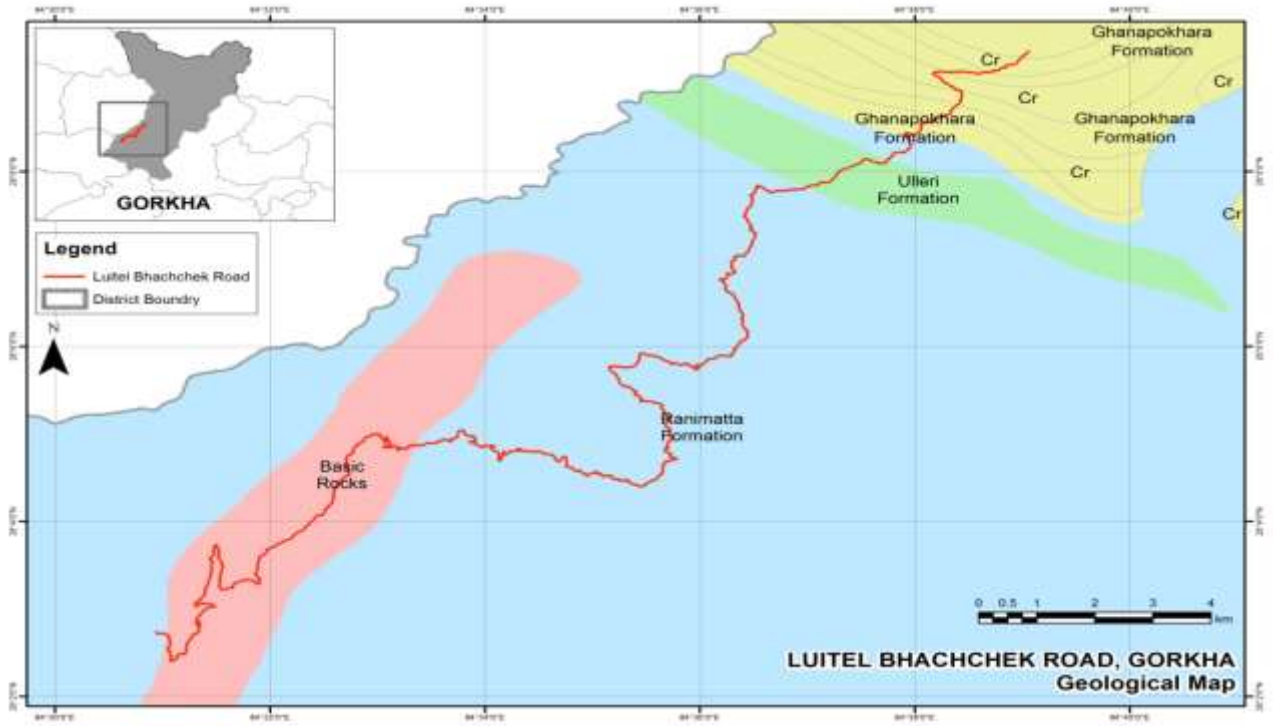


Figure 1 Geological Subdivision of Nepal Himalaya

Geologically, the road alignment lies in the Higher Himalaya Zone of Western Nepal. The road alignment passes through colluvial soil, residual soil and alluvial soil.



Source: Geological Map of Nepal

Figure 2: Geological Map of Project area

The detail of geology of the road alignment is given below:

Table 1: Summary of the Surface Geology along the Road Alignment

S.N.	Chainage		Geology and soil	Details
	From	To		
1	17+600	18+600	MaksangKhola Formation	White fine quarzites grass bedded.
2	18+600	20+000	TawaKhola Formation	Coarse grained dark grey garnetiferous muscovite biotite quartz schistsinterbedded with greyish impure quartzites. Pandrang quartzite member light green quartzites.
3	20+000	26+500	ShiprinKhola Formation	Coarse grained crystalline marbles with intercalations of schists.
4	26+500	30+575	Galyang Formation	Dark grey slates intercalated with thin grey calcareous slates and lamillge of carbonates. Thick beds of grey silicious dolomites are found at places.

The slope grades adopted for cutting and filling in different geological condition are tabulated below:

Table 2: Slope grade and geological condition for cutting slope/ Filling

S. No	Geological Classification		Slope grade (Cutting)	Slope grade (Filling)
	Major Classification	Minor classification		
1	Soil	Colluvium (soil)	1:0.5	1:1.5
2	Rock	Medium Rock,Hard Rock	1:0.3~1:0.4	-

2.6 SOIL TYPE ALONG THE ROAD ALIGNMENT

Based on the observations during field survey, the different soil types found along the alignment of the road are classified as Ordinary Soil (OR), Hard Soil (HR), Ordinary Rock (OR), Medium Rock (MR) and Hard Rock (HR). The weightage of the different soil type along the alignment are given below.

Table 3: Soil Type along the Road Alignment

Chainage	Soil Classification				
	OS	HS	OR	MR	HR
17+600 to 19+100	20%	65%	7%	5%	3%
19+120 to 20+160	25%	70%	5%	0%	0%
20+180 to 21+000	20%	65%	7%	5%	3%
21+020 to 21+480	25%	70%	5%	0%	0%
21+500 to 22+280	15%	70%	3%	10%	2%
22+300 to 23+580	20%	65%	7%	5%	3%
23+600 to 23+960	25%	70%	5%	0%	0%
23+980 to 29+000	20%	65%	7%	5%	3%
29+020 to 30+575	15%	65%	7%	10%	3%

2.7 LANDSLIDES AND SLOPE STABILITY

Slope Stability depends on the existing geological structures, lithology of the rock units, soil type, topography and hydrological condition of the particular site. The active gully and rills in the colluvium surface exhibits high mass waste phenomena. The slope with loose colluvium soil is highly susceptible to sliding after water saturation due to increased pore water pressure, which ultimately increases the driving force.

A few cut slope failures were observed along the road alignment. There were very less chances of occurring failure because of opposite natural hill slope. There is a landslide prone areas from Chainage 21+680 to 21+730 along the alignment. It is suggested to manage the drainage surface water and apply the bioengineering works in the landslide prone areas and loose soil exposed area as well as groundwater prone area.

Table 4: Landslide Area along the alignment

Chainage		Length (m)	Slope Height(m)	Area (m^2)	Type of failure/ Solution
From	To				
21+680	21+730	50	20	1000	Bioengineering Works

2.8 VEGETATION SURVEY

Along the alignment, various types of small trees and shrubs found and the major are Lajjavati, Titepati, Aaiselu, Dubo, Sisnu, Bamboo, Sissau, Kaphal, Laligurans, Uttisand Chilaune.

2.9 MATERIAL SURVEY

Stone and aggregates required for road works can be procured from quarry sites located along the road alignment at Ch. 19+800, Ch. 21+250, Ch. 21+500, Ch. 21+680 and Ch. 27+624. There is a provision of quarry sites at Daraudi River, which is about 6 km far from the starting point (Luitel Gaun) of the proposed road. Other construction materials such as GI wire, cement, reinforcement, hume pipes can be procured from Gorkha Bazar, which about 20 km far from the starting point of proposed road.

2.10 GENERAL INVENTORY

There are different types of retaining structures and cross drainage structures along the road alignment. Most of them are in good condition and proposed to be reused. The retaining walls in bad condition and walls falling within the design alignment are suggested to be demolished. Regarding cross drainages, the good condition hume pipes of pipe culverts are purposed to be reused after shifting.

The chainage wise general inventory of retaining structures and cross drainages are enlisted herewith:

Table 5:General Inventory of Existing Retaining Structures

Chainage	Dismantle	Reuse	Position		Type	Present Condition
22+760 to22+770	Dismantle			Right	GW	Fair
26+860to22+870	Dismantle			Right	GW	Fair

Note:
SMRTW: Stone Masonry Retaining Wall *GW :Gabion Retaining Wall*

Table 6:General Inventory of Existing Cross Drainage Structures

S.N	Chainage	Length (m)	Diameter (m)	Type of Structure	Present Condition
1.	20+097	4.5	0.6	Existing P. C	Fair
2.	20+325	4.5	0.9	Existing P. C	Good
3.	20+370	4.5	0.6	Existing P. C	Good
4.	20+869	4.5	0.9	Existing P. C	Good
5.	21+381	4.5	0.6	Existing P. C	Fair
6.	21+456	4.5	0.6	Existing P. C	Fair
7.	22+282	4.5	0.9	Existing P. C	Good
8.	22+632	4.5	0.6	Existing P. C	Good
9.	24+860	4.5	0.6	Existing P.C	Bad
10.	26+131	4.5	0.9	Existing P.C	Bad

Note:

P.C : Pipe Culvert

2.11 DATA ENTRY AND ANALYSIS

Design of the road was carried out by SW_ROAD 2006 and SW_DTM 2006 computer software developed by SOFTWEL (P) Ltd, Nepal. Design was carried out using strip survey method so that alignment could be optimized as per requirement. The design works are based on the Digital Terrain Model created from the 3D points captured through the detailed survey. Centerline was generated using the design environment and accordingly the profile and cross-sections were generated. Through an interactive design environment, the centerline (plan and profile) were optimized by adjusting the cross-sections.

2.12 GENERAL ALIGNMENT

Darby Shah Road (Chitre–Bhachek Road) Rehabilitation & Reconstruction Road Project lies in Gorkha district. It is connected with Abukhaereni-Gorkha Road via Mirkot Roadway. A total length of the alignment is 12.975 km with formation width 6.25 m. The road alignment starts from Chitre Pokhari of Chhoprak VDC and ends at Bhachek of Hansapur VDC. It passes through only one settlement i.e. Bhachek. This road has been proposed for upgrading. The road alignment passes through community forest, cultivated land and settlement area.

2.13 LANDUSE PATTERN ALONG THE ROAD

During field survey the land use pattern along the road corridor was noted. The land use has been classified into settlements, agricultural land and forest area. Chainage wise land use pattern is summarized in table given below.

Table 7 : Land Use Pattern along the alignment

Chainage	**Land Use Pattern**
17+600to18+500	National Forest
18+500 to19+100	Settlement Area and Agricultural land
19+100 to 20+120	National Forest on one side and Agricultural land on another side
20+120 to 21+200	Settlement Area and Agricultural land
21+200 to 26+000	National forest on one side and agricultural land on another side
26+000 to 28+220	Settlement Area and Agricultural land
28+220 to 30+575	Settlement Area and Agricultural land

Source: Field Survey

3 ROAD CORRIDOR COMMUNITY PROFILE

3.1 ZONE OF INFLUENCE

The road alignment passes through four VDCs namely Chhoprak, Shreenathkot, Jaubari and Hansapur and also passes through Bhachek settlement.

3.2 OCCUPATION OF PEOPLE

The majority of the people of this area are involved in the agriculture and livestock rearing followed by labour / porter, business and foreign employment mainly in gulf countries.

3.3 ETHNICITY

The ZoI has diverse ethnic/cultural and caste wise population is presented herewith:

Table 8: Distribution of Population with Household along the ZoI

S. N.	VDC s	Total HHs	Population			Caste/ Ethnicity
			Male	Female	Total	
1.	Chhoprak	1531	2608	3285	5893	Brahmin, Musalman, Kami, Sarki, Gharti, Baram, Chhetri
2.	Shreenathkot	771	1396	1751	3147	Gurung, Brahmin, Chhetri, Sarki, Damai,Baram
3.	Jaubari	740	1338	1649	2987	Gurung, Brahmin, Tamang, Sarki, Kami, Magar, Newar, Damai
4.	Hansapur	924	1640	2018	3658	Brahmin, Gurung, Kami, Newar, Chhetri
	Total	**3966**	**6982**	**8703**	**15685**	
	Percentage		**44.51**	**55.49**	**100**	

Source: CBS, 2012

A total population 15685 is living in 3966 HHs within the zone of influence with male 44.51% and female 55.49%. The majority of population of the area belongs to Brahmin followed by Chhetri, Magar, Newar, Tamang, Kami and Gurung.

3.4 EDUCATION AND HEALTH

There are facilities of education and health along the alignment at small scale.

3.5 COMMUNICATION AND ELECTRICITY

There is facility of communications as all the households have mobile facility as well as electricity through national grid line. In addition, some of the HHs have solar system.

3.6 WATER SUPPLY AND SANITATION

There is well facility of tap water through gravity flow scheme and spring water. Mostof the households have toilet facility. However, there is no proper solid waste management.

3.7 COMMUNITY DEVELOPMENT FACILITIES

There are 11 community organizations and are CFUGs, agricultural groups, mother's group and youth clubs etc.

3.8 FOOD SECURITY

Based on focus group discussion during field survey almost half of the HHs (60%) have enough food for nine to one year followed by 25% HHs have for three to nine months and remaining 11% HHs have for less or equal to three months food.

3.9 LAND ACQUISITION

The existing width of the road varies from 8 m to 10 m. Though the right of way is 10 m on either side from road centerline it is proposed to acquire only 5m on both side from the centre of the road for the carriageway, shoulder, side drains and passing bays. However, in the built up area even this may not be feasible accordingly in such areas only minimum required land has been proposed for acquisition. It is proposed to acquire additional 0.5 m to 2 m width of the road to avoid the demolition of RCC buildings, temples and schools. A summary of land proposed to be acquired is presented here within table given below:

*Table 9:*Land Area for Acquisition

Chainage	Length (m)	Existing Width (m)	Proposed Acquisition Width (m)	Acquisition Width (m)	Area (Ha)
17+600 to 18+200	600	10	10	0	0
18+200 to29+200	11000	8	10	2	2.2
29+200 to 30+375	1175	9.5	10	0.5	0.06
Total	30575				2.26

Source: Field survey, 2016

4 HYDROLOGICAL STUDY

4.1 GENERAL

A hydrological study was carried out to determine the design flood discharge for cross and side drains along the proposed road alignment. The type, size, span and shape of cross and side drains are to be fixed according to the corresponding design discharge.

4.2 SCOPE AND METHODOLOGY

The scope of hydrological study is to estimate the design flows for cross drains and side drains along the road alignment. For the better results in hydrological analysis, following stepwise procedures were followed:

- Collection of rainfall data in the vicinity of road area
- Rainfall analysis
- Review of previous studies/reports
- Delineation of catchment boundary of cross drains and determination of their catchment areas using digital topographical map
- Verification of cross and side drains during field visit and with survey data
- Estimation of design floods by rational formula for cross and side drains based on available rainfall data.

4.3 AVAILABILITY OF RAINFALL DATA

Rainfall stations located in the district are presented in table below. Mean Annual Rainfall (MAR) and Monsoon Wetness Index (MWI) at these stations are obtained from “Hydrological Estimations in Nepal”, DHM, 2004. About 80% of rainfall occurs in monsoon, which starts around the middle of June and continues until the end of August.

Table 10: List of Rainfall Stations in the district

Station Name	Index no.	Latitude	Longitude	Elevation
Jagat(Setibas)	0801	28°22'	84°54'	1334
Gorkha	0809	28° 00'	84°37'	1097

4.4 RAINFALLANALYSIS

Yearly maximum daily rainfalls for representative stations were collected from DHM and frequency analysis were carried out. Values obtained by frequency analysis were adopted for determination of design intensities for the design of cross and side drains.

There is no data available regarding maximum hourly rainfalls at these stations. Hence frequency analysis of hourly maximum is not possible at these stations. However, hourly intensity may be obtained by the use of some indirect methods. One of them Mononobe's equation was used to determine maximum rainfalls at different durations from average value of daily maximum at the selected stations. The hourly maximum values obtained by the method are presented in table below.

Table 11: Hourly Maximum Values

Return Period (years)	2	5	10	20	50	100
Hourly Rainfall (mm)	23.43	35.14	41.46	49.84	65.52	66.87

The IDF curve for project area has been established by Mononobe's equation, which is generally applied in mountainous catchment and presented by the following equation (Chow, VenTe, David R. Maidment, and Larry W. Mays. 1988. Applied Hydrology):

$$R_{t_c} = \frac{R_{24}}{24}\left(\frac{24}{t_c}\right)^{\frac{2}{3}} \qquad (1)$$

Where,

R_{tc} = Rainfall intensity in tc hours (mm/hr)

R_{24} = 24 hours maximum rainfall (mm)

t_c = Time of concentration in hr, calculated by equation 2.

$$t_c = \left(\frac{0.87L^3}{h}\right)^{0.385} \qquad (2)$$

(Refer: Chow, VenTe, David R. Maidment, and Larry W. Mays. 1988. Applied Hydrology)

L = Stream length in km

h = Difference of the maximum and minimum elevations in m.

If the time of concentration is less than 15 minutes then it is assumed to be 15 minutes as recommended by ASCE (American Society of Civil Engineers). The Intensity Duration Frequency values for LB road are presented in table below .

Table 12: Predicted Rainfall Intensity (mm/hr) of different Durations

Frequency, Year	**2-years**	**5-years**	**10-years**	**20-years**	**50-years**	**100-years**
Daily rainfall, mm	56	76	93	112	136	155
Design hourly maximum rainfall intensity in mm/hr						
Duration (hrs)	R_2	R_5	R_{10}	R_{20}	R_{50}	R_{100}
0.25	50	68	85	101	121	136
0.5	31	43	53	63	75	85
1	19	27	33	39	47	53
5	7	9	11	13	16	18
10	4	6	7	8	10	11
24	2	3	4	5	6	6
50	1	2	2	3	3	4
100	2	1	2	2	2	3

4.5 DESIGN FLOOD ESTIMATION

Drainage facilities should have sufficient capacity to carry off safely not only peak runoffs, which occur frequently, say several times a year, but also larger runoffs, occurring less frequently. For a rural highway where some minor traffic disturbances can be tolerated, a peak runoff that recurs in 10 years is sufficient. Highway culverts having low traffic may be designed for 5 - 10 years flow and having intermediate traffic for 10-25 years. Following these recommendations and considering that the road alignment passes through rural areas having low traffic and with very small catchments, cross drains are designed for 10 years return period flood and side drains for 5 years return period.

4.6 DESIGN INTENSITY

Rational method is used to compute design floods. This method needs design intensity corresponding to selected design frequency and time of concentration. As the catchments are very small and the concentration time is too short (less than 15 minutes), it is decided to use the intensity for 15 minutes duration as design intensity except for the special cases where concentration time is more than 15 minutes.

4.7 RUNOFF COEFFICIENT

The runoff coefficient depends on catchment characteristics such as slope, vegetation, shape and size of the catchment. These characteristics are different even in a single watershed. It is very difficult to define the accurate value of runoff coefficient. Thus, standard tables are used to select coefficient roughly for different cases.

In the present study, it is difficult to establish the coefficient for individual catchments as they are in plenty. It is very clear from topographical maps and field visit that the catchments are more or less homogeneous. Hence, a single value of runoff coefficient is used for all the catchments in the project area.

Slope of these catchments is so steep; most of the catchments are well vegetated and forested. It seems that more than 50% of rainfall will be retained by catchments due to dense vegetation and forests as well as by infiltration. Considering all these factors, an average value of 0.4 is used for all catchments.

4.8 FLOOD ESTIMATION BY RATIONAL METHOD

Rational formula is well applicable to small catchments and used to calculate the design floods for cross drainage and side drains using maximum hourly rainfall intensity for determined duration and adopted frequency. The average runoff coefficient is assumed equal to 0.4 for all catchments. The formula is as follows:

$$Q_P = \frac{C * I * A}{3.6} \qquad (3)$$

(Refer: Chow, VenTe, David R. Maidment, and Larry W. Mays. 1988. Applied Hydrology)

Where,

Q_p = Maximum flood discharge in m^3/s

I = Rainfall intensity within the time of concentration in mm/hr

A = Catchment area in km^2

C = Dimensionless run-off coefficient

Table 13: Design Rainfall Intensities and Design Flood Flows

S.No.	CH	Catc. Area	Tc	Rainfall intensity i (mm/hr)				Design Discharge (m3/s)			
	(Km+m)	(Sq.Km)	adopted (hr)	2_yr	5_yr	10_yr	20_yr	2_yr	5_yr	10_yr	20_yr
1.	17+400	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
2.	17+700	0.019	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.14**	0.19
3.	18+000	0.310	0.25	66.91	91.48	110.06	128.65	0.01	0.01	**2.31**	3.15
4.	18+300	0.029	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.21**	0.29
5.	18+600	0.173	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**1.29**	1.76
6.	18+900	0.165	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**1.22**	1.67
7.	19+460	3.51	0.53	154.1	183.46	202.56	220.89	26	31	**34**	41
8.	19+800	0.040	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.29**	0.40
9.	20+080	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
10.	20+490	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
11.	21+268	0.019	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.14**	0.19
12.	21+540	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
13.	22+015	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
14.	22+500	0.019	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.14**	0.19

15.	22+800	0.310	0.25	66.91	91.48	110.06	128.65	0.01	0.01	**2.31**	3.15
16.	23+100	0.029	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.21**	0.29
17.	23+400	0.173	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**1.29**	1.76
18.	23+970	0.165	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**1.22**	1.67
19.	24+200	0.070	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.52**	0.71
20.	24+500	0.044	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.32**	0.44
21.	24+950	0.038	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.28**	0.38
22.	25+200	0.028	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.21**	0.29
23.	25+500	0.054	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.40**	0.55
24.	25+800	0.028	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.21**	0.28
25.	26+185	0.038	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.28**	0.39
26.	26+400	0.040	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.29**	0.40
27.	26+700	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
28.	27+000	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
29.	27+300	0.019	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.14**	0.19
30.	27+600	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.12**	0.16
31.	27+900	0.016	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.11**	0.17
32.	28+200	0.019	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.14**	0.19
33.	28+500	0.310	0.25	66.91	91.48	110.06	128.65	0.01	0.01	**2.31**	3.15
34.	28+800	0.029	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.21**	0.29
35.	29+100	0.173	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**1.29**	1.76
36.	29+400	0.165	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**1.22**	1.67
37.	29+800	0.070	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.52**	0.71
38.	30+100	0.044	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.32**	0.44
39.	30+500	0.038	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.28**	0.38
40.	31+000	0.028	0.25	66.91	91.48	110.06	128.65	0.00	0.00	**0.21**	0.29

4.9 CROSS DRAINS

Cross drains are mainly designed to pass the stream flows. However in some cases the cross drains are provided to divert the flows coming from side drains. Following steps are followed for locating cross drains:

- Identifying stream points and valley curves in topographical map
- Verifying these locations during field visit and survey
- Locating finally after study of designed plan and profile of the road

The design discharge for a cross drain is a high flow corresponding to the selected return period. In order to economize on construction costs, frequency of flood is selected for return periods, depending upon the importance of the structure. For this road, it is recommended to design the cross drains for 20 years return period flood.

The drain size varies based on the design discharge. The design discharge for each drain is different. Pipe culvert is proposed for crossing the small streams as rivulet and springs do not carry debris. Pipe culverts of pipe dia 0.3 m , 0.60 m and 0.90 m are considered for crossing the drains.

0.60 m diameter pipe is not recommended for cross drains because of choking and clogging by sediment and debris coming from upslope of mountain catchments. However, it can be used for crossing of channel, road intersection and flow with low discharges. 1.20 m diameter pipe is to be avoided due to the difficulties of handling and transporting. In most of the places where seasonal waterways occur in the monsoon and for flash flood, stone or concrete causeways are recommended.

The hydraulics of pipe culverts is worked out in table given below. Maximum flow capacity and velocity are determined at a suitable head. The design discharge of a crossing is compared with flow capacity of a pipe and then size is fixed from standard pipe sizes.

Table 14:Hydraulics of Proposed Cross Drains (Pipe Culverts)

CD type	Size (m)	Full flowing area, m^2	Max. design slope, %	Length of CD, m	Max. Head loss, m	Friction coeff.(f)	Max. Velocity, m/sec	Max. flow, m^3/sec
Pipe Culvert	0.3	0.07	3	7.5	0.18	0.05	1.56	0.25
Pipe culvert	0.60	0.28	3	7.5	0.18	0.05	2.66	0.74
Pipe culvert	0.90	0.63	3	7.5	0.18	0.05	3.26	2.05

0.6 m and 0.9 m dia pipe culverts are used in the design. The provisional estimation of 0.3 m dia pipe culvert proposed for irrigation crossings is included in the estimating.

The table shows the full flow capacities, head losses and the design slopes for different pipes. Head losses are calculated by Darcy - Weisbach formula for pipe flow. The coefficient of friction (f)

for concrete pipe in this formula is assumed as 0.05. The maximum velocity at exit point for all size of pipes is to be maintained by providing an apron. The length of pipe in average is assumed to be 7.5 m.The table gives an idea of maximum flow capacity and velocity of proposed pipe culverts, so as to define the proper size of the culvert based on design discharge coming to a culvert. The maximum design slope for these culverts is assumed as 3% to create self flushing velocity.

For medium size streams where flow carrying boulders, pebbles and gravels and span is up to 6 m, box or slab culvert are recommended. The actual span of these culverts is fixed according to field survey. For larger stream, bridge of suitable span based on field survey is recommended.

4.10 SIDE DRAINS

Side drains are recommended for catching the flows from road surface and upside adjoining areas. In some stretches side drains exist but most of them occupied by new design width of the road and new side drains are proposed along the full length of this road. The design discharge for a side drain is a high flow corresponding to the selected return period. In order to economize on construction costs, frequency of flood is selected for return periods, depending upon the importance of the structure. For this road, it is recommended to design the longitudinal side drains for 5 years return period flood.

Table below shows the maximum flow capacity and velocity of side drains at maximum longitudinal slope of 10% and having full flowing area. The side drains must follow the longitudinal slope of the road and in most of the cases hill road has a maximum slope of 12%. To reduce the energy of flow at high gradient, cascade drainage is proposed along the road side having gradient more than 7%.

Table 15: Flow capacity of proposed side drains at maximum slope of 10%

Drain Type	b, m	d, m	A, m^2	P, m	R, m	n	S	V, m/s	Q, m^3/s
Trapezoidal drain covered (type 1)	0.45	0.45	0.2025	1.31	0.155	0.016	0.10	5.66	1.15
Trapezoidal drain open (type 3)	0.45	0.45	0.2025	1.31	0.155	0.016	0.10	5.66	1.15
Cascade drain	0.4	0.4	0.14	1.01	0.133	0.016	O.10	3056	0.98

5 ENGINEERING DESIGN AND ADOPTED DESIGN STANDARDS

5.1 GENERAL

Nepal Rural Road Standard (2055) with 2nd Revision, DoLIDAR is followed to design the road.

.

5.2 ROAD CLASSIFICATION

The road falls under the category of District Road Core Network as per NRRS as it connects village and district headquarters as well as SRN.

5.3 DESIGN PARAMETERS AND STANDARDS FOR DESIGN

The design parameters and standards are considered for the road design is presented in table given below:

Table 16:Design Parameters for Road

S.N.	Design Parameters	District Road Core Network (DRCN), Hill
1	Design Capacity - in both directions(Vehicle per day/P.C.U. per day	200 (400)
2	Design speed (km/hour)	Ruling-25,min-20
3	Road Way width(m)	5.25
4	Carriage way Width(m)	3.75
5	Shoulder Width , either side (m)	0.75
		0.75
6	Total Right of Way (ROW:m)	20
7	Setback distance from road land boundary /ROW to the building line on either side	6
8	Minimum safe stopping sight distance	For 25km/hr =25m, For 20km/hr = 20 m
9	Minimum radius in horizontal curve(m)	Ruling
		min-20
		Min-12.5
10	Hairpin Bends	
	Minimum spacing between Hairpin Bends(m)	100

S.N.	Design Parameters		District Road Core Network (DRCN), Hill
	Minimum radius of curve (m)		12.5
	Minimum roadway width at apex (m)		5.5 for 4.5 RW
			6.25 for 5.25 RW
	Maximum gradient (%)		4
	Maximum super elevation		10
	Maximum transition curve length		15
11	Ruling gradient (%)		7
12	Limiting gradient (%)		10
13	Exceptional gradient (%)		12
14	Limitation of maximum gradient length(m) above average /ruling gradient of 7%		300
15	Maximum recovery gradient (%) to be applied after gradient in excess of 7% for a minimum recovery length of 150 m		4
16	Maximum gradient at bridge approach (%)		6
17	Cross slope in carriageway camber (%)	Earthen (existing)	5
		Gravel	4
		Bituminous Seal Coat	3
18	Passing Zone strips at interval of (m) (Maximum)		300
19	Level of embankment above HFL (m)		1 (0.5 min)

5.4 DESIGN SPEED

The adopted ruling design speed is 25 km/hr, however a minimum design speed of 20km/hr is also adopted for the area where the nature of terrain and cost does not allowed to follow standard design speed as per NRRS 2nd revision.

5.5 RIGHT OF WAY

Right of way depends on the importance of a road and possible future development. A total right of way adopted as per NRRS 2nd revision is 20m (10 m on either side).

5.6 FORMATION WIDTH

Adopted Roadway width is 5.25 m which includes carriageway width (3.75 m) and drain. Shoulder width of 0.75 m is proposed at either side and hence the total formation width comes as 6.25m including drain. To reduce cost , common filling has been used in shoulder.

5.7 EXTRA WIDENING

At sharp horizontal curves, it is necessary to widen the carriageway to provide safe passage of vehicles. Widening is dependent on curve radius, width of carriageway and type of vehicle (length and width).Widening has two components: i) mechanical widening to compensate for the extra width occupied by the vehicle on the curve due to tracing of the rear wheels, and ii) psychological widening vehicles in a lane tend to wander more on a curve than on a straight reach.

Since the volume of traffic movement in this road is very low, only mechanical widening is considered to facilitate the extra width occupied by vehicle. The widening is done in inner part of the road using the following formula.

$W_e = (L^2/ \quad 2R)$

Where,

W_e = Extra widening

N = number of traffic lanes

L = length of wheel base (6.1 m)

R = radius of curve

The table below recommended increase in width as widening as per the NRRS. Also, the figure below shows the inner side widening of road.

Table 17: Extra Widening (m)

SN.	Radius		Extra widening(m)
	From	To	
1	0	20	0.90
2	20	60	0.6
3	60	1000	0

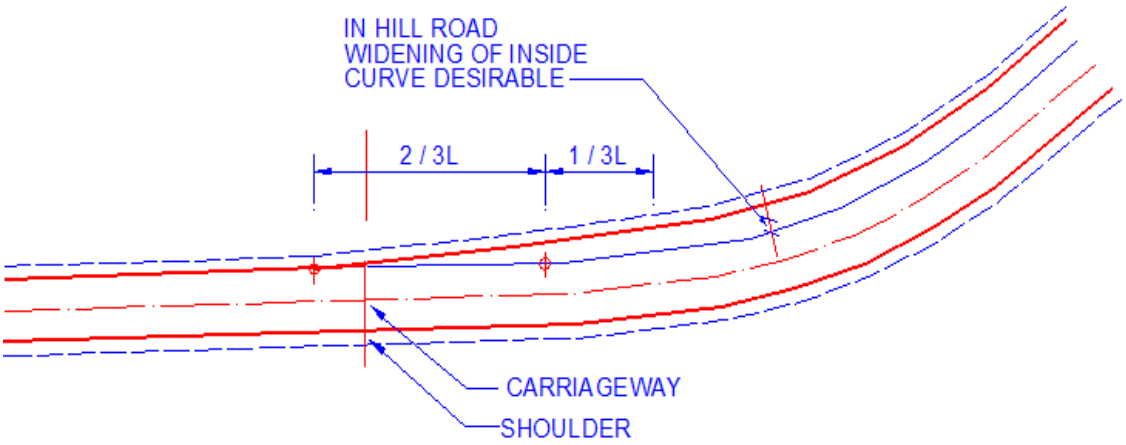


Figure 3 Extra Widening

5.8 STOPPING SIGHT DISTANCE

As per the NRRS (refer **Table:14** Design Parameters for Road), the adopted stopping site distance for design speed 25km/hr is 25m and for 20km/hr is 20m.

5.9 HORIZONTAL CURVES

For the alignment of the road where difficult site conditions are in predominance, the minimum radius of horizontal curves adopted are ruling minimum - 15 m and absolute minimum - 12.5 m (As per the NRRS - refer **Table: 14** Design Parameters for Road).

5.10 ROAD CROSS- SECTION

Following road width and other cross-sectional features are adopted in design of EEAP roads.

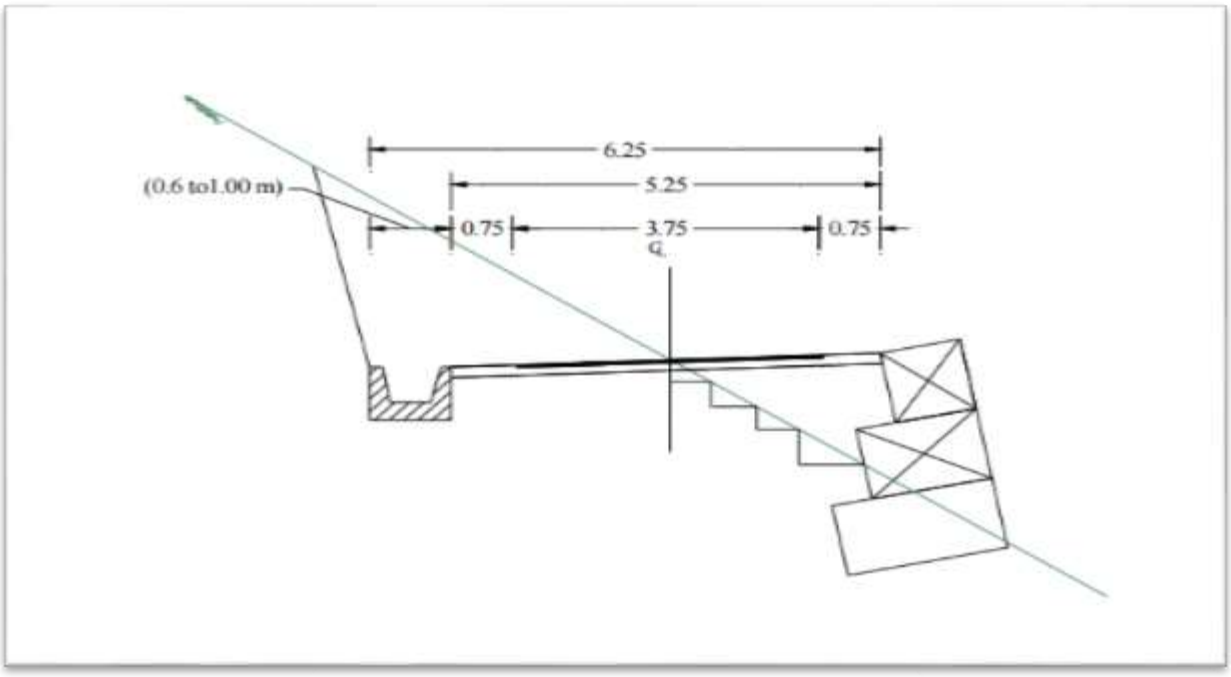


Figure 4 Single Lane Road with drain in Hill area of District Road – Core Network

5.11 PASSING BAYS

The increased width at passing zones should allow two trucks (2 axles) to pass. The width of carriage way should be 5.5 m and length about 12 m along the outside edge and 30 m along inside. This means that passing zones and lay bys should be tapered gradually towards the carriageway, so that vehicles can leave or join the traffic stream safely. At passing places, vehicles would be expected to stop or slow to a very low speed.

Normally, passing place should be located every 300 m for Hill and 500 m for Terai. In the design, the passive zone is proposed at an interval of 300 m and the adopted width of carriage way is 5.25 m and length along the outside edge is 12m.

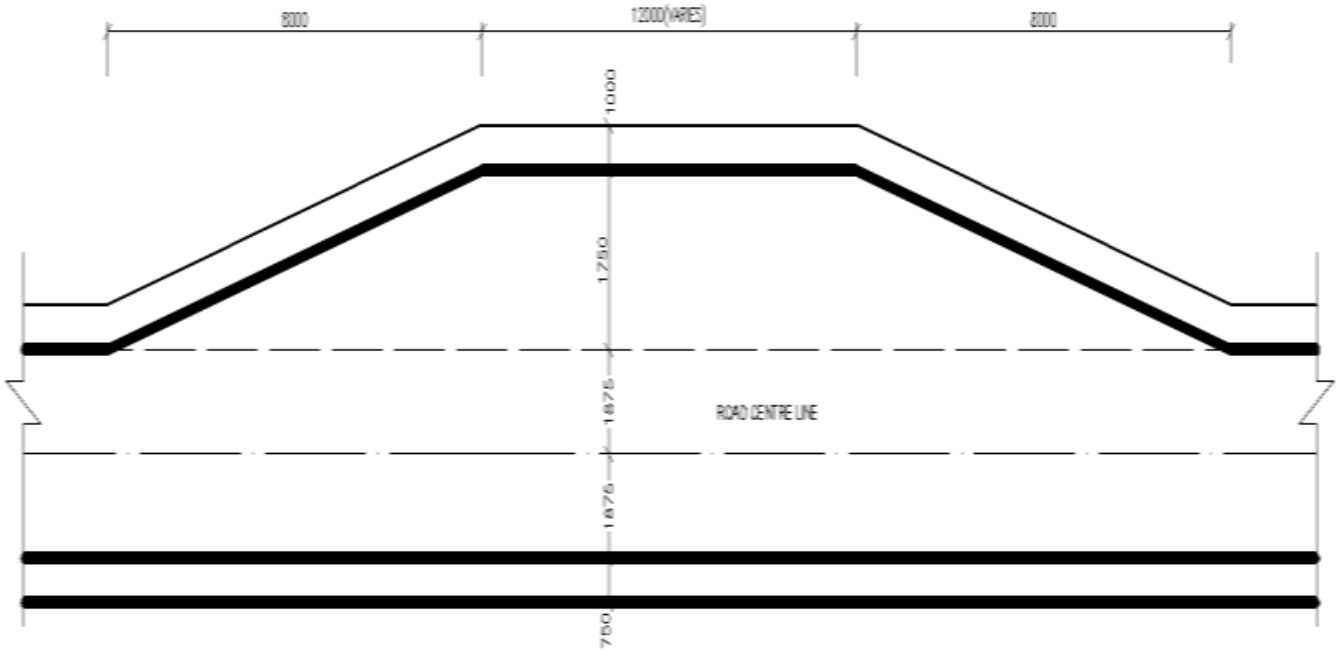


Figure 5 Plan of Adopted Passing Bay

5.12 PAVEMENT DESIGN

Design of pavement is done as per the “Pavement Design Guidelines” (Flexible Pavement) published by DOR. The pavement design is based on CBR values taken from DCP-CBR and Design traffic in terms of cumulative number of standard axles.

This Road is upgraded to bituminous pavement(premix carpeting).

Methodology and Scope of pavement design

Design of pavement essentially needs the traffic information, sub-grade soil strengths, availability of pavement materials (gravel and suitable rocks for crushing to produce the required pavement). The life of pavement is determined in terms of million standard axles (MSA) passing through the highway in its design life. A flexible pavement design essentially consists of sub-base, road base or base course and a suitable type of surfacing course.

Sub grade Strength of Soils

Sub-grade is the natural soil which may be existing local material or may be transported and placed as a fill and compacted to give added strength. The assessment of strength of the sub-grade soil is one of the most important tasks which give the design parameters for the pavements. Generally the strength of the sub-grade soil is assessed by carrying out the California Bearing Ratio (CBR) tests at the laboratory of the samples taken from the field. Sometimes, the CBR is also determined by means of Dynamic Cone Penetration (DCP) Test carried out along the road alignment. The penetration of the cone are interpreted and co-related with CBR. However, design

CBR of the sub-grade is recommended to be taken from the laboratory testing as CBR interpreted through DCP lacks accuracy.

a. Design Life of the Pavement

Design life of a pavement is measured in terms of cumulative number of standard axles passing through the pavement in its entire life. The standard axle is considered to be 8160 kg load in an axle of a vehicle as established by the AASHO road test. The conversion factor for the measured axle load to the standard axle lies in the exponent of 4 to 5. It is taken 4.55 for Nepal as suggested by TRRL. All axle loads of commercial vehicles are converted into standard axle loads and added together to get the cumulative number expressed in million standard axles (msa) considering the annual growth of traffic for the design life of pavement which could be between 10 to 15 years for a developing country like Nepal. Sub-grade strength in one hand and the design life msa in the other hand, the thickness of different structure layers of the pavement will be designed. There are various methods available for the design of pavement.

b. Sub-base

This forms a load distributing layer below the road base. Sub-base material essentially consists of naturally occurring gravel, gravel sand or gravel clay or the crushed rock or suitable material which meets the strength criteria and forms the lowermost layer of pavement structure. This layer serves as separating layer for the overlaying road base thus preventing contamination of the road base by the sub grade. This has also another important role to play that it protects the sub-grade from damage due to traffic. The thickness of sub-base is determined by the design and laid in accordance with the specified manner.

c. Road Base

This acts as the main load spreading layer for the pavement. This normally consists of crushed rock or gravel or of gravelly soils, decomposed rock, sands and sand clays stabilized with cement, lime or bitumen. Sometimes, premixed asphalt is also laid on top of the road base and they are called base course.

5.13 INVESTIGATION OF EXISTING SUB-GRADE

In road construction, there is a need to assess the adequacy of a sub grade to behave satisfactorily beneath a pavement. Proper pavement performance requires a satisfactorily performing sub grade. DCPT can be used to evaluate the mechanical properties of sub grade soils.

- **DCP Tests**

The Dynamic Cone Penetrometer (DCP) is a simple testing device used to estimate the in situ shear strength of soil and granular materials used in roadways and other construction related projects. The apparatus consists of 16mm diameter steel rod in which a tempered steel cone with a 20 mm base diameter and a 60 degree point angle is attached. The DCP is driven into the soil by a 8kg hammer with a free fall of 575mm. The hammer correction factor is unity for 8kg hammer.

The DCP index or reading is defined as the penetration depth (D) in mm for a single drop of hammer. The cone is driven in to the ground up to the desired depth and average DCP index is calculated for a single blow. The desired depth could be the depth till difference in the penetration value comes very close to each other.

DCP testing consists of using the DCP's free-falling hammer to strike the cone, causing the cone to penetrate the base or sub grade soil, and then measuring the penetration per blow, also called the penetration rate (PR), in mm/blow. This measurement denotes the stiffness of the tested material, with a smaller PR number indicating a stiffer material. In other words, the PR is a measurement of the penetrability of the sub grade soil.

The CBR value of uniform soils having similar characteristics can be determined quickly and with adequate accuracy using the DCPT results. The correlation is established between CBR index for tests conducted under different conditions and compaction level or in-situ density. The soaked CBR value in the field can be determined very quickly by conducting the in-situ DCPT for existing conditions and using the CBR value for that particular condition.

DCPT results consist of number of blow counts versus penetration depth. Since the recorded blow counts are cumulative values, results of DCPT in general are given as incremental values defined as follows:

$$PI = \frac{\Delta D_p}{\Delta BC}$$ [Oversees Road Note 31, 4th edition, 1993]

Where,

PI = DCP penetration index in units of length divided by blow count;

ΔDp = penetration depth;

BC = blow counts corresponding to penetration depth ΔDp. As a result, values of the penetration index (PI) represent DCPT characteristics at certain depths.

The investigation of existing sub-grade was carried out using Dynamic Cone Penetration (DCP) equipment to find out the CBR value of the sub grade using DCP test. The DCP test was carried out at 500 m interval.

There are several empirical relationships to calculate the CBR from DCP test. Some of the empirical co-relationships mentioned in oversees road note 31 is shown below:

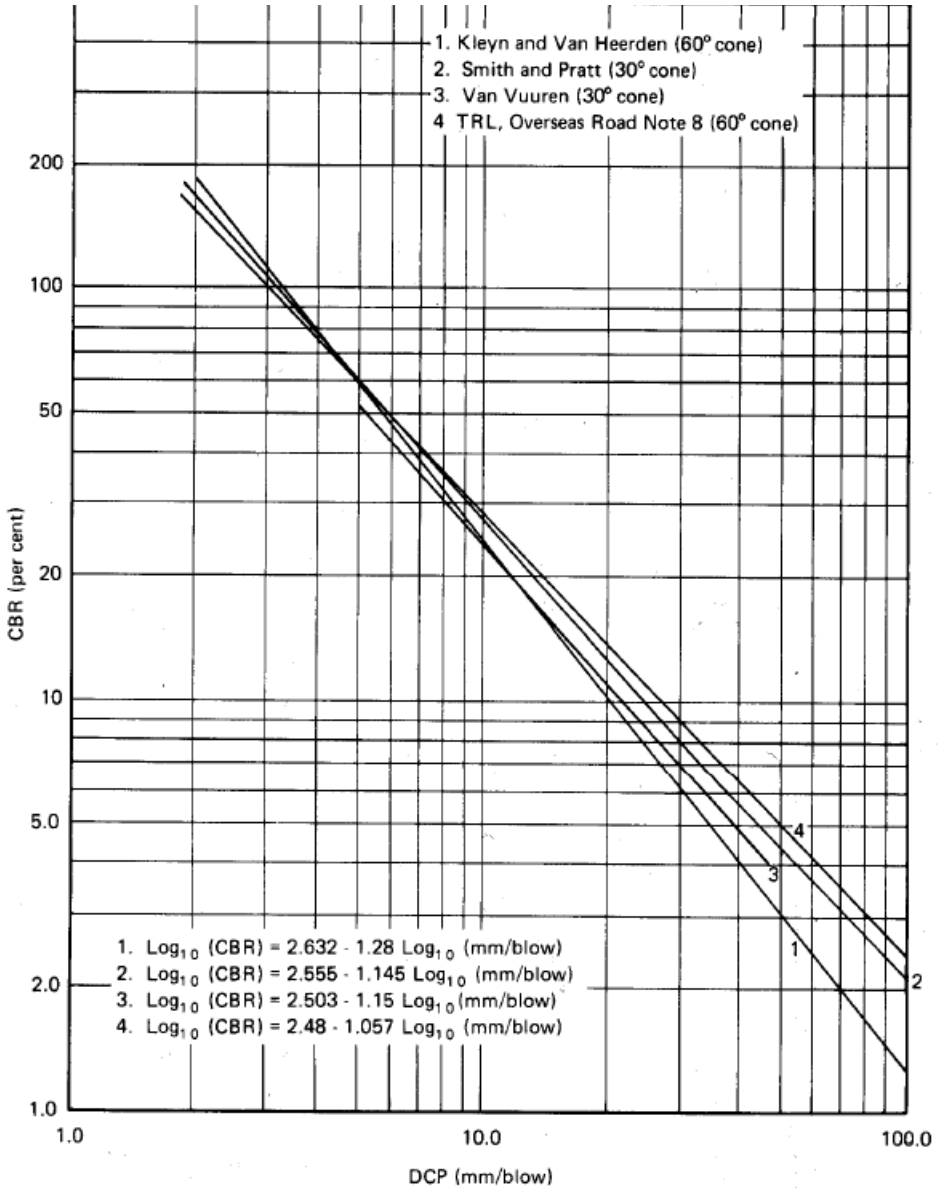


Figure 6 DCP-CBR relationships (Oversees Road Note 31, 4th edition, 1993)

Table 18: Correlation to find CBR from DCP test

Author	Correlation	Field or Laboratory based study	Material used
Kleyn (1975)	$\log CBR = 2.62 - 1.27(\log PI)$	Laboratory	unknown
Harison (1987)	$\log CBR = 2.56 - 1.16(\log PI)$	Laboratory	Cohesive
Harison (1987)	$\log CBR = 3.03 - 1.51(\log PI)$	Laboratory	Granular
Livneh et al. (1994)	$\log CBR = 2.46 - 1.12(\log PI)$	Field and laboratory	Granular and cohesive
Ese et al. (1994)	$\log CBR = 2.44 - 1.07(\log PI)$	Field and laboratory	ABC*
NCDOT (1998)	$\log CBR = 2.6 - 1.07(\log PI)$	Field and laboratory	ABC* and cohesive
Coonse (1999)	$\log CBR = 2.53 - 1.14(\log PI)$	Laboratory	Piedomont residual soil
Gabr (2000)	$\log CBR = 1.4 - 0.55(\log PI)$	Field and laboratory	ABC*

**Aggregate base course*

In this report, the CBR has been evaluated using Kleyn and Van Heerden.

In calculating the CBR, the soil layer is divided into different layers based on penetration index (PI) or the slope of the depth vs penetration curve. Among the different layers, the layer with minimum CBR is assumed as the CBR of the sub grade soil. In many cases, the original sub grade might have been graveled and in such case CBR is estimated below that depth (which represents true existing sub grade).

Mostly sub-grade soils on the existing pavement were found dominant of silty, sandy to gravelly soils. The summary of CBR obtained from DCPT is shown in table below.

Table 19: Summary of CBR of Sub grade obtained from DCPT

Chainage		Length, m	CBR
From	To		
17+500	18+000	500	9.00%
18+000	18+500	500	7.00%
18+500	19+000	500	8.00%
19+000	19+500	500	10.00%
19+500	20+000	500	11.00%
20+000	20+500	500	8.00%
20+500	21+000	500	9.00%
21+000	21+500	500	10.00%
21+500	22+000	500	10.00%
22+000	22+500	500	11.00%
22+500	23+000	500	7.00%
23+000	23+500	500	10.00%
23+500	24+000	500	10.00%

Chainage		Length, m	CBR
From	To		
24+000	24+500	500	8.00%
24+500	25+000	500	12.00%
25+000	25+500	500	10.00%
25+500	26+000	500	9.00%
26+000	26+500	500	10.00%
26+500	27+000	500	10.00%
27+000	27+500	500	9.00%
27+500	28+000	500	7.00%
28+000	28+500	500	8.00%
28+500	29+000	500	10.00%
29+000	29+500	500	11.00%
29+500	30+000	500	8.00%
30+000	30+500	500	9.00%
30+500	31+000	500	10.00%

The lowest CBR (7 %) is taken into account for the pavement design

5.14 TRAFFIC SURVEY AND STUDIES

All the traffic in the classified count was segregated into the following types of vehicles as per the DoR practice

- Multi axle trucks (MaT)
- Heavy trucks (HT)
- Light Truck (LT)
- Bus (B)
- Mini-bus (MB)
- Car, van, Taxi (C)
- Farm Tractor (TRA)
- Motor- cycle (MC)

In addition, the non-motorized traffic was segregated into pedestrians for this road. The classified count was conducted manually at the road link in taking proper precaution. The resulting average traffic from the traffic count was adjusted to the average annual daily traffic (AADT) using the DoR seasonal- variation factor to the month of august. There was no data on variation.

For analytical purpose, the AADT at the road is expressed both in terms of vehicle per day (vpd) and daily passenger unit (PCU/d) assuming the following PCU factor that are in practice in Nepal.

Table 20: PCU Factor adopted

Vehicle	PCU Factor	Vehicle	PCU Factor
HT	3	TRA	3
LT	1.5	MC	0.5
C	1	Pedestrian	0.25
B	3	Porter	0.4
MB	3	Mule	2

Designing of pavement of a road is based on cumulative Axle Load to which the road will be subjected to during the design period and the sub-grade strength. During the survey loads of front wheels and rear wheels of trucks and buses running in opposite directions are measured using portable weighting scales. Equivalent Factor (EFs) of trucks and buses are calculated by using following formula (*Refer: DoR /Pavement Design Guidelines - Flexible Pavement-2013)*.

EF = (Total Axle Load/8.16)^4.5

The axle load survey could not be carried out as the road was in very poor condition and not used by conventional vehicles on a regular basis to obtained valid representative equivalent factors. The equivalent factors of truck and buses for the road are adopted from factors determined.

5.15 ESTIMATION OF TRAFFIC DATA

Normal and Diverted Traffic Data

To forecast future traffic of a road section after improvement or after construction, it is first necessary to estimate the level of base year normal traffic of the existing road or track. Generally, base year volume and composition of normal traffic movements in the existing road are calculated through Classified Manual Vehicle Counts (CMVCs) or Origin and Destination (O-D) surveys.

Seasonal traffic influences are usually associated with agricultural activities and rainfall. During the harvesting season, traffic levels are increased due to more movements of labour, transport of harvested crops and an increase in other associated activities. The impact of rainfall on traffic level is due to disruptions caused by damage to roads and slides. DoR has developed a set of monthly traffic seasonal adjustment factors for general use based on the traffic data obtained from regular counts in different stations on strategic roads.

Generated Traffic

Additional journeys can be expected as a result of lower costs of travel. The principle behind generated traffic is that additional journeys will be made as a result of lower costs of travel on the improved roads. The number of additional trips is usually based on the reduction in travel and transport costs, with the response based on the price elasticity. Similar to demand elasticity, price elasticity is the proportional change in the number of trips per unit change in price. It has been measured in road appraisal studies in developing countries and usually found to fall in the range -

0.6 to -2.0, with an average of about -1.0. This means that a one per cent decrease in transport costs leads, on average, to a one per cent increase in traffic. Evidence suggests that the elasticity of demand for passenger transport is well above that for freight transport. The cost reduction following improvement depends largely on the existing condition of the track/road. Reductions of travel and transport costs by 30 to 40 percent can be expected in the case of track or unsealed roads. With improvements to sealed roads the cost reduction will normally be below 25 percent, and it is normally considered that there is no significant generation below this level.

Keeping in mind all the above possibilities and difficulties, a generation rate of 15 percent is assumed to current freight traffic and 40 percent to passenger traffic.

Induced Traffic

Induced traffic can occur when the increased economic growth, as a result of the road improvement, produces additional traffic on the road. This is not generated traffic, which is additional traffic resulting directly from a lowering of transport costs, but it overlaps with generated traffic and care must be taken to avoid double counting if induced traffic benefits are calculated. The increased economic development associated with the improvement of the sections of the project road could be in the form of opening up of new tourist facilities and agriculture development. 10 percent of normal traffic is assumed to be induced traffic after the implementation of the project.

5.16 TRAFFIC GROWTH

The demand for transport is related to the output of the economy that produces it. Traffic is almost invariably positively correlated with GDP and traffic growth with GDP growth. The relationship is as follows:

Q = k (real GDP) ^e(*Refer: Guidelines for Traffic Prediction on Rural Highways, IRC 1996]*

Where,

Q = some measure of demand for transport,
K = a constant
E = exponent - the elasticity of demand for transport with respect to GDP. Elasticity is the proportional change in demand per unit change in real GDP, so an elasticity of 0.2 implies a 2 percent growth in transport demand in response to a 10 percent in real GDP.

5.17 TRAFFIC FORECASTS

Using the analysis discussed in above paragraphs, the future traffic in the sections of the road is projected. The generated and induced traffics are assumed to grow similar to normal traffic. The table given below gives the baseline AADT of the sections of the alignment of the project road.

Table 21:Baseline AADT in VPD & PCU

Vehicle	AADT in VPD				AADT in PCU			
	Diverted traffic	Normal traffic	Generated traffic	Total	Diverted traffic	Normal Traffic	Generated traffic	Total
MaT	9	2	5	16	27	6	15	48
HT	20	5	15	40	60	15	45	120
LT	55	2	21	78	82.5	6	63	151.5
B	15	5	30	50	45	15	90	150
Mini B	30	6	6	42	90	18	18	126
Micro B	60	6	8	74	60	18	24	102
C	80	15	40	50	80	45	120	245
MC	150	15	100	265	75	45	300	420
UV	12	0	50	62	12	0	150	162
TRA	5	0	50	55	15	0	150	165
4WD	10	0	20	30	10	0	60	70
Total motorized	**446**	**0**	**345**	**762**	**556.5**	**168**	**1035**	**1759.5**

It is noteworthy that a large numbers of motorcycles will be run in the road after the construction. This will not affect much in the pavement design and not considered during this stage of the study.Only vehicles (buses and trucks) are considered for pavement design purpose. Cars, light vehicles are not further considered. Since ADT of the project road lies in between 2000-5000 in 20 year perspective period, the project road lies in Class III. Based on above adopted EFs and AADT of trucks and Buses, a predicted annual traffic growth rate of 5 percent for freight vehicles and 7 percent for passenger vehicles, annual total number of trucks and buses are given in table below.

Table 22: Projected Traffic in AADT

Year/Type of vehicles	MaT	HT	LT	B	Mini B	Micro B	Car	Tractor	MC	Remark/ Total AADT
2016	48	120	151.5	150	126	102	245	165	420	**1527.5**
2017	50	126	159	161	135	109	262	173	449	
2018	53	132	167	172	144	117	281	182	481	
2019	56	139	175	184	154	125	300	191	515	
2020	58	146	184	197	165	134	321	201	551	
2021	61	153	193	210	177	143	344	211	589	
2022	64	161	203	225	189	153	368	221	630	
2023	68	169	213	241	202	164	393	232	674	
2024	71	177	224	258	216	175	421	244	722	
2025	74	186	235	276	232	188	450	256	772	
2026	78	195	247	295	248	201	482	269	826	
2027	82	205	259	316	265	215	516	282	884	
2028	86	216	272	338	284	230	552	296	946	
2029	91	226	286	361	304	246	590	311	1012	

Year/Type of vehicles	MaT	HT	LT	B	Mini B	Micro B	Car	Tractor	MC	Remark/ Total AADT
2030	95	238	300	387	325	263	632	327	1083	
2031	100	249	315	414	348	281	676	343	1159	
2032	105	262	331	443	372	301	723	360	1240	
2033	110	275	347	474	398	322	774	378	1327	
2034	116	289	365	507	426	345	828	397	1420	
2035	116	289	365	507	426	345	828	397	1420	
2036	121	303	383	542	456	369	886	417	1519	**4996**

Note :

- *AADT/ADT lies between 2000-5000, the road is classified as Road Class III as per Functional classification.*
- *MaT=Medium Truck HL=Heavy Truck LT=Light Truck B=Bus Micro B=Micro Bus*

5.18 DESIGN LOADING FOR PAVEMENT DESIGN

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

N= [365{(1+r)^n -1}/r] *A*D*F(*Refer: DoR Pavement Design Guidelines, Flexible Pavement - 2013)*

Where,

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

A =Initial traffic in the year of completion of construction in terms of number of commercial vehicles per day

D = Lane distribution factor

F = Vehicle damage factor

n = Design life in year

r =annual growth rate of commercial vehicle (in the absence of detail traffic study r can be taken as 7% i.e0.07)

The traffic in the year of completion is estimated using the following formula: $A*(1+r)^{x}$

Where,

P = number of commercial vehicles as per the last traffic count;

X = number of years between the last traffic count and the year of completion of construction.

Table 23:Estimation of Cumulative Numbers of Vehicles (vpd)

Year/Type of Vehicle	MaT	HT	LT	B	Remark
1st Year	5840	14600	36865	18250	Road opening 2017
2nd Year	6132	15330	38708	19528	
3rd Year	6439	16097	40644	20894	
4th Year	6761	16901	42676	22357	
5th Year	7099	17746	44810	23922	
6th Year	7453	18634	47050	25597	
7th Year	7826	19565	49403	27388	
8th Year	8217	20544	51873	29306	
9th Year	8628	21571	54466	31357	
10 th Year	9060	22649	57190	33552	
11 th year	9513	23782	60049	35901	
12 th year	9988	24971	63052	38414	
13 th year	10488	26220	66204	41102	
14 th year	11012	27530	69514	43980	
15 th year	11563	28907	72990	47058	
16 th year	12141	30352	76640	50352	
17 th year	12748	31870	80472	53877	
18 th year	13385	33463	84495	57648	
20 th year	14055	35137	88720	61684	
20 th year	14757	36893	93156	66002	
Cumulative no of Vehicles	**193105**	**482762.9**	**1218976**	**748168**	

The cumulative equivalent standard axles for the design period are shown in below:

Table 24: Estimate of Equivalent Standard Axles (ESA)

Description	MaT	HT	LT	B	Total, Cumulative ESA
Cumulative number of vehicles during design life	193105	482763	1218976	748168	1755549, ***1.76 MSA***
ESA	1.77	2.63	0.02	0.16	
Cumulative ESA	341796	1269666.5	24379.53	119707	

Total Cumulative Equivalent Standard Axles = 1.76 MSA

5.19 DETERMINATION OF PAVEMENT THICKNESS

As per *Overseas Road Note 31 (Fourth Edition)* , based on CBR Value 7 %(Sub grade strength classes-S3) and traffic loading 1.76 MSA (Traffic Class- T4), the Pavement thickness is computed as 400 mm . The total thickness of the pavement adopted is 420 mm which includes 20 mm premix carpet.

The detail of pavement composition along the road alignment is discussed herewith:

Table 25: Pavement Composition along the Alignment

Chainage	Subbase (mm)	Base (mm)	Premix Carpet (mm)	Total Thickness (mm)
Ch.17+600 to Ch. 30+575	200 mm	200 mm	20 mm	420 mm

5.20 RETAINING STRUCTURES

Retaining walls are proposed to restrain soil and accordingly designed. They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in areas where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway over passes. DoR guidelines are followed to fix the base width and slope of retaining walls. In this project, the retaining structures such as gabion wall, stone masonry wall and dry stone masonry wall are proposed. The typical retaining structures adopted for the road and the schedule of retaining wall/breast wall are presented in **Volume 3:Drawing.**

5.21 TRAFFIC SAFETY

The traffic sign board, RCC delineator post / guard post, RCC kilometer post @ 1 km, RCC km post @ 5 km, gabion block / stone masonry wall as guard block at the high embankment area / curve area, high retaining wall at valley side are proposed in order to take traffic safety measures.

5.22 BIO-ENGINEERING WORKS

Slope instability and soil erosion prone zone is observed in Chainage 21+680 to 21+730. In this section, bioengineering is proposed along with retaining wall to stabilize the area. The bio-engineering work includes tree / shrubs as well as grass and bush/hedges plantation. These include Lajavati, Dubo, Sisnu, Titepati, Bamboo, Utis, Kadam and others.

5.23 CHANGES MADE IN THE DESIGN

As per the design parameters , the exceptional gradient to be provided along the alignment is 12 %. However, due to harsh site condition (like hard stratum / very steep slopes), the gradient exceeding the exceptional gradient needed to be adopted on the following sections along the road alignment.(Note: There is no alternative other than shifting the alignment if the gradient to be kept 12% and below as per site condition).

Table 26 Gradient adopted exceeding the exceptional gradient

S. No.	Chainage		Gradient Adopted
	From	To	
1	18+173	18+425	14.73%
2	18+425	18+703	15.96%

6 ENGINEERING COST ESTIMATE

6.1 QUANTITY ESTIMATE

Rate analysis of each of the items has been carried out according to the approved norms of DoLIDAR and approved district rates. The rate of items includes contractor's overhead and profit @ 15% in accordance to the Government Norms. The detail rate analysis and district rates are presented in **Volume 2.**

For estimating the cost of the project, detailed quantity estimation had been done for each item of works to be included in the project activities. The detail quantity estimates have been provided in **Volume 2: Cost Estimate** and the summary sheet of quantity estimation. (Refer ***Annex I*** for summary of quantities)

The cost of the project has been worked out based on the quantity estimate derived from engineering design and unit rates of each work items. The cost estimate makes provisions for general items e.g. cost of insurance, provision of site offices, cost of lab tests etc and they are based on rates for similar items in similar projects. A nominal provision for day works has also been made in cost estimate. The detailed cost estimate has been provided in **Volume 2 :Cost Estimate** of the technical report. The base cost of the project has been estimated to be **NRs. 230,918,402.89.** The total cost for rehabilitation and reconstruction of the road project (Package 2) Ch:17+600 to 30+57 Km is **NRs. 290,957,187.6** .This total cost includes work charge staff & Miscellaneous Expenses,Physical contingencies & VAT as per GON rules. The cost of per construction of works is **NRs 20,110,595.00** per Km inclusive of VAT to Base Cost . The abstract of costs is presented as ***Annex I*** of this report. The summary cost estimate is presented in table below.

Table 27: Summary of Cost

S.N.	Description of works	Amount (NRs)	Remarks
1	General Items	5,600,000.00	1.92%
2	Site Clearance Works	1,749,460.26	0.60%
3	Earthworks	18,012,174.59	6.19%
4	Structural/ Side Drain/ Cross Drainage Works	105,507,529.60	36.26%
5	Pavement Works	97,668,514.26	33.57%

6	Road Furniture / Traffic Sign Board409,595.00	1,781,177.06	0.61%
7	Bioengineering Works	406,097.11	0.14%
8	Day Works	193,450.00	0.07%
Base Cost(A)		**230,918,402.89**	SUM OF ALL ABOVE COSTS
VAT @13%(B)		30,019,392.38	13% OF A
Total Cost(C)		**260,937,795.26**	A+B
Cost Per Kilometer of construction works including Base Cost and VAT (D)		**20,110,595.74**	C/12.975
Work Charge Staff & Miscellaneous Expenses @ 3%(E)		**6,927,552.09**	3% of A
Physical Contingency @ 10%(F)		**23,091,840.29**	10% OF A
Grand Total(G)		**290,957,187.64**	(C+E+F)

6.2 QUANTITY ESTIMATE

The detail quantity estimates is done for each item of works required for rehabilitation and reconstruction of the road to gravel standard. These have been provided in **Volume 2:Cost Estimate**. For summary quantity estimates refer to ***Appendix I***.

6.3 ANALYSIS OF RATES

For estimating the cost of each item of works, prevailing norms of DoLIDAR and DOR for rate analysis has been used throughout. Rate analysis of each of the items has been carried out according to the approved norms of DoLIDAR and approved district rates of Fiscal Year 2073/2074. The copy of approved district rates are given in **Volume 2: Cost Estimate**. For rate of earthwork quantities, rate for earthwork excavation by machine and manually for roadway and drain and for foundation of structure is adopted 95% and 5% as carried out by DOR. The detailed analysis of rates of each items are provided in **Volume 2: Cost Estimate.**

7 ENVIRONMENT PROTECTION MEASURES

During the design of cut slopes consideration have been given to minimize possibility of destabilization have been considered. Similarly during survey suitable drainage facilities utilizing discharge to natural drainage channels was looked after and these has been adopted while designing.

Suitable materials obtained from excavation will be used for embankment filling, and backfilling of structures. Despite this, the surplus excavated materials obtained will be disposed at construction site as required. Wherever possible, the surplus spoil will be used to fill eroded gullies, quarries and depressed areas. Dry stone toe walls are required in some locations for disposal of spoils. The disposal sites recommended for spoil disposal are listed in table given below:

Table 28: Spoil Disposal Sites

S. No.	Chainage	Location	Remarks
1	18+560	Thalajung, VDC	Kholsi area
2	20+300	Chhoprak VDC	Stream
3	23+250	Chhoprak VDC	Natural depression
4	24+200	Chhoprak VDC	River area
5	26+300	Jaubari VDC	Natural depression
6	27+100	Jaubari VDC	Kholsi area
7	28+500	Hansapur VDC	Natural depression

During survey, it has been observed that from Chainage 21+680 to 21+730 is soil erosion prone zone. In this section, bioengineering works have been proposed along with retaining wall to stabilize the area. The bio-engineering work includes tree / shrubs as well as grass and bush/hedges plantation. These include Lajavati, Dubo, Sisnu, Titepati, Bamboo, Utis, Kadam and others.The total cost of bioengineering works is estimated to be NRs. 406,097.00.

8 CONCLUSION

Darby Shah Road – DRCN Code No: 36A006R--(Chitre Pokhari – Bhachek) Project lies in Gorkha District .The road alignment starts from Chitre Pokari of Chhoprak VDC and ends at Bhachek of Hansapur VDC. It passes through Chhoprak, Shreenathkot, Jaubari and Hansapur.

While considering the improvement of the road to gravel standard, provisions have been made for adequate cross drainage as well as side drains. However for the preservation of gravel surface it is important that surface water does not flow through the road surface. As such it is recommended that during rainy season in construction phase the adequacy of side drains and cross drainage shall be observed and modification as required shall be made to preserve the road asset. It shall be noted that a construction period of 18 months from start of works has been considered while preparing the estimates and any delay in completion of works may cause cost overrun.

Darby Shah Road in Gorkha district is given a high priority as it provides access to district headquarters and other parts of the country. After the road upgrading, the road can provide a better accessibility to the hinterland people. Local products can get market with improved transportation facility, so that people from the area may have better earning opportunities. And, ultimately it helps to boost up the economy of the area.

References

CBS, 2012. *National Population and Housing Census 2011*. Kathmandu, Nepal: Central Bureau of Statistics (CBS).

DoLIDAR, 2014. *Nepal Rural Road Standards (2055) 2nd Revision 2071*. Kathmandu, Nepal: Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR), Ministry of Federal Affairs and Local Development (MoFALD).

DoR, 2013. *Nepal Road Standard 2070*. Kathmandu, Nepal: Department of Roads (DoR), Ministry of Physical Infrastructure and Transport (MoPIT).