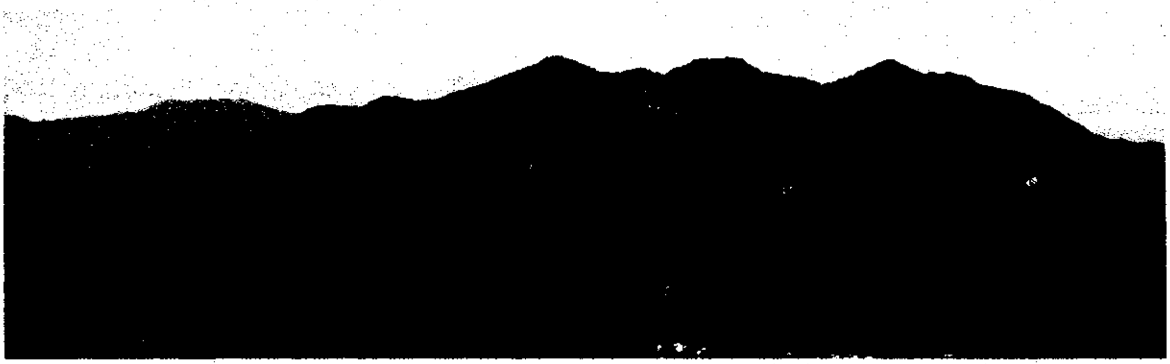
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

SUMMARY

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.

OUTLINE OF THE STUDY

The Feasibility Study on the Construction of Kathmandu - Naubise Alternate Road in the Kingdom of Nepal
Period: March 2000 - March 2001
Counterpart Agency: Ministry of Physical Planning and works, Department of Roads (DOR)

Background of the Project

The Kingdom of Nepal is a landlocked country and Kathmandu, the capital city, 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 Highway and Prithvi 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 many problems like steep longitudinal grade (over 10%), weak prevention against disaster and many traffic accidents due to poor alignment.

The traffic volume of this section has reached its traffic capacity already, and improvement of this section by widening of the existing road to 4-lane road or construction of alternate road is required to accomodate future traffic of this section. Since the existing road traverses extremely fragile and steep terrain area, it was considered that widening of the existing road is practically impossible and construction of another alternate road is the most feasible solution for the improvement.

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

Route Selection

Project road was divided into six sections, these being Ring road connection, Ramkot valley, Pass crossing, Chhatre Deurali mountain approach, Mahesh Khola plain and Dharke connection by the characteristic of geological condition and land utilization.

At first step, Study team identified several conceivable routes for each section by using the 1:10,000 scale topographical map and screened out the alternatives by using Land Use Map, Hazard Map, Slope Gradient Map and Soil Production Map prepared by satellite's remote sensing data and field investigation. Except pass crossing section, only one route was selected for each section. For pass crossing section, three alternatives - long tunnel route, short tunnel route and no tunnel route - were remained.

At next step, remaining alternatives for the pass crossing section were compared by construction cost, maintenance cost, land acquisition cost, compensation cost for resettlement, economical benefit and environmental aspect. Finally the short tunnel (0.7km) route was selected as the optimum route.

For the justification of the Project to construct a new alternate road in Kathmandu – Naubise Section, further comparison with other alternatives, which are 4-lane improvements of the existing Tribhuvan Highway, was conducted. The current condition of the existing Tribhuvan Highway is shown as below:

Nos. of Lanes	:	2 Lanes
Vertical Grade	:	Maximum is 11%, average of Nagdhunga Pass Crossing is 5.7%
Horizontal Curvature	:	Minimum is 20m
Hazard Potential	:	66% of whole stretch of the road has potentiality of failure:
		(110 nos of slope failures, 3 nos of debris flows and 1 no of huge land sl

Project Summary

Classification	
Road Classification Annual Average Daily Traffic Pavement Surface	National Highway 3,900 veh (2010 A.D.), 5,340 veh (2020 A.D.)* Asphalt Concrete
Road Network	
Beginning Point Ending Point Total Length	Ring Road (about 1km North of Kalanki Intersection) On Prithvi Highway at Dharke 21.4 km
Alignment	
Minimum Curve Radius Maximum Vertical Grade	60 m (55 m at hairpin bends) 5 %
Cross Section	
Lane Width Formation Width Paved Shoulder Width Side Ditch Top Width	7 m (2 × 3.5 m) 12 m 3 m (2 × 1.5 m) 1 m
Major Structures	
Tunnel Length Major Bridge at Dharke	0.7 km 50 m
Project Cost	
Total Construction Cost Total Compensation Cost Total Project Cost	38.7 Million US$ 2.4 Million US$ 56.9 Million US$
Economic Indices	
EIRR (Economic Int. Rate of Return) NPV (Net Present Value) B/C (Benefit/Cost Ratio)	18.1 % 19.1 Million US$ 1.57

Note: * Traffic volume in 2020 A.D. is with Kathmandu-Terai Road assumed to be implemented.

Environment Impact Assessment

Approval of Scoping Report & TOR of EIA : June 14, 2000

Approval of EIA : (Expected Date July 2001)

Estimated Project cost

Construction Cost	38.7 million US$
Engineering Cost	6.9 million US$
Contingency	3.9 million US$
Tax and Duty	4.5 million US$
Administration Cost	0.5 million US$
Land Acquisition and Compensation Cost	2.4 million US$
Total Project Cost	56.9 million US$

Economic Evaluation

EIRR	:	18.1%
NPV	:	19.17 million US$
B/C	:	1.57

Conclusion

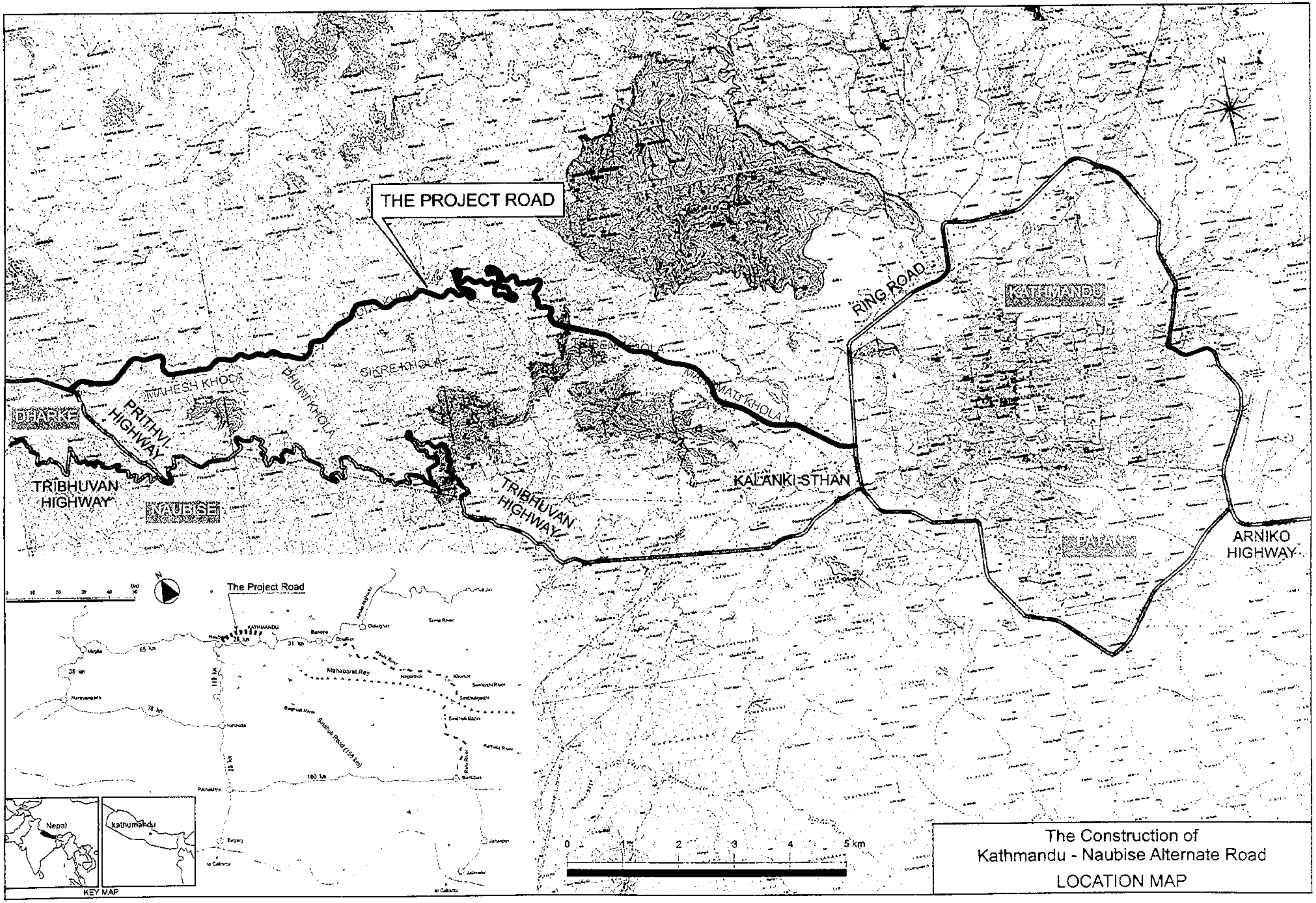
- The Project is assessed as technically feasible with scope of construction of a 2-lane paved road in a total length of 21.4km including a 705m highway tunnel.

- The Project is assessed as economically feasible with EIRR of 18.1%, NPV of 19.1 million US$ and B/C ratio of 1.57 with the assumption of Kathmandu - Terai Alternate Road opening in the year 2016.

- The existing Tribhuvan Highway, especially Thankot-Naubise Section, is considered to have a high disaster potential. Improvement of alignment, improvement of disaster prevention and possibility of 4-lane widening of the existing road were studied. These study results indicate that widening of the existing road is practically impossible and construction of a new alternative road is more advantageous.

- Traffic volume of the Project Road in the year 2010 and 2020 are expected to be about 3,900 vehicle/day and 5,340 vehicle/day, respectively. Traffic volume in the year 2020 is estimated under an assumption that Kathmandu - Terai Alternate Road is opened.

- It is strongly recommended that new truck terminal near the beginning of the Project Road is constructed in order to secure efficient operation of the Project Road and improvement of traffic condition of Kathmandu.


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

CONTENTS

1. BACKGROUND OF THE STUDY

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

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During the recent decade, the Department of Roads (DOR), Ministry of Physical Planning and Works 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 technical assistance from the Government of Japan was requested 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")

This Report presents a summary of all the study results and findings obtained through the overall study period.

2. PRESENT TRANSPORTATION SYSTEM

Transportation systems in Nepal consist of roadway, airway, railway, ropeway, and waterway. The carrying capacities of other transportation systems are much lower than that of road transport.

The total length of the nation's motorable road is 13,223 km in 1998. 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 1,835km long (14% of the total). Road network that consists of national highways and feeder roads is called "Strategic Road Network". Tibhuvan Highway and Pritivi Highway are classified as National Highway.

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 since 1993/94 and the number of vehicles has approximately doubled 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 that in Central Development Region is 80%.

The Department of Roads (DOR) collects 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.

HMG/N has given all 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 the road planning, construction, and maintenance of national highways and feeder roads.

3. 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) could be used as the national basic policies and development plans. National development plans also applied for establishment of future socio-economic frameworks. As a previous study, Priority Investment Plan (PIP) project, which is the road development master plan based on the strategy of DOR, was mainly applied.

In the PIP study, the road development master plan was proposed dividing the road network into two categories, namely strategic roads and rural roads. The Project Road was classified into the strategic road and identified as one of the high priority road link to be constructed in short term plan.

Two of competitive projects against the Project road, namely 4-lanes widening of the existing Tribhuvan Highway and Kathmandu – Terai Direct Links were also comparatively examined for the justification of the Project Road. The study concluded as follows.

- Any widening of the existing Tribhuvan Highway will have high construction cost and much difficulty in the construction due to the steep topography and poor geology. Therefore the widening of the existing Tribhuvan Highway is not recommended.
- Although the Kathmandu – Terai Direct Link project appears to be economical viable, the project is not considered practical in the short to medium term due to the high cost
- The Katmandu – Naubise Alternate Route via Bhimdhunga is recommended as a practical solution to accommodate future traffic in this section

Based on the above study results, DOR conducted following subsequent studies on the Project Road.

i) Alignment Study of Alternative Route to Kathmandu – Naubise Section (July 1997)
ii) Forth Road Improvement Project: FRIP (ADB, 1999)

Validity and necessity of the Project were confirmed by the above studies.

4. GENERAL CONDITION OF PROJECT AREA

The population of Kathmandu District Development Committee (DDC) and Dhading DDC that contain Project area is 675,341 and 278,068 (1991) respectively. Most of these people were considered to be direct beneficiary.

Land use distribution in Kathmandu DDC and Dhading DDC of Project area is as follow;

(%)

DDC	Crop Land	Meadows and Pasture	Woodland and Forest	Others	Total
Kathmandu	59.7	0.9	33.4	6.0	100
Dhading	38.1	8.3	48.2	5.4	100

In both DDC, the land is mainly used for agricultural land and forest and the ratio of these lands is as high as 90%. But around Kathmandu ring road area that is beginning of the Project road is developed for housing.

The Project area can be broadly divided into two area, Manamati Khola watershed in the Kathmandu valley and Mahesh Khola watershed outside of the valley.

Mainly the project road will run on lacustrine sediment in the Manamati Khola watershed and run through fragile weathered and metamorphosed geological terrain in the Mahesh Khola watershed.

5. EXISTING TRIBHUVAN HIGHWAY (KTM-NAUBISE)

Project road is an alternate road for existing Tribhuvan Highway. For the evaluation of the Project, the current condition of Tribhuvan Highway was surveyed and evaluated. The survey item is as follows;

- Inventory survey like Road width, longitudinal and horizontal alignment
- Slope condition survey for the cutting slope higher than 5m
- Arial photo reading for identification of hazard spots

1) Evaluation on the geometric condition

The existing Tribhuvan Highway was constructed in 1950s and geometric condition of the road does not satisfy the requirements as the National Highway. This geometric substandard situation reduces traffic capacity in this section. Considering recent economical growth of Nepal and traffic saturation of the road, it is necessary to carry out improvement of both vertical and horizontal alignment.

However, it is judged that present alignments are so bad that alignment improvement up to the extent satisfying standard as the National Highway can not be done technically.

2) Evaluation on Disaster Prevention Aspect

Through the slope condition survey and the aerial photo reading, following facts are identified.

- 66% of all cutting slopes in the section between Nagdhunga and Dharke have active failure or past failure trace. These slopes have high potentiality to cause slope failure triggered by heavy rainfall and/or earthquake.
- Three debris flow streams are identified. The existing roads are crossing these debris flow streams by bridges. However since the bridges have no sufficient clearance for the debris flow passing, the bridges are exposed to the dangerous situation to be flushed out by the debris flow. As countermeasures for the debris flow dangerous stream, realignment of the road and reconstruction of bridges are required.
- Furthermore one huge dormant landslide is identified in hairpin curve area.

The landslide has a magnitude of 300m in width and 500m in length, and the scouring of toe of the landslide mass by stream flow is considered to accelerate instability of the landslide. Since the existing road is passing at top of the landslide and middle of the landslide, it must be considered that the existing road will be fatally damaged, if actual collapse of the landslide happens.

Judging from the above results, it is concluded that construction of countermeasures against slope failures, debris flows and landslide must need huge amount of investment beyond practical range.

6. ENGINEERING SURVEY AND ANALYSIS

Natural condition surveys are conducted for the design of road, bridge and tunnel. The item of surveys are topographic survey, geological survey (geological boring investigation and seismic refraction survey), hydrological survey and material survey.

The main works of surveys are as follows;

Main Item	Quantity	
Topographic survey	170,000 m^2	Scale:1/2,500 For steep slope, tunnel and bridge
	4,900,000 m^2	Scale:1/2,500 For the optimum route
Boring investigation	29 nos	For tunnel and slope failure
	6 nos	For bridges
Seismic refraction survey	3,400m	For tunnel

7. TRAFFIC DEMAND FORECAST

1) Traffic Survey

To obtain basic data of present traffic movement of the Tribhuvan Highway, traffic count survey, roadside OD survey and vehicle speed survey were conducted in April 2000.

Average annual traffic volume (AADT) are 5,990 vehicle/day at Thankot and 14,300 vehicle/day at Kalanki.

The sampling ratios of the OD survey by vehicle type are shown below:

- Motorcycle: 87%
- Passenger Car: 93%
- Mini Bus: 100%
- Bus: 79%
- Mini Truck: 99%
- Truck: 77%

According to the results of the OD survey, it is found that 95% of total freight traffic to Kathmandu is occupied by loaded truck, on the other hand, only 13% loaded truck are recorded for the traffic going to the Naubise direction. It is also noteworthy that construction material loaded truck has highest share ratio among loaded track traffic in the traffic to Kathmandu.

In the section to Dharke from the Kalanki intersection (Ring Road), the average travel speed is 37 km/h. In the steep slope section between Nagdhunga and Naubise, the travel speed is lower than that in other section by 7~11 km/h.

2) Traffic Demand Forecast

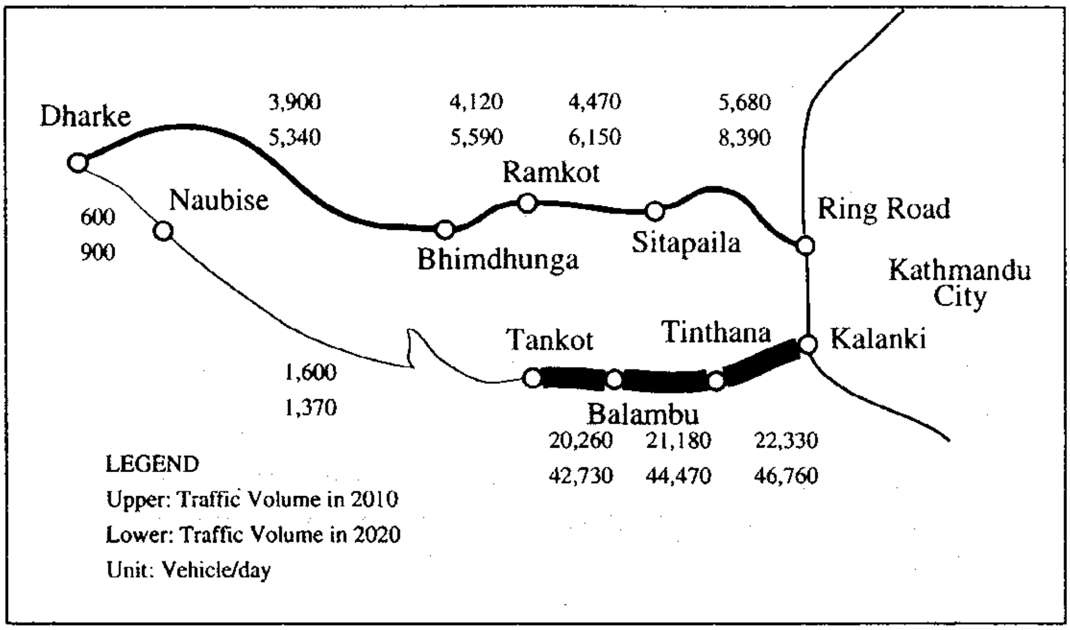
Based on the results of traffic survey and future socio-economic framework, future traffic demand of the Project Road was estimated. The target year in this estimate is 2020, and the year 2010 is also considered as the midterm target year. For this traffic demand forecast, "JICA STRADA", the software for traffic demand forecast established by JICA, was used.

Future network was established on the basis of road development plan in the 9th National Plan and through consultation with DOR. Basic road network for traffic demand forecast is established by 'Strategic Road Network', which consists of national highways and feeder roads. Road network in the year 2010 is prepared including the Project Road and Sindhuli Road. New Kathmandu-Terrai alternate road was added to the road network in the year 2020 accordig to the DOR's request.

For the purpose of forecasting future traffic demand of each road link, traffic assignment in some alternative cases are conducted. Future traffic volumes on various sections of road can be obtained as the result of the traffic assignment.

For the traffic demand forecast, toll rates as 5 NRs for motorcycle, 25 NRs for passenger car, and 35 NRs for truck were used.

The assigned traffic volumes in 2010 and 2020 on the Project Road are shown below.



In case of without Kathmandu – Terrai Road the traffic volume between Bhimdhunga – Dharke in 2020 is estimated at 7,700 vehicle/day.

8. APPLIED STANDARD

1) Highway

Nepal Road Standard (NRS) was reviewed and was compared with the Japanese design standards. Review of other international design standards like AASHTO were also done. Applicable design standards suitable for the conditions of the Project road were then selected. The project road was classified as National Highway (Strategic Road) in view of its importance in the national highway network. The design speeds of 60 km/h, 50 km/h and 40 km/h were selected for rolling/plain, mountainous and steep terrain conditions and other corresponding design elements were selected. Total formation width of the road was determined to be 12 m that consists 7 m of lane (2 lanes of 3.5 m), paved shoulder width of 1.5 m on both sides and unpaved shoulder width of 1 m on both sides.

2) Bridge & Culvert

The design standard applied in the Project basically follows the NRS's. Japanese Standard is applied for the items not covered by NRS. Indian Road Congress (IRC) standard is also referred to natural conditions such as wind, seismic, rainfall and temperature.

The typical cross section applied for the Project is shown in Fig 8.1

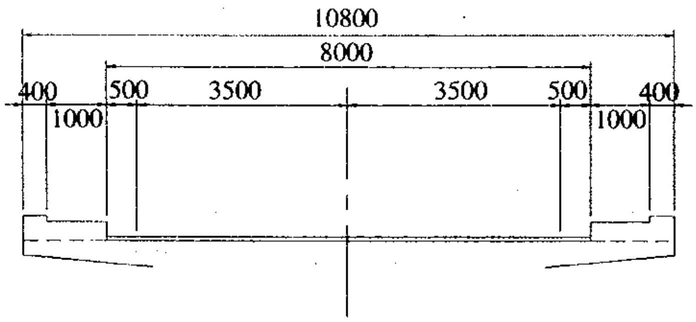


Figure 8.1 Typical Cross Section of Bridge

3) Tunnel

There is no design standards of tunnel in Nepal. Therefore design standards of tunnel applied to the Project was determined by referring to other countries design standards.

Structural facility	Standard	Remarks
Tunnel body	Japan	Japanese standard can be applied to any kind of rock
Emergency facilities	Japan	Japanese standard is so practical that required facilities can be selected specifically by tunnel length and traffic volume
Lighting system	Japan	Japanese standard is more suitable to be used in Nepal
Ventilation system	PIARC	It cover wider range in traffic condition

9. PREPARATION OF HAZARD MAP

In advance of the alternative route study, hazard map was prepared using GIS data, aerial photos and information obtained by site investigation. This map indicates locations of landslides, failures and danger stream of debris flows. Land use map was also prepared using remote sensing data and site reconnaissance results. Soil production potential of each slope was estimated by using hazard map, land use map and slope gradient map. The estimation followed the USLE method. These maps were used for road planning.

10 ALTERNATIVE ROUTE STUDY

Selection of the Optimum Route was done in three-steps as mentioned below;

1) Step-1: Initial Route Study
2) Step-2: Screening of Conceivable Alternative Routes
3) Step-3: Optimum Route Selection
4) Step-4: Comparison with existing Tribhuvan Highway improvement

Initial route study was done by identifying several Conceivable Alternative Routes based on the digital topographic map of 1:10,000 scale that was prepared from the existing topographic map of 1:25,000 scale and existing aerial photographs.

Based on the landuse map, hazard map with geological distribution, slope gradient distribution map and soil production map, which were prepared from satellite remote sensing data and field information, quantified items, representing a factor of project cost or benefit, were calculated for each Conceivable Alternative Route and the inferior alternatives were screened out. Three alternatives remained after screening process; one with long tunnel option (C-1 Route, 2 km tunnel), the other with short tunnel option (C-2 Route, 0.5 km tunnel) and the last with no-tunnel option (C-3 Route), which were termed as Possible Alternative Routes.

The Optimum Route was selected based on the calculated project costs (including construction cost, maintenance cost and land acquisition cost) and economical benefits as well as the environmental considerations and other social impacts.

Firstly, the long tunnel option (C-1 Route) was screened out because of its highest cost and lowest economic feasibility, of which extents in difference between the other alternatives are considered not to balance with its advantages of smaller social impact. Regarding the short tunnel option (C-2 Route) and the no-tunnel option (C-3 Route), there is no significant difference in all aspects. The short tunnel option has slightly higher economic feasibility than that of the no-tunnel option, but the project cost of the short tunnel option is slightly higher than that of the no-tunnel option.

The Study Team, however, recommended the short tunnel option as the Optimum Route based on the following considerations;

1) Reliability of the Road

   Since the short tunnel option can avoid the steepest topographic and poorest geological section in western side of the Bhimdhunga saddle, it should have higher reliability against the road disaster than the no-tunnel option.

2) Smooth Project Implementation

   The no-tunnel option requires larger amount of land acquisition and more number of resettlement of houses. On the other hand, the short tunnel option can mitigate such environmental and social impacts and will be more acceptable for the environmental authorities and local people. These are advantages of the short tunnel option not only from viewpoints of the environmental and social impacts but also from the viewpoint of the smooth implementation of the Project

3) Decrease in Traffic Accident Rate

   Generally, traffic accidents occur more frequently at critical alignment sections as sharp horizontal curves and steep gradient portions. The road length in such critical alignment section is much shorter in case of short tunnel option, so that the total traffic accident rate per whole road length in the short tunnel option is expected to be less.

4) Necessity of the Highway Tunnel in Nepal

Nepal is one of the eminent mountainous countries in the world. In consideration of future road development in Nepal, it will be indispensable to furnish highway tunnels in the long run. Since the Project route is the most important corridor, it would be highly worth introducing the highway tunnel from the viewpoint of future road network development, while the country is in a stage of its effort to strengthen the national road network. In other words, the introduction of the highway tunnel through the Project must have remarkable meaning in transfer of new technology for the future road network development in Nepal.

For the justification of the Project, further comparison with other alternatives, which are 4-lane improvements of the existing Tribhuvan Highway, was conducted.

As the alternatives of the 4-lane improvements of the existing Tribhuvan Highway, following alternatives were considered.

1) 4-lane widening of the whole section from Kathmandu – Naubise (Alternative-1)

2) Partial 4-lane widening and partial 2-lane new construction (Alternative-2)

4-lane widening from Kathmandu to Nagdhunga pass, new 2-lane construction for the pass crossing and connection to the existing road, and 4-lane widening of the section to Naubise.

3) Partial 4-lane widening and partial 2-lane new construction with tunnel (Alternative-3)

4-lane widening from Kathmandu to Nagdhunga pass, new 2-lane construction with tunnel for the pass-crossing, and 4-lane widening of the section to Naubise.

Preliminary route study and cost estimate was carried out for the above alternatives.

Following table shows the results of the cost estimate. As shown in the table, direct construction cost together with land acquisition/compensation cost of all alternatives are higher than that of the Project road, so it could be concluded that the Project road - a new alternate road via Bindhunga - is more advantageous from economical point of view.

Cost Comparison of Alternatives

Unit: million US$

	Existing Road Improvement Options			Kathmandu-Naubise Alternate Road
	Alt. 1	Alt. 2	Alt. 3	
Direct Construction Cost	53.7	44.1	52.2	33.6
Land Acquisition Cost	2.5	2.6	2.3	0.9

Furthermore, it must be preferable from the viewpoint of national security to have plural alternatives route in Kathmandu – Naubise section, where the existing Tribhuvan highway is the sole route at present. In addition, the new alternate road construction via Bhindhunga will extend the possibility of regional development in surrounding area of the Kathmandu valley.

According to the above results and consideration, it was concluded that the Project road is the most viable option as the highway improvement of Kathmandu – Naubise section.

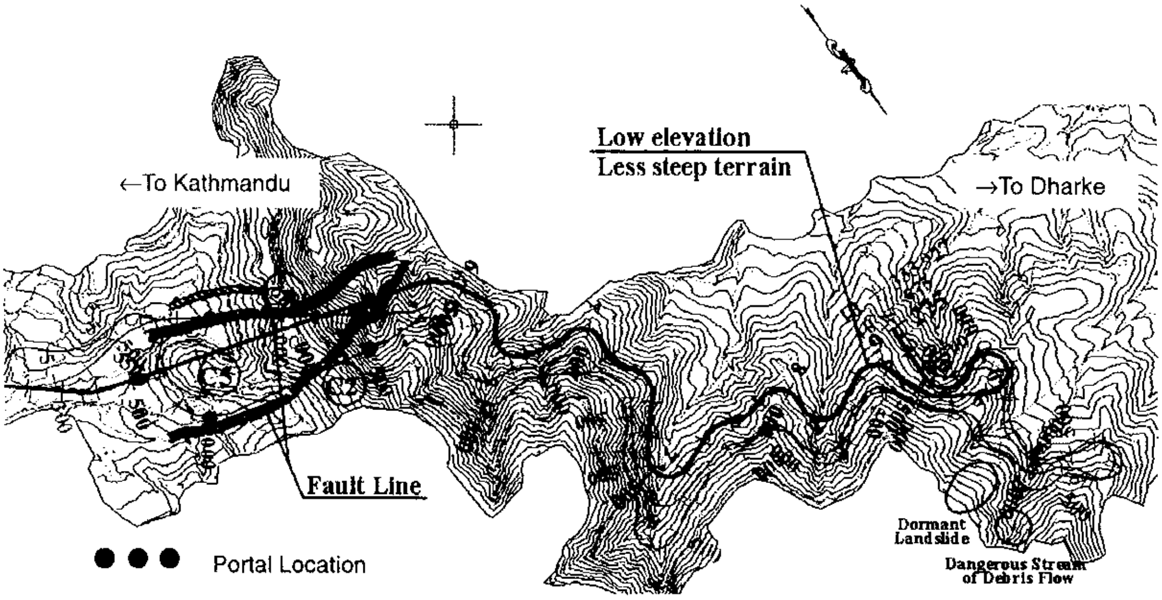
11. STUDY ON LOCATION AND FORMATIONOF TUNNEL

The Optimum Route was selected with 500m long tunnel, which was based on the topographic map of 1:25,000 scale. Detailed topographic survey was then done with an accuracy of at least 1:2,500. Seismic refraction survey was also carried out using blasting to obtain the geo-physical characteristics of the tunnel area. Detailed investigation on the location and formation height of the tunnel was then carried out.

Firstly, C-2 Route was shifted to the south and alternative C-4 Route was established to avoid the two landslides located near the Kathmandu side Portal in the C-2 Route.

But, from the results of the seismic refraction survey, it was found that geological fault zones exist almost parallel to the alignment of both the tunnel routes C-2 and C-4. Based on this finding, another tunnel route (C-5), passing nearly through middle of the two previously discussed routes C-2 and C-4, was studied, which has comparatively better geological conditions. Furthermore, the formation height of the tunnel can also be lowered more in this alternative such that the first hairpin bend can be shifted upstream towards more favourable terrain. This route can also avoid passing through the area of dormant landslide and crossing over dangerous stream of debris flow. Moreover, since the formation height of the road is lowered considerably, the total length of road passing through very steep topography and difficult terrain was also reduced. As a whole, the total road length in this section alone was shortened by about 1.2 km. However, the total length of the tunnel increased from 500m to 700m. So comparison of construction cost was done for these alternatives C-2, C-4 and C-5.

Comparison of the construction cost also showed that the alternative route C-5 had marginally less construction cost due to the shortening of the total road length as well as shortening of road through steep terrain. So, the alternative route C-5 was selected, which is better in terms of technical, financial as well as economical viewpoints.



12. PRELIMINARY DESIGN

1) Highway

Preliminary design was conducted based on the Optimum Route, which was further modified after results were obtained through detailed topographic survey works. Several alternatives for fine adjustments were studied and final alignment was selected based on the field investigations.

Two intersections, one at the beginning point on Ring Road and the other at the end of the project, where the project road terminates at existing Prithvi Highway, were designed. The intersection at the beginning point is facilitated with traffic signal.

Pavement design was carried out based on the axle load data surveyed and reported by DOR. The designed thickness of pavement layers includes 25 cm each of subbase and base courses and, 5 cm each of asphalt concrete binder and surface courses.

2) Bridge & Culvert

Along the optimum route, 10 bridges and 53 culverts are planned as the river crossing structures. Among ten bridges, three bridges exist in the Kathmandu

Valley area (from Ring road to Bindhunga), one is located in mountainous area and the remaining six are in Mahesh Khola plain area. Kathmandu Valley is relatively flat and the road alignment is formed in a straight line or with a gentle curve. The geometry of the Project Road at all bridge sites in the valley has straight configuration. On the other hand, mountainous area and Mahesh Khola plain area have steep slope and undulation. In these areas most bridges are planned to be curved bridges for shortening the bridge length and keeping favourable road alignment. Five of the ten bridges are curved bridges.

The flood discharge of each bridge, except Mahesh Khola, is relatively small. But some bridges are located at high potential area of debris flow. Basically, superstructures of bridges were designed applying short span. If the bridge location, however, is in the debris flow stream, it was designed to keep enough long span without pier in the river.

In case span length is shorter than 20m, RC Hollow slab type, which is suitable or curve bridge and maximum usage of local materials, was adopted. If the span is longer than 20m, steel girder type was applied.

The summary of each bridge is shown in Table 12.1.

Table 12.1 Summary of Bridges

No.	Station	River Name	Bridge Lenth (m)	Span Arrangement (m)	Type
Br-1	1 + 292 - 1 + 329	Kachaudha Khola	37.0	2@18.5	RC Hollow Slab
Br-2	3 + 648 - 3 + 682	Ghatte Khola	34.0	2@17	RC Hollow Slab
Br-3	4 + 728 - 4 + 756	Tribeni Khola	28.0	2@14	RC Hollow Slab
Br-4	7 + 497 - 7 + 558	Thulo Khola	61.0	18.0+25.0+18.0	RC Hollow Slab+Steel I Girder
Br-5	12 + 703 - 12 + 731	Ari Khola	28.0	2@14.0	RC Hollow Slab
Br-6	16 + 129 - 15 + 156	Bhalu Khola	27.0	27.0	Steel I Girder
Br-7	17 + 423 - 17 + 468	Rupse Khola	45.0	30.0+15.0	RC Hollow Slab+Steel I Girder
Br-8	19 + 310 - 19 + 339	Dhobi Khola 1	29.0	29.0	Steel I Girder
Br-9	19 + 820 - 19 + 855	Dhobi Khola 2	35.0	35.0	RC Hollow Slab+Steel I Girder
Br-10	21 + 136 - 21 + 186	Mahesh Khola	50.0	50.0	Steel Box Girder

There are four types of culverts. Size and number are shown in Table 12.2.

Table 12.2 Size and Number of Culvert

	Type	Nos
Pipe Culvert	ϕ 1.2m	32
	H2B2	16
Box Culvert	H3B4	4
	H3B4x 2 cell	1

Note: H3B4 means 3m in height and 4m in width

3) Tunnel

a) Inner section

The width of pavement inside tunnel is proposed to be 8 m consisting of two lanes with 3.5 m width and hard shoulder with 0.5 m on both sides. Inspection galleries on both sides are also proposed to be provided. The vertical clearance of 4.75 m is determined based on the Nepal Road Standards.

This inner section of tunnel has three-centerd-arch because that shape is durable against ground pressure. The detail tunnel dimension was established to minimize excavation volume satisfying required clearance.

b) Form of portal

Both portals of this tunnel are selected upright type.

c) Point of portal

Location of both portals and tunnel length are determined as follows.

East portal	:	STA5+515
West portal	:	STA6+220
Tunnel length	:	705m

d) Evaluation of geological ground condition

Evaluation of geological ground condition is done according to the rock classification introduced by the Japan Tunnel Technical Standards.

Grade	Section	Length (m)	Seismic Velocity
DIII-a	STA5+515 (Portal) ~STA5+555	40	Portal section
DII	STA5+555 ~STA5+620	65	1.9~2.1km/s
DI	STA5+620 ~STA5+750	130	3.0~3.2km/s
DII	STA5+750 ~STA5+825	75	1.9~2.1km/s
DI	STA5+825 ~STA6+175	350	3.0~3.2km/s
DII	STA6+175 ~STA6+195	20	1.2~2.1km/s
DIII-a	STA6+195~STA6+220 (Portal)	25	Portal section

e) Method of tunnel excavation

Base rock at tunnel location is considered to have unconfined compression strength of 600 kg/cm^2 or more, since it has seismic velocity of 3.2 km/s.

In this case, mechanical excavation method will be difficult to use, but excavation by blasting method could be employed.

f) Construction method of tunnel

Currently, the New Austrian Tunnelling Method (NATM) is usually employed for tunnel construction and seems to be the standard tunnelling method in the world.

In case of NATM, excavated surfaces are supported by rock bolts and shot-create immediately after excavation (initial lining). By this treatment, expansion of loosened zone can be minimized. Movement of tunnel body is always monitored by built-in instruments and if extraordinary condition occurs, necessary countermeasures are provided. Secondary lining, which is thicker concrete lining, is constructed after initial lining.

It is generally considered that by employing NATM, more speedy and safer construction can be expected. However, NATM require special construction machines such as shot-create machine and big scale drilling machine (Jumbo). In case of the Project Road, these special construction machines are not available in Nepal and must be procured from outside of Nepal. On the other hand, application of the conventional tunnelling method using H-shaped steel arched support and wooden logging can be considered also.

The conventional method was broadly used before the NATM became the prevailing tunnelling method. The method does not require big-scale special tunnelling machine. This method may be applicable if the tunnel excavation face is rather sound and stable, however, it needs more detail geological information.

g) Pavement in the tunnel

The pavement in the tunnel is proposed to be cement concrete pavement, since longer durability and better illumination effect.

h) Ventilation system

Due to following considerations, it is proposed that no mechanical ventilation system is provided for the tunnel.

- Both east and west sides of tunnel are the open area and have ravine terrain. Therefore, natural wind ventilation can be expected to a certain extent.
- According to following formula, which used for the judgement of necessity of mechanical ventilation, it is judged that mechanical ventilation is not required.
  $L \times N > 600$
  Where, L is tunnel length in km and N is hourly traffic volume.

If such situation that a mechanical ventilation system is required due to unexpected growth of traffic beyond forecast, comes out, the tunnel can accommodate 2 sets of jet fan ($\phi = 600$mm).

i) Lighting system

Tunnel lighting system was studied based on the following design conditions.

- Design speed 60km/h
- Length of tunnel 705m
- Outside luminance 3,000cd/m^2
- Design traffic volume 5,340vehicles/day

The study is conducted according to the Japanese Standard.

j) Emergency facilities

Emergency facilities are provided according to probability of disaster occurrence, which are determined by the length of the tunnel and the traffic volume.

According to the Japanese Standard, the tunnel is classified into "Class B" by its length (705m) and the traffic volume (5,340vec/day).

Required facilities are as follows.

	Name of facilities	Installation interval of facilities
1	Emergency telephone	installed at intervals of 200m (one side)
2	Pushbutton type information equipment	installed at intervals of 50m (one sides)
3	Emergency alarm equipment	95m interval from portal
4	Fire extinguisher	installed at intervals of 50m (one side)
5	Guide board	installed at intervals of 200m (both side)

k) Other facilities

The tunnel is required to be facilitated with site control office for 24 hours control. The site office should have bedrooms and control panel of the tunnel facilities.

For safety reasons, it is recommended to install rubber-post on pavement of the tunnel along centerline to restrict over taking of running car.

Switch-turn spaces inside of tunnel are also provided against the case that an accident in the tunnel happens.

13. OPERATION AND MAINTENANCE

The Project Road will introduce new technology, that is highway tunnel, in Nepal. Highway tunnel must require sufficient operation and maintenance for the safety of traffic.

To achieve the above objective, the Study Team recommends to establish a Project Operation Unit (POU) particularly for the operation and maintenance of the Project Road. The POU will consist of Financial Section, Operation and Maintenance Section and Safety Control Section.

The Financial Section will be responsible for toll collection. The collected toll should be used for all operation and maintenance work including salary of POU staff.

Operation and Maintenance Section will conduct all operation and maintenance work of highway, bridge and tunnel. Operation and maintenance of highway tunnel is first experience for Napalese staff, so sufficient level of transfer of knowledge and training must be conducted by the Consultant and supplier of tunnel equipment during construction and beginning of operation stage. Safety Control Section will be responsible for the safety assurance of the tunnel. Tasks of the section includes daily safety patrol and fire-fighting and rescue activities.

This work is also first experience for Nepalese staff so knowledge transfer and training shall be provided during construction and beginning of operation stage.

14. POTENTIAL STUDY ON THE WIND AND SOLAR POWER GENERATION

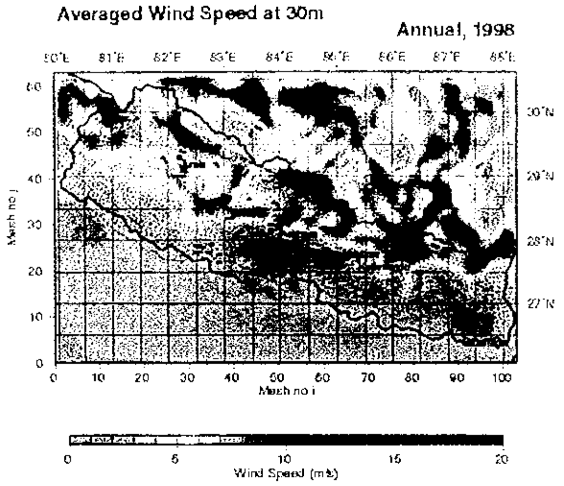
The aim of this study is to evaluate possibility to use wind and solar power generation as power source for operation and maintenance of the tunnel. The study was conducted evaluating potential of the wind and solar power generation in Nepal, especially around the Project area, by using a numerical weather prediction model.

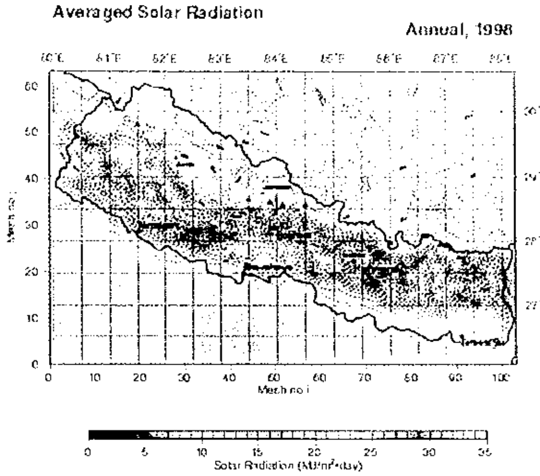
This numerical weather prediction model simulates weather condition in Nepal in each 8km grid using data throughout the year 1998. In a numerical weather prediction model, 0.5-deg grid (about 50km horizontal intervals) objectivity analysis value of the ECMWF (European Centre for Medium-Range Weather Forecasts) was used for the initial and the boundary weather conditions. In addition, altitude, land use and snow distribution data were collected as surface boundary conditions.

The annual/ monthly mean of wind velocity and solar radiation were calculated with all of the grids after the calculation for one year was finished. The calculated wind velocity could represent the variability of the seasonal wind. The monsoon wind was weaker than other season's wind velocity. The distribution of the wind speed was affected by land shape and wind velocity was large over the mountains, especially over the areas where average height within a mesh was higher than 3000m.

Similarly, in areas where the ridge was facing to south, the wind velocity exceeded 7m/s. In the other area, the wind velocity was weaker than 4m/s, in Kathmandu it was about 3m/s, and it seemed difficult to generate efficient electric power.

Meanwhile, the annual mean daily cumulative solar radiation per a unit in Nepal deeply depended on the monsoon activity. The plain areas such as Biratnagar and the northern side of the steep slopes such as Jumra or Tibet highland, shows larger amount of solar radiation, exceeding 20MJ/m^2/day. On the other hand, the solar radiation shows smaller amount than 15MJ/m^2/day in slope area because of the monsoon clouds.



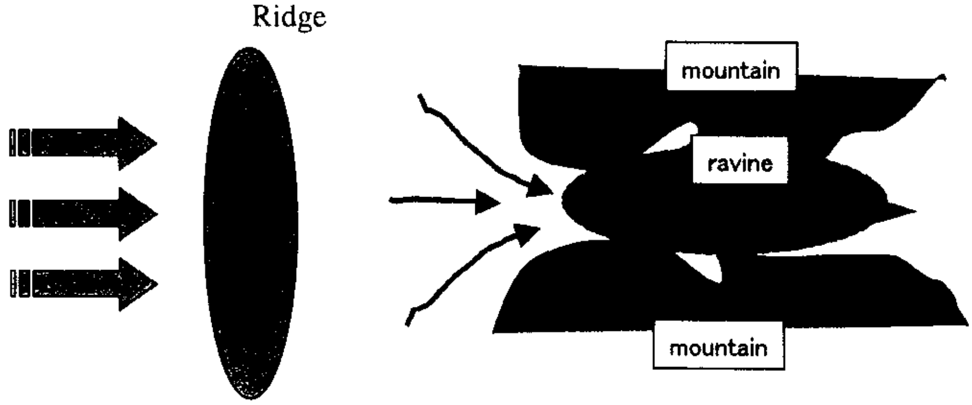


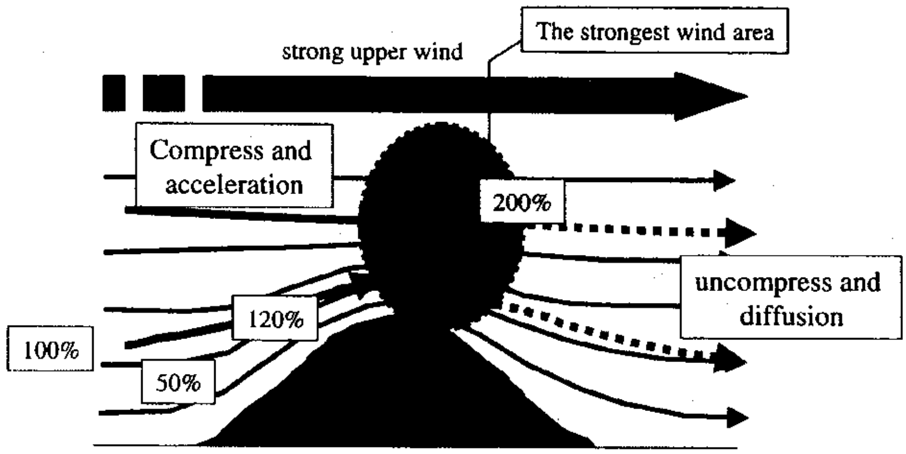
According to the results of the numerical weather prediction model, it was observed that the wind and the solar radiation was deeply influenced by the monsoon and the distribution of wind velocity and solar radiation were different between the dry season and the wet season.

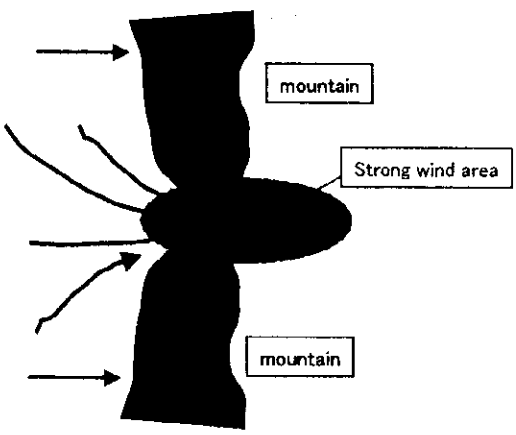
The quantity of power that can be generated by wind and solar radiation was estimated from calculated hourly wind velocity, solar radiation and temperature value, and assumed one generation capability. The necessary electricity to supply the tunnel of the Project area was assumed to be 66.6kWh/1h, 9.9kWh/1h, and 5.4kWh/1h for daytime, night time and midnight time respectively. The monsoon season was eliminated from the target period of power supply by natural energy because the monsoon season couldn't expect sufficient wind velocity and solar radiation. From the results it was calculated that two windmills and solar panels of approximately 1,000m^2 area will be required to meet the demand during daytime. In order to utilize surplus energy for the daytime for night and the hours that electricity isn't provided sufficiently, it is possible to supply 85% of that hour by using the battery that has effective capacity of 130kWh. Indeed, the conversion efficiency of both input and output are estimated as about 70%, so it is necessary to use the battery with capacity of 260kWh.

However, above results are based on the data obtained from mesh size of 8km. More detailed data with mesh size 250m will be required that can be used in the simulation model to get more precise results. Moreover the observation of wind velocity and solar radiation are essentially required at the target area at least 1 year.

The wind velocity is affected considerably by the local topography. Generally speaking, the figures of suitable topography for windmill are the following; the plain and the grassy plain in high altitude, the ridge which is near to right angle for the dominate wind direction, the peak and the summit of the mountain of opening in the area where upper wind is strong, the long valley which reaches underneath from mountains area, the area that forms a large-scale path, as shown in following Figures.







15. ENVIRONMENTAL STUDY

1) Environmental Impacts

Based on the project features and the present environmental condition in the Project area, the environmental impact assessment was carried out. Items which are considered to cause a certain extent of environmental impact to the Project area are summarised as follows.

- Landscape change due to the cutting/embankment work and appearance of structures
- Risk of increment of soil erosion on new-created slopes due to cutting/ embankment work
- Increment of TSP concentration and noise level due to the trucks/ equipment activities in construction stage, and due to the vehicle travel in post construction stage
- Discharge of turbid water due to earthwork, and discharge of turbid and alkaline water due to tunnel construction
- Reduction or depletion of domestic water supply by drawdown of groundwater due to cutting work and tunnel construction
- Generation of surplus soil and domestic waste in construction stage
- Forest / tree clearance due to construction activities
- Land acquisition and resettlement due to construction
- Relocation of such social/living facilities as irrigation canals and community water taps
- Relocation of such cultural/religious sites as small temple and shrine
- Deterioration of health and sanitary state due to mobilization of labor forces in construction stage, and due to urbanization in post construction stage

2) Mitigation Measures

In order to mitigate the predicted environmental impacts, the mitigation measures were proposed as described in the main report. The cost of mitigation measures was estimated to compose the total Project cost.

Mitigation measures should be incorporated into the tender documents to ensure that the contractors are obliged to comply with measures.

3) Environmental Monitoring

Environmental monitoring plan was proposed so as to monitor the progress and effectiveness of the mitigation measures, and other environmental impacts which are not anticipated in EIA preparation stage. Organisational frame for monitoring was also proposed, including MPPW, MOPE, other central/local agencies, contractors, and DOR (project office, GEU, consultants group, etc.).

4) Others

A Draft EIA Report was separately prepared according to the S/W and M/M of the Study. DOR conducted a public hearing according to the draft EIA report on February 2001 and will follow the required procedures, so as to meet the EIA approval for the project implementation as per the legal EIA scheme of Nepal.

16. LAND ACQUISITION AND RESETTLEMENT PLAN

1) Legal Frame

Such legal frame in Nepal as Land Act, Land Acquisition Act, Land Acquisition Rules, and Public Road Act was studied. The policies on involuntary resettlement of JBIC, and other international donors, were also reviewed. The detail is described in the main report.

2) Land Acquisition and Resettlement Plan

A project-specific plan for the land acquisition and resettlement was preliminarily developed based on the existing conditions of the project area, characteristics of the project, legal framework in Nepal, and other donors' policy requirement. The basic principles are as follows.

- Land acquisition and resettlement should be avoided where possible, or be minimized through incorporating the social consideration into the project design.
- Where the land acquisition and resettlement is unavoidable, any person who will lose his property and livelihood should be adequately compensated and assisted so that he can at least restore his former economic and social conditions.

The land acquisition and resettlement plan was developed especially proposing the frame of public involvement and monitoring/evaluation of the plan. Besides, the roles and responsibilities of related agencies/organizations were identified. The detail is described in the main report.

3) Magnitude of Land Acquisition and Resettlement

The magnitude of land acquisition and resettlement, in case of the selected optimum ROW of 50m, was calculated as shown below.

(Unit: ha、nos.)

	Package 1-1	Package 2	Package 3	Package 1-2	Total
Khet	21.5	1.2	15.6	10.9	49.2
Bari	3.7	6.1	22.0	11.2	43.0
Barren land	0.2	0.2	1.2	4	5.6
Forest	1.0	1.3	1.7	0.1	4.1
Orchard	0.0	0.0	1.1	0.0	1.1
Total	26.4	8.8	41.6	26.2	103
House structures	53	9	62	61	185
Concerned VDC	Sitapaila, Ramkot,Bhimdhunga	Bhimdhunga,Chhatre Deurali	Chhatre Deurali,Jiwanpur	Jiwanpur, Naubise	Total 6 VDCs

Remarks: 1. Except tunnel portion
2. as of November 2000

4) Cost Estimate of Land Acquisition and Resettlement

The cost for the land acquisition and resettlement was estimated as shown below. (in case of ROW of 50m)

(Unit: million NRs)

	Package 1-1	Package 2	Package 3	Package 1-2	Total
Land acquisition cost	49.9	1.5	23.2	19.2	93.8
Resettlement cost	29.2	2.6	11.6	12.0	55.4

Remarks: 1. Except tunnel portion
2. The governmental rate was applied to unit price of land for estimation of Land acquisition cost.

17. CONSTRUCTION PLAN

1) General

The main future considerations in the construction plan for the Project are as follows;

- The Project should be divided into contract packages in consideration of the proper scale.

- So far as practical, locally available construction materials are planned to be used as much as possible to save the construction cost and to create job opportunity in and around the Project area.

- Construction works are assumed to be conducted by qualified international contractors that have sufficient capability to perform the work.

2) Proposed Contract Packages

General descriptions of each contract package, which are determined in consideration of each work scale, accessibility, mass haulage balance, etc., are as follows:

	Package 1	Package 2	Package 3
Length	10.5 km	2.4 km	8.4 km
Bridges	7 (total 258 m)	1 (61 m)	2 (total 55 m)
Tunnels		1 (705 m)	
Construction Cost	9.0 million USD	18.8 million USD	10.9 million USD

Currency exchange rate: 1 USD = 72.57 NRs (average rate from 1st July to 31st Dec. 2000)

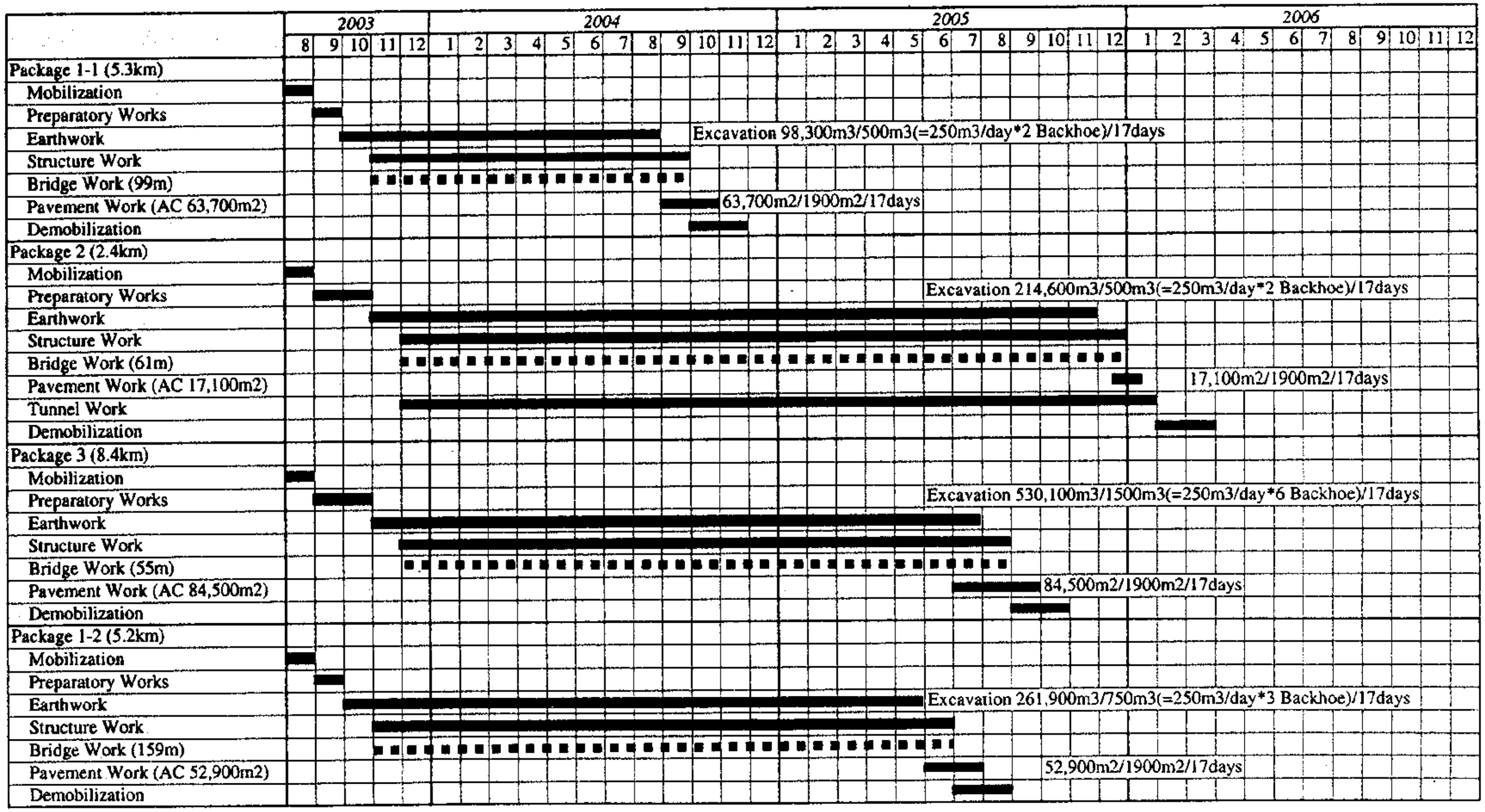
3) Procurement Sources of Construction Material and Equipment

Most construction material and equipment are available in Nepalese market. However, some of these for tunnel and bridge construction shall need to be imported from abroad.

4) Construction Schedule

The overall construction period of the Project is estimated at 32 months including mobilization period and site cleaning period. Estimated overall construction schedule is shown in Table 17.1.

Table 17.1 Overall Construction Schedule



Monthly workable day was calculated in consideration of rainy days.

18. COST ESTIMATE

1) General

The composition of the project cost is shown in Figure18.1.

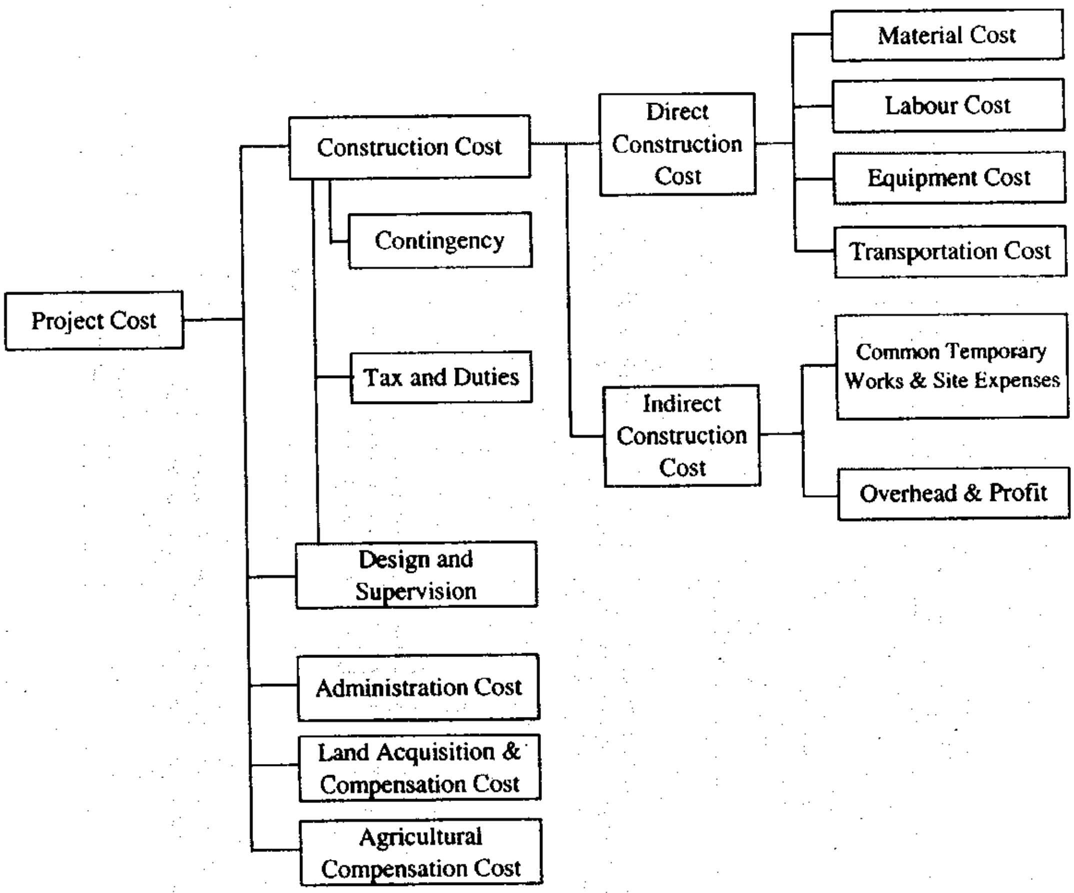


Figure 18.1 Composition of the Project Cost

2) Basic Premises and Conditions

The basic premises and conditions employed in the estimate are as follows:

a) The cost was estimated based on the prevailing prices in 2000

b) The exchange rates are: US$ 1.0 = Nrs72.57 = Yen 109.76

c) All construction works will be executed by the contractor(s) to be selected through international competitive bidding.

d) Direct construction cost was estimated based on the estimated work quantities of major works and updated unit prices. The unit prices were estimated based on basic prices of necessary material, manpower and equipment and input requirements of those components.

e) Unit prices were split into foreign and local currency portion taking procurement source and shadow foreign portion in the basic prices into consideration.

f) Physical contingency was estimated at 10% of the construction cost

g) The cost of engineering services was derived from the estimated man-months of foreign and local consultants and other relevant cost required for detailed design and construction supervision.

h) The administration cost of the Nepal Government was assumed to be 1% of the total amount of construction cost and engineering cost referring other similar projects in Nepal.

i) Land acquisition cost was estimated based on the governmental rate fixed by the District Land Administration and Revenue Office. It shall be noted that actual land acquisition prices must be settled according to the legal procedure in Nepal with negotiation with land owners and will be much higher than the governmental rate.

3) Cost Estimate

Summary of work quantity of the Project is shown in Table 18.1 and summary of the project cost is shown in Table 18.2.

Table 18.1 Summary of Work Quantity of the Project

Work Item	Unit	Quantity			
		Package1	Package2	Package3	Total
1.Preparation Work					
1-1 Clearing (forest area)	m2	291,009	65,088	274,613	630,710
2.Earthwork					
2-1 Excavation (Common Soil)	m3	359,055	57,245	342,874	759,174
2-2 Excavation (Rock)	m3	0	140,169	164,184	304,353
2-3 Excavation (Spoil)	m3	17,264	82,522	27,398	127,184
2-4 Embankment	m3	341,791	115,107	479,660	936,558
2-5 Structural Excavation	m3	0	22,119	26,238	48,357
2-6 Back Filling	m3	0	22,119	26,238	48,357
3.Drainage					
3-1 Side Ditch	m	14,363	6,107	14,474	34,944
3-2 Pipe Culvert (dia.900mm)	m	475	15	195	685
3-3 Pipe Culvert (dia.1200mm)	m	337	77	376	790
3-4 Box Culvert (2m*2m)	m	231	42	190	463
3-5 Box Culvert (3m*4m)	m	127	0	42	169
3-6 Box Culvert (3m*4m*2shell)	m	0	0	40	40
3-7 Shute Drainage (for C-Pipe)	m	59	198	218	475
3-8 ShuteDrainage (for C-box)	m	25	50	80	155
3-9 Catch Pit (for C-Pipe)	nos.	3	4	6	13
3-10 Catch Pit (for C-Box)	nos.	2	1	3	6
3-11 Catch Basin (for C-Pipe)	nos.	3	4	6	13
3-12 Gabion Work	m3	56	10	83	149
3-13 Miscellaneous	L.S.				1
4.Slope Protection					
4-1 Wet Masonry Wall	m2	7,175	9,507	17,504	34,186
4-2 T-shaped wall	m3	0	6,183	8,815	14,998
4-3 Concrete Foundation for T-shaped Wall	m3	0	5,360	1,593	6,953
4-4 Gravity Wall	m3	0	246	295	541
4-5 Vegetation Work (Sodding)	m2	115,143	20,200	115,071	250,414
5.Bridge					
5-1 RC Hollow Slab	L.S.	1			1
5-2 RC Hollow Slab	L.S.	1			1
5-3 RC Hollow Slab	L.S.	1			1
5-4 Steel Box Girder + RC Hollow Slab	L.S.		1		1
5-5 RC Hollow Slab	L.S.			1	1
5-6 Steel I Girder	L.S.			1	1
5-7 Steel Box Girder + RC Hollow Slab	L.S.	1			1
5-8 Steel Box Girder	L.S.	1			1
5-9 Steel I Girder	L.S.	1			1
5-10 Steel Box Girder	L.S.	1			1
6.Mitigation Measure					
6-1 Canal Relocation(Open Ditch)	m	2,503	0	2,038	4,541
6-2 Canal Relocation(C-pipe Dia.300)	m	488	0	270	758
6-3 Planting Tree Work	L.S				1
6-4 Electric pole and Line Relocation	L.S				1
6-5 Sound Insulation Cost	L.S				1
7.River Treatment					
7-1 Excavation(weathered rock)	m3	14,688	313	0	15,001
7-2 Rivetment	m2	6,641	113	0	6,754
8.Pavement					
8-1 Subbase Course (purchase)	m3	9,965	0	2,342	12,306
8-2 Subbase Course (in site)	m3	25,660	5,681	25,660	57,000
8-3 Base Course	m3	35,108	5,314	26,542	66,964
8-4 Asphalt Concrete	m2	122,894	17,184	85,208	225,286
9.Tunnel	L.S.		1		1
10.Miscellaneous					
10-1 Guard Rail	m	1,926	1,268	6,849	10,043
10-2 Side Walk	m2	1,412	0	0	1,412
10-3 Traffic Signal	L.S.	1			1
10-4 Access Road No.1	L.S.		1		1
10-4 Access Road No.2	L.S.			1	1
10-5 Toll Gate and Maintenance Office	L.S.		1		1
10-6 Others(Road mark, km post etc.)	L.S.				1
10-7 Transportation	L.S.				1

Table 18.2 Summary of the Project Cost

Major Item	Unit	Package 1			Package 2			Package 3			Total Cost (rounded)		
		F/C (USD)	L/C (USD)	Total (USD)	F/C (USD)	L/C (USD)	Total (USD)	F/C (USD)	L/C (USD)	Total (USD)	F/C (USD)	L/C (USD)	Total (USD)
1. Construction Cost													
1-1.Direct Construction Cost													
- Preparation Work		61,069	73,609	134,677	13,659	16,464	30,122	57,628	69,462	127,089	132,000	160,000	292,000
- Earthwork		477,599	516,388	993,987	1,174,116	926,715	2,100,832	1,607,475	1,343,013	2,950,488	3,260,000	2,786,000	6,046,000
- Drainage		167,746	677,636	845,382	30,774	209,062	239,836	153,380	651,073	804,453	352,000	1,538,000	1,890,000
- Slope Protection		14,331	161,868	176,199	491,433	1,086,849	1,578,282	528,965	1,236,840	1,765,804	1,034,000	2,484,000	3,518,000
- Bridge		1,306,966	640,264	1,947,230	627,126	353,894	981,020	201,889	115,242	317,131	2,136,000	1,109,000	3,245,000
- Mitigation Measure		7,571	154,293	161,864	0	33,014	33,014	5,504	87,095	92,599	13,000	273,000	286,000
- River Treatment		95,822	195,843	291,665	1,985	3,611	5,596	0	0	0	97,000	199,000	296,000
- Pavement		917,659	1,087,162	2,004,821	131,363	153,292	284,656	650,450	777,342	1,427,792	1,700,000	2,018,000	3,718,000
- Tunnel		0	0	0	7,703,448	1,543,954	9,247,402	0	0	0	7,704,000	1,544,000	9,248,000
- Miscellaneous		497,254	124,334	621,588	298,757	240,827	539,584	724,292	526,210	1,250,502	1,521,000	891,000	2,412,000
Total Direct Construction Cost		3,546,017	3,631,398	7,177,415	10,472,661	4,567,682	15,040,343	3,929,581	4,806,277	8,735,858	17,948,000	13,005,000	30,953,000
1-2.Indirect Construction Cost													
- Common Temporary Works & Site expenses	L.S.	531,903	544,710	1,076,612	1,570,899	685,152	2,256,051	589,437	720,942	1,310,379	2,692,000	1,951,000	4,643,000
- Overhead & Profit	L.S.	354,602	363,140	717,741	1,047,266	456,768	1,504,034	392,958	480,628	873,586	1,795,000	1,301,000	3,096,000
Total Indirect Construction Cost		886,504	907,849	1,794,354	2,618,165	1,141,920	3,760,086	982,395	1,201,569	2,183,965	4,487,000	3,251,000	7,738,000
Total Construction Cost		4,432,522	4,539,247	8,971,769	13,090,827	5,709,602	18,800,429	4,911,977	6,007,846	10,919,823	22,435,000	16,257,000	38,692,000
2. Design & Supervision	L.S.										4,875,500	2,089,500	6,965,000
3. Contingency		443,252	453,925	897,177	1,309,083	570,960	1,880,043	491,198	600,785	1,091,982	2,244,000	1,626,000	3,870,000
Sub Total (1+2+3)											29,554,500	19,972,500	49,527,000
4. Administration Cost	L.S.											457,000	457,000
5. Land Acquisition and Compensation Cost	L.S.											2,394,000	2,394,000
6. Tax and Duties												4,566,000	4,566,000
Sub Total (3+4+5)	L.S.											7,417,000	7,417,000
Total Project Cost											**29,554,500**	**27,389,500**	**56,944,000**

19 PROJECT EVALUATION

1) Economic Evaluation

The economic evaluation of the Project is usually done by the "With Project" and "Without Project" comparison method. Three type of indicators such as economic internal rate of return (EIRR), net present value (NPV), benefit/cost ratio (B/C) were calculated by estimating input (economic costs) and output (economic benefits).

The basic adjustment to convert financial prices to economic prices was made excluding any taxes, duties or subsidies, and land acquisition and compensation cost from the financial cost. Based on the construction plan and cost estimate, the estimated economic costs are assumed as shown.

Economic Cost Stream

Unit: million US$

2001	2002	2003	2004	2005	2006
0.43	1.71	13.23	19.65	14.66	0.30

There exist many types of benefits on the national economy by the Project. Those are classified conveniently into "Direct Benefits" and "Indirect Benefits". Direct benefits are defined as the benefits enjoyed by road users who use the Project Road directly. The vehicle operating cost savings (VOCs) and the travel time cost savings of passengers were estimated quantitatively in this economic evaluation.

The economic vehicle operating costs were estimated by using Highway Design Maintenance Standards Model (HDM) which is a computer model developed by the World Bank as shown below.

VOCs

unit: million US$

2010		2020	
With Project	Without Project	With Project	Without Project
37.65	47.89	66.62	75.38

Based on the time values, the traffic volume and the travel speed which were obtained from the results of the traffic assignment, the travel time costs are estimated as presented below.

Travel Time Costs

unit: million US$

2010		2020	
With Project	Without Project	With Project	Without Project
4.36	6.28	8.90	10.43

Based on the VOCs and travel time costs in case of with and without project, the economic benefits are estimated as shown below.

Economic Benefits

unit: million US$

	Economic Benefits	
	2010	**2020**
VOCs Saving	10.24	8.76
Travel Time Costs Saving	1.92	1.53
Total Benefits	12.16	10.29

In addition to those benefits, the interruption time due to landslide and other structures of road was analysed based on the traffic interruption survey in Tankot-Naubise Road conducted by the Study Team on September of 2000.

According to the results of the survey, total interruption time due to road disasters was estimated to be 12 hours per year. Based on the time values by vehicle type, traffic volume and interruption time, the interruption time costs were estimated at 0.02 million US$ per year. In case of the With Project, vehicles using the existing road can pass the Project Road. Consequently, a large part of the interruption time costs will be reduced. These costs are not so big comparing the VOCs and travel time costs savings, so that the interruption time costs savings were not included in this economic evaluation.

The results of calculation of EIRR, NPV, and B/C are shown below.

EIRR, NPV and B/C Calculation

EIRR (%)	NPV (million US$)	B/C
18.1	19.17	1.57

The sensitivity tests for the Project Road was conducted changing the costs and benefits. If the project costs go up by 20% and benefits go down by 20% simultaneously, EIRR of more than 12% is still maintained.

The Project Road appreciated to be economically feasible and implementation of the Project is justified from the viewpoint of national economy.

2) Financial Analysis

Financial analysis was conducted with assumption that the toll collection is a barrier type toll system at both sides of the tunnel.

For the analysis, toll rates as 5 NRs for motorcycle, 25 NRs for passenger car and 35 NRs for truck were used. These toll rates were set considering toll rate of the existing Tribhuvan Highway, direct benefit of road users and forcasted traffic volume. Annual toll revenue in the target years are estimated as shown below.

Toll Revenue

Unit US$

2010	2020
498,939	604,561

Based on the above toll revenue, financial internal rate of return (FIRR) was estimated to be -9.7%. If toll rate as high as double of the above toll rates are applied, the FIRR will increase but still remain at -6.4%. In this case, traffic volume in 2010 was 2,820 vehicles per day, in 2020 4,340 vehicles per day.

The activities of the DOR are financed through appropriation from the National Budget. The percentage of annual expenditure for the DOR in the National Expenditure is about 10 from 4 % in recent three years.

DOR Budget and Expenditure

Unit: NRs

Fiscal Year	Budget	Expenditure	% of National Expenditure
1994/95	3,162,750,000 (43,582,000)	1,738,293,899 (23,953,000)	4.4%
1995/96	3,821,207,690 (52,655,000)	3,182,041,305 (43,848,000)	6.8%
1996/97	4670,301,000 (64,356,000)	5,000,779,997 (68,910,000)	9.9%
1997/98	4,767,257,000 (65,692,000)	3,979,376,472 (54,835,000)	-
1998/99	5,192,926,000 (71,557,000)	3,579,619,537 (49,326,000)	-

Source: Central Financial Statements, DOR
Note: Figures in parentheses show US$.

Given the financial costs and toll revenue, FIRR was calculated at -9.7%.

Estimated toll revenue can not cover repayment of the Project cost but can cover annual maintenance cost and a part of the project costs, which would result in saving in total maintenance cost of DOR.

3) Indirect Benefits

Beside the direct benefits, following effects are indirectly brought in the area by the Project road.

Promotion of Agriculture

Jiwanpur and Chhatre Deurali VDC in which agriculture is prosperous would be greatly advantaged by shortening of time distance to Kathmandu City. Although there is no road linking with Kathmandu, these areas are major supply sources of crops to Kathmandu. Therefore the Project Road will contribute to the change in agricultural structure from lower priced production to cash crops in these areas, and also to the stable supply of the agricultural production to Kathmandu.

Promotion of Commerce

Market area is magnified by construction of the Project Road. Business activities in each VDC along the road will be activated. When access to Kathmandu City is improved, anybody can easily go shopping in Kathmandu City. As a result, it seems that local retail will make effort by themselves. Competition among them can produce, and the commerce whole becomes active and attractive.

Improvement of Living Conditions

The improvement in traffic conditions through construction of the Project Road will help people in a rural area in utilising and gaining access to such social facilities as government offices, hospitals, schools, etc. located far from their residence. Furthermore, they will be able to enjoy shopping, sports, watching movies, etc., and will also gain access to libraries, cultural centers and museums in Kathmandu City. Accordingly, life conditions of people will be wider without changing their residences.

Rise of Value on Resources and Changes for Land Utilisation

The effect of constructing the project road that is most conspicuous is land utilisation. Especially the areas located outside of Kathmandu Valley in the west, such as Jiwanpur and Chhatre Deurali VDC, have relatively flat land and water source from Mahesh River, so opportunity to develop these areas as industrial area will increase by the construction of the Project Road. These activities will accelerate decentralisation of the Kathmandu Valley and contribute to reduction of such urban problems of the Valley as over-population and serious air pollution.

Influence of Project Investment

When construction of the Project Road begins, a wage is paid to worker who engages in project road construction, and construction materials are purchased. As a result, income of employer and business profit of company for production of construction materials will increase.

20. IMPLEMENTATION PLAN

1) Project Implementation Plan

a) Executing Agency

The Department of Roads (DOR), Ministry of Physical Planning and Works, HMG/N will be responsible for construction and operation/maintenance of the Project.

b) Expected Financial Source

Considering annual budget constraint of DOR, it is obviously impossible to implement the Project under DOR local fund. Through discussions with agencies and authorities concerned during the study period, it is considered that foreign financial assistance by soft loan will be the most probable financial source for the Project. Up to the present no definitive donor is fixed, the HMG/N should find a donor for the Project and apply for financial assistance for the Project based on the results of this Feasibility Study.

c) Implementation Schedule

The implementation schedule of the Project is shown in Figure 20.1. The schedule is planned on condition that the Project fund is provided by foreign financial assistance by soft loan. Under this schedule, construction work is started in 2003 and finished in the beginning of 2006.

2) Overall Implementation Schedule for Roads improvement between Kathmandu and Terai

Figure 20.2 shows traffic demand of each section with relation to the traffic capacity.

From the results shown in the figure, following matters are clearly understood.

a) Despite of the biggest traffic demand, traffic capacity of the Kathmandu – Naubise section appears the smallest figure along the whole Kathmandu – Narayangadh road. Present traffic volume has reached the traffic capacity of the existing road. Therefore construction of the alternate road in this section, which is proved in the previous chapter to be more feasible than 4-lanes improvement of the existing road, is urgently required.

b) The Naubise – Mugling sections has sufficient level of traffic capacity to accommodate future traffic demand till year 2010. Therefore the critical issue in this section is only to strengthen the road against road disasters.

c) The Mugling - Narayangadh section has sufficient level of traffic capacity to accommodate future traffic demand of year 2010, except about 10-kilometer section where the road width is relatively narrow and the road does not have 2-lane carriageway. Traffic condition of this narrow section will be close to saturated level in 2010.

d) The traffic demand of year 2020 will exceed traffic capacity in all sections, even if the Kathmandu – Naubise Alternate Road is provided. On the other hand, if the Kathmandu –Terai Alternate Road is assumed to exist in 2020, the traffic demand in the Naubise – Narayangadh section will be so reduced that the traffic can be accommodated under the existing road condition except the narrow section between Mugling - Narayangadh. At the same, as for the Kathmandu – Naubise section, the future traffic demand can be accommodated by total capacity of the existing Tribhuvan Highway and the Kathmandu – Naubise Alternate Road in this case. Therefore it is concluded that the Kathmandu – Terai Alternate Road shall be constructed before year 2020.

Based on the above study results, necessity of urgent implementation of the Project is justified and the Study Team recommend the following overall implementation schedule for the road improvement between Kathmandu and Terai.

1) Objectives of short term plan (2002 - 2006)

- Construction of the Kathmandu – Naubise Alternate Road
- Road Disaster Prevention for the existing Kathmandu – Narayangadh Road

2) Objective of medium term plan (2007 - 2011)

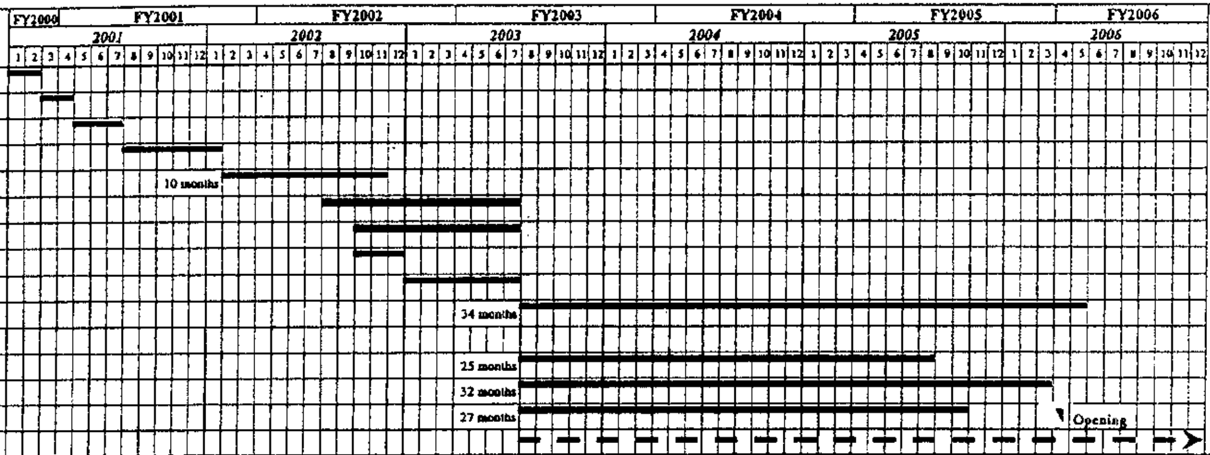
- Improvement of Mugling - Narayangadh Section

3) Objective of long term plan (2012 - 2020)

- Construction of the Kathmandu – Terai Alternate Road

Table 20.1 Implementation Schedule

Items	Period (months)
Feasibility Study	–
Application for Foreign Financial Assistant	2
Appraisal on the Application	3
Employment of the Consultant (D/D&S/V)	6
Detailed Design	10
Land Acquisition and Compensation	12
Procurement of the Contractor	10
Pre-qualification	3
Tender	7
Construction Supervision	34
Construction	
Package 1 (1-1 and 1-2)	25
Package 2	32
Package 3	27
Environmental and Social Monitoring	



Annual Disbursement Schedule	Total Cost (USD)	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	Remarks
1. Total E/S Cost	6,965,000		365,663	1,619,363	1,251,651	1,720,765	1,720,765	286,794	
1-1. Detailed Design Stage	1,828,313		365,663	1,462,650	-				
1-2. Tendering Stage	261,188			156,713	104,475				
1-3. Supervision Stage	4,875,500				1,147,176	1,720,765	1,720,765	286,794	
2. Total Construction Cost	38,692,021				10,806,576	16,209,865	11,675,580		
2-1. Package 1 (1-1 and 1-2)	8,971,769				2,870,966	4,306,449	1,794,354		
2-2. Package 2	18,800,429				4,700,107	7,050,161	7,050,161		
2-3. Package 3	10,919,823				3,235,503	4,853,255	2,831,065		
3. Contingency	3,869,202				1,080,658	1,620,986	1,167,558		10% of 2
Subtotal 1+2+3 (million USD)	49.53		0.37	1.62	13.14	19.55	14.56	0.29	1+2+3
4. Land Acquisition and Compensation Cost	2,394,000			1,596,000	798,000				
5. Administration Cost	457,000		63,034	94,552	94,552	94,552	94,552	15,759	1% of (1+2)
6. Tax and Duties	4,566,000		36,566	161,936	1,205,823	1,793,063	1,339,634	28,679	10% of (1+2)
Subtotal 4+5+6 (million USD)	7.42		0.10	1.85	2.10	1.89	1.43	0.04	
Total (million USD)	56.94		0.47	3.47	15.24	21.44	16.00	0.33	

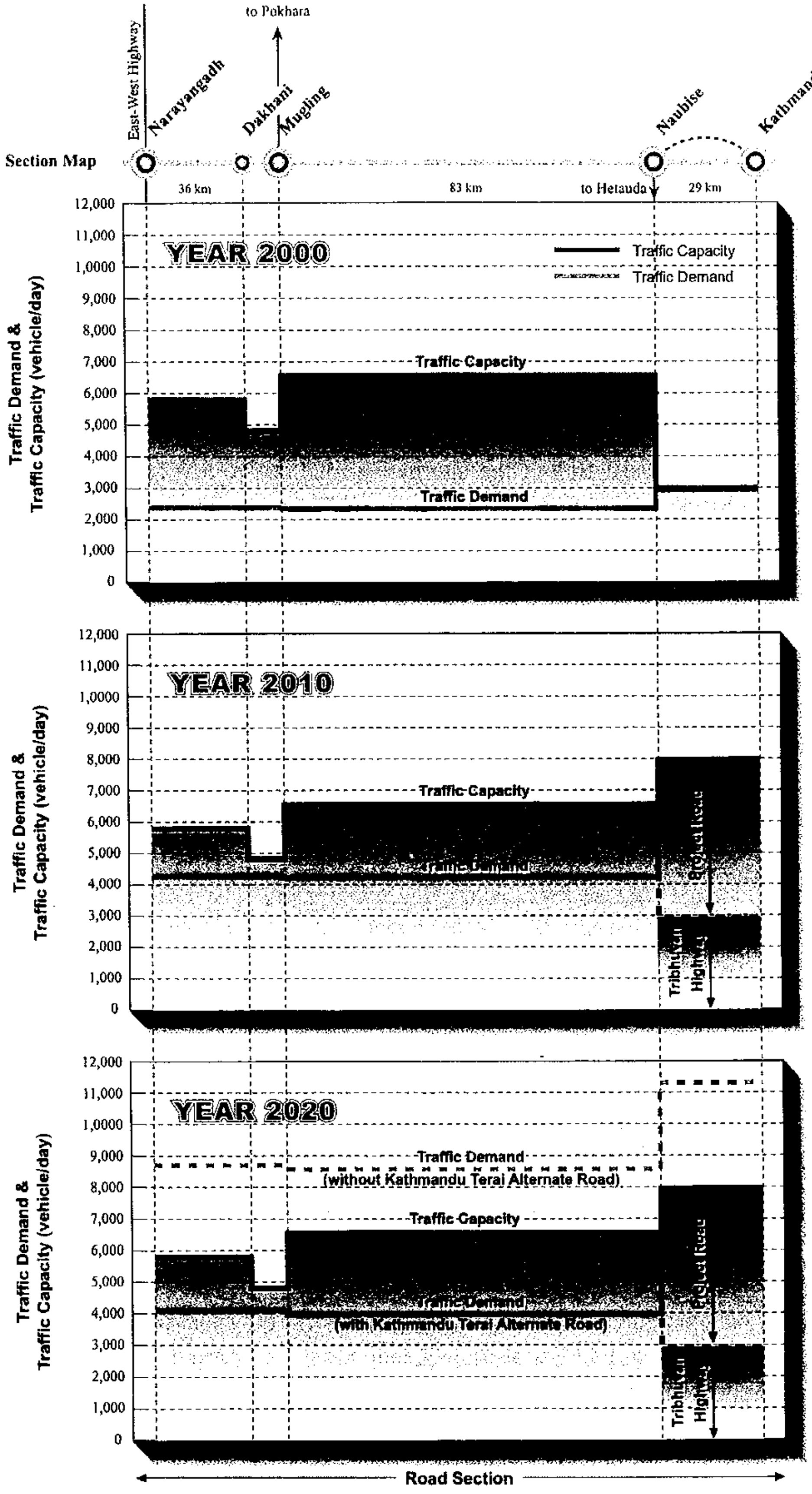


Figure 20.2 Traffic Demand of Each Section with Relation to the Traffic Capacity

21. CONCLUSION

The necessity of the urgent implementation of the Project has been justified by the following reasons:

- The Kathmandu – Naubise section of the Existing Tribhuvan Highway was justified to be the most critical section in the present road network linking Kathmandu with Terai in terms of traffic volume and capacity. The traffic of the Kathmandu-Naubise section has already reached its traffic capacity, and either 4-lane improvement of the existing road or construction of an alternative road is urgently required.

- The 4-lane improvement of the existing road, however, will cost more than that of construction of the alternative road due to it fragile geology and steep terrain and would cause tremendous traffic disturbance during the construction period. The 4-lane improvement option was judged to be practically impossible accordingly.

- Socio-economic activities in the Kathmandu valley, however, depend on this road, since the road is the sole route to other area in Nepal and India. Therefore construction of more reliable alternate road is necessary from the national security point of view.

This chapter presents the conclusion and recommendation of the Study.

1) The Project is assessed as technically feasible with scope of construction of a 2-lane paved road in a total length of 21.4km including a 705m highway tunnel.

2) The Project is assessed as economically feasible with IRR of 18.1%, NPV of 19.1 million US$ and B/C ratio of 1.57 with the assumption of Kathmandu - Terai Alternate Road opening in the year 2016.

3) The Project is assessed as financially not feasible. Toll revenue can not recover full financial cost invested in the Project. However, the toll revenue can recover annual operation and maintenance cost from the beginning of operation.

4) The existing Tribhuvan Highway, especially Thankot-Naubise Section, is considered to be high disaster potential area. Improvement of alignment and improvement of disaster prevention were studied. These study results indicate that the improvement of alignment is technically not feasible and cost for full scale of countermeasures for the disaster prevention will be beyond the practical range.

5) 4-lane improvement of the existing Tribhuvan Highway alternative was

studied for justification of the Project. The result shows that construction cost and land acquisition cost of all conceivable alternatives for the 4-lane improvement will be far higher than those of the Kathmandu – Naubise Alternate Road. Therefore it was concluded that the Project is economically more preferable to the 4-lane improvement alternatives.

6) Total project cost is estimated to be 56.9 million US$. Breakdown of the project cost is as follows.

Construction Cost	38.7 million US$
Engineering Cost	6.9 million US$
Contingency	3.9 million US$
Tax and Duty	4.5 million US$
Administration Cost	0.5 million US$
Land Acquisition and Compensation Cost	2.4 million US$
Total Project Cost	56.9 million US$

7) Traffic volume of the Project Road in the year 2010 and 2020 are expected to be about 3,900 vehicle/day and 5,340 vehicle/day, respectively. Traffic volume in the year 2020 is estimated under an assumption that Kathmandu - Terai Alternate Road is opened. Diversion traffic to Shindhuli Road is incorporated in the traffic demand forecast for year 2010 and 2020 as well.

8) It is proposed that the Project is divided into three (3) contract packages taking into consideration magnitude of the Project as well as the characteristic of the individual package. Construction period of each section is estimated as follows.

Package 1-1 & 1-2	:	25 months
Package 2	:	32 months
Package 3	:	27 months

9) It is recommended that the Project is implemented under foreign financial assistance by soft loan.

10) According to the examination of the overall implementation schedule on the road improvement between Kathmandu and Terai, the following schedule is recommended.

Objectives of short term plan (2002-2006):

- Construction of Kathmandu – Naubise Alternate Road
- Road Disaster Prevention for the existing Kathmandu - Narayangadh Road

Objectives of medium term plan (2007-2011):

- Improvement of Mugling - Narayangadh Section

Objectives of long term plan (2012 – 2020)

- Construction of Kathmandu – Terai Alternate Road

11) Initial Environmental Examination and Environment Impact Assessment carried out in the Study identified no serious negative environmental/social impact. Appropriate mitigation measures should be considered in detailed design stage and conducted during construction stage. After the Project Road is open, monitoring program should be employed as well.

12) Potential study on wind and solar power generation indicates a possibility to utilize these power generation systems for operation of the tunnel. It is recommended to conduct feasibility study on utilization of wind and solar generation for operation of tunnel in detailed design stage of the Project consecutively.

13) It is strongly recommended that a new truck terminal near the beginning of the Project Road is constructed in order to secure efficient operation of the Project Road and improvement of traffic condition of Kathmandu.