BASIC DESIGN STUDY REPORT ON THE PROJECT FOR RECONSTRUCTION OF BRIDGES IN KATHMANDU

THE KINGDOM OF NEPAL

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of His Majesty's Government of Nepal, the Government of Japan has decided to conduct a Basic Design Study on the Project for Reconstruction of Bridges in Kathmandu and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Nepal a survey team headed by Mr. Akio OHTSUKA, Head, Maintenance Engineering Division, Maintenance and Facilities Department, Metropolitan Expressway Public Corporation, from October 15 to November 23, 1989.

The team exchanged views with the officials concerned of the Government of Nepal and conducted a field survey in Kathmandu area. After the team returned to Japan, further studies were made. Then, a mission was sent to Nepal in order to discuss the draft report and the present report has been prepared.

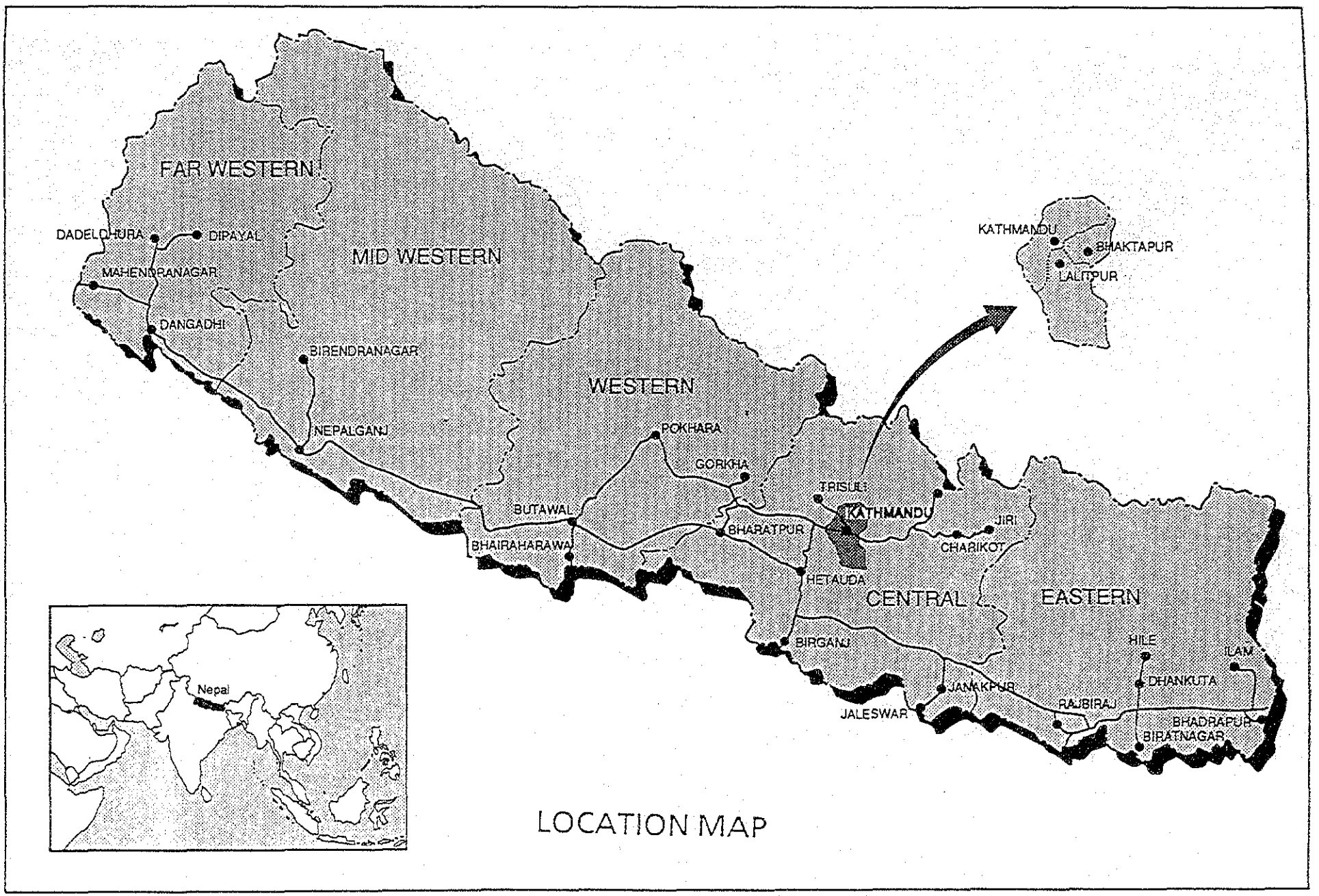
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of His majesty's Government of Nepal for their close cooperation extended to the team.

March 1990

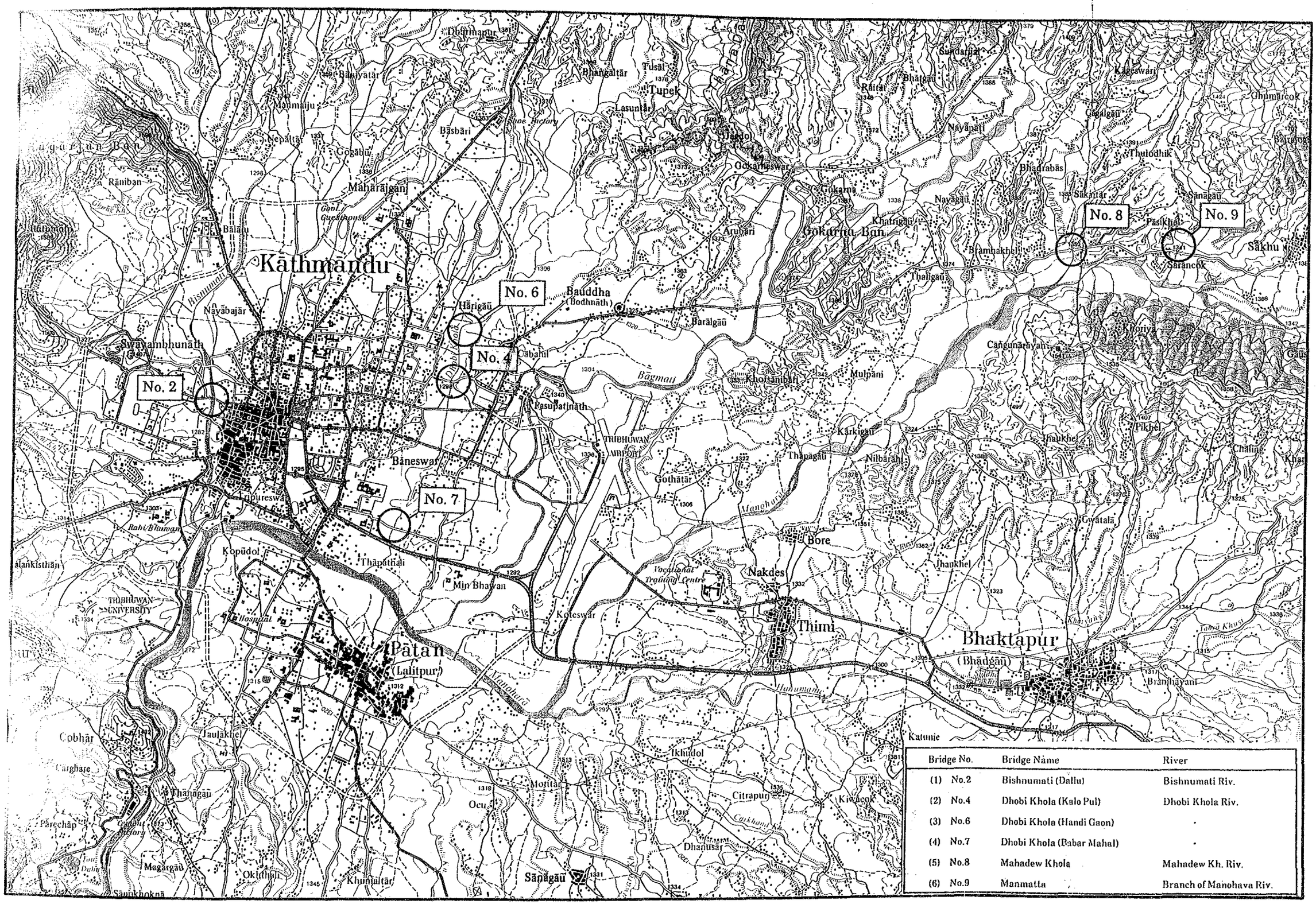
Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency



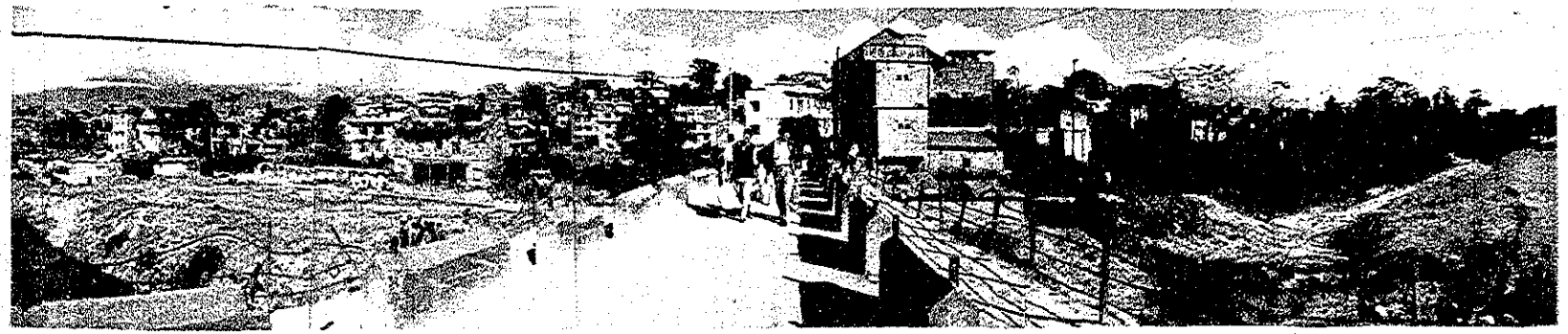
LOCATION MAP

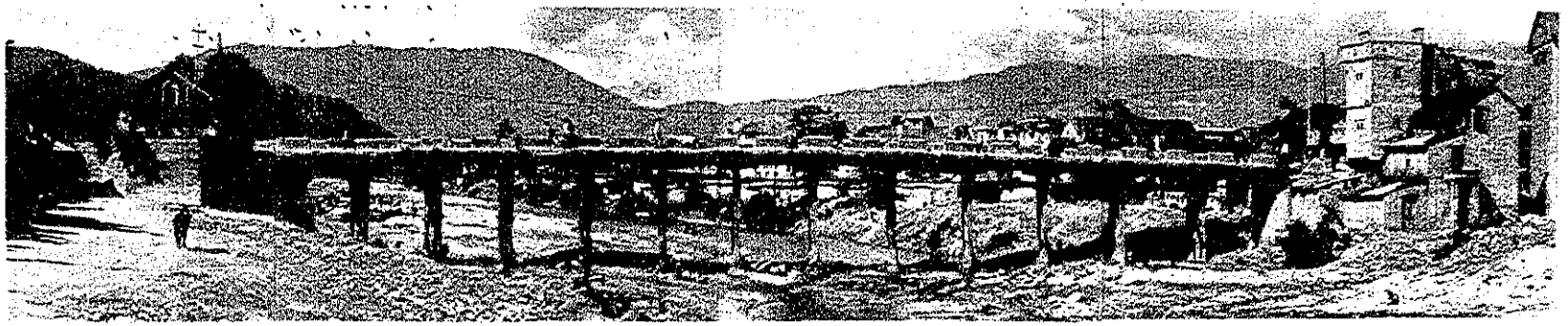
PLANNED BRIDGE LOCATIONS



Bridge No.	Bridge Name	River
(1) No.2	Bishnumati (Dallu)	Bishnumati Riv.
(2) No.4	Dhobi Khola (Kalo Pul)	Dhobi Khola Riv.
(3) No.6	Dhobi Khola (Handi Gaon)	-
(4) No.7	Dhobi Khola (Babar Mahal)	-
(5) No.8	Mahadew Khola	Mahadew Kh. Riv.
(6) No.9	Manmatta	Branch of Manohava Riv.

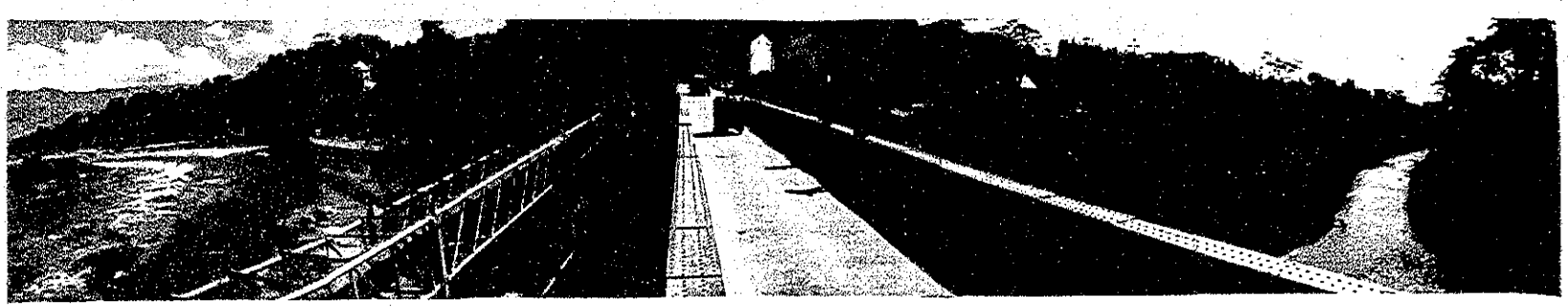
(1) No.2 Bishnumati (Dallu)





Bridge Type	:	Wooden Bridge	Bridge Length	:	56m
Bridge Width	:	3.0+2×1.5=6.0 m	Approach Road Width	:	5.5m~8.0m (Right),4.0m~9.0m (Left)
Circumstances	:	Not passable to vehicles. Serious disruption during construction is not allowed because of the high number of pedestrians. There are buildings near each existing abutment. There is general progressive scouring of the riverbed in this vicinity.			

(2) No.4 Dhobi Khola (Kalo Pul)

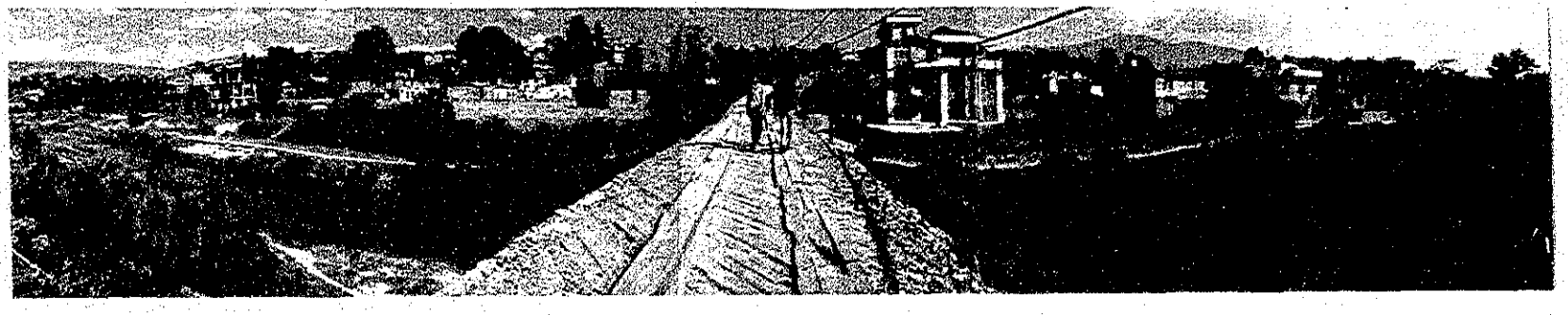


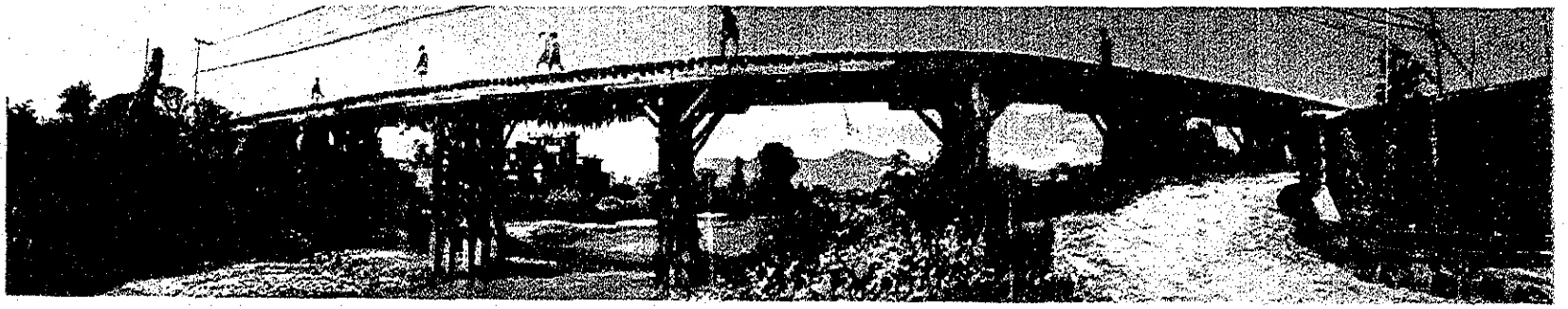
Bridge Type	:	Half-Through Steel Plate Girder Bridge
Bridge Length	:	44m
Bridge Width	:	4.0m
Approach Road Width	:	5.1m~8.6m (Right), 7.0m~9.0m (Left)
Circumstances	:	A lot of vehicles pass over the existing bridge linking the city area and Chabahil. Vehicles cannot pass on the bridge because of the inadequate width. There is progressive local scouring around the existing piers.

(3) No.6 Dhobi Khola (Handi Gaon)

Bridge Type	:	The bridge type, width and length cannot be confirmed as it has been washed away.
Approach Road Width	:	5.6m~6.7m (Right), 4.2m~6.5m (Left)
Circumstances	:	The wreckage of the bridge remains at the bridge site. Pedestrians cross the stream by stepping on logs. The bridge is in an important position linking Handi Gaon and the Chabahil area.

(4) No.7 Dhobi Khola (Babar Mahal)





Bridge Type	:	Wooden Bridge
Bridge Length	:	56m
Bridge Width	:	3.5m
Approach Road Width	:	4.6m~6.5m (Right), 4.6m~6.5m (Left)
Circumstances	:	The bridge is mainly used for pedestrians from the surrounding residential area. The wooden structure is badly dilapidated and the piers show signs of severe settlement.

(5) No.8 Mahadev Khola

Bridge Type	:	Wooden Bridge
Bridge Length	:	42m
Bridge Width	:	3.9m
Approach Road Width	:	5.5m (Right & Left)
Circumstances	:	The wooden bridge crosses Mahadev Khola river at a rice paddy field. Since the bridge structure is severely dilapidated, it is not usable. There is a temporary detour provided on the upstream side.

(6) No.9 Manmatta

Bridge Type	:	Wooden Bridge
Bridge Length	:	42m
Bridge Width	:	3.9m
Approach Road Width	:	5.5m (Right & Left)
Circumstances	:	The bridge, like the Mahadev Khola bridge, is located on the route connecting Kathmandu city area and Sankhu. It is not usable due to severe dilapidation.

SUMMARY

SUMMARY

Most of the bridges in the Kathmandu valley have been constructed during the past 50 to 80 years. They are severely dilapidated, as a result of flooding, and a recent increase in traffic volumes and loads. Given this situation, His Majesty's Government of Nepal (hereinafter referred to as HMG/N) made a request for Grant Aid assistance from Japan to reconstruct six bridges in the Kathmandu valley on January 12th, 1989.

In response to the request made by HMG/N for the Project for Bridge Reconstruction in Kathmandu Valley (hereinafter referred to as the Project), the Government of Japan (hereinafter referred to as GOJ) decided to carry out a basic design study (hereinafter referred to as the Study) on the Project. According to this decision, the Japan International Cooperation Agency (hereinafter referred to as JICA), was entrusted to carry out the Study and JICA decided to send a Basic Design Study Team (hereinafter referred to as the Team), headed by Mr. Akio OHTSUKA, Metropolitan Expressway Public Corporation, to the Kingdom of Nepal. The Team exchanged views with HMG/N on the basic design of the Project requested by the His Majesty's Government of Nepal. The Team carried out a bridge site investigation and data collection to determine the bridge locations and configurations, and then clarified the undertakings to be covered by HMG/N. The Team continued the structural design of the bridges and the cost estimate for the Project from the results of the field survey.

The Study's conclusions on the Basic Design are covered in the Final Report which is to be submitted to HMG/N the end of March, 1990.

The objectives of the Project are to provide solutions to traffic problems in the Kathmandu valley by reconstructing 6 existing bridges, i.e. (1) Maintain the effective traffic function and also facilitate the movement of urban and tourist traffic in the Kathmandu valley, and (2) Avoid

traffic-blocks on the existing bridges by reconstructing the bridges to meet new specifications.

Brief descriptions of the 6 bridges chosen for reconstruction under the Project follow:

(1) Bishnumati Bridge (No.2)

- Reconstruction Plan : to construct a new bridge to replace the existing bridge which is seriously dilapidated
- Bridge Type : 3-Span Simple Steel H-Beam
- Span Arrangement/ Bridge Length : 20.00+20.00+20.00=60.00m
- Bridge Width : 1×3.50 (Carriage way)+2×1.50 (Sidewalk)=6.50m

(2) Dhobi Khola Bridge (No.4)

- Reconstruction Plan : to construct a new bridge to replace the existing steel bridge whose width is inadequate for traffic
- Bridge Type : Simple Steel H-Beam and Simple Steel Plate Girder
- Span Arrangement/ Bridge Length : 15.00+30.00=45.00m
- Bridge Width : 2×3.25 (Carriage way)+2×1.00 (Sidewalk)=8.50m

(3) Dhobi Khola Bridge (No.6)

- Reconstruction Plan : to construct a new bridge of the existing bridge which has been washed away
- Bridge Type : 3-Span Simple Steel H-Beam
- Span Arrangement/ Bridge Length : 10.00+25.00+10.00=45.00m
- Bridge Width : 1×3.50 (Carriage way)+2×1.50 (Sidewalk)=6.50m

(4) Dhobi Khola Bridge (No.7)

- Reconstruction Plan : to construct a new bridge to replace the existing bridge which is seriously dilapidated
- Bridge Type : Simple Steel H-Beam and Continuous Reinforced Concrete Slab
- Span Arrangement/ Bridge Length : 2×8.50+25.00+2×8.50=59.00m
- Bridge Width : 1×3.50 (Carriage way)+2×1.50 (Sidewalk)=6.50m

(5) Mahadev Khola Bridge (No.8)

- Reconstruction Plan : to construct a new bridge ro replace the existing bridge which is closed to traffic due to serious structural dilapidation
- Bridge Type : Simple Steel H-Beam and Simple Reinforced Concrete Slab
- Span Arrangement/ Bridge Length : 8.50+25.00+8.50=42.00m
- Bridge Width : 1×4.00 (Carriage way)+1×1.50 (Sidewalk)=5.50m

(6) Manmatta Bridge (No.9)

- Reconstruction Plan : to construct a new bridge to replace the existing bridge which is closed to traffic due to serious structural dilapidation
- Bridge Type : Simple Steel H-Beam and Simple Reinforced Concrete Slab
- Span Arrangement/ Bridge Length : 8.50+25.00+8.50=42.00m
- Bridge Width : 1×4.00 (Carriage way)+1×1.50 (Sidewalk)=5.50m

In addition to the above, the substructure and foundation type are reinforced concrete wall and precast reinforced concrete pile type respectively.
The project cost is estimated at approximately 3.5 million Nepalese Rupees for the recipient portion.

The overall project implementation is scheduled for 16 months after conclusion of exchange of notes (E/N) between GOJ and HMG/N. Consultant contract, detailed design, tender document preparation and tender will be completed in 4 months. The prequalification evaluation and tender process is to be carried out in parallel with the detailed design. The construction period will be 12 months.

After completion of the reconstruction of the bridges, the requirements for maintenance activities relating to the new bridges will be: repair of damage by vehicle collision to such bridge accessories as handrails, curb-stones and end-posts; treatment of any corrosion of the steel girders and bearing shoes caused by insufficient maintenance of the bridges; repair of Spalling of the concrete bearing beds due to thermal and earthquake forces; remedial action in the event of local scouring around the piers and abutments due to river flood, and repair of damage on the approach roads due to deterioration caused by traffic increases.

The 6 bridges to be reconstructed are located in such circumstances as an earthquake-hazard zone, a river flood area, soft ground and a dense residential area. These circumstances are greatly influential on bridge stability. Reconstruction of the 6 bridges is very important, as they can be built to withstand the effects of future flooding and increased traffic loads, and thus enhance the economic activities of Kathmandu city and the surrounding area.

To increase the project's effectiveness in contributing to bridge safety and function and therby economic development in the Kathmandu valley, it is recommended that:

a) Existing Bridge Data Should be Prepared

Existing bridge data such as structural type, structural size, river conditions, traffic situation and other natural circumstances should be recorded on a bridge data file. These bridge data files would be effective in bridge planning and in drawing up a maintenance program.

b) Bridges Should be Inspected and Maintained

Bridge inventory sheets covering all bridges in Nepal should be prepared. An inspection and maintenance program based on these sheets would be effective in allowing rational management and budget savings for the existing bridges.

c) An Inspection and Maintenance System Should be Established

It is also recommended that an inspection and maintenance system for the existing bridges should be established so that the system can enhance further development of infrastructure in Nepal.

d) Bridge Structures should be Protected from River Flooding

Local scouring around the piers and abutments due to river flooding will easily cause settlement and inclination of the substructure. However, the bridge can be protected from these by systematic inspection activities.

e) Inspections for Abnormal Changes Should be Conducted

It is important to find out any abnormal change in the bridge structures by regular inspection. It is

particularly recommended to monitor changes on the substructure of No.4 bridge, including the existing water pipe line bridge. This is because lowering of the riverbed is occurring in the Dhobi Khola river which may cause settlement and inclination of the substructures.

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ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
ACRS	-	Atmospheric Corrosion Resistant Steel
ADB	-	Asian Development Bank
AOHWL	-	Annually Occurring High Water Level
D	-	Day
DCA	-	Department of Civil Aviation
DEPT	-	Depth of Hypocenter
DHPP	-	Department of Housing and Physical Planning
DOR	-	Department of Roads
DOT	-	Department of Transport
Ele.	-	Elevation
E/N	-	Exchange of Notes
EPCL	-	Epicenter Location
GDP	-	Gross Domestic Product
IBRD	-	International Bank for Reconstruction and Development
IMF	-	International Monetary Fund
JICA	-	Japan International Cooperation Agency
JS	-	Japanese Standard
LAT	-	Latitude
LONG	-	Longitude
M	-	Month
MOF	-	Ministry of Finance
MOT	-	Ministry of Tourism
MOWT	-	Ministry of Works and Transport
MPLD	-	Ministry of Panchayat and Local Development

NBCI	-	National Building Code of India
NCCN	-	National Construction Company of Nepal
NPC	-	National Planning Commission
NRS	-	Nepal Road Standards
NTC	-	National Transport Corporation
RNAC	-	Royal Nepal Airlines Corporation
SY	-	Sajha Yatayat
Y	-	Year
cm	-	centimeter
kg/cm^2	-	Kilogram per square centimeter
kg/m^2	-	Kilogram per square meter
kVA	-	Kilo Volt Ampere
km^2	-	Square kilometer
kg/m^3	-	Kilogram per cubic meter
kg	-	Kilogram
m	-	meter
mm	-	millimeter
t	-	metric ton
%	-	percent
US$	-	United States Dollar

CHAPTER 1. INTRODUCTION

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Most of the bridges in the Kathmandu valley have been constructed during the past 50 to 80 years. They are badly dilapidated, as a result of flood damage and are suffering the effects of the recent increase in traffic volume and heavy loads. Given this situation, His Majesty's Government of Nepal (hereinafter referred to as HMG/N) made a request on January 12th, 1989 for Grant Aid assistance from Japan to reconstruct the six bridges in the Kathmandu valley.

In response to the request made by HMG/N in respect of the Project for Bridge Reconstruction in the Kathmandu Valley (hereinafter referred to as the Project), the Government of Japan decided to carry out a basic design study (hereinafter referred to as the Study) of the Project. According to this decision, the Japan International Cooperation Agency (hereinafter referred to as JICA), was entrusted with carrying out the Study and JICA decided to send a Basic Design Study Team (hereinafter referred to as the Team), headed by Mr. Akio OHTSUKA, Metropolitan Expressway Public Corporation, to the Kingdom of Nepal. The Team exchanged views on the basic design of the Project requested by the His Majesty's Government of Nepal. The Team carried out bridge site investigations and data collection to determine the bridge locations and configurations, and then clarified the undertakings to be covered by the recipient. The Team continued the structural design of the bridges and the cost estimate of the Project from the results of the field survey.

CHAPTER 2. BACKGROUND OF THE PROJECT

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2.1 General Conditions in the Kingdom of Nepal

(1) Land and Population

The Kingdom of Nepal is situated from longitude 80°04' to 88°12' east and from latitude 26°22' to 30°27' north with a total area of 147,181 km^2 and is roughly the shape of a rectangle running east west. The northern border faces China, and the east, south and west borders face India. The capital city of the Kingdom of Nepal is Kathmandu at a height of about 1,300 m above sea level. The city lies east of the centre of the Kathmandu valley. The total population is reportedly 18,440,000 in 1989, the population growth rate was 2.6 percent per year from 1981 to 1989, and the population density is 125 people per square kilometer. The population of Kathmandu city was 308,002 in 1987. Average annual growth rate is 4.6 percent which is higher than the average for the country, which is 2.5 percent.

(2) National Economy

The Economy of the Kingdom of Nepal is mainly dependent on agriculture, which generates about 53 percent of GDP, that is 6,785 million NRs in the years from 1987 to 1988, or 3,870 NRs (approx. 180 US$) per person, with an average growth rate of 6.5 percent per year over the past 5 years. Major exports of the Kingdom of Nepal are agricultural products mainly supported by foods while imports consist of fuel, chemical products, medicine and industrial products. There is a trade deficit. Imports to Nepal come mainly from India. Expenditure exceeds income and the economy depends on foreign loans and domestic borrowing.

(3) National Development Plans

Targets of the seventh 5-year plan in the Kingdom of Nepal consist of expanding and accelerating production, increasing employment opportunities in production and providing for the minimum needs of the people. The growth rate target during the seventh 5-year plan is 4.5 percent, including 3.5 percent in the agricultural sector and 5.7 percent in the non agricultural sector.

(4) Transport and Traffic

In Nepal, the rugged mountains make development of roads and highways difficult. Recently, however, the construction of the East-West Highway started with financial assistance from foreign countries, namely China, United Kingdom, United States, U.S.S.R and India. The railway network consists of only two lines at present, one running for 48 km from Raxaul on the border with India to Amlekganj and the other running from Jainagar in India to Janakhpur in Nepal. A 42km long ropeway is being developed between Kathmandu and Hetauda. Despite the difficulties created by the mountainous terrain, the important trans-highways are now under construction with the assistance of foreign aid. Highway transport and civil aviation are emerging as the main modes of transport. Rivers suitable for transportation use are almost nonexistent.

(5) Roads and Bridges

The total length of roads reached 6,015km in 1986. The East-West Highway, called the Mahendra-Rajmarga Highway, with a total length of 1,052km, is under construction with financial assistance from the above mentioned countries. Two other highway routes, Dharam to Dhankuta (65km) and Butawal to Khoharpur (242km), have also been opened to traffic with aid from the United Kingdom and India aids. For mountainous areas which are further from the arterial roads, 350-suspension bridges were

planned during the sixth 5-year plan (1980~1985), and 50 of them have now been completed. During the seventh 5-year plan (1985~1990), Budgetary allocation for roads and bridges is 3,382 million rupees for road development, 149 million for normal girder bridges and 199 million for suspension bridges making a total of 3,730 million rupees.

2.2 Actual Condition of the Sector Concerned

The Executing Agency for the Project is the Department of Roads (DOR) under the Ministry of Works and Transport (MOWT), the agency that is responsible for planning, design, construction and maintenance of roads and bridges. The other organizations relevant to the Project are the National Planning Commission (NPC), the Ministry of Finance (MOF), the Ministry of Home Affairs/Police, the Ministry of Panchayat and Local Development (MPLD) and the Ministry of Tourism (MOT). A brief description of their functions or roles is given below.

Ministry of Works and Transport (MOWT)

- Department of Transport (DOT)	Control & Regulation of Commercial Vehicles
- Department of Roads (DOR)	Roads, Bridges, Maintenance
- Ministry of Housing and Physical Planning (DHPP)	Urban Planning
- National Transport Corporation (NTC)	Railways, Ropeways, Trolley Buses, Road Transport
- Sajha Yatayat (SY)	Urban Transport

National Planning Commission (NPC)	Transport Planning Review Functions
Ministry of Finance (MOF)	Budget Allocation for Transport
Ministry of Home Affairs/Police	Traffic Police, Safety, Accidents
Ministry of Panchayat and Local Development (MPLD)	Suspension Bridges, Trails, Local Road and Maintenance
Ministry of Tourism (MOT)	
- Department of Civil Aviation (DCA)	Airports and Airport Regulation
- Royal Nepal Airlines Corporation (RNAC)	Domestic & International Air Transport

2.3 Related Plans and Programs

Related plans and programs in the Kingdom of Nepal are mainly projects assisted by aid from India, China and Japan, as well as from international financial organizations such as the International Monetary Fund (IMF), the International Bank for Reconstruction and Development (IBRD) and the Asian Development Bank (ADB). The projects are mainly infrastructural, including road construction and rehabilitation. The IBRD assisted project for the reconstruction of Kathmandu valley bridges is closely related to the Project. A four-lane highway along the Bishnumati river and an arterial road crossing the Dhobi Khola river are at the planning stage.

2.4 Outline of the request

The Kathmandu Valley is populated by the three main centres of population namely, Kathmandu, Patan or Lalitpur and Bhaktpur. These are almost adjoining and there is a very heavy movement of traffic from one to another.

The valley slopes roughly towards the south west and the main drainage channels are Vishnumati River from north to south,

Baghmati River from north east to south west and Manahara River from east to west. There are a number of small rivulets known as Kholas which flow approximately southwards and meet the three above mentioned rivers.

A number of bridges have been constructed during the past 50 to 80 years across these rivers/kholas for the use of pedestrians and light vehicles. Most of these bridges have wooden pile foundations, a substructure of wooden members, with fabricated steel girders and sleepers making the superstructure.

A number of these bridges are now in a dilapidated condition and most of them are unsuitable for present day traffic demands which have increased many fold in the recent past, not only in the number of vehicles but also in speed and axle load. The present state of these bridges is imposing constraints on the movement of urban and tourist traffic. Indeed, it is considered a significant retarding factor in economic development and the tourist industry in the Kathmandu valley.

It is, therefore, very important for the over-all development of the valley, as well as for the benefit of the urban population, that the bridges in the valley should be improved, strengthened or reconstructed.

CHAPTER 3. OUTLINE OF THE PROJECT AREA

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3.1 General Conditions

Kathmandu is in a valley surrounded on all sides by mountains reaching an average height of 1,300m above sea level. Geologicallly, the valley is formed by sediments washed down from the surrounding mountains. Kathmandu city, which is Nepal's main population center, lies near the middle of the valley being located between the two main rivers, Bishnumati and Bagmati Khola, which flow from the northern to the southern part of the valley. The population of the Kathmandu area including Kathmandu city was 363,807 in 1981, which is approximately 2.4% of the total population of Nepal, 15,022, 839. In the Kathmandu valley almost 40% of transport means is non-motor vehicles such as bicycles and rickshaws. Although it might be thought that these light vehicles, in general, would not seriously damage the roads in the Kathmandu valley, nonetheless the existing bridges in the valley, wooden girder and steel truss bridges constructed from 50 to 80 years ago, are seriously deteriorated. They are also at risk of collapse in the event of river flooding and earthquake shock.

No.2 Bishnumati Bridge crosses over the Bishnumati river on the west side of Kathmandu city. Since Swayambhunath temple is on the right bank at the bridge site, a lot of sight-seers and local citizens pass over the bridge. There are a number of grocers, souvenir shops and houses.

No.4 Dhobi Khola bridge crosses over the Dhobi Khola river which is situated on the east side of Kathmandu city center and surrounded by residential property. The access road on the left side goes to Pashupatinath temple.

No.6 Dhobi Khola bridge is upstream of No.4 bridge and is surrounded by residential property. The access road on the left side crosses the ring road.

No.7 Dhobi Khola bridge also crosses over the Dhobi Khola river. Arniko highway (Kathmandu~Kodari) towards China runs downstream of the bridge. There are a lot of government offices on the right bank but mainly residential buildings on the left bank.

No.8 Mahadev Khola bridge is slightly isolated from Kathmandu city center. The bridge location is on the way to Sankhu from the ring road and is surrounded by agricultural fields.

No.9 Manmatta bridge is situated further from the city than No.8 bridge, on the same route, also surrounded by agricultural fields.

3.2 Traffic conditions

(1) Access Roads

The planned bridge locations are in dense population areas except for No.8 and No.9 bridges. The condition of each access road is as follows:

Table 3.1 CONDITIONS OF ACCESS ROADS

Bridge No.	Access Road Width (m)		Surface Condition
	Left	Right	
2	4.0~9.0	5.5~8.0	Bituminous Macadam
4	7.0~9.0	5.1~8.6	Asphalt Concrete Pav.
6	4.2~6.5	5.6~6.7	Bituminous Macadam
7	4.6~6.5	4.5~6.5	Bituminous Macadam
8	5.5	5.5	Bituminous Macadam
9	5.5	5.5	Bituminous Macadam

(2) Traffic Conditions

A traffic survey (12 hours observation) was carried out by the Team on November 16, 1988, at which time Bridges No.2 and No.7 were not passable to vehicles and Bridge No.6 had collapsed in a previous flood. The number of vehicles and pedestrians in the following table are the results of studies at the bridge sites.

Table 3.2 RESULT OF TRAFFIC SURVEY

Bridge	Bicy-cle	Motor-Cycle	Light-Vehicle	Truck	Bus	Total	Pedes-trians
No.2	1,707	533	0	0	0	2,240	11,799
No.4	3,290	1,886	3,658	131	216	9,181	5,528
No.6	863	9	0	0	0	872	4,864
No.7	522	85	0	0	0	607	3,481
No.8	176	81	134	33	72	496	1,258
No.9	199	88	136	37	72	532	1,167

Note : Units for Pedestrians : Number of people
Units in all other cases : Number of vehicles

3.3 Natural Conditions

(1) Topography

The Kathmandu valley is surrounded by mountains such as Purchouki, Nagarkot, Swaburi, Nagarjun and Chandragiri, with an average height of 1,300 meters. In the valley, the Bishnumati, Dhobi Khola and Bagmati rivers run generally from north to south and the Manohara and Hanumante rivers run from east to west. After these rivers join the main Bagmati river, the flow is towards Chobar gauge.

(2) Climate

The climate of the Kathmandu valley, which is situated at a latitude of 27° North, is semitropical, with maximum and minimum temperatures of 28°C and -2°C respectively. Rainfall is 100 to 400 mm during the rainy season of May to September and 15 to 45 mm during the dry season of October to April.

(3) Flooding

Gauge at Chobar is located where the Bagmati river flows out of the Kathmandu valley. According to the records from the gauge, maximum water levels occur between June and September and minimum levels occur between March and June. It is conceivable that flooding periods on the

Bishnumati and Dhobi Khola rivers bear a close relationship to those on the Bagmati river since these two rivers are branches of the Bagmati river.

(4) Geology and Soils

The northern part of the valley is dominated by a granite layer (Gokarna formation) while the southern part is dominated by sedimentation, 400~500 m in depth. At the No.2 Bishnumati bridge site, from the river bed to a depth of 2 m the soil consists of coarse-sand and gravels.

Below this layer, very soft clayey silt lies more than 35 m deep. At the No.4 Dhobi Khola bridge site, the river bed up to 8 m deep is silty sand with fine gravels. Below this layer, relatively soft silty sand lies from 8 to 25 m. At the No.6 Dhobi Khola bridge site, loose-coarse sand lies from the river bed up to 8 m deep. Below, fine-silty sand lies from 8 to 16 m and silty clay lies up to 30 m deep.

At the No.7 Dhobi Khola bridge site, a soft layer lies from the river bed to 7 m. Below, soft clayey silt lies up to 35 m. At the No.8 Mahadev Khola bridge site, the surface portion of the river bed consists of coarse sand, fine gravels, clayey silt, and sandy clay alternately. Below, from 5 to 13 m it consists of sand and fine sand, and dense sand with gravels up to 20 m deep. At the No.9 Manmatta bridge site, loose sand lies from the river bed to 5 m, dense-clayey sand up to 13 m deep, and silty sand with gravels up to 20 m deep.

(5) Earthquakes

According to records of past earthquakes in Nepal, there is on average one earthquake per year with a magnitude greater than five. The Nepal-Bihar earthquake in January, 1934, severely shook Kathmandu city causing many deaths. Kathmandu city is specified in zone V,

maximum hazard, in the National Building Code of India 1970, Part IV, Indian Standards.