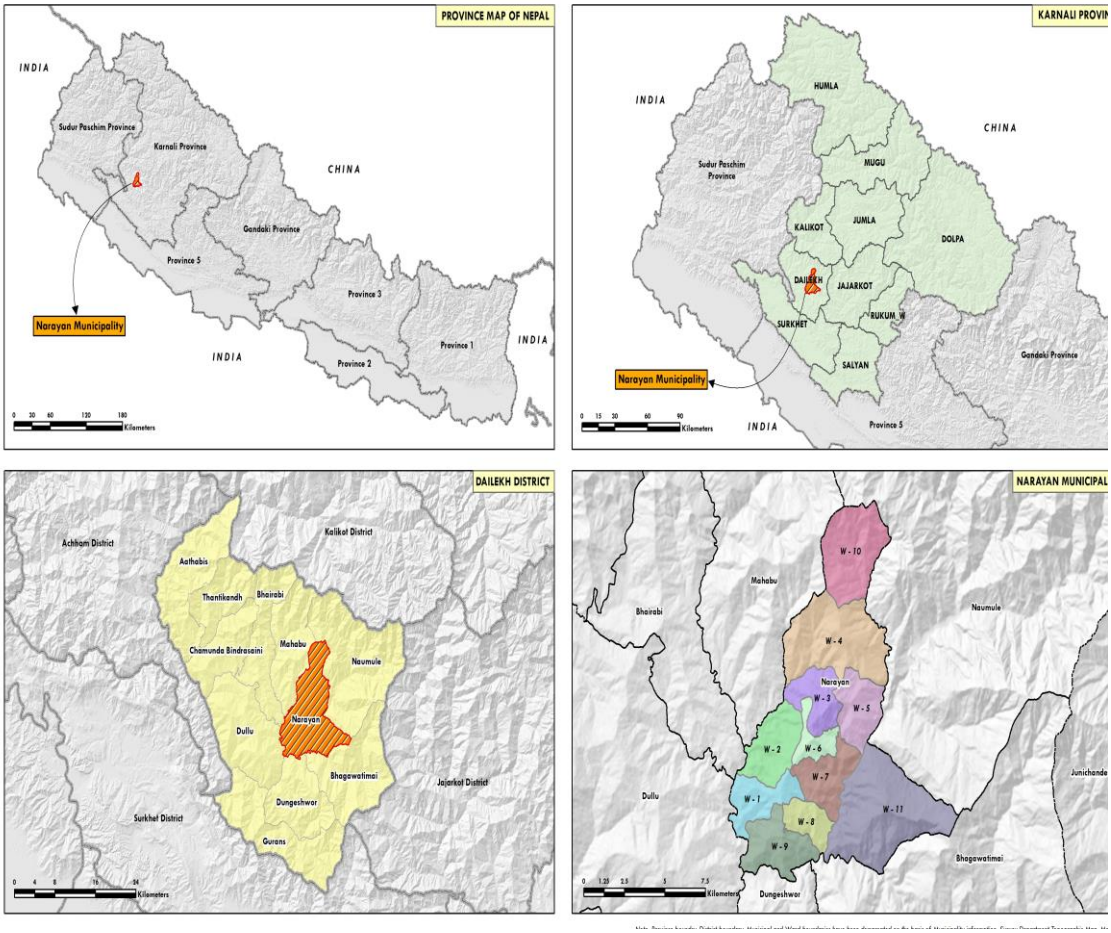
Government of Nepal
Ministry of Urban Development
Department of Urban Development & Building Construction (DUDBC)
Babarmahal, Kathmandu.

PREPARATION OF INTEGRATED URBAN DEVELOPMENT PLAN OF NARAYAN MUNICIPALITY, DAILEKH DISTRICT, KARNALI PROVINCE, NEPAL.

DRAFT REPORT

Volume-IV: Detail Engineering Design (Road)



Submitted by:

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Executive Summary

This report has been prepared as per the contract between the Urban Statistics and GIS Section. Department of Urban Development and Building Construction as the Client and the GOEC Nepal-GRID-RAJDEVI JV, Kathmandu as the Consultant for Detailed Project Report of "Upgradation of road - "Dailekh-Mahabu-Jumla Road" (DED 1) and Tourism developmentmaster plan, Pallo Kalimati, ward-03 (DED 2) ". This Report for Upgradation of road - "Dailekh-Mahabu-Jumla Road" is submitted in accordance with the given Terms of Reference (TOR).

This report consists of several chapters. For this purpose, a multidisciplinary team of experts were engaged for carrying out desk, field and office studies as well as analysis of all available primary and secondary information and data pertaining to a variety of disciplines such as: topography, geomorphology, geology, geo-techniques, hydrology, sociology, demography, economy, traffics, agriculture, forestry, ecology, design and drawing of the surveyed roads in the area and districts. Study of the characteristics of the area to be influenced directly by the construction of the road was given due stress. All these studies helped to understand the project area in terms of physical model so as to design the road in the most optimal fashion, and the mitigate for any potential adverse impact on the environment.

Chapter 1 of the report highlights the general introduction, location of project, significance, connection with other road network and map study.

Chapter 2 of the report highlights the Traffic Study, Hydrological Study, Topographical Study and Geographical Study

Chapter 3 of the report highlights the design and drawings. It describes about the design parameters followed during design of road, about design software and preparation of drawings as mentioned.

ABBREVIATION

AADT	Average Annual Daily Traffic
ADT	Average Daily Traffic
ADB	Asian Development Bank
AMSL	Average Mean Sea Level
BCR	Benefit Cost Ratio
CDMA	Code Division Multiple Access
DCC	District Coordination Committee
DOR	Department of Roads
ECD	Early Childhood Development Centers
EIRR	Engineering Internal Rate of Return
GPS	Global Positioning System
HH	House Hold
IEE	Initial Environment Examination
IRC	Indian Road Congress
MRE	Mountain Risk Engineering
NFRP	Nepal Feeder Road Project
NRS	Nepal Road Standard
NTFP	Non Timber Forest Product
PHC	Public Health Clinic
TOR	Terms of Reference
VAT	Value Added Tax
VOC	Vehicle Operating Cost

SALIENT FEATURES OF THE PROJECT

Name of project: Preparation of Detailed Engineering Survey, Design and Report for Upgradation of road - "Dailekh-Mahabu-Jumla Road", 13.240 Km

Location:

Geographic Location: Narayan Municipality, Dailekh District, and Karnali Province

S.N	Name of Road	Starting Point	End Point
1	Upgradation of road - "Dailekh-Mahabu-Jumla Road"	Location: Dailekh Easting: 570494.6 Northing : 3192124 Elevation : 1431.3	Location: Bhawani Easting: 572157.4 Northing : 3200311 Elevation : 1597.51

(Dimension: All are in Meter)

Geographical Feature : Hilly Region
Terrain : Hilly Terrain
Climate : Temperate
Geology : Boulder mixed Soil and Hard Soil
Hydrology : Phulbari River, Ghatte River and Many revaluates
Precipitation : Average annual rainfall 964.8 ml.

Classification of Road:

Classification : Class--III (NRS) &, Collector Street (IRC 86)
Surface : Asphalt
Suggested longitudinal grade: 0.3% to 4%

Structures

S.N.	Structures	Quantity	Unit	Remarks
1	Earthwork Excavation	196,227.96	Cum.	
2	Filling	8,899.89	Cum.	
3	Pipe Culvert (900 mm Dia)	22	Nos.	
4	Pipe Culvert (4 m * 3 m)	8	Nos.	
5	Pipe Culvert (3 m * 2 m)	6	Nos.	
6	Machine mixed cement concrete M15/40	2735.80	Cum.	
7	Machine mixed cement concrete M20/40	1912.60	Cum.	
8	Reinforcement	233.710	Mt.	
9	Sub base	23100.00	Cum.	
10	Base	13860.00	Cum.	
11	Asphalt Pavement	4620.00	Cum.	
12	Road Furniture's (Road Paint)	3,641.00	Sqm.	
13	Standard Kilometre post (Placed at each km)	8	Nos.	
14	Bigger Kilometre post (Placed at each 5 km)	3	Nos.	
15	Providing street lights along the road	441.00	Nos.	
16	Planting Tree along the road	530.00	Nos.	

Table: Summary of Cost

Summary of Cost

SN	Description of Works	Amount	Remarks
1	General Item	8,566,011.09	
2	Road Way Excavation	9,704,268.62	
3	Drain, Cross Drainage and Structures Work	213,996,228.57	
4	Pavement work	289,493,866.20	
5	Foothpath	1,366,234.04	
6	Road Furnitures & Traffic Safety	1,658,116.72	
7	Miscellaneous Works	22,570,188.75	
	Total = 1+2+3+4+5+6+7 = 8	547,354,913.99	
	4%Contingency for the supervision work of 8=9	21,894,196.56	
	10% Price adjustment Contingency of 8=10	54,735,491.40	
	10% Physical Contingency of 8=11	54,735,491.40	
	13 % VAT of 8=12	71,156,138.82	
	Total cost=8+9+10+11+12=13	**749,876,232.17**	
	Cost Per Km	**56,637,177.66**	

Total Project Cost:
NRs. 749,876,232.17 (Without Bridge and Property Acquisition Cost)

(In Words: Seventy Four Crores Ninety Eight Lakhs Seventy Six Thousands Two Hundred Thirty Two Rupees and Seventeen Paisa only).

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1. INTRODUCTION

1.1. Project Background

Nepal's urbanization process is rapid and imbalance compared to regional context. This trend is concentrated mainly in Kathmandu Valley and other cities of terai or fertile Valleys. The result is that the large cities are failing to cope with the demand of infrastructure services and job opportunities and are increasingly reeling under the externalities of the haphazard urbanization. Environmental degradation, congestion, urban poverty, squatter settlements, unemployment and lagging provisions of infrastructure services have become increasingly visible phenomenon in these large cities. Hence, much of the economic gains acquired from urbanization have been eroded from its negative externalities. Despite non-agricultural sector being a major contributor to gross domestic product (GDP), urban centres in the country have yet to emerge as the engines of economic growth and contribute to reduction of urban or rural poverty alike.

Government of Nepal has already enacted and has been implementing National Urban Policy since 2007 and National Urban Development Strategy, 2016. The policy is prominent by prioritizing investment to the lagging regions of the country, while fostering development of regional cities and intermediate towns as well. Therefore, with an objective of reducing poverty and increasing urban physical facilities, GON has prioritized to invest in 90 emerging municipalities in country. Among 90 Municipality Narayan Municipality is one of the proposed Municipality for preparing Integrated Urban Development Plan including Building Bye-Laws of Government of Nepal.

Main goal for preparing IUDP is to make the vision operational, necessary development principles to guide the sectoral activities of the municipality and principles should be formulated in consultation with Municipal body, local stakeholders etc.

Detail engineering design of prioritized Major Projects: in order to prepare reliable project banks for the recent execution of 2 different projects and the cost estimate of each project should not be less than 30 crore.

Therefore, we prepared two numbers of different projects DPR.

1. Road Project
    A. Upgradation of Upgradation of road - "Dailekh-Mahabu-Jumla Road" Road (DED1)
2. Tourism developmentmaster plan, Pallo Kalimati, ward-03 (DED2)

From above, this report covers detailed project report of road projects.

1.2. Location, Zone of Influence of the Project and its Socioeconomic Status

1.2.1. Location

The proposed road alignment lies in Dailekh district of Narayan Municipality, Karnali Province the alignment passes through many, settlement areas, cultivated land, and crosses many major and minor river crossings, plain terrain, of Narayan Municipality. The studied alignment is in table:-

Table 1: Location of road alignment

S.N	Name of Road	Starting Point	End Point
1	Upgradation of road - "Dailekh-Mahabu-Jumla Road"	Location: Dailekh Easting: 570494.6 Northing : 3192124 Elevation : 1431.3	Location: Bhawani Easting: 572157.4 Northing : 3200311 Elevation : 1597.51

(All Dimensions are in meter)

Figure 1: Location Map

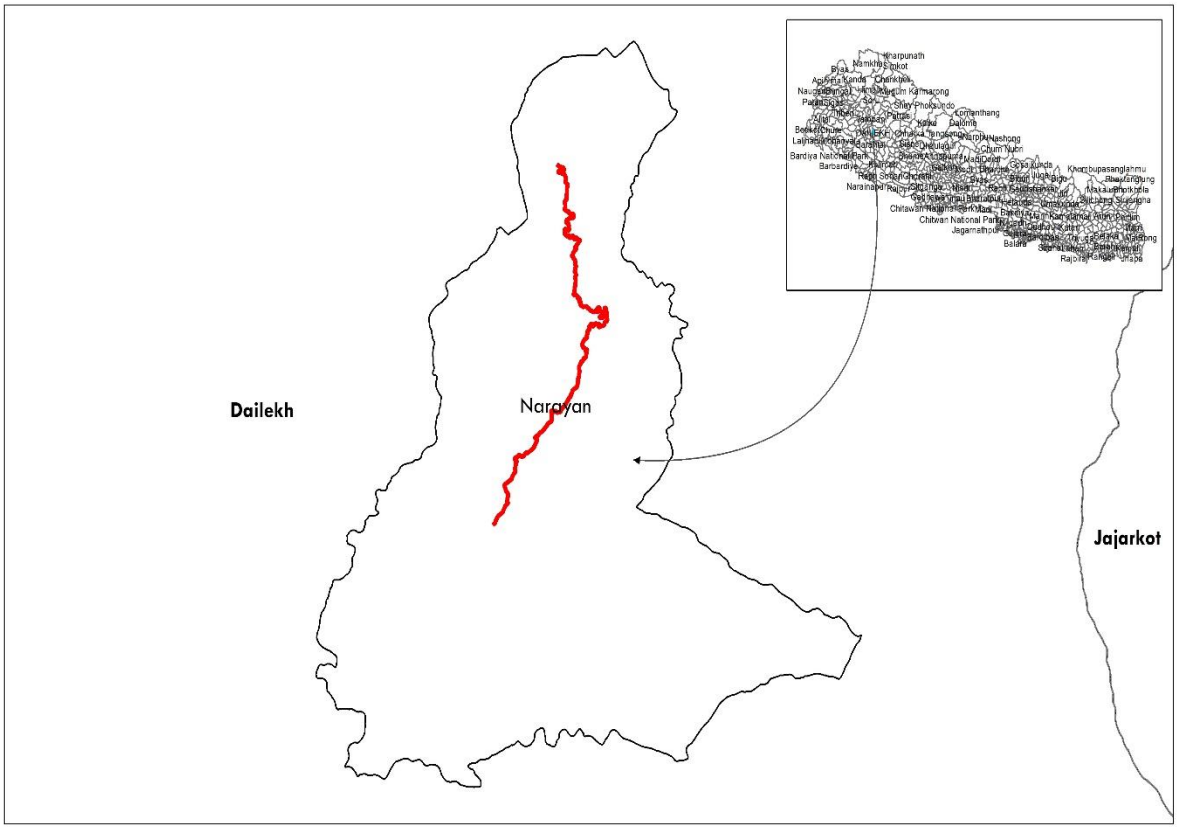
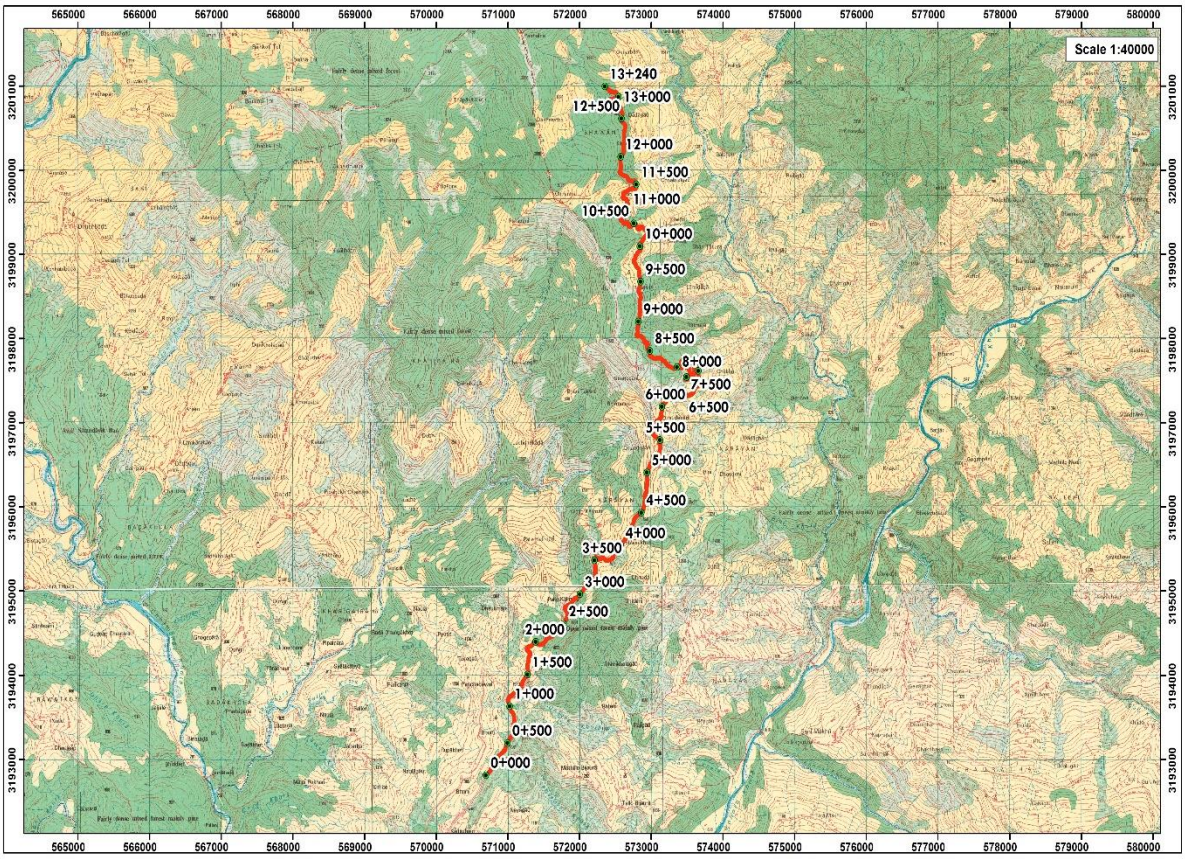


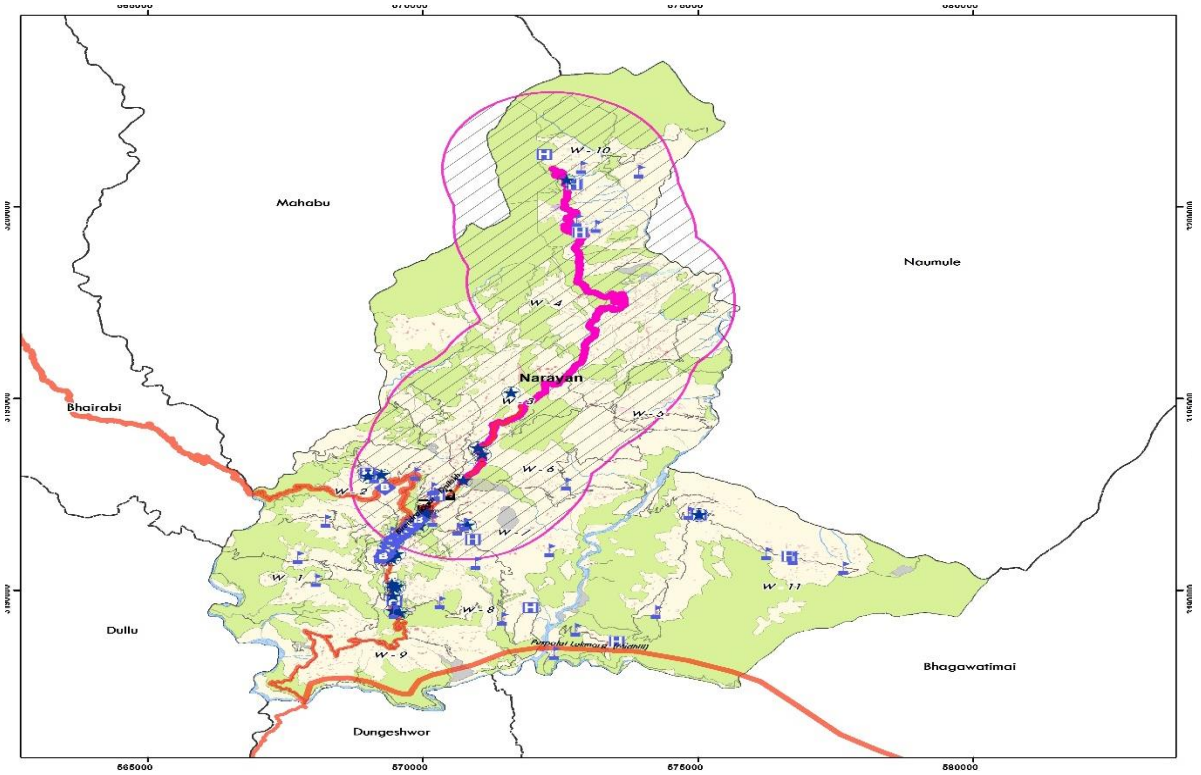
Figure 2: Road Location of Upgradation of road - "Dailekh-Mahabu-Jumla Road"



1.2.2. Zone of Influence of the Project and its Socioeconomic Status

The Identification and Prediction of impact shall be carried out by considering the proposed Project actions/activities in terms of rehabilitation and constructions of road project. The impact of the activities shall be on bio-physical, socio-economic and cultural resources in a defined Zone of influence (i.e. one hour walking distance from the road alignment).

Figure 3: Zone of Influence



1.2.3. Socio Economic Status

1.2.3.1. Demographic data

According to census 2011, it was reported that population of Narayan municipality is 27038 among them 12645 is male and 14392 are female. Sex ratio of this municipality is 113.81% and total household of this municipality is 5791.

According to survey by local volunteer of this municipality, among them all, ward 1 has the highest population of 3,580 whereas the lowest population was found in ward 8 with population of 1704. The average household size of the Narayan municipality is 4.67.

Table 2: Demography based on Ethnicity, Religion and Disability

S.N.	Population according to	Description
1	**Ethnicity**	As per the census 2011, the major ethnic/caste group of Narayan Municipality is Chhetri whose population is 10808 of total population. The second major ethnic/caste group is Kami whose population is about 3801 of total population. Brahmin has population of 2978 total population. Similarly, the other major ethnic/caste groups Magar, Gurungm Damai, thakuri, Sarki Newar Sanyasi and so on.
2	**Literacy Rate**	Literacy is defined as being able to read and write, or having knowledge about a specific subject. Literacy is further categorized in four categories i.e. can read and write, can read only, can't read and write and not stated. The literacy rate of the municipality was 51% which is lower than national average literacy rate (68%), whereas 19% of the total population aged 5 years and above of the

S.N.	Population according to	Description
		municipality were illiterate. Out of the literate population aged 5 years and above, 59% were male which is15% higher than the female literacy rate (44%).
3	**Disability**	According to the Census 2011,217 of total population of Nepal has some kind of disability in Physical. 117 in Blind, and 7 is Hear Disability.However, a number of organizations suggest that the actual figure is far higher. People having an illness, injury, or condition that makes it difficult for them to do the things that other people do are disabled people. People who are mentally unstable, physically impaired, cant listen, watch or both, people suffering from Autism, can't speak etc are disable people.

1.2.3.2. Physical Infrastructure

This data gives information about the physical form of infrastructure and services existing in this municipality. Table below shows the brief introduction of the different physical data existing in this municipality.

Upgradation of road - "Dailekh-Mahabu-Jumla Road"

Table 3: Physical Infrastructure

S.N.	Physical data	Description
1	**Road**	All the 11 wards of the municipality are connected by earthen roads while 12 km black topped road, 27 km gravel road, 1.5 km PCC road and 142 km earthen road have already been constructed. Similarly, 728 m blacktopped road, 7 km gravel road and 42 km earthen road is under construction. The municipality plans to construct a city chakrapath of 35 km length and 8 m width. However, the conditions of roads are not good and it is necessary to upgrade the quality of roads. Table below shows different roads existing in the municipality, classified based on the road surface
2	**Water supply**	Access to safe drinking water supply and sanitation services is fundamental to improving human health and meeting national poverty reduction objectives. Narayan Municipality is surrounded by rivers and immense water source but it faces problem of drinking water. Drinking water is accessed through (i) Tap or piped water, (ii) Tubewell or hand pumped water, (iii) Covered well or kuwa, (iv) Uncovered well or kuwa, Spout water and River or stream water and so on. About 62.62 percent of household is dependent on pipe water, 16.58 percent is dependent on kuwa and 16.78 percent on tap water. There are two water supply projects currently running in the municipality which are: Sahare Water supply project and Majhuwa water supply project.

S.N.	Physical data	Description
3	**Sanitation/Sewerage**	Sanitation is the effective use of tools and actions that keep our environment healthy. According to National Population & Housing Census 2011 (Village Development Committee/ Municipality), In Narayan, the condition of sanitation is not satisfying. About 62.5% of the population does not have any toilet facility. This data shows that the sanitation condition of the municipality needs the attention of the government. Public awareness is must for the improvement of this situation.
4	**Electricity**	According to census 2011, 54.29% are using electricity and rest of using Kerosene, Bio- gass and household are using Solar as their main source of lightening.
5	**Tele-communication**	Landline, internet, television, FM radio, newspaper, etc. are the major means of information and communication in the municipality. All the wards of Madhuwan municipality have access to mobile networks. NTC tower, Transformer, Ncell tower, Mobile towers have been installed at all wards. Besides 2G, 3G services are made available through mobile networks internet are used through internet providers like World link, Broad link etc. Postal services are also available. Dish home and few local cable networks provide television service. Locals here have access to regional and national radio programs and newspapers. Telephone, G.S.M, Mobile, CDSM, email etc services are available in Madhuwan Municipality.. There is one post office in the municipality.

1.2.3.3. Institution Information

Table 4: The social data of this municipality gives existing social information.

S.N.	Social data	Description
1	**Education**	Education is very important for the development of the Municipality. Total literacy population of the municipality is 27038. Male literacy rate is 10325 However, the female literacy rate is far lower which 9337. Sufficient, secure and quality infrastructures with sufficient subjects and level wise teachers are the basic requirements for right to education. Fundamentally, the school buildings, classrooms, drinking water, toilets, playground, library and laboratory are considered here as educational facilities. Dailekh Technical School, Samata School, Shree Balmandir Prathamik Vidyalaya, Shree Janata Basic School, Sunrise B. School, Shree Redcross Ma. Vidyalaya,Kalika Boarding School, Shree Fulbari Vidyalaya mandir, Basantamala School, Narayan Compus, Janata Aadharvut Vidyalaya, Shree Malika Samudayik Sikai Kendra, Bara bhairav Aadharvut Vidyalaya, Rainadevi Ma. Vidyalaya, Tribhuwan Primary Vidyalaya, Saraswati Pra. Vidyalaya etc are the education institutions in Narayan Municipality.
2	**Health**	Most of the people of this municipality are having their health check-up in their nearby health post, health centers and medical.Among them most of the people are going to healthpost and medical for their simple health checkup. But there is also old myth that people can be cured with the help of Dhami and jhakri. So people from some community are still approaching them. Again according to the survey of this municipality, it was reported for chronic disease most of the people of this municipality are going medical Sufficient, secure and quality infrastructures with sufficient subjects and level wise teachers are the basic requirements for right to education. Fundamentally, the school buildings, classrooms, drinking water, toilets, playground, library and laboratory are considered here as educational facilities District Public Health office, Government Hospital, District Ayurbedic Pharmacy, Ayurved Centre, Health Post, City Health Kendra Pharmacy and Polyclinic etc are the Health institution in Narayan Municipality. Health is wealth. So, improvement of health facilities should be major priority in order to develop the municipality. The municipality consists of 15 bed district hospital, 1 primary health centre, 3 sub-health posts and 1 city health centre
3	**Culture and Tourism**	They observe different festivals like Dashain, Tihar, Teej, Maha Shivaratri, Maghe Shankranti, Buddha, Poornima, Ubhauli,etc.

S.N.	Social data	Description
		Narayan Municipality's major tourist includes religious sites and sighting. Like; Kalika mandir, Radha Krishna mandir, Ram janaki mandir, Mahadev agni kunda, Church, Haliman, Shiva mandir, Durga mandir, Malkumari, Devi mandir, Sarswati mandir, Krishna mandir etc are the tourist are in Narayan municipality .

1.2.3.4. Economic Information

The people of this municipality are involved in different occupation for income generation.. Some of economic infrastructure of this municipality are as follows:

Table 1: Economic infrastructure

S.N	Economic	Description
1	**Agriculture, animal Husbandry and Industries**	Narayan has great potential for financial development. Most of the land are cultivable which is plus point for the municipality. This place has high possibility of Irrigation projects as most of the people are farmers. Fruits, vegetables, food crops etc are cultivated here. Potatoes, Paddy, Wheat, Maize, Millet, Barly etc are the cultivation . Livestock are regarded as one of the major assets of farm households. Livestock are primarily reared for draught power cultivation and transport, with the latter also providing milk and meat for on-farm consumption and opportunity sales. However commercial livestock farming is deployed by people for additional income sources. Some Cow, Goat and Pig/Swine and poultry farming are established in this municipality.
2	**Financial Institutions**	Financial institutions, cooperatives and banks are located in Narayan a Municipality bazaar area. Similar is the case for NGOs, INGOs and social institutions, these institutions, when available are concentrated in Narayan Municipality Bazaar area. Krishi Gyan Kendra. Dailekh Jilla Adalat, Dictrict Police office, Nepal Khadya Sanstha, pashu sewa Centre , Shree Malika Samudayik Sikai Kendra , Sundar Nepal Sanstha , National Cooperative Bank, Nepal life insurance, NMB bank, Prabhu Bank, Rastriya Banujya Bank Shikhar Insurance Company, Siddhartha Bank, Prime life Insurance , etc are the Financial institution of Narayan Municipality.
3	**Culture and Tourism**	They observe different festivals like Dashain, Tihar, Teej, Maha Shivaratri, Maghe Shankranti, Buddha, Poornima, Ubhauli,etc. Narayan Municipality also consists of vast forest which can be utilized as a tourist destination forest sightseeing. If the tourist areas can be developed in the Municipality, it can generate revenue through tourism and provide the employment facilities to the locals.

1.3. Project Rationale

The proposed Project:

- **is consistent with and supportive of the Government of Nepal,** , Department of Roads, Planning and Monitoring Branch, Planning Monitoring and Evaluation Unit.
- helps in development of roads to connect economical potential areas.
- alongside the ones being carried out by the Government of Nepal, will provide a more complete coverage of infrastructure needs in the country.
- shows alignment with its modification and connecting Narayan Road, bridge locations, potential economical areas, stretch wise status of implementation.

Existing Road Condition

The length of proposed road is 13.240 Km. Dailekh-Mahabu-Jumla Road is, 26 feet width with Gravelled There are among five major settlements along the road and most of the alignment passes through the municipality road. The proposed road is seriously lacking many factors.

The existing road conditions are as follows:

- Lack of road system and hierarchy.
- Unpaved road in poor condition in terms of narrow width broken pavement in carriage way.
- Lacking proper side drain and cross drainage structures.
- Clogged drainage pipeline
- Uncomfortable footpath
- Lack of safety facilitate such as street light, signal board.

Expected benefit of the project

- Connecting 1 highways so that providing easy access into the urban place.
- Formulating urban spatial structure with land use plan.
- Propose phrasal road development plan
- Identify priority arterial road for implementation
- Catalytic spill-over effect into the improvement of road network.
- Encourage traffic flow both in-and intra municipality
- Enhance the urban economic development

Significance

The proposed road alignment has got very important significance in terms of Municipality. The main objectives of the study are:

- To investigate alignments in terms of socio-economic factors, topography, geology, environmental aspects, other related factors, etc.
- To perform alignment detailed survey and design.
- To perform socio-economic and traffic study.
- To suggest the option of upgrading and design accordingly.
- To develop an environmental mitigation plan to reduce environmental impacts due to the road activities.

- To prepare a detailed project report of the stated road based on sound techno-economical approach.

Connection with road network

The road connects Ratna Rajmarga. Therefore, proper implementation of this road alignment will be very much beneficial for infrastructure development as well as the socio-economic development of Nepal.

2. SURVEY AND INVESTIGATIONS

Based on the Political map, topographical map and desk study was carried out. From the desk study tentative information of topography of the project area, the alignment of road, settlement along the road corridor, nearest GPS point, material site, nearest market etc was carried out to make the survey and other field work easier. Prior to Commencement of work for detail survey a meeting was held with Municipality Staffs about the survey work which was followed.

2.1. Traffic Study

Traffic data plays a vital role for any Road project. The proposed road would connect the Dailekh Bazaar. Also, Road will connect Ratna Rajmarga. The people from the nearby settlement will be directly benefitted from this project.

The existing traffic flow and traffic growth rate can be taken as fundamental for the traffic forecast. To determine the present traffic volume manual count was conducted at different road section as mentioned below. Bus, Truck, Jeep, Tractor, Car, Bike, Pedestrian, Porter, etc. are the existing type of t**r**affic on the route of the proposed alignment.

Table 6: Nos. of Vehicle for East West Highway

S.N.	Types of Vehicle		Nos. of Vehicle
1.a	Truck	Multi-Axle	0
1.b		Heavy	13
1.c		Light	30
2.a	Bus	Big	10
2.b		Mini	33
2.c		Micro	14
3	Tractors	Tractors	40
4	Car	Car	14
5	Motorcycle	Motorcycle	77
6	Utility Vehicle	Utility Vehicle	27
7	Three Wheeler	Three Wheeler	0
8	Four Wheel Drive	Four Wheel Drive	34
9	Power Tiller	Power Tiller	9
10	Auto Rickshaw	Rickshaw	0
11	Non-Motorized Cart	Bullock Cart	0
Total			**301**

2.1.1. Existing Roads and Traffic flow

Presently, normal traffic flow Upgradation of road - "Dailekh-Mahabu-Jumla Road"occurs along the proposed road alignment. The existing road is servicing the traffic in both season. The field team has recorded traffic volume directly at some nodal points. Further, traffic volume varies from season to season. When the consultant preceded the field survey, there is good movement of vehicles and pedestrians due to relatively good road condition. The reliability of traffic count is checked with the interview of local people, some DoR & traffic office.

The Average Daily Traffic (ADT) obtained from the survey needs adjustment to determine Annual Average Daily Traffic (AADT). The seasonal factor was taken as 0.91

for this project based on the DoR publish Documents on the traffic volume and 7% growth rate.

2.1.2. Traffic Estimation

2.1.2.1. Normal Traffic

Future traffic volume basically depends upon the two factors population growth rate and development in the agricultural as well as local productions. The population growth rate of the influence area is 1.49% annually.

2.1.2.2. Future Traffic

The normal practice in road construction is anticipating future traffic with a base to present traffic and arrive at the parameters and standard of the road. It should be noted that at least 10-20 years ahead planning should be done with the present mode of data. For our purpose, we have taken 15 years after the completion of the project that the anticipated traffic will play on it. Hence, we assume that up to the next 20 years the road will be sufficient for traffic volume. Three types of traffic that is normal, development and generated traffic and diverted traffic are to be considered for future traffic generation. The proposed roads traffic forecast will be high as the proposed road will link/connect the road at Narayan Bazaar as well as the road will link to major markets and service centre of the project area. The population growth rate of the influence area is 1.49% according to the census 2011 which is not sufficient enough for the traffic growth rate So, the traffic growth rate (r) in the project area is taken as 7% (r=0.07).

Normal Traffic: It is the traffic that would occur on existing of planned Road in absence of the project. The normal traffic is calculated as given below.

$N1 = N (1+ i)^n$ Where,

N = No. of traffic at present

n = No. of Years

N1 = No. of traffic obtained after n years

I = Growth rate of traffic considering the growth rate of population

In our case, the population growth rate of Project district is 1.49% (Considering National Growth Rate)

Passenger Car Unit & Traffic Forecast: The traffic coefficient for different types of vehicular traffic taken passenger car as a unit is given below.

Traffic Coefficient

S. No	Description	Transport Units (T.U.)
1.	Car, light vans and pick-up	1.0
2.	Truck 10 ton gross	3.0
3.	Buses (45 passenger)	3.0
4.	Pedestrian where no separate footpath is provided	0.25
5.	Porters where no separate footpath is provided	0.50

Traffic Projection for 20 Years:

a. The population growth for the areas is taken as that of Narayan Municipality i.e. 1.49% annually. The number of passengers is calculated based on the growth rate of 7%. The number of bus assuming a bus carries 45 passengers.

b. A number of light vehicles mostly depends upon the government offices tourist etc. A growth rate of 7 % will be sufficient to anticipate it.

The growth rate is assumed as mentioned earlier. Nos of development and generated traffic is taken for light vehicles as 7% growth rate of normal will take care of it. The traffic projection for 20 years from the opening of traffic is shown below:

Table 7: Traffic Data Forecasting for Upgradation for Upgradation of road - "Dailekh-Mahabu-Jumla Road"

S. N.	Vehicle	Type	Manual 2019 Traffic Count (Both Direction)	Growth Rate 7% (Trend Analysis)	2 Yrs Construction Period 2021 Traffic Forecast with 7% Growth Rate (A)	Divert from Other Roads (B)	Sum of Normal + Diverted Traffic (C=A+B)	Generated Traffic due to Road Improvement (1-20 Years) (D)	Total Traffic (E = C+ D)	PCU (F)	ADT 2021 in PCU (G=E*F)	ADT in PCU for 20 Years Forcast 2041 (H)
1	Truck	Multi-Axle	0	0.07	0	0	0	0	0	4	0	0
2		Heavy	13	0.07	15	8	0	0	0	3	0	0
3		Light	30	0.07	34	22	12	14	26	1.5	39	151
4	Bus	Big	10	0.07	11	5	0	0	0	3	0	0
5		Mini	33	0.07	38	21	59	68	127	3	381	1474
6		Micro	14	0.07	16	9	25	29	54	1.5	81	313
7	Tractors	Tractors	40	0.07	46	28	55	63	118	1.5	177	685
8	Car	Car	14	0.07	16	7	23	26	49	1	49	190
9	Motorcycle	Motorcycle	77	0.07	88	52	80	92	172	0.5	86	333
10	Utility Vehicle	Utility Vehicle	27	0.07	10	17	27	31	58	1	58	224
11	Three Wheeler	Three Wheeler	0	0.07	0	0	0	0	0	0.75	0	0
12	Four Wheel Drive	Four Wheel Drive	34	0.07	39	21	60	69	129	1	129	499
13	Power Tiller	Power Tiller	9	0.07	10	3	13	15	8	1.5	12	46
14	Auto Rickshaw	Rickshaw	0	0.07	0	0	0	0	0	1	0	0
15	Non Motorized Cart	Bullock Cart	0	0.07	0	0	0	0	0	6	0	0
	Total ADT in PCU for 20 Years											**3915**

Note: Additional traffic which occurs in response to the provision or improvement of the road. Generated traffic arises either because a journey becomes more attractive by virtue of

a cost or time reduction or because of the increased development that is brought about by the road investment. Generated traffic is difficult to forecast accurately and can be easily overestimated. The consultant has assumed the generated traffic will be about 15% of sum of normal and diverted traffic.

Total Traffic Upgradation of road - "Dailekh-Mahabu-Jumla Road"= Normal Traffic + Diverted Traffic + Generated Traffic=3915 ADT in vpd

As the 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. AADT in PCU for 20 years forecast is calculated as 3915 which lies between ranges 3000-5000. So, the studied road is classified as Class II (NRS 2070).

2.1.2.3. Axle loading

An accurate estimate of the current traffic loading is essential for 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 not rational 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 tonnes (80 KN). In Nepal, the legal axle load limit is 10.2 tonnes. Axle load surveys have been carried out as per the 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.

2.1.2.4. 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 an 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 arrives 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 8: Vehicle Damage Factor

S.N.	Vehicle Type	VDF
1	Heavy truck (three axles 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

2.1.2.5. Equivalence factor

The damage that vehicles do 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 tonnes (80 kN) 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 (esa). 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 $EF = \left(\frac{Axle\ load, kgf}{14968\ kgf (146.8kN)} \right)^4$

Note: As traffic forecast is made for 20 years after completion of road construction with 7% annual growth rate. As the road is existing and the only improvement is being done in this road project, it is assumed that 7% growth rate in normal traffic will accommodate for diverted and generated traffic so no any separate calculation is made for diverted and generated traffic.

2.1.2.6. Distribution of commercial traffic over the carriageway

Total traffic AADT (both way) is distributed over the whole carriageway for the 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 a total number of commercial vehicles in both direction.
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 the significant difference between the two streams can occur, condition in the more heavily trafficked lane should be considered for design.

When the distribution of traffic between the carriageway lanes and axle loads spectrum for the carriageway 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 carriageway width.

2.1.2.7. Computation of Design Traffic

The design traffic is considered in terms of a 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
F = Vehicle damage factor (as shown above VDF table)
n = Design life in years = 15 years
r = annual growth rate of commercial vehicle

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 = No. of years between the last count and year of completion of construction (3 years).

2.1.2.8. 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 a 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 7 Days.

2.1.2.9. Traffic Volume count in 7 Days (Sample)

Table 9: Traffic Volume Count Sample

Result of Classified Manual Vehicle Count

Start Date: 3 Location:
Road Link: Station:
Name of Road: Station No.:
Seasonal Variation Factor for the Month of Surveyed By:
Day 1 Date:

Date	Start Time (Hrs.)	Volume of Vehicles																														
		Truck						Bus						Car		Motor Cycle		Utility Vehicle		Tractor		Three Wheeler		Rickshaw		Bullock Cart		Four Wheel Drive/Jeep,Van		Power Tiller		Total		
		Multi Axle		Heavy		Light		Big		Mini		Micro																					
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	6:00-7:00																																	
	7:00-8:00																																	
	8:00-9:00																																	
	9:00-10:00																																	
	10:00-11:00																																	
	11:00-12:00																																	
	12:00-1:00																																	
	1:00-2:00																																	
	2:00-3:00																																	
	3:00-4:00																																	
	5:00-6:00																																	
Sub total for 12 hr.																																		
Sub total (a+b)																																		

(Details are attached in Annex)

2.2. Hydrological Study

Hydrological studies have been carried out for estimating design flood flows for the design of road drainage system and are given below:

- All relevant meteorological (rainfall and temperature) data were collected
- River and its river system are described and catchment area was calculated.
- Collection and review of previous reports and studies were done.
- Desk study on topographical maps and aerial photographs were
- Investigations about flood marks in streams and actual locations of waterways during a field visit.
- Identification of erosion-prone areas during the field visit
- Verification of drainage locations with survey, inventory and field visit data
- Delineation of watershed boundary and determination of drainage area from topographical maps
- Frequency analysis of relevant stream flow data
- Frequency analysis of maximum daily rainfall at relevant stations
- Establishment of IDF (Intensity-Duration-Frequency) curves for different road sections
- Establishment of catchments and channel characteristics (time of concentration and runoff coefficient)
- Estimation of flood flows for adopted return periods by different methods
- Comparison and selection of design discharge for cross and side drains
- Design of cross and side drains.

2.2.1. Hydrology:

General Introduction

Detailed hydrological study at the proposed river crossing has been carried out to find out the hydrological design parameters required for the design of cross drainage structures. The catchment area is estimated from the topographical map and ARCGIS 9.3. The high flood discharge was estimated for the return periods of 50 years.

Catchment Characteristics

The coordinate of the outlet point of the catchment in the river crossing is taken from the field. The catchment is delineated from ARCGIS 9.3 and the catchment area at the outlet point is estimated. The length of the stream from its head to outlet point is determined.

Study Approach

Although the rainfall measuring stations in Nepal are established nearly during the sixties the rainfall data is not continuously available. Since the short period of the data will not provide a better result for the frequency analysis, which requires a minimum 30 years data. Hence, to solve the problem the appropriate rainfall data are collected.

Estimation of peak flow

The high flood discharge is estimated by using different approaches. They are as follows:

Water and Energy Commission Secretariat (WECS) Approach

The Water and Energy Commission Secretariat (WECS) has developed an approach to estimate the flood flows in any ungauged catchment area below 3000 m elevation. The 2 years (Q2) and 100 years (Q100) return period floods are given by:

Q_2 = 1.8767 x (area below 3000 m + 1) $^{1.183}$

Q_{100} = 14.63 x (area below 3000 m + 1) $^{0.7342}$

The flood for any return period of R years is given by:

$$Q_R = e^{(lnQ_2 + s\sigma)}$$

Where, s = standardized normal variable for a particular return period, R

$$\sigma = \ln\left(\frac{Q_{100}}{Q_2}\right)/2.326$$

Table 10: Values of S for Different Return Periods

Return period	2 yrs	5 yrs	10 yrs	20 yrs	50 yrs	100 yrs	200 yrs
S	0	0.842	1.202	1.645	2.054	2.326	2.576

Dicken's Method

The flood flows for T years of return period can be estimated by Dicken's method as;

$Q_T = C_T A^{3/4}$

Where, $C_T = 2.342 \log(0.6T)\ log\ (1185/P) + 4$

$P = \left(\frac{a+6}{A+a}\right) * 100$

a = Perpetual snow area in sq. km.

A + a = Total catchment area in sq. km.

Medium Hydro Study Project

The Medium Hydro Study Project (MHSP) under the Nepal Electricity Authority (NEA) in 1997 developed a method to predict flood flows at ungauged sites through regional regression technique. The MHSP method has been used to estimate flood flows of 66 hydrometric stations, which were obtained from DHM are used in the regression analysis. The input variables are similar to those used in WECS/DHM method. Regression Coefficients for flood peaks are used for the bridge.

$$Q = K\ A^n$$

Table 11: Regression Coefficients for Different Return

Return Period	K	n
5	1.6762	0.966
20	3.2303	0.9281
50	4.609	0.9071
100	5.9865	0.8888

HFL calculation

Rating curve of the bridge site is developed with the slope-area method. The river profile and cross sections of the river are surveyed during the field study. The resulting water level for the flood is computed.

Waterway width

Linear waterway is defined as a width of the waterway between the extreme edges of water surface at H.F.L. measured at right angles to the axis line. Likewise, the effective linear waterway is the total width of the waterway of the bridge at H.F.L. minus effective width of obstruction. This waterway width can be determined by two methods.

Lacey's Formula,

Linear waterway $W = 4.75\sqrt{Q}$

Where Q = Flood discharge

Kellerhals's Formula,

Linear waterway $W = 3.26\sqrt{Q}$

Where Q = Flood discharge

In the case of hill region, River bed consist of gravel and boulders, thus the waterway adopted by Kellerhal's method and seems to be reasonable in this type of river.

Side Drain and Cross Drainage Design

The cross-drainages are constructed in the form of Culverts, Floodway's and Side Drain. The choice of the structures depends on the design discharge, anticipated sediment loads, the configuration of flow, foundation condition, ease of construction and cost of structures. Out of the many types of the culverts, the choice depends on the local topography, sediment load, availability of material and costs. Mainly masonry concrete box culverts and concrete or masonry floodway's are considered for the design of the cross drainages.

The hydrological data are obtained from the Hydrology Chapter of this report. The data are precisely derived and the cross drainage structures and side drains are designed based on these data. The hydrology report gives the data of flood estimation derived using the different Method. The catchment area is the only variable factor for the calculation of the discharge for each of the streams or watercourses.

As shown in the hydrology report, each natural drain or gully has a different catchment area Thus having different flood discharges. This will require many sizes of cross drains on the road. It is not practicable to design cross drain for each of these gullies. It is not only practicable but also not economical to provide cross drain of many sizes. Therefore, the discharges from the hydrology report are grouped together. The maximum value of discharge of each group shall be taken for design purpose. For the seasonal water ways carrying flood water during monsoon season, causeways could be designed as cross drains. Causeways are proposed at the places where the location is appropriate for it and unsuitable for other types of culverts.

Analysis for Maximum 24 hours Rainfall (Gumbel's Type I Extreme Distribution Function)

Table 12: Maximum 24 hours of Rainfall (Gumbel's Type I Extreme Distribution Function)

Analysis for Max 24hr rainfall (Gumbel's Type I Extreme Distribution Function					
S.N.	**Description**	**Symbol**	**Value**	**Unit**	**Remarks**
1	Average	Q_{avg}	68.40	mm	
2	Standard Deviation	s	10.77	-	

Table 13: Maximum 24 hours of Rainfall Data for Various Return Periods

S.N.	Return Periods T (Years)	Reduce Variate (Y)	Maximum 24 hr Rainfall (mm) (R24)	Remarks
1	2	0.367	117.0	
2	5	1.5	127.5	
3	10	2.25	154.1	
4	25	2.97	174.0	
5	50	3.902	186.6	

S.N.	Return Periods T (Years)	Reduce Variate (Y)	Maximum 24 hr Rainfall (mm) (R24)	Remarks
6	100	4.6	194.6	
7	200	5.296	258.3	

Design of Side Drain and Culverts:

The discharge in a drain is computed from the rational formula

Q = 0.278*C*I*A

Where,

Q = Discharge in m^3/s

C = Run off Coefficient which is taken 0.30 for side drain and 0.40 for pipe culverts.

I = Intensity of Rainfall in mm/hr.

A = Catchment area in sq.km.

Run off Coefficient:

Run off Coefficient which is taken 0.30 for side drain and 0.40 for culverts.

Therefore,

Run off Coefficient (C) = 0.30 for side drain

Run off Coefficient (C) = 0.40 for culverts

The intensity of Rainfall:

The intensity of Rainfall is calculated from a given table for a return period of 10 years.

Table 14: Maximum 24 hours of rainfall data for various return periods

S.N.	Return Periods T (Years)	Reduce Variate (Y)	Maximum 24 hr Rainfall (mm) (R24)	Remarks
1	2	0.367	117.0	
2	5	1.5	127.5	
3	10	2.25	154.1	
4	25	2.97	174.0	
5	50	3.902	186.6	
6	100	4.6	194.6	
7	200	5.296	258.3	

The rainfall intensity for a return period of 10 years is 154.1 mm and for 25 years is 174.0 mm in 24 hours.

Therefore,

Intensity of rainfall for side drain (I) = 6.4207 mm/hr.

Intensity of rainfall for side drain (I) = 7.2486 mm /hr.

Catchment Area:

Catchment Area is taken for side drain as 200m from point of entry to side drain and 500m alongside drain assuming that there is a cross drainage structure at every 500m interval. Similarly, Catchment Area is taken for the cross drain as the longest length of stream or watershed is 1.0 km beyond the road with covering distance 100m.

Therefore,

Catchment Area for side drain (A) = 0.049 sq.km.

Catchment Area for cross drains (A) = 0.049 sq.km.

Design Discharge:

Design Discharge for side drain (Q) = 0.278*C*I*A
= 0.278*0.30*6.4207*0.049
=0.0262 m^3/s

Design Discharge for cross drain (Q) = 0.278*C*I*A
= 0.278*0.40*7.2486*0.049
= 0.0395 m^3/s

Hydraulic Design of Side Drains and Cross Drains

For the design of the cross drainages over watercourses, and the road side drains, discharge for a return period of 25 and 10 years is taken into consideration. The hydrological study has determined the discharges, of 25 and 10 years return period, for all significant watercourses along the road. Other streams or watercourse also need to be bridged to allow the water to flow through even if the discharge is insignificant. The result of the discharges is given in hydrology report. The objective of the hydraulic design is to determine the size of the culvert over the watercourse so that the estimated discharge flow freely through it.

To determine the size of the slab or box culverts and the side drains, to allow the design discharge of a stream to flow freely through it, Manning's formula is used. For this purpose, allowable discharge capacity of different sized culverts and side drains are determined using the formula.

The Manning's formula is as follows:

V = 1/n*R2/3 *S1/2 Where,

V = velocity in m/sec

n = coefficient of surface roughness which depends on the roughness of the surfaces. It is generally taken as 0.018 for slab culverts having a concrete bottom slab and rubble masonry side walls and it is 0.016 for culverts having all sides of formed concrete.

R = Hydraulic Radius in meters

= Aw/Pw

Aw = Area of flow cross section in m^2

Pw = Wetted Perimeter in m

S = Slope of energy slope of channel, which is roughly taken as slope of culvert bed and drain in %

Finally, the discharge is calculated using the formula,

Q = V*Aw Where

Q = discharge in m^3/s

For calculating the discharge capacity of the open or covered Semi- Trapezoidal, rectangular and right triangular or tick drains, same formula as above is applied.

Using the above formula, the allowable discharge capacity of the slab and box culverts and a different section of road side drain with different slopes, are determined and given in tables below. Generally, a free board of 0.6m is provided for the slab and box culverts while determining the discharge capacity. The size of the slab or box culverts and its free board depends in the topography of the stream, design profile of the road, expected sedimentation load, debris flow and location of the culverts such as culverts in valleys, mid-hills and the ridges.

The slope of the culvert bed is limited to a maximum of 3% because slopes exceeding this value may generate the excess velocity of flow to cause erosion at the outlets, requiring additional erosion control measures. For design purpose, the bed slope considered is 3% and the resulting allowable discharges are taken for all types of culverts.

However, the road side drain slopes are determined by the road profile gradient. Therefore, the drains will have the same slope as the road gradient. The steeper slopes of the drain, cause the water to flow in higher velocity than the shallower slopes. Higher the velocity of the flow higher will be the discharge capacity of the drain and higher the probability of erosion. Therefore, to counter erosion, concrete is recommended as the bedding of side drains.

For the design of the road side drains, Manning's formula is used with different longitudinal

Slopes The discharges for a rectangular section of side drains are calculated. The discharge capacities of these sections are calculated for different slopes ranging from below 1% up to 12% depending upon the road gradient. The calculated discharges for different slopes are given in tables for both types of side drains.

Table 15: Allowable Discharge Capacity of Rectangular Side Drain

S. N	Description	Top Width (w) m	Bottom Width (b) m	Depth (d) m	Wetted Area (Aw)	Wetted Perimeter (Pw)	Hydraulic Radius (R) m	Roughness (n)	Slope %	Velocity (V) m/sec	Discharge (Q) cum/sec
1	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.01	0.015481004	0.02502
2	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.02	0.043786892	0.02502
3	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.03	0.080441656	0.02502
4	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.04	0.123848032	0.02502
5	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.05	0.173082887	0.02502
6	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.06	0.227523363	0.02502
7	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.075	0.317973567	0.02502
8	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.08	0.350295133	0.02502
9	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.09	0.417987108	0.02502
10	Rectangular Drain	0.1	0.6	0.5	0.3	2.2	0.136363636	0.017	0.1	0.489552331	0.02502

Recommended for Side Drain

Rectangular side drain is proposed on both sides of the road the size of the drain is proposed to be 0.5*0.6 to drain out the water from hill side.

Recommended for Cross Drains

The size of lab culverts proposed matches with the calculated discharge with adequate free board even in 3% of longitudinal slope as design discharge is calculated as 0.02502$m^{3/}$s and maximum capacity of cross drains are more than design discharge.

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2.3. Topographical Survey

In this method of survey, the survey is done of a strip of the proposed alignment. The second stage detail survey of the road alignment was conducted to prepare topography maps. In case of existing tracks, a detail survey will be conducted only in case of realignment is required or the places of crossing. The exact need of detail topography survey in case of upgrading sections will be established in the field and survey will be carried out accordingly.

2.3.1. Fixing of Gradient between Consecutive Control Points

In order to control the vertical gradient of road alignment between two consecutive control points, this survey is conducted.

2.3.2. Establishment Bench Marks and Control Points

Permanent Bench Marks were established along the road alignment at about 500m intervals. Permanent objects along the alignment were given the first priority for the establishment of BM. If permanent objects were not available, then concrete pegs with a nail at the top were mounted as BM. The BMs will provide vertical control points for the survey and also serve as baseline stations and traverse points for horizontal ground control. At least three reference points were provided for each BM and Description Cards has been prepared which helps in locating the BM during the construction phase.

2.3.3. Bench Mark Survey

Bench mark survey was carried out by running a double run, second-order split level circuits. All closing errors are kept within the acceptable limits of second-order accuracy.

Baseline Survey

In order to provide horizontal control for the engineering survey, a baseline survey was conducted. A closed baseline survey was carried out by the help of Total Station. Visibility guided the distance between the two consecutive baseline points.

Traverse Survey

A primary traverse survey was carried out along the road alignment. The survey was connected to the baseline survey so that both have a single coordinate system. The survey covered the right of way and recorded the location of the existing and proposed centre line, BMs and TBMs, physical and manmade features of permanent nature, which might influence the road alignment.

Data Entry and Analysis

The survey conducted for the proposed road was of strip survey method. In order to obtain the existing grade and nature of terrain, longitudinal and cross-section survey was conducted by pegging the chainage point at every 20m interval. The cross-section survey was extended to a distance of 20m.

The traverse survey was conducted with the help of Total Station. The coordinate of the first traverse point was computed from the available topographic map of Department of Survey. Strip survey was conducted for the proposed road. The traverse was closed at the various locations for obtaining the higher accuracy. Bench Mark was fixed at about 500 m interval and the level was closed at every BM points. The reading of level machine was entered in the Excel to compute the elevation of each change points, control points and cross section points.

SW Road was used for the designing of alignment. Detail data were entered in Excel and contour was drawn in AutoCAD with the help of **SW DTM 2014**. Fixing of alignment was done as per the nature of contour. Wherever possible, the existing track was followed.

2.4. Geological Study

Following study was carried out and in-situ tests on the sub-grade soil of the road have been conducted at intervals of 500 m along the alignments of project roads:

- General Geology of the region, project area and the proposed road corridor were described and geological map of the area has been presented along with major features.
- Nature, type and structure of surface soil were clearly identified.
- Natural hazardous area and flooding area have been identified and necessary recommendations have been provided.

2.4.1. General Geology

Geology is the study of earth and its physical components such as soil, rock, its formation and deformation. Nepal is a mountainous country. Since the Himalayan range is a result of the collision of Tibetan and Indian Plates, the zone is the most active tectonic zone. The area is widely known for its complex structural deformations. Due to this, Nepal is suffering from a different type of geo-hazards and instabilities. The rapid construction of infrastructures such as roads, irrigation canals, and dams, without due relating geology and engineering may cause the failure of such infrastructures. So, there should be consideration of geology of the site in the engineering aspect in all stages of investigations and constructions.

2.4.2. Geomorphology

The alignment of road sections passes with various areas of Dailekh district. The project areas are parts of the mid-mountain and constitute the Gravel Mixed Soil, Medium Rock, Hard Rock and Soft Rock in the mountain. Regional geology in the Nepal Himalaya is divided into four geo- tectonic zones. These zones, arranged latitudinal from north to south along the length of the country, are;

- Tibetan Tethys Himalayan Tectonic Zone
- Higher Himalayan Tectonic Zone
- Lesser Himalayan Tectonic Zone
- Sub- Himalayan Tectonic Zone

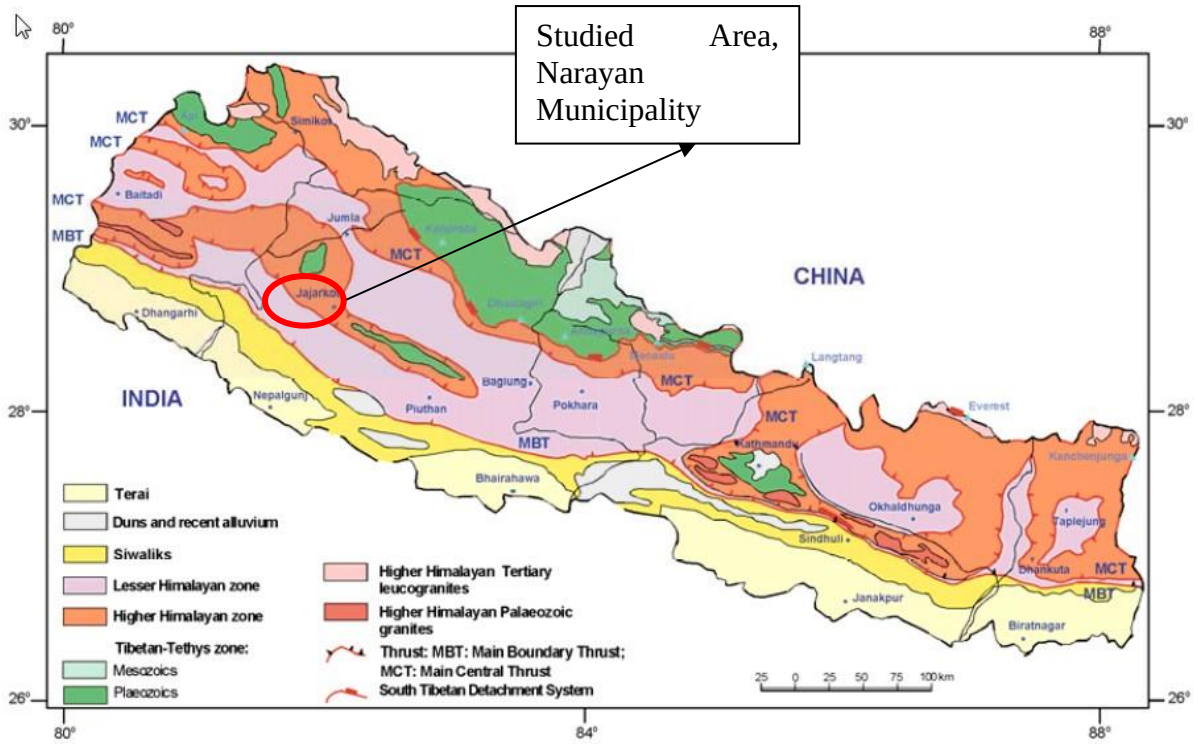

Figure 4: Geological Map of Nepal Showing Studied Area

2.4.3. Local Geology:

Dailekh is a High hilly district out of ten districts of Karnali Province. It is situated at coordinates of 28° 35' 00" N to 29° 08' 00" N Latitudes and 81° 25' 00" E to 81° 53' 00" E of Longitudes. The lowest elevation is 544m and the highest elevation is 4,168m. The headquarter is situated at an elevation of 1448m. The district has covered 80% of mid-hill land and 21% of high-hill land. The total area of the district is 1,505 square kilometres (581 sq mi).

Table 16: Visual Survey of Soil type

S.N	Name of Road	Type of Soil
1	Upgradation of Upgradation of road - "Dailekh-Mahabu-Jumla Road"	70% OS, 30% BMS

3. DETAIL DESIGN OF ROAD AND COST ESTIMATES

The design standard adopted for the detailed design followed the "Design Standards for Highway of "Nepal Road Standard (2027), Second Revision 2070", based on traffic volume and possible network importance. Geometric parameters followed are described below:

3.1. Geometric Design

The design of the proposed road has been done as per Nepal Road Standard 2070

Table 17: Geometric Design Standard

S.N.	Design Parameter	Propose value as Per NRS 2070,IRC86,IUT and NURS 2070		
		12m		Remark
	Name of Road	Upgradation of road - "Dailekh-Mahabu-Jumla Road"		
1	Class of Road	Access Street/Collector Road	IUT	
		Local Street/Collector	IRC 86	
		Urban Road-Class-II	NRS	
		Sadak/Marga	NURS	
2	Capacity (PCU/hr)	700		
3	Design Speed (km/hr)	40		
5	Right of Way(existing) (m)	12/16		
7	Camber of Carriageway (%)	2.50%		
8	Shoulder Width(m)	0.5		Hard shoulder
9	Camber of Shoulder (%)	4%		
10	Minimum Radius in Horizontal Curve (m)	70		15/20(Exceptional)
11	Minimum Vertical Curve Length (m)	20		
12	Maximum Gradient (%)	7		
13	Minimum Gradient for drainage only (%)	0.3		
14	Minimum stopping sight distance (m)	30		
15	Maximum Super Elevation (%)	10		
16	Footpath (m)	1.5		
17	Cycle Track (m)	N/A		
18	Side Drain	Rectangular RCC		Only in Settlement area
`19	Proposed Type	**Type II**		
		Type III		
		Type IV		

Structures

S.N.	Structures	Quantity	Unit	Remarks
1	Earthwork Excavation	196,227.96	Cum.	
2	Filling	8,899.89	Cum.	
3	Pipe Culvert (900 mm Dia)	22	Nos.	
4	Pipe Culvert (4 m * 3 m)	8	Nos.	
5	Pipe Culvert (3 m * 2 m)	6	Nos.	
6	Machine mixed cement concrete M15/40	2735.80	Cum.	
7	Machine mixed cement concrete M20/40	1912.60	Cum.	
8	Reinforcement	233.710	Mt.	
9	Sub base	23100.00	Cum.	
10	Base	13860.00	Cum.	
11	Asphalt Pavement	4620.00	Cum.	
12	Road Furniture's (Road Paint)	3,641.00	Sqm.	
13	Standard Kilometre post (Placed at each km)	8	Nos.	
14	Bigger Kilometre post (Placed at each 5 km)	3	Nos.	
15	Providing street lights along the road	441.00	Nos.	
16	Planting Tree along the road	530.00	Nos.	

3.1.1. Design Speed

When the design speed is higher, the design standards should be of a higher order which ensures road safety, capacity, and comfort and decreases the users' operational expenditure. The choice of design speed, however, would be influenced by the class of road, traffic volume, available budget and the terrain. The design speed adopted for the proposed road is 40kmph.

3.1.2. Right of Way

As per the Nepal Urban Road Standard, right of way adopted for the proposed road is 16 m and due to unavoidable reasons ROW is fixed 12 m at dense settlement areas.

3.1.3. Formation Width

Formation width of the adopted for the Existing road is 7+2*Shoulder (without Drain) m. Shoulder width of 0.5m on either side camber slope of 2.5%.

- Carriageway: : 7/5.5/11 m, Hard Shoulder: 0.3 m and 0.5 m
- Footpath: 1.5m

3.1.4. Extra Widening

Extra widening has been proposed at curves. Following table shows the nature of extra widening adopted for the designing of the proposed road.

Table 18: Extra Widening Adopted for Design

S.N.	The radius of Curve (m)	Extra Widening (m)
1	Less than 45	1.5
2	45 to 70	1.2
3	71 to 110	0.9
4	111 to 210	0.6
5	Greater than 210	0

3.1.5. Sight Distance

Sight distance is the length of road ahead visible to the driver. This distance should be long enough for the driver to see a situation and successfully react to it. The stopping sight distance considered for the design of the proposed road is taken as 50m.

3.1.6. Horizontal Curves

The horizontal alignment of a highway consists of a number of straight (tangent) sections connected by horizontal curves. These curves are sections of a circle or spiral. Curves should be designed to minimize vehicles skidding off the travelled way (excessive vehicle yaw) or overturning (excessive vehicle roll). As per the Nepal Road, Standard and IRC 86, the minimum radius of the horizontal curve is taken as 70m and at junction 15m.

3.1.7. Vertical Curves

Vertical curves provide for a gradual change in grade between the approach tangents. Vertical curves should be designed to provide sufficient sight distance, comfortable operation, efficient drainage, and a pleasant appearance. Long vertical curves generally have a more pleasing appearance than short vertical curves. As per the IRC 86, the minimum vertical curve length is taken as 20m.

3.1.8. Longitudinal Section

The longitudinal section shows the existing profile of the proposed road. The longitudinal section of the road was taken at 20m intervals by driving wooden pegs. The centre line survey of the road was carried out at each chainage point by auto level. Any sudden change in the gradient was also recorded. A general minimum gradient of 0.3% was adopted in very flat conditions. Maximum recommended a grade of 7% as per the IRC 86.

3.1.9. Cross Section

The cross-section survey was conducted at every chainage point to obtain the existing ground condition. Other necessary details were also taken during the cross section survey. The cross section survey was conducted to a minimum of 20m on either side of the proposed centre line of the road. However, at places requiring further details the survey was extended beyond 15m to cover the features.

3.1.10.Footpath

Provision of footpaths should be made on all roads passing through populated areas. On high traffic, urban roads footpaths should be constructed outside of the roadway on the separate formation or buffer areas should be established so as to separate them from the carriage way. Width of the footpath depends on the volume of anticipated pedestrian traffic. But a minimum width of 1.75 m is required.

3.1.11.Traffic light

Road signal for directing vehicular traffic by means of coloured lights typically red for stop, green for go and yellow for proceed with caution. Also called stoplight, traffic signal. A set of electrically operated signal lights used to direct or control traffic at intersections.

3.1.12.Utility duct

A utility duct was provided just below the road surface, and provide the access (to water supply pipeline, electricity system, telecom line etc.) for crossing road as per requirement

3.1.13. Water Management Measures

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 drainage structures. Water accumulated and concentrated on the road surface is a major threat to earth roads as it causes rutting and formation of gullies and rills. A fundamental technique applied in water management is to ensure that the rain water is evenly distributed off the road surface, towards the valley side. This is achieved by providing the road surface with an outward cross slope. Thereby preventing the rain water from accumulating on the road surface.

3.1.14. Outward Cross Slope

The road surface is generally provided with 2.5% outward cross slope to allow the surface run off to disperse gently towards longitudinal drain along the complete length of the road, thereby reducing the possibility of erosion. Displacement of water by the outward cross slope also eliminates the problem of discharging water collected from the drains in larger volumes. Construction of low bund with local material enhances the driver's confidence when the surface is wet. Ideally, it is preferred if such slippery areas are gravelled.

3.1.15. Side Drains

At locations where the road profile gradient is greater than 5%, rain water may flow longitudinally along the road, scouring weak surfaces and forming a gully along the road. In such cases, drains are provided to guide the rain water to the nearest cross drainage structure or gully. Outlets to side drains are designed in such a manner that scouring by the water flow is prevented. Generally, rectangular drain and Semi- Trapezoidal drain will be used for design.

3.1.16. Cross Drains

The cross drainage structures proposed for the construction on urban roads are RCC causeways, vented concrete causeways, and box and slab culverts, irrigation water crossings. 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.

3.1.17. Structure

The selection of one or the other types of structures is a subjective matter and reference has been made to the type of cross-section, hazard level, soil characteristics and many other parameters. Historical data were used widely rather than going into detailed quantity measurement. It is assumed that for this level of study, the exact quantity calculation is neither necessary nor relevant. The cross-drainage, however, has been considered when the proposed alignment passes through the natural depression (e.g., river, stream, gully, etc.). The cross-drainage structures like culvert and bridge are classified as following. This classification is merely based on the recommendation of NRS 2045.

Culverts: up to 6m span (Slab, Box)
Minor bridge: up to 20m span
Medium bridges: about 20m length, span<20m
Major bridges: Span>20m

In addition, pipe drains at frequent intervals depending upon the extent of catchment uphill have been proposed to let the surface run off downhill. In all cross-drainages, the width of the road is kept equal to the carriageway width plus shoulders. The loading standard to be adopted for the design of bridges and culverts will be IRC class AA and A.

3.1.18. Engineering Drawings

The designing work was carried out in SW Roads Software. After the completion of the designing works, the drawings were exported in AutoCAD. Drawings were prepared according to norms provided in terms of reference and submitted in a separate volume.

3.2. Intersection/Junction Design

Hence, alignment does not lies in Intersection point.

3.3. Pavement Design

The pavement is the most important component of highway section. 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, and terrain and sub-grade soil conditions. Depending upon specific regional or nationwide characteristics, most of the countries are practising some empirical and experience based methods for the design of flexible pavements. Therefore, pavement design is done by IRC Method.

3.3.1. 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 a cumulative number of standard axles to be catered for design in terms of million standard axles (msa). This guideline follows analytical designs and developed a set of designs upto 150msa in IRC: 2012

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 1% to 15% and design traffic ranging from 1 msa to 150 msa,
3. Using the following simple input parameters, appropriate designs could be chosen for the given traffic and soil strength.
   - Design Traffic in terms of a 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)
- The traffic growth rate during the design life
- Design life in a number of years
- Vehicle Damage Factor (VDF)
- Distribution of commercial traffic over the carriage way

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 lade weight of three tonnes 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 7-day 24-hour classified traffic counts (ADT). In the 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 the 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 arterial roads like National Highway should be designed for a life of 15 Years. Feeder roads and urban roads should be designed for 20 years and other categories of roads for 10 to 15 years.

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 an 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 the table below. They are used for converting different axle load repetitions into equivalent standard axle load repetitions.

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 the table below may be used.

Table 19: Vehicle Damage Factor According to Terrain

S.N.	Initial Traffic Volume in terms of CVPD	Terrain		Remarks
		Rolling	Hilly	
1	0-150	1.5	0.5	
2	150-1500	3.5	1.5	
3	More than 1500	4.5	2.5	

In case the class mark of the axle load survey does not match with the above axle loads, 4th Power Law may be used for converting axle loads into equivalent standard axle loads using the following formula.

Single Axle Load

Equivalency Factor = (axle load in kg/8160)4

Tandem Axle Load

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

Pavement Thickness Design Chart

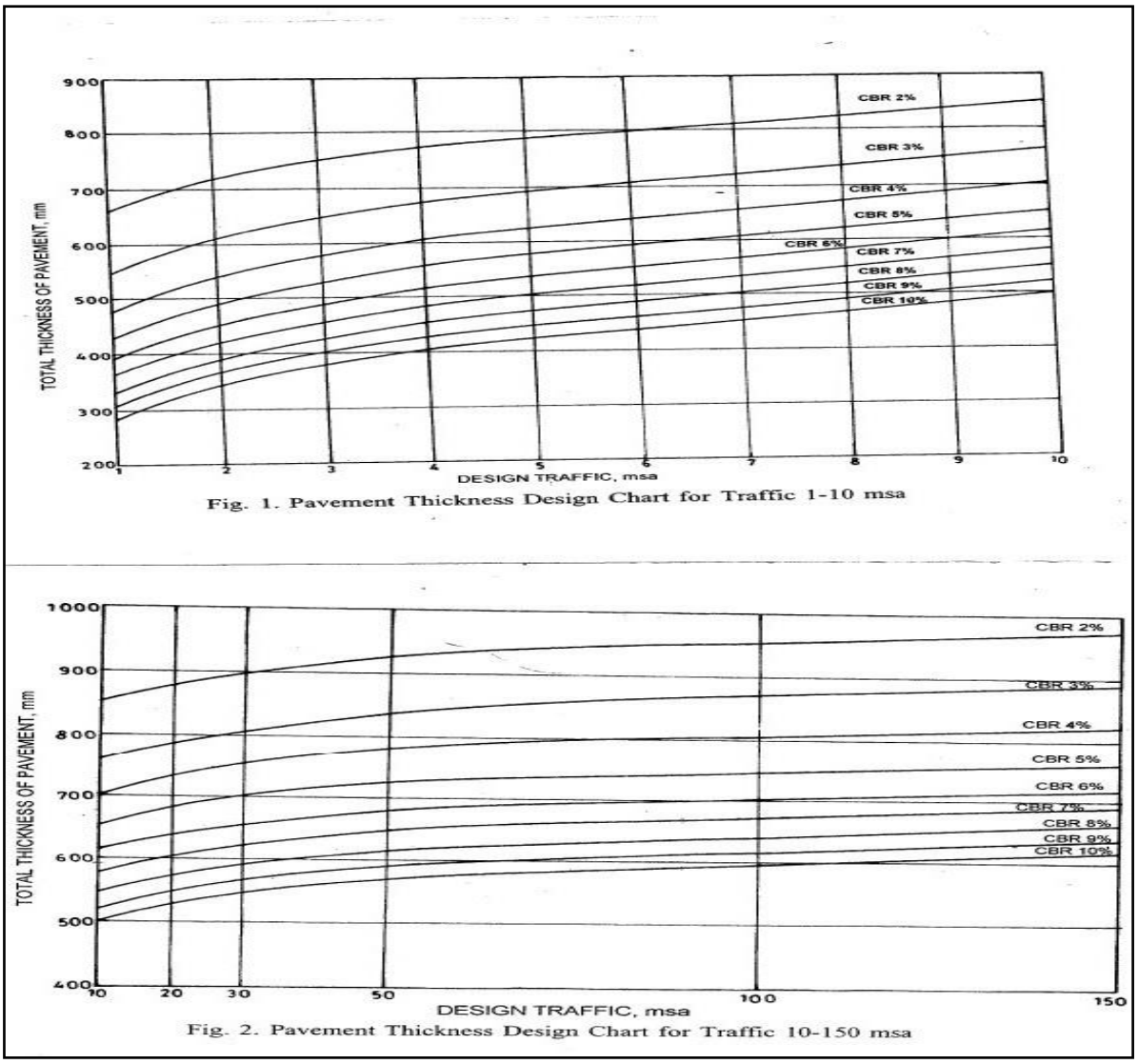

Figure 5: Pavement Thickness Design Chart

Design Calculation of Design Traffic and Cumulative Number of Standard Axles as per IRC Method inUpgradation of Upgradation of road - "Dailekh-Mahabu-Jumla Road"

Table 20: Calculation of Cumulative Number of Standard Axles by IRC Method

S.N.	Vehicle	Type	2019 Traffic Count (Both Direction)	Growth Rate 7% (Trend Analysis)	2021 Traffic Forecast with 7% Growth Rate	Divert from Other Roads	Sum of Normal + Diverted Traffic	Generated Traffic due to Road Improvement (for 15 Years) (Assumed)	Total ADT	AADT 2021 (A) with seasonal factor 0.91	VDF (F)	Lane Distribution Factor (D)	A*F*D	Cumulative Number of Standard Axles (N)	Remarks
1	Truck	Multi-Axle	0	0.07	0	0	0	0	0	0	6.5	0.75	0	0	
2		Heavy	13	0.07	16	8	24	0	24	22	4.75	0.75	78	715423	
3		Light	30	0.07	37	22	59	14	73	66	1	0.75	50	458605	
4	Bus	Big	10	0.07	12	5	17	0	17	15	0.5	0.75	6	55033	
5		Mini	33	0.07	40	21	61	68	129	117	0.35	0.75	31	284335	
6		Micro	14	0.07	17	9	26	29	55	50	0.35	0.75	13	119237	
7	Tractors	Tractors	40	0.07	49	28	77	63	140	127	1	0.75	95	871349	
	Total													2503982	
													Cumulative Number of Standard Axles for design period (N)	**2503982**	**esa**
													Cumulative Number of Standard Axles for design period (N)	**2.5**	**msa**

Cumulative Number of Standard Axles for design period is taken as 2.50≈**5 msa** which lies between 1 to 10msa

Pavement design for this project according to IRC Method of Pavement Design Guideline is Plate 7 – Recommended Design for Traffic 5 msa for CBR Value 9%. According to that Plate 5, the total pavement thickness is 475 mm with 25 mm Bituminous Concrete, wearing course 50 BM and, Granular Base 250 mm and Granular Sub-base 150 mm

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Pavement Design Catalogue

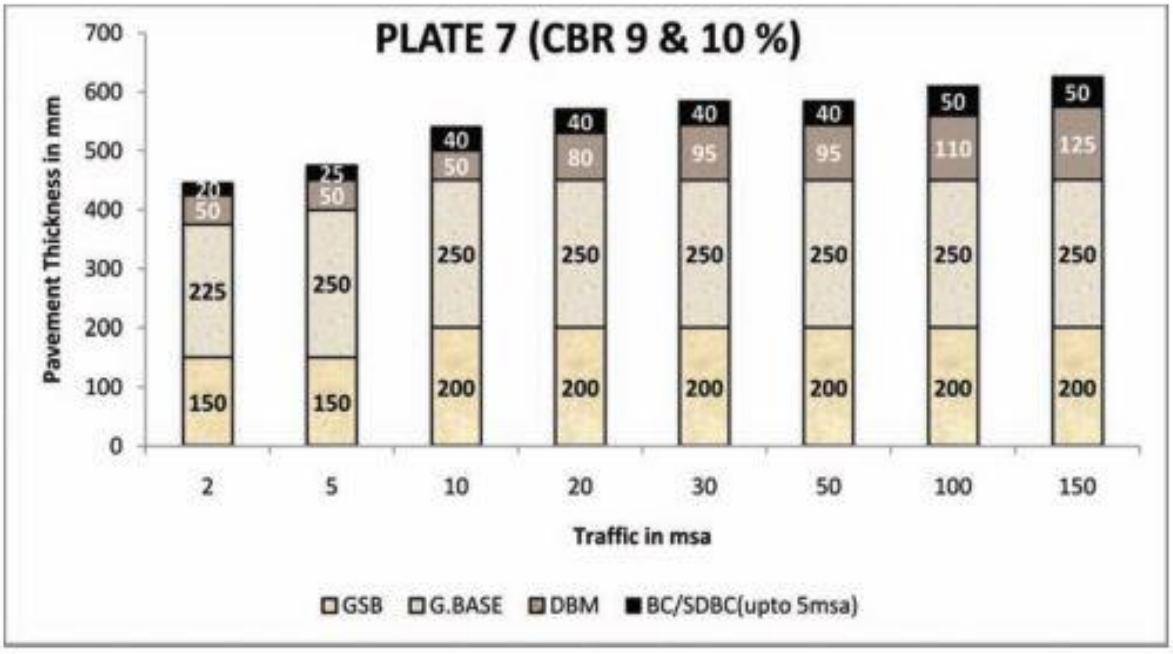

Figure 6: Pavement Composition and Thickness

Pavement Thickness and Composition

Pavement design for this project according to IRC Method of Pavement Design Guideline is Plate-7 – Recommended Design for Traffic 5 msa for CBR Value 9%. According to that Plate-7, the total pavement thickness is 475 mm with 25 mm Bituminous Concrete, wearing course 50 BM and, Granular Base 250 mm and Granular Sub-base 150mm.

3.4. Design of Drainage

Required Size of Drain is recommended from Hydrological Study i.e.

Conclusion for Side Drain

Rectangular side drain is proposed in only one side of the road. The size of the drain is proposed to be 0.5*0.6 to drain out the water from hill side.

Conclusion for Cross Drains

The size of slab culverts proposed matches with the calculated discharge with adequate free board even in 3% of longitudinal slope as design discharge is calculated as 0.02502$m^3$and maximum capacity of cross drains are more than design discharge.

Note: Refer Annex: Detail of Cost Estimate and Quantity

3.5. Road Furniture /Road Safety Assessment

Different kinds of traffic controllers and safety precautions are undertaken during the study and design of this road and the estimated cost is also included in the total project cost. Following things are undertaken during this study.

- Placing of different traffic sign post at various chainages as required.
- Placing of km post at various chainages as required (per one km and per five km).
- Placing of RCC delineator and guard post at various places as required.
- Traffic Controller and diversions are provided as required

(Note: Refer Annex: Detail of Cost Estimate and Quantity)

3.6. Quantity and Cost Estimate

Quantity estimate

Quantity estimate of different item is done to reflect the actual construction cost for economic analysis of the project. However, some assumptions are also made for certain items detail procedure and method of calculation is presented below:

- Quantity calculation of earthwork is done with the help of a typical cross-section.
- Quantity of retaining structure is calculated according to the typical drawing developed.
- Type of side drains is designed and quantities are assumed on the basis of the design drain throughout the length of the alignment.
- Quantity of cross drainage structures is calculated based on the catchment area and flood forecast of ten years for Causeway.
- Quantity of pavement work is calculated based on cross section developed for highway of formation width of the adopted for the proposed road.

Rate Analysis

Detail analysis for the rate is performed by taking DoLIDAR, DoR and DUDBC Norms and district rate of the proposed location. The total project cost are shown below:

Table 2: Summary of Cost

Summary of Cost

SN	Description of Works	Amount	Remarks
1	General Item	8,566,011.09	
2	Road Way Excavation	9,704,268.62	
3	Drain, Cross Drainage and Structures Work	213,996,228.57	
4	Pavement work	289,493,866.20	
5	Foothpath	1,366,234.04	
6	Road Furnitures & Traffic Safety	1,658,116.72	
7	Miscellaneous Works	22,570,188.75	
	Total = 1+2+3+4+5+6+7 = 8	547,354,913.99	
	4%Contingency for the supervision work of 8=9	21,894,196.56	
	10% Price adjustment Contingency of 8=10	54,735,491.40	
	10% Physical Contingency of 8=11	54,735,491.40	
	13 % VAT of 8=12	71,156,138.82	
	Total cost=8+9+10+11+12=13	**749,876,232.17**	
	Cost Per Km	**56,637,177.66**	