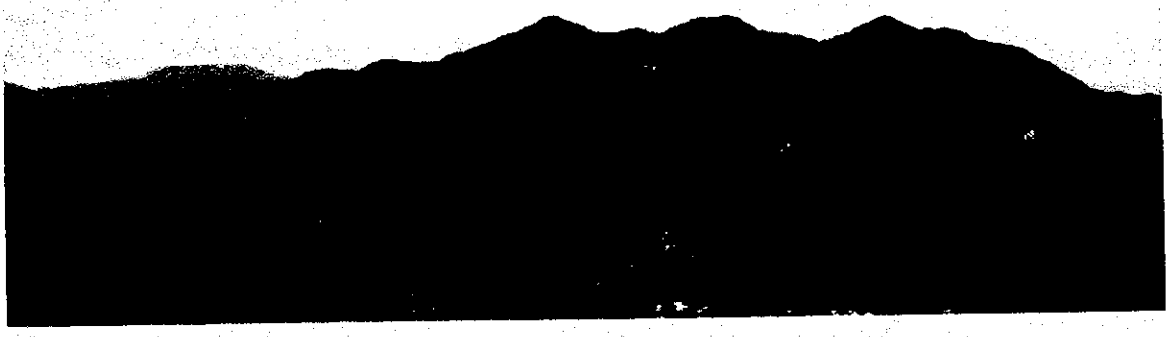
社会開発調査部報告書

No. 32

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

HIS MAJESTY S GOVERNMENT OF NEPAL
MINISTRY OF PHYSICAL PLANNING AND WORKS
DEPARTMENT OF ROADS

# THE FEASIBILITY STUDY ON THE CONSTRUCTION OF KATHMANDU-NAUBISE ALTERNATE ROAD IN THE KINGDOM OF NEPAL



## FINAL REPORT

## VOLUME I: MAIN REPORT



MARCH 2001

NIPPON KOEI CO., LTD.

CURRENCY EQUIVALENTS
(Average of July 1st to December 31st, 2000)

| | | |
|---|---|---|
| 1USD | = | 72.57 NRs (Nepalese Rupee) |
| 1USD | = | 109.76 JPY (Japanese Yen) |
| 1USD | = | 42.34 TLB (Thailand Baht) |

# PREFACE

In response to a request from His Majesty's Government of Nepal, the Government of Japan decided to conduct a feasibility study on the Construction of Kathmandu - Naubise Alternate Road and entrusted the study to the Japan International Cooperation Agency (JICA).

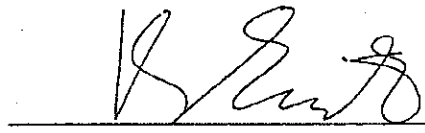
JICA selected and dispatched a study team headed by Mr. Tatsuya Masuzawa of Nippon Koei Co., Ltd. to Nepal three times between March 2000 and February 2001. In addition, JICA set up an advisory committee headed by Hideki Okamura, Director of Traffic Engineering Division Engineering Department, Japan Highway Public Corporation between March 2000 and February 2001, which examined the study from specialist and technical point of view.

The team held discussions with the officials concerned of His Majesty's Government of Nepal and conducted field surveys at the study area. Upon returning of Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the official concerned of His Majesty's Government of Nepal for their close cooperation extended to the Team.

March 2001



Kunihiko Saito
President
Japan International Cooperation Agency

# LETTER OF TRANSMITTAL

We are pleased to submit to you the Feasibility Study Report on the Construction of Kathmandu-Naubise Alternate Road in His Majesty's Government of Nepal.

This study was conducted by Nippon Koei Co., Ltd., under a contract with Japan International Cooperation Agency (JICA), during the period from March, 2000 to March, 2001. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your agency as well as the comments made by the authorities concerned in His Majesty's Government of Nepal.

Necessity and technical and economical feasibility of the Kathmandu – Naubise Alternate Road has been confirmed in the Study and early implementation of the Project is recommended in the Report.

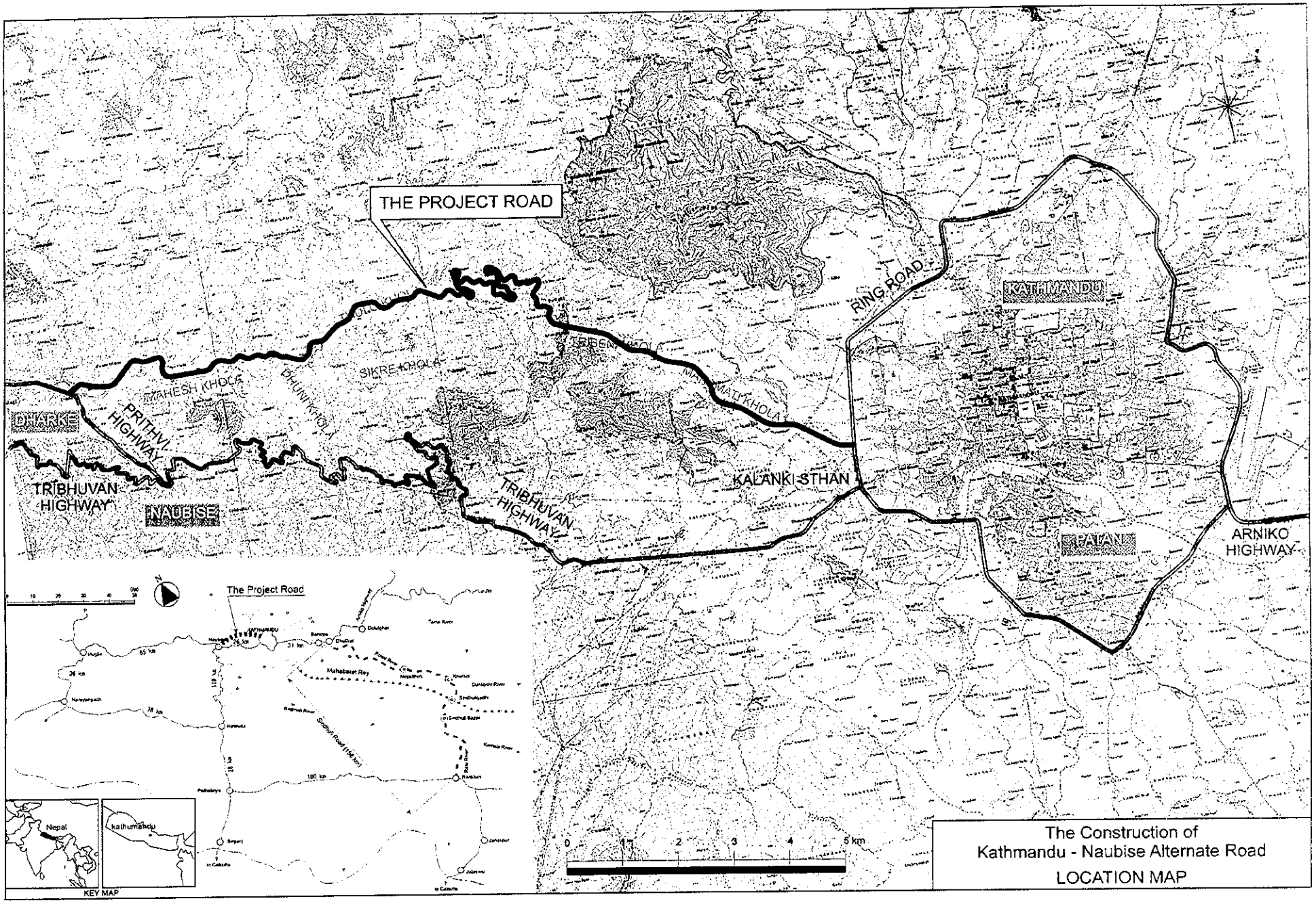
We sincerely hope that the Project is realized smoothly and contributes to economic growth of Nepal through the improvement of traffic situation in the country.

Finally, we wish to take this opportunity to express our sincere gratitude to the persons concerned of your agency, Embassy of Japan in Kathmandu, Japan Highway Public Corporation, Honshu-Shikoku Bridge Authority and Department of Road, Ministry of Physical Planning and Works, His Majesty's Government of Nepal, for their cooperation and supports extended to the Study Team.

Very truly yours,

March 2001

Tatsuya MASUZAWA
Team Leader,
JICA Study Team
Nippon Koei Co.,Ltd.


THE PROJECT ROAD
RING ROAD
KATHMANDU
PATAN
DHARKE
PRITHVI HIGHWAY
TRIBHUVAN HIGHWAY
NAUBISE
KALANKI STHAN
TRIBHUVAN HIGHWAY
ARNIKO HIGHWAY
MAHESH KHOLA
BHUNI KHOLA
SIKRE KHOLA
The Project Road
Nepal
kathumandu
KEY MAP
0 1 2 3 4 5 km
The Construction of
Kathmandu - Naubise Alternate Road
LOCATION MAP

# PHOTOGRAPH 1

## EXISTING ROAD

(1) Kalanki Intersection (Tribhuvan Highway)

The Beginning Point of Tribhuvan Highway at Ring Road.

(4) Slope Failure (Tribhuvan Highway)

There are many slope failures along Tribhuvan Highway.

(2) Hairpin (Tribhuvan Highway)

There are many hairpin bend on Tribhuvan Highway.
The Radius of curvature is as small as 20m.

(5) Traffic Congestion (Tribhuvan Highway)

The road width is very narow.
It is very hard to overtake slow sped heavy vehicles.

(3) Naubise Check Point (Prithivi Highway)

The entrance of Prithivi Highway.
The toll fee is 25 NRs for cars and 35 NRs for heavy vehicle.

(6) Existing Local Road at Ramkot

The existing road is narrow and undulated. No asphaltic and gravel pavement is provided.

**PHOTOGRAPH 2**

## PROJECT ROAD 1

(7) Intersection Site at Ring Road

There are many houses and factories along Ring Road.

(10) Section B (Tunnel Approach)

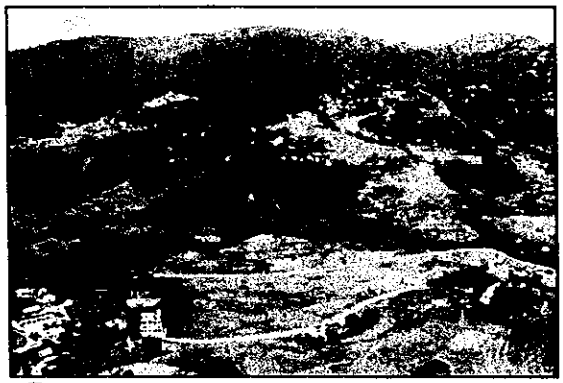
The project road is approaching tunnel portal with 3% grade.

(8) Section A (Sitapaila)

This area is close to Ring Road and is going to be urbanized.

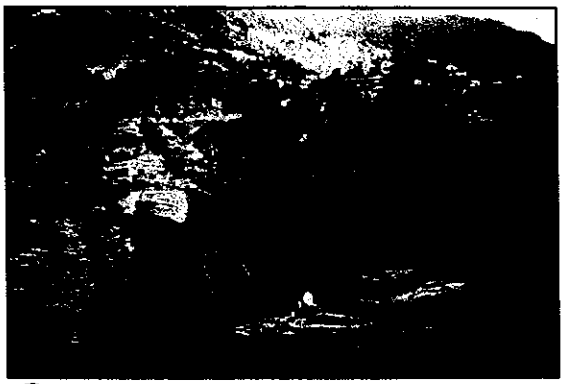
(11) Tunnel Portal Site (Kathmandu Side)

The Kathmandu side portal is located near Bakhrigau Village.



(9) Section B (Ramkot Valley)

This area is mainly used for cultivation.



(12) Tunnel Portal Site (Naubise Side)

The Naubise side potal is located on the steep slope.

# PHOTOGRAPH 3

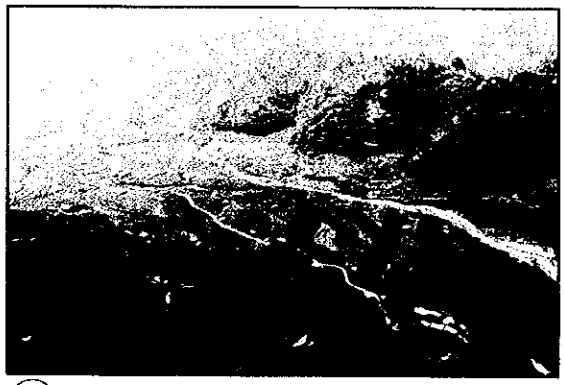
## PROJECT ROAD 2

(13) Section C (Mountainous Area)

This section has very steep terrain.

(16) Intersection Site at Dharke

There are some houses along Prithivi Highway.



(14) Section E (Mahesh Khola Plain)

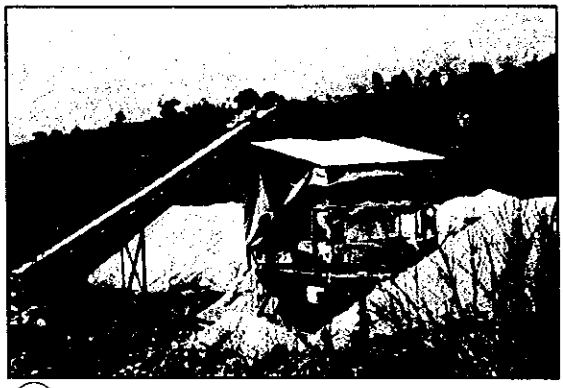
This area is relaively gentle and used for cultivation.

(15) Dharke Bridge Site

New bridge crosses over Mahesh Khola and located near existing pedestrian bridge.

## PHOTOGRAPH 4

### PROJECT ROAD 3



(17) Crusher plant at Thankot

13 crusher plans exist between Thankot and Dharke along the Tribhuvan Highway and each plant has approximate $30m^3$/day crushing capacity.

(20) Approach Road for Package III

Approach road to Badritar and Fulaure is required for construction of Package III.

(18) Quarry Site at Mahesh River

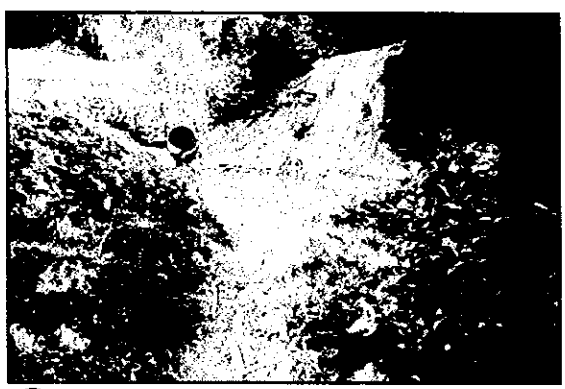
Stone material are available in Mahesh River.

(21) Chautari (Chape, Chhatre Deurali)

Local people commonly gather around Chautaris for resting and communication.

(19) Approach Road for Package II

It shall be necessary to construct the approach road for access to tunnel portal. Proposed route is shown in the Photograph.



(22) Irrigation Canal (Gajurelgaun, Jiwanpur)

Restoration or relocation of these canals should be considered during consruction of the project road.

TABLE OF CONTENTS


CHAPTER 1 INTRODUCTION ..... 1-1

1.1 Background of the Study ..... 1-1
1.1.1 General ..... 1-1
1.1.2 Objectives of the study ..... 1-2
1.2 The Project Road ..... 1-2
1.3 Work Schedule and Progress ..... 1-4
1.4 Organization of the Study ..... 1-6

CHAPTER 2 PRESENT TRANSPORTATION SYSTEM ..... 2-1

2.1 General ..... 2-1
2.2 Road Networks and Existing Facilities ..... 2-1
2.3 Road Traffic ..... 2-3
2.3.1 Car Ownership ..... 2-3
2.3.2 Traffic Volume ..... 2-4
2.4 Administration ..... 2-4
2.5 Other Transportation Systems ..... 2-6

CHAPTER 3 REVIEW OF ROAD DEVELOPMENT PLAN ..... 3-1

3.1 Road Development Plan ..... 3-1
3.1.1 Review of national development plan ..... 3-1
3.1.2 Road development plan ..... 3-2
3.2 Previous Study ..... 3-3
3.3 Development Policy for the Project Road ..... 3-6

CHAPTER 4 GENERAL CONDITIONS OF THE PROJECT AREA ..... 4-1

4.1 Socio-economic Conditions ..... 4-1
4.2 Topography and Geology ..... 4-2

CHAPTER 5 EXISTING TRIBHUVAN HIGHWAY (KATHMANDU - NAUBISE SECTION) ..... 5-1

5.1 Historical Background ..... 5-1
5.2 Geometric Condition and Traffic Capacity ..... 5-2
5.3 Hazard Potential along the existing road ..... 5-4
5.4 Evaluation of the Existing Tribhuvan Highway ..... 5-10

CHAPTER 6 ENGINEERING SURVEY AND ANALYSIS ..... 6-1

6.1 General ..... 6-1
6.2 Topographic Survey ..... 6-1
6.2.1 Control points survey ..... 6-1

6.2.2 Ground survey using Total Station ..... 6-2
6.3 Hydrological Surveys ..... 6-2
6.3.1 General ..... 6-2
6.3.2 Rainfall Analysis ..... 6-2
6.3.3 Run-off Analysis ..... 6-5
6.3.4 Flood Water Level Analysis ..... 6-5
6.4 Geological Survey ..... 6-6
6.4.1 Geological Boring Investigation ..... 6-6
6.4.2 Seismic Refraction Survey ..... 6-10
6.5 Material Survey ..... 6-13

CHAPTER 7 TRAFFIC DEMAND FORECAST ..... 7-1

7.1 Traffic Survey ..... 7-1
7.1.1 Outline of the survey ..... 7-1
7.1.2 Zoning in the study area ..... 7-1
7.1.3 Method of survey ..... 7-4
7.1.4 Result of traffic count survey ..... 7-8
7.1.5 Result of roadside OD survey ..... 7-15
7.1.6 Result of vehicle speed survey ..... 7-17
7.2 Demand Forecast Methodology ..... 7-19
7.2.1 Estimation of present OD (Origin/Destination) traffic ..... 7-20
7.2.2 Future socio-economic framework ..... 7-20
7.2.3 Forecast of future OD traffic ..... 7-21
7.2.4 Future road network modeling ..... 7-22
7.2.5 Future assigned traffic volumes ..... 7-23
7.3 Traffic Demand at the Boundary of Kathmandu Valley ..... 7-26
7.4 Results of Future Assigned Traffic Volume ..... 7-28

CHAPTER 8 APPLIED DESIGN STANDARDS ..... 8-1

8.1 General ..... 8-1
8.2 Classification of the Project Road ..... 8-1
8.3 Highway Design Standards ..... 8-2
8.3.1 Relevant current design standards ..... 8-2
8.3.2 Applied geometric design standards ..... 8-2
8.3.3 Design speeds ..... 8-3
8.3.4 Design vehicle ..... 8-4
8.3.5 Cross section elements ..... 8-4
8.3.6 Horizontal Alignment ..... 8-5
8.3.7 Vertical alignment ..... 8-6
8.3.8 Typical Cross sections ..... 8-7
8.3.9 Pavement design standards ..... 8-9
8.4 Bridge and Culvert Design Standards ..... 8-11
8.4.1 Review of current design standard ..... 8-11
8.4.2 Applied Design Standard ..... 8-11
8.4.3 Concept of Bridge Planning ..... 8-12
8.4.4 Type of Bridge ..... 8-13
8.4.5 Design Criteria ..... 8-18

8.5 Tunnel Design Standards ..... 8-18
8.5.1 General ..... 8-18
8.5.2 Review of international design standards ..... 8-19
8.5.3 Applied design standard ..... 8-28
8.5.4 Cross section of tunnel ..... 8-30
8.5.5 Ventilation system ..... 8-34
8.5.6 Lighting system ..... 8-34
8.5.7 Emergency and other incidental facilities ..... 8-34

CHAPTER 9 PREPARATION OF HAZARD MAP ..... 9-1

9.1 Hazard Map using GIS ..... 9-1
9.2 Preparing of Digital Map ..... 9-2
9.3 Observation of the Aerial Photograph ..... 9-2
9.4 Road Disaster Hazard Map ..... 9-3
9.5 Land Use Map ..... 9-3
9.6 Estimation of Annual Soil Production Volume of Each Sub-stream ..... 9-4

CHAPTER 10 ALTERNATIVE ROUTE STUDY ..... 10-1

10.1 Procedure of Alternative Route Study ..... 10-1
10.1.1 Step-1: Initial Route Study ..... 10-1
10.1.2 Step-2: Screening of Conceivable Alternative Routes ..... 10-1
10.1.3 Step-3: Optimum Route Selection ..... 10-3
10.1.4 Step-4: Comparison with Existing Tribhuvan Highway Improvement ..... 10-3
10.2 Initial Route Study ..... 10-5
10.3 Screening of Conceivable Alternative Routes ..... 10-8
10.3.1 Initial screening of Conceivable Alternative Routes ..... 10-8
10.3.2 Further screening of Conceivable Alternative Routes ..... 10-13
10.3.3 Results of the Screening of Conceivable Alternative Routes ..... 10-15
10.4 Optimum Route Selection ..... 10-16
10.4.1 Possible Alternative Routes ..... 10-16
10.4.2 Cost estimates of Possible Alternative Routes ..... 10-22
10.4.3 Construction plan and schedule ..... 10-23
10.4.4 Comparison by environmental criteria ..... 10-25
10.4.5 Economic evaluation ..... 10-28
10.4.6 Result of optimum route selection ..... 10-31
10.5 Comparison with 4-lane Improvement of Existing Tribhuvan Highway Options ..... 10-35
10.5.1 General ..... 10-35
10.5.2 Possible Improvements of Existing Tribhuvan Highway (Kathmandu-Naubise Section) ..... 10-35
10.5.3 Cost Estimate of Different Options ..... 10-40
10.5.4 Evaluation of 4-lane Improvement of Existing Tribhuvan Highway Alternatives ..... 10-41

CHAPTER 11 STUDY ON LOCATION AND FORMATION OF TUNNEL ..... 11-1

11.1 General ..... 11-1
11.2 Initial Study Based on Topographic Survey ..... 11-1
11.3 Further Study Based on Seismic Refraction Survey ..... 11-4
11.4 Comparison of Different Alternatives ..... 11-5
11.5 Longer Tunnel More Favorable? ..... 11-8

CHAPTER 12 PRELIMINARY DESIGN ..... 12-1

12.1 General ..... 12-1
12.2 Highway Design ..... 12-1
12.2.1 Alignment study ..... 12-1
12.2.2 Intersections ..... 12-13
12.2.3 Slope protection ..... 12-13
12.2.4 Drainage structures ..... 12-15
12.2.5 Pavement design ..... 12-16
12.2.6 Other incidentals ..... 12-18
12.3 Bridge & Culvert Design ..... 12-18
12.4 Tunnel ..... 12-23
12.4.1 Design Conditions ..... 12-23
12.4.2 Inner section ..... 12-24
12.4.3 Type of portal ..... 12-25
12.4.4 Station of portal ..... 12-27
12.4.5 Evaluation of geological ground condition ..... 12-27
12.4.6 Method of tunnel excavation ..... 12-29
12.4.7 Construction method of tunnel ..... 12-30
12.4.8 Pavement in the tunnel ..... 12-31
12.4.9 Ventilation system ..... 12-32
12.4.10 Lighting system ..... 12-32
12.4.11 Emergency facilities ..... 12-33
12.4.12 Other facilities ..... 12-35

CHAPTER 13 OPERATION AND MAINTENANCE ..... 13-1

13.1 General ..... 13-1
13.2 Maintenance of Road ..... 13-1
13.3 Maintenance of Bridges ..... 13-2
13.4 Operation and Maintenance of Tunnel ..... 13-3
13.4.1 Inspection of Tunnel ..... 13-3
13.4.2 Safety Control of Tunnel ..... 13-4
13.5 Maintenance of Slope ..... 13-4
13.6 Organization for Operation and Maintenance ..... 13-5

CHAPTER 14 POTENTIAL STUDY ON THE WIND AND SOLAR POWER GENERATION ..... 14-1

14.1 Introduction ..... 14-1
14.2 Method ..... 14-2
14.3 Data ..... 14-2

14.3.1 ECMWF global analysis data ..... 14-2
14.3.2 Height data ..... 14-6
14.3.3 Land use data ..... 14-6
14.3.4 Snow data ..... 14-7
14.4 The Weather prediction model ..... 14-8
14.4.1 Outline of the model ..... 14-8
14.4.2 Calculative conditions ..... 14-8
14.5 Results of monthly mean wind and solar radiation ..... 14-9
14.6 Precision of the calculated data ..... 14-15
14.7 Estimation of power generation ..... 14-15
14.7.1 Estimation of wind-generated power ..... 14-15
14.7.2 Estimation of power from solar energy ..... 14-17
14.7.3 The estimate quality ..... 14-17
14.7.4 Estimation of power generation for the operation of tunnel ..... 14-22
14.7.5 Possibility of utilization of wind and solar power ..... 14-25

CHAPTER 15 ENVIRONMENTAL STUDY ..... 15-1

15.1 General ..... 15-1
15.2 Official EIA Procedure in Nepal ..... 15-1
15.2.1 Legal frame on EIA ..... 15-1
15.2.2 EIA procedure ..... 15-2
15.2.3 Environmental guidelines of road sector ..... 15-4
15.3 Environmental Survey ..... 15-4
15.3.1 Water quality survey ..... 15-4
15.3.2 Household interview survey ..... 15-8
15.4 Initial Environmental Examination ..... 15-8
15.4.1 Site description ..... 15-8
15.4.2 Examination on potential environmental impact ..... 15-18
15.5 Environmental Impact Assessment on Optimum Route ..... 15-23
15.5.1 Introduction ..... 15-23
15.5.2 Impact prediction and assessment ..... 15-23
15.5.3 Mitigation measures ..... 15-29
15.5.4 Environmental monitoring ..... 15-35

CHAPTER 16 LAND ACQUISITION AND RESETTLEMENT PLAN ..... 16-1

16.1 Introduction ..... 16-1
16.2 Legal Frame on Land Acquisition and Resettlement ..... 16-1
16.2.1 Land Act 2021 (1964) ..... 16-1
16.2.2 Land Acquisition Act 2034 (1977) ..... 16-1
16.2.3 Land Acquisition Rules 2026 (1969) ..... 16-2
16.2.4 Public Road Act 2031 (1974) ..... 16-3
16.2.5 Guthi Corporation Act 2033 (1976) ..... 16-3
16.3 Legal Procedure for Land Acquisition and Compensation ..... 16-3
16.4 Other policies to be referred on involuntary resettlement ..... 16-6
16.5 Magnitude of Land Acquisition and Resettlement ..... 16-7
16.6 Land Acquisition and Resettlement Plan ..... 16-8
16.6.1 Policy for the project ..... 16-11

16.6.2 Entitlement to be compensated ..... 16-12
16.6.3 Organisational framework ..... 16-15
16.6.4 Monitoring and evaluation ..... 16-22
16.6.5 Others ..... 16-22
16.7 Cost Estimate of Land Acquisition and Resettlement ..... 16-22

CHAPTER 17 CONSTRUCTION PLAN ..... 17-1

17.1 General ..... 17-1
17.2 Proposed Contract Packages ..... 17-1
17.3 Access to the each contract package ..... 17-4
17.4 Procurement Sources of Crushed Stone Material ..... 17-5
17.5 Workable day ..... 17-5
17.6 Construction Schedule ..... 17-6
17.7 Annual Requirement of Material, Manpower and Equipment ..... 17-9

CHAPTER 18 COST ESTIMATE ..... 18-1

18.1 General ..... 18-1
18.2 Basic Prices and Procurement Sources ..... 18-2
18.2.1 Procurement Sources ..... 18-2
18.2.2 Basic Prices of Construction Material ..... 18-3
18.2.3 Construction Equipment and Machine ..... 18-3
18.2.4 Manpower ..... 18-4
18.2.5 Transportation ..... 18-5
18.2.6 Tax and Duties ..... 18-5
18.2.7 Ability of Local Contractors ..... 18-5
18.3 Cost Estimate ..... 18-6
18.3.1 Construction Quantity ..... 18-6
18.3.2 Unit Cost Analysis ..... 18-6
18.3.3 Indirect Construction Cost ..... 18-6
18.3.4 Contingency ..... 18-6
18.3.5 E/S Cost ..... 18-6
18.3.6 Tax and Duties ..... 18-6
18.3.7 Administration Cost ..... 18-9
18.3.8 Land Acquisition Cost and House Compensation Cost ..... 18-9
18.3.9 Agricultural Compensation ..... 18-9
18.3.10 Result of Cost Estimate ..... 18-9

CHAPTER 19 PROJECT EVALUATION ..... 19-1

19.1 Economic Evaluation ..... 19-1
19.1.1 Economic Costs ..... 19-1
19.1.2 Economic Benefits ..... 19-1
19.1.3 Economic Evaluation ..... 19-4
19.1.4 Sensitivity Analysis ..... 19-6
19.2 Financial Analysis ..... 19-7
19.2.1 Toll Collection System ..... 19-7
19.2.2 Estimation of Toll Revenue ..... 19-8
19.2.3 DOR Budget and Expenditure ..... 19-8

19.2.4 Financial Evaluation ..... 19-8
19.3 Indirect Benefits ..... 19-9

CHAPTER 20 PROJECT IMPLEMENTATION PLAN ..... 20-1

20.1 Implementation Plan of the Project ..... 20-1
20.1.1 General ..... 20-1
20.1.2 Executing Agency ..... 20-1
20.1.3 Expected Financial Source ..... 20-1
20.1.4 Implementation Schedule of the Project ..... 20-2
20.2 Overall Implementation Schedule for Road Improvement between Kathmandu and Terai ..... 20-6
20.2.1 Related existing roads and road development plans ..... 20-6
20.2.2 Present Condition of the Naubise – Narayangadh Section ..... 20-8
20.2.3 Future Traffic Demand of the Kathmandu – Narayangadh Road ..... 20-9
20.2.4 Overall Implementation Schedule for Roads improvement between Kathmandu and Terai ..... 20-10

CHAPTER 21 CONCLUSION AND RECOMMENDATION ..... 21-1

## List of Table


| | | |
|---|---|---|
| Table 2.1 | Road Length, Influenced Population and Area | 2-1 |
| Table 2.2 | Length of Roads with Classification and Pavement | 2-3 |
| Table 2.3 | Cumulative Number of Vehicles Registered | 2-3 |
| Table 2.4 | Number of Vehicles Registered by Zone | 2-4 |
| Table 2.5 | AADT (Logger data) | 2-5 |
| Table 3.1 | Long-term Projection of Macro Economic Indicators | 3-2 |
| Table 3.2 | Long-term Projection of Road Infrastructure Indicators | 3-3 |
| Table 4.1 | Population Distribution | 4-1 |
| Table 4.2 | Land Use in the Districts of Project Area | 4-1 |
| Table 4.3 | Features of the Watersheds of the Study Area | 4-3 |
| Table 5.1 | Summary of Geometric Conditions of Existing Tribhuvan Highway | 5-2 |
| Table 5.2 | Calculation of Capacity Based on Australian Capacity Manual | 5-3 |
| Table 5.3 | Slope Stability Check Sheet | 5-4 |
| Table 5.4 | Road Length with Failure of Cutting Slope | 5-7 |
| Table 5.5 | Number of Potential Disaster Spots | 5-11 |
| Table 6.1 | Results on GPS Co-ordinates in Nepal Datum (UTM Grid) | 6-1 |
| Table 6.2 | Summary of Rainfall Stations | 6-3 |
| Table 6.3 | Probable Maximum Daily Rainfall (in mm/day) | 6-3 |
| Table 6.4 | Rainfall Intensity (mm/hr) | 6-4 |
| Table 6.5 | Work Quantities of Geological Survey | 6-7 |
| Table 6.6 | Description of Seismic Profiles | 6-10 |
| Table 6.7 | Velocity Layers and Rock Formation | 6-11 |
| Table 6.8 | Quantity of Material Survey | 6-13 |
| Table 7.1 | Zoning Level | 7-1 |
| Table 7.2 | Zone Table | 7-2 |
| Table 7.3 | OD Survey Interview Sheet | 7-6 |
| Table 7.4 | Road Grade of Survey Section | 7-7 |
| Table 7.5 | Result of Traffic Count Survey by Vehicle Type at Thankot | 7-8 |
| Table 7.6 | Result of Traffic Count Survey by Vehicle Type at Kalanki | 7-8 |
| Table 7.7 | Peak Ratio at Thankot | 7-10 |
| Table 7.8 | Peak Ratio at Kalanki | 7-12 |
| Table 7.9 | Daytime Traffic Ratio | 7-13 |
| Table 7.10 | Seasonality Factor by DOR | 7-13 |
| Table 7.11 | AADT at Thankot in 2000 | 7-14 |
| Table 7.12 | AADT at Kalanki in 2000 | 7-14 |
| Table 7.13 | Detail of AADT by Vehicle Type | 7-15 |
| Table 7.14 | Extract Ratio by vehicle Type | 7-15 |
| Table 7.15 | Average number of passenger by each vehicle type | 7-16 |
| Table 7.16 | Modal Share by Commodities of Trucks | 7-17 |
| Table 7.17 | Travel Speeds between Kalanki and Dharke | 7-18 |
| Table 7.18 | Travel Speeds of Heavy Vehicle on Uphill Slope from Naubise | |

| | | |
|---|---|---|
| | to Nagdhunga | 7-18 |
| Table 7.19 | Travel Speeds Regress ional Model by Grade | 7-19 |
| Table 7.20 | Basic Methods of Estimating Generated and Attracted Trips | 7-22 |
| Table 7.21 | Q-V Formula | 7-25 |
| Table 7.22 | Summary of Growth Rate | 7-26 |
| Table 7.23 | Traffic Demand at the Boundary of Kathmandu Valley | 7-26 |
| Table 7.24 | Capacity in Nepal Road Standard (National Highway) | 7-28 |
| Table 7.25 | Assigned Traffic Volume by Vehicle Type in 2010 and 2020 | 7-29 |
| Table 8.1 | Proposed Geometric Design Standard for Highway Design | 8-3 |
| Table 8.2 | Slope of Cut on Different Soil Types along the Project Road | 8-5 |
| Table 8.3 | Summary of Design Criteria for Pavement Design | 8-11 |
| Table 8.4 | Minimum Clearance | 8-13 |
| Table 8.5 | Conceivable Types of Superstructures | 8-15 |
| Table 8.6 | Selection Criteria of Foundation | 8-17 |
| Table 8.7 | Applicable Length of Piles | 8-18 |
| Table 8.8 | Standards of Rock Classification and Support | 8-21 |
| Table 8.9 | Limit for Exhaust Gas from PIARC (for V = 60 km/h) | 8-23 |
| Table 8.10 (1/3) | Standard of Lighting System | 8-24 |
| Table 8.10 (2/3) | Standard of Lighting System | 8-25 |
| Table 8.10 (3/3) | Standard of Lighting System | 8-26 |
| Table 9.1 | Erosion depth/year along each sub-stream from its gradient | 9-6 |
| Table 10.1 | Quantified Items for Screening | 10-2 |
| Table 10.2 | Length of Alternatives in Each Section | 10-5 |
| Table 10.3 | Comparative Lengths of Alternatives in Each Section | 10-7 |
| Table 10.4 | Results of the Quantified Items for Screening | 10-9 |
| Table 10.5 | Results of Initial Screening of Conceivable Alternative Routes | 10-10 |
| Table 10.6 | Approximate Cost Estimate of Remaining Alternatives in Section B | 10-14 |
| Table 10.7 | Approximate Cost Estimate of Remaining Alternatives in Section D | 10-14 |
| Table 10.8 | Remaining Alternatives after Screening | 10-15 |
| Table 10.9 | Composition of New Alternatives (Possible Alternative Routes) | 10-16 |
| Table 10.10 | Approximate Cost Estimate | 10-23 |
| Table 10.11 | Comparison of each Alternatives in Section C by Environmental Criteria | 10-26 |
| Table 10.12 | Economic Benefits by Alternative Routes | 10-29 |
| Table 10.13 | Economic Cost Stream | 10-29 |
| Table 10.14 | EIRR, NPV and B/C Calculation | 10-30 |
| Table 10.15 | Results of Rating of Alternative Routes | 10-31 |
| Table 10.16 | Cost Estimation for Possible Improvements of Existing Tribhuvan Highway | 10-40 |
| Table 10.17 | Cost Comparison between 4-lane Improvement of Existing Tribhuvan Highway and Kathmandu – Naubise Alternate Road Project | 10-41 |
| Table 11.1 | Comparison of Construction Cost | 11-8 |

| | | |
|---|---|---|
| Table 12.1 | Standard Slope Gradient for Cutting Slope | 12-14 |
| Table 12.2 | Standard Slope Gradient for Embankment Slope | 12-14 |
| Table 12.3 | ESAL Factors for Different Vehicle Types | 12-17 |
| Table 12.4 | Calculated Thickness of Pavement Layers | 12-18 |
| Table 12.5 | List of Location of Bridges and Culverts | 12-20 |
| Table 12.6 | Vertical Clearance | 12-21 |
| Table 12.7 | Minimum Span Length of each Bridge | 12-21 |
| Table 12.8 | Summary of Bridge Types and Length | 12-22 |
| Table 12.9 | Type of Culverts | 12-23 |
| Table 12.10 | Study of Inner Dimension of Tunnel | 12-25 |
| Table 12.11 | Type and Features of Tunnel Portal | 12-26 |
| Table 12.12 | Comparison Table of Portal Locations | 12-28 |
| Table 12.13 | Evaluation of Geological Ground Condition along the Tunnel | 12-29 |
| Table 12.14 | Seismic Velocity and Unconfined Compression Strength of Phyllite | 12-30 |
| Table 12.15 | Standard Supporting Patterns of Tunnel (NATM method) | 12-31 |
| Table 14.1 | The outline of collected ECMWF data | 14-2 |
| Table 14.2 | Classification of the snow covered area | 14-7 |
| Table 14.3 | The calculative conditions in the model | 14-8 |
| Table 14.4 | Output characteristics (amount of 300kW grade, hub 30m) of the wind-generated electricity system | 14-16 |
| Table 14.5 | Monthly and annual mean wind velocity, solar radiation and the quantity of generation at the Project area | 14-22 |
| Table 14.6 | Tunnel facility electric capacity | 14-23 |
| Table 14.7 | Rough Cost Estimate for Wind and Solar Power Generation System | 14-25 |
| Table 15.1 | Sampling Points | 15-5 |
| Table 15.2(1/4) | Test Results of River Water Samples (dry season) | 15-6 |
| Table 15.2(2/4) | Test Results of Well/Spring Water Samples (dry season) | 15-6 |
| Table 15.2(3/4) | Test Results of River Water Samples (wet season) | 15-7 |
| Table 15.2(4/4) | Test Results of Well/Spring Water Samples (wet season) | 15-7 |
| Table 15.3 | Numbers of Household and Sample | 15-8 |
| Table 15.4 | Values Observed by KVVECP | 15-11 |
| Table 15.5 | Demographic Features of Districts | 15-12 |
| Table 15.6 | Demographic Features of VDCs | 15-12 |
| Table 15.7 | Landholdings by Districts | 15-14 |
| Table 15.8 | Occupational Status by Districts | 15-14 |
| Table 15.9 | Principal Activities in the Study area | 15-14 |
| Table 15.10 | Production of Cereal Crops by Districts | 15-15 |
| Table 15.11 | Schools and Students of VDCs | 15-17 |
| Table 15.12(1/2) | Results of Examination on Potential Environmental Impact | 15-21 |
| Table 15.12(2/2) | Results of Examination on Potential Environmental Impact | 15-22 |
| Table 15.13 | Land Use within ROW | 15-24 |
| Table 15.14 | Air Quality along Tribhuvan High Way | 15-25 |
| Table 15.15 | Future Traffic Volume of Project Road | 15-25 |
| Table 15.16 (1/5) | Proposed Mitigation Measures | 15-30 |
| Table 15.16 (2/5) | Proposed Mitigation Measures | 15-31 |
| Table 15.16 (3/5) | Proposed Mitigation Measures | 15-32 |

Table 15.16 (4/5) Proposed Mitigation Measures ..... 15-33
Table 15.16 (5/5) Proposed Mitigation Measures ..... 15-34
Table 15.17 Framework of Environmental Monitoring ..... 15-36

Table 16.1 Magnitude of Land Acquisition (ROW=50 m) ..... 16-8
Table 16.2 House Structures within ROW (50m width) ..... 16-8
Table 16.3 (1/2) Summarised Issues of Land Acquisition and Resettlement Plan ..... 16-9
Table 16.3 (2/2) Summarized Issues of Land Acquisition and Resettlement Plan ..... 16-10
Table 16.4 (1/2) Roles and Responsibilities of Related Oganisations ..... 16-16
Table 16.4 (2/2) Roles and Responsibilities of Related Organisations ..... 16-17
Table 16.5 Cost Estimate of Land Acquisition and Resettlement ..... 16-23

Table 17.1 Calculation Sheet of Workable Days ..... 17-6
Table 17.2 Overall Construction Schedule ..... 17-7
Table 17.3 Construction Schedule of the Tunnel ..... 17-8
Table 17.4 Annual requirement of material, Manpower and Equipment ..... 17-9

Table 18.1 Procurement Sources of Major Items ..... 18-2
Table 18.2 Material Unit Price ..... 18-3
Table 18.3 Equipment Operation Unit Rate ..... 18-4
Table 18.4 Labour Unit Rate ..... 18-5
Table 18.5 Summary of the Direct Construction Cost of the Project ..... 18-7
Table 18.6 Summary o the Project Cost ..... 18-8

Table 19.1 Economic Cost Stream ..... 19-1
Table 19.2 VOCs ..... 19-3
Table 19.3 Travel Time Costs ..... 19-3
Table 19.4 Economic Benefits ..... 19-4
Table 19.5 EIRR, NPV and B/C Calculation ..... 19-5
Table 19.6 Cost Benefit Cash Flows ..... 19-6
Table 19.7 Sensitivity Analysis for EIRR (%) ..... 19-7
Table 19.8 Unit Toll Rate ..... 19-7
Table 19.9 Toll Revenue by Vehicle Type ..... 19-8
Table 19.10 DOR Budget and Expenditure ..... 19-8

Table 20.1 Future Traffic Demand of the Kathmandu – Narayangadh Road ..... 20-9
Table 20.2 Traffic Capacity of Kathmandu – Narayangadh Road ..... 20-10
Table 20.3 Calculation of the Traffic Capacity ..... 20-15

Table 21.1 Major Features of the Project Road ..... 21-4

## List of Figure


| | | |
|---|---|---|
| Figure 1.1 | Overall Work Flow | 1-5 |
| Figure 1.2 | The Organization Chart of the Study | 1-7 |
| Figure 2.1 | Strategic Road Network | 2-2 |
| Figure 2.2 | Logger Point | 2-5 |
| Figure 2.3 | Organization Chart of DOR | 2-6 |
| Figure 5.1 (1/2) | Classification of Section by Slope Soundness Condition (Existing Tribhuvan Highway) | 5-5 |
| Figure 5.1 (2/2) | Classification of Section by Slope Soundness Condition (Existing Tribhuvan Highway) | 5-6 |
| Figure 5.2 | Hazard Map of Existing Tribhuvan Highway | 5-8 |
| Figure 5.3 | The conceptual profile of dormant landslide | 5-9 |
| Figure 6.1 | Rainfall Intensity curve of Dhunibesi Station | 6-4 |
| Figure 6.2 | Rainfall Intensity curve of Thankot Station | 6-4 |
| Figure 6.3 | Location Map of Boreholes | 6-8 |
| Figure 6.4 | Geological Map of Bhimdhunga Pass Area | 6-9 |
| Figure 6.5 | Seismic Survey Center Lines | 6-12 |
| Figure 6.6 | Location of Material Sampling Points | 6-15 |
| Figure 7.1 | Zoning Map | 7-3 |
| Figure 7.2 | Point of Traffic Count Survey and OD Survey | 7-4 |
| Figure 7.3 | Key Plan of Vehicle Speed Survey Section | 7-7 |
| Figure 7.4 | Daily Fluctuation of Traffic | 7-9 |
| Figure 7.5 | Hourly Fluctuation of Traffic (Thankot / from Naubise to Kathmandu) | 7-9 |
| Figure 7.6 | Hourly Fluctuation of Traffic (Thankot / from Kathmandu to Naubise) | 7-10 |
| Figure 7.7 | Hourly Fluctuation of Traffic (Kalanki / from Naubise to Kathmandu) | 7-11 |
| Figure 7.8 | Hourly Fluctuation of Traffic (Kalanki) / from Kathmandu to Naubise) | 7-11 |
| Figure 7.9 | AADT on the Tribhuvan Highway | 7-14 |
| Figure 7.10 | Trip Composition by Purpose (Motorcycle and Passenger Cars) | 7-16 |
| Figure 7.11 | Travel speeds of Vehicles by Grade | 7-18 |
| Figure 7.12 | Procedure for Future Traffic Demand Forecast | 7-19 |
| Figure 7.13 | Future Road Network | 7-24 |
| Figure 7.14 | Q-V Formula | 7-25 |
| Figure 7.15 | Traffic Demand between Kathmandu and Other Area | 7-27 |
| Figure 7.16 | Assigned Traffic Volume in 2010 and 2020 | 7-29 |
| Figure 8.1 (1/2) | Typical Cross Sections on Roadway | 8-7 |
| Figure 8.1 (2/2) | Typical Cross Sections on Roadway | 8-8 |
| Figure 8.2 | AASHTO Design Equation, Nomograph | 8-10 |
| Figure 8.3 | Applicable Superstructures by Span Length | 8-14 |

| | | |
|---|---|---|
| Figure 8.4 | Setting of Abutment on Steep Slopes | 8-15 |
| Figure 8.5 | Typical Cross Section of Bridges | 8-18 |
| Figure 8.6 | Ventilation System | 8-22 |
| Figure 8.7 | Comparison of Intensity of Lighting (Field luminance 400cd/m$^2$) | 8-29 |
| Figure 8.8 | Typical Cross Section of C-1 Route Tunnel (Hard Rock) | 8-31 |
| Figure 8.9 | Typical Cross Section of C-1 Route Tunnel (Soft Rock) | 8-32 |
| Figure 8.10 | Typical Cross Section of C-2 Route Tunnel (Soft Rock) | 8-33 |
| Figure 9.1 | Procedure of Hazards Map | 9-1 |
| Figure 9.2 | Observation of Aerial Photograph & Route Selection | 9-2 |
| Figure 9.4 | Result of NDVI Analysis in Siwalik | 9-3 |
| Figure 9.6 | The Procedure of Estimating the Soil Production Volume | 9-4 |
| Figure 9.3 | Hazard Map | 9-7 |
| Figure 9.5 | Land Use Map | 9-8 |
| Figure 9.7 | Slop Gradient Map | 9-9 |
| Figure 9.8 | Soil Potential Map | 9-10 |
| Figure 10.1 | Outline Procedure of Alternative Route Study | 10-4 |
| Figure 10.2 | Conceivable Alternative Routes | 10-6 |
| Figure 10.3 | Possible Alternative Routes | 10-17 |
| Figure 10.4 (1/2) | Vertical Profile of Alternatives in Section C | 10-18 |
| Figure 10.4 (2/2) | Vertical Profile of Alternatives in Section C | 10-19 |
| Figure 10.5 (1/2) | Geological Profile Along Tunnel Routes | 10-20 |
| Figure 10.5 (2/2) | Geological Profile Along Tunnel Routes | 10-21 |
| Figure 10.6 | The Optimum Route | 10-34 |
| Figure 10.7 | Typical Cross Sections for Widening of Existing Tribhuvan Highway to Four Lanes | 10-36 |
| Figure 10.8 | Options of Realignment in the Nagdhunga Pass Section in Existing Tribhuvan Highway | 10-39 |
| Figure 11.1 | Alternative Alignment C4 of Short Tunnel | 11-2 |
| Figure 11.2 | Profile of Alternative Alignment C4 | 11-3 |
| Figure 11.3 | Final Tunnel Alignment C5 | 11-6 |
| Figure 11.4 | Profile of Final Tunnel Alignment C5 | 11-7 |
| Figure 11.5 | Another Long Tunnel C6 (Not Recommended) | 11-9 |
| Figure 12.1 | Section from STA. 0+000 to STA. 1+800 | 12-5 |
| Figure 12.2 | Section from STA. 1+800 to STA. 3+800 | 12-6 |
| Figure 12.3 | Section from STA. 3+800 to Kathmandu Side Tunnel Portal | 12-7 |
| Figure 12.4 | Section from Kathmandu Side Tunnel Portal to STA. 14+000 | 12-8 |
| Figure 12.5 | Section from STA. 14+000 to STA. 16+200 | 12-9 |
| Figure 12.6 | Section from STA. 16+200 to STA. 18+300 | 12-10 |
| Figure 12.7 | Section from STA. 18+300 to STA. 20+700 | 12-11 |
| Figure 12.8 | Section from STA. 20+700 to End STA. 21+355 | 12-12 |
| Figure 12.9 | Drainage System on Cutting Slope | 12-15 |
| Figure 12.10 | Typical Cross Section by Conventional Method | 12-31 |
| Figure 12.11 | Classification of Tunnel for Emergency Facilities | 12-34 |
| Figure 12.12 | Proposed Arrangement of Tunnel Facilities | 12-35 |
| Figure 12.13 | Recommended Location for Truck Terminal | 12-36 |

| | | |
|---|---|---|
| Figure 13.1 | Proposed Organization of the Project Operation Unit (POU) | 13-6 |
| Figure 14.1 | The Map of the Objective Area | 14-1 |
| Figure 14.2 | Research Flow of the Analysis | 14-3 |
| Figure 14.3 | Monthly Wind Distribution Map | 14-4 |
| Figure 14.4 | Monthly Wind Distribution Map | 14-5 |
| Figure 14.5 | The Distribution Average Height by 8km Mesh | 14-6 |
| Figure 14.6 | The Distribution Average Land Use by 8km Mesh | 14-7 |
| Figure 14.7 | Annual Mean Wind Map | 14-11 |
| Figure 14.8 | Monthly Mean Wind Map | 14-12 |
| Figure 14.9 | Annual Mean Daily Cumulative Solar Radiation | 14-13 |
| Figure 14.10 | Monthly Mean Daily Cumulative Solar Radiation Map | 14-14 |
| Figure 14.11 | The Wind-generated Electricity System (Example for stall control, rated output 300kW machine) | 14-15 |
| Figure 14.12 | Electric Power by Wind (Annual Mean) | 14-18 |
| Figure 14.13 | Electric Power by Wind (Monthly Mean) | 14-19 |
| Figure 14.14 | Electric Power by Solar Panel, Annual Mean | 14-20 |
| Figure 14.15 | Electric Power by Solar Panel, Monthly Average | 14-21 |
| Figure 14.17 | Frequency distribution of electricity | 14-23 |
| Figure 14.16 | Time Sequence of the Hourly Demand and Supply of Power in the Tunnel | 14-24 |
| Figure 14.18 | The Wind Velocity affected by Topographic Condition | 14-27 |
| Figure 15.1 | EIA Procedure Flow | 15-3 |
| Figure 15.2 | Ethnic Composition in the Study Area | 15-12 |
| Figure 15.3 | Religious Composition in the Study Area | 15-13 |
| Figure 15.4 | Relationship among Related Organisations | 15-37 |
| Figure 16.1 | Legal Procedure for Land Acquisition | 16-4 |
| Figure 16.2 | Proposed Organisational Chart | 16-18 |
| Figure 18.1 | Composition of the Project Cost | 18-1 |
| Figure 19.1 | Location of Toll Gate on the Project Road | 19-7 |
| Figure 19.2 | Toll and FIRR | 19-9 |
| Figure 20.1 | Proposed Organization during Detailed Design and Construction Stage | 20-4 |
| Figure 20.2 | Implementation Schedule and Annual Disbursement Schedule | 20-5 |
| Figure 20.3 | Related Existing Roads and Road Development Plans | 20-13 |
| Figure 20.4 | Traffic Demand of Each Section with Relation to the Traffic Capacity | 20-14 |

## Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| BOD | Biochemical Oxygen Demand |
| CBS | Central Bureau of Statistics |
| CDC | Compensation Determination Committee |
| CDO | Chief District Officer |
| COD | Chemical Oxygen Demand |
| dB | Decibel |
| DDC | District Development Committee |
| DIRDP | Dhading Integrated Rural Development Project |
| DLRO | District Land Administration and Revenue Office |
| DO | Dissolved Oxygen |
| DOHM | Department of Hydrology and Meteorology |
| DOR | Department of Roads |
| EC | Electric Conductivity |
| E-coli | Escherichia Coli |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Act |
| EPR | Environmental Protection Regulations |
| GEU | Geo-Environmental Unit |
| IEE | Initial Environmental Examination |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| JBIC | Japan Bank for International Cooperation |
| JICA | Japan International Cooperation Agency |
| KVVEPC | Kathmandu Valley Vehicle Emission Control Project |
| LPG | Liquid Petroleum Gas |
| MOPE | Ministry of Population and Environment |
| MPPW | Ministry of Physical Planning and Works |
| NGO | Non-Governmental Organization |
| $NO_2$ | Nitrogen Dioxide |
| $PM_{10}$ | Particulate Matter of 10 microns or less |
| PVC | Polyvinyl Chloride |
| ROW | Right of Way |
| SPAF | Severely Project Affected Family |
| $SO_2$ | Sulfur Dioxide |
| TDS | Total Dissolved Solids |
| TOR | Terms of Reference |
| TSP | Total Suspended Particles |
| VDC | Village Development Committee |
| WB | World Bank |
| WHO | World Health Organization |

# CHAPTER 1 INTRODUCTION

## 1.1 Background of the Study

### 1.1.1 General

The Kingdom of Nepal is a landlocked country located between the Republic of China and India. Kathmandu, the capital city of the Nepal, is located in the Kathmandu Valley surrounded by 1,500 – 2,500 m high mountains.

Currently there are two main roads connecting Kathmandu with Terai Plain, namely Tribhuvan Rajpath Highway (hereinafer referred as "Tribhuvan Highway") and Prithvi Highway. The Tribhuvan Highway, which was constructed under Indian assistance and completed in the 1950s, links Kanthmandu and Hetauda via Naubise. However, the section between Naubise and Hetauda crossing the Daman Pass (EL. 2,300) is not used as a main transport route because of its narrow, swinging and steep alignment due to extremely steep topography.

The Prithvi Highway, which was constructed under Chinese Assistance and completed in 1974, is extending to the east from Naubise to Bharatpur in Terai plain through Mugling. Most traffic from/to Kathmandu are using this highway.

Regarding the section between Kathmandu and Naubise, this part of the Tribhuvan Highway is the sole corridor linking Kathmandu with other areas of Nepal and has the most important role in Nepal road network from socio-economic and national security viewpoints. However, the existing road in this section has the following major problems.

- Longitudinal grade exceeds 10% in several parts due to steep topography
- Slope failures have occurred and blocked traffic frequently during the rainy season because of poor geology and heavy rainfall
- Traffic accidents have often happened
- Improvement and/or widening of the road is practically impossible due to geological and geographical constraint

During the recent decade, the Department of Roads (DOR), Ministry of Physical Planning and Works (formerly Ministry of Works and Transport, MOWT) of His Majesty's Government of Nepal (HMG/N), conducted a series of master-plan and pre-feasibility studies on future road improvement, and construction of an alternate road for the Kathmandu - Naubise section has been highlighted as a top priority project and requested technical assistance from the Japanese Government to carry out a feasibility study for the construction of the Kathmandu - Naubise Alternative Road

In response to the request, the Government of Japan decided to carry out the Study and entrusted its execution to the Japan International Cooperation Agency (JICA); official agency responsible for the implementation of technical cooperation program by the Government of Japan.

In March 2000, JICA organized a study team (hereinafter referred as "the Study Team") and dispatched it to Nepal for the Feasibility Study on Construction of the Kathmandu - Naubise Alternate Road (hereinafter referred as "the Study")

The Study Team commenced their works after submission of the Inception Report in April 2000. Meetings with the Department of Roads, Ministry of Works and Transport, HMG/N (hereinafter referred as "DOR"), counterpart agency for the Study, were held to confirm the scope of the works and schedule of the Study.

The Study Team conducted their first stage works in Nepal during the period between the end of March 2000 and the middle of June 2000 and their first stage works in Japan during July and August 2000. The second stage works in Nepal were conducted during the period between the middle of August 2000 and the middle of December 2000. The second stage works in Japan were conducted during the period between the middle of December 2000 and the middle of January 2001.

This Draft Final Report presents all the study results and findings obtained in the period of the first and second stage works in Nepal and the first and second stages work in Japan.

### 1.1.2 Objectives of the study

The objectives of the Study are:

1) To conduct Feasibility Study for the new road construction from Kathmandu to Naubise; and

2) To pursue technology transfer to the counterparts on the Nepalese side in the course of the Feasibility Study.

In essence, the Study aims at determination of the optimum scheme of Kathmandu – Naubise Alternate Road through the comparison among conceivable alternatives. The scope of works of the Study was made clear through the discussion between DOR and JICA Study Team on 6 April 2000.

## 1.2 The Project Road

The Kathmandu – Naubise Alternate Road will form a new national trunk road, which connects Kathmandu with other areas of Nepal. At present, there is only one trunk road, which is a part of Tribhuvan Highway and called as 'Naubise – Thankot Road', in Kathmandu – Naubise section. Most traffic between Kathmandu and other major

parts of Nepal and/or India pass this road. Current traffic level of the road was estimated at around 3,000 vehicles per day through the previous surveys.

A second trunk route access to Kathmandu, the Sindhuli Road, is currently under construction in the east by Japanese grant aid program. However a previous study, Priority Investment Plan (PIP) Study, estimated that diversion traffic to the Shindhuli road would be only about 500 vehicles per day and concluded that the status of the Kathmandu – Naubise route as the life line of the Kathmandu Valley will be maintained.

On the other hand, future traffic demand of the route is estimated by this Study and PIP study and it can be concluded that traffic volume of the road will be beyond its capacity in the near future. Since the widening of the existing Naubise – Thankot Road is practically impossible due to the steep geography and poor geology, construction of a new Kathmandu – Naubise Alternate Road is required to meet the future traffic demand in this section.

Considering these conditions, the role of the Project Road can be concluded to be:

i) To function as new major trunk road connecting Katmandu with Terai Plain and western part of Nepal and secure constant supply of consumers' good to the people in the capital city.

ii) To ensure more reliable transportation route for international trade between Kathmandu and India

iii) To reduce traveling cost of most traffic between Kathmandu valley and outside area

iv) To stimulate and enhance economic and social activities in the Study area along the Project Road.

## 1.3 Work Schedule and Progress

The Study started from the end of March 2000 and will come to the end in March 2001. An overall work flow illustrating the inter-relationships of the activities in the Study is presented in Figure 1.1. The main study items in each stage of work are summarized as below.

[A] Preparatory Work in Japan

1) Collection and Analysis of Relevant Data
2) Establishment of the Basic Policy for the Implementation of the Study
3) Preparation of Inception Report

[B] 1st Stage Work in Nepal (April – Mid. of June 2000)

1) Submission and Discussion of Inception Report
2) Collection and Analysis of Relevant Data
3) Traffic Survey
4) Establishment of Socio-economic Framework
5) Traffic Forecast
6) Environmental Investigations
7) Review of Existing Design Standard
8) Alternative Routes Study
9) Preparation of the Hazard Map (map of potential disaster areas)
10) Natural Condition Surveys (topographic survey (phase-1), geological survey (phase-1) and hydrological survey)
11) Preparation of the Proposed Road Development Policy for the Project Road
12) Preparation of the Progress Report and its Submission and Discussion with the HMG/N

[C] 1st Stage Work in Japan (July 2000)

Based on the comments from the HMG/N on the Progress Report, the following work was done in Japan

1) Determination of Future Socio-economic framework and Future Traffic Forecast.
2) Determination of Road Development Policy of the Project Road
3) Determination of Design Concept and Design Standard
4) Comparison Study of Alternative Routes
5) Selection of Optimum Route
6) Preparation of the Initial Environmental Examination (IEE)
7) Preparation of Interim Report

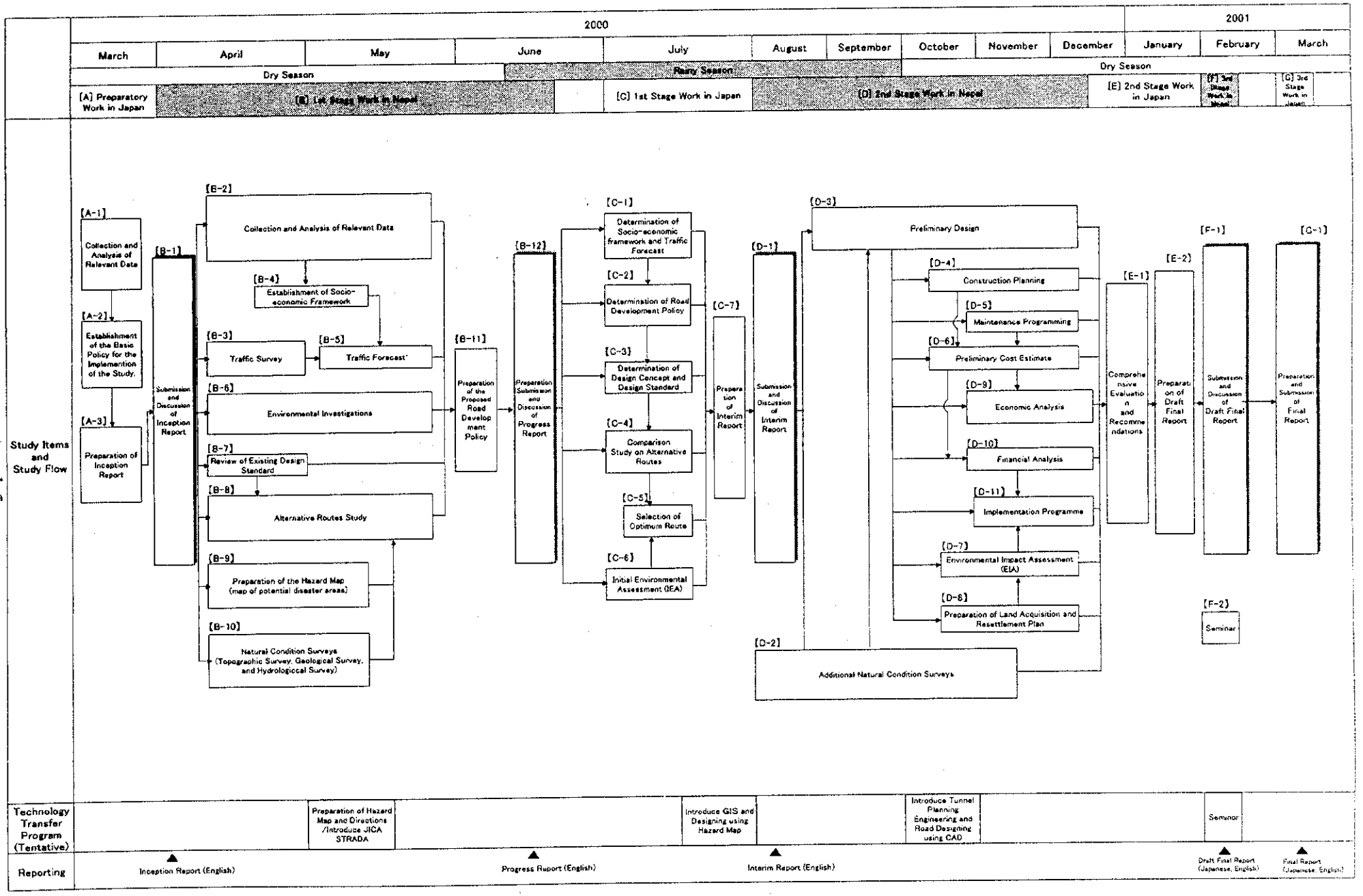



Figure 1.1 Overall Work Flow

[D] 2nd Stage Work in Nepal (Mid. August – Mid. December 2000)

1) Submission and Discussion of Interim Report
2) Additional Natural Condition Surveys (topographic survey (phase-2), geological survey (phase-2) and material survey)
3) Preliminary Design
4) Construction Planning
5) Preparation of Operation and Maintenance Plan
6) Preliminary Cost Estimate
7) Preparation of Environmental Impact Assessment (EIA)
8) Preparation of Land Acquisition and Resettlement Plan
9) Economic Analysis
10) Financial Analysis
11) Preparation of the Project Implementation Schedule

[E] 2nd Stage Work in Japan (Mid. December 2000 – January 2001)

1) Comprehensive Evaluation and Recommendations
2) Preparation of Draft Final Report

[F] 3rd Stage Work in Nepal (February 2001)

1) Submission and Discussion of Draft Final Report
2) Technical Seminars for the Technology Transfer

[G] 3rd Stage Work in Japan (March 2001)

1) Preparation and Submission of Final Report

## 1.4 Organization of the Study

The Study has been carried out by the Study Team under the supervision of the Advisory Committee organized by JICA and with cooperation of DOR counterparts.

The organization chart of the Study is presented in Figure 1.2.

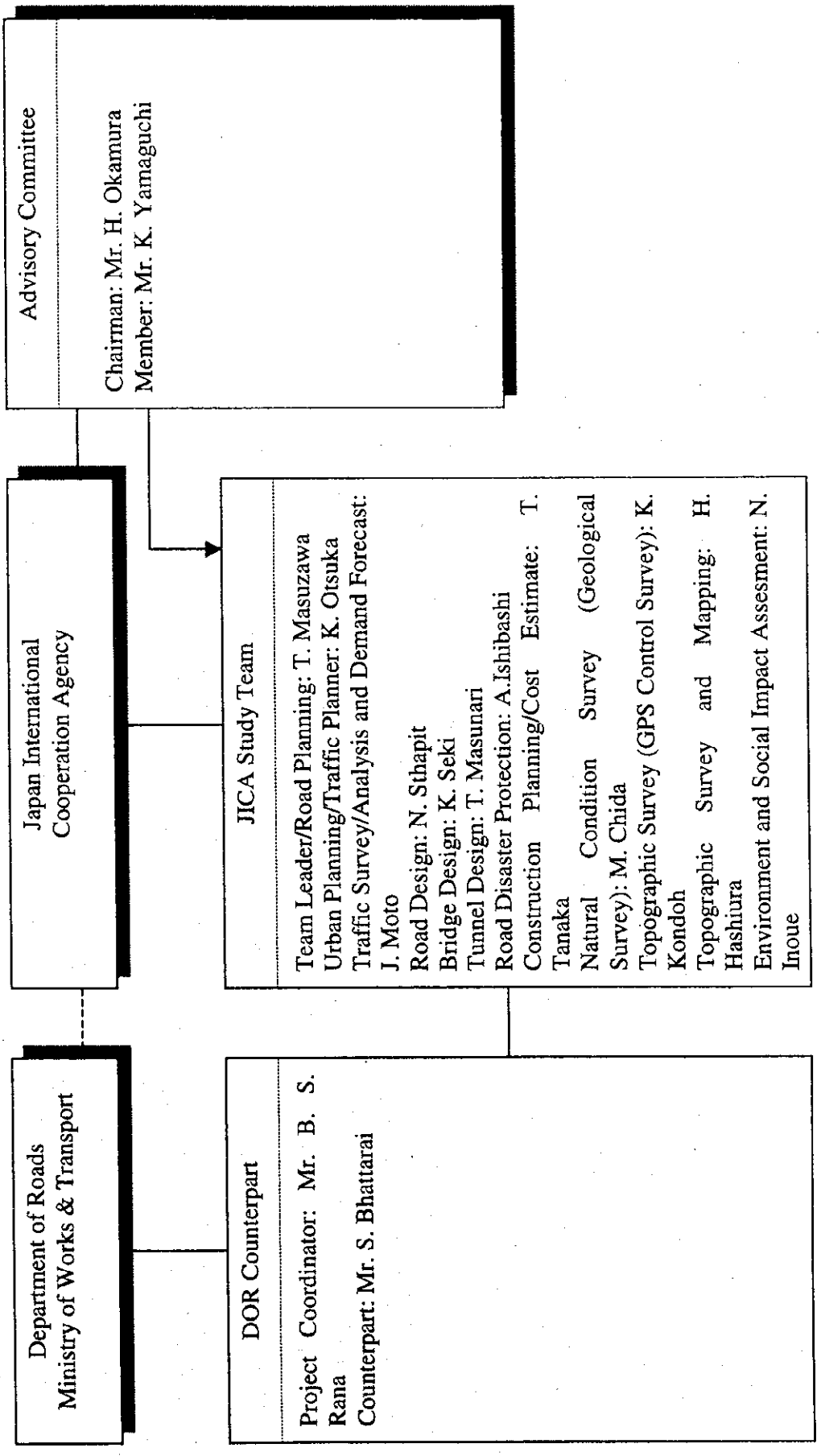



**Figure 1.2 The Organization Chart of the Study**

# CHAPTER 2 PRESENT TRANSPORTATION SYSTEM

## 2.1 General

Transportation systems in Nepal consist of roadway, airway, railway, ropeway, and waterway. Road transport system is described in detail in the following sections. But other transportation systems are explained only briefly later in this chapter, because the carrying capacities of other transportation systems are much lower than that of road transport.

## 2.2 Road Networks and Existing Facilities

Road improvement in Nepal, that includes Tribhuvan Highway, the first motorable road construction under the assistance of India completed by the year 1956, has advanced under the aid of foreign countries such as China, the old Soviet Union, England, and Switzerland. As shown in Table 2.1, although the total length of roads increased to the rate of 1km in 11km$^2$ in the present 9th Plan (five year plan), share of blacktopped roads are only 30.8% and that of earthen roads of national highways are still 12.9%. Moreover, there are many blacktopped road sections, that are difficult to drive because of bad surface conditions.

**Table 2.1 Road Length, Influenced Population and Area**

| Year | Description | Total Length of Roads (km) | Influenced Population (per km) | Influenced Area (km$^2$ per km) |
|---|---|---|---|---|
| 1951 | | 376 | 21,250 | 378 |
| 1956 | 1st plan | 624 | 13,609 | 228 |
| 1962 | 2nd plan | 1,193 | 7,970 | 119 |
| 1965 | 3rd plan | 2,039 | 5,130 | 69 |
| 1970 | 4th plan | 2,504 | 4,600 | 57 |
| 1975 | 5th plan | 3,173 | 3,800 | 45 |
| 1980 | 6th plan | 4,940 | 2,844 | 28 |
| 1985 | 7th plan | 5,925 | 2,840 | 25 |
| 1990 | | 7,330 | 2,579 | 20 |
| 1991 | 8th plan | 8,328 | 2,217 | 18 |
| 1993 | | 9,534 | 1,939 | 15 |
| 1995 | | 10,724 | 1,741 | 14 |
| 1998 | 9th plan | 13,223 | 1,398 | 11 |

Source: Nepal Road Statistics (1998), Department of Roads

Road network in Nepal consists of the national highways, feeder roads, district roads, and urban roads. National highway is defined as a major trunk road which constitutes east-west or north-south axis of this country, and that is also defined as a road that connects National Highway and regional headquarters. Feeder road is the trunk road that connects National Highway and zonal/district headquarters.

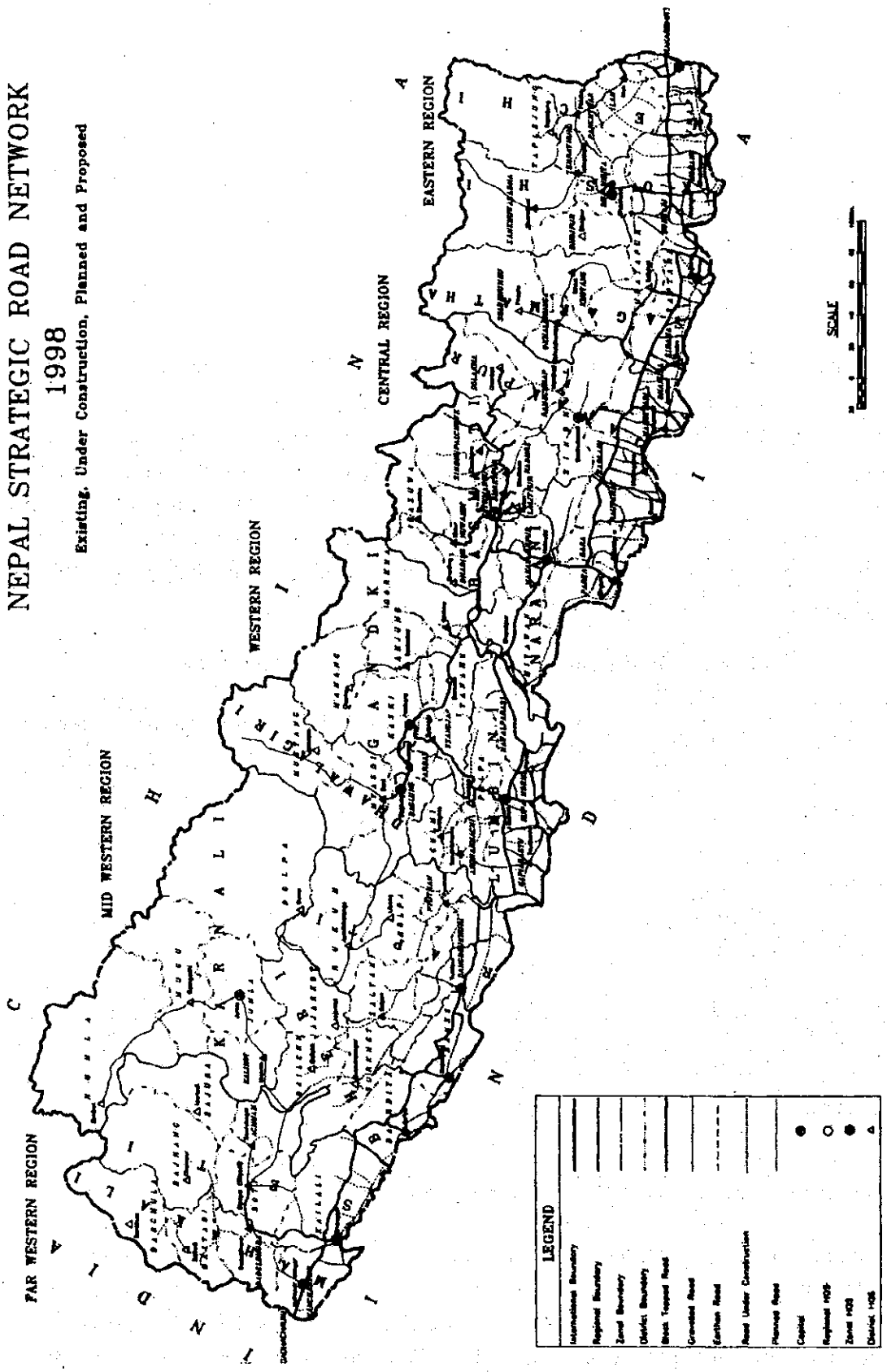



**Figure 2.1 Strategic Road Network**

The total length of the nation's motorable road is 13,223 km in 1998 as shown in Table 2.2. There are 15 routes of national highway, and length of national highways is 2,950 km (22% of the total network). Feeder roads have 52 routes and 1,835 km long (14% of the total). Road network that consists of national highways and feeder roads is called "Strategic Road Network" and has been shown in Figure 2.1.

**Table 2.2 Length of Roads with Classification and Pavement**

unit: kilometer

| Classification | Black Topped | Graveled | Earthen | Total |
|---|---|---|---|---|
| National Highway | 2,205 | 324 | 376 | 2,905 |
| Feeder Road (major) | 531 | 556 | 569 | 1,656 |
| Feeder Road (minor) | 120 | 35 | 24 | 179 |
| District Road | 306 | 2,039 | 4,270 | 6,615 |
| Urban Road | 911 | 522 | 435 | 1,868 |
| Total | 4,073 | 3,476 | 5,674 | 13,223 |

Source: Nepal Road Statistics (1998), Department of Roads

## 2.3 Road Traffic

### 2.3.1 Car Ownership

The total number of vehicles registered in Nepal is about 253,000 as of February 2000. Almost 20,000 vehicles have been registered every year after 1993/94 and number of vehicles became approximately twice in recent 6 years. Number of motorcycles is 139,000 that occupies more than half of all vehicles. Share of motorcycles has recently risen year by year. Number of car registration in Bagmati Zone including Kathmandu City amount to 56% of total in Nepal, and 80% of car registration come from the Central Development Region.

**Table 2.3 Cumulative Number of Vehicles Registered**

| Year | Light vehicles | Bus | Mini bus | Trucks/ tankers | Tractors | Motor cycles | Three wheelers | Heavy equipment | Others | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1989/90 | 22,160 | 2,489 | 1,464 | 7,671 | 6,166 | 32,748 | 2,359 | 102 | 0 | 75,159 |
| 1990/91 | 24,053 | 2,947 | 1,690 | 8,471 | 6,954 | 37,702 | 3,215 | 109 | 1,877 | 87,018 |
| 1991/92 | 26,158 | 3,360 | 1,838 | 9,995 | 7,512 | 45,856 | 4,422 | 129 | 2,215 | 101,485 |
| 1992/93 | 28,434 | 3,966 | 2,023 | 11,486 | 7,764 | 53,464 | 4,484 | 164 | 2,561 | 114,346 |
| 1993/94 | 31,483 | 5,134 | 2,100 | 13,226 | 9,160 | 62,117 | 4,638 | 175 | 2,922 | 130,955 |
| 1994/95 | 34,526 | 5,984 | 2,183 | 14,855 | 10,974 | 71,518 | 4,879 | 175 | 3,275 | 148,369 |
| 1995/96 | 39,787 | 6,470 | 2,265 | 16,006 | 13,157 | 85,373 | 4,996 | 184 | 3,324 | 171,562 |
| 1996/97 | 42,780 | 7,078 | 2,440 | 16,913 | 14,414 | 98,006 | 5,181 | 267 | 3,593 | 190,672 |
| 1997/98 | 46,919 | 7,977 | 2,570 | 18,204 | 15,679 | 110,312 | 5,525 | 300 | 3,611 | 211,097 |
| 1998/99 | 49,426 | 8,849 | 2,589 | 19,182 | 17,927 | 127,402 | 5,913 | 335 | 3,613 | 235,236 |
| 1999/2000 | 51,869 | 9,305 | 2,699 | 19,936 | 19,519 | 138,820 | 6,366 | 350 | 3,666 | 252,530 |

Source: Department of Transport Management

**Table 2.4 Number of Vehicles Registered by Zone**

| Zone (Office) | Bus/Mini Bus | Truck | Car/Jeep/ Van | Tempo | Motorcycle | Tractor /Other | Total |
|---|---|---|---|---|---|---|---|
| Bagmati | 3,103 | 5,226 | 33,016 | 4,106 | 81,331 | 4,950 | 131,732( 56%) |
| Narayani | 4,800 | 8,949 | 7,001 | 1,000 | 12,436 | 5,630 | 39,816( 17%) |
| Lumbini | 1,122 | 1,331 | 1,715 | 240 | 7,736 | 3,579 | 15,723( 7%) |
| Koshi | 495 | 1,234 | 2,541 | 281 | 9,214 | 1,681 | 15,446( 7%) |
| Gandaki | 723 | 688 | 2,897 | 0 | 6,517 | 639 | 11,464( 5%) |
| Janakpur | 200 | 379 | 442 | 37 | 2,776 | 1,496 | 5,330( 2%) |
| Bheri | 219 | 470 | 512 | 132 | 2,726 | 947 | 5,006( 2%) |
| Mechi | 271 | 400 | 444 | 18 | 1,700 | 374 | 3,207( 1%) |
| Sagarmatha | 109 | 247 | 376 | 9 | 1,198 | 572 | 2,511( 1%) |
| Seti | 100 | 319 | 159 | 37 | 861 | 1,025 | 2,501( 1%) |
| Mahakali | 167 | 177 | 157 | 43 | 461 | 263 | 1,268( 1%) |
| Rapti | 129 | 97 | 166 | 10 | 446 | 284 | 1,132( 0%) |
| TOTAL | 11,438 | 19,517 | 49,426 | 5,913 | 127,402 | 21,540* | 235,236* (100%) |

*; Total number is not same with the sum of numbers by zone.
Source: Department of Transport Management (1998/99)

### 2.3.2 Traffic Volume

The Department of Roads (DOR) accumulates traffic data by the automatic traffic observation machines (Logger) which are installed in the main points on the trunk roads of the country. The annual average daily traffic volume (AADT) shown by the Logger data in 1998 was highest of 2,733 vehicles at Nagdhunga in Tribhuvan Highway. It recorded more than 2,000 AADT on the points of the route from Kathmandu to Hetauda and further to India like Gajuli in Prithvi Highway, Bharatpur in Narayanghat-Mugling Road and Tikauli in Mahendra Highway. Though traffic volumes increase at every point, growth rate is lower than that of vehicles registered.

## 2.4 Administration

HMG/N has given all the responsibility to the DOR for the development of national highways and feeder roads in Nepal. DOR belongs to the Ministry of Physical Planning and Works. This department looks after all the road planning, construction, and maintenance work. The organization chart for highway management is shown in Figure 2.3.

Nepal is divided into 75 districts forming 14 zones and 5 development regions. To maintain law and order, zonal commissioners and chief district officers are responsible for the zones and districts, respectively.

## Table 2.5 AADT (Logger data)

Unit: vehicle/day

| No. | Name of Road | Station | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|
| ① | Mahendra Highway (H01) | Pathalaiya(E) | - | 852 | 963 | 1,095 | - |
| ② | | Tikauli | 1,819 | 1,916 | 2,185 | 2,388 | 2,488 |
| ③ | | Bhardaghat | - | 936 | 1,111 | 1,225 | 1,314 |
| ④ | Tribhuvan Highway (H02) | Naghdhunga | 2,237 | 2,482 | 2,684 | 2,606 | 2,733 |
| ⑤ | | Pathalaiya(N) | 1,379 | 1,492 | 1,620 | 1,731 | 1,775 |
| ⑥ | | Pathalaiya(S) | 1,275 | 1,369 | 1,618 | 1,692 | 1,754 |
| ⑦ | Arniko Highway (H03) | Panchkal | 360 | 513 | 537 | 543 | 636 |
| ⑧ | Prithivi Highway (H04) | Gajuri | 1,736 | 1,854 | 2,031 | 2,114 | 2,217 |
| ⑨ | | Damauli | - | - | 589 | 740 | 924 |
| ⑩ | Narayanghat Mugling Highway(H05) | Bharatpur(N) | 1,817 | 1,838 | 2,146 | 2,303 | 2,368 |

Source: Logger Traffic Count Station, Department of Roads

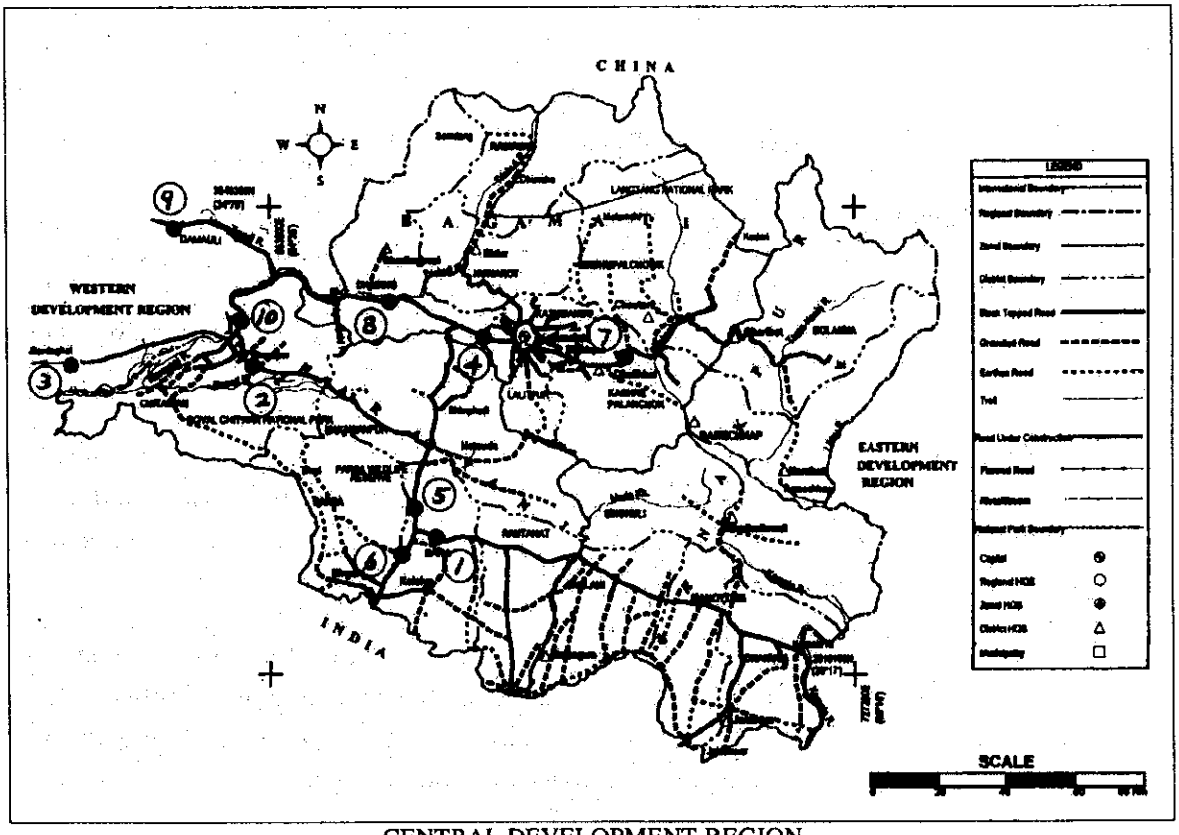



**Figure 2.2 Logger Point**

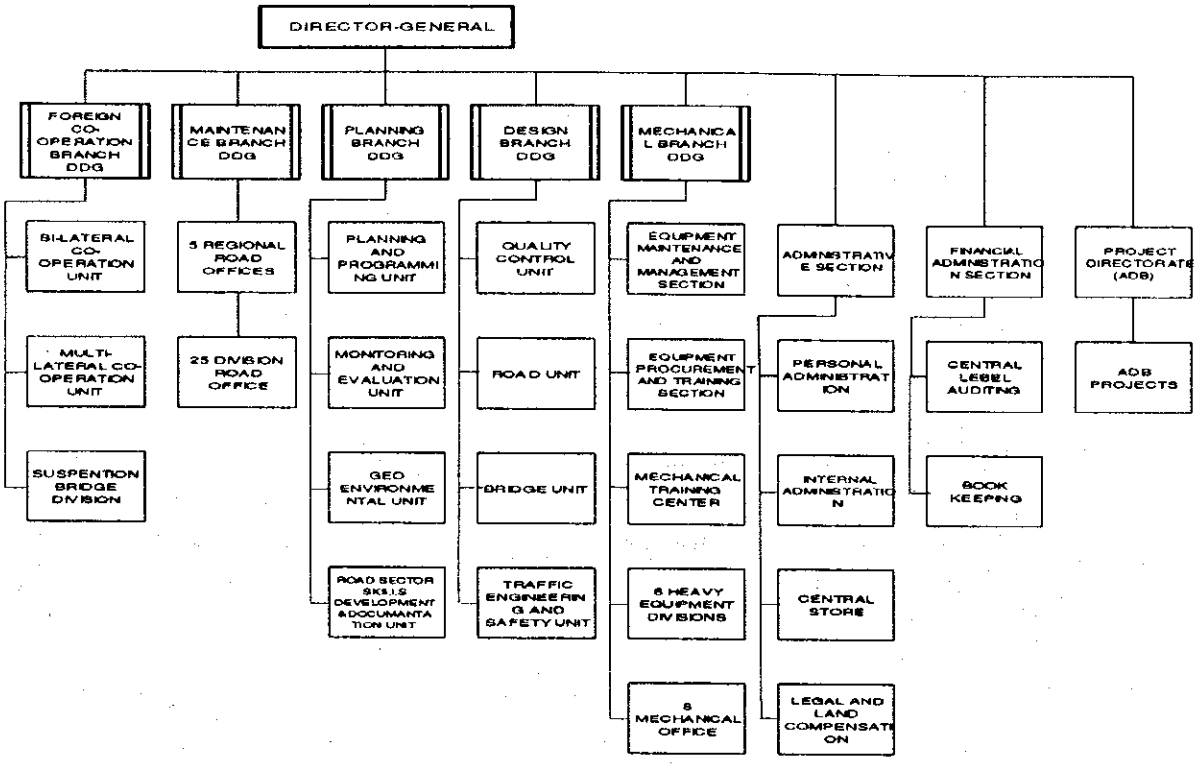



**Figure 2.3 Organization Chart of DOR**

## 2.5 Other Transportation Systems

To complement to this developing road, many airports and short-take-off and landing runways have been constructed in various parts of the country. There are 26 airports among which regular flights are scheduled. Tribhuvan Airport in Kathmandu Valley is located at only around 5 km from the center of the Kathmandu city. Airways are operated by the government-owned Royal Nepal Airlines Corporation and a number of private companies such as Necon Air, Buddha Air, Lumbini Airways, and so on. Though air passenger and cargo movement is competitive with road movement, influence on this study road may not be high.

Railways in Nepal consist of three lines with a total length of 96 km. The Janakpur line 53 km long built in 1929 is an extension of the Indian Railway network from Janakpur. Other two lines are also an extension from India. Therefore, railways play no significant role in the inter-regional transportation in Nepal.

Ropeway between Kathmandu and Hetauda has been operating since 1964. It covers a length of 42km with capacity of 42,768 ton per annum. The low capacity utilization is due to the poor condition of the system at present and non-availability of goods at Hetauda.

# CHAPTER 3 REVIEW OF ROAD DEVELOPMENT PLAN

## 3.1 Road Development Plan

To propose the development policy for the Project Road in this Study, national development plan and other road development policies in the previous studies were considered. The Ninth Five-Year Plan (1997-2002) were used as the national basic policies and development plans. National development plans also applied for establishment of future socio-economic frameworks. A previous study, Priority Investment Plan (PIP) project, which is the road development master plan based on the strategy of DOR, was mainly applied.

### 3.1.1 Review of national development plan

The process of planned economic development commenced in Nepal in 1956 with the inception of the First Five-Year Plan (1956-1961). After eight periodic plans had been implemented, the Ninth Plan was published by the National Planning Commission in 1998. The Eighth Plan (1992-1997) set the objectives of attaining sustainable economic growth, alleviating poverty and reducing regional disparity. Though some progress has been made towards socio-economic infrastructure, achievements of these five-year plans do not measure up to the expectation. No substantial progress has registered in the agricultural sector. Only a limited number of industries have been established. As a consequence, unemployment and economic inequality has not been reduced, and the problem of poverty still remains unresolved.

As for the past long-term sectoral plan including transportation sector, a clear vision could not be formed because of the lack of formulation of an overall framework for long-term development. In this situation, it is necessary to formulate and implement strategies for the immediate and long-term development of the country.

After due consideration of the implementation experience of the Eighth Plan, the main objective of the Ninth Plan is to alleviate poverty, and sectoral objectives, policies and programs are focused on the fulfillment of this challenging objective. For achieving the objective of poverty alleviation, ten strategies have been adopted in the Ninth Plan. Within these strategies, some related to this Project are briefly described as follows:

- Integrated development of agriculture and forestry sectors and high sustainable and poverty alleviation-oriented economic growth with a focus on those sections.
- Acceleration of industrial development process through the advancement of such sectors as agriculture, water resource, industry, tourism, and transportation.
- Enabling the local institutions to take leadership in rural development through decentralization.

- Expanding education and family planning programs through gradual reduction in the population growth rate and promotion of social awareness.

As for the macro-economic framework, the target of long-term economic growth rate is based on the Agricultural Perspective Plan. The growth rate of agriculture sector in the Ninth Plan is less than the target set in the long-term plan, and that of non-agriculture sector has been set by considering the changed structure of relative contribution of agriculture and non-agriculture sector to GDP. It is estimated that the GDP at producer's prices will grow by 6% per annum in the Ninth Plan and by 8.3% in the Twelfth Plan, thus making the average rate of 7.2% during the 20-year period.

**Table 3.1 Long-term Projection of Macro Economic Indicators**

(in percentage)

| Indicator | 1996/97 | Ninth Plan | Tenth | Eleventh | Twelfth |
|---|---|---|---|---|---|
| Gross Domestic Product (at factor cost) | | 6.0 | 7.0 | 7.5 | 8.3 |
| Agricultural Sector Growth Rate | | 4.0 | 5.0 | 5.0 | 5.0 |
| Non-agriculture Sector Growth Rate | | 7.3 | 8.2 | 8.8 | 9.7 |
| Contribution to Gross Domestic Product | | | | | |
| · Agriculture Sector | | 38.0 | 34.0 | 30.0 | 25.0 |
| · Non-agriculture Sector | | 62.0 | 66.0 | 70.0 | 75.0 |
| Investment (as a percentage of GDP) | | 25.0 | 27.0 | 31.0 | 34.0 |
| National Saving (as a percentage of GDP) | | 17.0 | 20.0 | 25.0 | 30.0 |
| Growth Rate (per year) | | 8.8 | 10.0 | 12.0 | 12.0 |
| Poverty and Unemployment | | | | | |
| · People Living below Poverty Line | 42 | 32 | 23 | 15 | 10 |
| · Unemployed Population | 4.9 | 4.0 | 3.6 | 3.3 | 3.0 |
| · Underemployed Population | 47 | 32 | 23 | 15 | 10 |

Source: The Ninth Plan (1997-2002), National Planning Commission

As for the development plans in the Kathmandu and Dhading District on which the study road is located, there are no large-scale projects in this five-year period. Moreover, there are no specific plans in about 20 years from now.

### 3.1.2 Road development plan

Transport sector, particularly road, is an inseparable component of physical infrastructure and plays an important role even in the development of other sectors. The development of transport directly influences the development of both productive

and social sectors such as agriculture, industry, commerce, education and health sectors. Much achievement has been made towards the development of transport due to top most priority accorded from the very beginning of planned development in Nepal.

From the First Plan (the national five-year development plan) till the end of the Eighth Plan, the length of roads has increased seven fold as compared to the population and the density of roads has increased about 18 fold. However, with increase in road transport, movement has tremendously increased, and problems on road accidents and air pollution have also increased.

Under these circumstances, road infrastructure indicators including the road length to be newly constructed have been projected, which is shown in Table 3.2. Roads that link districts are accorded high priority while constructing roads in the next 20 years since 19 districts still have no links with roads. People's participation will be mobilized for building agricultural roads on a massive scale as the roads assist the marketing of agricultural products. Transportation costs in the country will be minimized by reconstruction, improving and upgrading the existing roads, considering the present state of transportation and vehicle situation. In the coming 20 years, a total of 12,600 km of various types of roads in the mid-hills, Kathmandu-Hetauda tunnel ways; inner, outer and super outer ring roads and radial roads in Kathmandu valley; other district and urban roads. All of them together sum up to a total 6,400 km; and a total of 6,200 km of agricultural roads. The total road length including existing roads will be 24,314 km in the coming 20 years.

**Table 3.2 Long-term Projection of Road Infrastructure Indicators**

| Category | 1996/97 | Ninth Plan | Tenth | Eleventh | Twelfth |
|---|---|---|---|---|---|
| Total Road(km) | 11,714 | 13,564 | 15,114 | 16,614 | 18,114 |
| Black Topped(km) | 3,655 | 3,955 | 4,355 | 4,705 | 5,055 |
| Graveled(km) | 3,011 | 3,611 | 4,061 | 4,511 | 4,961 |
| Earthen(km) | 5,048 | 5,998 | 6,698 | 7,398 | 8,098 |
| Agricultural Road(km) | | 2,238 | 5,146 | 6,200 | 6,200 |
| Number of Districts with Road Links | 56/75 | 66/75 | 70/75 | 73/75 | 75/75 |

Source: The Ninth Plan (1997-2002), National Planning Commission

## 3.2 Previous Study

During the last decade a variety of studies and proposals on the construction of new links into Kathmandu Valley have been prepared. In 1997, DOR conducted the Priority Investment Plan (PIP) Study, which is the latest master plan study to establish a 10-year development plan and program for the road sector.

The related previous studies after the PIP study are briefed here.

a) Priority Investment Plan (PIP) Study (February 1997)

The study was conducted in 1997 for the sake of establishment of a 10-year development plan and programe for both the Main Strategic Road Network and Rural Transport Network, together with the optimal phasing of new construction and maintenance. The Kathmandu – Naubise Alternate Road via Bhimdhunga had been examined in the PIP study and selected as one of the strategic road to be implemented near future. The major results of the study conducted for the Kathmandu – Naubise Alternate Road in the PIP are summarized as below.

i) According to the traffic studies made in the PIP study, traffic volume of the existing Naubise – Thankot road is approaching its maximum practical capacity (3,000-3,500 AADT). Some measures to accommodate future traffic volume (5,000 AADT in 2007) will be required.

ii) Any widening of the existing road will not be recommended. The widening works – if it is done – will have high construction cost due to the topographic constraint, serious affect to the traffic flow during construction and increased number of future landslide and/or slope failure. Widening through the built-up area of Thankot, Itakhel, Gurudhara, Kalankisthan and others will be impossible due to the great number of buildings located along the road.

iii) Thankot tunnel option was also examined and concluded to be very costly – the cost will be US 100 million - and its contribution to the improvement of roadway capacity is very limited. Therefore the option is not recommendable.

iv) The Kathmandu – Naubise Alternate Route via Bhimdhunga is recommended as a practical solution to accommodate future traffic in this section. Topography from Ring Road (Sitapaila) to Bimdhunga is relatively gentle, 1-2% of longitudinal grade can be applied. The terrain in the Naubise side of the ridge is mostly gently sloped, maximum 5% grade can be applied. There is very steep slope near the ridge in the Naubise side, the steep slope, however, can be avoided by facilitating a 500 m long tunnel. The overall construction cost for construction of this new 2-lane road including tunnel will be around US$ 27 million.

v) Despite the relatively low rate of return (around 4%), the project does resolve the major strategic concern regarding dependence of the Kathmandu Valley on a single access route

vi) The study also examined the possibility of a new direct link between Kathmandu and Terai. Although the direct link appears to be economically viable, the link is not considered practical in the short to medium term due to the high construction cost estimated at US$140 – 180 million.

b) Alignment Study of Alternative Route to Kathmandu – Naubise Road Section (July 1997)

The study was done by DOR after PIP study and covers alternative alignment study, verification of feasibility and recommendation on the optimum alignment.

Three alternatives, which are a long tunnel (5.25 km length) option, a short tunnel (500 m length) option and no tunnel options, for the corridor connecting the Ring Road (Manmati) and Dharke via Bhimdhunga saddle are compared. The total construction cost and EIRR of the long tunnel option, short tunnel option and no tunnel option are estimated to be NRs 6,350 million, 1,530 million, and 1,433 million and 7.72%, 8.16% and 4.94% respectively. The study concluded that short tunnel option with 20.65km total length and 500 m length tunnel is the optimum option to be recommended.

c) Fourth Road Improvement Project (FRIP), August 1999

The study was carried out under Asian Development Bank's (ADB's) technical assistance. The objectives of the study are to screen projects for the feasibility studies and examine fusibilities of the selected projects, which will be implemented ADB's FRIP program. The study was conducted keeping consistent with Government's Priority Investment Plan (PIP) for the road sector, and initially 21 road projects are reviewed for screening. Upgrading, rehabilitation and new construction projects are included in the 21 projects. As the result of the screening, 12 projects – including construction of Kathmandu – Naubise Alternate Road Construction Project - were selected for the further feasibility studies.

In the study on the Kathmandu – Naubise Alternate Road via Bhimdhunga saddle, two alternatives, one is the tunnel (700-m length) option and the other is no-tunnel option, are examined. The results of the study are summarized as follows.

i) There is no significant cost difference between the tunnel option and no-tunnel. Total construction cost of the tunnel option and no-tunnel option was estimated at US$ 43.2 and 42.7 million, respectively.

ii) Economic evaluation result shows 25.0 % and 10.4 % of EIRR for the tunnel option and No-tunnel option. The tunnel option will be recommended.

iii) Economic viability of the Kathmandu – Naubise Alternate Road was verified. However, it will not be suitable for private financing, since it is unlikely to ever be a financially viable project and should be pursued by more traditional means. (Private finance opportunity has been examined, but the result shows the potential toll revenue is far in excess of that required to cover maintenance costs)

## 3.3 Development Policy for the Project Road

The Project Road will be an alternate road of the existing Naubise – Thankot road and should be a new trunk road and new lifeline linking the Kathmandu with other areas of Nepal. Existing Naubise – Thankot Road, which is a current sole trunk road and lifeline in this section, has the following critical issues.

i) Geometric standard - both horizontal and vertical, used for this road does not meet the standards required of a National trunk road.

ii) Vehicle running speed, especially those of heavy vehicle, in this section is quite low (5-10 km/hr) and a number of vehicles are always halting on the road in trouble. These situations cause partial traffic congestion at many places and remarkable number of traffic accidents on the road.

iii) During monsoon season, slope failures often happen and block the traffic.

iv) Very steep geography and poor geology does not allow any widening of the road

v) In the section between Thankot and Ring road, both sides of the road were well built-up and this situation makes widening work very difficult.

The development policies for the New Project road will be those which overcome the above issues of the existing road. As the development policies, the following are proposed.

i) The Project Road will be planned and designed to be safe and disaster proof.

ii) Since there is no paved road in the Project area, the Project Road will keep the accessibility to the local community as long as it doesn't mar the trafficability as a trunk road.

iii) The Project Road will be facilitated with the geometric standard suitable for the National Trunk Road.

iv) The Project Road will be sustainable for future maintenance and operations.

v) The Project Road will be planned and designed to mitigate environmental and social impacts.

# CHAPTER 4 GENERAL CONDITIONS OF THE PROJECT AREA

## 4.1 Socio-economic Conditions

1) Population

The population census is done every decade and the latest was in the year 1991. The population of Kathmandu and Dhading districts are given below with the distribution based on religion and economically active population.

**Table 4.1 Population Distribution**

| | | Kathmandu | Dhading |
|---|---|---|---|
| By Religion | Hindu | 529,812 | 213,232 |
| | Bauddha | 135,178 | 58,691 |
| | Islam | 5,409 | 254 |
| | Jain | 947 | 33 |
| | Christian | 1,586 | 5,501 |
| | Kirati | 755 | 2 |
| | Others | 773 | 290 |
| | Not stated | 881 | 65 |
| Major Occupation | Prof/Tech. workers | 12,116 | 1,306 |
| | Administr. workers | 8,527 | 80 |
| | Clerical workers | 15,451 | 429 |
| | Sales workers | 32,638 | 1,875 |
| | Service workers | 32,335 | 2,555 |
| | Farm fish workers | 60,323 | 123,905 |
| | Prod. labor workers | 50,537 | 2,909 |
| | Others | 23,487 | 1,865 |
| | Not stated | 1,486 | 275 |

2) Land use

The land use distribution in the two districts of Kathmandu and Dhading of the Project area is given below.

**Table 4.2 Land Use in the Districts of Project Area**

| District | Agricultural Land | | | | | | Woodland and forecast | | All other land | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crop Land | | | | Ponds | | | | | | | |
| | Land Under Permanent Crops | | Land under Meadows and Pasture | | | | | | Unused/overdeve lop Potentially Productive Land | | Land in the Holding not elsewhere Mentioned | |
| | No. Of Holdings | Area (ha) | No. Of Holdings | Area (ha) | No. Of Holdings | Area (ha) | No. Of Holdings | Area (ha) | No. Of Holdings | Area (ha) | No. Of Holdings | Area (ha) |
| Kathmandu | 613 | 19 | 128 | 6.9 | 32 | 0.1 | 612 | 52.2 | 546 | 28.8 | 45540 | 788.1 |
| Dhading | 3071 | 237.9 | 1387 | 227.6 | | | 1593 | 203.2 | 770 | 137 | 48258 | 1030.3 |

## 4.2 Topography and Geology

The Study area can be topographically divided into two characteristic watersheds. One is Mahesh khola watersheds from Bimdhunga pass to Dharke. And the other is Manamati khola watershed from Bimdhunga pass to Ring Road in Kathmandu City. Bhimphedi group (Early Cambrian) and Phulchoki group of Cambrian - Devonian age is geologically distributing over the Study area as base. The former is mainly consisted of limestone and the later is consisted phyllite. Apart from this main geological formation, talus deposit are developed along the base of mountain while the colluvium deposit consisting mainly of limestone boulders in sand silt matrix is found occurring all along the hill slopes. The lacustrine sediments with minor bands of lignite can be observed in Manamati watershed. Distinctive topographical and geological features of both watersheds can be summarized in the Table 4.3

## Table 4.3 Features of the Watersheds of the Study Area

| Locations in the planing road | From Bimdhunga pass to the End (Dharke) | From The Start (R.R) to Bimdhunga pass |
|---|---|---|
| Watershed | Mahesh Khola | Manamati Khola |
| Altitude in the watershed | E.L.850～EL2000m | E.L.1275～EL2000m |
| Shape of watershed | Deep basin with about 450 m depth | Shallow basin with about 250 m depth |
| Geographical Outline | Flat and gentle hill landform exists along the Mahesh Kohla in the watershed. Gentle slope abounds the ridge and steep slope with 70 to 80 degree is distributing below the ridge. Mountainous slope is consisted of 20 degree between the ridge and hillside area. | Flat and hillside landform widely exists along the Manamati Khola. Gentle slope abounds the ridge and steep slope with about 60 degree is distributing below the ridge. Between the steep slopes and hill side area, about 20 degree slope, which is not very steep, exists. |
| Terrace | Terrace phase has not almost been remained | Terrace phase has almost been remained |
| Flat to Hill form | Flat and hill landform with about 400 m width narrowly exists along Mahesh Khola. Landform like hill is originated in terrace and old debris flow. Talus sediments are also distributing around this area. | Flat and hill landform with about 700m width widely exists along Manamati Khola. This kind of flat area is almost originated in terrace and lacustrine of Kathmandu. |
| Mountain land form | Many dormant landslides and slope failures are distributed on the mountainous slope along the Mahesh Khola. Steep gradient slopes are almost failure trace. Mountainous slope is almost all used in cultivation except forest. | Dormant landslides and failures exist on the steep failure along the Manamati Khola. Cultivation are also distributing in the steep slope area. |
| Landslides distribution | Landslides have been located on any portions of mountain slopes. Its distribution tends to concentrate on the mountain side rather than flat area. | Landslides distribution tends to concentrate on the toe side of mountain slopes rather than half way. |
| Failures distribution | Big failure traces have been located around the northern and western ridges of watershed. Further, these are also located in the mountain slope of southern ridges. These failures traces are composed of very steep slope and valley. Active failures are located around very thin ridges, in red soil distribution area and undercut slopes of the streams. | Active failures distributions are concentrated in the cliff of terrace. Failures traces do not almost exist. |
| Dangerous stream of debris flow | Dangerous stream of debris stream is located on the western and northern mountain slopes since its slope is very steep and many failures, failures traces exist. | Two dangerous stream of debris flow is located on the western south mountain slope. |
| Geological distribution | Limestone as base rock is distributed in the area of northern west of watershed. Schist originated from sandstone and mudstone alternation is distributed in other area of the watershed. Terrace deposits by river and debris flow are distributed along Mahesh Khola. Talus deposits is also distributing on the foot of mountain slopes. | Limestone as base rock is distributed in the northern mountain of watershed. Schist originated from sandstone and mudstone alternation is distributed in other area of the watershed. Lacustrine sediment originated from old Kathmandu lake is widely distributing on flat area along Manamati Khola. Furthermore, some terrace sediment and debris terrace are also distributing in the watershed. Talus deposits exist on the mountain slopes. |

# CHAPTER 5 EXISTING TRIBHUVAN HIGHWAY (KATHMANDU - NAUBISE SECTION)

## 5.1 Historical Background

- Brief History

Before construction of the Tribhuvan Raj Path (TRP) the only means to enter Kathmandu valley from Terai was either on foot or by air, the latter being almost inaccessible to the general public. Access to the valley through a motorable road was materialized for the first time after construction of Thankot – Naubise - Bhainse section of TRP with assistance from India in 1956 (1953 – 1956). But the capital of the country was directly connected with the outside world only after completion of the Bhainse – Hetauda section in 1962 and Hetauda – Raxaul section in 1967 with the assistance from the USA. After completion of the Prithvi Raj Marga (PRM) in 1974 (1967 – 1974) and development of the East – West Highway in the seventies, the capital was further connected with the other parts of the country. But the TRP remained the major link of the Kathmandu valley with the Terai region until construction of the Mugling – Narayangadh road in 1982 with assistance from China. The longer but comfortable route via Mugling – Narayangadh was preferred by the road users in the following years. Although the traffic level reduced drastically after completion of Mugling – Narayangadh road, the Thankot – Naubise section of the TRP still remains the sole link that connects both the TRP and PRM. Any blockage in this section would completely disconnect the capital from both the highways and subsequently from the other parts of the country.

- Major improvement and rehabilitation works in Thankot – Naubise road

To meet the requirements of increasing traffic volume and to upgrade the service level, the first major improvement works in the Thankot – Naubise road were carried out in 1984/85 with finance from the World Bank. The works included slope stability, construction and repair of off-road structures, rehabilitation of the pavement, replacement of the bridges and some curve improvements.

The heavy rainfall in 1987 caused a lot of damage to Thankot – Naubise road along with many other roads in the country. It resulted in big landslides and damage to the road structures. Therefore, major repair works in this road were included in the Road Flood Rehabilitation Project (RFRP) which started in February 1992 and was completed in March 1994. The works included improvement of drainage structures; landslide control measures with anchored breast walls, crib walls, sub-surface drainage and bio-engineering works; gully erosion control, construction of causeways etc. The total cost of the rehabilitation was nearly 90 million NRs. (equivalent to 1.9 million USD) and funds were provided by the International Development Agency (IDA) of the World Bank (NEP-1922) and UNDP (TA NEP/88/008).

The ever-increasing traffic volume soon necessitated rehabilitation of the pavement on this road. Therefore, soon after completion of the RFRP, the Thankot – Naubise road was also selected for rehabilitation under Road Maintenance and Rehabilitation Project (RMRP). The works included pavement rehabilitation, reconstruction of side drain throughout the whole length, installation of crash barriers, replacement of one culvert and some retaining walls. The road was also widened at some places. The works began on October 1995 and were completed on June 1999. The total cost of rehabilitation was nearly 200 million NRs. (equivalent to about 4 million USD). Funds were provided by the World Bank.

Apart from these major improvement/rehabilitation the DOR is carrying out the routine maintenance of this road. Responsibility of the routine maintenance falls upon two maintenance divisions, viz. Kathmandu division (up to Pipalmod) and Bharatpur division (from Pipalmod to Naubise).

## 5.2 Geometric Condition and Traffic Capacity

The existing Tribhuvan Highway from Kathmandu to Dharke was surveyed to gather information on horizontal curves, vertical profile and the road width. The result of the survey showed that very sharp horizontal curvature of radius, as low as 20m, has been abundantly used and, the vertical profile grade as high as 11% exists. The summary of the geometric conditions of existing Tribhuvan Highway from Kalanki to Dharke has been given in Table 5.1.

**Table 5.1 Summary of Geometric Conditions of Existing Tribhuvan Highway**

| Section | Deflection (Deg/km) | Abs.Grade (%) |
|---|---|---|
| Kalanki – Thankot | 102.0 | 3.6 |
| Nagdhunga Pass Crossing | 732.0 | 5.7 |
| Nagdhunga Pass Crossing – Thapathok | 791.0 | 4.7 |
| Thapathok-Dharke | 319.0 | 4.3 |

The Nagdhunga pass crossing (a total length of about 6 km) is the critical section, where the combination of high deflection angle in the horizontal alignment and highest profile grade in the vertical alignment, creates difficult situation for heavily loaded trucks. Similar situation persists in the section after Nagdhunga pass crossing to Thapathok, in a length of about 4.5 km.

The operation of heavy vehicles in the upgrade direction (to Kathmandu) has serious impact on the overall roadway capacity. Study on the heavy vehicle running speed on this section also showed that the average running speed is less than 10 km/h. The capacity of the Tribhuvan Highway in this section will be drastically lower than a normal two-lane highway. Estimation of capacity based on the Australian Capacity Manual has been performed and is given in Table 5.2.

## Table 5.2 Calculation of Capacity Based on Australian Capacity Manual

| Factor | Basic Data | Project Road | | Tribhuvan Highway | | | Project Road (PIP Report) | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2020 | 2000 | 2010 | 2020 | | |
| $(v/c)_i$ Ratio of Flow Rate | Grade | 5.0% | | 6.0% | | | 6% | Section Average |
| | Average Upgrade Speed | less than 56km/h | | less than 56km/h | | | less than 56km/h | |
| | No Passing Zones | more than 80% | | more than 80% | | | 80% | |
| | | **1.00** | **1.00** | **0.98** | **0.98** | **0.98** | **0.98** | |
| $f_d$ Adjustment Factor for Directional Distribution | Percent of Traffic on Upgrade | 60% | | 60% | | | 60% | Traffic Count Result |
| | | **0.87** | **0.87** | **0.87** | **0.87** | **0.87** | **0.87** | |
| $f_w$ Adjustment Factor for Narrow Lanes and Restricted Shoulder Width | Lane Width | 3.5m | | 3.7m | | | 3.3m | |
| | Usable Shoulder Width | 1.5m | | 0 m | | | | |
| | | **0.91** | **0.91** | **0.88** | **0.88** | **0.88** | **0.91** | |
| fg Adjustment Factor for the Operational Effects of Grades on Passenger Cars | Proportion of Passenger Cars | 39% | 53% | 23% | 40% | 46% | 20% | Traffic Demand Forecast |
| | Passenger-car Equivalent for 0 Percent Grade | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | |
| | Maximum Grade | about 5% (4.7%) | | about 6% (5.3%) | | | 6% | |
| | Length of Maximum Grade | more than 6km (about 9.6km) | | more than 6km (about 8.0km) | | | 6km | Tribhuvan Highway: assumption |
| | Passenger-car Equivalent for Given Percent Grade Length of Grade, and Speed Percent Grade | 10.0 | 10.0 | 16.0 | 16.0 | 16.0 | 16.0 | |
| | | **0.94** | **0.92** | **0.94** | **0.89** | **0.88** | **0.94** | |
| $f_{HV}$ Adjustment Factor for the Presence of Heavy Vehicles | Proportion of Heavy Vehicles | 61% | 47% | 77% | 60% | 53% | 80% | Traffic Demand Forecast |
| | Proportion of Truck among Heavy Vehicles | 57% | 61% | 44% | 67% | 70% | 60% | Traffic Demand Forecast |
| | Passenger-car Equivalent for Specific Mix of Heavy Vehicle | 8.38 | 8.74 | 11.35 | 14.80 | 15.25 | 13.75 | |
| | | **0.18** | **0.22** | **0.11** | **0.11** | **0.12** | **0.09** | |
| $f_m$ Adjustment Factor for the Presence of Motorcycle | | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | - | |
| ft Adjustment Factor for the Situation on the Roadside | | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | - | |
| $SF_i$ Total Service Flow Rate in Both Direction (vehicle/h) | | **377** | **438** | **219** | **203** | **216** | **183** | |
| PHF Peak Hour Factor | | 0.075 | 0.075 | 0.075 | 0.075 | 0.075 | 0.86 | |
| Maximum Traffic Volume for Both Direction (vehicle/h) | | - | - | - | - | - | **158** | |
| Maximum Traffic Volume for Both Direction (vehicle/day) | | **5,031** | **5,835** | **2,925** | **2,701** | **2,885** | **2,521** | |

Note: To compare the result of PIP Report, Australian Capacity Manual was used in the Study.

Comparison is also done for the calculated capacity of Tribhuvan Highway in PIP Report (Priority Investiment Project). The calculated capacity for the Project Road by the same method is also given in the table.

## 5.3 Hazard Potential along the existing road

(1) Hazard potential of slope along the existing road

Inventory study of slope stability had been done along the existing road by the Study Team. In this study, stability of all cutting slopes higher than 5 m had been checked from Dharke to the Nagdunga Path. The contents of investigation are shown in Table 5.3. In this investigation, not only active failure but also failure traces have been checked. The result of this study is summarized as shown in Figure 5.1. Slope with any active failure is plotted in red color line and failure traces are plotted in green color line. Slope with both failures is plotted in yellow color in the Figure. The road length with these colors slope is summarized in Tables 5.4.

**Table 5.3 Slope Stability Check Sheet**

Date: Nov. 00 Checked by

| | | | |
|---|---|---|---|
| **Series Slope No.** | | **K.P.** | |
| **Slope Width** | m | **Slope Heights** | m |
| **Slope Gradient** | degree | **Portion** | C: Curve S: Straight |
| **Geological Condition** | A: Talus Sediment<br>C: Weathered Phyllite<br>AC: Combination of A or B and C<br>AD: Combination of A or B and D<br>CD: Combination of C and D | B: Terrace Sediment<br>D: Fresh Phyllite | |
| **Vegetation** | B: Bare | G: Only grass | M: Trees in grasses |
| **Existing Failure** | S: Sound<br>in case of A or T<br>E : Erosion<br>I : Failure limits in the slope<br>O : Failure beyond of the slope | A: Active failure | T: Failure trace |
| **Structure in the Slope** | N: nothing<br>Type<br>H = m<br>Drain | M: Mason<br>I: Incline<br>L = m<br>E: existing | C: Concrete wall<br>G: Gravity<br>T = m<br>N:nothing |
| | B: Buttress<br>I = | N: Gabion<br>degree | |