



Province Government
Bagmati Province

Ministry of Physical Infrastructure Development

Transport Infrastructure Directorate

Hetauda, Makawanpur, Nepal



Guidelines

For

**Survey, Design and Preparation
of Detailed Project Report (DPR) of Roads**

2021

Hetauda, Nepal

PREAMBLES

Bagmati Province is one of the seven provinces of Nepal, formed on 20 September 2015 following Schedule of 4 of the constitution of Nepal. It is situated at the center of the country that includes the capital of Nepal, Kathmandu. The province is located in between Tibet (China) in the north and province 2 in the south. The province covers an area of 20,300 sq. km and 13 districts of the 77 districts of Nepal. At the local level, there are 3 metropolitan cities, 1 sub-metropolitan city, 41 urban municipalities, and 74 rural municipalities in the province. The population of the province is 5,529,452 as per the census of 2011.

Bagmati Province Government, Ministry of Physical Infrastructure Development, **Transport Infrastructure Directorate** is responsible for the planning, implementation, and maintenance activities related to provincial roads and bridges within the province. For qualitative and sustainable development of roads and uniform and consistency in the road design process and preparation of detailed project report of the road project, this **Guideline for Survey, Design and Preparation of Detailed Project Report (DPR) of Road, 2021** is prepared. This guideline aims to provide technical assistance for the preparation of DPR of all roads within Bagmati province.

Very special gratitude goes to Chief Minister **Mr. Dormani Paudel, Chief Minister**, Minister of Ministry of Physical Infrastructure Development of Bagmati Province, **Mr. Rameshwor Phuyal, and Mr. Sanjeeb Baral, Secretary**, Ministry of Physical Infrastructure Development of Bagmati Province who gave suggestions and feedback during the preparation of this guideline. I would also like to acknowledge many appreciations the crucial role of **Mr. Aashish Khadka**, a Road Expert who worked actively to prepare this guideline. I would also like to thank **SDE Mr. Puskar Prasad Pokhrel, SDE Mr. Navin Kumar Singh, Er. Hari Prasad Ojha**, Road Expert **Er. Ram Babu Paudyal**, Account Officer **Rajesh Thapa**, and other colleagues for their comments that helped in improving this guideline.

.....
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ABBREVIATIONS AND ACRONYMS

AP	Affected Person
AADT	Average Annual Daily Traffic
BCR	Benefit Cost Ratio
BES	Brief Environment Study
BM	Bench Mark
BoQ	Bill of Quantities
CBR	California Bearing Ratio
DCPT	Dynamic Cone Penetration Test
DEM	Digital Elevation Model
DGPS	Digital Global Positioning System
DOM	Digital Orthographic Map
DOLI	Department of Local Infrastructure
DOR	Department of Road
DPR	Detailed Project Report
DSM	Digital Surface Model
DTM	Digital Terrain Model
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMAP	Environmental Management Action Plan
EPA	Environmental Protection Act
E, N, Z	Easting, Northing, Reduced Level
ESMF	Environmental and Social Management Framework
FS	Financial Sanction
FY	Fiscal Year
GCPs	Ground Control Points
GIS	Geographic Information System
GPS	Global Positioning System
GoN	Government of Nepal
HDM	Highway Development and Management Model
IDF	Intensity Duration Frequency
IDO	Infrastructure Development Office
IEE	Initial Environmental Examination
IPP	Indigenous People Plan
IRC	Indian Road Congress
LIDAR	Light Detection and Ranging
LRBP	Local Road Bridge Programme
MoPID	Ministry of Physical Infrastructure Development, Bagmati Province, Nepal

NPV	Net Present Value
POS	Positioning and Orientation System
PPMO	Public Procurement Monitoring Office
PRDO	Provincial Road Division Office
PTMP	Province Transport Master Plan
PWD	Project Work Directive
QAP	Quality Assurance Plan
RAP	Resettlement Action Plan
RGB	Red, Green and Blue
RM	Rural Municipality
ROW	Right of Way
RSA	Road Safety Audit
RTK	Real Time Kinematic
SEZ	Special Economic Zone
SFM	Structure From Motion
TA	Technical Approval
TBM	Temporary Bench Mark
TID	Transport Infrastructure Directorate
TRL	Transport Research Laboratory
UAV	Unmanned Aerial Vehicle
VOC	Vehicle Operation Cost

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1 INTRODUCTION

1.1 Transport Infrastructure Directorate (TID)

Transport Infrastructure Directorate (TID) was established in 2018 under the Ministry of Physical Infrastructure Development in order to develop transport infrastructures including roads and bridges in Bagmati Province. The main aim of the organization is to develop plans, policy, programs, guidelines, and specifications for the construction of transport infrastructure and implement the design, construction and maintenance works of roads, bridges, trail bridges etc, with efficiencies and effective way self or through the under offices. The organogram of TID is shown in **Figure 1.1**;

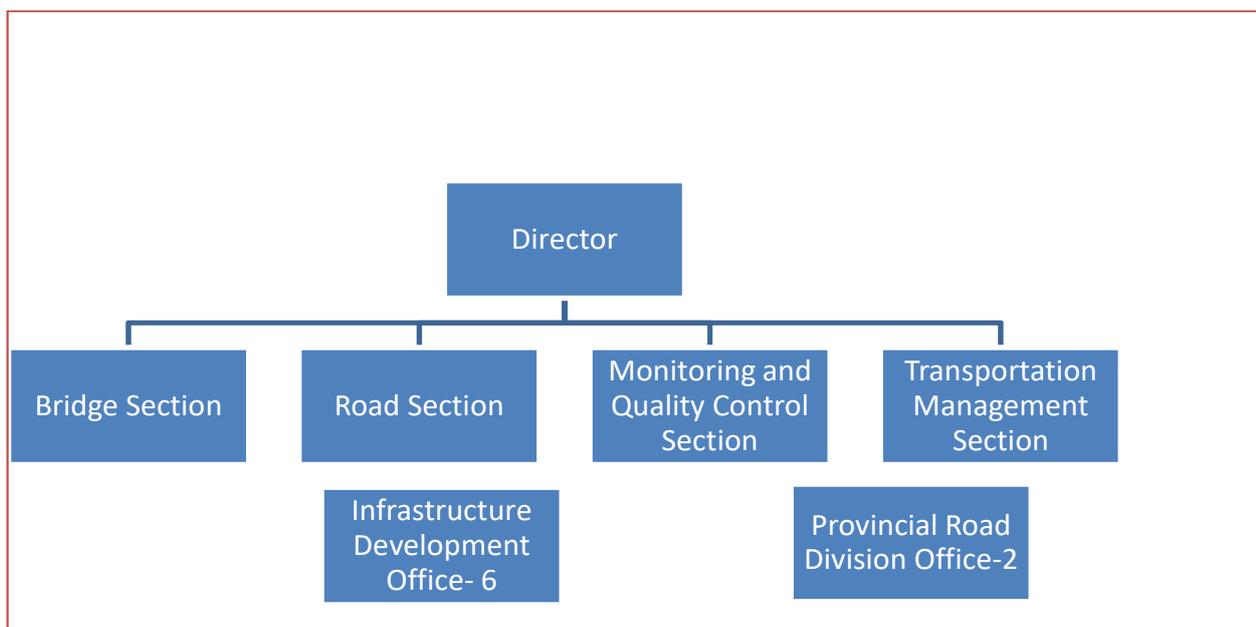


Figure 1.1 : Organogram of TID

1.2 Scopes and Works of TID

The TID is the central authority of Bagmati Province Government charged with the responsibilities for enhancing the economic and social development of the Province by linking various geographical and economic regions through the provincial strategic transport network. TID is responsible for linking rural areas of the Province with markets to support various economic activities and projects related with tourism, agricultural, electrical, and industrial and other sectors of Nepal. Moreover, the key role of the Directorate lies with preparing plans, policies, and programs regarding the development of physical infrastructures such as roadways, railways, waterways, subways, flyovers, and ropeways; transport and transit management and its operation related plans, policies, and programs; its implementation; monitoring and evaluation and inspection.

1.3 Classification of the Province Road

In order to maintain the convenience and economic interest of the general public living within the territory of Bagmati, it is necessary to prepare, maintain, expand or improve and operate and manage all types of public roads by preparing classification and standards. According to the proposed Province Public Road Act, 2076 the Bagmati Province Government has classified provincial roads as follows:

- Province Expressway
- Province Highway
- Province Road
- Province Urban Road
- Province Other Transportation modes

Province Expressway

Province Expressway is the highway with controlled entrances and exits at designated places, two way traffic lane separated by median restricting lateral access to change the lane and no intersection at the grade. These are developed for high-speed traffic flow.

Province Highway

Province Highway is the road that connects to National Highway with Province Headquarters, District Headquarters with the National Highway or that connects Province Headquarter with District Headquarter or the Road connecting the District Headquarters with another District Headquarters within the Province or the Road or connecting two National Highways.

Province Road

Province Road means the road that connects the center of Local level with National Highways or Province Highway or District Headquarter or road connecting two or more Local centers, or National Highway and Province Highway connected with important market place, religious place, historical, touristic and other important places.

Province Urban Road

Urban Road" means urban ring road, road connecting important places within the city, flyover, elevated road, subway, sky (overhead) bridge or bypass (bypass).

Province Other Transportation

Other modes of transportation such as Rail Transport, Air transport, Water Transport, Cable etc. fall under this class.

1.4 Objective of Guidelines

Preparation of road projects involves a chain of activities, such as field surveys and investigations, selection of alignment, carrying out various designs, preparation of drawings and estimates, etc. To be compatible with technical requirements, consistent with the economy, every project must be prepared after thorough investigations and collecting all relevant information, and evaluating all possible alternatives.

The extent and quality of survey and investigations have a strong influence on the selection of the most cost-effective design, estimation of quantities cost, and execution of the job itself. As such, the accuracy and completeness of surveys deserve very special attention in project preparation. The objective can be achieved by carrying out the project preparation work either departmentally or with the help of consultants. In any case, it should be ensured that experts having the required knowledge are deployed on the work. The use of modern instruments and survey techniques ensures a high degree of accuracy and can speed up the work. A proper work plan is required to be drawn before the start of field investigations.

Adequate funds should be earmarked for the work of survey, investigation, and project preparation. Estimation of the realistic fund and time requirement needed for project preparation will highly contribute in meeting goals and objectives of project. It will be found that in the long

run, such investment pays more than for itself in the form of well prepared and cost-effective projects, orderly schedule of work, and timely completion.

The objective of this guideline is to provide planners and designers with sufficient information on the fundamentals underpinning the planning and design of roads to allow them to understand the context of their projects. It brings together the issues to be considered and discusses, in a general sense, environmental considerations, transport planning principles, engineering considerations, and public consultation.

1.5 Scope

This guideline deals with new construction as well as improvements in existing provincial roads. Special aspects of each have been highlighted wherever necessary. In order to ensure the surveys and investigations, Feasibility Report and Detailed Project Report are complete and no essential detail is missed, this guideline is prepared along with a checklist for all the required activities and are presented in the **Appendixes**.

It should be understood clearly that the extent of operations involved in surveys and investigations including the detailing of individual aspects, would depend very much on the size of each project and the class of road. Depending on needs of the situation, one or more phases of investigations might be curtailed, telescoped or made more extensive than prescribed in manual.

The order in which various surveys are discussed in the manual should not be taken to mean that such work must strictly follow the same pattern or sequence. Some of the surveys could be easily initiated in advance and carried out simultaneously overlapping each other.

The structure of this guideline is addressed in terms of requisite outputs of roads which are:

- Safer Road
- Efficient and effective transport
- Fair access and amenity and
- Social and environmental and management

1.6 Content

The content of this guidelines is;

- Stages in Project Preparation
- Surveys and Investigations
- Design
- Economic Analysis
- Environmental Assessment
- Social Assessment
- Preparation and Presentation of Project Documents Detailed Project Report
- Bibliography
- Appendixes

2 STAGES IN PROJECT PREPARATION

Broadly, the stages involved in the preparation and sanction of the project are:

1. Initial Identification
2. Screening
3. Ranking and Prioritization
4. Feasibility study
5. Detailed Study and Preparation of Detailed Project Report (DPR)

The different stages in the project preparation are shown in **Figure 2.1**

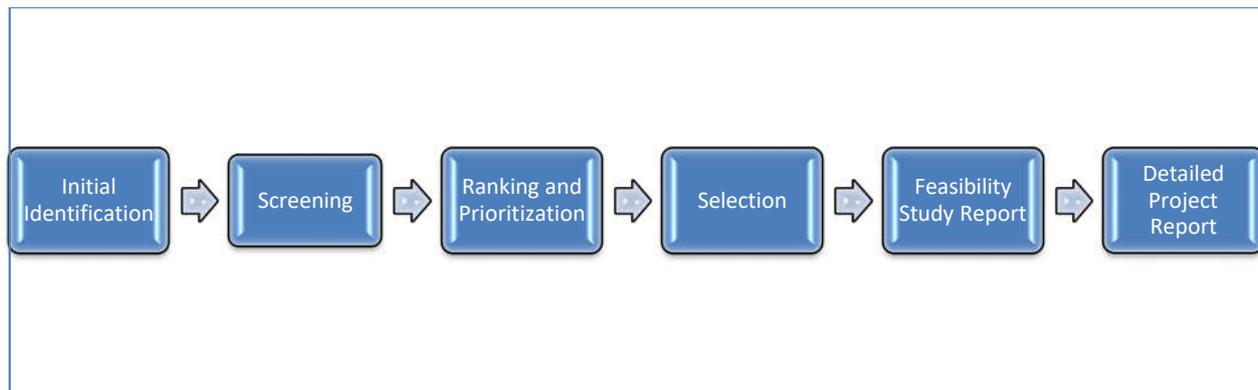


Figure 2.1 : Stages in Project Preparation

2.1 Initial Identification

The initial identification step is the first step for project preparation. In this stage, preparation of a list of proposed roads to be improved or maintained are prepared. The initial list, will in most cases be based on PTMP, with the involvement of local communities or political representation (Provincial parliament members, Federal parliament members, Chief of local levels etc.)

2.2 Screening

A Project Screening is a preliminary assessment or examination of the project suitability for the selection and application process for further study that evaluates or investigates a large number of project candidates to identify the rationale of project. The Project Screening may conduct by different procedures and methods to compare the strengths and weaknesses. The factors to be considered for screening of project are:

- I. Listed in PTMP
- II. Its linkage to settlements
- III. Connectivity with respect to inter province/inter district/ National Highways/Provincial Highways/Transport terminals/ municipality centers /district headquarters.
- IV. Providing access to industry/SEZ/ fishing/agriculture/ tourist/ religious/heritage places
- V. Connectivity to economically backward areas.

The project will be selected for further study if the road alignment meets any one of the above criteria from I to V

2.3 Ranking and Prioritization

After screening of project, the next step is ranking and prioritization of roads. A network consists of several links. It is not possible to construct all roads at a time due to resource and time constraint. Therefore, each link in a network should be prioritized. An overall ranking of the selected roads, on the basis of the overall population per unit cost, will be necessary in order to decide which road should receive priority and in what order.

Population per unit cost has been taken as an important parameter for ranking and prioritization of linkage. To prioritize the linkage from this parameter, population of influence area and cost of linkage are required.

Population per unit cost is calculated from total population divided by investment cost in lakh (hundred thousand) rupees i.e. no of person per 100000 rupees. The road having the highest beneficiary's population per investment cost is given highest score.

The principle criteria for ranking and prioritization criteria for road project consist of the following index:

- a) Population of Influence Area (Number of Population Served/Benefited)
- b) Rough Estimates of Project Cost

a) Population of Influence Area (Number of Population Served/Benefited)

The population served is defined as the total population of all Municipalities and Rural Municipalities. Population data is collected for each local bodies (total population only). The total population served by each road as the sum of the populations of the different RM linked by the road concerned as an estimation of the population served by each road. The population within the zone of influence (ZOI) area i.e. left and right of the road link within 2 hours walking time in terai and 4 hours walking time in hills and 6 hours in mountains is taken as the beneficiaries of a proposed road. Estimating population within Zol needs careful division.

After locating the Zol, the settlements within that Zol should be identified. Collection of settlement level population is very difficult, so if settlement wise population is not available, ward-wise population can be collected from Municipality/Rural Municipality office or other local level centers and summed up all ward-wise population to get the total number of population

b) Rough Estimates of Project Cost

The rough estimates of the roads, the cost of the different interventions based on inventory survey and DPR of similar roads within the districts needs to be estimated. This is done based on a reconnaissance survey by collecting information on the present status of the road, deficiency/distress identification, development potential, environmental impact, traffic data (present and future) and an approximate estimation of cost.

Based on the total estimated cost and the number of populations benefited, the population per unit costs are calculated and the roads are ranked and prioritized for further study. Prioritization of the road projects shall be given in order of scoring.

Based on the prioritization of the local road and availability of budget of each year, further study program shall be formulated.

2.4 Feasibility Study

The Feasibility Study is intended to establish whether the proposal is acceptable in terms of soundness of engineering design and expected benefits from the project for the investments involved. The Feasibility Report enables the funding agency to accord approval to the project. When the international funding is involved, the Feasibility Study forms a basis for an investment.

2.5 Detailed Engineering Study

The Detailed Engineering covers detailed alignment surveys, soil and materials surveys, pavement design studies, drainage studies, environment management plan based on environmental impact assessment studies, detailed drawings, estimates, and implementation schedules and documents. Based on such work, Technical Approval and Financial Sanction (TA and FS) are accorded to the project, enabling it to be executed.

The sequence of survey operations and project preparation may thus, have to be structured to meet the specific needs of the project, its funding option, and the requirements of the authority sponsoring it.

3 SURVEYS AND INVESTIGATIONS

Preparation of road projects involves a chain of activities, such as, field surveys and investigations, selection of alignment, carrying out various designs, preparation of drawings and estimates, etc. To be compatible with technical requirements, consistent with economy, it is essential that every project should be prepared after thorough investigations and collecting all relevant information and evaluating all possible alternatives. The extent and quality of investigations have a strong influence on selection of the most cost-effective design, estimation of quantities cost and execution of the job itself. As such, accuracy and completeness of surveys deserves very special attention in project preparation. The objective can be achieved by carrying out the project preparation work either departmentally or with the help of consultants. In any case, it should be ensured that experts having the required knowledge are deployed on the work. Use of modern instruments and survey techniques ensure high degree of accuracy and can speed up the work. Quality Assurance Plan is required to be drawn before the start of field investigations. Adequate funds should be earmarked for the work of survey, investigation and project preparation. Estimation of realistic fund and time requirement needed for project preparation will go a long way in making the project preparation a success. It will be found that in the long run, such investment pays more than for itself in the form of well prepared and cost effective projects, orderly schedule of work and timely completion. Systematic presentation of project details is no less important.

3.1 Guiding Principles of Route Selection and Alignment Improvement

The fundamental principle of route selection and alignment improvement is to achieve the least overall cost on transportation, having regard to the costs of initial construction of the highway facility, its maintenance, and road user cost, while at the same time, satisfying the social and environmental requirements.

Factors that should be kept in view in the process are listed in **Appendix-I**

Where the project involves improvements to an existing road, every effort should be directed towards the inherent deficiencies concerning

- Plan and profile
- Sight distance/visibility in horizontal as well vertical plan
- Carriageway, shoulder, and roadway width
- Cross-drainage structures
- Roadside drainage provisions as well as area drainage consideration
- Safety features.

Any disregard of these aspects may well lead to unnecessary expenditure, since at a later date the alignment may again have to be improved at considerable extra cost. It is, therefore imperative that the final centre line of with respect to which, the improvements are designed and are to be carried out, is fixed with care in the light of ultimate geometric requirements and economy. The other important point is removal of structural deficiencies with an eye on future needs with respect to pavement, culverts, road and drainage requirement etc.

Proper location and orientation of cross drainage structure is an important factor in the selection of the road alignment. The importance increases with their length and cost.

Apart from engineering factors, the environmental and social impact of the proposal should be fully kept in view in terms of such aspects as air pollution, damage to life systems, soil erosion,

drainage pattern, landscaping, disruption of local communities, resettlement, land acquisition, etc.

3.2 Reconnaissance Survey

The main objective of the reconnaissance survey is to examine the general character of the area to determine the most feasible routes for further more detailed investigations. Data collected should be adequate to examine the feasibility of all the different routes and furnish the approximate quantity estimates for deciding on the most suitable alternative or alternatives. The survey should also help in determining basic geometric standards to be adopted for the highway facility.

3.2.1 Survey Method

The reconnaissance survey may be conducted in the following sequence:

- Study of topographical survey sheets, agricultural, soil, geological, and meteorological maps, and aerial photographs, if available.
- Aerial reconnaissance (where necessary and feasible)
- Ground reconnaissance

3.2.1.1 Study of Topographical Survey Sheets

Reconnaissance begins with a study of all the available maps. The types of useful map information which are currently available in the country are topographical map, land use map, hydrological map, and geological map.

After the study of the topographical features on the maps, several alignments feasible in a general way are selected keeping in view the following points:

- The alignment should take into account all the control points and should be the shortest and most economical compatible with the requirements of grade and curvature.
- The shape of the alignments.
- Avoidance, as far as possible, of marshy ground, steep terrain, unstable hill features, and areas subject to severe climatic conditions, flooding, and inundation.
- Land use pattern, Soil type, village, settlements, etc.
- The need of connecting important villages and towns.
- Bridging cross-drainage and drainage problems.
- Need to preserve the environment and maintain ecological balance.
- Geology, geomorphology and groundwater prospecting and
- Environmental factors, e.g., vegetation, soil condition, land use, etc.

3.2.1.2 Aerial Reconnaissance

An aerial reconnaissance will provide a bird's eye view of the alignments under consideration along with the surrounding area. It will help to identify factors that call for rejection or modification of any of the alignment. The final decision about the alignments to be studied in detail on the ground could be taken based on the aerial reconnaissance.

3.2.1.3 Ground Reconnaissance Survey

The various alternative routes located as a result of the map study are further examined in the field by ground reconnaissance. As such, this part of the survey is an important link in the chain

of activities leading to the selection of the final route. General reconnaissance consists of a general examination of the ground walking or riding along the probable route and collecting all available information necessary for evaluating the same. In the case of hill sections, it may sometimes be advantageous to start the reconnaissance from the obligatory point situated close to the top. If an area is inaccessible for the purposes of ground reconnaissance, recourse may be had to aerial reconnaissance to clear the doubts.

While carrying out ground reconnaissance, it is advisable to leave reference pegs to facilitate further survey operations.

Instruments generally used during ground reconnaissance include GPS, compass, Abney level/Altimeter, Pedometer, Aneroid barometer, Clinometer, Ghat tracer, etc. Walkie-talkie sets, mobile phones are useful for communication, particularly in difficult terrain. Use of the instruments mentioned above to obtain ground slopes, maximum gradients, the elevation of critical summits or stream crossings, and location of obligatory points, serve as a check on the maps being used.

Points and Formats on which data may be collected during ground reconnaissance are listed in **Appendix II**.

3.2.2 Reconnaissance Report

Based on the information collected during the reconnaissance survey, a report should be prepared. The report should include all relevant information collected during the survey, a plan to the scale of 1:50,000 or larger as available showing the alternative alignments studied along with their general profile and rough cost estimates. It should discuss the merits and demerits of the different alternatives to help the selection of one or more alignments for detailed survey and investigation.

3.3 Road Inventory Survey

Many projects involve improvement to an existing road (strengthening/widening) or construction of new facilities (bypasses) which are an improvement in traffic conditions over the existing facility. In these cases, the scope of the improvement measures and economic justification for them depends upon the condition of the existing pavement. It therefore, becomes necessary to prepare a road inventory and carryout condition survey. An inventory of the project road shall be carried out through dimensional measurement and visual inspection supplemented with sample measurements using tape etc. Features like chainage, terrain and land-use, name of village/town, type, condition and width of carriageway and shoulders, important road junctions and geometric deficiencies, utilities etc., shall be recorded along with photographs. The format of road inventory is presented in **Appendix III**.

3.4 Pavement Condition Survey

The pavement condition survey is a visual inspection of the pavement. The survey provides measures to assess the magnitudes of various types of pavement distress. This inventory will include such information as length, width, and type of pavement surface; shoulder and curb and gutter information. Additional information such as sidewalks, drainage, resurfacing, utility information, signs, etc. may be included. The result of a pavement condition survey indicate the overall condition of the road and will give an estimate of the amount of funding needed to preserve pavement. The format for pavement condition survey is in **Appendix IV**.

3.5 Inventory and Condition Survey of Existing Bridges, Culverts and Other Structures

Inventory and condition survey of the existing bridges and culverts shall be carried out to identify their number, type, condition and hydrological aspects. Mainly visual inspection and dimensional measurements shall be carried out during this survey. The format for this condition survey is in **Appendix V**.

3.6 Socio-Economic Profile Survey

The economy of a region and its transport infrastructure are closely inter-related. The economic justification for a project often depends upon the economic activities in the region and potential for their future growth. The growth of roads likely to be closely governed by inter-relationship between transport demand and certain selected indicators. A survey of the economic profile is, thus an important competent in project preparation.

The socio-economic survey of the road influence area should provide a detailed information on Demographic picture, Land use pattern, existing and planned Transport and communications network, Education Administrative facilities.

- **Demographic picture:**
 - (a) Influenced population/economic activity of influenced population
 - (b) Structure of population
 - (c) Nature of migration and outside influx etc.
- **Land use pattern:**
 - (a) Wild life sanctuary
 - (b) Forest
 - (c) Production in influenced area and surplus in influenced area
 - (d) Settlement pattern etc.
- **Trade, Industry and Commerce (existing & planned):**
 - (a) Local productions and other resources
 - (b) Export and import
 - (c) Major industries and cottage industries
 - (d) Market development
 - (e) Tourism potential etc.
 - (f) Major development works (hydro power project, irrigation project, other governmental/no-governmental development programs etc.)
- **Health (existing & planned):**
 - (a) Hospital
 - (b) Health post
 - (c) Ayurvedic clinic etc.
- **Education (existing & planned):**
 - (a) Primary schools
 - (b) Secondary schools

- (c) High schools
- (d) Colleges/institutions etc.
- (e) Universities
- **Transport and communications network (existing & planned):**
 - (a) Trail network and trail bridges
 - (b) Airport, STOL strips, helipad etc.
 - (c) Water transport
 - (d) Rope-ways
 - (e) Road network
 - (f) Telecommunication, postal service & other communication networks etc.
- **Administrative facilities:**
 - (a) Government offices
 - (b) Cooperative offices
 - (c) Banks etc.
 - (d) Police station

3.7 Topographical Survey for Road Works

3.7.1 Objectives

A topographic survey is an engineering survey to understand and analyze the ground features along the proposed alignment. The topographical survey and design are based on the baseline approach. By applying baseline approach existing or future horizontal and vertical position will be determined. The main objective of a topographic survey for a road is to create a digital terrain model (DTM) by acquiring terrain data. Survey activities include road alignment, fixing the centerline of the road, providing permanent grid lines and benchmarks as per the applicable standards.

The topographic survey helps the engineers to:

- prepare alignment drawings
- prepare cross-sectional profiles
- identify existing structures in the proposed road alignment
- Finalize requirement of bridges, culverts, diversions, etc.
- plan land acquisition requirements
- establish control of locations
- establish an elevation difference between fixed points
- Identify the presence of underground utilities like pipelines, electrical cables, etc.

The objectives of this chapter are to provide guidelines to carry out a topographical survey and prepare topographical maps of the project alignments for the preparation of DPR of Road and Bridge Works. While conducting survey works, the Survey work must consider the following works but not limited to;

- Establishment of Control Point by DGPS / TS
- Monuments of the major control points.

- Prepare Description Cards
- Control traverse
- Detailed topographical survey project alignments.
- Prepare a topographical map of contour interval 1m from the survey data.
- Submit a detailed survey report.

3.7.2 Control Station

All survey for road projects shall be adequately referenced to the nationwide coordinate system directly derived from or indirectly connected to GPS satellite observations. The position coordinate coordinates shall be based on the national horizontal geodetic control points unless otherwise authorised.

Levels shall be preferred to the mean sea level and related to a vertical network of national geodetically heightened primary, secondary and tertiary benchmarks unless otherwise authorised.

3.7.2.1 Establishment

The first step of the topographical survey is the establishment of control points. The process of establishment of control points depends on instrument used DGPS or Total Stations or combination of both. Survey monuments are used to provide horizontal and vertical control for survey works. These project control monuments provide the basis for all survey works. Their stability and positional accuracy are crucial as they are the only references for the detail survey as well as construction survey.

3.7.2.2 Location

The permanent station should be placed within the right of way. They should be placed in areas that minimize the possibility of disturbance due to construction activities. Each location should also be chosen to avoid potential conflicts with underground utilities. When possible, adjacent project control monuments should be placed on opposite sides of the roadway. The permanent station should be placed so as to avoid nearby and overhead obstruction (i.e. clear horizon).

3.7.2.3 Spacing

The control points shall be installed at maximum interval of 250 m within ROW and on both sides of the riverbanks in case of bridges for traverse survey of alignment. The control points shall be connected to the Trig Points established by the Government of Nepal. The entire project and its components shall be connected to the National Coordinate System. Closed traverse loops shall be carried out between control points to check the accuracy of the survey. A topographic survey shall be carried out to high precision.

3.7.2.4 Monuments and D-cards

Control Points have to be established either on a concrete pillar (0.15 x 0.15 x 0.60 m) LxBxH size of M20 concrete or cross chiselled on a boulder or concrete nail on permanent features. Every control point has to be marked with suitable colour paint on the site. A separate BM reference sheet, together with a BM card has to be prepared and submit which will be useful during the further survey and construction stage of the project. All the surveyed data and

topographic map thus prepared shall be handed over to the client in (Dwg/Dxf) format along with the report.

Description cards of all the major control points shall be prepared and the description cards of the control points / BMs shall depict the following information:

- The ID of the control point.
- Method of the establishment.
- Location description of the point.
- Monuments type.
- Dimension to the references of the points.
- Coordinates of the point (E, N, and Z) of the point
- Photographs

The survey code to be used during survey is in **Appendix VI** and sample of the D-card is presented **Appendix VII**.

3.7.2.5 Control Traverse

In every stretch traversing in loop has to be completed prior to detailed survey. Traverse shall be done from GPS to GPS (Established BM to BM). While traversing, TBM stations will be established 100 m apart and all reference/BM pillars shall be connected. These points would be further used for detailed survey. The minimum accuracy of this survey will be 1:10000. Traverse line diagrams for each closed loop traverse shall be submitted. Surveyor shall keep hand written survey notes for all the observations of traverse and the same shall be submitted with traverse data. Traverse loops shall be submitted in XLS format. Distance & included angle observations format shall be used in traversing. Traverse lines shall also be run along the selected realignments and proposed bypasses along the project corridor, if any in same manner as described above.

All the existing traverse (control) stations shall be connected while doing the traverse and accuracy of existing horizontal control needs to be verified.

The detailed topographical survey shall cover a strip of right of way on the proposed alignments. As well as in the contest of curves or turnings, the survey shall be extended up to 100m or requirement of designers.

The detailed survey shall carry out to prepare a topographical map of contour interval 1m and generate longitudinal - sections and cross-sections of the transmission alignments, distribution alignments, and sub-distribution alignments of the proposed and existing water supply pipeline.

3.7.3 Detailed Survey

The detailed survey shall depict the following information on the ground:

- Existing track, road details, tress, forests, water bodies, existing infrastructures, and other features
- Details of existing cross drainage structures such as length, width, and height of culverts, bridges, High Flood Level, Water Level, River Center, River Bank, etc., details about bridge span, river training works, riverbank structures, and Gully or Streams, etc. if any
- Existing power line details such as high-tension poles, low tension poles, transformers, sub-stations, street lighting poles, underground electrical supply if any
- Existing telecommunication details such as telephone lines, poles, tower, and underground lines if any

- Existing water supply line details such as trunk sewers, branches, manholes, location/position of septic tanks and soak pits of the adjacent building on both sides of the road within ROW.
- Existing building details such as Temples, Church, Gumba, Mosque, Government/Residential Buildings, Boundary Walls, City Boundary, etc.,
- Existing Irrigation canal structures if any,

3.7.3.1 Longitudinal Sections Survey

Collection of Longitudinal centerline Points would be 10 m for hill and 20 m for plain terrain (Except in Curve Locations). On the vertical and horizontal curves, it has to be 2 m to 3 m apart depending on the nature of curve i.e. degree of sharpness of the curve. Apart from this, in case of vertical curves the points should be captured in such a fashion by which the crest and bottom most points of the curve should not be missed.

3.7.3.2 Cross-Sections Survey

The cross section data must be taken at the interval of 5 m in straight section and at 3 m interval in sharp curve locations. Besides, cross-sections should be taken at points of beginning and end of spiral transition curves, at the beginning, middle, and end of circular curves, and at other critical locations. All cross-sections survey must cover whole ROW.

3.7.3.3 Trees Survey

Location of individual tree having girth of equal or more than 300 mm coming within the proposed right of way on either side has to be collected along with their broad categorization and girth as mentioned below;

- Girth from 300 mm to 600 mm
- Girth from 600 mm to 900 mm
- Girth from 900 mm to 1800 mm
- Girth from 1800 to 2500 mm
- Girth above 2500 mm

The template for data collection for tree count is given in **Appendix VIII**.

3.7.4 Digital Terrain Model (DTM) Preparation

After completion of survey, the DTM model have to be prepared by survey and designer team, and DTM data should be verified and approved by client for further process. To prepare DTM, survey data are imported to AutoCAD by using SW DTM and then a three-dimensional base plan with contour and all the features has to be prepared by connecting all the collected points with 3D poly lines. This data should be sufficient enough to support base plan prepared and the plan must be verified and approved by client for design process. During verification if the data is found insufficient then again data must be collected of missing section and if data is completely mismatching with field topography then resurvey must be conducted.

3.7.5 Topographical Mapping

After the preparation of the DTM, the Topographic Survey and Mapping Report shall be prepared to describe the activities undertaken including all necessary basic data and records relating to the topographic surveys. The topographical map shall be prepared showing all the above-

mentioned information in Auto CAD drawing. All the features such as houses, rivers, roads, tracks, etc. shall be drawn and appropriate symbols are used to show the detailed features like trees, poles, transmission lines, temples, hospitals, schools, etc. The final map of the road corridor shall be prepared with a contour interval of 1m on the scale of 1:500. DTM (Digital Terrain Model) shall be prepared. The Digital Terrain Module of the surveyed area shall be prepared by using AUTOCAD / AUTOCAD Land Development Software. The produced digital map shall be compatible with computer-aided design and GIS system.

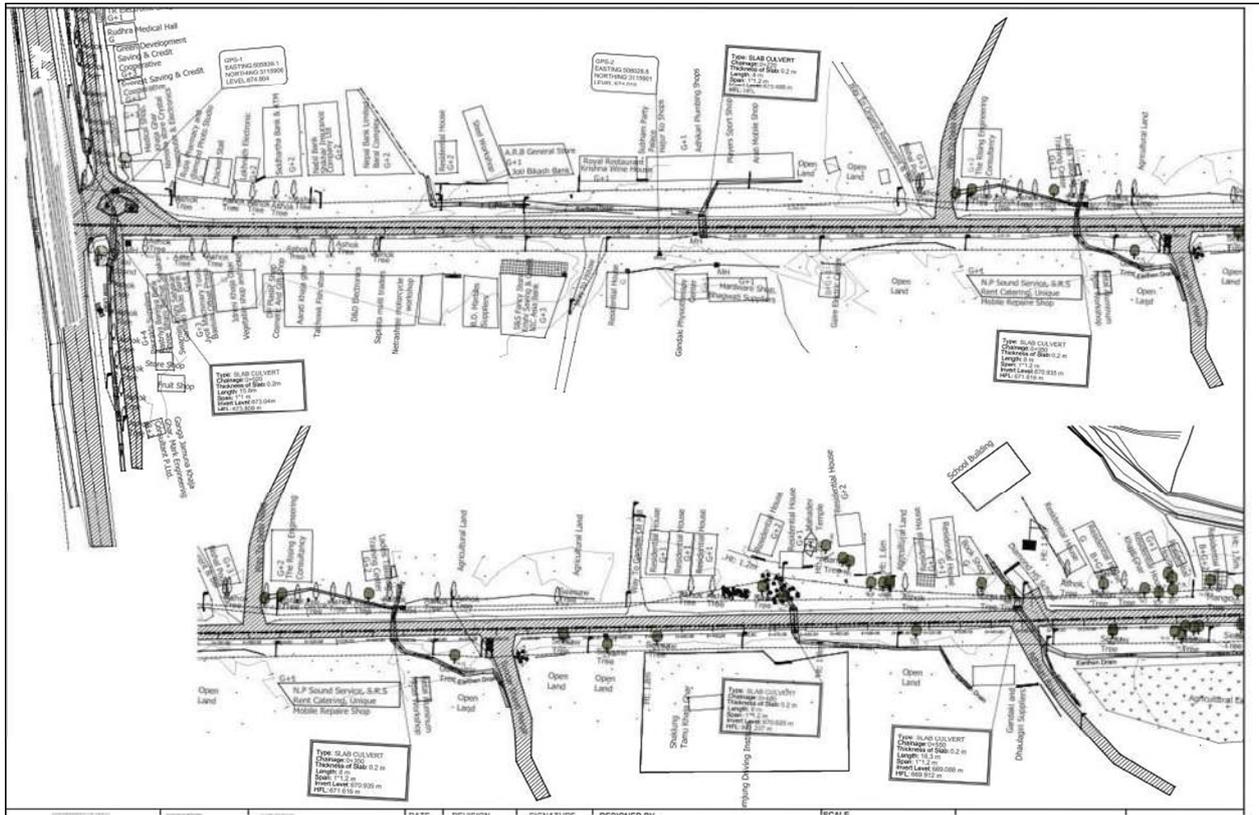


Figure 3.1: Sample of Topographic Map

3.7.6 Topographical Survey Reports

The topographical reports must contain following data, drawings and information;

- Traverse Calculation Sheet
- Levelling Sheet
- D-Cards
- Field sketches
- Points Data (Serial No., Easting, Northing, Reduced Level, Description)
- Complete topographic survey drawings in AutoCAD format

3.8 Topographical Survey for Bridge Works

While conducting the topographical survey for bridge design, the survey area shall cover a minimum distance of 500 m upstream, 200 m downstream, and 200 m from the river banks on either side of the river at the proposed bridge site. In the case of the topographical survey of the bridge site, the topographical survey of the bridge site, the topographic map should show the following:

- Contours at 1.0 m intervals in hilly area and at 0.25 m in plain area.
- Flood lines on either side of the river in the entire area surveyed.
- Lines with spot level along which the bed slope of the river is taken.
- Both banks of the river
- Lines along which the cross section of river is taken.
- Details of government and /or public establishment on the river banks, details of existing river training works (if any)
- Traverse lines benchmark reference lines and /or points concerning which the present topo map is prepared.
- The angle and direction of skew, if the bridge is proposed to be aligned skew.
- The names of the nearest identifiable villages/towns etc. in either ends of bridge
- Other information relevant to the design, construction, and /or maintenance of the bridge.
- Drawing should show the following minimum scales:
 - Site Plan 1 : 50,000
 - Plan 1: 1,000
 - Horizontal Profile 1 : 1,000
 - Vertical Profile 1 : 200
 - Cross sections 1:200

3.9 Differential Global Positioning System (DGPS)

Differential global positioning system (DGPS) is an enhancement to the global positioning system that provides improved location accuracy, from the 15- meter nominal GPS accuracy to about 10 cm in case of the best implementations. DGPS uses one or several (network) fixed ground-based reference stations in known locations. DGPS components are the base receiver, rover receiver.

A modification of the relative positioning method is the differential GPS (DGPS) technique, where one of the two receivers observing simultaneously is equipped with a transmitter and the other receiver(s) can receive the messages given by this transmitter. The transmitting receiver (Base Station) is kept fixed on a point whose location is known to a high degree of accuracy. Based upon this position, the receiver (Rover) computes corrections to the range/phase observations from a GPS satellite and transmits them to the other receiver, which can apply these corrections to improve the accuracy of its own position computed from GPS observations.

❖ Methodology for Establishment of Base station / Control Points with DSPS

- Base Stations to be fixed by Multi/Dual-frequency DGPS receivers with Trig Control Point of Government of Nepal as reference (to be supplied by Department of Survey).
- The minimum observation time for the base station shall be 3 hours.
- Required number of Control Points shall be established in such a way that the distance between the DGPS base station & rover shall be less than 5 km.
- The panoramic view surrounding the Base Station as well as antenna location showing the terrain nearby should be digitally photographed (should be taken in three or four different directions) and documented.
- Rovers shall be of Dual/Multiple frequency DGPS receivers within a radius of 50 km from the base. In case Single frequency DGPS receivers are used they should be used within a 10 km radius only. Readings of the BMs shall be taken with a minimum observation period of 1 hour.

3.10 Drone Survey

The Drone based survey is not a separate type of survey but it is a basic aerial photography survey which has been used for many years to prepare topographical maps. Only difference is the aircraft and the format of the aerial photo. The Drone survey flies at lower height e.g. 80 to 100m and takes digital photo at 12 to 50-megapixel resolution. Due to lower height and high-resolution camera the resulting ortho-photo has very high resolution e.g. 3cm to 10cm.

A drone survey refers to the use of a drone, or unmanned aerial vehicle (UAV), to capture aerial data with downward-facing sensors, such as RGB or multispectral cameras, and LIDAR payloads. During a drone survey with an RGB camera, the ground is photographed several times from different angles, and each image is tagged with coordinates.

With a drone, it is possible to carry out topographic surveys of the same quality as the highly accurate measurements collected by traditional methods, but in a fraction of the time. This substantially reduces the cost of a site survey and the workload of specialists in the field.

The primary outputs of the survey are:

- High-resolution aerial images
- A detailed map of the entire road section: high-resolution ortho-photo, contour maps of 1m contour intervals, and a complete top map.
- Profile and cross-section maps at each chainage.
- A web-based road inventory to store images and different outputs of the project

3.10.1 Benefits of Drone Survey

❖ Reduce Field Time and Survey Costs

Capturing topographic data with a drone is up to five times faster than with land-based methods and requires less manpower. This survey ultimately delivers your survey results faster and at a lower cost.

❖ Provide Accurate and Exhaustive Data

Total stations only measure individual points. One drone flight produces thousands of measurements, which can be represented in different formats (orthomosaic, point cloud, DTM, DSM, contour lines, etc). Each pixel of the produced map or point of the 3D model contains 3D geo-data. Surveying drone solutions can produce surveys with different degrees of accuracy, depending on the requirements of the project.

3.10.2 Methodology

Photos are taken with at least 85% frontal and at least 60% side overlaps to generate accurate model. Structure from Motion (SfM) is used to calibrate the camera, generate automated tie points, and dense point clouds. The ground controls points are established using professional GPS systems to transform the point cloud to the true ground scale.

Ortho-Photo is prepared from the projected point clouds and DTM is prepared from classified point cloud with ground surfaces (excluding building, structures and vegetation). The process is more or less automatic from image processing to the generation of the Point Clouds, DEM, DTM and ortho-photo. The drones with RTK (Real Time Kinematic) GPS facility even do not require ground control points. The flow diagram mentioned below represents how drones are typically integrated into surveying workflows:

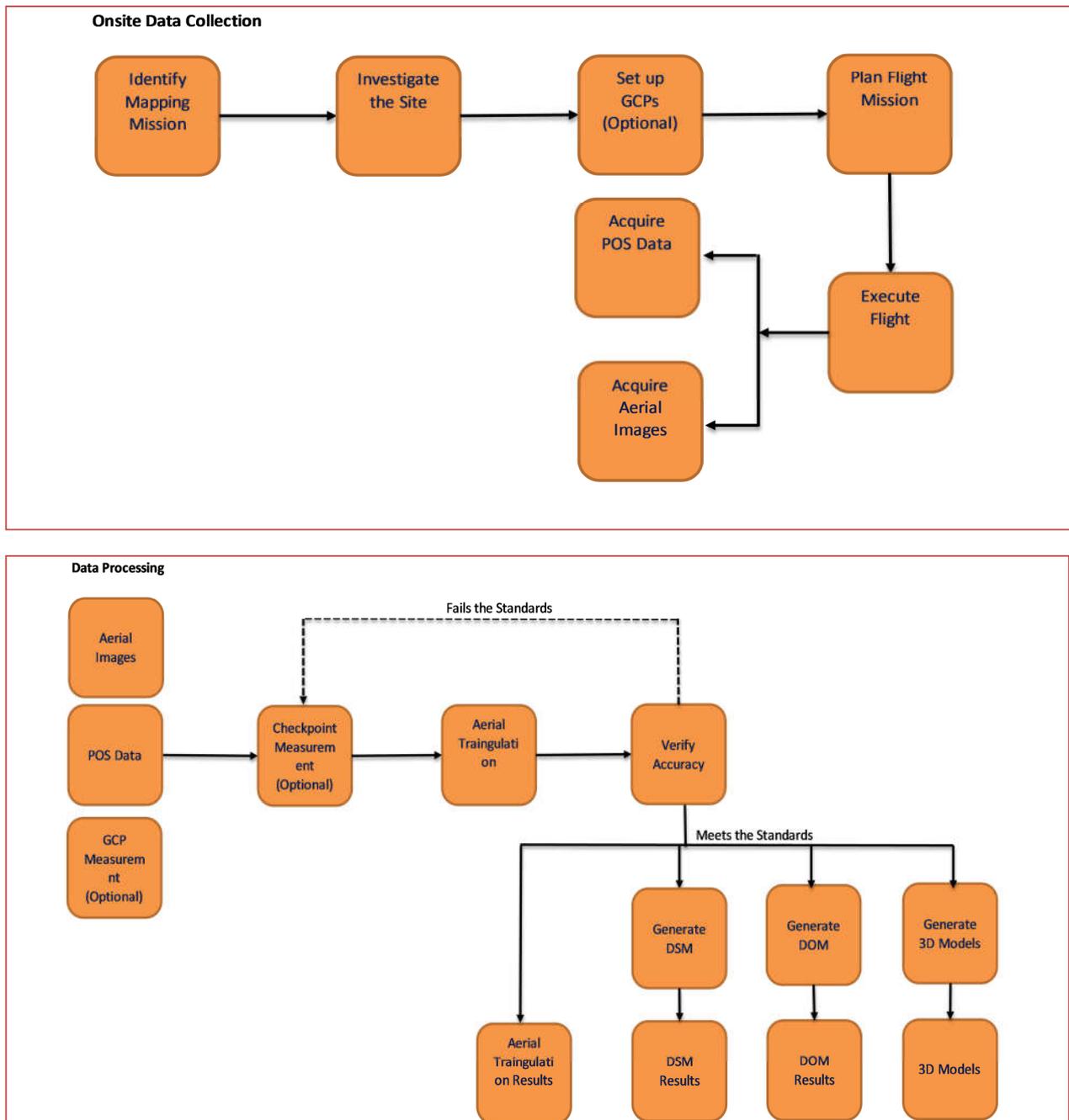


Figure 3.2 : Flow Chart for Data Collection and Processing

3.11 Hydrographical Survey

The detailed hydrological survey shall be carried out based on the analysis of the rainfall and flood records, supplemented by engineering field investigations necessary for detailed design of bridges, culverts, longitudinal drainage and protection works including river training works for drainage structures and bridges.

The objective of the hydrological study will be to determine the different hydrological parameters of the river/streams/gullies, which are to be crossed by the road. This will help in selecting, identifying, and determining the type of river crossing structures, different design data for the design of longitudinal and cross-drainage works, requirement of erosion protection and river training works, the capacities of side drain as well as cross drainage works, catch and

subsurface drains, etc. For these tasks, all relevant data and meteorological records shall be assembled to enable the necessary hydrological calculations (design discharge, required span/openings, scour depth, high flood levels, etc) and assessments of drainage requirements along the proposed roads and bridges.

For the determination of design data of bridge, detailed hydrometrical survey and hydrological study of the river and bridge site shall be performed and include the following:

- Catchment area of the river up to bridge site.
- Length of the river from origin up to bridge site.
- Possibility of change of catchment.
- Nature, size and quantities of debris carried by the river.
- Intensity, duration and distribution of rain in the catchment
- Vegetation, cultivation etc. of the catchment
- Existence of reservoir's, Lakes in the catchment
- Existing bridge or other hydraulic structures across the river in the vicinity of the proposed bridge site with their details as much as possible.
- General slope of the river from the critical point (origin) of the river up to bridge site and general slope of the catchment in both sides of the river.
- Cross sections covering 200 m beyond flood lines of the river at proposed bridge site, at about 500 m u/s and about 200 m d/s. Wherein HFL, LWL, LBL, area of the cross section, wetted perimeter and geological profile with silt factor of each strata (at proposed bridge site only) shall be indicated. (Horizontal and vertical scale of the cross section shall be the same.)
- Bed slope of the river which must start from 100 m up of the U/S cross section and end at 100 m down of d/s cross section.
- Maximum discharge calculated by established formulas with different return periods and the peak discharge observed over a period of 100 years.
- Velocity and depth of flow at the time of survey.
- Shifting of the river in the past at proposed bridge site and in its vicinity.
- Other information required for river control, design, construction and maintenance of bridge.

3.12 Geological and Geotechnical Survey

3.12.1 Engineering Geological Survey

In hilly and mountainous terrain, engineering geological investigations need thorough detailed study. The main objectives of the study are to identify those geological and geo-morphological conditions present in the region, as well as site-specific issues, which may have a direct bearing on the location, design, and operational aspects of the roads and the road allied structures. Engineering geological studies shall be carried out using simple hand-held instruments, eg: Brunton compasses, altimeters, geological hammers, measuring tapes, Abney levels, etc.

Engineering geologic field survey shall include mapping on the topographic base map of the different parameters of the State of Nature and of the Danger. These will include the followings:

- rock types, including weathering state
- soil type (Generic and Unified Soil Classification) and soil thickness
- rock structures (bedding plane, joint, foliation, cleavage, fault, fold, shear faces)

- Hydro-geologic conditions (drainage pattern and drainage characteristics, springs and seepage, and their discharge). Dry seed holes will also be mapped.
- Slope characteristics inclination, irregularities, breaks, hummocky topography, cliffs, escarpments, etc.
- Landslide (classification and geometry)
- Erosion (type and extent) and debris flow areas etc.

All the field observations will be recorded in a standard format using the MRE prescribed form with necessary improvements. The format of data collection for Geological and Soil Stability is in **Appendix IX**.

3.12.2 Geo-technical Survey

Geo-technical investigations and sub-surface explorations for the proposed road and bridges shall be carried out for the proper design of the works and conduct all relevant laboratory and field tests on soil and rock samples.

The investigation and testing works for road works will comprise mainly of investigation of sub-grade and the main objective will be to determine the general and strength properties of sub-grade soil and to decide the sub-grade characteristics for pavement design. The sub-grade investigation for road works will involve:

❖ Dynamic Cone Penetrometer (DCP) Tests

Dynamic Cone Penetrometer tests shall be undertaken for the entire road length sections in order to establish the strength of the subgrade. The DCP tests will be undertaken normally at an interval of approximately 500 m or as required. Test shall be started from subgrade level and it will be continued to 1 m depth from the test level. An 8 kg hammer and 10 mm cone will be used and rate of penetration against each blow shall be measured. The results shall be analysed in order to calculate the Field CBR of the subgrade at each test location.

Principles of DCP

- DCP is an instrument designed for the rapid in situ measurement of the structural properties of existing sub grade condition.
- Continuous measurement can be made to a depth of 800 mm. Measurement is possible to a depth of 1200 mm if an extension is fitted.
- The underlying principle of the DCP is the rate of penetration of the cone, when driven by a standard force, is inversely related to the strength of material as measured.
- The basic principle involved in the operation of this apparatus is the measuring of the resistance offered by the pavement layers to the penetration of a standard cone with a diameter of 20 mm (with 60° apex angle) driven by an 8 kg hammer freely falling through a height of 575 mm. the amount of penetration (in mm) of the cone is generally reported in terms of the average penetration per blow, (mm/blow).

Apparatus/ Equipment

A complete set of TRL DCP instrument and its accessories is shown below:

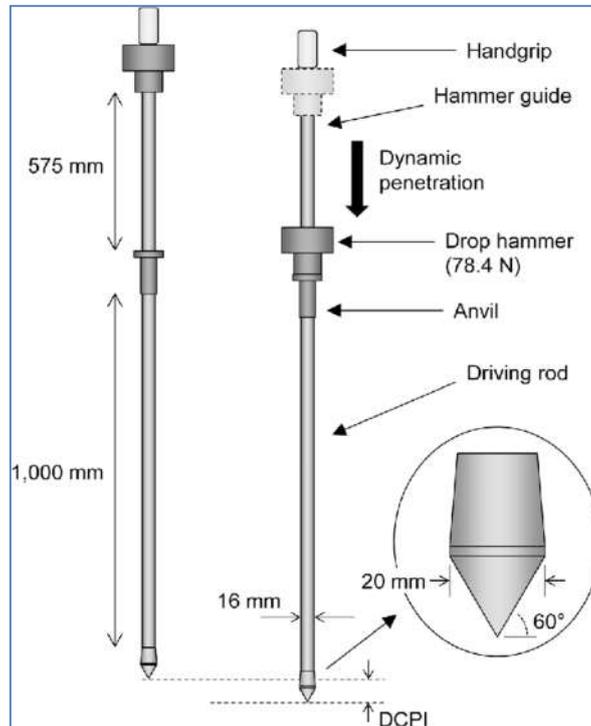


Figure 3.3 : A complete set of TRL DCP instrument

Procedure

- Three operators are required for carrying out this test. One to hold instrument, one to raise and drop the weight and a technician to record the results.
- Hold the instrument vertically and raised the weight carefully to handle.
- Care should be taken to ensure that the weight touches the handle, but does not lift the instrument.
- Before it is allowed to drop the operators should let weight fall freely without lowering it with his hands.
- Record the initial reading on the dynamic cone penetrometer scale.
- Calculate the value of penetration (in mm) for each blow by subtracting the previous recorded reading (i.e. reading on scale) from the current reading.
- Calculate the cumulative depth of penetration (in mm) for each blow by adding all the previous individual depth of penetrations.
- Determine the rate of penetration (mm/blow)
- Use the following formula for calculating the CBR value.
 $\log_{10} \text{CBR} = 2.48 - 1.057 \log_{10} (\text{mm/blow})$

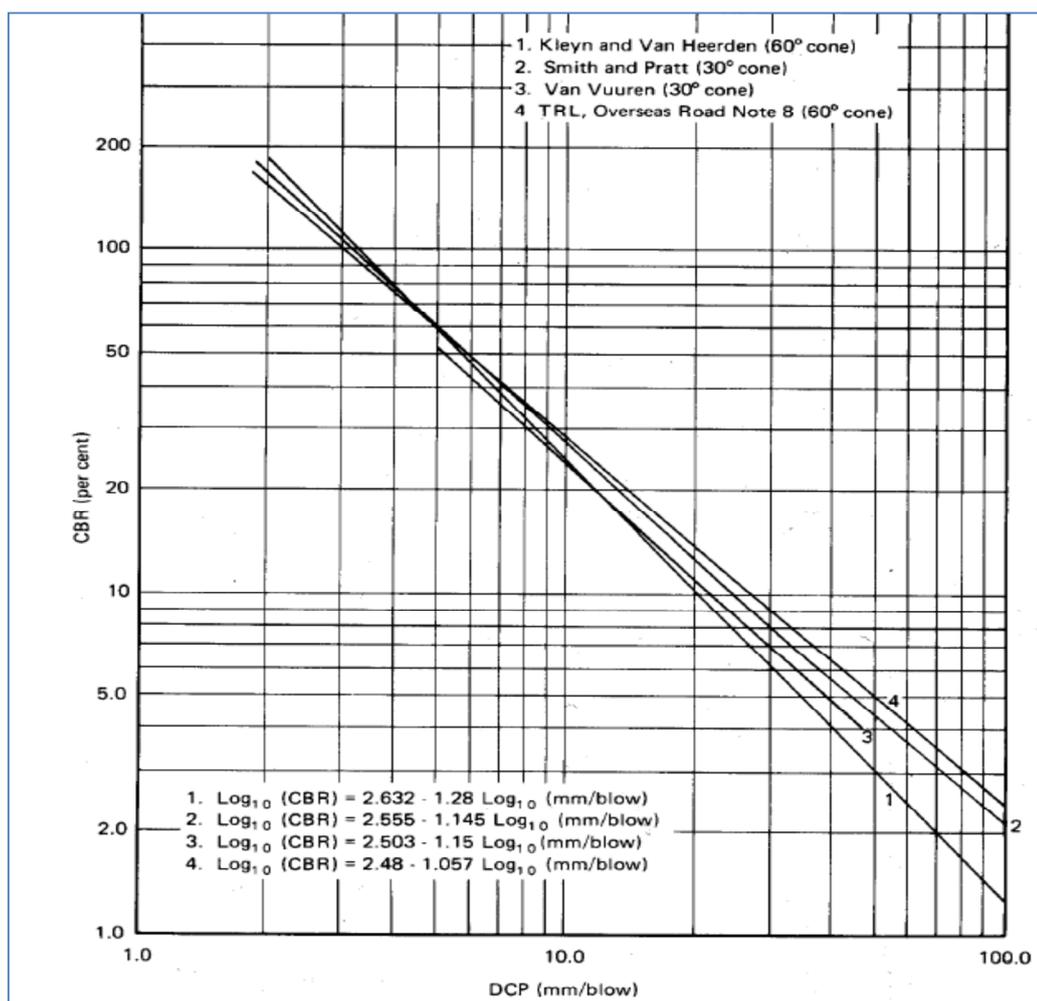


Figure 3.4 : Graph of DCP-CBR Relationship

3.13 Cadastral Survey

The cadastral survey shall be carried out of the land parcels to verify and finalize those areas that need to be acquired. Cadastral maps (ammonia prints) of the road alignment corridor of concern shall be collected from the district office of the Department of Land Survey. The Surveyor shall mark the road centerline and existing road width on the cadastral maps. In coordination with the topographic survey team, the additional land needed according to the final designed width and alignment of the road for upgrading works shall be marked on the site with pegs, as well as on the cadastral map. This activity shall lead to the initial finalization of land parcels from which the area needs to be acquired. The Surveyor, in the presence of the landowners and his immediate neighboring landowners, shall then confirm the area. Any house, structure, tree, and standing crops falling within the area will also be documented. The format for house hold survey for cadastral survey is in **Appendix X**.

3.14 Assessment of Bioengineering Works

Bio-engineering is the application of vegetative and vegetation structures to replace or strengthen the minor engineering structures for soil stabilization and slope protection works. It is cost-effective and environmentally friendly. In many places, bio-engineering can be applied for

the beautification of the roadside development. There are different planting configurations, the choice of which will depend on different factors. Choice of species of vegetation should adequately address engineering, physical, biological, and social factors.

The sites for the application of bio-engineering methods shall be analyzed by a process of prioritization, appraisal, and characterization. Possible danger to the road, to its associated drainage and other structures as well as the danger to neighboring land and environmental degradation, shall also be assessed thoroughly. Hence, for the design of the most suitable and appropriate bio-engineering measures, first shall prepare a Bio-engineering Map of the road corridor by undertaking field surveys and by using information from the Engineering Geologist/Geotechnical Engineer, Highway Design Engineer, and the Structural Engineer.

This map shall be a schematic diagram in which the features of the road corridor shall be shown such as attitude, topographical features, slope angle, and slope type, soil type, site moisture (wet, moist, dry, seasonality), drainage characteristics, groundwater, causing increased pore pressure, surface erosion (sheet erosion, gully erosion, piping, and slide, etc.) land river bank cuttings, cultivation practice, type and characteristics of indigenous quick-growing local plants and species, indigenous method and practice of vegetation, possibilities of planting fuel and fodder trees, etc. Nurseries developed in the vicinity of the project area, if any, will be inspected; the type, characteristics, available stock of plants and species will be noted.

Using all the above information and field findings, the sites for bio-engineering application shall be finalized in conjunction with Engineering Geological/Geotechnical Engineer, Structural and Highway Engineer. Different possible alternatives and their combination shall also be identified for each site and reflected into the Bio-engineering map.

3.15 Traffic Surveys

Information about traffic is vital for road project since it would form the basis for the classification of road, design of the pavement, fixing the number of traffic lanes, design of intersections and economic appraisal of the project. Traffic surveys required to be conducted in connection with the preparation of road project are as under:

- a. Classified Traffic Volume Counts
- b. Origin-Destination Surveys
- c. Speed and delay studies
- d. Traffic Survey for the Design of Road Junction
- e. Axle Load Surveys
- f. Accident Records

3.15.1 Classified Traffic Volume Counts

The main objective of the traffic survey is to determine the traffic volume with vehicle classifications suitable for pavement design. It requires an estimate of the annual average daily traffic (with vehicle classification), which shall be based on manual classified volume counts and historical traffic data. The classified counts shall be done for seven days and a full 24 hours at important locations and one day period ranging from 16 hours to 24 hours at other locations. The daily and hourly variations shall be analyzed and used from the 24 hours; seven days counts locations. Standard count forms will be used and the results screened to ensure accuracy. Using the classified volume count information, together with historic traffic data such as the daily and seasonal variations, derived from the survey and previous studies, the current level of traffic will be determined for each section of the project roads. Future traffic levels shall then be

determined from the information on growth rates for the normal traffic, generated traffic, and diverted traffic.

The format of manual traffic count survey is given in **Appendix XI**.

3.15.2 Axle Load Survey

The objective of the axle load survey is to quantify the damage that any vehicle type will cause to the road. It requires an estimate to be made of the average equivalence factor per each type of commercial vehicle using the road, which shall be based on 24 hours axle load surveys of commercial following the procedure set out in IRC guidelines. This survey will record not only the axle loads of vehicles but also; loaded or empty state; origin-destination; and cargo type. The axle load data will be analyzed to calculate the equivalency factor (number of standard 10.2 t axles) for each class of commercial vehicle, thus providing the current level of axle loading on the project road. The equivalency factors used in or derived from other studies will be reviewed and analyzed. Care shall be taken to finalize the equivalency factor of each.

In the absence of axle survey work, the survey data together with axle load information from previous studies can be used if available. The Government has adopted a legal axle load limit of 10.2 tons per standard axle type of commercial vehicle because it will affect to great extent in the design thickness of the pavement.

The format of Axle load survey is given in **Appendix XII**.

3.15.3 Accident Records

If accident records are maintained in a methodological manner, they form a good basis for designing the improvements at accident-prone locations on existing roads. Such records, if available, should invariably be consulted before deciding the improvements.

3.15.4 Traffic Projections

Traffic counts would provide information about present traffic on the road (in the case of existing roads), or the possible diverted traffic (in the case of new construction, such as bypass). For design purpose, however it is necessary that classified traffic should be predicted for the future perspective year for which the facility is to be designed.

Period of projection depends on the type of project, importance of the road, availability of finance and other related factors. The desirable and minimum forecast periods is 20 years for provincial roads.

Traffic growth should be assessed in the first instance on the basis of observed trend of traffic in the recent years and other economic indicators. In this connection the Pavement Design Guideline by Department of Road (DOR) shall be followed for traffic projection.

3.16 Material Availability Survey

The material availability survey and study shall be carried out. It shall determine the quantity and quality of the materials required for construction. The availability of the necessary materials shall be surveyed to determine the following:

- Information for the manufactured materials such as cement, steel, fuel, timber, bitumen, etc. will be collected from the potential and prospective importers and suppliers in terms of quality, quantity, and costs.

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

- Natural occurring material sources such as stone quarries, sand, aggregates, and fill material borrow areas, and water sources will be identified and investigated for quality and quantity.
- All potential quarry sites/borrow areas to evaluate the composition of deposition and quantities. Bulk samples of the materials encountered shall be collected for laboratory testing (natural moisture content, gradation, water absorption, unit weight, CBR, Los Angeles, flakiness index, Aggregate Crushing Value)
- The lead distances of the source from road alignment, base price, and royalties, etc. at the source will also be enquired and recorded for use in cost estimations.
- Possible environmental impacts due to the extraction of construction materials and their mitigation measures will also be assessed.

The format for collection of information on quarry sites near the road alignment is in **Appendix XIII**.

4 DESIGN

Based on survey and investigation works, the extent and type of new alignment design, road improvement, rehabilitation, and up-gradation work throughout the road length is determined. The Detailed Engineering Design is prepared that shall include improvement of road geometrics, drainage structures, retaining and protection structures, slope stabilization, and bioengineering work, road pavement works, road safety works, and miscellaneous ancillary works. All the design work must follow the requirement and standard acceptable to Bagmati Province road standard or DOR and should be based on current proven and acceptable practices.

4.1 Design Standards

The standards and criteria adopted shall be as per **Bagmati Provincial Road Standard, 2076**. The recommended design parameters for provincial roads and bridge are given in **Table 4.1** and **Table 4.2**.

Table 4.1: Recommended Design Parameters for Provincial Roads

Design Parameter	Province Roads				Remarks
	I	II	III	IV	
Design Capacity, PCU day	>10000	5000-10000	1000-5000	<1000	
Design Speed, kmph	P-120 R-100 M-80 S-60	P-100 R-80 M-60 S-40	P-80 R-60 M-40 S-30	P-60 R-40 M-30 S-20	
No. of Lanes	4 min	>=2	2	1	
Lane Width, m	3.75	3.5	3.5	5.5	
Shoulder Width (minimum), m	P,R-3.75 M,S-2.5	P,R-2.5 M,S-2.0	P,R-2.0 M,S-1.0	P,R-1.5 M-0.75 S-0.50	
Median Strip, m	3.50	-	-	-	
Minimum Radius of Hor. Curve (when super elevation is not provided), m	P-800 R-500 M-300 S-200	P-400 R-250 M-150 S-60	P-250 R-150 M-60 S-30	P-150 R-60 M-30 S-15	
Minimum K- Value for Vertical Curves (Summit/Valley)	P-807/441 R-427/236 M-231/111 S-94/42	P-427/236 R-231/111 M-94/42 S-29/17	P-231/111 R-94/42 M-29/17 S-4/6	P-94/42 R-29/17 M-4/6 S-2/3	
Minimum Gradient	0.5	0.5	0.5	0.5	
Maximum Longitudinal Gradient,%	P-4	P-5	P-6	P-7	
	R-5	R-6	R-7	R-9	
	M-6	M-7	M-9	M-10	
	S-7	S-9	S-10	S-12	
RoW in both side from CL	21	15	12	10	
Maximum Super Elevation	P,R- 7%, SB-7%, Hill not bound by snow-10%				
Critical Length of Maximum Gradient	P-600	P-450	P-400	P-300	
	R-450	R-400	R-300	R-200	
	M-400	M-300	M-200	M-150	
	S-300	S-200	S-150	S-150	
Cross Slope	As per Pavement Type				

Table 4.2: Recommended Design Parameters for Bridge

Bridge	Province Highway	Province Road	Urban and Local Road	Remarks
Carriageway Width of Bridge	7.5 m	6 m	As per traffic	
Width of Footpath	1.5 m both side	1.2 m both side		

4.2 Engineering Design

4.2.1 Interactive Design Environment

All the design works shall be carried out using an Interactive Design Environment such that the changes in the plan, profile, and cross-sections are instantly updated. Initially the Centre line alignment will be created from the corridor mapping to match the existing road widths. The cross-sections at required intervals and profile will be generated from the Triangulated Irregular Network (TIN) model. The interactive environment provides a lot of benefits which include trial design, selection of appropriate structures and continuity check, placement of the cross-drainage structures, checking off the drain invert levels especially at the hairpin bends. Road alignment designed on Digital Terrain Model (DTM) shall be set out at the site with staking the central line and taking levels with verification of the design.

4.2.2 Geometric and Cross-Section Design

The detailed design of geometric elements shall cover mainly the major aspects of horizontal alignment, longitudinal profile, cross-sectional elements, junctions, and intersections. These road geometric elements shall be designed following project road design standards. Design of the road geometrics shall be carried out by using internationally and nationally acceptable software such as SOFTWELL, SMART Road etc. This is windows based software and the output can be exported to AutoCAD and Microsoft Excel. All the design works shall be done by extensive utilization of Computer-Aided Design software for the highest accuracy and quality of work, as well as to complete the work in the specified limited time.

4.2.3 Design of Extra Widening, and Super Elevation

All the extra-widening works shall be calculated and must be included in the plan and cross-section itself rather than leaving it for the construction stage. The extra-widening placement i.e. inner or outer or mixed will be decided for each of the curves and the rate of extra widening will be according to agreed design criteria. Precise super-elevation design including the chainage-wise values shall be prepared. The complex nature of the hill road shall be carefully incorporated in the super-elevation design works.

4.2.4 Design of Retaining Structures

Various types of retaining structures shall be designed and included in the cross-section. All the retaining structures shall not only be shown in the cross-section but also be shown in the plan and profile. A three-dimensional view of the structure shall also be generated and the quantity extracted accordingly rather than from the cross-section. This method provides a more accurate method of retaining quantity estimation which takes into account of the total volume rather than the areas in each cross-section. The retaining structures up to 10 m height can be designed from the Standard Drawing for Road Elements Published by DOR.

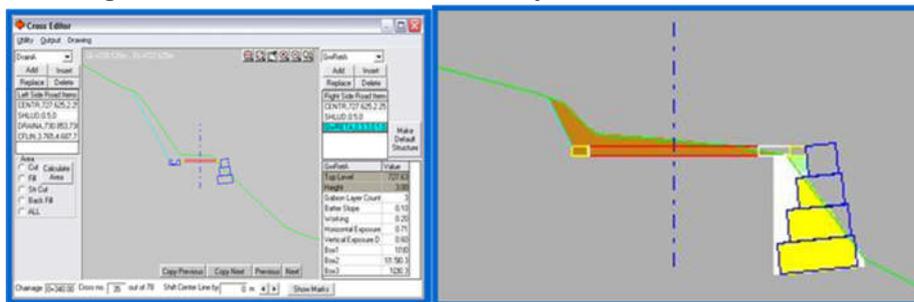


Figure 4.1 : Example of Cross-Section Editing with Structures and Drains

4.2.5 Design of Pavements

The design of pavement shall be done using DOR Pavement Design Guidelines, 2021 for a period of 20 years. The design alternatives in some selected reaches, mostly in the urban area, high gradient sections and hairpin bends shall be investigated both for rigid and flexible pavement design options to avoid the deterioration of pavement due to drainage problems.

For the design of the new pavement / paved shoulder, each set of design input will be decided based on rigorous testing and evaluation of its suitability and relevance in respect of the in-service performance of the pavement. Values of various design inputs criteria will be carefully chosen taking into consideration to the local practice and conditions. The pavement design task will also cover working out the maintenance and strengthening requirements and periodicity and timing of such treatments.

4.2.6 Design of Drainage and Cross Drainage System

The requirement of a roadside drainage system and the integration of the same with the proposed cross-drainage system shall be worked out for the entire length of the project roads. In addition to the roadside drainage system, the special drainage provisions for sections with super-elevated carriageways, high embankments, and road segments passing through cuts shall be designed. Adequate drainage provisions shall be worked out for road segments passing through urban areas. Following are the important factors which are required to be kept in mind before designing a drainage system for a road:

- Expected traffic, importance and configuration of the road (single lane, intermediate lane, double lane)
- Sources of water which may reach the road from above, side and below
- Drainage catchment areas and existing drainage system.
- Geometric characteristic of the road (alignment, profile and cross section)
- Presence of extreme gradients and cross slope, areas of excavation and land fill, probably of frost formation
- Any limitation in and around the road which may affect the design of drainage system.

For the better results in hydrological analysis, following stepwise procedures are followed:

- Collection of rainfall data in the vicinity of road area
- Rainfall analysis (Construction of IDF Curves)
- 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.

The data required for hydrological design include intensity of rainfall of the area concerned, the catchment area characteristic viz. soil type, vegetation cover, and land use pattern.

4.2.6.1 Rainfall

The rainfall data from the nearest rainfall stations along the road alignment shall be established by Department of Hydrology and Meteorology shall be collected.

4.2.6.2 Return Period

The return period is an average interval of time within which an event (rain fall/flood) of given magnitude will be equaled or exceeded at least once. The return period (design frequency) for various types of cross drainage structures such as road side drain, pipe culvert, slab culvert and major-minor bridges etc., has been adopted referring the “IRC: SP guidelines and Nepal bridge standard” as followed;

Return Period		
i	Road side drain	5 years.
ii	Culverts	25 Years
ii	Bridges and major culverts	100 years

4.2.6.3 Time of Concentration

Time of concentration is the time taken to flow storm water from far most point of the catchment area to the outlet point. It is the sum of Inlet time and flow time. The inlet time has been estimated using IRC: SP: 12 formula as follow;

$$t_c = (0.87 * L^3 / H)^{0.385}$$

where,

- t_c = Time of concentration in hr,
- L = Stream length in km (the distance from the remote point to the outlet)
- h = Difference of the maximum and minimum elevations in m. (the fall in level from the most remote point to the outlet 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).

4.2.6.4 Rainfall Analysis

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

The extreme rainfall data of available years from rainfall station shall be considered for rainfall analysis of the catchment. The frequency analysis method using Gumbel method (1941) shall be used to determine the rainfall intensity in mm/day for the required return period.

The expression for Gumbel equation is

$$X_T = \bar{X} + K\sigma_x$$

Where

X_T = Intensity of Rainfall for Return Period T.

\bar{X} = Mean Value of Rainfall

σ_x = Standard Deviation

K is the frequency factor and is given as

$$K = -[0.45 + 0.78 \ln \left(\ln \frac{T}{T-1} \right)]$$

Where, T= return period

Similarly, the rainfall intensity in mm/hr. shall be calculated using Mononobe's equation.

$$I = (R/24) * (24/t_c)^{2/3}$$

Where,

R= return period rainfall event in mm/day

t_c= time of concentration in hrs.

The rainfall **Intensity Duration Frequency Curve (IDF)** shall be established from the Mononobe's equation.

4.2.6.5 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. However standard tables are available to select this coefficient roughly for different cases.

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

Runoff Coefficient

Runoff Coefficient	Paved surface – 0.9
	Unpaved surface – 0.3
	Green area (loamy) – 0.3
	Green area (sandy) – 0.2
	Lawns and parks – 0.15
	Moderately steep built up area – 0.8

4.2.6.6 Design Flood Estimation

Rational formula is well applicable to small catchments. Hence it is used to calculate the design floods for cross and side drains using maximum hourly

$$Q_p = \frac{C * I * A}{3.6} \tag{3}$$

Where,

- Q_p = Maximum flood discharge in m³/s
- I = Rainfall intensity within the time of concentration in mm/hr
- A = Catchment area in km²
- C = Dimensionless run-off coefficient

4.2.6.7 Velocities

The minimum & maximum velocities adopted for the cross drainage and side drain are based on the “table 3.11, CPHEEO manual 2013”. The minimum and maximum velocity adopted is as follows:

- Minimum – 0.6 m/sec
- Maximum – 5 m/sec

The minimum limiting velocity has been considered to prevent siltation in channel bed, whereas, the maximum limiting velocity has been limited to prevent excessive scouring in channel wetted surface by flow water.

4.2.6.8 Capacities of Cross Drain and Side Drains

The capacities of the cross drainage and side drains shall be calculated/checked by using the Manning’s formula as below;

$$Q = \frac{1}{n} AR^{\frac{2}{3}}S^{\frac{1}{2}}$$

Where,

- A= Wetted area (m²)
- P= Wetted perimeter (m)
- R= Hydraulic radius (A/P) in m
- S= Bed slope
- N= Manning’s roughness coefficient

4.2.6.9 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. It is recommended to design the cross drains pipe culverts for 25 years return period flood. The drain size varies based on the design discharge. The design discharge for each drain is different. Pipe culvert shall be proposed for

crossing the small streams as rivulet and springs do not carry debris. Pipe culverts of pipe diameter 0.60, 0.90 and 1.20 m are considered for crossing the drains.

4.2.6.10 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. It is recommended to design the longitudinal side drains for 5 years return period flood.

4.2.7 Design of Traffic Safety Features and Road Markings

Traffic safety features and road furniture including traffic signals in province highways, urban areas, if required, traffic signs, markings, overhead signboards, crash barriers, street lighting in urban and semi-urban areas shall be designed, etc. The traffic sign and marking shall be designed following Traffic Signs Manual published by DOR. Data on accident statistics shall be compiled, showing accident type and frequency so that, black spots are identified along the project road. Possible causes (such as substandard geometric features, poor intersection layout, pavement condition, etc.) of accidents will be investigated and suitable cost-effective remedial measures will be suggested.

The purpose of carrying out design will be to:

- Minimize the risk of accidents occurring on adjacent roads as a result of operation and maintenance of the main roads
- Recognize the importance of safety in highway design needs and perception of all type of road users, and to achieve a balanced safety solution thereto; and
- Reduce the long term cost schemes, bearing in mind the overall cost-effective safe solutions.
- Minimize the risk and severity of accidents on roads

The alignment design will be verified for available sight distances as per the approved design criteria for the Project. The provision of appropriate markings and signs will be made wherever the existing site conditions do not permit the adherence to the sight distance requirements as per the standard norms of DOR.

4.2.8 Design of Bioengineering Measures

Bioengineering is the use of living plants for engineering purpose. Vegetation is carefully selected for the functions it can serve in stabilizing road side slope and for its suitability to the site. It is usually used in combination with civil engineering structures. The basis for the design of bio-engineering measures shall be the detailed analysis of the results of field investigation and the information and knowledge of bio-engineering works in other road projects. The selection of plant species for a specific site shall be done taking into consideration functional requirements, physical and biological factors, the possibility of grazing by cattle and/or human intervention, local availability of plants and species, etc. The main engineering functions of structures are; Catch, Armour, Reinforce, Anchor, Support and Drain.

The steps for design and implementation of bioengineering techniques are:

➤ Step 1 Make the Initial Plan and Priorities the Work
➤ Step 2 Divide the Site into Segments
➤ Step 3 Assess the Site
➤ Step 4 Choose the Right Bioengineering Works
➤ Step 5 Selected the Species to Use
➤ Step 6 Calculate the Required Quantities and Rates

1. STEP 1: MAKE THE INITIAL PLAN AND PRIORITISE THE WORKS

The first step is making an initial plan and schedule for design and construction of bioengineering works. The whole alignment must be inspected and make a list of sites that require treatment. Then priorities them according to the importance of stabilization. Weighting of seriousness of the existing or potential failure against the damage it could cause helps to priorities and schedule works.

Expected Consequence if the Site in not Treated	Priority Rating
Slope movement threatens houses	Priority 1 (i.e Very High Priority)
Slope movement threatens complete loss of road	Priority 2
Slope movement threatens partial loss of road	Priority 3
Slope movement threatens complete road blockage	Priority 3
Debris may fall on top of pedestrians or vehicles and cause injury	Priority 3
Slope movement threatens loss of productive farmland	Priority 4
Slope movement threatens blockage of drains	Priority 4

2. STEP 2: DIVIDE THE SITE INTO SEGMENTS

It is very important to have a good knowledge of the site. A slope segment can be defined as a length of slope with a uniform angle and homogenous material that is likely to erode or fail in uniform manner.

The mechanical, hydrological and biological process at work in a slope are many and complex. Nevertheless, before any remedial work can begin, it is necessary to identify the major factors contributing to instability in order to decide on appropriate action.

The assessment and treatment of each site is based on the use of one or more techniques for each segment. So, it is necessary to divide the slope into its component segments. Each segment of slope must be considered a separate entity for treatment: both civil engineering and bio-engineering techniques should be planned for each segment rather than for an entire state.

3. STEP 3 : ASSESS THE SITES

This is the most important step, and the one of which you must spend the most time. You must make a site visit and you will need:

- Format for data collection
- Tape
- A clinometer or an Abney level
- A GPS or maps or site drawings of the road line that show the altitude

The study of detailed factors contributing to instability within each slope segment. In order to achieve this, it is very essential to look carefully at each segment of the site and note down following factors;

Erosion and Failure List and Process: Each site has a different variety of erosion processes at work, which must be identified before remedial work can be started; often, there will be more than one process affecting each slope. The common types of erosion and slope failure are erosion on the surface, gully erosion, debris fall, and debris flow

Slope Angles: Record the slope angles and assign each segment to one of three classes; $<30^\circ$, $30-45^\circ$, or $>45^\circ$. Slopes of less than 300 will need only mild treatment, those falling in the other two classes will require more substantial stabilization.

Slope Length: Record the length of each segment of the site as <15 m or > 15 m. A slope length of 15 meter represents a practical dividing line between 'big' and 'small' site segment.

Material Drainage: This related to internal porosity of soils and the likelihood of their reaching saturation, losing cohesion and starting to flow. Materials with internal poor drainage tend to have more clay than sand. They are prone to slumping at a shallow depth if they accumulate too much moisture. In such a case, a stabilization required some kind of drainage in addition to other functions.

Segment Moisture: The moisture regime of the entire site must be considered although, in the field, this can only be estimated. In assessing sites, it is necessary to determine into which of four categories each segment falls.

- Wet : permanently dam sites
- Moist : sites that are reasonably well shaded or moist for some other reasons
- Dry : generally dry sites
- Very dry : sites that are very dry, these are usually quite hot as well.

Altitude: Altitude is the main determinant of temperature in Nepal and therefor regulated the local climate to a large extent. It is necessary to know the altitude to a reasonable f=degree of accuracy when the actual species are selected for bio-engineering works.

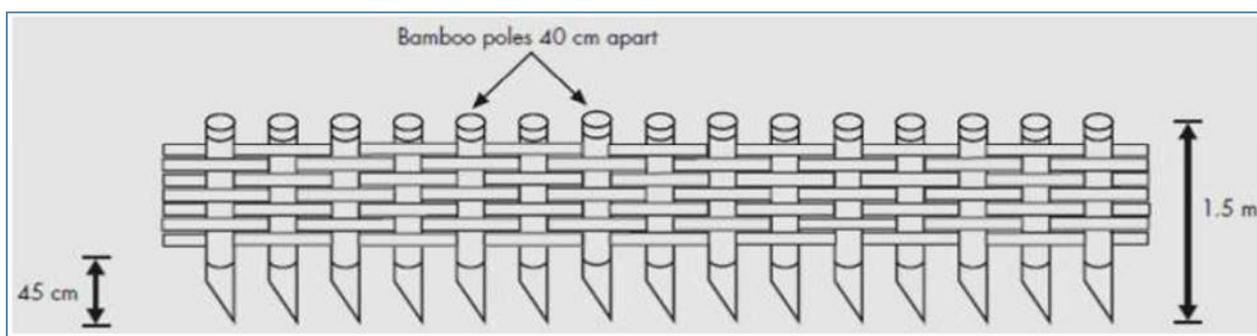
4. STEP 4: CHOOSE THE RIGHT BIO-ENGINEERING TECHNIQUES

This step gives detail of bioengineering and other related techniques for protecting surface, stabilizing and improving surface drainage and enhancing and protecting large civil engineering structures.

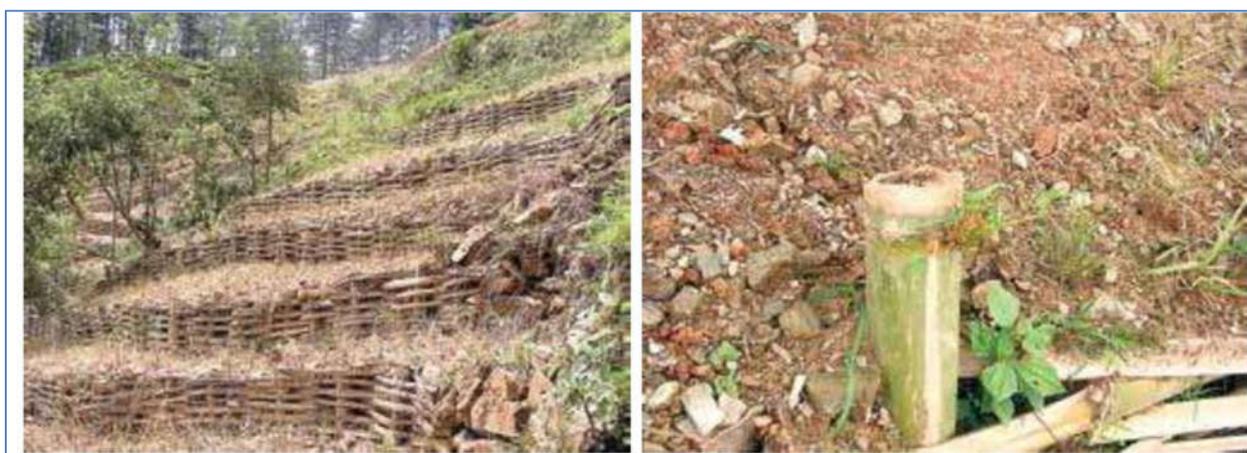
The bioengineering techniques that are adopted in Nepal are:

A. Bamboo Fencing

Bamboo fencing can be used to prevent soil creep or surface erosion on a slope, to hinder gully extension, particularly in seasonal water channels, and to control flood waves along a river bank. Live bamboo pegs can be used for the main posts so that the whole structure becomes rooted.



The growing bamboo can be further interleaved between the posts (as in a wattle fence) to increase the strength of the fence. Shrubs and grasses are planted on the upper side of the fence to hold small soil particles. The main purpose is to trap loose sediments on the slope, to improve the conditions for growing vegetation, and to reduce the surface runoff rate.



Bamboos fencing on a slope – the posts (pegs) are live bamboo that will sprout to provide foliage (left); detail showing live bamboo peg with sprouting leaves (right).

Materials

- Live bamboo pegs or strong bamboo poles about 1.5 m long and 10–15 cm in diameter
- Digging tools
- Seeds or plants of grasses or shrubs

Installation

- Starting from the base of the slope, mark the line for the fence with string.
- Dig a long pit about 45–50 cm deep along the contour of the slope for each line of fencing.
- Insert a row of bamboo poles or pegs 40 cm apart into the pit and back fill the pit to stabilize the poles.
- Weave split bamboo or branches in and out between the poles to form a semi-solid face.
- Plant small grasses and/or shrubs along the upper side of the fence.
- Regular maintenance is important to ensure longevity of the fence. Any broken sections should be replaced immediately.

B. Brush Layering

In brush layering, live cut branches are interspersed between layers of soil to stabilize a slope against shallow sliding or erosion. Fresh green cuttings are layered in lines across the slope. As

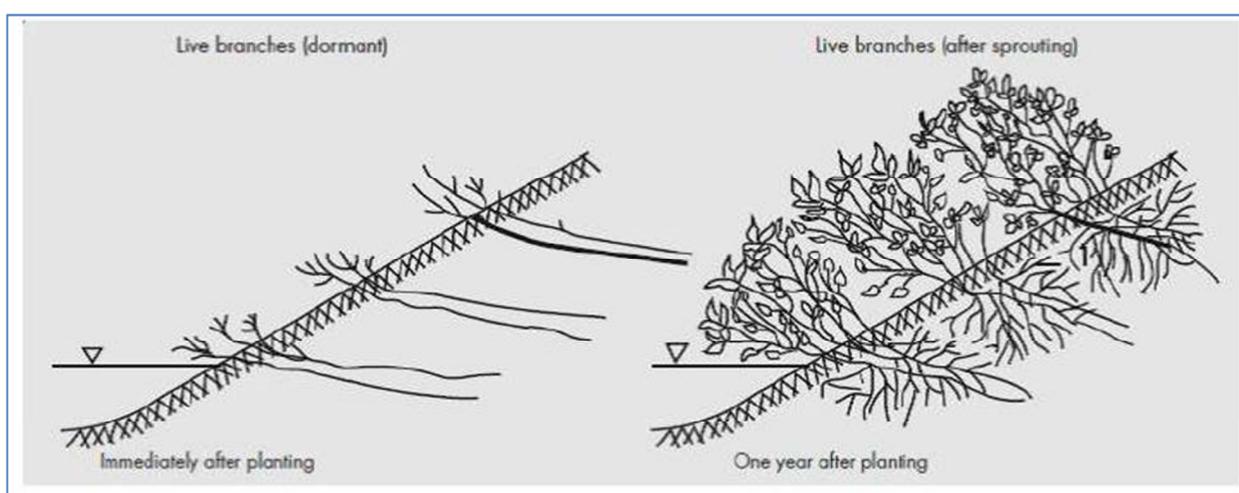
the roots grow, they anchor and reinforce the upper soil layers (up to 2 m depth), and the foliage helps to catch debris. Some toe protection structures such as wattle fencing, fiberschine, or rock riprap may be required to support brush layering.

Materials

- Branches of different age and diameter cut from rooting woody plants of different species (e.g., willow, alder, populus spp., garuga spp., Malabar nut [Justicia adhatoda], mulberry, five leaved chaste trees [Vitex negundo]). Branches should be at least 1 m long and 4 cm in diameter.
- Mixed plants of different easily growing species, both rooted and freshly cut
- Shovels or other digging tools
- Measuring tape and string line to calculate and mark the surface

Installation

- Mark lines across the slope to be planted at intervals of 0.5–1.0 m upwards from the base. The slope should have an inclination of at least of 10–20%. Dig a small channel along the line by hand or machine.
- Cut fresh branches with a right angle at the top and 45° angle at the bottom. If possible, cut the branches on the same day that they are to be planted. Ensure branches are at least 1 m long with a mixture of different species. This will allow the root system to penetrate deeper into the soil, giving greater chances of survival and producing mixed vegetation.
- Place branches in the dug terrace, with only $\frac{1}{4}$ – $\frac{1}{5}$ of their length overhang.
- Place rooted and unrooted plants of species that grow easily 0.5–1.0 m apart among the layers of branches. Regular supervision and care are needed until the branches are fully rooted. The pre-monsoon season is good for installing brush layering. If the site is moist, installation can be done in any season.



C. Brush Mattress

A brush mattress is a layer of interlaced live branches placed on a bank face or slope, often with a live fascine and/or rock at the base. The aim is to provide a living protective covering to an eroding bank to hinder erosion, to reduce the river velocity along the bank, and to accumulate sediment. The mattress is generally constructed from live stakes, fascines, and branches from species that root easily, but can be made from any brushy and woody branches to provide

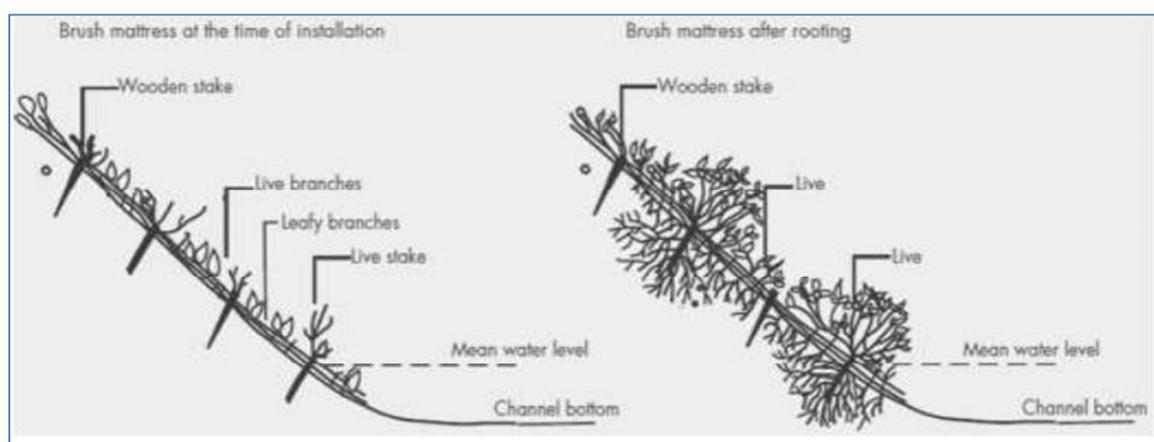
immediate and effective protection. A layer of biodegradable material such as loosely woven jute can be placed under the mat on steep slopes to increase stability if the soil is very loose. The mattress that is formed protects the surface of the bank until the branches can root and native vegetation becomes established.

Materials

- Live branches 2–3 m long and approximately 2.5 cm in diameter
- Fascine bundles
- Live and/or dead wooden stakes
- Digging tools (shovel)

Installation

- Prepare the site by clearing away large debris and other materials
- If desired, cover the slope with a layer of biodegradable material, e.g., jute netting, to provide extra stability
- Dig a horizontal trench 20–30 cm deep at the toe of the bank or slope.
- Lie the cuttings flat on the graded slope in an overlapping crisscross pattern with the root ends pushed into the soil in the trench to below the water level and the growing tips placed at a slight angle in the direction of the stream flow (if on a stream bank) or parallel to the slope.
- Branches should be placed at a density of approximately 4 branches every 15 cm.
- Pound wooden stakes between the branches into the soil to half their length and about 1 m apart.
- Wrap wire around the stakes and over the branches as tightly as possible.
- Pound the wooden stakes further in to tighten the wire and press the branches down onto the slope.
- Push live stakes into the ground between the wooden stakes.
- Place bundles of fascines along the trench at the base of the slope over the bottom of the branches and cover with soil, leaving the tops slightly exposed.
- Fill any voids around and in between the branches with loose soil (from the trench) to promote rooting.
- Periodic maintenance is required to ensure the mattress is securely tied to the slope.



D. Fiberschine

Fiberschine is a roll of material made from coconut fiber used to form a toe protection structure on a slope and to trap any sediment derived from erosion. The most common use is to stabilize the base of a stream bank or shoreline, but it can also be used in slope stabilization to support other measures such as brush layering. Live cuttings from herbaceous plants are planted together with the fiberschine; by the time the fiberschine decomposes, the vegetation will have

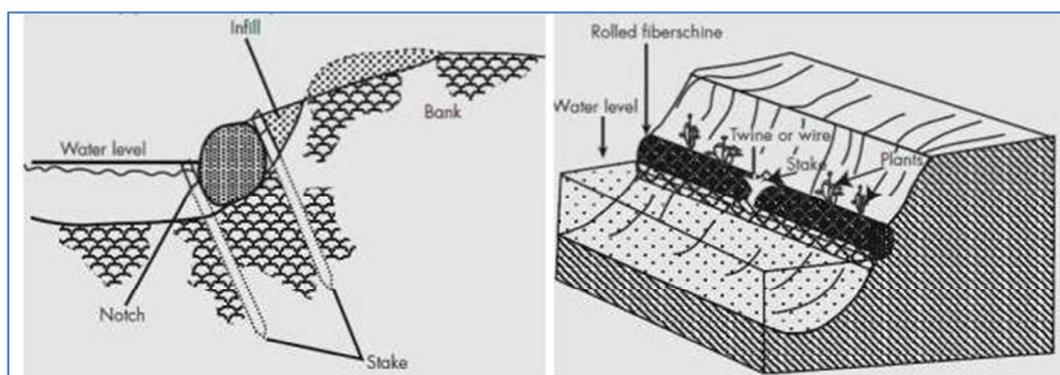
stabilized the stream bank or slope. Fiberschine can usually be installed throughout the year, but the high water season should be avoided along streams. The following describes installation along a stream bank. The method can be adapted for use on a slope.

Materials

- Fiberschine roll
- Wedge-shaped wooden stakes 60–90 cm long Twine or wire
- Herbaceous wetland plants or willow twigs

Installation

- Determine the length of the treatment area and obtain the necessary amount of fiberschine.
- Place a roll of fiberschine along the toe of the stream bank at the level of the low flow line with approximately half the roll below the water line and half above. Place additional rolls of fiberschine along the bank for the extent of the treatment area. Tie the ends of adjacent fiberschine rolls together with strong twine.
- Secure the fiberschine on both sides with wedge-shaped wooden stakes 60–90 cm) long at 1.5 m intervals. Cut a 7.5–10 cm deep notch in each stake about 12.5 cm from the top. Secure each pair of stakes together by binding around the notches. Drive the stakes in so that the twine is secured against the top of the fiberschine.
- Key the ends of the fiberschine into the bank to prevent the flow from entering behind it and protect the ends with something hard such as rock to prevent scouring.
- Backfill behind the fiberschine by knocking down the top of the stream bank onto the fiberschine.
- Plant herbaceous wetland plants or willows into and behind the fiberschine at approximately 15–30 cm intervals.



E. Jute Netting

Jute netting is a useful way of stabilizing steep slopes of 35°– 80° where it is difficult to establish vegetation. Locally available woven jute net is used as a form of armor on the slope and low growing grass is planted through the holes. The technique is often used in South Asia to reduce landslides along roads. The aim is to protect the bare slope from rain splash erosion, to improve the condition of the site, and to enable vegetation to become established by retaining soil moisture and increasing infiltration.

Materials

- Woven jute net
- Digging tools
- Sledgehammer
- Live wood pegs

- Grass seed or small-rooted tufts of grass

Installation

- Trim the slope so that it is even and clear away any hanging masses or depressions.
- Spread fertile soil on the bare slope.
- Mulch with straw or other soft vegetation.
- Start laying netting along a line above the slope to be covered, secure by hammering wooden pegs through the net at 0.3 m intervals.
- Unroll the net down the slope and fix by hammering live wood pegs through it at intervals of 0.5–1.0 m. Continue until the whole slope is covered by netting. Sow grass seed or plant small grass clumps through the netting diagonally at a spacing of 10cm by 10cm over the entire area.
- Regular supervision and care are needed until the grass is fully grown



F. Live Crib Wall

A crib wall is a box structure made of interlocking struts (either logs or precast structures made of concrete, recycled polymers, or other material) and back-filled with boulders, soil, or similar. They are mainly used to stabilize steep banks and protect them against undercutting, for example a stream bank or the side of a cutting made for a road, and are also a useful method for stabilizing the toe of a slope. However, they are only effective where the volume of soil to be stabilized is relatively small. In a live crib wall, live branches and well-rooted plants are placed between interlocking logs where they can grow and develop a root network that further strengthens the wall. If needed, the anchor and cross logs can be held together with nails or bolts. Vegetated crib walls provide immediate protection, and their effectiveness increases over time as the vegetation grows. Once the plants become established, the vegetation gradually takes over the structural functions of the wooden supports. Crib walls should be installed at an angle of 10–15° towards the slope to increase stability. Green willow branches can be used to ensure a quick outcome.

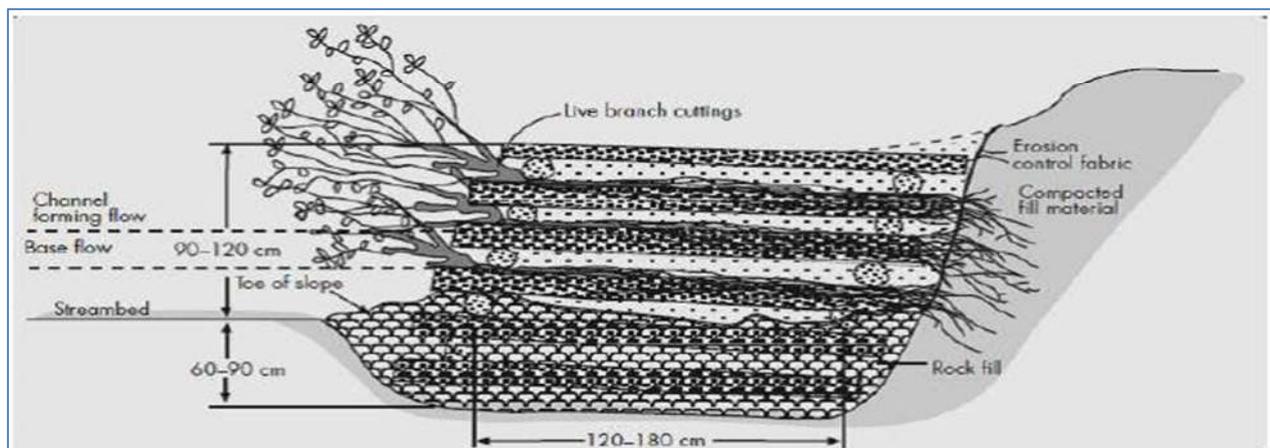
Materials

- Live branches 1–6 cm in diameter and long enough to reach from the front to the back of the structure with an overhang at both ends.
- Logs, timber, or bamboo 1–2 m long

- Steel reinforcing bars
- Excavator or digging tools (shovels), rakes, sledgehammers, knife, measuring tape, level instruments
- Rock and soil

Installation

- Excavate an area 1–2 m wide along the toe of the bank (stream bank or toe of a landslide) to a level around 1 m below the surface and fill with rock.
- Place a series of large logs on the rock end to end along two lines marking the front and back of the wall. Place a series of large logs on the rock end to end along two lines marking the front and back of the wall.
- Place a layer of live willow (or other) cuttings from front to back of the wall between the logs, and protruding over the front logs and extending into the slope behind the back logs.
- Cover the branches with a layer of rock and soil and press down to fill the box. (Steps 4 and 5 can also be carried out in reverse order.)
- Continue for as many layers as needed to reach the desired height, alternating layers of soil and cuttings and logs and ending with soil. Each successive course of logs parallel to the bank should be set back by 15–20 cm from the log beneath.
- To ensure success, the upstream and downstream sections should be well-secured to the bank to prevent undercutting.



G. Live fascines

A fascine is a bundle of sticks or brushwood used in construction, generally to strengthen an earthen structure, fill ditches, or make a path across uneven or wet terrain. Live fascines are bundles of live branches intended to grow and produce roots. They can be placed in shallow

trenches on a stream bank to reduce erosion across the bank and increase soil stability. The rooted branches protect the toe of the stream bank from erosion and improve infiltration. Properly placed, the bundles can also trap debris and sediment. Live fascines can also be used to reinforce slopes and increase drainage and infiltration. They are installed perpendicular to the slope in dug trenches or in existing gullies and rills. The optimum spacing depends on the steepness of the slope, usually 4 m intervals for slopes of less than 30° and 2 m intervals for slopes of 30–45°. They are most effective on soft cut slopes or slopes with consolidated debris. Draining effects can be seen as soon as the fascines are established.

Materials

- Live branches of rooting plants of different species 3–5 cm in diameter and 50–100 cm or more long.
- Live wooden stakes ready to sprout 3–6 cm in diameter and 50–100 cm long.
- Dead wooden stakes 3–6 cm in diameter and 50–75 cm long
- Digging tools
- Jute or coir string or wire to bind the fascines.

Installation

- Prepare the site by clearing away loose material and protrusions and firmly infill any depressions.
- Mark the lines along which fascines are to be installed. The lines should follow the contours, or be at a desired angle or along rills and at intervals of 2–4 m up the slope (2 m for slopes of 30°–45°; 4 m for slopes of less than 30°).
- Excavate trenches approximately 10 cm deep and 20–40 cm wide along the marked lines starting from the bottom of the slope and working upwards.
- Bind 4–8 live branches into bundles (fascines) using string or wire.
- Place the fascines lengthwise in the trenches.
- Drive alive or dead stakes directly through the fascines every meter or so flush with the top of the fascines, and where the bundles connect.
- Drive live stakes into the soil immediately below the fascines, protruding about 7 cm above the fascine. Backfill the trench with moist soil to the side of the fascine, but allow the top of the fascine to show. Riprap can be used to stabilize the toe of the slope and prevent scouring.
- Backfill the trench with moist soil to the side of the fascine, but allow the top of the fascine to show.
- Riprap can be used to stabilize the toe of the slope and prevent scouring.

H. Palisades

A palisade is a fence or wall made from wooden stakes or tree trunks. Palisades were used historically as a defensive structure. In slope protection, palisades are barriers made from live wood cuttings or bamboo installed across a slope following the contour in order to trap debris moving down the slope, to armour and reinforce the slope, and to increase the infiltration rate. Palisades are used to prevent the extension of deep, narrow gullies and the erosion of V-shaped rills by forming a strong barrier which stabilizes the gully floor and traps material moving downwards (Lammeranner et al. 2005). They are also effective on steep landslide or debris slopes. Palisades can be used on a wide range of sites with slopes of up to about 60°.

Materials

- Stakes made from cuttings of rooting plants of different species 3–5 cm in diameter and 30–50 cm long
- Cross beam

- Gabion wire
- Digging tools such as crowbars and shovels

Installation

- Installation should start from the top of the slope and work down
- Clean or trim the site, remove unnecessary irregularities of slope and loose material.
- Mark the places to be planted. Palisades should be spaced at intervals of about 2 m down a slope of less than 30° and 1 m down a slope of 30-60°.
- Make holes with the help of a pointed bar or crowbar for planting the cuttings.
- Trim the top of the cuttings at a right angle to the stem and the bottom at an angle of 45°.
- Place at least two-thirds of the length of the cutting into the hole and pack the soil around it.
- Tie the stakes with pieces of gabion wire to a cross beam which is anchored in the sides of the gully and protected by pegs at either end.
- On steep gullies and rills, support the palisade by placing a layer of stone and soil in front of and below the structure.
- Regular inspection is necessary throughout the year. Broken stakes should be repaired and strengthened to encourage vegetation to develop.
- Thinning might be required after a few years.

Major Problems and their Remedies

Phenomenon	Erosion Problem and Condition	Suitable Bioengineering Techniques
<p>Landslide</p>	<p>Deep-rooted landslide (>3m depth</p> <p>Slumping</p> <p>Planar Sliding</p> <p>Shear Failure</p> <p>Cut and fill area at deep and shallow rooted landslide (< 3 m depth)</p>	<ul style="list-style-type: none"> ○ Smoothing to a suitable slope gradient ○ Diversion canals, channel lining, catch drains, waterways ○ Stone pitching and planting of trees, shrubs and grass slip ○ Bamboo fencing with live poles, planting and seeding grass ○ Terracing and planting with bamboo, trees, shrubs, grass ○ Live peg fence, wild shrubs, live check dams ○ Contour strips planted with grass, shrubs, and pegs ○ Fascines, brush layering, and palisades ○ Planting bamboo with or without a structure ○ Check dams planted with deep-rooted species (e.g., bamboo, trees)
	<p>Bare and Steep slope or newly exposed surface</p>	<ul style="list-style-type: none"> ○ Bamboo fencing above zone; zone covered with polythene sheet ○ Catch drain with vegetation ○ Fascines, brush layering, and palisades
	<p>Cracking Zone</p> <p>Head scarp of landslide or slope failure</p>	<ul style="list-style-type: none"> ○ Slope excavated to an appropriate gradient and rounded (when high and steep) and planted with deep-rooted plants (e.g., bamboo, trees) ○ Bamboo fencing, planting grass, seeding, and mulching ○ Fascines, brush layering, and palisades ○ Jute netting or straw mat covering soil, seeds, and compost mixture; turfing ○ Stone pitching; planting of trees, shrubs, and grass slip ○ Planting grass slip and seeding grass
	<p>Sediment production zone</p>	<ul style="list-style-type: none"> ○ As for landslides ○ Series of gabion check dams, retaining wall, and side wall planted with deep-rooted species (e.g., bamboo, trees) ○ Bamboo fencing; grass planting, seeding, and mulching
	<p>Sediment transportation zone</p>	<ul style="list-style-type: none"> ○ Diversion canal, channel lining, retaining wall, and side wall planted with trees, shrubs, and grasses ○ Plantation of deep-rooted species (e.g., bamboo, trees)
	<p>Sediment deposition zone</p>	
<p>Debris flow</p>		

Phenomenon	Erosion Problem and Condition	Suitable Bioengineering Techniques
	Sheet and rill erosion	<ul style="list-style-type: none"> ○ Planting of bamboo, trees, shrubs, and grass with or without terracing ○ Live peg fence, wild shrubs, and live check dams' Contour strips planted with grass, shrubs, trees, and pegs Fascines, brush layering, and palisades with wild and thorny shrub species.
	Gully erosion	<ul style="list-style-type: none"> ○ Diversion canals, channel lining, catch drains, waterways, cascade retaining wall, and ○ side wall, planted with trees, shrubs, and grasses Bamboo fencing with live pegs ○ Planting of bamboo, trees, with or without check dams Series of retaining walls and plantation ○ Vegetated stone pitching in small gullies and rill beds
	Erosion on bare land, degraded steep sloped land, dry and burnt area	<ul style="list-style-type: none"> ○ Planting of deep-rooted species (e.g., bamboo, trees) Bamboo and live peg fencing and live check dams Vegetated stone pitching in small sheets and rill beds Stone pitching and planting of trees, shrubs, and grass slip.
Soil Erosion	Planting of deep-rooted species (e.g., bamboo, trees) Bamboo and live peg fencing and live check dams Vegetated stone pitching in small sheets and rill beds Stone pitching and planting of trees, shrubs, and grass slip.	<ul style="list-style-type: none"> ○ Bamboo fencing with live poles, planting and seeding grass ○ Planting of bamboo, trees, shrubs, and grass with or without terracing and structure ○ Live peg fencing and live check dams ○ Vegetated stone pitching in small gullies and rill beds ○ Contour strips planted with grass, shrubs, trees, and pegs ○ Planting fascines, brush layering, and palisades.
	Water induced degraded land (spring, water source damaged area, canal command area)	<ul style="list-style-type: none"> ○ Planting of bamboo, trees, shrubs, and grass with or without terracing and structure ○ Stone pitching and planting of trees, shrubs, and grass slip ○ Planting of deep-rooted species (e.g., bamboo, trees) Live peg fences and live check dams ○ Vegetated stone pitching and loose stone masonry walls or check dams
	Cut and filled area or newly exposed area on slope	<ul style="list-style-type: none"> ○ Jute netting and straw mats covering soil, seeds, and compost ○ Live peg fences and stone masonry walls ○ Plantation, seeding, and planting grass ○ Live wattling with terracing and seeding

5. STEP 5: SELECT THE SPECIECES TO USE

It is important to select the right species for use in each bio-engineering technique. To do this there are three factors to consider: function/technique, propagation and site suitability.

The ability of a particular plant to grow in a certain site is determined by the suitability of the species to that site. Plants should become well-established in the season of planting so that they are able to survive the dry months until the next rainy season.

Many bio- engineering sites have extremely poor and stony soils, which drain rapidly. The species should be robust enough to fulfill the bio-engineering function. Vegetation growth depends upon the temperature and moisture conditions for which the species is adapted. Species used for bio-engineering have a tolerance for site conditions and grow on almost any site, depending on specific characteristics. Water is the main factor for plant growth in the warmer months. The use of pioneer species for bioengineering on bare roadside slopes helps to allow a vegetation community to establish through the development of shade and better soil. The factors contributing to the final choice of species are:

- The species that will address the specific problems for bio-engineering techniques.
- Types of appropriate propagation techniques.
- Suitable species for the environmental conditions on site.
- Performance of the required functions on site and also usefulness to local farmers.
- Availability of species at the right place, at the right time, and in the right quantities

Local species are generally better suited to local conditions than species introduced from another area. This means that the choice should normally be a species found in the area where the bioengineering is being implemented. Many of the recommended bio-engineering plants are pioneer species, which means that they are naturally adapted to grow and survive on poor sites with extremes of sunlight, heat, drought and low nutrition levels. The main points related to the establishment of stable natural vegetation are:

- Use of fast-growing species for rapid establishment.
- Establishment of a stable, easily maintained plant community.
- Development of a vegetation cover that will reduce erosion.
- Development of a canopy which shades the soil and improves rooting conditions.

Many bio-engineering sites in the sub-projects are in inhabited areas. Local farmers may be able to make use of the plants grown on the sites. Wherever possible, the choice of species should be made with the consideration that products are of potential use to local people

6. STEP 6: CALCULATE THE REQUIRED QUANTITIES AND RATES

The quantity for bioengineering works is calculated based on site conditions and adopted bioengineering techniques. The quantity of work is estimated by measuring area (length and width) proposed for bioengineering works. The rate analysis for bioengineering is adopted from Department of Roads and rates are taken from district rates. Calculate the quantities and rates required for the work.

4.2.9 Design of Ancillary Works

The design of Ancillary Works shall include treatment of local instabilities, gully, and torrent control works, and road signs and safety markings. Detail designs shall also be prepared for

facilities such as the construction of tracks, trails, footpaths, pedestrian bridges, bus stations/stops, and market centers as per DOR Standards. The location of such facilities shall be determined in close consultation with the local community to ensure that their social needs are met. Typical designs shall be prepared for these facilities. The design shall ensure that the facilities to be constructed are simple and yet functional. As far as possible, local materials will be specified. The design shall ensure that the facilities can be constructed with locally available labor.

4.3 Preparation of Drawings

4.3.1 General

Project drawings should depict the proposed works in relation to the existing features, besides other information necessary for easy and accurate translation of the proposals in the field. For easy understanding and interpretation, it is desirable that the drawings should follow a uniform practice with regard to size scales, and the details to be incorporated. Drawing should be adequate size to accommodate a reasonable length of the road or as structural unit in full details. It is recommended that the size of drawing sheet shall be A3 paper.

4.3.2 Drawing

All the engineering drawings shall be prepared with appropriate details and scales suitable for bidding and construction, and in the format acceptable to the Client. The drawings and details shall, among others, include

- I. **Locality Map:** Locality map (sometimes called a "key map") showing the location of the works in relation to the region/district/municipality/ Rural Municipalities commonly at a scale of 1:2,500,000.
- II. **Site Plan:** Site plan (sometimes called "index map") showing the project and its immediate neighborhood including the important physical features such as hills, rivers, tracks, etc. It may be to a scale of 1:50,000. The locality map and site plan are commonly drawn on a single sheet.
- III. **Topographic Map:** Map showing complete alignment with Kilometer, names of area, land use, Rural Municipalities, municipalities, name of natural drainage etc., showing linkage of the road with surrounding road network.
- IV. **Plan and Longitudinal Section:** Plan and longitudinal section (profile) for 300 m length of the road should be shown on a single drawing sheet and the plan should be at the top and profile at the bottom.

The plan should show the complete details of road geometry of the designed alignment such as final centerline of the road, carriageway, shoulder, extra widening, right of way, existing road, existing structures, drainage, junctions, horizontal alignment with coordinates of IP, deflection angle, IP to IP distances, Chainage of IP, curve data etc. names of Rural Municipalities or municipalities, forest, land use pattern, cross drainage structure, retaining and protection structure and contours required or as directed by Engineer in charge.

The profile should show the profiles of the proposed road (design profile), existing ground profile, gradient, vertical curves, radius of curves, super-elevation, crossing structures etc.

The Plan with Topographical Map, Profile (Longitudinal Section) should be in the following Scale:

- Plan - 1:1000
- Horizontal Profile - 1:1000
- Vertical Profile - 1:200

- V. **Cross Section:** The cross section must be presented for in every 10 m interval for the alignment. The interval for cross section may be change as per requirement. These should show the existing ground level, designed level, carriageway, and pavement, shoulder, drain, and structures, camber slope, cut/fill line and area. These should be drawn to scale Plans and 1:200.
- VI. **Drawings of Cross-drainage and Retaining Structures:** Standard charts of mentioned cross drainage structures, retaining/Brest wall and protection works, side drain, typical cross section of the road according to types of soil, passing zone (if provided), hairpin bend (If provided)
- VII. **Others:** D-card, Topo-Map (all colored), legend of drawings, KMZ files etc. directed by Engineer in charge.

The standard template for drawing of plan and profile and cross section is given in **APPENDIX XIV**.

Note: To finalize the design and drawing, the design must be verified in the field, jointly by designer and TID/IDOs engineer. The design must be updated/modified based on field condition and finalized.

4.4 Preparation of Cost and Quantity Estimates

Based on the detailed design/drawings (plan, profile and cross section) quantities of civil work shall be computed for each item of works. The capital cost estimate shall include the initial cost of construction, engineering supervision, environmental management cost, acquisition of land and properties, and contingencies. The rate analysis for the civil engineering items will be made following the DoR norms and market prices of construction materials, labor and equipment hiring rates. The rates for civil engineering items shall be based on approved district rates of respective district. The cost shall also incorporate the cost for implementation of Environmental Mitigation Measures. The estimate should consists of

- I. Abstract of Cost
- II. Abstract of Quantities
- III. Estimates of Quantity of Each Items
- IV. Rate Analysis for Items
- V. Rate of Each Items including Rate of Collection of Materials and Transportation
- VI. Approved District Rate.

The template of quantity and cost estimates is given in **APPENDIX XV and XVI**.

4.5 Preparation of Bill of Quantities (BOQ)

Each item shall be clearly described and corresponding clauses of the standard and special specifications should be referenced to allow the contractor to easily find the corresponding

specification. The BOQ may be broken down into different types of works and shall clearly provide for VAT and contingencies.

The template of BOQ is given in **APPENDIX XVII**.

4.6 Preparation of Bid Documents

Suitable Bid Documents for the procurement of works NCB contracts shall be prepared in Standard Bidding Documents. The bid documents shall be prepared by incorporating the mandatory requirements of the PPMO, GON's prevailing Public Procurement Act and Regulations. It shall be ensured that the environmental and social requirements identified are incorporated in the Bill of Quantities, specifications, and contract clauses. R Standard Specification will be used along with modifications/additions/deletions and/or amendments, which shall be included in the Special Specifications. The specifications shall also incorporate the findings of the BES, IEE, EIA, EMP, RP, IPP, etc.

The bidding documents shall include

- Notice of Invitation of Bids
- Letter of Invitation of Bids
- Form of Bid
- Form of Agreement
- Condition of Contract, both General and Particular Specification and Drawings
- Bill of Quantities and Schedule of Prices
- Bidding Data Sheet or Appendix
- Bid Security Form
- Performance Security Form
- Bank Guarantee Form for Advance Payment
- List of Additional Information Required from Bidders

The specification shall comply with the standards adopted in Nepal as well as realistically achievable by the classes of contractors who are being invited to bid.

5 ECONOMIC ANALYSIS

5.1 Introduction

The basic objective of the economic analysis is to enable the client or the stakeholder to determine whether the project is an economically worthwhile investment proposal and whether it should be taken up at all. This is done by identification of the potential benefits expected to accrue to the community and comparison with the economic costs of the project. But, for a project to be economically viable, it must be financially sustainable, as well as economically efficient. If a project is not financially sustainable, economic benefits will not be realized. Here, the concept of financial profit is not the same as economic profit. The financial analysis of a project estimates the profit accruing to the project operating entity or to the project participants, whereas economic analysis measures the effect of the project on the national economy.

The economic analysis of projects includes an assessment of the sustainability of project effects to ensure that

- The project provides sufficient incentives for investors
- Sufficient funds are available to maintain project operations
- The least cost means of providing the project benefits is used
- The distribution of project benefits and costs is consistent with project objectives
- Environment effects are included in the analysis

5.2 General Approach

The approach used for the evaluation of the project follows conventional appraisal methodology of considering two stages: i. e, **without project situation and with project situation**. The “**with project situation**” is the situation after the implementation of the proposed project, whereas, “**without project situation**” is the situation of not implementing the proposed or similar project in that area. But, the without project situation is not the same as the before project situation. It can be represented by the present levels of productivity of the relevant resources. However, present levels of productivity can frequently change without the project.

Generally, following four basic steps can be used to analyze the economic viability of a project.

- Identify the economic costs and benefits
- Quantify the costs and benefits,
- Value the costs and benefits, initially in market or financial prices as much as possible
- Compare the benefits with the costs.

5.3 Economic Evaluation

In economic analysis, project benefits and costs are measured in constant prices of a base year and, therefore, the effect of general inflation is eliminated.

Economic evaluation is done in terms of comparison;

- I. Economic Benefits and
- II. Economic Costs.

I. Economic Benefits

Economic Benefits of the project were estimated in terms of savings in vehicle operating cost (VOC) and savings in travel time for passenger and goods vehicles, plus accident cost savings

and reduction in environmental impacts. The estimates of VOCs and time costs of each vehicle type in with and without project scenario shall be used.

VOC savings vary by vehicle type (such as cars, trucks, buses) and are influenced by road characteristics (such as surface roughness, width, curvature), vehicle characteristics (such as speed, weight, age), and costs (such as prices of vehicle and fuel, and maintenance costs for parts, materials, and labor). For road improvements, VOC savings are typically calculated using the Highway Development and Management Model (HDM-4). For traffic diverted from other routes or modes, VOC savings can be estimated by comparing the VOC of the road project under consideration with that of the other routes or modes. When the traffic diversion reduces costs for existing users on other routes or modes from where the diversion takes place, such cost savings should also be included as a benefit.

Travel time cost savings can arise from reduction in travel distance, or in congestion, or from faster road speeds, and can benefit both passengers and cargo in transit. For passengers, when measuring benefits from time savings, the analysis should separate work from leisure time, with the value of work time saved usually based on the relevant hourly wage rate, and that for leisure time approximated by a proportion of the hourly wage. For cargo, shorter trip time means the earlier delivery of goods. This benefit can be estimated based on the reduction in working capital as a result of the earlier delivery of goods and opportunity cost of capital, which can be approximated by the minimum required EIRR. Where perishable goods are involved, the time savings may create an additional benefit in avoided spoilage cost.

Accident cost savings include avoided medical expenses; avoided damage to vehicles, properties, and road structure; avoided income loss due to injuries; and avoided deaths. These can be estimated using data on accident related medical expenses, replacement cost of assets, and income loss per accident, as well as estimates of the statistical value of life. When country specific data are not available, data from other countries of similar economic conditions and at a comparable income level may be used.

Road projects also generate environmental impacts, and these should be considered in economic analysis. For clean transport projects, for example, reduction in air pollution, in carbon dioxide (CO₂) emissions, or in other environmental effects associated with normal (existing) traffic could be major sources of benefit. Air pollution or CO₂ emissions can also be reduced as a result of reduced congestion. Benefits from reduction in air pollution can be approximated by the cost of air pollution in avoided health expenditure and loss of productive time.

II. Economic Costs

The Economic Costs includes construction cost and maintenance cost. The construction cost includes the cost of widening of road where track opened and opening of track & widening at new section, construction of drainage structures & stabilizing structures, Tunnel (if any) pavement finishing, physical contingencies, costs of environmental mitigations and cost of resettlement etc. The maintenance cost includes Routine maintenance cost, Emergency Maintenance Cost & Periodic maintenance cost.

Basically, following three indicators of economic indicators are ascertained and compare to test project viability.

- Economic Net Present Value (ENPV)
- Benefit Cost Ratio (BCR) and
- Economic Internal Rate of Return (EIRR)

These are calculated using discounted cash flow methods since costs are incurred and benefits accrue at different dates. The feasibility of the project is determined by comparing the EIRR with

the current (considered) accounting rate of 12%. The project is further subjected to sensitivity analysis by varying the project costs and benefits by different percentage and the effect on the EIRR reviewed. This helps to gauge the economic strength of the project to withstand future risks and uncertainties.

5.4 Investment Decision and Criteria

After identifying and valuing project benefit and cost flows accrued in different years of a project's life that normally spans over 15–30 years, the future flows should be converted to their present value (or the value of a base year) by discounting at a required economic discount rate. The discounting allows calculating aggregated indicators of economic viability of a project for making investment decisions. The most commonly used indicators to determine economic viability are economic net present value (ENPV) and economic internal rate of return (EIRR). Other commonly used indicators are the benefit–cost ratio (BCR) and cost-effectiveness ratio (CER).

The ENPV is the sum of the differences between the discounted benefit and cost flows, and can be estimated as

$$\text{ENPV} = \sum_{t=1}^n \frac{(B_t - C_t)}{(1+r)^t}$$

Where B_t is the gross economic benefit in year t , C_t is the sum of economic costs (including capital costs, operating and maintenance costs) in year t , r is the required economic discount rate, and n is the project life.

The EIRR is the discount rate at which the ENPV becomes zero, and it can be estimated from the following:

$$\sum_{t=1}^n \frac{B_t}{(1+r)^t} - \sum_{t=1}^n \frac{C_t}{(1+r)^t} = 0$$

Where r is the EIRR, at which, the sum of the discounted stream of economic benefits equals that of the economic cost of project.

The BCR is the ratio of the sum of the present value of the project benefits to the sum of the present value of the total project costs, and it can be estimated as

$$\text{BCR} = \sum_{t=1}^n \frac{B_t}{(1+r)^t} \div \sum_{t=1}^n \frac{C_t}{(1+r)^t}$$

When there is only one project option and there are no alternatives to compare with and choose from, the ENPV, the EIRR, and the BCR should yield the same result: accept the project when its ENPV calculated using a minimum required discount rate is positive, or when the EIRR is greater than the minimum required discount rate, or when the BCR calculated using the minimum required discount rate is greater than 1. However, when an investment has several alternative project options that are mutually exclusive, the ENPV, the EIRR, and the BCR may or may not yield the same result. In such cases, the use of the ENPV is recommended.

6 ENVIRONMENTAL ASSESSMENT

The Environmental Assessment or Environmental Study has become an integral part of highway project preparation work. The main purpose of assessment is to identify the environmental impact of the project and its different alternatives, their significance and severance, proposed mitigation measures and provide information for taking decision regarding the overall acceptability of the project from environmental angle.

Environmental Assessment of the project shall be undertaken as per provisions of applicable Laws on Environment Protection Act 2077 of the Bagmati Province Government and identify a measures to reduce/eliminate the adverse impact identified during environmental study. The Environmental Study means a Brief Environmental Study (BES), an Initial Environmental Examination (IEE) and an Environmental Impact Assessment (EIA).

It is necessary to address the issues of environmental aspects for environmentally-friendly sound and sustainable planning, designing, and construction of road structures. The environmental issues are, but not limited to, preservation of natural landscape, forest, and existing monuments, the arrangement of construction materials and techniques, construction of cross drainage structures, management of mucks and by-product waste, bio-engineering for slope protection, conservation of the aquatic and terrestrial community, environmental pollution, health and safety of construction workers and the road users, etc.

Different environmental interventions shall be proposed for the entire project cycle of the project road e.g. landslide and slope protection, cross drainage and flood control structures, minimal removal of trees and vegetation, use of eco-friendly construction materials and techniques, health and safety precautions for the construction and operation phases. The intervening measures are either preventive or corrective or compensatory depending upon the nature of the impact and its gravity. These interventions have to be kept in mind during the entire project cycle of the project.

Moreover, an environmental assessment shall include the mitigation measures for the potential impacts of road construction, criteria of monitoring of the mitigation measures employed in the subproject, Environmental Management Plan (EMP), and the budgetary arrangements for implementing the EMP.

7 SOCIAL ASSESSMENT

The social assessment should be carried out especially the persons affected due to the Project and requiring resettlement and rehabilitation. GoN rehabilitation and resettlement guidelines should be the basis for undertaking the assessment. Plan for resettlement and land acquisition shall be prepared if required, which shall include the following:

- Draft Resettlement and Land Acquisition Plan;
- The social assessments should include gender and local aspects;
- Scope and magnitude of likely resettlement and land acquisition effects, likely losses of households, lands, business, and income opportunities, as well as affected community assets and public buildings;
- Development of an entitlement matrix i) in consultation with local stakeholders, government and the Authority, ii) socio-economic surveys, and iii) inventories of losses that will determine the amount of compensation following the guidelines and policies of the Government;

8 PREPARATION AND PRESENTATION OF PROJECT DOCUMENTS DETAILED PROJECT REPORT

8.1 General

The project data collected during the survey and investigation together with the detailed design, estimate, drawing and economic and financial assessment should be presented in proper form for full appreciation by TID/IDOs. These should be prepared in three parts under the following headings which when read together will constitute the complete project documents:

- I. Volume I- Main Report**
- II. Volume II – Drawing**
- III. Volume III- Cost Estimate**

Details to be presented in each part are brought out in subsequent paragraphs for guidance. It should, however, be understood that the extent of detailing of aspect would depend upon the size of concerned project and its scopes, e.g. whether new construction or improvement to an existing road.

8.2 Main Report

The project report is most important project document and should contain information under the following headings:

- Acknowledgments
- Executive Summary
- Salient Features
- Introduction
- Socio-Economic Profile
- Traffic Surveys including traffic forecast
- Hydrology and Meteorology
- Geology and Geotechnical Investigation
- Engineering Surveys and Investigations
- Detailed Engineering Design
- Environmental and Social Consideration
- Cost Estimates
- Economic and financial analysis
- Construction Programme
- Conclusion and Recommendation

8.3 Drawings

The drawings should be prepared as described in the **Chapter 4.3**.

8.4 Cost Estimates

The project estimate should give a clear picture of the financial commitment involved and should be realistic. This is possible only if the items of work are carefully listed, the quantities determined to a reasonable degree of accuracy, and the rates provided on realistic basis. The detailed for cost estimate must be as described in **Chapter 4.4**.

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APPENDIX-I: GUIDING PRINCIPLES OF ROUTE SELECTION AND ALIGNMENT IMPROVEMENT

General

- The road should be as direct as possible between the cities or towns to be linked, thereby, satisfying the major desired links. A direct highway link results in the economy in construction, maintenance, and operation.
- The location should result in minimum interference to agriculture and industry.
- The location should, as far as possible, facilitate easy grades and curvature.
- The location should steer clear of obstruction, such as cemeteries, burning ghats, places of worship, archaeological and historical monuments, and as far as possible, from public facilities, like hospitals, schools, playgrounds, etc.
- Where the proposed location interferes with utility, services, like, overhead transmission lines. Water supply lines, etc., a decision between changing the highway alignment or shifting the utility services should be based on the study of the relative economics and feasibility.
- An important obligatory point in the selection of the route is the location of river crossings. While crossings of major rivers (waterway exceeding 200 m.) may have to be as normal to the river flow if possible, with highway alignment sub-ordinated to considerations of the bridge sitting. Crossings of medium/minor streams should be generally governed by the requirements of the highway proper. If necessary, such structures could be made skew/located on curves.
- The location should be such that the road is fully integrated with the surrounding landscape of the area. In this connection, it would be necessary to study the environmental impact of the highway and ensure that the adverse effects of it are kept to the minimum.
- The highway should, as far as possible, be located along edges of properties rather than through their middle to cause the least interference to cultivation and other activities and to avoid the need for the frequent crossing of the highway by the local people.
- The location should be, such as, to avoid unnecessary and expensive destruction of wooded areas. Where intrusion into such areas is unavoidable.
- The road should be aligned on a curve if possible to preserve an unbroken background.
- The location should, as far as possible, be close to sources of embankment axil pavement materials so that haulage of these over long distances is avoided and the cost minimized.
- A preferred location is one which passes through areas having the better type of soil and permits a balancing of the cost of the cut and fills for the formation.
- Marshy and low-lying land and areas having poor drainage and very poor embankment material should be avoided, as far as possible. Also, areas susceptible to subsidence due to mining operations should be by-passed.
- Areas liable to flooding should be avoided, as far as possible.
- Highways through villages and towns increase traffic hazards and cause delays and congestion. Wherever a serious problem of this nature is encountered it may be advisable to by-pass the built-up area playing well clear of the limits up to which the town or village is anticipated to grow in the future.
- As far as possible, areas likely to be unstable due to toe-erosion by rivers shall be avoided.

Special Problems of Locating in Hilly Areas

- The route should enable the ruling gradient to be attained in most of the length.
- Steep terrain and other inaccessible areas should be avoided, as far as possible.
- Unstable hilly features, areas having frequent landslide or settlement problems, and upslope benched agricultural field with potential for standing water may be avoided as far as possible.
- Locations, along a river valley, have the inherent advantage of comparatively gentle gradients, proximity of inhabited villages, and easy supply of water for construction purposes. However, this solution is beset with disadvantages, such as the need for a large number of cross-drainage structures and protective works against erosion. It would, therefore, be necessary to take the various aspects into account before making the final selection.
- The alignment should involve the least number of hairpin bends. Where unavoidable, the bends should be located on stable and gentle hill slopes.
- In certain cases, it may be expedient to negotiate high mountain ranges through tunnels. For such cases, the decision should be based on relative economics or strategic considerations.
- In crossing mountain ridges, the location should be such that the highway preferably crosses the ridge at their lowest elevation.
- An alignment likely to receive plenty of sunlight should be preferred over the one which will be in shade.
- Areas liable to snowdrift should be avoided.
- As far as possible, needless rise and fall must be avoided, especially where the general purpose of the route is to gain elevation from a lower point to a higher point.
- Areas of valuable natural resources and wildlife sanctuaries shall be avoided.

APPENDIX II: DATA TO BE COLLECTED DURING RECONNAISSANCE SURVEY

- Details of route vis-à-vis topography of the area, whether plain, rolling, or hilly.
- Length of the road along with the various alternative.
- Bridging requirements number, length.
- Geometrics Features:
 - The gradient that is feasible, specifying the extent of deviations called for
 - Curves hair-pin bends, etc.
 - Railway crossings.
 - Ground constraints.
- Existing means of surface travel-mule path, jeep track, earthen cart tracks, railway lines, waterway, etc.
- Right-of-way available, bringing out constraints on account of built-up-area, monuments, and other structures.
- Terrain and soil conditions:
- Geology of the area
- Nature of soil, drainage conditions, and nature of hill slopes
- Road length passing through
- Geology of the area
 - Steep terrain
 - Rocky stretches with the indication of the length in loose rock stretches
 - Areas subject to avalanches and snowdrift
 - Areas subjected to inundation and flooding
 - Areas subjected to sand dunes including the location of dunes
 - Areas of poor soils and drainage conditions
 - Areas with very poor sub-soil strength, e.g. marshes
 - Areas of high salinity or wet saline soil.
 - Cliffs and gorges
- Drainage characteristics of the area including susceptibility to flooding
- General elevation of the road indicating maximum and minimum heights negotiated by main ascents and descents in hill sections
- Total number of ascents and descents in hill sections
- Disposition and location of sand dunes
- Vegetation – extent and type
- Climatic Conditions
 - Temperature – monthly maximum and minimum readings
 - Rainfall data – average annual, peak intensities, monthly distribution (to the extent available)
 - Snowfall data – a average annual, peak intensities, monthly distribution (to the extent available)
 - Wind direction and velocities
 - Visibility
 - Exposure to sun
 - Water Table and its variation between maximum and minimum
 - History of unusual weather, like, cloudbursts, etc.
- Facility Resources
 - Landing ground in case of hilly stretches
 - Dropping zones in case of hilly stretches

- Foodstuffs
- Labour – local availability and need for import
- Construction material timber, bamboo, sand, stones, shingle, etc. with the extent of
 - their availability leads involved and availability of easy access
 - Availability of water, especially in arid zones
 - Availability of local contractors
- Value of land-agriculture land, irrigated land, built-up land, forest land, etc.
- The approximate construction cost of various alternatives.
- Access points indicating the possibility of induction of equipment.
- The period required for construction.
- Strategic considerations.
- Recreational potential.
- Important villages, towns, and marketing centers connected.
- Economic factors:
 - Population served by the alignment
 - The agricultural and economic potential of the area
 - Marketing centers
- Other major developmental projects being taken up in the area, e.g., railway project
- Hydro-electric projects, railway projects, dams, reservoirs, mining/agricultural projects, etc.
- Crossings with Railway Lines and other existing highways.
- Location of existing or proposed utilities along the alignment.
- The necessity of by-passes for towns and villages.
- Position of ancient monuments, burial grounds, cremation grounds, religious structures, hospitals, and schools.
- Ecology and environmental factors.
- Aspects of needing coordination with other administrative authorities.
- Traffic counts from existing records.

APPENDIX IV: PAVEMENT CONDITION SURVEY FORMAT

PAVEMENT CONDITION SURVEY												Sheet No:						
Road Name:																		
Section (FROM) :																		
To :																		
District (FROM) :																		
To :																		
CHAINAGE	From (km)	To (km)	Pavement Composition				Shoulder		Riding Quality		Pavement Condition				Pavement Edge Drop (mm)	Embankment Condition (Good/Fair/Poor)	Road Side Drain (NE/PF/F)**	Remarks
			Composition	Type*	Thickness (mm)	Condition (Fair/Poor)	Speed (Km/hr)	Quality (GIF/IVP)	Cracking (%)	Ravelling (%)	Pot Hole (No. and % 100m)**	Rut (None/Moderate/Severe)	Patching (No. and % 100m)**					
			Surface															
			Base															
			Sub-Base															
			Sub-Grade															

Note* - BUSG= Built up Spray Grout; AC= Asphaltic Concrete; SDC= Semi Dense Concrete ; PC= Premix Concrete; MSS= Mix sealing surface; WBM= Water Bound Macadam; DBM= Dense Bituminous Macadam; BM= Bituminous Macadam; BS= Brick Soling; SS= Stone Soling
 No. and %/100 m= Total no. of Potholing/Patching and % age area of Potholing/Patching 100m of length of road
 NE= Non Existing; PF= Partially Functional; F= Functional

Surveyed By:

Date:

APPENDIX VI: SURVEY CODES AND MARKINGS

List of Survey to be used as follows: Survey Coding Method

Example

MW/T/E - Top of Masonry wall end

NS/Mill/C - Natural surface at mill corner

Main	Description	Main Code	Description
CL	Road Center line	BL	Baseline Point
RE	Right Road Edge	ST	Traverse Station
LE	Left Road Edge	FS	Fly Stations
SRE	Right Road Shoulder Edge	BM	Benchmark
SLE	Left Road Shoulder Edge	TBM	Temporary Benchmark
PRE	Right Road Pavement Edge	TK	Track Road Centre
PLE	Left Road Pavement Edge	TR	Tree
JNC	Road Junction	WL	Water Level
DR	Drain	BDG	Bridge
EP	Electric Pole	F	Fill
PC	Pipe Culvert	CU	Cut
SC	Slab Culvert	CA	Canal
BOC	Box Culvert	TEL	Telephone Pole
HW	Culvert Head wall	RO	Rocky Outcrop
NS	Natural Surface	BO	Boulder
PW	Parapet Wall	W	Wall
CH	Chainage	FE	Fence
HC	House Corner	TOL	Toilet
GW	Gabion Wall	HP	Hand Pump
MW	Cement Masonry wall	PW	Parapet Wall
DW	Dry Wall	CP	Catch Pit
HFL	High Flood Level	FL	Normal Flood Level
KI	Stream / Gully	Others	As instructed by Field Engineer

Description Codes	Description	Description Codes	Description
C	Corner	R	Right
T	Top	IL	Invert Level
B	Bottom	DS	Downstream
S	Start	US	Upstream
CL	Centre	Temple	Temple
E	End	Pipal	Pipal
L	Left	Wing	Wing Wall/ Guide Wall
BRL	Break Line		

APPENDIX VII: D-CARD SAMPLE

Provincial Government
 Ministry of Physical Infrastructure Development
Transport Infrastructure Directorate
 Bagmati Province
 Hetauda, Makawanpur

Name of Project.....

Description card of BASELINE/BENCHMARK STATIONS

page.....of.....

Name of Road:

District: -

Municipality/Rural Municipality: -

Ward No:-

Station Type	Description	Monumentation Mark (Photographs)	
	Chainage:		
	Easting:		
	Northing:		
	Elevation:		
Location Sketch Showing the Station and Reference Points			
Sketch		Photographs of BM with Reference Points	
Ref. No.	Distance	Bearing	Remarks
R1	m	DMS	
R2	m	DMS	
R3	m	DMS	

APPENDIX VIII: TREE DATA COLLECTION WITHIN ALIGNMENT FORMAT

SN	CH	Location	Left/Right	Type of tree	Girth cms	Ownership	Remarks (Road/RoW)

Surveyed By:

Date:

APPENDIX IX: GEOLOGICAL AND SOIL STABILITY DAT COLLECTION FORMAT

Checklist for Road Instability Survey

Road Instability Survey										
Road:		Chainage with landslide No:				Date:				
1 LOCATION Of INSTABILITY AREA (Natural Hill slope (DD/DA):)										
Along the road		Above road - any distance			Below road - any distance					
Type of instability: Rock/Soil		Slide/Erosion/fall/debris flow								
Deep seated / shallow slide: River undercutting/ drainage blocked										
2 MATERIAL FORMING ORIGINAL (FAILED) SLOPE:										
Colluvium		Alluvium		Residual Soil		Glacier till		Fill material		Rock
Thickness of the soil on the bed rock:					Color:					
3 ROCK WEATHERING GRADE:										
Completely		Highly		Moderately		Slightly		Fresh		
Discontinuities (DD/DA)		Continuity		Spacing		Waviness		Opening		Filling materials
Bedding/Foliation:										
Joint 1										
Joint 11										
Joint 111										
4 HYDROLOGICAL CONDITIONS AND LANDUSE PATTERN:										
Spring /Seepage flow/Active seepage flow				Monsoon saturation/well drained. Dry/ wet						
Forest		Barren		Wet cultivated		Dry cultivated		Sparsely dense forest		Grassland
5 DIMENSION OF THE FAILURE (m):										
Length			Breadth				Depth			
6 TYPE OF SLOPE AFFECTED:										
Road cutting but not hill slope			Hill slope but not road cutting			Road cutting plus hill slope				
7 SIOPE CONDITIONS ABOVE THE SLIDE (above road, if road is at top of slide):										
Gentle slope (less than 35)				Stable, undisturbed hill slope						
Unstable hill slope. Cracked ground, another landslide or topography that collects water										
8 SLOPE CONDITIONS BELOW SLIDE (or below road, if road is at base):										
Stable, undisturbed hill slope				Stream						
Unstable hill slope. Cracks, landslide or topography collecting water.										
9 GENERAL TYPE OF FAILURE:										
Rock/soil; Fall/topple; Rotational/translational										
10 FAILURE MECHANISM:										
Erosion (sheet, rill, pipe)		Shear failure (slide, slump, flow)								
Plane failure Wedge failures in rock										
11 CAUSE OF FAILURE:										
Surface water. Erosion, or soaking of surface: shallow slide/flow										
Ground water, causing increased pore water pressure at depth					Weathering					
Undercutting of slope by strem or road cutting			Active/passive		Addition of spoil or landslide debris			Other:		
12 HISTORY OF SLIDE:										
Moved this year for the first time, if possible mention year:					Moves every year by initial mechanism - diminishing					
Moves every year by initial mechanism - constant or getting worse										
Reactivated		Brief history if possible:								
13 LIFE PROGRESSION OF SLIDE:										
Stable slope formed, or will stabilise naturally					Further movement expected, by less serious mechanism					
Repeated movement expected, by initial mechanism or another equally serious										

Engineering geological log of the road alignment

ENGINEERING GEOLOGICAL LOG OF ROAD ALIGNMENT											
Road Name:											
Starting from CH. to											
Chainage (km)	+000	+200	+400	+600	+800	+000	+200	+400	+600	+800	+000
LEFT SIDE	Rock (W)/Soil (D)										
	Hill slope/Height CS										
	Attitudes										
	Landuse										
	Hydrology										
	Instability Type										
	Terrain Type										
	Causes										
	Recommendations										
ROAD											
RIGHT SIDE	Rock (W)/Soil (D)										
	Hill slope/Height CS										
	Attitudes										
	Landuse										
	Hydrology										
	Instability Type										
	Terrain Type										
	Causes										
	Recommendations										
W-Weathering; F-Fresh; SW-Slightly weathered; MW-Moderately weathered; HW-Highly weathered; CW-Completely weathered; BE-Bioengineering; CKD-Check Dam CSF-Cut slope failure, TR-Trimming; D-depth; F-Foliation, J-Joints, DR-Drain; CS-Cut Slope; Dry Cultivated (DCL); Wet cultivated (WCL); Forest (F); Bush (B); G-Grassland; Set-Settlement; GE-Gully erosion; SE-Soil erosion; L SD-Landslide											
LEGEND											

APPENDIX X : HOUSEHOLD SURVEY (CADASTRAL SURVEY) FORMAT

आयोजनाको नाम :
.....

सि. नं. :.....
घरधुरी नं.:

आयोजना प्रभावित घरधुरी सर्वेक्षण फारम

१. अन्तरवार्ता लिनेको नाम: २. अन्तरवार्ता मिति:

१. परिचयात्मक र साधारण जानकारी

१.१ उत्तरदाताको नाम: १.२ जिल्ला:
१.३ गा.पा. / न.पा. : १.४ वार्ड नं.:
१.५ गाउँ / टोल : १.६ जग्गाधनीको नाम:
१.७ नागरिकता नं. :
१.८ जग्गाधनीको बाबु/आमा वा पति/पत्निको नाम:
१.९ जग्गाधनीको ससुरा/बाजे को नाम:
१.१० जात/जाति:

अन्तरवार्ताकार र सुपरिवेक्षकको विचारमा आयोजनामा पर्ने व्यक्तिलाई के कस्तो पुनर्वास सहयोग आवश्यक पर्ने हो सो बारेमा आफ्नो धारणा उल्लेख गर्नुहोस् ।
.....
.....
.....
.....
.....

दृष्टव्यः आयोजनामा पर्ने सबै घरधुरीमा सर्वेक्षण गर्दा उपयुक्तता हेरी यहाँ दिईएका सबै प्रश्नहरू सोध्नु पर्नेछ ।

२. पारिवारीक विवरण

२.१ जम्मा परिवार संख्या

क्र. सं.	परिवारका सदस्यको नाम	लिङ्ग	उमेर	शिक्षा (६ वर्ष माथिको)	आर्थिक गतिविधी	गत १ वर्ष भित्र एक महिना भन्दा बढि समय घर छोडी बाहिर गएको भए		घरमुलीको नाता	कैफियत
						घर छोडी जानुको उदेश्य	घर छोडि गएको ठाउँ		
१									
२									
३									
४									
५									
६									
७									
८									
९									
१०									
११									
१२									
१३									
१४									
१५									

संकेत:

लिंग: १= पुरुष, २= महिला

शिक्षा: १= साक्षर मात्र र प्राथमिक शिक्षा पुरा नगरेको, २= प्राथमिक शिक्षा (कक्षा १-५ सम्म) पुरा गरेको, ३= निम्न माध्यमिक (६-८ सम्म) शिक्षा पुरा गरेको, ४ = माध्यमिक शिक्षा (९-१० सम्म) पुरा गरेको, ५= उच्च माध्यमिक शिक्षा (प्रमाण पत्र तह वा सो सरह) पुरा गरेका, ६= स्नातक वा माथि । ७= निरक्षर (पढ्न, लेख्न नसक्ने) ।

आर्थिक गतिविधि: १= खेती (आफ्नै जमिनमा), २= खेती (आफ्नै जमिनमा र अधियाँ समेत), ३= खेती अधियाँ मात्र, ४= कृषि मजदुरी, ५= सरकारी जागिर, ६= निजी जागिर, ७= उमेर नपुगेको, ८= व्यापार/व्यवसाय, ९= पशुपालन, १०= वनजङ्गलको उत्पादन सङ्कलन, ११= विद्यार्थी, १२= केहि पनि छैन, १३= वैदेशिक रोजगार, १४= बेरोजगार, १५= अन्य भए उल्लेख गर्ने,

घर छोडि जानुको उद्देश्य : १= कामको खोजीमा, २= अन्यत्र जागिरे, ३= व्यापार/व्यवसाय, ४= औषधी उपचार, ५= शिक्षा,

६= नातेदार/साथी भेटन, ७= तिर्थ/भ्रमण

घर छोडि गएको ठाउँ : १= जिल्ला भित्र २= जिल्ला बाहिर ५= भारत, ६= अन्य मुलुक

घरमुलीको नाता: १= घरमुली २= श्रीमति, ३= श्रीमान, ४= छोरा, ५= छोरी, ६= दाजुभाई, ७= दिदीबहिनी, ८= नातीनातिनी,

९= छोराबुहारी, १०= भाउजु/बुहारी, ११= भतिजा/भतिजी, १२= बुवाआमा, १३= अन्य (कोहि भए)

३. जीविकोपार्जनको स्थिति

३.१ तपाईंको वा परिवारका अन्य सदस्यको नाममा कति जग्गा छ, र कतिमा खेति गर्नुहुन्छ ? सबै लपट र उपभोगको बारेमा उल्लेख गर्नुहोस् ।

क्र. सं.	धनीको नाम	लिङ्ग	लपटको नाम वा स्थान	क्षेत्रफल/ ईकाई	जग्गाको प्रकार	सिचाई सुविधा	जग्गाको उपयोग	उपभोगको तरीका	कैफियत
१									
२									
३									
४									
५									
६									
७									
जम्मा क्षेत्रफल (प्रचलित ईकाईमा)					जम्मा क्षेत्रफल (ब.मी.)				
संकेत:									
जग्गाको प्रकार: १= अब्बल, २= दोयम, ३= सीम, ४= चाहार ५ =अन्यभए ।									
सिचाई सुविधा: १= छ, २= छैन ।									
जग्गाको उपयोग: १= घरवारी, २= खेत, ३= वारी, ४= व्यापारीक क्षेत्र, ५=खरवारी/बुट्टयान, ६= बाँझो/चरिचरन, ७= निजी वन, ८= अन्य भए उल्लेख गर्ने,									
उपभोगको तरीका: १= आफ्नो जग्गा आफैले कमाएको, २= आफ्नो जग्गा अरूलाई अधियाँमा दिएको, ३= बन्दकी दिएको, ४= मोही, ५= ठेक्का वा भाडामा दिएको ।									

३.२ तपाईंको परिवारले कसैको जग्गा अधियाँ/ ठेक्कामा कमाएको भए सोको विवरण दिनुहोस् ।

क्र. सं.	धनीको नाम	लिङ्ग	लपटको नाम वा स्थान	क्षेत्रफल/ ईकाई	जग्गाको प्रकार	सिचाई सुविधा	जग्गाको उपयोग	उपभोगको तरीका	कैफियत
१									
२									
३									
४									
५									
६									
७									
जम्मा क्षेत्रफल (प्रचलित ईकाईमा)					जम्मा क्षेत्रफल (ब.मी.)				
संकेत:									
जग्गाको प्रकार: १= अब्बल, २= दोयम, ३= सीम, ४= चाहार ५ =अन्य भए ।									
सिचाई सुविधा: १= छ, २= छैन ।									
जग्गाको उपयोग: १= घरवारी, २= खेत, ३= वारी, ४= व्यापारीक क्षेत्र, ५=खरवारी/बुट्टयान, ६= बाँझो/चरिचरन, ७= निजी वन, ८= अन्य भए उल्लेख गर्ने,									
उपभोगको तरीका: १= अरूको जग्गा आफुले अधियाँमा कमाएको, २= बन्दकी लिएको, ३= ठेक्का वा भाडामा लिएको ।									

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३.३ तपाईंको आफ्नो तथा अधियाँमा कमाएको जग्गाबाट हुने कृषि उत्पादनको विवरण दिनुहोस ।

क.स.	वालीहरु	क्षेत्रफल (रोपनी)		उत्पादन (के.जी.मा)	विक्री परिमाण (गतवर्षको)	
		खेत	पाखो		परिमाण (के.जी.)	जम्मा आमदानी (रु.मा)
१	धान					
२	मकै					
३	गहुं					
४	कोदो					
५	दाल / गेडागुडी					
६	तेलवाली					
७	आलु/ तरकारी					
८	जडिबुटी					
९	अन्य (खुलाउने)					
					जम्मा	

३.४ तपाईंको आफ्नो जग्गाको उत्पादनले वर्षको कति महिना खान पुग्दछ ?

- | | |
|-------------------|----------------------|
| (१) उत्पादन नभएको | (२) ३ महिना भन्दा कम |
| (३) ३-६ महिना | (४) ६-९ महिना |
| (५) ९-१२ महिना | (६) बचत हुन्छ |

३.५ यदि तपाईंको परिवारलाई आफ्नो जमिनमा उत्पादित खाद्यान्न नभएको समयमा किनेर खानुपर्दा मासिक कति रूपैयाँ खर्च गर्नुपर्दछ ?रूपैयाँ ।

३.६ खाद्यान्न नभएको समयमा तपाईंले कुन स्रोतबाट खाद्यान्नको लागि आवश्यक व्यवस्था गर्नुहुन्छ ? [बहुउत्तर]

संकेत:

- १ = नोकरी , २ = व्यापार, ३ = कृषि श्रम, ४ = गैर कृषि श्रम, ५ = वैदेशिक रोजगारीबाट प्राप्तहुने कमाइ,
६ = सापट, ७ =संपत्ति बेचेर, ८ = अन्य भए उल्लेख गर्ने,.....

४. परिवारीक आम्दानी तथा खर्चको विवरण

४.१ परिवारीक आम्दानीका श्रोतहरु

श्रोतहरु					
क्र.स.	कृषि क्षेत्र	वार्षिक आम्दानी (रु.)	क्र.स.	गैर कृषि क्षेत्र	वार्षिक आम्दानी (रु.)
१	अन्नबाली विक्रीबाट		१	कृषि मजदुरीबाट	
२	नगदेबाली विक्रीबाट(हरियो तरकारी तथा फलफूल, विउविजन तथा बागबानी समेत)		२	ज्याला मजदुरीबाट	
३	जडिवुटी विक्रीबाट		३	नोकरीबाट	
४	पशु/पंक्ष विक्रीबाट		४	लघुउद्यमबाट	
५	दुग्धउत्पादनबाट		५	व्यापार / व्यवसायबाट	
६	मौरी पालन		६	पेन्सन/विदेशबाट पठाएको	
७	माछा पालन		७	भाडा/व्याज	
८	अन्य (खुलाउने)		८	सम्पति बेचबिखनबाट	
९	अन्य		९	अन्य	
१०	अन्य		१०	अन्य	
जम्मा			जम्मा		
कूल जम्मा (कृषि क्षेत्र र गैर कृषि क्षेत्रबाट भएको कूल वार्षिक आम्दानी)					

४.२ परिवारीक खर्च को विवरण

क्र.स.	खर्चको किसिम	जम्मा वार्षिक खर्च (रु.)
१	खानेकुरा	
२	लत्ताकपडा	
३	स्कूल शुल्क, किताब कापी आदि	
४	औषधी, डाक्टर अस्पताल आदि	
५	बत्ति बाल्ने, पकाउने इन्धन आदि	
६	सुनचाँदी, गरगहना आदि	
७	वस्तुभाउ / मलखाद आदि	
८	यातायात / सञ्चार आदि	
९	सामाजिक, चाडपर्व, पुजा आदि	
१०	सामाजिक कार्यमा चन्दा / दान दिन	
११	जाँड, रक्सी, जुवा, तास आदिमा	
१२	आयआर्जन सम्बन्धी कार्यमा लगानी	
१३	ऋण/व्याज तिर्न	
१४	कर/विभिन्न शुल्क/जरिवाना आदि	
१५	अन्य	
जम्मा वार्षिक खर्च:		

४.३ यदि आम्दानी भन्दा खर्च अमिल्दो रूपले बढी आएमा त्यसो हुनाको कारणहरु उल्लेख गर्नुहोस् ?

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६.२ के तपाई वा तपाईको परिवारका अन्य सदस्यहरु सडक निर्माण सम्बन्धी योजनामा काम गर्न चाहन्छन् ?

१, [] चाहन्छन् । २, [] चाहदैनन् ।

६.३ यदि चाहन्छन् भने, निम्न विवरण दिनुहोस् । (नाममा प्र. नं. २.को पारिवारीक विवरण वाट परिवार नं. राख्नुहोस्)

क्र.सं.	नाम	लिङ्ग	दक्ष	अदक्ष
१.				
२.				
३.				
<p>संकेत: दक्ष: १= गाह्रो लगाउने, २= ढुङ्गा काट्ने, ३= डण्डी बाध्ने ४= जाली बुन्ने, ५= पाईप जोड्ने, ६= भोलुङ्गेपुल सम्बन्धी काम गर्ने, ७= सिमेन्टको काम गर्ने, ८= वायोईन्जिनियरिङ्गको काम गर्ने, ९= साधारण मेसिन चलाउन जान्ने, १०= अन्य भए उल्लेख गर्ने ।</p> <p>अदक्ष: १= ढुङ्गामाटो खन्ने/बोक्ने, २= ढुङ्गा फुटाउने, ३= ज्यामी/हेल्पर, ४= अन्य भए उल्लेख गर्ने ।</p>				

६.४ तपाईको घरबाट सडक निर्माण स्थलसम्म पुग्न कति समय लाग्दछ ?
पुग्न लाग्ने समय

७.४ आयोजनामा पर्ने जग्गाधनीको हाल बासोवास गरिरहेको ठेगाना दिनुहोस् ?

१. जग्गाधनीको नाम: २. पुरा सम्पर्क ठेगाना र फोन नं.:

३. कहिले देखि बाहिर बसोवास गर्दै आएको: ४. वारिसको नाम:

८. कृपया, विगत एक वर्षको अवधिमा आयोजनामा पर्ने लप्टमा भएको अन्न तथा नगदेवालीको उत्पादन र बिक्रीको विवरण दिनुहोस् ।

क्र.सं.	प्रभावित प्लटको		बाली	उत्पादन क्षेत्रफल	जम्मा उत्पादन (के. जी.)	गत वर्षको औषत बिक्री परिमाण (के.जी.)		प्रभावित भागमा हुने उत्पादन (के. जी.)	प्रभावित लप्टको बाली चक्र
	सिट नं.	कित्ता नं.				आम्दानी (रु.)	आम्दानी (रु.)		

९. आयोजनामा पर्ने घर/संरचनाको पूर्ण विवरण दिनुहोस् ।

क्र. सं.	भवन/संरचना नं.	गाविस	वार्ड नं.	बस्ती	चनेज	केन्द्र बाटको दुरी (मि.)	सिट नं. / कित्ता नं.	धनीको नाम	संरचनाको प्रकार	निर्माणमा प्रयोग भएको सामग्री	जम्मा क्षेत्रफल ब.मि.	तला संख्या	प्रभावित क्षेत्रफल ब.मि.	% प्रभावित	निर्माण वर्ष वि.सं.	उपयोग
१																
२																
३																
४																
५																

संरचनाको प्रकार: १= बस्ने घर, २= व्यापारीक भवन, ३= सामुदायिक भवन, ४= गोठ, ५= शौचालय, ६= पखाल, ७= अन्य भएमा उल्लेख गर्नुहोस् ।

हालको उपयोग : १= आफै बसोवास गरिरहेको, २= व्यापार/व्यवसायमा उपयोग भएको, ३= बसोबास वा व्यापार व्यवसाय दुवैमा प्रयोग भएको, ४= अन्य कसैलाई भाडामा दिएको ।

(भवन वा संरचनाको जम्मा क्षेत्रफल वा प्रभावित क्षेत्रफल निकाल्दा तलाको क्षेत्रफल (लम्बाई X चौडाई) लाई तला संख्याले गुणन गरि निकाल्नुपर्नेछ ।)

- ९.१ यदि घर/संरचना हटाउनु पर्ने छ भने, के यो संरचना तपाईंको आफ्नै जमिनमा बनेको हो ?
- १, [] हो २, [] होईन
- यदि होईन भने, यो जमिन कस्को हो नाम ठेगाना बताईदिनुहोस् ।
-
- ९.२ यदि बसोबास गरिरहेको घर हटाउनु पर्ने भएमा, तपाईं बसोबास गर्नको लागि यो बाहेक कुनै अर्को घर छ ?
- १, [] छ २, [] छैन ।
- ९.३ यदि छ भने कहाँ छ ?
- १, [] यहि ल्पटको अर्को स्थानमा २, [] दोस्रो कुनै ल्पटमा ।
- ९.४ यदि यो घर आयोजनाका कारणले भत्काउनु पर्ने भएमा अर्को घरमा तपाईंको परिवार बस्न सक्ने ठाउँ उपलब्ध छ ?
- १, [] छ २, [] छैन ।
- ९.५ यदि हाल बसिरहेको ल्पटदेखि फरक ल्पटमा जानुपर्ने भएमा, सो ल्पट कति टाढा छ ? कि.मि. ।
- ९.६ हालको ल्पटबाट नयाँ ल्पटसम्म सामान लैजान कस्तो प्रकारको साधन प्रयोग गर्नुपर्दछ ?
- १, [] पैदल २, [] बस ३, [] रिक्सा
- ४, [] ट्रयाक्टर ५, [] निजी कुनै सवारी साधन ६, [] अन्य कुनै
- ९.७ नयाँ ल्पटसम्म सामान लैजान अनुमानित कति जति खर्च लाग्दछ ? रूपैयाँ ।
- ९.८ यदि अर्को घर छैन भने, बसोबासको व्यवस्था कसरी गर्नुहुन्छ ?
- १, [] नयाँ घर बनाएर २, [] बसाई सरी नयाँ ठाउँमा गएर
- ३, [] भाडामा घर लिएर ४, [] अन्य कुनै सोच भएमा

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९.९ यदि तपाईंले यो घर सडक आयोजनामा परेपछि नयाँ घर किन्ने वा बनाउने योजना बनाउनु भएको छ भने, यस्तै प्रकारको घर बनाउन कति जति रकम खर्च होला ?
..... रूपैयाँ ।

९.१० सडक आयोजनामा पर्ने यो घरमा तपाईंको बाहेक अन्य कुनै परिवारका सदस्य पनि बसोबास गर्दछन् ?
१, [] छन् २, [] छैनन् ।

९.११ यदि छन् भने, पूर्ण विवरण दिनुहोस् ।

घर नं.	परिवारमुलीको नाम	ठेगाना	जात/जाति	जम्मा परिवार संख्या	मूख्य पेशा	कति समयदेखि बसोबास गरिरहेको	उपभोग गरेको कोठा संख्या	भाडा प्रति महिना	बस्ने विकल्प

१०. आयोजनामा पर्ने ल्याटवाट कुनै रूखविरूवा हटाउनु पर्दछ ।
१, [] पर्छ । २, [] पर्दैन ।

१०.१ आयोजनामा पर्ने ल्याटवाट कुनै रूखविरूवा हटाउनु पर्ने भएमा निम्नानुसारको विवरण दिनुहोस् ।

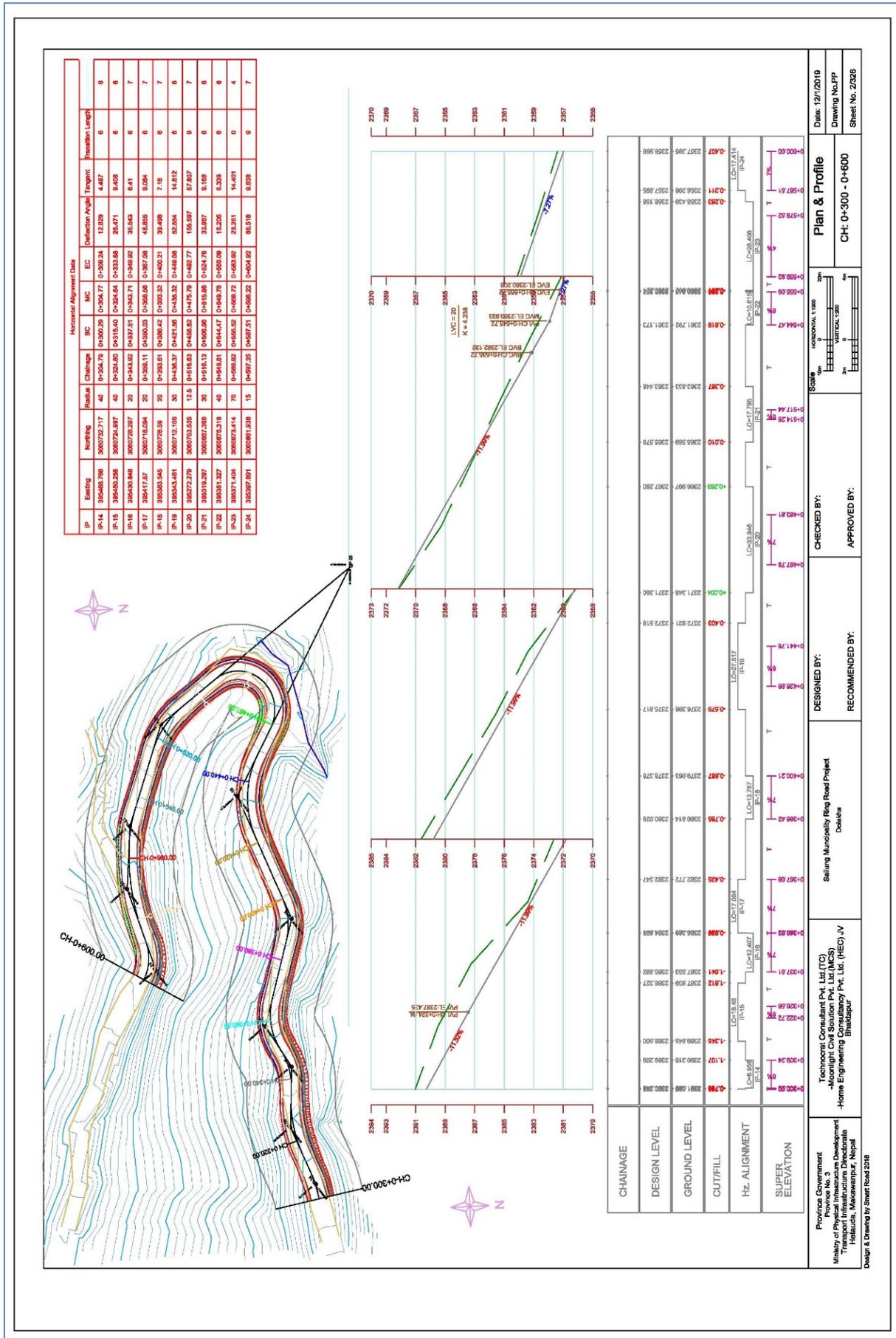
चेनेज		नाम/जात	प्रकार	गोलाई (सेमी)	उचाई (मि.)	संख्या	कैफियत
देखि	सम्म						

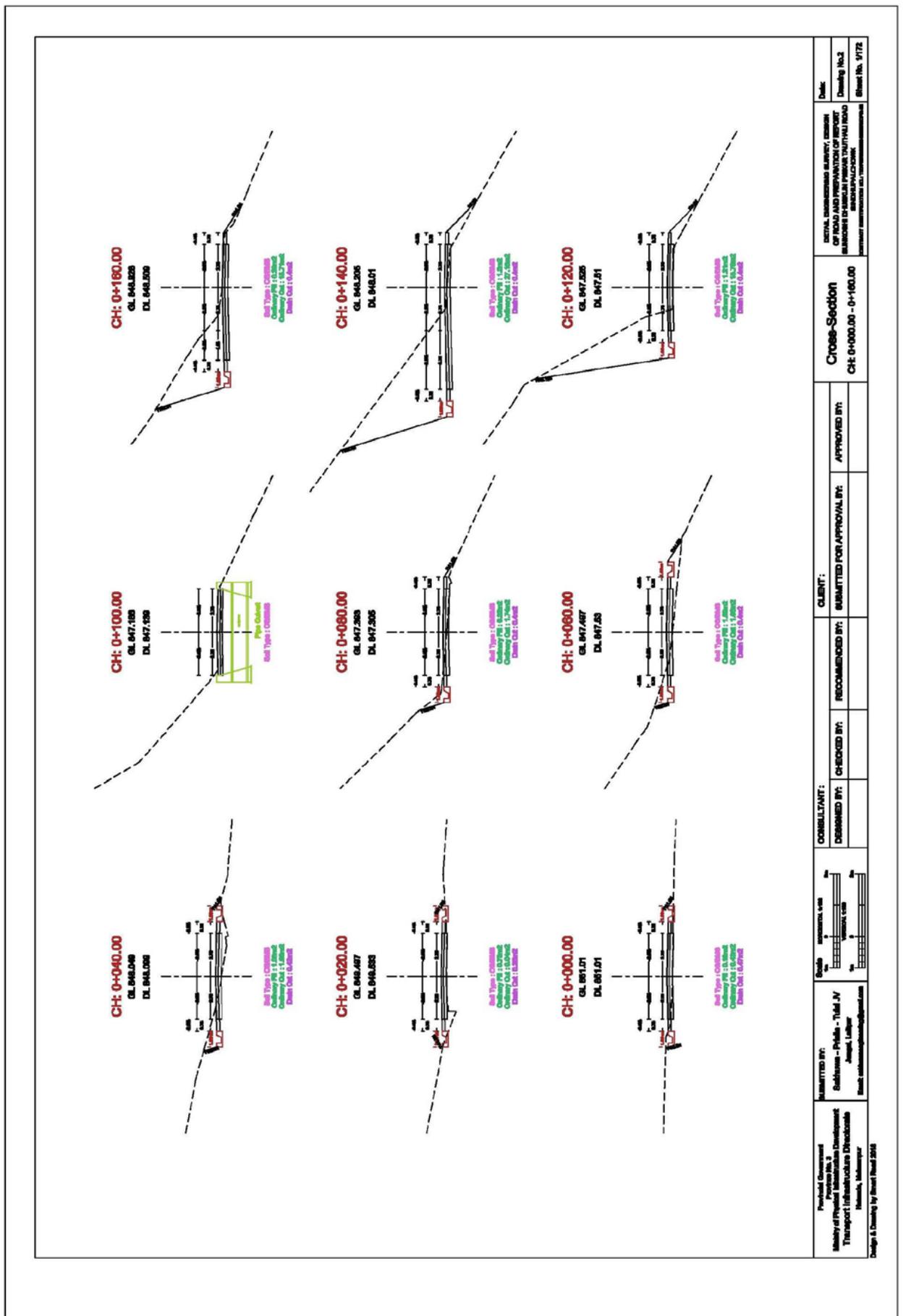
संकेत: प्रकार: १= काठका लागि प्रयोग हुने रूख, २ =दाउराको लागि प्रयोग हुने रूख, ३ =बहु प्रयोगको रूख, , ४= गैह्र काष्ठ वन पैदावर, ५= अन्य भए उल्लेख गर्ने

APPENDIX XII: AXLE LOAD SURVEY FORMAT

Axle Load Survey																		
Station:	District:			Surveyed by:			Day & Date:			Supervisor:								
Road Name:	Direction:			Rear Wheel 1 Load (kg)			Rear Wheel 2 Load (kg)			Axle-load (kg)			Equivalent Std. Axle-load					
Pavement Type:	Origin	Destin.	Front Wheel Load (Kg)		Rear Wheel 1 Load (kg)		Rear Wheel 2 Load (kg)		Gross Weight (kg)			Front	Rear	Veh. ESAL				
Time	Veh. Type	Load Type	L/S	R/S	L/S	R/S	L/S	R/S	L/S	R/S	Front	Rear 1	Rear 2	Front	Rear 1	Rear 2	ESAL	
1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SUMMARY ANALYSIS OF THE AXLE DATA																		
Vehicle	A to B						B to A											
	ESA/unit	No. of Samples		ESA/unit		No. of Samples		ESA/unit		No. of Samples								
Multi-axle Truck (>2 axles)																		
Heavy Truck (2 Axle)																		
Mini Truck																		
Big Bus																		
Micro Bus																		
4WD																		
Utility/Pickup																		
Car, Jeep, Van																		
Auto Rikshaw (Three-wheeler)																		
Motorcycle																		
Tractor/Power Tiller																		
Total																		

APPENDIX XIV: TEMPLATE FOR PLAN PROFILE & CROSS-SECTION





APPENDIX XV: QUANTITY ESTIMATES TEMPLATE

Provincial Government
 Ministry of Physical Infrastructure Development
 Transport Infrastructure Directorate
Bagmati Province
 Hetauda, Makwanpur, Nepal

SUMMARY OF QUANTITY SHEET

Name of Project:

Contract No:

Location:

Section:

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
A.	General												
A.1	Insurance for the loss of damage to works, plant, material, equipment property and personnel injury or death, including third party insurance as described on Condition of Contract [GCC 19]	LS											
A.2	Relocation of services / minor infrastructures, as per specifications and instruction of the Engineer. [SS 111]	PS											
A.3	Operation and Maintenance of Temporary diversion of road/bridges to keep the road serviceable throughout the contract period as per specification and instruction of engineer. [SS 104]	Km-Month											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
A.4	Carry out maintenance of the existing road to keep the road serviceable throughout the contract period including control dust nuisance by sprinkling water as required and instructed by Engineers per specification and instruction of Engineer [SS 104 and SS 109]	Km-Month											
A.5	Providing and installation of project information board with the size of 1.8 x 1.2 m as per specification and instruction of engineer [SS 110]	Nos											
A.7	Providing, installing and maintaining Quality control laboratory with equipment as specified in Technical Specification [SS 504]	LS											
B.	Site Clearance Works												
B.1	Clearing Grass and Removal of Rubbish and Dressing and levelling the construction surface Clearing grass/ top soil and removal up to a distance of 50 meters outside the periphery of the area, including cutting and filling of small undulation. [SS 201]	sqm											
B.2	Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including scaffolding wherever necessary, sorting	cum											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
	the dismantled Material, disposal of unserviceable Material and stacking the serviceable [SS 202]												
B.3	Dismantling of Flexible Pavements and disposal of dismantled material up to a lead of 1000 meter, stacking of serviceable and unserviceable material separately. [SS 202]	cum											
B.4	Dismantling of Cement Concrete Pavement [SS 202]	cum											
B.5	Dismantling of Guard Rails [SS 202]	Rm											
B.6	Removal of Telephone/Electric poles including excavation and dismantling of foundation, concrete and lines under the supervision of concerned department [SS 202]	Nos											
C.	Earthwork												
C.1	Road way Excavation in all types of soil as per Drawing and technical specifications including removal of stumps and other deleterious matter, all lifts and lead as per Drawing and instruction of the Engineer. [SS 905]	cum											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
C.2	Providing, laying, spreading and compacting embankment with suitable material and compact to the required density as per Drawing and Technical Specifications. [SS 909,910]	cum											
	SUB TOTAL												
D.	Pavement Works												
D.1	Providing and laying sub-grade and earthen shoulders with approved Material (including Capping Layer) obtained from borrow pits with all lifts & leads as per Drawing and Technical Specifications. [SS 1004]	sqm											
D.2	Providing and laying sub-grade and earthen shoulders with approved Material obtained from borrow pits with all lifts & leads as per Drawing and Technical Specifications. [SS 1003]	sqm											
D.3	Providing and laying granular sub-base on prepared surface, mixing at OMC, and compacting to achieve the desired density, complete as per Drawing and Technical Specifications.. [SS 1201]	cum											
D.3	Providing, laying, spreading and compacting Water bound macadam including booming requisite type of screening/binding materials to fill up the interstices of coarse	cum											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
	aggregate, watering and compacting the required density as per Drawing and Technical Specifications; [SS 1203]												
D.4	Providing and laying Crusher Run Macadam on a prepared surface, spreading and mixing, watering and compacting to form a layer of Base course as per Drawing and Technical Specifications., [SS 1204]	cum											
D.5	Providing and applying prime coat with Hot Bitumen (including cutter) on prepared surface of granular base including cleaning of road surface and spraying by mechanical means as per Technical Specification. [SS 1302]	lit											
D.6	Providing and applying tack coat with Hot Bitumen at specified rate on the prepared non-bituminous surface including cleaning as per Technical Specification [SS 1302]	lit											
D.7	Surface Dressing, Providing and laying surface dressing as wearing course in single coat using gravel of specified size on a recently applied layer of bituminous binder on prepared surface as per Drawing and Technical	sqm											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
D.8	Surface Dressing, Providing and laying surface dressing as wearing course in single coat using gravel of specified size on a recently applied layer of bituminous binder on prepared surface as per Drawing and Technical Specifications., 10 mm nominal size chipping [SS 1303]	sqm											
D.9	Providing and laying Bituminous concrete/Asphalt concrete using crushed aggregate of specified grading, premixed and bituminous binder and filler as per Drawing and Technical Specifications [SS 1309]	cum											
D.10	Providing and laying close-graded premix carpet of 20 mm thickness composed of 13.2 mm to 5.6 mm aggregates as wearing course on a previously prepared base as per drawing and Technical Specifications. [SS 1310]	cum											
D.11	Providing and laying of Reinforced Cement Concrete Grade M 20 in Rigid	cum											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
D.1	Pavement including formwork as per drawing and Technical Specifications. [SS 2000]												
2	Providing and Laying of impermeable PVC sheet of 125 micron thickness on prepared sub base as per drawing and technical specifications.	sqm											
D.1	Providing and laying, fitting and placing HYSD bar reinforcement in Rigid Pavement including Dowel Bar and Tie bars complete as per drawing and technical specifications [SS 2014]	tonnes											
3													
D.1	Providing Joint cutting as per specification for rigid pavement complete as per drawing and specifications.	Rm											
4													
D.1	Providing Joint filler for rigid pavement complete as per drawing and specifications.	Rm											
5													
E.	Drainage, Cross Drainage and Structural Works												
E.1	Earth work in excavation of foundation of structures for all types of soil, including construction of shoring and bracing, removal of stumps and other deleterious matter and backfilling with approved Material as per Drawing and Technical Specifications. [SS 907]	cum											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
E.2	Providing suitable material and Back filling behind abutment, wing wall and return wall complete as per Drawing and Technical Specifications. [SS 908]	cum											
E.3	Providing and applying 12.5 mm thick Plaster with cement mortar on brick work structure as per Technical Specifications, Cement Mortar 1:3 (1 cement: 3 sand) [SS 2500]	sqm											
E.5	Providing and laying of Plain Cement Concrete M 10 in Foundation including formwork complete as per Drawing and Technical Specifications. [SS 2000]												
E.6	Providing and laying of Plain Cement Concrete M15 in Foundation including formwork complete as per Drawing and Technical Specifications. [SS 2000]	cum											
E.7	Providing and laying of Reinforced Cement Concrete M20 in Foundation including formwork complete as per Drawing and Technical Specifications. [SS 2000]	cum											
E.8	Providing and laying, fitting and placing HYSD bar reinforcement in super-structure complete as per drawing and technical specifications [SS 2014]	Kg											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/Bioengineering	Others	Total
E.9	Providing and laying Plum concrete (Boulder mixed concrete) as per Drawing and Specifications, 60% M 15 concrete and 40% boulders/stones.[SS 2416]	cum											
E.10	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 450 mm internal dia. [SS 701]	meter											
E.11	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 600 mm internal dia. [SS 701]	meter											
E.12	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 900 mm internal dia. [SS 701]	meter											
E.13	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 1200 mm internal dia. [SS 701]	meter											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
E.1 4	Providing and laying Stone Masonry work in cement mortar 1:4 in structure complete as per Drawing and Technical, Random Rubble Masonry [SS 2607]	cum											
E.1 5	Providing and Assembling mechanically woven double twisted crates / mattress including rolling, cutting and with lacing wire and binding wire as per specification, Hexagonal mesh type 100 mm x 120 mm, mesh wire 3 mm, selvaige wire 3.9 mm, lacing wire 2.4 mm and Providing and filling stone/boulder in gabion boxes/mattress etc.. Including dressing, bedding, bonding all complete as per Drawing and Technical Specifications. [SS 2402]	cum											
E.1 6	Laying and fixing of Geo-Textile all complete as per specification. Providing and laying of a geotextile filter between pitching and embankment slopes as per Drawing and Technical Specifications. [SS 2404]	sqm											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
G.	Road Furniture and Traffic Safety Measures												
G.1	Non Reflective Traffic Signs, Providing and fixing of Non reflective warning, mandatory and informatory sign board of 2 mm thick MS Sheet with back support frame fixed on heavy 50 mm tube or Channel section of 75 mm X 40 mm firmly fixed to the ground by means of properly designed foundation with M 10/40 grade cement concrete 300 mm x 300 mm x 300 mm, I as per drawings and Technical Specification/ DOR Publication., Mild Steel Angle Iron 75 * 40 * 6 mm, 3 m long @ 6.8 kg/m, MS Sheet 90 cm height equilateral triangle [SS 1501]	no											
G.2	Providing and laying of hot applied thermoplastic compound at least 2 mm thick including reflectorizing glass beads as per DOR Traffic sign manual/ Specifications [SS 1504]	sqm											
G.3	Retro-Reflectorized Traffic Signs, Providing and fixing of retro- reflectorized warning, Regulatory and informatory sign as per specification	no											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
	clause 1501 made of high intensity grade sheeting , fixed over aluminum sheeting, 1.5 mm thick supported on a 50 mm internal dia steel tube or mild steel angle iron post 75 mm x 40 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M 10/40 grade cement concrete 30 cm x 30 cm , 30 cm below ground level or as per Drawing and Technical Specifications., MS Sheet 90 cm height equilateral triangle [Norms S. No. 15.2 and Ref to SS clause No 1501]												
G.4	Providing and Fixing Reinforced cement concrete M 15 grade kilometer Post including painting and printing as per Standard Drawing-2070 and Technical Specifications. position, Five kilometer Post (precast) [SS 1506]	no											
G.5	Kilometer Stone, Providing and Fixing Reinforced cement concrete M 15 grade kilometer Post including painting and printing as per Standard Drawing-2070 and	no											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
G.6	Technical Specifications. position, One kilometer post (precast) [SS1506] Providing and installation of 150 mm * 150 mm 1. 5 m long delineators post (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 20 cm wide strips, buried or pressed into the ground and conforming to the drawings and Technical Specifications. [SS 1507]	no											
G.7	Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m center to center, 1.8 m high, 1.1 m below ground/road level metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per Drawing and Technical Specifications. [SS 1509]	meter											

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
H.	Bio Engineering Works/Plantation Works												
H.1	Preparation of Slopes for Bioengineering Operation [SS 2806]	sqm											
H.2	Planting of rooted grass slips on the slopes including preparation of slips on the site. [SS 2807]	sqm											
H.3	Planting containerized tree and shrub seedlings, including pitting, transplanting, composting and mulching. [SS 2807]	no											
H.4	Grass sodding works including sod cutting, transporting, placing in position and water sprinkling [SS 2812]	sqm											
H.5	Preparation and planting of live pegs selected species (e.g. assuro, namdi phul, simali) of minimum length to 0.5 m depth in to any ground surface. [SS 2807]	meter											
H.6	Preparation and Laying of live fascines using live hardwood cutting of selected species of minimum length placed in bundles including backfilling of trench and careful compaction [SS 2807]	meter											

S.N.	Description of Works	Unit	General	Roadway incl. Shoulder	Side Drain	Stone Masonry Wall	Gabion Wall	Pipe Culvert	Causeway	Slab Culvert	Road Safety/ Bioengineering	Others	Total
H.7	Providing and Assembling mechanically woven double twisted crates / mattress including rolling, cutting and with lacing wire and binding wire as per specification, Hexagonal mesh type 100 mm x 120 mm, mesh wire 3 mm, selvaige wire 3.9 mm, lacing wire 2.4 mm and Providing and filling stone/boulder in gabion boxes/mattress etc.. Including dressing, bedding, bonding all complete as per Drawing and Technical Specifications. [SS 2402]	Cum											
H.8	Providing and laying of a geotextile filter as per Drawing and Technical Specifications. [SS 2404]	sqm											
	SUB TOTAL												
	Total (Excl. VAT & Contin.)												
	Provisional Sum (For security safety & Insurance)												
	Contingencies												
	VAT												
	Grand Total												

APPENDIX XVI: ABSTRACT OF COST TEMPLATE

Provincial Government
Ministry of Physical Infrastructure Development
Transport Infrastructure Directorate

Bagmati Province

Hetauda, Makwanpur, Nepal

ABSTRACT OF COST

Name of Project:

Contract No:

Location:

Section:

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
A.	General				
A.1	Insurance for the loss of damage to works, plant, material, equipment property and personnel injury or death, including third party insurance [GCC 19]	LS			
A.2	Relocation of services / minor infrastructures, as per specifications and instruction of the Engineer. [SS 111]	PS			
A.3	Operation and Maintenance of Temporary diversion of road/bridges to keep the road serviceable throughout the contract period as per specification and instruction of engineer. [SS 104]	Km- Month			
A.4	Carry out maintenance of the existing road to keep the road serviceable throughout the contract period including control dust nuisance by sprinkling water as required and instructed by engineer as per specification and instruction of Engineer [SS 104 and SS 109]	Km- Month			
A.5	Providing and installation of project information board with the size of 1.8 x 1.2 m as per specification and instruction of engineer [SS 110]	Nos			
A.6	Providing, installing and maintaining Quality control laboratory with equipment as specified in Technical Specification [SS 504]	LS			
A.7	Operation of Laboratory with Technical Support of Laboratory Staff [SS 504]	MM			
A.8	Providing complete built up drawing and report with photographs [GCC 71.2]	LS			

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
B.	Site Clearance Works				
B.1	Clearing Grass and Removal of Rubbish and Dressing and levelling the construction surface Clearing grass/ top soil and removal up to a distance of 50 meters outside the periphery of the area, including cutting and filling of small undulation., [SS 201]	sqm			
B.2	Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including scaffolding wherever necessary, sorting the dismantled Material, disposal of unserviceable Material and stacking the serviceable [SS 202]	cum			
B.3	Dismantling of Flexible Pavements and disposal of dismantled material up to a lead of 1000 meter, stacking of serviceable and unserviceable material separately. [SS 202]	cum			
B.4	Dismantling of Cement Concrete Pavement [SS 202]	cum			
B.5	Dismantling of Guard Rails [SS 202]	meter			
B.6	Removal of Telephone/Electric poles including excavation and dismantling of foundation, concrete and lines under the supervision of concerned department [SS 202]	Nos			
C.	Earthwork				
C.1	Road way Excavation in all types of soil and rocks as per Drawing and technical specifications including removal of stumps and other deleterious matter, all lifts and lead as per Drawing and instruction of the Engineer. [SS 905]	cum			
C.2	Providing, laying, spreading and compacting embankment with roadway cutting material and compact to the required density as per Drawing and Technical Specifications. [SS 909,910]	cum			
C.3	Earth work in excavation of foundation of structures for all types of soil and rocks, including construction of shoring and bracing, removal of stumps and other deleterious matter and backfilling with approved Material as per Drawing and Technical Specifications. [SS 907]	cum			
C.4	Providing suitable material and Back filling behind abutment, wing wall and return wall complete as per Drawing and Technical Specifications. [SS 908]	cum			
D.	Pavement Works				
D.1	Construction of Subgrade and Earthen Shoulders with approved Material as	sqm			

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
	per Drawing and Technical Specifications. [SS 1004]				
D.2	Providing and laying granular sub-base on prepared surface, mixing at OMC, and compacting to achieve the desired density, complete as per Drawing and Technical Specifications., [SS 1201]	cum			
D.3	Providing, laying, spreading and compacting Water bound macadam as per Drawing and Technical Specification. [SS 1203]	cum			
D.4	Providing and laying Crusher Run Macadam on a prepared surface, spreading and mixing, watering and compacting to form a layer of sub-base course as per Drawing and Technical Specifications. [SS 1204]	cum			
D.5	Providing and laying Crusher Run Macadam on a prepared surface, spreading and mixing, watering and compacting to form a layer of Base course as per Drawing and Technical Specifications., [SS 1204]	cum			
D.6	Providing and applying Prime coat with Hot Bitumen (including cutter) on prepared surface of granular base including cleaning of road surface and spraying by mechanical means as per Technical Specification. [SS 1302]	lit			
D.7	Providing and laying Surface Dressing as wearing course in single coat using gravel of specified size on a recently applied layer of bituminous binder on prepared surface as per Drawing and Technical Specifications., 19 mm nominal chipping size [SS 1303]	sqm			
D.8	Surface Dressing, Providing and laying surface dressing as wearing course in single coat using gravel of specified size on a recently applied layer of bituminous binder on prepared surface as per Drawing and Technical Specifications., 10 mm nominal size chipping [SS 1303]	sqm			
D.9	Bituminous Concrete/Asphalt Concrete; Providing and laying Bituminous concrete/Asphalt concrete using crushed aggregate of specified grading, premixed and bituminous binder and filler as per Drawing and Technical Specifications [SS 1309]	cum			
D.10	Providing and laying Close Graded Premix surfacing material of 20 mm thickness as wearing course on a previously prepared base as per drawing and Technical Specifications. [SS 1310]	cum			
D.11	Providing and Laying of impermeable PVC sheet of 125 micron thickness on prepared sub base as per drawing and technical specifications.	sqm			
D.12	Providing and laying of Reinforced Cement Concrete Grade M 20 in Rigid Pavement including formworks as per Drawing and Technical Specifications [SS 2000]	cum			

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
D.13	Providing and laying , fitting and placing HYSD bar reinforcement in Rigid Pavement including Dowel and Tie bars complete as per Drawing and technical specifications [SS 2014]	Kg			
D.14	Providing Joint cutting as per specification for rigid pavement complete as per drawing and specifications.	Rm			
D.15	Providing Joint filler as per specification for rigid pavement complete as per drawing and specifications.	Rm			
E.	Drainage, Cross Drainage and Structural Works				
E.1	Providing and applying 12.5 mm thick Plaster with cement mortar on brick work structure as per Drawing and Technical Specifications, Cement Mortar 1:3 (1 cement: 3 sand) [SS 2500]	sqm			
E.2	Providing and laying of Plain Cement Concrete M 10 in Foundation complete as per Drawing and Technical Specifications. [SS 2000]				
E.3	Providing and laying of Plain/Reinforced Cement Concrete in complete as per Drawing and Technical Specifications, PCC Grade M 15 [SS 2000]	cum			
E.4	Providing and laying of Reinforced Cement Concrete complete as per Drawing and Technical Specifications, RCC Grade M 20 [SS 2000]	cum			
E.5	Providing and laying Plum concrete (Boulder mixed concrete) including weep hole as per Drawing and Specifications, 60% M 15 concrete and 40% boulders/stones, [SS 2416 and SS3109]	cum			
E.6	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 450 mm internal dia. [SS 701]	meter			
E.	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 600 mm internal dia. [SS 701]	meter			
E.8	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 900 mm internal dia. [SS 701]	meter			
E.9	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 1200 mm internal dia. [SS 701]	meter			
E.10	Providing and laying Random Rubble Stone Masonry work in cement mortar 1:4 in structure including weep holes complete as per Drawing and Technical Specification. [SS 2607 and SS 3109]	cum			

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
E.11	Providing and Assembling mechanically woven double twisted crates / mattress including rolling, cutting and with lacing wire and binding wire as per specification, Hexagonal mesh type 100 mm x 120 mm, mesh wire 3 mm, selvaige wire 3.9 mm, lacing wire 2.4 mm and Providing and filling stone/boulder in gabion boxes/mattress etc. Including dressing, bedding, bonding all complete as per Drawing and Technical Specifications. [SS 2402]	cum			
E.12	Providing and laying of a geotextile filter as per Drawing and Technical Specifications. [SS 2404]	sqm			
G.	Road Furniture's and Traffic Safety Measures				
G.1	Providing and fixing of Non reflective warning, mandatory and inforamatory sign board as per Drawing and Technical Specification [SS 1501]	no			
G.2	Providing and laying of hot applied thermoplastic compound at least 2 mm thick including reflectorizing glass beads as per DOR Traffic sign manual/ Specifications[SS 1504]	sqm			
G.3	Providing and fixing of retro- reflectorized warning, Regulatory and inforamatory sign as per Drawing and Technical Specifications. [SS-1501]	no			
G.4	Providing and Fixing Reinforced cement concrete M 15 grade kilometer Post including painting as per Drawing and Technical Specifications. position, Five kilometer Post (precast) [SS 1506]	no			
G.5	Providing and Fixing Reinforced cement concrete M 15 grade kilometer Post as per Drawing and Technical Specifications. position, One kilometer post (precast)[SS 1506]	no			
G.6	Providing and installation of 150 mm * 150 mm 1.5 m long delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 20 cm wide strips, buried or pressed into the ground and conforming to the drawings and Technical Specifications. [SS 1507]	no			
G.7	Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m center to center, 1.8 m high, 1.1 m below ground/road level metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per Drawing and Technical Specifications. [SS 1509]	meter			

Guidelines for Survey, Design and Preparation of Detailed Project Report (DPR) of Roads

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
H.	Bio Engineering Works/Plantation Works				
H.1	Preparation of Slopes for Bioengineering Operation [SS 2806]	sqm			
H.2	Planting of rooted grass slips on the slopes including preparation of slips on the site. [SS 2807]	sqm			
H.3	Planting containerized tree and shrub seedlings, including pitting, transplanting, composting and mulching. [SS 2807]	no			
H.4	Grass sodding works including sod cutting, transporting, placing in position and water sprinkling [SS 2812]	sqm			
H.5	Preparation and planting of live pegs selected species (e.g assured, namdi phul, simali) of minimum length to 0.5 m depth in to any ground surface. [SS 2807]	meter			
H.6	Preparation and Laying of live fascines using live hardwood cutting of selected species of minimum length placed in bundles including backfilling of trench and careful compaction [SS 2807]	meter			
H.7	Providing and Assembling mechanically woven double twisted crates / mattress including rolling, cutting and with lacing wire and binding wire as per specification, Hexagonal mesh type 100 mm x 120 mm, mesh wire 3 mm, selvaige wire 3.9 mm, lacing wire 2.4 mm and Providing and filling stone/boulder in gabion boxes/mattress etc.. Including dressing, bedding, bonding all complete as per Drawing and Technical Specifications. [SS 2402]	Cum			
H.8	Providing and laying of a geotextile filter as per Drawing and Technical Specifications. [SS 2404]	sqm			
I.	Days Work				
I.1	Supply of labor as required as per preamble and as instructed by Engineer.				

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Total Amount (NRs)
	a. Unskilled Labor	Nos			
	b. Skilled Labor	Nos			
1.2	Supply of Equipment as required as per preamble and as instructed by Engineer				
	a. Truck-4.6 Cum Capacity	Hours			
	b. Excavator	Hours			
			Total of Procurement Items		
				VAT (13%)	
				Grand Total	

APPENDIX XVII: BILL OF QUANTITY TEMPLATE

Provincial Government
 Ministry of Physical Infrastructure Development
 Transport Infrastructure Directorate

Bagmati Province
 Hetauda, Makwanpur, Nepal

Bill of Quantity (BOQ)

Name of Project:

Contract No:

Location:

Section:

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
A.	General					
A.1	Insurance for the loss of damage to works, plant, material, equipment property and personnel injury or death, including third party insurance [GCC 19]	LS				
A.2	Relocation of services / minor infrastructures, as per specifications and instruction of the Engineer. [SS 111]	PS				
A.3	Operation and Maintenance of Temporary diversion of road/bridges to keep the road serviceable throughout the contract period as per specification and instruction of engineer. [SS 104]	Km- Month				
A.4	Carry out maintenance of the existing road to keep the road serviceable throughout the contract period including control dust nuisance by sprinkling water as required and instructed by engineer as per specification and instruction of Engineer [SS 104 and SS 109]	Km- Month				
A.5	Providing and installation of project information board with the size of 1.8 x 1.2 m as per specification and instruction of engineer [SS 110]	Nos				
A.6	Providing, installing and maintaining Quality control laboratory with equipment as specified in Technical Specification [SS 504]	LS				
A.7	Operation of Laboratory with Technical Support of Laboratory Staff [SS 504]	MM				

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
A.8	Providing complete built up drawing and report with photographs [GCC 71.2]	LS				
B.	Site Clearance Works					
B.1	Clearing Grass and Removal of Rubbish and Dressing and levelling the construction surface Clearing grass/ top soil and removal up to a distance of 50 meters outside the periphery of the area, including cutting and filling of small undulation., [SS 201]	sqm				
B.2	Dismantling of existing structures like culverts, bridges, retaining walls and other structure comprising of masonry, cement concrete, wood work, steel work, including scaffolding wherever necessary, sorting the dismantled Material, disposal of unserviceable Material and stacking the serviceable [SS 202]	cum				
B.3	Dismantling of Flexible Pavements and disposal of dismantled material up to a lead of 1000 meter, stacking of serviceable and unserviceable material separately. [SS 202]	cum				
B.4	Dismantling of Cement Concrete Pavement [SS 202]	cum				
B.5	Dismantling of Guard Rails [SS 202]	meter				
B.6	Removal of Telephone/Electric poles including excavation and dismantling of foundation, concrete and lines under the supervision of concerned department [SS 202]	Nos				
C.	Earthwork					
C.1	Road way Excavation in all types of soil and rocks as per Drawing and technical specifications including removal of stumps and other deleterious matter, all lifts and lead as per Drawing and instruction of the Engineer. [SS 905]	cum				
C.2	Providing, laying, spreading and compacting embankment with roadway cutting material and compact to the required density as per Drawing and Technical Specifications. [SS 909,910]	cum				
	Earth work in excavation of foundation of structures for all types of					

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
C.4	Providing suitable material and Back filling behind abutment, wing wall and return wall complete as per Drawing and Technical Specifications. [SS 908]	cum				
D.	Pavement Works					
D.1	Construction of Subgrade and Earthen Shoulders with approved Material as per Drawing and Technical Specifications. [SS 1004]	sqm				
D.2	Providing and laying granular sub-base on prepared surface, mixing at OMC, and compacting to achieve the desired density, complete as per Drawing and Technical Specifications., [SS 1201]	cum				
D.3	Providing, laying, spreading and compacting Water bound macadam as per Drawing and Technical Specification. [SS 1203]	cum				
D.4	Providing and laying Crusher Run Macadam on a prepared surface, spreading and mixing, watering and compacting to form a layer of sub-base course as per Drawing and Technical Specifications. [SS 1204]	cum				
D.5	Providing and laying Crusher Run Macadam on a prepared surface, spreading and mixing, watering and compacting to form a layer of Base course as per Drawing and Technical Specifications., [SS 1204]	cum				
D.6	Providing and applying Prime coat with Hot Bitumen (including cutter) on prepared surface of granular base including cleaning of road surface and spraying by mechanical means as per Technical Specification. [SS 1302]	lit				
D.7	Providing and laying Surface Dressing as wearing course in single coat using gravel of specified size on a recently applied layer of bituminous binder on prepared surface as per Drawing and Technical Specifications., 19 mm nominal chipping size [SS 1303]	sqm				
D.8	Providing and laying surface dressing as wearing course in single coat using gravel of specified size on a recently applied layer of bituminous binder on prepared surface as per Drawing and Technical Specifications., 10 mm nominal size chipping [SS 1303]	sqm				
D.9	Providing and laying Bituminous concrete/Asphalt concrete using crushed aggregate of specified grading, premixed and bituminous binder and filler as per Drawing and Technical Specifications [SS 1309]	cum				

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
D.10	Providing and laying Close Graded Premix surfacing material of 20 mm thickness as wearing course on a previously prepared base as per drawing and Technical Specifications. [SS 1310]	cum				
D.11	Providing and Laying of impermeable PVC sheet of 125 micron thickness on prepared sub base as per drawing and technical specifications.	sqm				
D.12	Providing Joint cutting as per specification for rigid pavement complete as per drawing and specifications.	Rm				
D.13	Providing Joint filler as per specification for rigid pavement complete as per drawing and specifications.	Rm				
D.11	Providing and laying of Reinforced Cement Concrete Grade M 20 in Rigid Pavement/structures as per Drawing and Technical Specifications [SS 2000]	cum				
D.12	Providing and laying, fitting and placing HYSD bar reinforcement in Rigid Pavement and Foundations of Structures complete as per Drawing and technical specifications [SS 2014]	Kg				
E.	Drainage, Cross Drainage and Structural Works					
E.1	Providing and applying 12.5 mm thick Plaster with cement mortar on brick work structure as per Drawing and Technical Specifications, Cement Mortar 1:3 (1 cement: 3 sand) [SS 2500]	sqm				
E.2	Providing and laying of Plain Cement Concrete M 10 in Foundation including formworks complete as per Drawing and Technical Specifications. [SS 2000]					
E.3	Providing and laying of Plain/Reinforced Cement Concrete including formworks complete as per Drawing and Technical Specifications, PCC Grade M 15 [SS 2000]	cum				
E.4	Providing and laying Plum concrete (Boulder mixed concrete) including weep hole as per Drawing and Specifications, 60% M 15 concrete and 40% boulders/stones, [SS 2416 and SS3109]	cum				
E.5	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 450 mm internal dia. [SS 701]	meter				

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
E.6	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 600 mm internal dia. [SS 701]	meter				
E.7	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 900 mm internal dia. [SS 701]	meter				
E.8	Providing and Laying Reinforced cement concrete NP3 Flush jointed pipe for culverts including fixing with cement mortar 1:2 as per Drawing and Technical Specifications., 1200 mm internal dia.[SS 701]	meter				
E.9	Providing and laying Random Rubble Stone Masonry work in cement mortar 1:4 in structure including weep holes complete as per Drawing and Technical Specification. [SS 2607 and SS 3109]	cum				
E.10	Providing and Assembling mechanically woven double twisted crates / mattress including rolling, cutting and with lacing wire and binding wire as per specification, Hexagonal mesh type 100 mm x 120 mm, mesh wire 3 mm, selvaige wire 3.9 mm, lacing wire 2.4 mm and Providing and filling stone/boulder in gabion boxes/mattress etc.. Including dressing, bedding, bonding all complete as per Drawing and Technical Specifications. [SS 2402]	cum				
E.11	Providing and laying of a geotextile filter as per Drawing and Technical Specifications. [SS 2404]	sqm				
G.	Road Furniture's and Traffic Safety Measures					
G.1	Providing and fixing of Non reflective warning, mandatory and informatory sign board as per Drawing and Technical Specification [SS 1501]	no				
G.2	Providing and laying of hot applied thermoplastic compound at least 2 mm thick including reflectorizing glass beads as per DOR Traffic sign manual/ Specifications [SS 1504]	sqm				
G.3	Providing and fixing of retro- reflectorized warning, Regulatory and informatory sign as per Drawing and Technical Specifications. [SS1501]	no				

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
G.4	Providing and Fixing Reinforced cement concrete M 15 grade kilometer Post including painting as per Drawing and Technical Specifications. position, Five kilometer Post (precast) [SS 1506]	no				
G.5	Providing and Fixing Reinforced cement concrete M 15 grade kilometer Post as per Drawing and Technical Specifications. position, One kilometer post (precast)[SS 1506]	no				
G.6	Providing and installation of 150 mm * 150 mm 1. 5 m long delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 20 cm wide strips, buried or pressed into the ground and conforming to the drawings and Technical Specifications. [SS 1507]	no				
G.7	Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m center to center, 1.8 m high, 1.1 m below ground/road level metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per Drawing and Technical Specifications. [SS 1509]	meter				
H.	Bio Engineering Works/Plantation Works					
H.1	Preparation of Slopes for Bioengineering Operation [SS 2806]	sqm				
H.2	Planting of rooted grass slips on the slopes including preparation of slips on the site. [SS 2807]	sqm				
H.3	Planting containerized tree and shrub seedlings, including pitting, transplanting, composting and mulching. [SS 2807]	no				
H.4	Grass sodding works including sod cutting, transporting, placing in position and water sprinkling [SS 2812]	sqm				
H.5	Preparation and planting of live pegs selected species (e.g assurro, namdi phul, simali) of minimum length to 0.5 m depth in to any ground surface. [SS 2807]	meter				
H.6	Preparation and Laying of live fascines using live hardwood cutting of selected species of minimum length placed in bundles including backfilling of trench and careful compaction [SS 2807]	meter				
I.	Days Work					

S.N.	Description of Works	Unit	Quantity	Rate in Figure (NRs)	Rate in Words (NRs)	Total Amount (NRs)
1.1	Supply of labor as required as per preamble and as instructed by Engineer.					
	a. Unskilled Labor	Nos				
	b. Skilled Labor	Nos				
1.2	Supply of Equipment as required as per preamble and as instructed by Engineer					
	a. Truck-4.6 Cum Capacity	Hours				
	b. Excavator	Hours				
Total of Procurement Items						
				VAT (13%)		
				Grand Total		

APPENDIX XVIII: TERM OF REFERENCE FOR DETAILED ENGINEERING SURVEY AND DESIGN OF ROADS

1.0 BACKGROUND

The Ministry of Physical Infrastructure Development/ Transport Infrastructure Directorate, Bagmati Province, Hetauda (herein after referred as "the Client"), intends to utilize services of engineering consulting firms well experienced in the fields of survey and design of roads and its associated structures, environment aspects etc. (herein after referred to as the "Consultant") for providing engineering consulting services for detailed project report preparation of proposed roads.

Name of Road:

District:

2.0 OBJECTIVES OF THE WORK

The main objective of the consulting services are:

- to perform alignment detailed survey and design
- to perform socio-economic and traffic study
- to suggest option of upgrading and design accordingly
- to prepare detailed report of the Provincial road(s) based on sound techno-economical approach.
- to develop project implementation plan

3.0 SCOPE OF WORK

The firm shall carry out the necessary field works along the alignment. The firm shall be responsible for accuracy, interpretation, analysis of all data received and for the conclusion and recommendations in their report. The scope of work to be carried out by the firm shall include but may not be limited to the following:

3.1 PHASE A

3.1.1 Desk Study

A desk study shall be carried out, collecting all data, political & geological map, hazard map, road network map, map of earthquake zoning, land use map, aerial photo and information relevant to survey and design of the road and reviewing for planning of field survey and investigation works. After the desk study, the firm shall submit the inception report.

3.1.2 Preliminary Site Visit

The firm shall perform preliminary site visit by a walk-over survey to get information about:

- o Existing Road Condition
- o Tentative road length as new road section

3.1.3 Socio-economic studies of influence area with maps and sketches

- ❖ Demographic picture:
 - a. Influenced population/economic activity of influenced population
 - b. Structure of population
 - c. Nature of migration and outside influx etc.
- ❖ Land use pattern:

- a. Wild life sanctuary
 - b. Forest
 - c. Production in influenced area and surplus in influenced area
 - d. Settlement pattern etc.
- ❖ Trade, Industry and Commerce (existing & planned):
- a. Local produces and other resources
 - b. Export and import
 - c. Major industries and cottage industries
 - d. Market development
 - e. Tourism potential etc.
 - f. Major development works (hydropower project, irrigation governmental/no-governmental development programs etc.) project, other
- ❖ Health (existing & planned):
- a. Hospital
 - b. Health post
 - c. Ayurvedic clinic etc.
- ❖ Education (existing & planned):
- a. Primary schools
 - b. Secondary schools
 - c. High schools
 - d. Colleges/institutions etc.
 - e. Universities
- ❖ Transport and communications network (existing & planned):
- a. Trail network and trail bridges
 - b. Airport, STOL strips, helipad etc.
 - c. Water transport
 - d. Rope-ways, Road network
 - e. Telecommunication, postal service & other communication networks etc.
- ❖ Administrative facilities:
- a. Government offices
 - b. Co-operation offices
 - c. Banks etc.
 - d. Police station

3.1.4 Traffic Study

To determine the type and volume of future traffic for the proposed roads, the firm shall analyze all existing statistical data affecting traffic within influence area. The firm shall carry out traffic counts and origin/destination surveys or any other surveys as necessary to determine the nature of traffic and the present volume of goods, animal and pedestrian movements (motorized as well as non- motorized traffic) within the influence area. Traffic data shall be co-related to the influenced population (or economically active population) and production (surplus or deficit in agriculture/industry etc.)

Threshold traffic value for construction and upgrading of the road, for the reduction of total transport cost, judgment shall be applied considering all possible method.

In broad terms, the firm shall also identify, describe and quantify existing and probable future traffic generating sources, based on the probable future development of the influence area on relevant factors, such as;

- (a) Population growth and changes in population distribution.
- (b) Regional economic growth.
- (c) Development of agriculture, forestry, mineral and other resources.

Anticipated domestic trade in agriculture and non-agriculture commodities. A second traffic forecast shall be made assuming that an appropriate accelerated development program within the zone of influence is undertaken by the Government.

Traffic study should include the detail study of normal, diverted and generated traffic.

3.1.5 Report submission of Phase A

The consultant shall have to submit a report covering socio-economic study and traffic study along with KMZ file of the Road. After necessary correction and suggestions issued by the Unit, the firm shall start phase B.

3.2 PHASE B

3.2.1 Detailed Engineering Study

The consultant shall coordinate with the respective Infrastructure Development Offices (IDOs)/Transport Infrastructure Development (TID), Hetauda prior to commencement of Detail survey. In addition, after completion of the detail survey, the consultant shall request the respective Infrastructure Development Offices (IDOs) for certification regarding completion of survey works.

3.2.1.1 Topography Survey

The detailed Topographic survey of road corridor covering a width of 10 m on either side of centerline will be carried out. The density of survey points will be at least 1 point per 10 square metres. Topographic map in 1:1000 should contain details of Survey control points. Settlement with starting and end points, Landslide/Slope instabilities, natural stream and structures.

For existing & new road section, the firm shall perform the task as below, but may not be limited to the following:

- Fixing of road alignment by setting out intersection point (IP) and intermediates points.
- Establishment of Bench Marks (BM):- BM should be established at spacing shouldn't be greater than 500 m interval along the road alignment with RCC pillar post of size 15cm*15cm*50cm with M20 or equivalent concrete, nails embedded flushed with top surface and 5cm above the natural ground level. All the reference point and control point should be established on the permanent structure.
- Cross Section shall be taken at LS 15-25 m interval depending upon the terrain and 2.5m interval across the alignment, minimum 10 m both side from the centreline.
- Topographical survey of road in minimum 10 m wide strip on either side of the centre line.
- During construction layout, if BM coordinates, reference point and D-card details are deviate from design, the consultant must be liable to layout these details.

3.2.1.2 Engineering Study and Inventory Survey

- Road Inventory Survey

- Sub grade Condition Survey (Visual Survey)
- Existing structure Survey
- Side drains requirements Survey (L-drain, catch drain, intercepting drain etc.)
- Cross drainage requirements Survey (Culverts, bridge, aqueducts etc.)
- Retaining and protection work requirements Survey (retaining wall, breast wall, drops, cascade, benching etc.)
- Land use Survey
 - The locations of settlements off the road structures, electric poles, streams, and water taps within the area of the plan.

3.2.1.3 Construction Materials Survey

- Identification of potential sources (query sites, min 2 site)
- Investigation of existing road materials on sites.

The firm shall perform the 2 set of Los Angeles Abrasion Test and Impact value test (in authorized lab) of the potential quarry material proposed for sub-base, base and chips.

3.2.1.4 Geological and Geotechnical Survey

- General geology of the region, project area and the proposed road corridor shall be described and a geological map of the area be presented along with identification of major features, pertinent to the project.
- Nature, type and structure and surface soil of the area need to be clearly identified and further required investigations listed.
- Whenever applicable, slope stability analyses of the representative site need to be carried out and the finding and recommendation.
- The location of debris flow and other possible obstruction to the road alignment.
- For existing road section, the firm shall perform DCP test of existing subgrade at 500m interval and conformity CBR should be conducted in laboratory.

3.2.1.5 Hydrological and Meteorological Studies

- All relevant meteorological (Rainfall and Temperature) data and recommendation shall be presented.
- Study of the river and river system: The river system of the area shall be described in the report. Preferably a river system map of the catchment's area and beyond (whenever applicable) shall be produced.
- At least one cross-section of river at each crossing shall be produced. In the cross section all bed and bank characteristics shall be mentioned.
- Assessment of flood pattern and preliminary estimation of discharges shall be carried out. Similarly, expected HFL shall be fixed as far as applicable
- Information necessary for the design of the side drain and protection works as well as preliminary design of cross drainage structure shall be produced.

3.2.2 Design and Drawings

The design standard to be adopted for the detailed design shall be "Bagmati Province Road Standard, 2077" prepared by Ministry of Physical Infrastructure Development

(MoPID), Bagmati Province. The design standard shall be finalized in close coordination with the Transport Infrastructure Directorate, Bagmati Province.

Design of Road

- Calculate and plot the reduced ground level of longitudinal and cross section.
- Design the most economical road profile by balancing the volume of cut and fill to the nearest. (mass haul diagram)
- Design Horizontal and Vertical Curves.
- Design of grade and geometry of existing road that needed to be improved
- Design of sub-base, base based on DCP value.
- Appropriate Design of Pavement layer as per site condition, availability of material and equipment using minimum three standard methods and recommendation can be done for any other special condition if required.
- Design of appropriate road side structures and facilities
- Design of road safety facilities and structures.
- Design of the retaining structure (retaining wall, breast wall, Rcc wall etc. according to site condition)

- Design of drainage (side drain, drop, cascade etc.) and minor cross-drainage structure (Hume pipe culvert, slab culvert etc.)

Engineering Drawings Details

The firm will prepare the following plans and working drawings on suitable reports material using the format and title sheets as required by the engineer in charge.

- Locality map (sometimes called a “key map”) showing the location of the works in relation to the region/district/municipality/ Rural Municipalities commonly at a scale of 1:2,500,000.
- Site plan (sometimes called "index map") showing the project and its immediate neighborhood including the important physical features such as hills, rivers, tracks, etc. It may be to a scale of 1:50,000. The locality map and site plan are commonly drawn on a single sheet.
- Map showing complete alignment with Kilometer, names of area, land use, Rural Municipalities, municipalities, name of natural drainage etc.
- Location Map showing linkage of the road with surrounding road network.
- Map showing survey and design status of the complete road, intersection points, Benchmarks and other references points.
- Plan with Topographical Map, Profile (Longitudinal Section) and Cross- Section in the following Scale.
 - Plan - 1:1000
 - Horizontal Profile - 1:1000
 - Vertical Profile - 1:200
 - Cross Section - 1: 200

- Plans and profile of the road shall contain contour along with details of geometry viz. horizontal alignment with coordinates of IP, deflection angle, IP to IP distances, Chainage of IP, curve data etc. names of Rural Municipalities or municipalities, forest, land use pattern, cross drainage structure, retaining and protection structure required or as directed by Engineer in charge.
- Standard charts of mentioned cross drainage structures, retaining/Brest wall and protection works, side drain, typical cross section of the road according to types of soil,

passing zone(if provided), hairpin bend (If provided)

- D-card, Topo-Map (all colored), legend of drawings, KMZ files etc. Directed by Engineer in charge.

3.2.3 Preparation of Engineering Cost Estimate

- The quantities of the civil works shall be computed on the basis of the detailed plan, design profiles and cross-sections following the standard methods of measurement.
- The rate analysis for the civil engineering items will be made following the unified norms and market prices of construction materials, labor and equipment hiring rates.
- The cost shall also incorporate the cost for implementation of Environmental Mitigation Measures.
- The rates for civil engineering items shall be verified with the mean rates of prevailing contract prices of the last 5 years in the sector and geographical region.
- The costs will be broken down into local and foreign currency components. It will also be further broken down into direct cost, taxes, physical and price contingencies.
- The work may require a range of skills and expertise that a single contractor may not have.
- The firm and implementing agency shall consider all practical combinations of contract packages and decide the preferred combination based on their expert judgment and consideration of supervision and administration costs.

After the preparation of design and drawing, the design must be verified in the field, jointly by the designer and TID/IDO engineer. The design shall be updated/modified based on field condition and finalized. No separate payment is made for field verification. All the cost of field verification shall be borne by the consultant and is supposed to be included in the costs stated in the price schedule.

3.2.4 Bill of Quantities (BOQ)

Each item shall be clearly described and corresponding clauses of the standard and special specifications shall be referenced to allow the contractor to easily find the corresponding specification. The BOQ may be broken down into different types of works and shall clearly provide for VAT and contingencies.

3.2.5 Preparation of the Programme

The programme shall include the duration of activities and critical milestones on the following activities:

- Pre-construction activities of the implementing agency
- Consultancy services
- Construction of works.

For each construction package, detailed work schedules shall be developed which shall include the durations and milestones for the following activities.

Depending on the number of work packages, there may exist a number of parallel activities to be undertaken simultaneously and hence a critical path network may be developed which will include the following aspects:

- Definition of tasks/activities and their types
- Estimated duration of each of the task/activity
- Definition of task dependency relations
- Assignment of lead and lags on such dependencies
- Built in slack
- Identification of critical and near-critical paths.

The critical path network shall be drawn indicating all the tasks along with their durations and floats and highlighting the critical path.

3.2.6 Submission of Detailed Report

The firm shall submit draft report covering the entire task performed in details. The minimum volume of the report shall be:

- o Volume I : Main Report
- o Volume II : Cost Estimate
- o Volume III : Drawing

All the photograph of BM, IP references, specific features shall be clearly mentioned in the report.

The Firms shall present the report, prior to the submission of the final report. They shall review the issues raised during the presentation while finalizing the report and make necessary amendments/corrections if needed. The date and venue of the presentation shall be determined by mutual agreement between the Transport Infrastructure Directorate (TID) and the firms. Maximum 10 no. of TID and MoPID personnel shall attend the presentation. The cost of such presentation shall be borne by the firms.

3.2.7 Coordination for Construction Survey

The consultant shall coordinate along with necessary technical support with respective IDO's /Project office during implementation of the works.

4.0 REPORT OBLIGATIONS

The firm shall submit the following reports in English.

- (a) Two copies of Inception report;
- (c) Two copies of Phase A Report;
- (d) Two copies of draft report; (min. 1 copy color report).
- (e) Three copies of final report with original photos and maps all colored.

5.0 WORKING TEAM

The working team for field and office works shall necessarily consist of the following Key Professional Personnel together with adequate supporting manpower.

- (1) Highway / Transport Engineer
- (2) Geotechnical Engineer
- (3) Structural Engineer
- (4) Hydrologist
- (5) Transport Economist/Sociologist
- (6) Environmentalist
- (7) Civil Engineer
- (8) Surveyor

APPENDIX XIV: TERM OF REFERENCE FOR STUDY FOR SITE SELECTION, DETAILED ENGINEERING SURVEY, GEO- TECHNICAL I HYDROLOGICAL INVESTIGATION AND DETAILED DESIGN OF BRIDGE

1. INTRODUCTION

Transport Infrastructure Directorate, Ministry of Physical Infrastructure Development (MoPID), Bagmati Province (herein after referred to as the "Client") intends to utilize services of and engineering consulting firms, well experienced in the fields of soil investigation, hydrological studies; bridge engineering, river training works, environment aspects etc. (herein after referred to as the "Consultant") for providing engineering consulting services for detail design work of proposed Bridge(s)/ River Crossing(s) including river training works, and approach roads (herein after referred to as the "Service").

2. OBJECTIVE

Objective of this "Service" is to

- 2.1 Identification of probable axis/axes for location (of a bridge / river crossing) based upon the initial geological study and river hydrology as well as access road and demand. Identification of possible alternatives of river crossings feasible for the site (Identification Phase)
- 2.2 Detailed topographical survey, hydrological and geological / geo technical investigation of the identified river crossing site. (Investigation Phase)
- 2.3 Detailed analysis, design, drawings and cost estimate of river crossing (bridge / vented causeway / multi cell culvert as required) and its approach as well as protection works. (Design Phase)

3. SCOPE OF WORK

The scope of work to be carried out by the consultant shall include but may not be limited to the following:

3.1 Identification Phase

Desk study: The "Consultant" (team of Bridge Engineer, Geologist and Hydrologist) shall carry out a desk study collecting all data, maps and information and reviewing for planning of further field survey and investigation works as well as detailed design. In this study the following points related to the probable location of the river crossing shall be studied in detail.

- I. Topography, available maps and imageries.
- II. Nature and structure of the surface soil
- III. Nature and structure of local as well as regional geology
- IV. River hydrology

Site Observation: A comprehensive site visit shall be carried out by the team of bridge engineer, geologist and hydrologist. In the site observation visit, the Consultant shall

- identify the possible axes and its location (GPS aided)
- the condition of approach/access road
- initial geological and hydrological studies
- Collect information on general description of the alignment for which the river crossing is meant to be.
- Sketch the rough plan and cross-section of the axes with indication of flow pattern and level.

After the site observation, the Consultant shall submit a Site Visit Report, which shall include.

- Maps and imageries showing the identified possible axes and comparative analysis
- Access to the bridge site and brief description of the alignment
- In the suitable and available base map, the access to the site.
- Findings from geological and river hydrology
- Description of possible types of river crossings and comparative study

The Employer shall review the "Site Visit Report" and shall give comments if there are any.

3.2 Investigation Phase

During the Investigation Phase the "Consultant" shall perform

3.2.1 Topographical Survey: The topographical survey of the area should cover a minimum distance of 500 m upstream, 200 m downstream and 200 m from the river banks on either sides of the river at the proposed bridge site. The Topographic map should show the following:

- a. Contours at 1.0 m. intervals in hilly area and at 0.25 m in plain area.
- b. Flood lines on either sides of the river in the entire area surveyed.
- c. Lines with spot levels along which the bed slope of the river is taken
- d. Both banks of the river
- e. Lines along which cross section of the river is taken
- f. Govt. and/or public establishments
- g. Traverse lines, benchmarks reference lines and/or points with respect to which the present topo-map is prepared.
- h. The angle and direction of skew, if the bridge is proposed to be aligned skew.
- i. The Names of the nearest identifiable villages/towns etc. in either ends of the bridge.
- j. Other information relevant to design, construction and/or maintenance of the bridge.

3.2.2 Hydrological Study: For determination of all design data the "Consultant" shall carry out a detailed hydrometrical survey and hydrological study of the river and bridge site, which shall include the following:

- I. Catchment area of the river up to bridge site
- II. Length of the river from origin up to bridge site
- III. Possibility of change of catchment
- IV. Nature, size and quantities of debris carried by the river
- V. Intensity, duration and distribution of rain in the catchment
- VI. Vegetation, cultivation etc. of the catchment.
- VII. Existence of reservoir's, Lakes etc. in the catchment.
- VIII. Existing bridge or other hydraulic structures across the river in the vicinity of the proposed bridge site with their details as much as possible.
- IX. General slope of the river from the critical point (origin) of the river up to bridge site and general slope of the catchment in both sides of the river.
- X. Cross sections covering 200m beyond flood lines of the river at proposed bridge site, at about 500m. u/s and about 200m d/s. wherein HFL, LWL,LBL, area of the cross section, wetted perimeter and geological profile with silt factor of each strata (at proposed bridge site only) shall be indicated. (Horizontal and vertical scale of the cross section shall be the same.)
- XI. Bed slope of the river which must start from 100m up of the U/S cross section

and end at 100m down of the d/s cross section.

- XII. Maximum discharge calculated by established formulas with different return periods and the peak discharge observed over a period of 100 years.
- XIII. Velocity and depth of flow at the time of survey.
- XIV. Shifting of the river in the past at proposed bridge site and in its vicinity.
- XV. Other information required for river control, design, construction and maintenance of the bridge.

3.2.3 Geo-technical Investigation: After discussion and finalizing of the site/axis the Consultant shall carry out subsurface exploration, which shall include the followings:

Test pits and auguring

Test pits and auger-holes in the riverbed to a depth as mentioned in the BOQ for determining the mean particle size of riverbed materials in each layer.

Bore-holes, field tests and laboratory tests

The properties of the underlying soil are determined by field and laboratory tests of the soil samples obtained from the bore holes drilled to a depth as mentioned in the next section and/or the Bill of Quantities. As far as possible, the locations of the boreholes shall be under each abutment and piers. Generally the following tests are conducted for determination of soil properties:

SN	Type of test	Frequency
1	Undisturbed Soil Sampling	at least 2 at each borehole
2	Standard Penetration Test	as required but the interval not less than 1.5 m
3	Grain size analysis	at least 2 at each borehole
4	Hydrometer analysis	at least 2 at each borehole
5	Moisture content	at least 2 at each borehole
6	Bulk and dry density	at least 2 at each borehole
7	Unconfined compression test	at least 2 at each borehole
8	Consolidation test	at least 2 at each borehole
9	Direct shear test	at least 2 at each borehole

If required by the field condition, the Consultant shall conduct other types of tests. Similarly the frequency of the above tests can be increased if required. The cost of all the field and laboratory tests shall be incorporated in the cost of soil investigation works. No separate payment shall be made for the tests.

The depth of soil exploration from the ground level shall be as follows:

SN	Type of soil	Governing depth
1	Silty, sandy, clayey soil	3 times the design scour depth, or 1.5 times the least dimension of the foundation footing, or 20 m, whichever is maximum
2	Granular soil (gravels, boulders)	2 times the design scour depth, or 1.5 times the least dimension of the foundation footing, or 16 m, whichever is maximum
3	Rocks (soft or hard)	Not exceeding 8 m.

The above mentioned depths are indicative. The Consultant shall decide the actual required depth of soil investigation according to the field condition and design parameters. But in

any case the Consultant shall be paid only up to the depth mentioned in the Bill of Quantities. If rock is found at the beginning or at mid-depth then the drilling works shall not exceed the depth as mentioned in the table above. In such case the payment shall be made only for the actual depth.

3.2.4 Reports of the Investigation Phase (Analysis of Data, Conclusion and Recommendation of Design Parameters):

The consultant perform concept design before proceeding with detail design, the consultant shall inform the Client on;

- Geometry of the intended bridge
- Type of the bridge and its Structural arrangements
- Design Standards to be followed
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For this, the consultant submit and **Investigation and Concept Design Report** based upon the above mentioned studies and investigation. Consultant shall make the best use of their technical know-how and professional skill to arrive at and recommend the most cost effective design parameters regarding appropriate river crossing. The consultant shall also in the Report discuss in detail at least three different options and shall recommend the most appropriate option for the proposed river crossing.

Design Phase

During the Design Phase the "Consultant" shall perform the following tasks.

Detailed design and quantity/cost estimates: Based on the collected and presented information in the "Preliminary Design Report" mentioned above the Consultant shall design the bridge following the approved standard codes of practice, norms and guidelines.

With the design, the consultant shall process Erection method and Risk analysis during flood, if there is any.

The Consultant shall produce detailed quantity estimate of the bridge and its accessories. The Consultant shall collect information on sources of materials and their lead distances and prepare rate schedules and cost estimates based on the standard norms and prevailing district rates.

Depending upon the site condition and other factors the Consultant can use the Standard Design of the part(s) of the bridge, which shall be made available by the Employer. This matter will be discussed and finalized during the presentation of the Preliminary Design or at a later stage convenient to both parties. If such Standard Design is used the Consultant shall adjust the design of other parts of the bridge to incorporate the parameters of the Standard Design. If it is decided to use any Standard Design, the Payments shall be adjusted according to the Conditions of Contract and/or as mentioned in the Price Schedule.

Draft Report (2 Copies): The Consultant shall submit a Draft Design Report and the report shall in all respect be complete, containing all the required components of the design. The Report shall be in the format as decided and required by the Client.

Final Report (5 copies). After receiving the comments in Draft Design the Consultant shall consider the comments/suggestions and make corrections or amendments if required and submit the Final Report. It does not, however, relieve the Consultant of their responsibility over the technical content of the design. The final report shall be submitted in electronic version too.

Time Schedule

It is not indicated otherwise in the contract documents the consultant shall complete the assigned works as per the following schedule:

	Duration	Remarks
Preparation	1 Week	After the each phase, the Client may terminate contract and stop the further execution of Works
Phase 1: Site Visit / Survey and Hydrology works for “ Site Visit / Preliminary Report as per ToR	1 Week	
Phase 2: Geo teh Investigation and Concept Design	6 Week	
Phase 3 : Detail Design	4 Week	

4. DEFECT LIABILITY

If not indicated otherwise in the contract documents the consultant shall have the following responsibilities;

Responsibility for survey and design

Submission of the final reports does not relieve the consultant from their responsibility to the design. They shall bear full responsibility for:

- I. Authenticity of all the field data including socio-economic, environmental, topographic, hydrological and geological information;
- II. Correctness of the design and all the calculations (except for the Standard Design, if used);
- III. Correctness of the drawings;
- IV. of any other details related to construction

Assistance during construction phase

During construction the consultants, upon written request from the Client, shall visit the bridge site and provide necessary technical assistance. The consultants shall make necessary site visits and do all the necessary design revisions as and when required for all the cases arising out of the shortcomings in the design submitted and approved earlier.

5. REPORTS AND DELIVERABLES

The Consultant shall submit the following Reports

Reports and Documents	Remarks
1.0 Site Visit/ Preliminary Report including Survey, Hydrological and Preliminary Reporting	Presentation on Inception Report within 5 days after submission of report.
2.0 Geotechnical Investigation and Concept Design Report	Presentation on Concept Design Report within 5 days after submission of report.
3.0 Detailed Design Reports (Draft and Final) (Survey, Investigation, Analysis and Design Drawings, Detail Quantity Calculation and Cost Estimate)	Presentation on Draft Design Report within 5 days after submission of report.

<p>4.0 As the part of the Final Report the consultant provide</p> <ul style="list-style-type: none"> ○ The electronic copy of the workable input files, if any software has been used for the design ○ The electronic copy of editable calculation sheets that have been used during the design calculations. 	
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All the reports are considered to be owned by Client.

All the Drawings and Reports shall be signed by the respective expert/engineers and checker with clear names and contact indicating that it has been internally checked and approved prior submission to client.

6. CONSULTANT'S TEAM

The Consultant shall engage a team of experts as mentioned below for the tasks as per this Terms of Reference

	Minimum Qualification Requirement
Team Leader / Bridge Engineer	Master degree with 10 years of general experience and 5 years of experience in bridge engineering
Geo-tech Engineer	Master degree with 10 years of general experience and 5 years of experience in bridge engineering
Hydrologist	Bachelor degree in any civil engineering field with 5 years of general experience and 2 years of experience in bridge engineering

Besides, the Consultant shall deploy all the required human resources and support staffs for the completion of all the tasks as per this Terms of Reference.

7. TRANSFER OF KNOWLEDGE

As a part of "Transfer of Knowledge", the Consultant is required to perform the tasks as indicated in the table below during the Design Phase;

Tasks	Requirements
Presentation on submission of each report. All the cost of this explanatory presentation shall be borne by the consultant and is supposed to be included in the costs stated in the Price Schedule.	Required
Perform the explanation of entire bridge design process and calculations in the Client's premises to the designated persons of the Clients in a workshop. All the cost of this explanatory workshop shall be borne by the consultant and is supposed to be included in the costs stated in the Price Schedule.	
During the design of the bridge, the consultant take a designated engineer of the Client to be with the design of the Consultants as "on the job trainee (OJT)". The cost of this task to the consultant is supposed to be included in the costs stated in the Price Schedule.	Required