(ii) Proposed Alignment

Starting and end points of South Link of Inner Ring Road are fixed in the prospect of long term plan proposed in this study.

- Starting Point : Kuleswor (at intersection of Kalimati and Teku road)
- End Point : Arniko Highway (at East of the Dhobi Khola Bridge)
- Estimated Route Length : 3,750 m

Proposed alignment of South Link of Inner Ring Road was determined considering the control points described in Table 3.3.

Table 3.3 Control Points along South Link of Inner Ring Road

Control Point	Description
C - 1	Starting point at intersection of Kalimati and Teku Road.
C - 2	to move around Ramghat (a historical place)
C - 3	to keep the existing row of trees and use it as roadside trees.
C - 4	to pass about 50 m south of existing Bagmati bridge with view to prepare right turn lane.
C - 5	to pass just north of compound wall belonging to maternity hospital staff residence
C - 6	to move around Barahi temple
C - 7	to use left side bank of Dhobi Khola as far as possible to avoid building compensation where possible.
C - 8	End point, about 50 m east of existing Dhobi Khola bridge

(2) New Bagmati Bridge at Thapathali

New Bagmati Bridge is planned to be constructed beside the existing 2 -lane Bagmati Bridge at Thapathali, which is only the bridge across Bagmati river inside the Ring Road. Present traffic volume on the bridge was counted to be 50,000 ADT approx. according to the survey result conducted by the Study Team in December, 1992, which is far beyond the traffic capacity of the existing 2 lane bridge. The expansion of traffic capacity across Bagmati river, therefore, is required from 2 lanes to 4 lanes.

The existing bridge at Thapathali had been suspended by the settlement of one of its pier due to scouring of foundation bed since August 1991 till March 1992. The countermeasure was carried out by DOR to reconstruct the broken pier as well as to prevent the further scouring of foundation bed. The bridge would be retained at least for five to ten years if the protection work for another section of piers would be done properly against the lowering of river bed.

(i) Alternative plans;

Three alternative plans were considered for expansion of bridge capacity as follows (see Fig. 3.4):

Alternative 1: Construction of new bridge with 4 lanes

Total replacement from the existing 2 lane bridge to new bridge with 4 lanes. Existing bridge will be utilized as detour during the construction of new bridge and be demolished upon completion of new bridge.

Alternative 2: Construction of dual bridge with 2 lanes (total 4 lanes)

Firstly 2-lanes bridge will be constructed downstream in parallel with the existing bridge. Upon completion of it, existing bridge will be demolished and new 2-lanes bridge will be constructed at the same location of existing bridge.

Alternative 3: Construction of bridge with 2 lanes and Improvement of existing 2-lanes bridge (total 4 lanes)

New 2-lanes bridge will be constructed downstream in parallel with the existing bridge and existing bridge will be rehabilitated and improved.

(ii) Evaluation of Alternative plans;

Alternative 1 should be constructed 25 m downstream of the existing bridge since the existing bridge should be used as detour during the construction of new bridge. In order to keep suitable alignment of the bridge, it requires demolishment of large numbers of houses and buildings including historical monuments and temples at both end of proposed bridge, which may raise the difficulty of implementation of the project.

Alternative 2 has no serious compensation problems on house and building demolishment, however, it will be the highest construction cost among three.

Alternative 3 is the lowest construction cost among them and no compensation problems on house and building are expected, so that an initial investment could be minimized. However, since the lowering the river bed is progressing seriously, protection of the existing bridge against scouring foundation might be necessary in fiture.

(iii) Conclusion

Alternative 3 is recommendable taking into consideration the smallest initial investment, availability of existing bridge and ease of implementation.

Proposed new 2 -lanes bridge will be constructed at downstream of the existing bridge where the old existing pedestrian steel bridge existed. It must be demolished before starting the construction of new bridge.

Intersection at Thapathali side should be reconstructed properly taking into account the turning movement of pedestrians and vehicles including slow vehicles, such as bicycle and rickshaw. General view of the proposed bridge is as shown in Fig. 3.5.

(3) Koteswor Access

(i) Alternative Route Study

Two alternative routes were proposed at middle section of Koteswor Access as shown in Fig. 3.6.

The alternative 1 was planned taking into account of bridge crossing point as well as the accessibility to inner area. Alternative 2 was proposed to protect the encroachment of river by placing the road as a hard edge of the river side.

	Alternative 1	Alternative 2
- Length of the Road	1,250 m	1,150 m
- Construction cost	NRs. 120 M	NRs. 150 M
- Land/building acquisition cost	NRs. 40 M	NRs. 35 M
- River protection cost	small	large
- Impact on development of inner areas	large	small

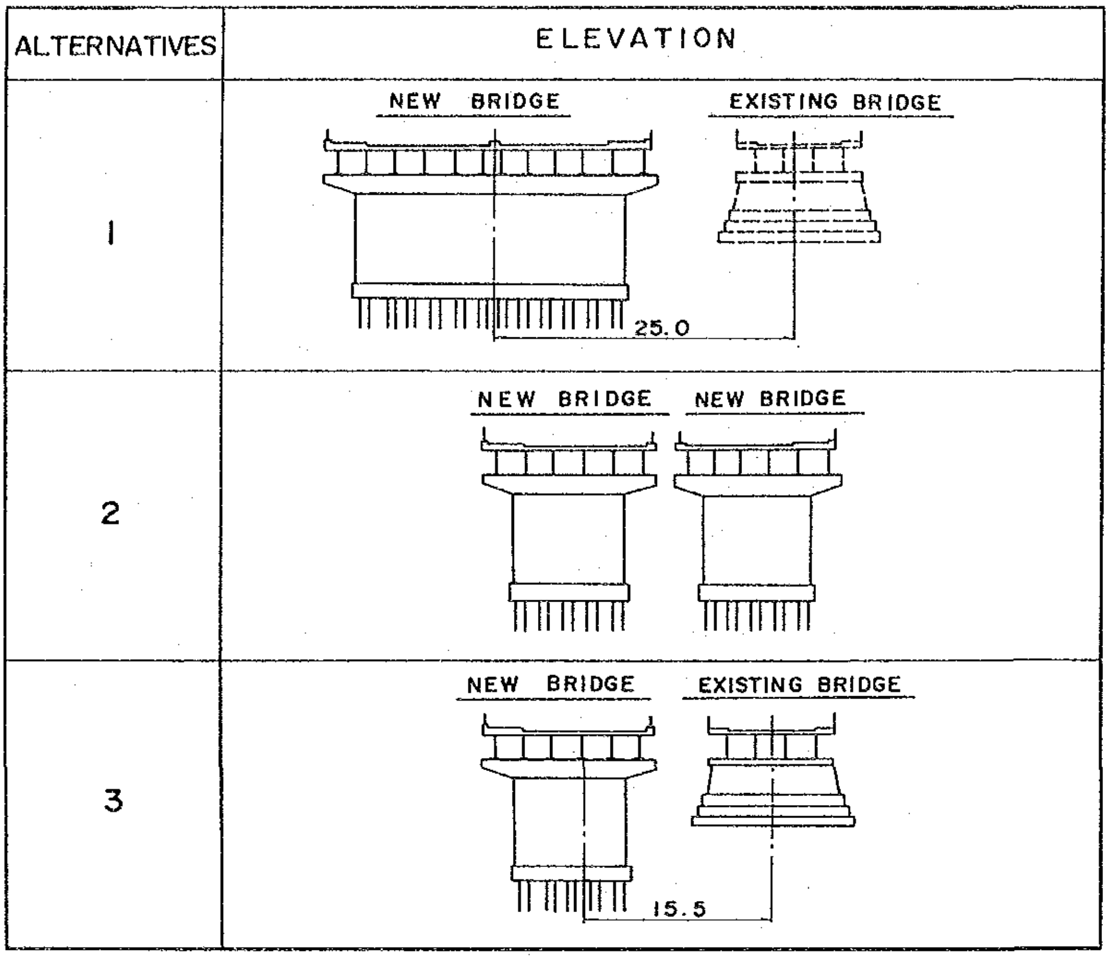


Figure 3.4 BAGMAT BRIDGE No.2 ALTERNATIVES

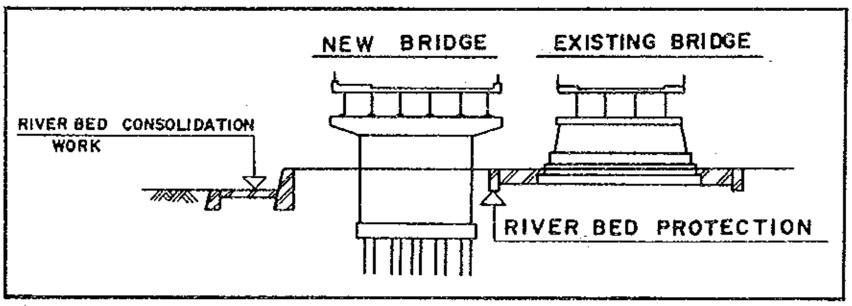
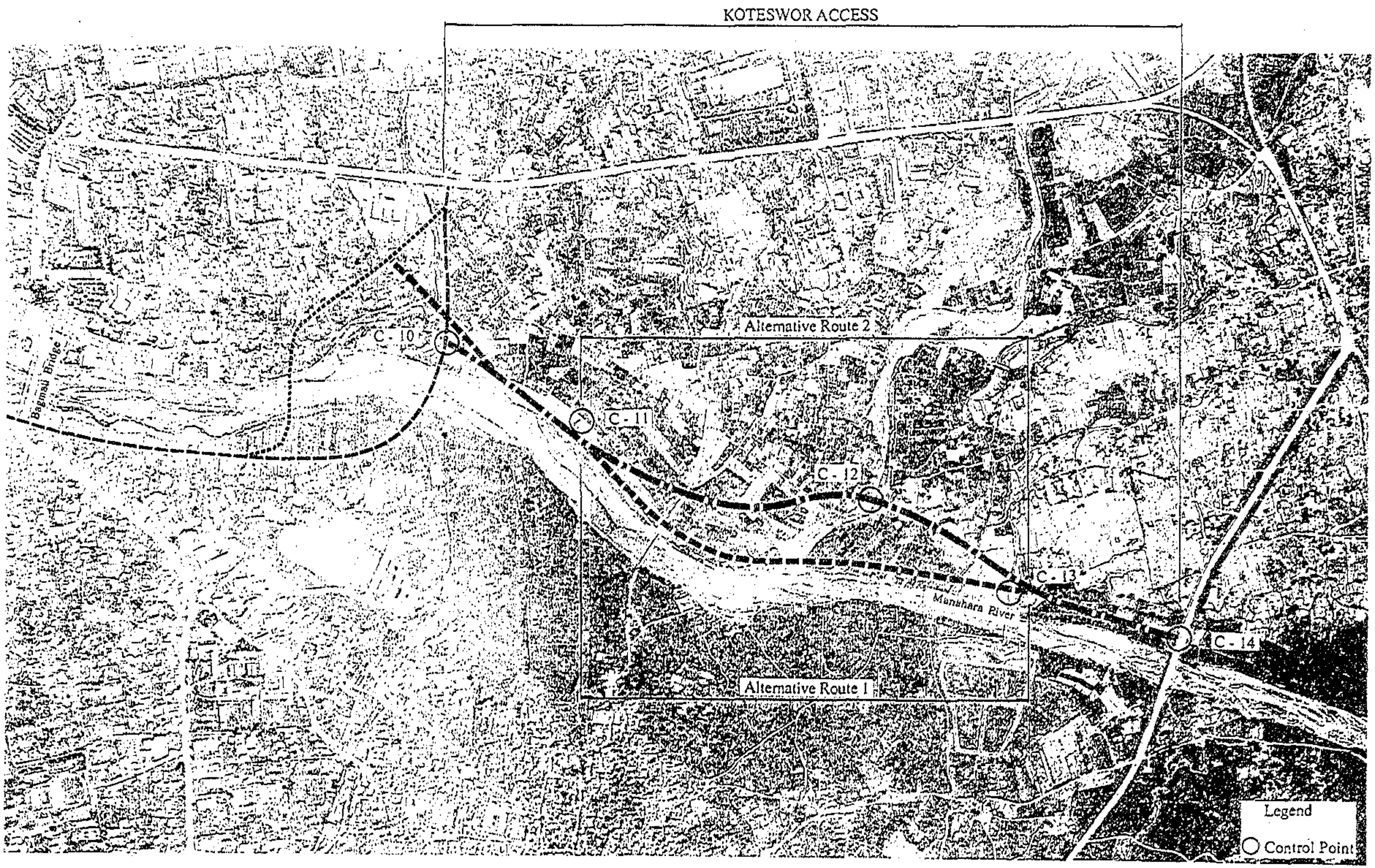


Figure 3.5 BAGMAT BRIDGE No.2 CROSS-SECTION



Scale 1:10,000 (Approximately)

Figure 3.6 PROPOSED ROUTE OF KOTESWOR ACCESS
(Showing alternative route and control point)

As a result of the comparison of each alternative route, Alternative route 1 was selected for its advantage in construction and maintenance costs and effect on development of inner area.

(ii) Proposed Alignment

Proposed alignment of Koteswor Access was planned considering control points as shown Table 3.4.

Table 3.4 Control Points Along Koteswor Access

Control Point	Description
C - 10	Starting point at 50 m north of New Bagmati Bridge No. 3
C - 11	to pass south of Ram Ghat
C - 12	to pass suitable bridge site
C - 13	to avoid back stay of existing bridge
C - 14	to meet Ring Road at about 50 m south of the existing bridge

(4) Sanepa Access

Starting point of Sanepa Access will be at the point about 50 m east of Bagmati bridge No.1 on South Link of Inner Ring Road, and the Access meets Ring Road (C-9) at about 50 m east of the existing bridge. There is no other alternative route for this Access. Estimated route length is 500 m. (See Fig. 3.3)

(5) Patan Access

Patan Access will be constructed by widening the existing feeder road located 350 m south of the existing Bagmati Bridge. The length of the road will be about 200 m.(See Fig. 3.3)

Although the widening of the feeder road passing around the Engineering Campus with length of about 1,300 m is possible alternative route, it is not positively considered in the Guide Plan of the Patan Conservation and Development Program, in which the road has been proposed as a secondary road.

3.3.3 New Bus Terminal Access at Balaju

(1) Alternative Route Study

Two alternative routes are considered as follows:

Alternative 1; Construction of new access from Narayabazar to the Ring Road

Alternative 2; Widening of existing road

The location of each alternative route is presented in Fig. 3.7 and the results of comparative study was summarized in Table 3.5.

Alternative 1 is recommended taking into consideration ease of implementation due to less numbers of house compensation and land acquisition as well as better traffic movement in Nayabazar area near city center.

(2) Proposed Alignment

The starting point of Alternative 1 should be connected with Bishnumati Link Road proposed in ADB's Kathmandu Urban Development Programme (C - 15).

The route in the Samakhushi area should be run to minimize the building compensation cost (C - 16, C - 17, C - 18).

End point of the route should be located at middle point between existing Samakhushi Road and entrance of the New Bus Terminal considering the safety and efficient traffic turning movement at each intersection.

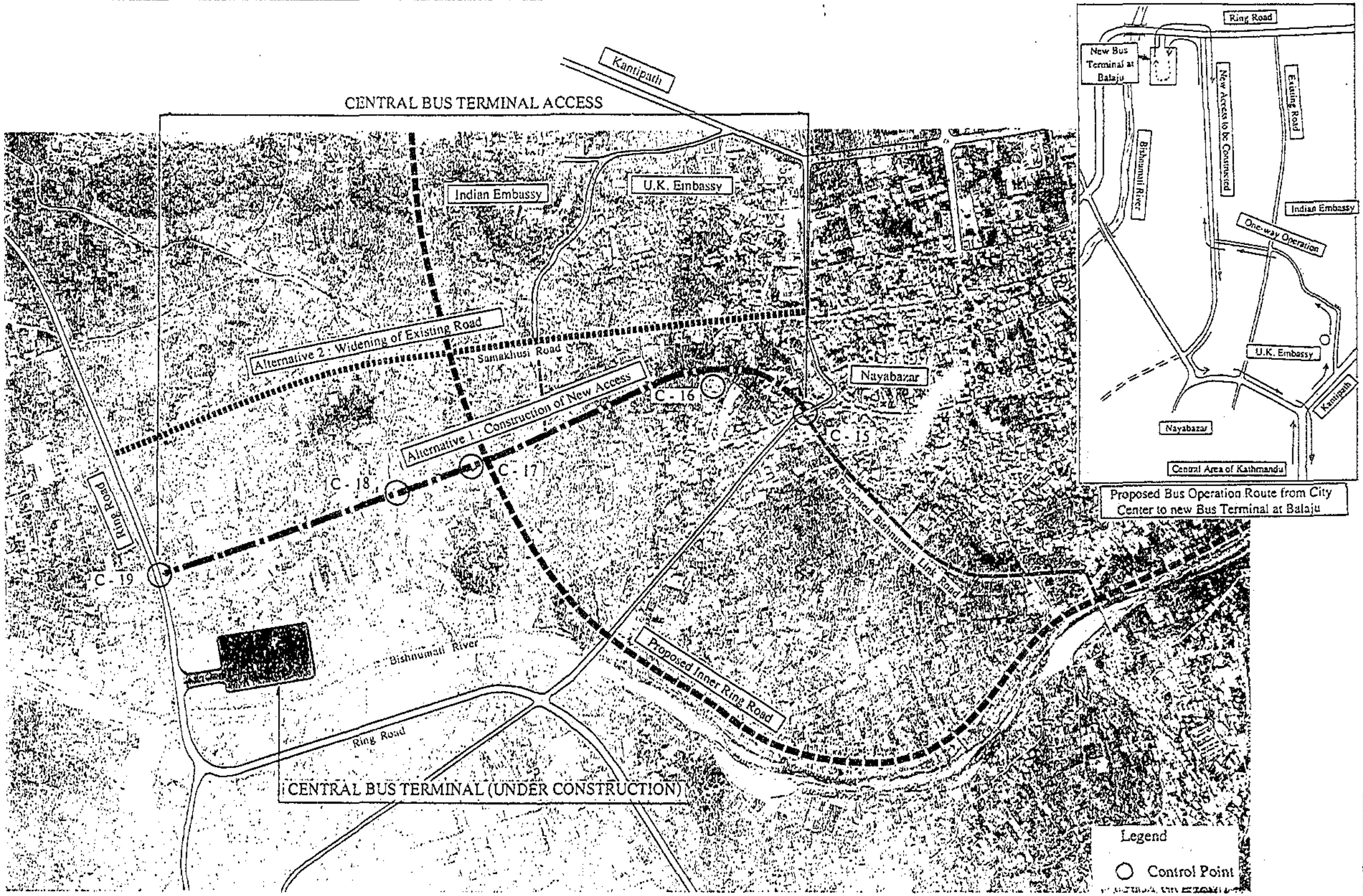


Figure 3.7 PROPOSED ROUTE OF CENTRAL BUS TERMINAL ACCESS
(Showing control point)

Table 3.5 Comparative Study on access Route to New Bus Terminal

29-Apr-92
Unit: NRs.1,000 (¥1,000)

Description	Alternative 1	Alternative 2
Objectives:	To provide access to the New bus Terminal at Balaju by extending the Bishnumati Link Road up to the Ring Road, with partial one way system from UK Embassy.	To provide access by widening of the existing gravel road from the Narayabazar up to the Ring Road.
Route Length	1,750 m	1,650 m
Two - Way (new construction)	1,750 m	
Two - Way (widening of existing road)	-	1,650 m
One - Way (widening section)	800 m	-
	(500 m)	-
Approx. Construction Cost		
(a) Construction Cost		
Two - Way (new construction)	106,000	-
Two - Way (Widening of existing road)	-	100,000
One - Way (widening & new const.)	24,000	-
Sub total (1)	130,000	100,000
	(Equiv. to ¥373,000)	(Equiv. to ¥279,000)
(b) Land/Building Compensation Cost		
Land Acquisition	45,000	62,000
Building Acquisition	27,000	71,000
(Nos. of buildings to be demolished)	(25 nos. approx.)	(65 nos. approx.)
Sub total (2)	72,000	133,000
Total (1) + (2)	202,000	233,000
	(Equiv. to ¥564,000)	(Equiv. to ¥65.000)

Remarks:

(1) Construction on widening of existing road includes the demolishment cost of houses and buildings.

(2) Land acquisition area was calculated on the basis of ROW 20 m for new construction, and 14 m for widening section. Unit cost of land and building acquisition were referred to ADB "KTM Urban Development Project Preparation Report", March 1992.

(3) Exchange Rate: US$1.0 = NRs. 48.0 = ¥134, or NRs. 10 = ¥2.79, (As of April, 1992)

Evaluation:

1. Construction cost of Alt. 1 is slightly larger than that of Alt. 2, however, land and building acquisition cost is small compared with Alt. 2, because Alt. 2 must relocate and demolish numbers of houses and buildings which are densely developed along the existing road.
2. Alignment of Alt. 1 is connected with the Bishnumati Link Road proposed by ADB, which will reduce traffic congestion on the city roads around Nayabazar area caused by the shifting of new bus terminal at Balaju, by dispersing the traffic to Bishnumati link road and surrounding other roads.
3. Alt. 1 provides good access between the CBD and the northern part of the Ring Road, which will induce the urbanization in the surrounding areas and increase road density.

Conclusion:

Alt. 1 is recommended taking into consideration good accessibility, small cost of land and building acquisition, ease of construction, better traffic movement and road network.

3.4 Alternative Bridge Study

3.4.1 General Description of the Proposed Bridge

As the result of the alternative route study made in the previous paragraph 3.3, the four number of bridge were planned to cross Bagmati River. Name of bridge given by the Study team is as shown below:

(i) Bagmati Bridge No.1 located at Kalimati

(ii) Bagmati Bridge No.2 located at Thapathali

(iii) Bagmati Bridge No.3 located at Chakupat

(iv) Bagmati Bridge No.4 located at Koteswor

The following is the general conditions and situation around the proposed bridge sites which should be taken into consideration in the bridge planning:

(1) Bagmati River;

Bagmati river is flowing in the central area of Kathmandu Valley, separating Kathmandu and Patan cities. The width of river is almost the same along its length. However, the main stream seems to change its course regularly. In recent years the river bed level seems to have lowered considerably and local scouring around the existing piers is noticeable.

(2) Existing Bagmati Bridge at Thapathali;

There is the existing 2-lanes bridge at Thapathali which is only the bridge across the Bagmati River inside the Ring Road. The existing Bagmati bridge could be utilized for at least five to ten years should the protection works against the scouring foundation be properly done.

(3) Geological conditions;

Kathmandu valley consists of very soft sediments with the low bearing capacity of the soil up to a depth of 400 - 650 m. As such, superstructure should be as light as possible and friction piles be considered rather than bearing piles or shallow foundation.

(4) Weather conditions;

Rainfall in Kathmandu valley is concentrated in the rainy season from mid June to mid September. According to the rainfall data, almost 70% of the total annual precipitation occurs during this period and flood levels are at their highest.

(5) Maintenance capability;

Bridge structure requires periodical maintenance, however, it has not been done properly in Nepal due to financial difficulty. Bridges should be planned to minimize the maintenance cost.

(6) Environmental Problems;

The planned bridges are located in an urban area so that it should be planned not to disturb adjacent residence.

(7) Earthquake;

The Kathmandu Valley is situated in a strong seismic zone. Earthquake resistant design has to be adopted for these bridges.

3.4.2 General Concept in Bridge Planning

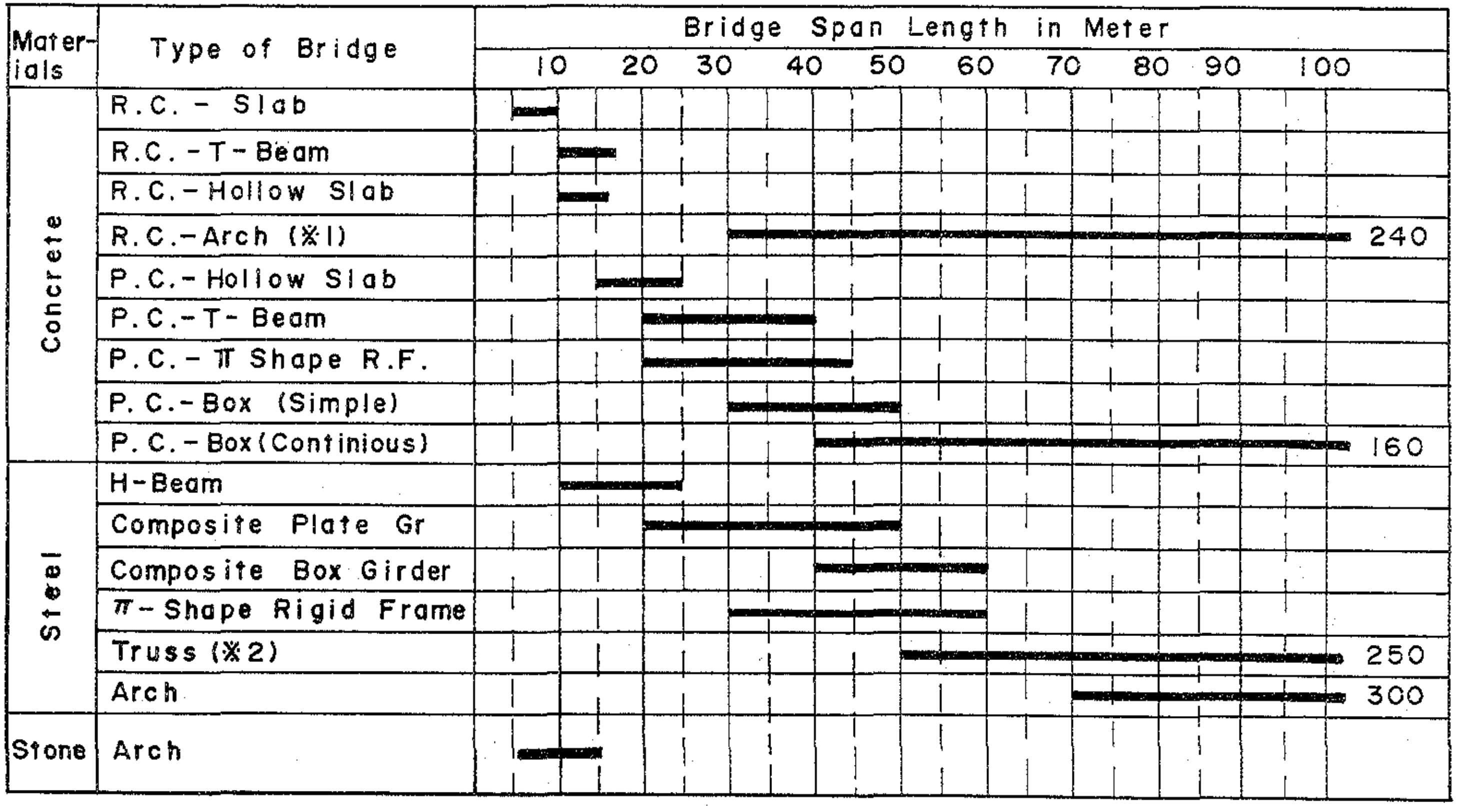
(1) Superstructure

Fig. 3.8 shows the conceivable alternative superstructures on the basis of bridge span length. Considering the natural conditions, construction methodology and planning conditions (bridge width, length, formation height, etc.), the following types of superstructure are considered for the of proposed bridges:

a) Reinforced Concrete T-Girder (RC-T)

b) Reinforced Concrete Hollow Slab (RC-S)

c) Pre stressed Concrete T-Girder (PC-T)



Note : ※1, In case of contilever election method applied, prestress is required.

※2, continious type is advantageous in case span less length more than 80m.

Figure 3.8 Conceivable Alternatives of Superstructure

d) Pre stressed Concrete Hollow-Slab (PC-H)

e) Composite Rolled Steel Girder (H-Gr)

f) Composite Steel Plate Girder (St-Gr)

RC-T girder and RC-Hollow slab bridges are advantageous for its easier material availability from local. However, the self weight of superstructure is relatively heavy so that span length are limited to about 13 m to 15 m. Since Bagmati river is considered to be a main stream, which requires the minimum bridge span of 20 m, RC bridges are not recommendable.

Pre-stressed concrete (PC) bridge is applicable. However, there seems to be technical problems in producing high strength concrete due to the quality of local cement. In case of longer span bridge, PC bridge is disadvantageous because of the bigger reactions to the foundations, if it is friction pile foundation.

Steel structure is of advantage to the bridge located on the soft ground, especially the bridge required for friction pile foundation. The material cost is relatively high because it must be imported from the outside, however, construction period is shorter than that of PC bridge.

Based on the above concept, following type of superstructures are considered as alternatives.

c) PC-T

d) PC-H

e) H-Gr

f) St-Gr.

(2) Sub-Structure

The applicable types of sub-structure are wall type, cylindrical column type and rahmen type. Since the pier height of proposed bridge seems to be low and local scouring are expected, the wall type is recommended and no alternative is proposed.

(3) Foundation

The main geological constituent at the proposed bridge sites is silt/clay with the black cotton soil. The N-value up to more than 30 m depth from the surface are found to be less than 10. This kind of soft lake sediment lies to a depth of 400 - 650 m. In this kind of soil the friction pile foundation is the most suitable type. The types of pile that may be used are steel pipe piles, bore piles, PC or RC piles.

Proposed bridges are located in urban areas so that noise and vibration should be minimized during the construction of bridge foundation. For low noise and low vibration, steel pipe piles driven by vibro-hammers or bore piles are suitable. The steel pipe piles is advantageous on quality assurance, however it is disadvantageous on construction cost because of the imported materials.

The constructions cost of bore piles (cast-in-place concrete) is lower than that of steel pipe piles. However, bore pile is not suitable for the bridge where a lot of natural gas are producing because of the safety of the construction as well as the difficulty of quality control of concrete.

According to the geotechnical investigation conducted by the Study Team, a natural gas are expected at the bridge sites. Use of bore pile foundation therefore should be studied carefully. Some bore pile foundations are being constructed at present in another project in Kathmandu Valley, however, they may have a large risk on quality of concrete due to natural gas.

3.4.3 Alternative Bridge Planning

(1) Bagmati Bridge No. 1 (Kalimati Bridge)

River section at this bridge site is wide and nearly of a rectangular shape. It has changed the main stream frequently so that the uniform span arrangement with more than 20 m span length seems to be appropriate. The following alternative bridges have been proposed for this bridge:

(i) PC-T Girder

(ii) PC-H Slab

(iii) H-Girder

(iv) St-Girder.

(2) Bagmati Bridge No. 2 (New Bagmati Bridge)

The proposed new bridge is planned to be located downstream of the existing Bagmati Bridge. The position of piers span arrangement should be the same as that of existing bridge to obtain smooth flow of river. Either St-Girder or PC-T bridge are considered for superstructure taking into account the span arrangement of existing bridge (approx. 30 m) as follows;

(i) PC -T

(ii) St - Girder

(3) Bagmati Bridge No. 3 (Chakupat Bridge)

The section of the river and other site conditions are similar to Bridge No. 1. The alternative plan proposed for this bridge is the same as Bridge No.1 as follows:

(i) PC-H Girder

(ii) PC-T Slab

(iii) H-Girder

(iv) St-Girder.

(4) Bagmati Bridge No. 4 (Koteswor Bridge)

The shape of the river cross-section at this site is double tier trapezoidal section. The span arrangement should be planned not to locate the central pier in the main stream. The following alternative plans are considered for this bridge:

(i) PC-T Slab

(ii) St-Girder

(5) Summary of Bridge Alternatives

Summarizing above, the following alternatives are considered for selection of optimum bridge type and span arrangement: (See Fig. 3.9).

Bridge Name and No.	Length m	Alternatives	Bridge Type	Approx. Span Arrangement
Bagmati Bridge No. 1	150.0	a)	PC-H	20+5 x 22+20
		b)	PC-T	5 x 30
		c)	H-Gr	20+5 x 22+20
		d)	St-Gr	5 x 30
Bagmati Bridge No. 2	140.0	a)	PC-T	16+4 x 31
		b)	St-Gr	16+4 x 31
Bagmati Bridge No. 3	120.0	a)	PC-H	6 x 20
		b)	PC-T	4 x 30
		c)	H-Gr	6 x 20
		d)	St-Gr	4 x 30
Bagmati Bridge No. 4	60	a)	PC-T	3 x 20
		b)	St-Gr	2 x 30

Note :
- PC-T : Prestressed Concrete T-Girder
- PC-H : Prestressed Concrete Hollow Slab
- H-Gr : Composite Rolled Steel Girder
- St-Gr : Composite Steel Plate Girder

3.4.4 Criteria for Selection of Alternative Bridge Plan

Alternative plans for each bridge are evaluated to select the optimum bridge type taking into consideration the following factors:

- River Conditions
- Soil Conditions
- Seismicity
- Construction costs
- Construction Period
- Maintenance

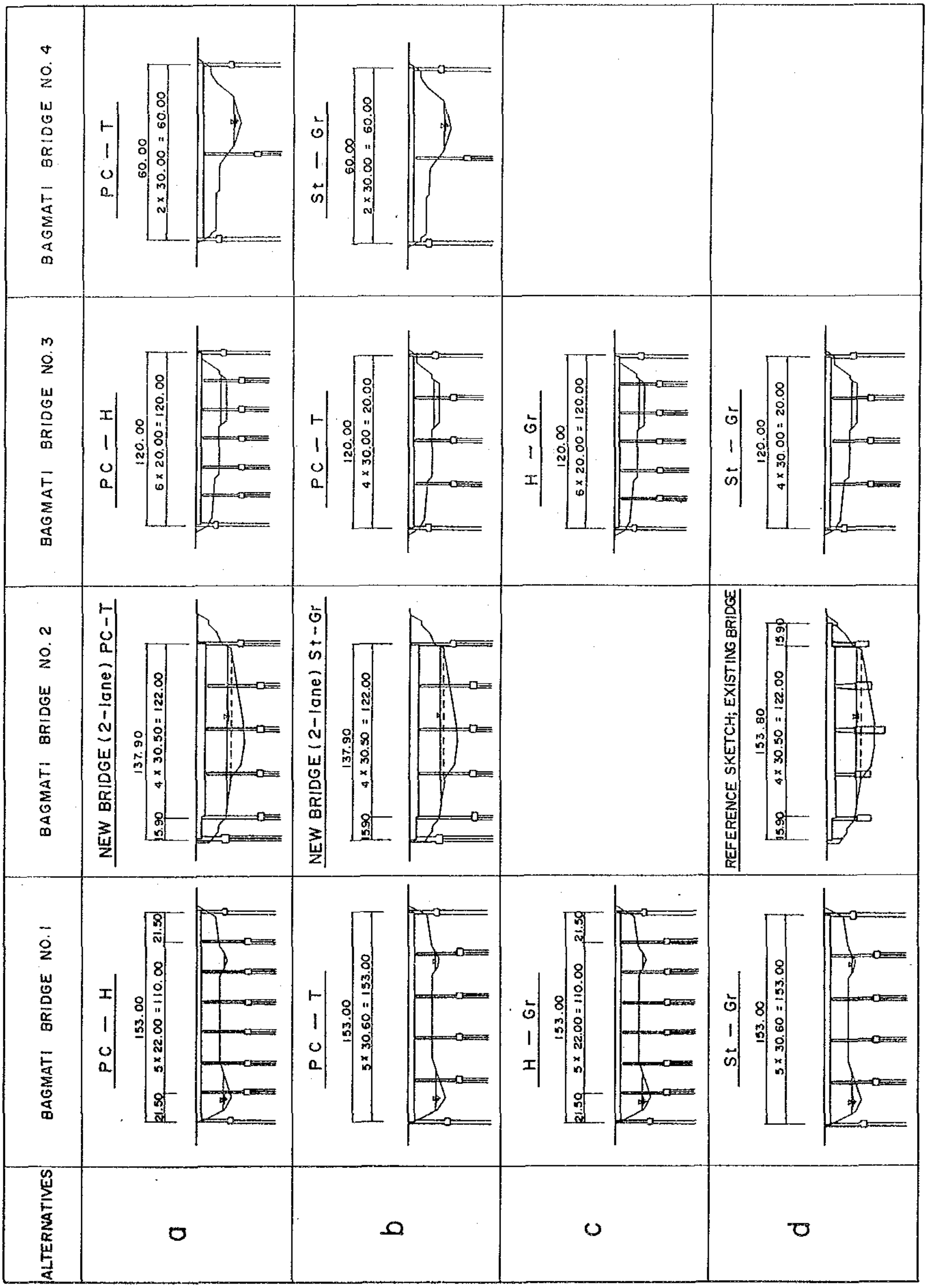


Figure 3.9 BRIDGE TYPE AND ALTERNATIVES

3.4.5 Selection of Optimum Bridge Plan

(a) Bagmati bridge No. 1 (Kalimati Bridge):

A multiple span composite steel plate girder bridge (St-Gr) has been selected for the reasons that (1) light weight superstructure is better for earthquake resistance, (2) longer span will reduce the number of piers and consequently local scouring will be less, (3) construction period will be short, and (4) construction cost is smallest.

(b) Bagmati bridge No. 2 (New Bagmati Bridge):

Composite steel plate girder bridge (St-Gr) was selected for the reasons that (1) light weight superstructure, (2) construction period, and (3) construction cost.

(c) Bagmati bridge No. 3 (Chakupat Bridge):

A multiple span composite steel plate girder bridge (St-Gr) is selected for the reasons mentioned for Bagmati Bridge No. 1.

(d) Bagmati Bridge No. 4 (Koteswor Bridge):

A 2-span composite steel plate girder bridge (St-Gr) is selected for the reasons that the superstructure is light and reactions on foundations will be small, resistance to earthquakes is good and construction period is short.

CHAPTER 4

ENGINEERING SURVEY AND ANALYSIS

CHAPTER 4 ENGINEERING SURVEY AND ANALYSIS

4. 1 General

Engineering survey has been conducted by the Study Team to obtain the engineering data and information to be used for the preliminary design of the high priority road project.

Survey consisted of geological investigation including soil/materials investigation, hydrological survey, seismic survey and topographical survey.

4.2 Geological and Soil Materials Investigations

4.2.1 General

The survey was done to obtain the basic data for preliminary design of bridge and of road.

The sub-surface exploration including rotary drilling, insitu tests, sampling and laboratory tests was conducted at the proposed four bridge sites. Properties of sub-grade soil and borrow pit areas are also evaluated by conducting field test and laboratory tests.

The work was subletted to a local consultant, SILT Consultant (P.) Ltd, and carried out under the supervision of the Study Team.

All the detailed result obtained through the above investigation including the laboratory tests are presented in Appendices and Vol. III Drawings.

4.2.2 Geological Characteristics

Proposed bridge sites are located in the central part of Kathmandu Valley along the east-west stretch of Bagmati River. Excepting the Koteswor site where the river is confined into a pronounced narrow channel, the river is significantly wide with braided channel and point bars.

Kathmandu is a synclinal tectonic basin with Paleozoic and Precambrian rocks at the periphery and covered with a thick fluviatile deposits in the northern part and dominantly lacustrine deposit in the south. The proposed bridge sites are regarded as the transition zone between the predominantly fluvial deposits (sand, silt) to the north and the predominant lacustrine deposits (organic clayey silt and clay) to the south. The clayey silt is generally highly porous, organic and compressible. This necessitates a understanding of the compressibility characteristics of the clay with potential settlement if it is loaded.

No significant problem of slope instability is foreseen for all of the bridge sites. However analysis of the liquefaction potential of bank erosion may be necessary to carry out during more detailed study and design.

One of the major problems is lowering of Bagmati river bed which has caused the problem to the existing bridges. The main causes of lowering of river bed are as follows:

(i) Taking out excessive sand from river bed

(ii) Rocky river bed at Chobhor Gorge going down

(iii) Flow of river at river soil bed

4.2.3 Soil Investigation at Bridge Site

(1) Field Work

The field work including boring, sampling and standard penetration test was carried out at four proposed bridge site in Kuleswor, Thapathali, Chakupat and Koteswor.

The was conducted near the abutment of proposed bridge as shown in Table 4.1.

Table 4.1 Location of Boring Sites

Bridge Name	Location	Boring Site	Estimated Bore Depth (m)
Bagmati No. 1	Kuleswor	Left bank	40
		Right bank	40
New Bagmati	Thapathali	Left bank	40
		Right bank	40
Bagmati No. 3	Chakupat	Left bank	40
		Right bank	40
Bagmati No. 4	Koteswor	Left bank	40
		Right bank	40
Total 8 Places			320

The detail boring sites are shown on topographic map (1/500) prepared for design of bridge.

The samples were taken for laboratory test. Two undisturbed samples were extracted from each bore holes as essential data for foundation analysis.

The standard penetration test were conducted at every 2m depth intervals to estimate the bearing capacity of stratum to be used for determination of bridge foundation.

(2) Laboratory Test Results

The following laboratory test were carried out:

(a) Natural Moisture Content Tests
(b) Specific Gravity Tests
(c) Atterberg Limits Tests
(d) Particle size analysis tests (sieve and hydrometer tests)
(e) Bulk Density Tests
(f) Unconfined Compression Tests
(g) Consolidation Tests

(3) Description of Detailed Geological Condition

The geological condition at each bridge site is presented in Appendix 4.2.1.

4.2.4 Evaluation of Subgrade

(1) Field Work

The field works, consisting of the excavating of trail pit for soil sampling, cone penetration tests and field density tests, were conducted to evaluate subgrade soil properties along the proposed road.

The test pits were excavated at an interval of 1 km along the proposed road. The detailed location is shown on location map in Appendix 4.2.2.

The field density test was carried out by sand replacement method at all the location where the test pits were excavated.

The dynamic cone penetration test was carried out approximately at an interval of 500 m along the proposed road.

The location and the result of field work is shown in Appendix 4.2.2.

(2) Laboratory Test Result

The samples collected from test pits were tested in the laboratory on the following items.

(a) Specific Gravity

(b) Natural Moisture Content

(c) Particle Size Analysis (sieve and hydrometer tests)

(d) Liquid Limit

(e) Plastic Limit

(f) Compaction (Modified) test

(g) CBR test

The results of these tests are presented in Appendix 4.2.2.

(3) Evaluation of Subgrade

The proposed roads are located on fluvial deposits of silt and sand with few percentage of gravel and clay.

On the basis of the test results, an average CBR value to be used for flexible pavements design is determined to be 5% for Kuleswor-Koteswor Road and 7% for Ring Road Sorhakhutte Road.

4.2.5 Aggregate and Embankment Materials

(1) Field Work

As the materials sources of aggregate and embankment for base course, surface course, concrete and road embankment, the following sites were investigated to collect the samplings as shown in Table 4.2.

Table 4.2 Location of Borrow Pits and Quarry Sites

Type of Materials	Location	Number of samples collected
Soil	Thimi, Gokarna Ban and Kapan	4
Gravel	Chunnikhel	2
Sand	Pikhel, Kapan and Basundhara	6
Coarse Aggregate	Godawari, Thankot & Jhalungtar	6

The location of the quarry sites are shown in Appendix 4.2.3

(2) Laboratory Test Result

Following laboratory tests were conducted:

(a) Specific Gravity
(b) Natural Moisture Content
(c) Particle Size Analysis
(d) Liquid Limit
(e) Plastic Limit
(f) Compaction
(g) CBR
(h) Bulk Density

The result of laboratory testes is presented in Appendix 4.2.3.

(3) Evaluation of Construction Materials

The following is the test results for each materials:

Soils

As stated, one sample was extracted from Gokarna Ban, two from Thimi and one from Kapan. The test revealed that the soil obtained at Kapan and Gokarna Ban had CBR value of 6.7% and 3.1% respectively, while the soil obtained from Thimi had CBR value ranging from 4.1% to 4.5%. Based on the above results, the following priority was given to the proposed borrow pits:

Priority	Proposed Borrow pits
1	Kapan
2	Thimi
3	Gokarna Ban

Gravel

The gravel sampled from Chunnikhel has a CBR value of 40% approx. which meet the requirements sub-base and based-course.

Sands

The samplings were conducted at Pikhel, Kapan and Basundhara. The sieve analysis showed that the sand from Pikhel is the best quality among three borrows pits, however, it might be costly because of the long hauling distance.

Crushed Stone

Jhalungtar, Godawari and Thankot were identified as the material sources for crushed stone. Two samples for each sites were collected for laboratory tests. The results are shown in Appendix 4.2.3. Los Angeles abrasion, water absorption, crushing value and soundness were carried out at Thankot crushing plant. The result of tests are summarized as show in Table 4.3.

Table 4.3 Test Result of Aggregate

Source	Los Angles Abrasion	Crushing Value	Soundness	Water absorption
Godawari	27.12	16.85	2.2	0.6
Thankot	31.94	18.15	1.425	0.67

The test concluded that the aggregate obtained from Godawari and Thankot are suitable both for pavement and concrete works.

4.2.6 Foundation Analysis

(1) Soil Condition

Bagmati Bridge No. 1

The surface is covered with the deposit of loose sand and gravel up to 2 m depth. After which clayey silt is struck up to the last depth of boring 40 m. This layer has SPT values (N-value) of 5 to 8.

New Bagmati Bridge No.2

4m thick of clayey silt and sand is struck reciprocally up to the depth of 20 m. The N-values of these strata are 10 to 20.

Bagmati Bridge No. 3

The site is covered with mostly soft clayey silt. The N-values from the top to 10m depth is ranging from 3 to 7 and after which N-value from 10 to 20..

Bagmati Bridge No. 4

Top 7.0 m of boring was observed to be the deposit of sand medium compactness. Below this, homogenous clayey silt continues up to the boring end of 20 m. The N-values of the upper stratum and lower stratum are 15 to 18 and 6 to 9 respectively.

(2) Study of Foundation Type

For analysing the stability of foundation, the bearing capacity of the foundation at each bridge site was evaluated.

Pile foundation is considered to be the most suitable for the proposed site. Among the various pile types, the driven precast pile is recommended taking into account soil conditions which may cause the noise and vibrations during driving. The bored cast-in-place pile is considered as an alternative.

The scouring depth of Bagmati River is observed ranging from 2m to 4m below the existing river bed. The subsoil stratum at bridge sites is mainly soft and stiff clay in a depth of 0 - 4 m.

4.3 Hydrological Study and Analysis

4.3.1 General

The main objective of the hydrological study is to grasp the hydro-meteorological condition the peak flood discharge bridge and culvert design.

The hydro-meteorological data and information to be used for evaluating the peak flood discharge were obtained from Department of Hydrology and Meteorology (DOHM) and authorities concerned. The field surveys were conducted to identify the following items of river condition:

- Change of river course and lowering of riverbed
- Flood mark of water level in the past
- Observation of riverbed materials
- River cross sectional survey

The estimation method of peak flood discharge depends on the availability of the hydro-meteorological data. In Nepal, several attempts have been made for estimating peak flood discharge The comprehensive study was carried out by the Water and Energy Commission Secretariat (WECS) in 1982, in which a regional analysis was suggested. In this study, the peak flood discharge was calculated using three (3) methods including the regional analysis in order to obtain the most realistic figure.

4.3.2 Review of Hydro-meteorological Data

(1) Hydro-meteorological data

Rainfall data are recorded at 11 meteorological stations. (See Appendix 4.3.1) Out of these station, the stations at Tokha, Sundarijal and Indian Embassy were halted in 1981, 1978, and 1976 respectively. Annual mean rainfall during the past 15 year are more than 3000 m/m in mountain area, 1500 to 2000 m/m in high land, and less than 1500 m/m in flat area. (See Appendix 4.3.2)

Discharge records are available at Chobhor and Sundarijal in Kathmandu Valley. Table 4.4 shows their annual peak discharge. As seen in the table, peak discharge is observed in the rainy season from July to September.

(2) River condition

Bagmati river and its tributaries have changed its river course frequently and lowered its riverbed in the past. Especially river bed of Bagmati, Manohara, Bagmati branch, and Dhobi Khola are considerably lowering by almost 2.0 m during the past 10 years. The main cause of lowering is taking out of excessive amount of sand from riverbed. As the result, the foundation of existing bridge on these river are deeply eroded and scored.

Bagmati River is 100 to 150 m wide up to Chobhor, out let of Kathmandu Valley. There is a ravine of approximately 350 m length and 20 m wide at Chobhor, known as Chobhor George, where discharge is controlled at this point.

The results of the field survey along these river are presented in Appendix 4.3.2.

4.3.3 Hydrological Calculation

(1) Frequency Analysis of Daily Rainfall.

Out of the data of annual maximum daily rainfall recorded at 11 stations the data at Godawari was selected for frequency analysis of daily rainfall because of its reliability.

Frequency analysis is performed using Hazen, Gumbel and Pearson III methods. The result is shown in Appendix 4.3.3. In Nepal, Pearson III method is considered to be best fit. The result by Pearson III method is summarized as follows.

Table 4.4 ANNUAL PEAK DISCHARGE

	SUNDARIJAL		CHOVAR	
YEAR	DATE	PEAK DISCHARGE	DATE	PEAK DISCHARGE
1963	-	-	02 SEP.	206.00
1964	-	-	93 SEP.	251.00
1965	-	-	09 JUL.	420.00
1966	-	-	24 AUG.	633.00
1967	10 JUL.	31.10	10 JUL.	680.00
1968	27 JUN.	28.90	04 OCT.	497.00
1969	27 JUL.	6.00	-	-
1970	19 JUL.	41.00	16 JUL.	785.00
1971	14 JUL.	9.52	12 JUN.	617.00
1972	28 JUL.	7.28	28 JUL.	876.00
1973	-	-	28 JUL.	335.00
1974	02 SEP.	3.76	30 AUG.	350.00
1975	09 SEP.	18.20	03 AUG.	591.00
1976	08 JUN.	31.20	30 JUN.	245.00
1977	09 JUL.	16.20	20 JUN.	299.00
1978	25 AUG.	53.20	16 JUL.	407.00
1979	23 AUG.	3.26	21 AUG.	416.00
1980	22 AUG.	11.00	31. JUL.	254.00
1981	02 SEP.	16.20	-	-
1982	28 AUG.	6.16	-	-
1983	01 AUG.	20.80	-	-
1984	26 AUG.	4.76	-	-
1985	26 JUN.	7.00	-	-

Return Period (year)	10	20	50	100
Daily Rainfall (mm)	146.5	164.2	188.2	206.0

(2) Estimation of Peak Flood Discharge

Peak flood discharge is estimated applying three (3) methods, that is Rational Formula, Frequency Analysis and Regional Analysis as follows:

1) Rational Formula

A Rational Formula is presented as shown below:

$$Q = 0.2778\ f.r.A.$$

Where
- Q : peak flood discharge (m^3/s)
- f : run-off coefficient
- r : rainfall intensity (mm/hr)
- A : catchment area (km^2)

(i) Run-off Coefficient (F)

Run-off coefficient is set at 0.6 taking into account the topographic condition of the catchment area which can be identified as undulating slop land and cultivated flat land.

(ii) Rainfall Intensity (r)

Considering of characteristics of the study area, rainfall intensity is estimated by means of following equation.

$$r = R24/24\ (24/t)^{1/2}$$

where,
- r : rainfall intensity
- R24 : probable daily rainfall
- t : concentration time

t is given by means of following equation

$$t = to + ti$$

where,
- to = time of inlet (minute)
- ti = flowing time (minute)

(iii) Inlet Time

The duration of inlet time is estimated at 20 minutes taking into account deforested slop area.

(iv) Flowing Velocity and Time

Flood flowing velocity is estimated by means of following equation.

$$w = 20\,(h/L)^{0.6} \quad (m/sec)$$

Flowing time is given by following equation.

$$ti = t_1 + t_2 + t_3$$
$$= L1/60\,w_1 + L2/60w_2 + 13/60\,w_3$$

(v) Catchment Area

Catchment area of each proposed bridge is calculated on the basis of Kathmandu Valley map with scale 1:10,000. (see Fig.4.1)

River conditions and rainfall intensity are summarized in Table 4.5.

2) Frequency Analysis of Recorded Discharge

Discharge data is available only at 2 stations, Chobhor and Sundarijal. The probability discharge at these two station was estimated and presented in Table 4.8.

3) Regional Analysis

The regional analysis is recommended by WECS for estimation of flood peak discharge in Nepal.

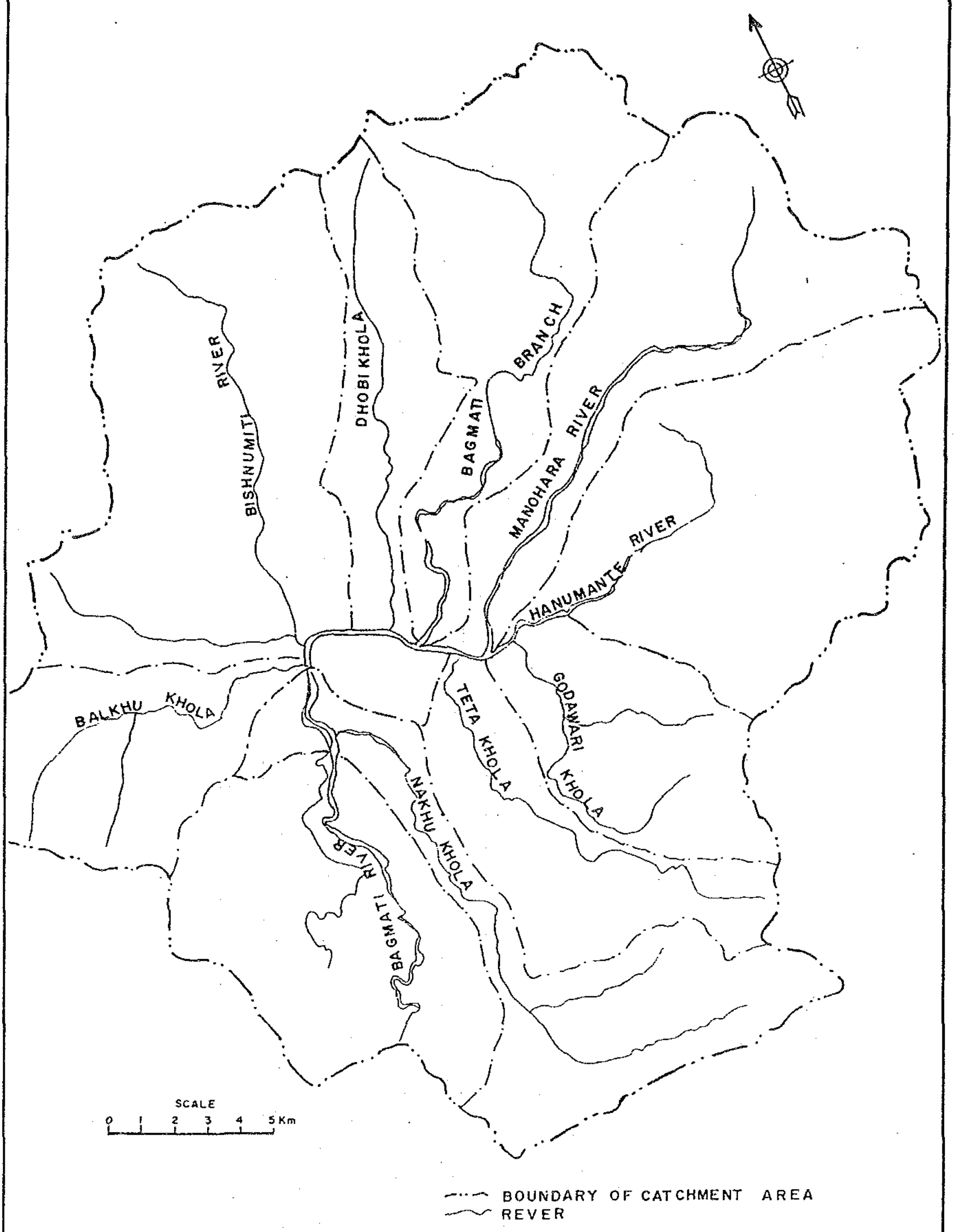


Figure 4.1 MAP OF DIVIDED CATCHMENT AREA IN KATHMANDU VALLEY

TABLE 4.5 RIVER CHARACTERISTICS & RAINFALL INTENSITY

	CA	River Length (m)			ti (min)			to	t	Rainfall Intensity (r)			
	Sq. Km.	L1	L2	L3	t1	t2	t3	(min)	(Hr.)	100 years	50 years	20 years	10 years
Chobar D.S.	585	7800	20000	8000	130	222	67	20	7.3	15.56	14.22	12.41	11.07
Bagmati (1)	486	3900	20000	8000	65	222	67	20	6.2	16.88	15.43	13.46	12.01
Bagmati (2)	382	2000	20000	8000	33	222	67	20	5.7	17.61	16.09	14.04	12.52
Bagmati (3)	352	1000	20000	8000	17	222	67	20	5.4	18.09	16.53	14.43	12.87
Bagmati (4)	70	-	19500	8000	-	217	67	20	5.1	18.61	17.01	14.84	13.24
Bishnumati	104	6000	8000	3000	100	89	25	20	3.7	21.85	19.97	17.43	15.54
Dhobi Khola	25		9000	6000		100	50	20	2.8	25.12	22.96	20.03	17.87
Manohara (1)	265	2300	18000	6000	38	200	50	20	5.1	18.61	17.01	14.84	13.24
Manohara (2)	72		18000	6000		200	50	20	4.5	19.82	18.11	15.80	14.10
Sundarijal D.S.	16			6000			50	20	1.2	38.37	35.07	30.60	27.29

The mean flood peak discharge is estimated by following formula.

$$Q = bA^c$$

where, Q = mean flood peak discharge (m^3/s)
A : catchment area (km^2)
b, c : coefficient given for each region.

Nepal is divided into four (4) hydrological regions as shown in Fig. 4.2. The coefficients "b" and "c" for each region are given in Table 4.6. Flood peak discharge for a particular return period is estimated by following equation.

$$Qt = kQ$$

where, Qt : flood peak discharge for return period (m^3/s)
K : regional multiplier

Since Kathmandu Valley belongs to southern region, the formula of estimate peak flood discharge is obtained as follows:

$$Qt = K \times 3.03\ A\ 0.747$$

Return Period

	10,	20,	100	Remark
K	1.6	1.9	2.6	Southern Region

Flood peak discharges are estimated by means of the above three method and the results are presented in Table 4.8.

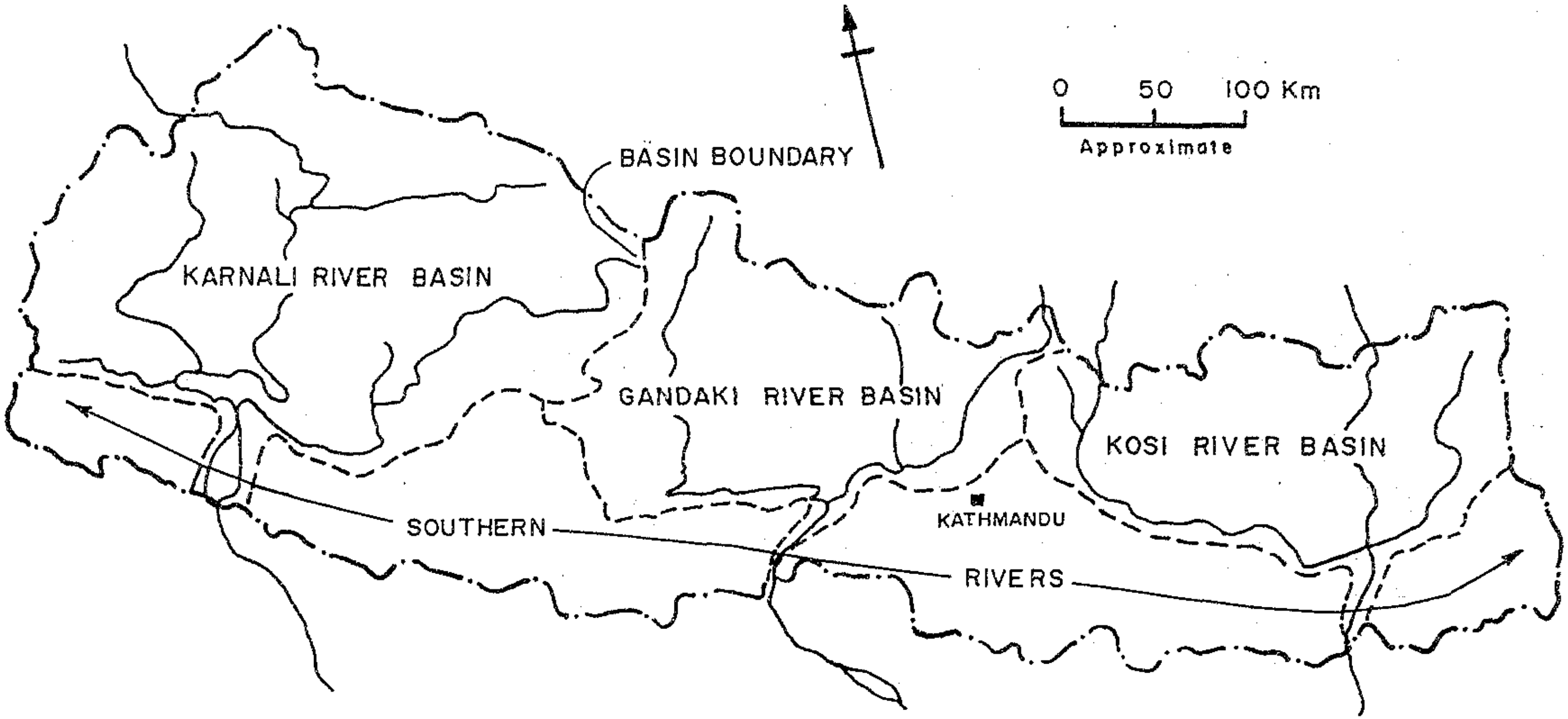


Figure 4.2 MAP OF NEPAL SHOWING HYDROLOGIC REGIONS
(from KARMACHARYA, 1982)

TABLE 4.6 REGIONAL COEFFICIENTS FOR MEAN ANNUAL FLOOD PEAK ESTIMATES

Region	Coefficients	
	b	c
Kamali	1.27	0.864
Gandaki	2.39	0.826
Kosi	1.92	0.854
Southern	3.03	0.747

TABLE 4.7 REGIONAL MULTIPLIERS FOR FLOOD DISCHARGE ESTIMATES

Region	Multiplier - k				
	Return Period (Years) (t)				
	5	10	20	50	100
Kamali	1.3	1.6	1.9	2.2	2.5
Gandaki	1.2	1.4	1.6	1.9	2.1
Kosi	1.2	1.4	1.6	1.9	2.1
Southern	1.3	1.6	1.9	2.3	2.6

TABLE 4.8 PEAK FLOOD DISCHARGE

	Rational Formula				Probability Discharge			Reagional Analysis	
	100 years	50 years	20 years	10 years	100 years	50 years	10 years	100 years	10 years
Chobar D.S.	1516.97	1386.15	1209.73	1078.99	1194.78	1056.21	745.92	919.35	565.75
Bagmati (1)	1367.49	1249.56	1090.53	972.66	-	-	-	800.44	492.58
Bagmati (2)	1121.01	1024.34	893.97	797.35	-	-	-	668.67	411.49
Bagmati (3)	1061.28	969.76	846.33	754.86	-	-	-	629.04	387.10
Bagmati (4)	217.17	198.44	173.18	154.47	-	-	-	188.23	115.83
Bishnumati	378.81	346.14	302.08	269.43	-	-	-	253.01	155.69
Dhobi Khola	104.68	95.65	83.48	74.45	-	-	-	99.95	61.51
Manohara (1)	822.14	751.24	655.63	584.77	-	-	-	508.83	313.13
Manohara (2)	237.80	217.29	189.64	169.14	-	-	-	204.08	125.59
Sundarijal D.S.	102.33	93.51	81.61	72.79	94.28	74.24	37.87	62.50	38.46

4.3.4 Design Returned Period

WECS suggested to apply the following flood returned period for road design in Nepal.

Bridge and associated structure

Major structure	100 to 200 years
Minor structure	50 to 100 years

Road culverts

Major structure	25
Minor structure	10

Based on the above criteria, design returned period to be applied for this study was determined as follows:

Bridge	100 Years
Road	10 to 20 years

4.3.5 Hydraulic Calculation and High Water Level

(1) Determination of Design Flood Discharge

Flood peak discharges shows different values depending on the formula to be applied as seen in Table 4.8.

Generally, flood peak discharge estimated by regional analysis tend to be too low. While flood discharge (100 year-flood) calculated by rational formula shows nearly equal to the estimated flood discharge on the basis of flood mark of high water level obtained by field survey. Therefore it is determined that design flood discharge shall be calculated by means of rational formula.

(2) Hydraulic Calculation and Design Flood Water Level

Hydraulic calculation was conducted to determine the design flood water level for the proposed bridges.

1) Bagmati River and Manohara River

The design flood water level is calculated using Manning's uniform flow formula as shown below:

$$V = 1/n \cdot R^{2/3} \cdot I^{1/2}$$

$$Q = A \cdot V$$

where,
- Q : discharge (m^3/s)
- A : flow area (m^2)
- V : flow velocity (m/s)
- R : hydraulic radius (m)
- I : water surface slop
- n : roughness coefficient

I was obtained to be 0.0025 on the basis of topographic map.

n is given as follows on the basis of river bed condition.

River bed condition	n
Sand, gravel	0.035
Black cotton soil	0.020
Average	0.030

Flood water level at proposed Bridge No. 1 to No.3 are shown in Appendix 4.3.4.

2) Bagmati Tributary and Dhobi Khola

Design flood level of Bagmati tributary and Dhobi Khola is estimated by ununiformed calculation method at outlet of each tributary.

The results are presented in Appendix 4.3.4.

4.4 Seismic Analysis

4.4.1 General

Nepal is located in an earthquake-prone area. On an average, one earthquake with a magnitude greater than 5 took place in a year according to the past earthquake records in Nepal. The Nepal-Bihar earthquake in January 1934, severely shook Kathmandu valley causing many deaths, around 4,300 according to the Journal of Nepal Geological Society 1988. Kathmandu valley is specified in zone V, maximum hazard by Indian Standard Criteria for Earthquake Resistant Design of Structure, Third Revision, 1980, Indian Standards Institution (refer to Appendix 4.4.1).

4.4.2 Seismicity

Seismic design has been based on equivalent static force method. The equivalent static forces to be applied horizontally at the centre of gravity of structures have been calculated based on Specification for Highway Bridges, Japan Road Association and Indian Standard, Criteria for Earthquake Resistant Design of Structure, Third Revision, 1980, Indian Standards Institution.

(1) Specification for Highway Bridges, Japan Road Association :

$$k_h = k_o \times a_1 \times a_2 \times a_3$$

Where,
- k_h : Coefficient of Static Force
- k_o : Base static force = 0.2
- a_1 : Constant for structural significance = 0.8
- a_2 : Constant for area's characteristic = 0.7
- a_3 : Constant for subsoil condition = 1.2

Consequently k_h was determined as follows:

$$k_h = 0.2 \times 0.8 \times 0.7 \times 1.2 = 0.13$$

(2) Indian Standard, Criteria for Earthquake Resistant Design of Structure, Third Revision, 1980, Indian Standards Institution:

$$k_h = \partial_o \times \beta \times I$$

Where,
- k_h : seismic coefficient
- ∂_o : basic horizontal seismic coefficient = 0.08
- β : a coefficient depending upon the soil foundation system = 1.2

I: a coefficient depending upon the importance of the structure = 1.5

Consequently; k_h was determined as follows:

$k_h = 0.08 \times 1.2 \times 1.5 = 0.14$

Considering all, Coefficient of static force should be adopted Kh = 0.14 for safety side.

4.5 Mapping and Topographic Survey

4.5.1 General

Objective of this survey is to prepare topographic map to be used for preliminary design of bridge and road.

The survey consists of supplemental survey for existing topographic map with scale 1/2000, topographic survey and river cross sectional survey. The work was subletted to SILT Consultant under the supervision of the Study Team.

The location of topographical surveying, coordinates and elevation of traverse points including benchmarks are presented in Appendix 4.5.1.

4.5.2 Preparation of Topographic Map (1/2,000)

The topographic map with scale 1:2,000 covering the area inside the Ring Road is available. However, since it was prepared in 1983, topographic conditions are changed greatly due to construction of buildings and roads. The survey was carried out to up date these existing map along the project road.

Traverse survey was conducted along the proposed road in accordance with national coordinate system. Plan and coordinate of the traverse point were indicated in map.

All the control points, such as buildings, existing roads, etc. were measured and plotted in the map. The leveling was done referring to near National Bench Mark.

4.5.3 Preparation of Topographic Map (1/500) for Bridges.

The survey was carried out to prepare the topographic map with a scale of 1/500 for designing of bridges.

New benchmarks were established on the permanent structure at every proposed bridge site.

The leveling on the topographic survey was done at nearly 10 m grid on the basis of the new benchmarks.

4.5.4 River Cross Sectional Survey

The survey was carried out at center line of the proposed bridge and 200 m upstream some additional cross sectional survey were conducted for hydrological study.

The cross sectional survey was done at every 10 m along the line, indicating slop changing points, water level of the river, and road and other artificial structure.

CHAPTER 5

PRELIMINARY DESIGN

CHAPTER 5 PRELIMINARY DESIGN

5.1 General

In this chapter, the preliminary design for the proposed high priority projects including (1) South Link of Inner Ring Road including New Bagmati Bridge, (2) Access to the New Bus Terminal at Balaju and (3) Traffic management of Intersections were presented.

The preliminary design was conducted for the following items:

- Highway design including intersections
- Bridge design
- Drainage design
- Pavement design
- Road facilities design
- Utilities relocation and protection design
- Preliminary right-of-way plan

5.2 Highway Design

5.2.1 Concept of Highway Design

Since the proposed roads including South Link of Inner Ring Road and New Bus Terminal Access are sensitive to land acquisition and property demolishment for the project, the right-of-way (ROW) aspects was studied carefully. The following concepts was established for the highway design:

(1) The proposed South Link of Inner Ring Road will form a basic frame of urban road in the Kathmandu Valley, so that the geometric design including the alignment should meet the requirement of expected road function as arterial urban road.

(2) The road should be designed paying due attention on the characteristics of traffic component and local traffic movement in Kathmandu, that is, mixed traffic with low speed vehicles including bicycle, large numbers of pedestrian, tempos, etc.

(3) Permanent buildings and historical monuments should be avoided as much as possible to minimize the demolition and affects on these building.

(4) Vacant space of the river bed along Bagmati River should be utilized for road construction as much as possible since they are the property of Government.

(5) The roads should be designed with a space of public utilities taking into account the future development in the vicinity.

(6) The proposed South Link of Inner Ring Road should have the necessary space for widening to 4 lane in the future.

(7) At-grade intersections connecting with major road should be designed taking into account the road function as well as anticipated traffic volume on the proposed road.

5.2.2 Design Speed and Geometric Standard

The geometric standards to be applied for the proposed roads is as shown in Table 5.1.

Table 5.1 Geometric Design Standards to be adopted

Items	Unit	South Link of Inner Ring Road	Sanepa Access	Koteswor Access	Patan Access	New Bus Terminal Access
Design Speed	Km/hr	60	40	40	40	40
Sight Distance	m	85	45	45	45	45
Minimum Radius	m	105	45	45	45	45
Minimum Radius without Transition	m	200	200	200	200	200
Maximum Gradient	%	5.0	7.0	7.0	7.0	7.0
Crossfall	%	2.5	2.5	2.5	2.5	2.5

5.2.3 Lane Numbers

(1) South Link of Inner Ring Road

Staged construction is adopted for the South Link of Inner Ring Road considering the expected future traffic volume in the year 2015. According to the traffic forecast shown in Part A: Master Plan Study, forecasted traffic volume in both direction on South Link of Inner Ring Road ranges from 30,000 to 50,000 vehicles/day in 2015.

Traffic capacity of the proposed road is calculated applying the following values of traffic elements:

1) Basic capacity of highway ; 2,200 pcu/hour/lane
2) Heavy vehicle ratio ; 15 %
3) Peak hour ratio ; 10 %
4) Directional factor ; 55 %
5) Volume/Capacity Ratio ; 0.8 (Service level = 1)

Table 5.2 shows the design capacity of the proposed road in 1997 and 2015 in which required lane number is concluded as shown below:

- 2 -lane road satisfies the year 1997 traffic demand in the entire length of the South Link of Inner Ring Road, and
- 4 -lane road generally satisfies the year 2015 traffic demand.

(2) New Bagmati Bridge and Other Access Roads

Required lane numbers of New Bagmati Bridge and other access road are calculated in the same manner and summarized below:

(i) New Bagmati Bridge ; 2 lanes (Lane numbers of Bridges at Thapathali becomes 4 lane in total including the existing Bagmati Bridge)
(ii) Sanepa Access ; 2 lanes
(iii) Koteswor Access ; 2 lanes
(iv) Patan Access ; 2 lanes
(v) New Bus Terminal Access ; 2 lanes

Table 5.2 Analysis of Highway Capacity

		2 lane Road Year 1997	4 lane Road Year 2015
Design Speed (km/hr)		60	60
Width of Lane (m)		4.5	3.5
Lateral Clearance Outer (m)		2.0	2.0
	Inner (m)	0.50	0.75
Heavy Vehicles	Ratio (%)	15	15
	Passenger car Equiv.	3.5	3.5
Coefficient	Width of Lane	1.00	1.00
	Lateral Clearance	0.98	1.00
	Heavy Vehicle	0.87	0.87
	Land-use Condition	1.00	1.00
	Total	0.85	0.87
Basic Capacity (pcu/hour/lane)		1,250	2,200
Possible Capacity		1,060	1,910
Service Level		1	1
Coefficient of Service Level		0.8	0.8
Design Capacity		850	1,530
Peak Hour Ratio (%)		10.0	10.0
Rate of Direction	(D %)	55	55
Design Daily Capacity (veh/lane/day)		8,500	13,900
Total Design Daily Capacity (veh/day)		17,000	55,700

5.2.4 Typical Cross Sections

(1) South Link of Inner Ring Road

The typical cross sections to be applied for the South Link of Inner Ring Road is presented in Fig. 5.1 which shows initial stage construction (2-lane road) and ultimate stage construction (4-lane road in dotted line). Open space reserved for widening to 4-lane carriageway in the future might be used as a green belt until widening work will be commenced.

Lane width

In the initial stage, 5.0 m lane width is recommended taking into account the bicycle and emergency parking (3.5 m carriageway plus 1.5 m clearance for bicycle and emergency parking).

However, lane with is recommended to be decreased from 5.0 m to 4.0 m when the road is widened from 2 lane to 4 lane road taking the difficulty of land acquisition into consideration.

Shoulder and Sidewalk

Considering the function of Inner Ring Road, 2.0 m left shoulder and 3.0 m right sidewalk are recommended at the initial stage. The left shoulder could be used as a temporary parking lot.

Median width

Median slip is important facility for the high standard road with more than 4 lane carriageway. The functions of median slip are:

- i) to provide freedom from undesirable interference of opposing traffic;
- ii) to minimize headlight glare;
- iii) to provide open green space;
- iv) to provide for pier construction of grade separation structures, such as pedestrian bridge;
- v) to provide space for speed change and storage of right-turning and U-turning vehicles; and
- vi) to provide a reserved width for future lanes.

A standard 2.0 m wide median is adopted with 0.5 m raised.

(2) New Bagmati Bridge

Typical cross section of proposed new Bagmati Bridge is shown in Fig. 5.2.

The bridge is planned to have a 10 m wide 2-lane carriageway taking into account the large numbers of slow vehicles including bicycle and motor cycle. A 3.0 m wide sidewalk was also considered to secure the safety of pedestrian across the Bagmati River.

(3) Other Access Roads

Lane width of access roads are proposed to be 8.0 m to 10.0 m as shown below:

(i) Sanepa access ; 10.0 m (2 - lane road) with 3.0 m wide sidewalk at both sides

(ii) Koteswor access ; 10.0 m (2 - lane road) with 3.0 m wide sidewalk at both sides

(iii) Patan access ; 8.0 m (2 - lane road) with 2.5 m wide sidewalk at both sides

(iv) New Bus Terminal Access at Balaju;

10.0 m (2 - lane road) with 3.0 m wide sidewalk at both sides

Typical cross section of each access is presented in Fig. 5.3.

5.2.5 Alignment Design

(1) South Link of Inner Ring Road

The proposed road, starting from the intersection of Kalimati - Teku Road, runs toward east and crosses the Bagmati River with 150 m long bridge (Bagmati Bridge No.1). After the bridge, the route follows the riverbed along the left bank of Bagmati River in order to minimize the land and house acquisition. The route meets the existing Bagmati Bridge at Kupandol where New Bagmati Bridge is planed.

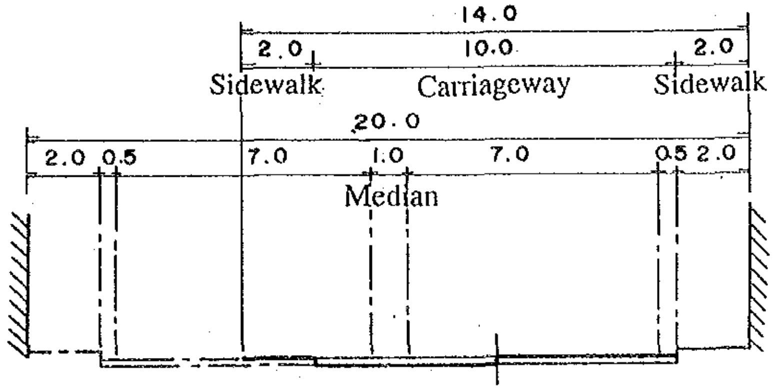
After the Bagmati Bridge, the route extends toward east along the left bank of Bagmati River up to the opposite bank at the confluence of Dhobi Khola. The route crosses Bagmati River at this point and connects with Arniko Highway at east of the Dhobi Khola Bridge.

The proposed road is aligned on the riverbed of Bagmati River so that it would give a positive impact on the river environment as well as public activities as follows:

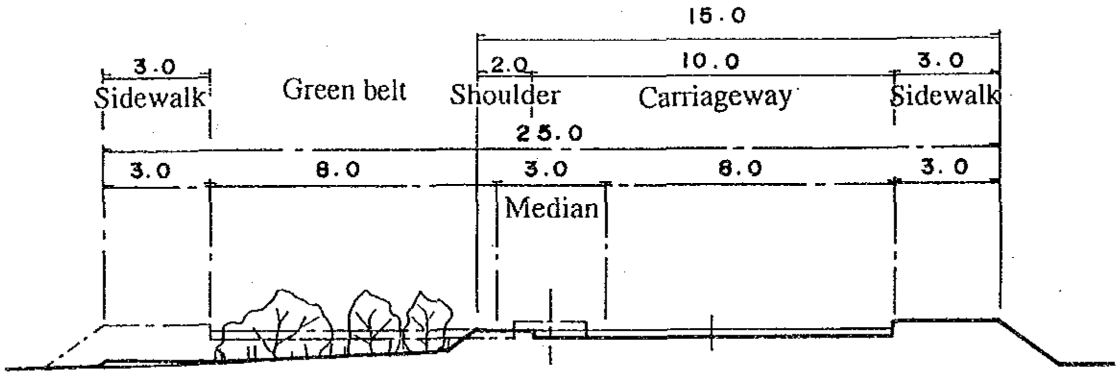
(i) It will sever the river from the residential area which may stop the pollution activities and result in cleaner river bank.

(ii) The open space between the proposed road and the bank could be used for pedestrian and bicycle road as shown in Fig. 5.4.

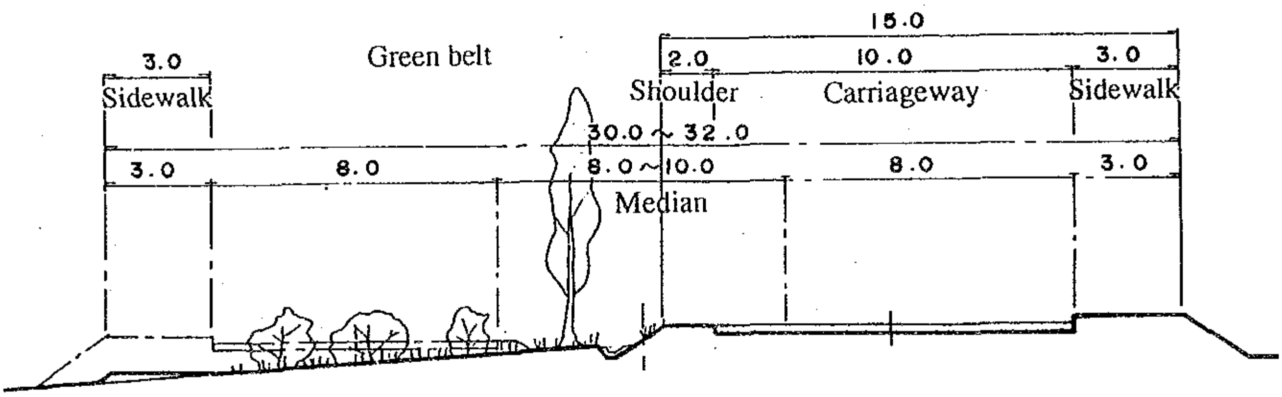
Vertical alignment shall be determined taking into consideration the elevation of existing road to be connected, drainage condition and high water level at maximum flood discharge of Bagmati Bridge.



Type - A (BP ~ STA. 0+ 85)
To be adopted in Kalimati Road



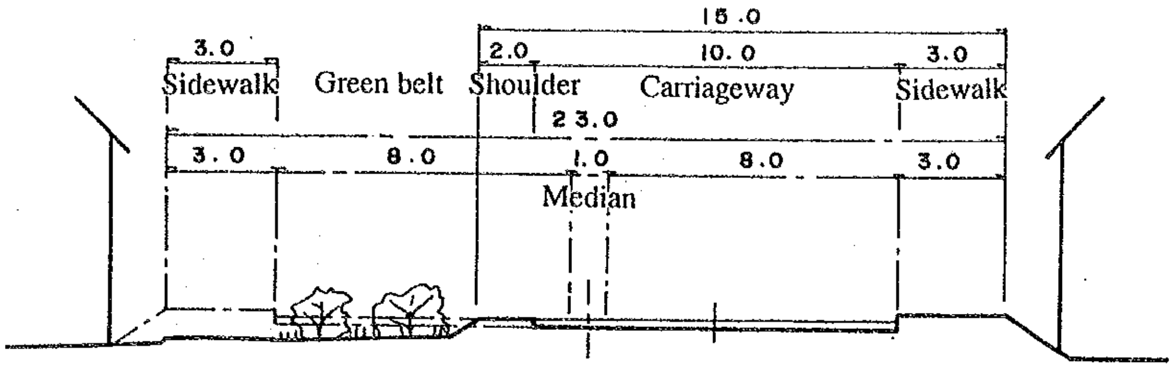
Type - B (STA. 0+390 ~ STA. 1+000)
(STA. 1+500 ~ STA. 3+120)
To be adopted in build up area



Type - C (STA. 1+000 ~ STA. 1+500)
To be adopted in open area beside the river

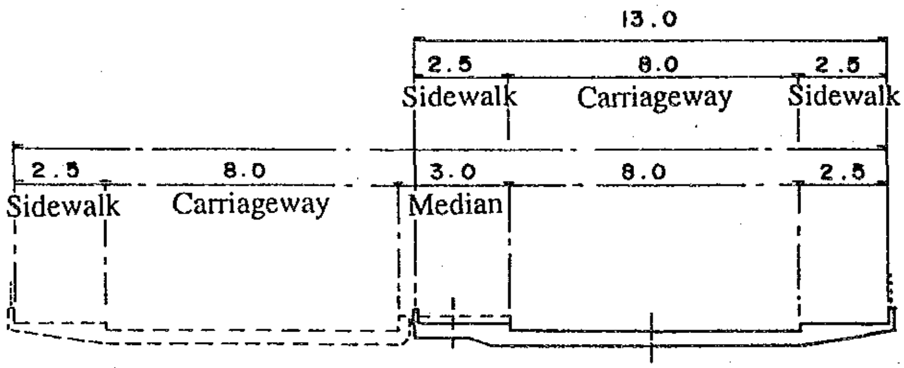
Legend:
——— First Stage Construction (2 - Way)
– – – Second Stage Construction (4 - Way)

Figure 5.1 Typical Cross-Section of South Link of Inner Ring Road 1/2



Type - D (STA. 3+245 ~ EP)
To be adopted in open area

(2nd. Stage Construction) (1st. Stage Construction)



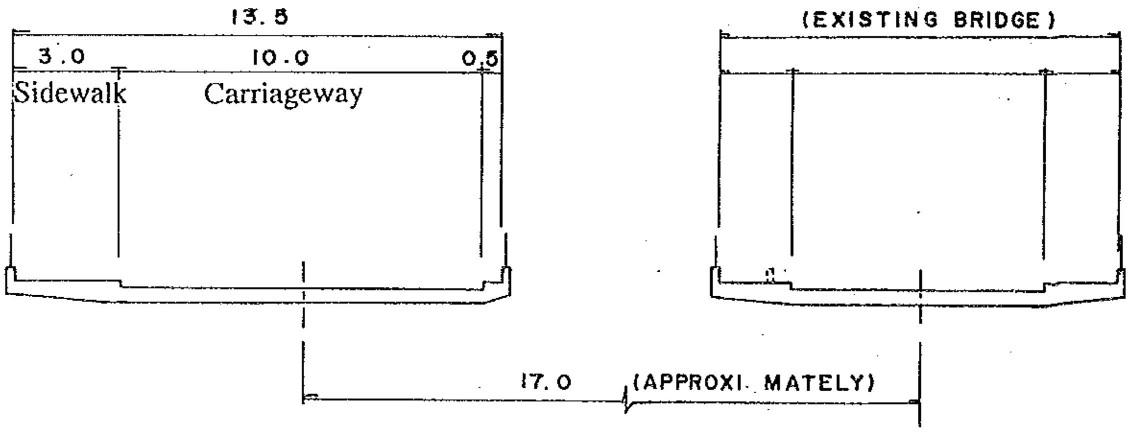
BRIDGE

Legend:

——— First Stage Construction (2 - Way)

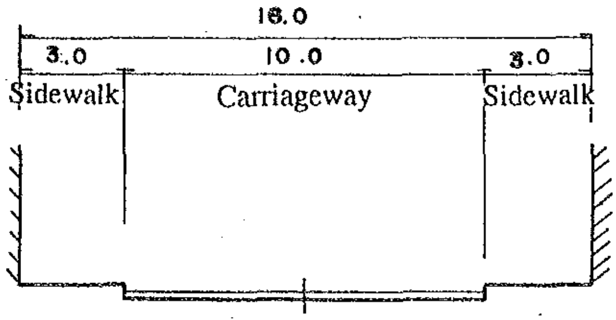
– – – Second Stage Construction (4 - Way)

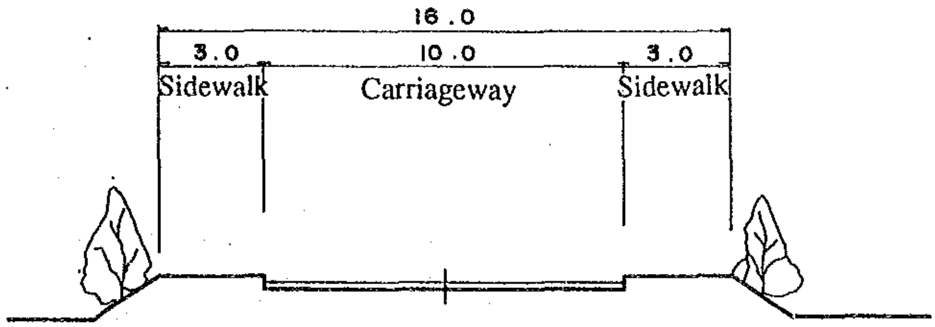
Figure 5.1 Typical Cross-Section of South Link of Inner Ring Road 2/2



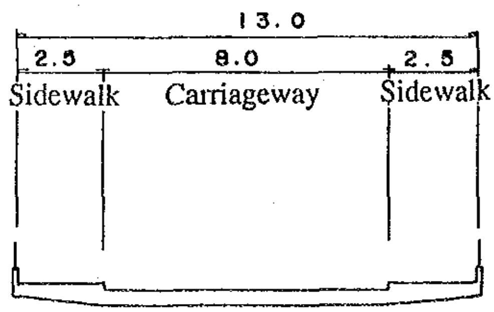
NEW BAGMATI BRIDGE AT THAPATHALI

Figure 5.2 Typical Cross-Section of New Bagmati Bridge

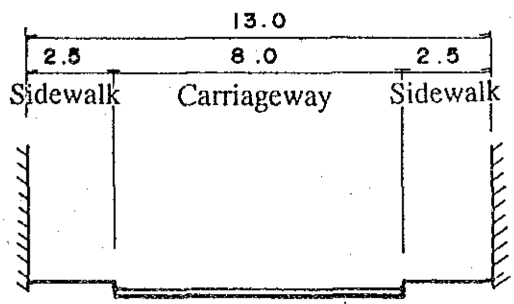




SANEPA ACCESS, KOTESWOR ACCESS
AND CENTRAL BUS TERMINAL ACCESS



BRIDGE (KOTESWOR ACCESS)



PATAN ACCESS
(Build up area)

Figure 5.3 Typical Cross-Section of Other Access Roads and Bridge

(2) New Bagmati Bridge

The alignment of New Bagmati Bridge was determined taking into account the following factors:

(i) Minimum affect on the Existing Bagmati Bridge during the construction.

(ii) Smooth connection with Thapathali intersection.

(iii) Existing temples and ghuts located in the vicinity of Thapathali intersection.

(3) Other Access Roads

The alignment of other access roads was determined to minimize the construction cost as well as to minimize acquiring land and houses. Temples, historical monuments and public utilities, such as transmission line and water main, were avoided in order to minimize the affects on environment.

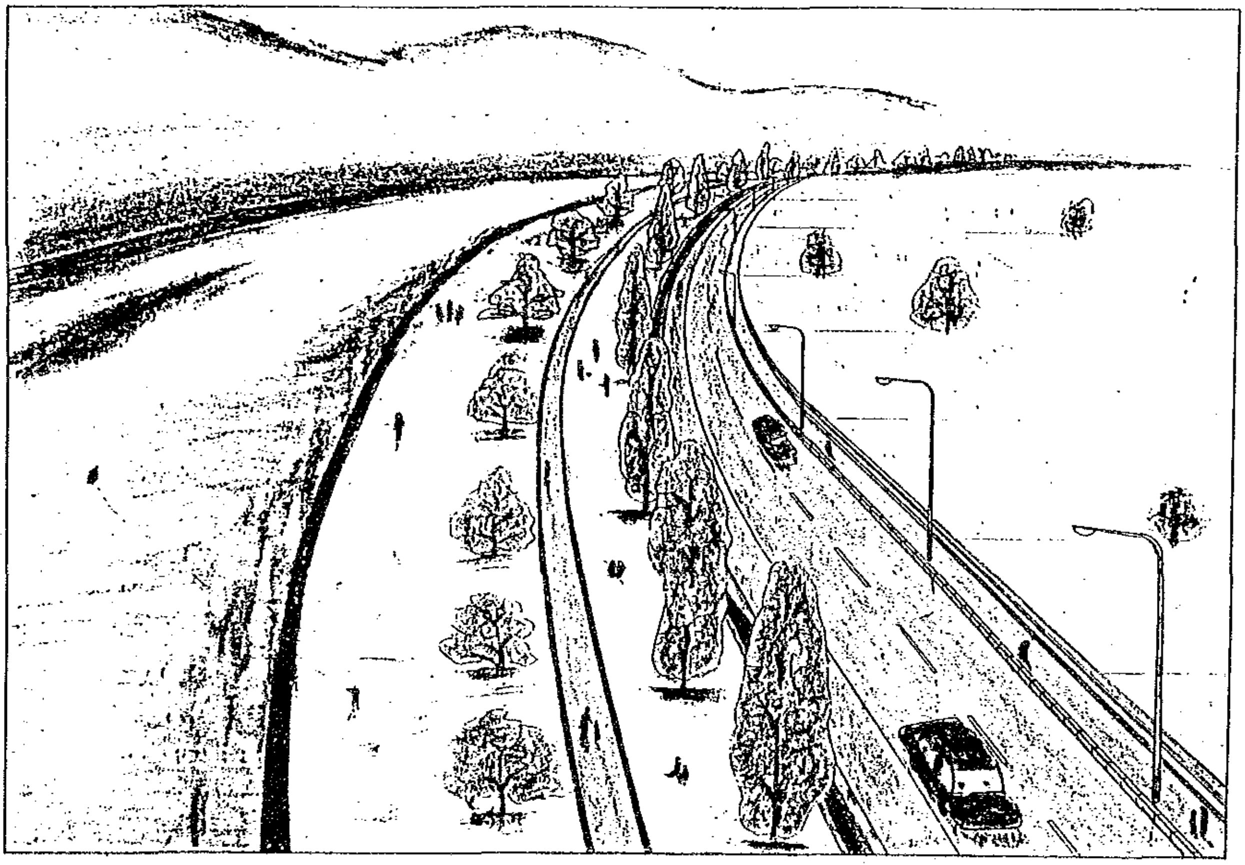


Fig. 5.4 Open Space for Public facilities

5.2.6 Intersection at New Bagmati Bridge at Thapathali

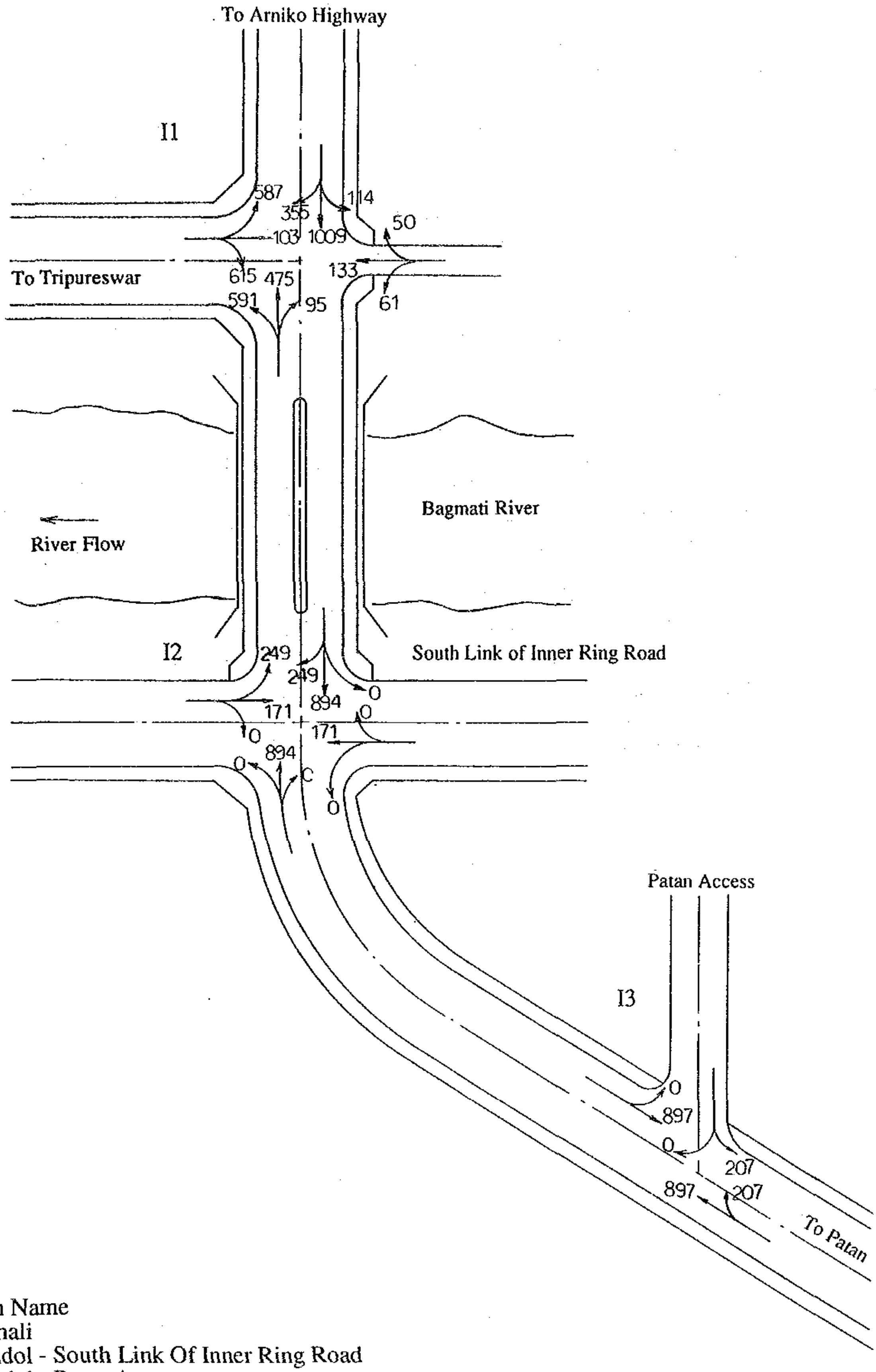
Existing intersection at Thapathali is one of the bottleneck point of traffic movement in Kathmandu city. With the construction of new 2- lane bridge at Thapathali, in addition to the existing 2-lane bridge, river crossing capacity across Bagmati would be increased remarkably, however, full benefits will not be realized unless good intersection is provided at Thapathali side..

The concept used for intersection capacity analysis is based on the "Japan Road Association" since much similarity is found in types and sizes of vehicles and in their operations in Nepal and Japan. Fig. 5.5 shows the result of traffic capacity on Thapathali intersections at Patan and Kathmandu sides.

Pedestrian overbridges are proposed at both intersections in Kathmandu and Patan in order to maintain the traffic capacity of intersection by separating. Guardrail should be provided between traffic lane and sidewalk in the vicinity of intersection in order to eliminate the pedestrian from the intersection.

The traffic focusing on the Thapathali intersection is very large and mixed up with fast and slow vehicles. Turning movements in the intersection should be controlled by the modernized traffic control signal system in order to maintain the traffic capacity of intersection.

The proposed new intersection at Thapathali is presented in Fig. 5.6.



Intersection Name
I1 : Thapathali
I2 : Kopundol - South Link Of Inner Ring Road
I3 : Kopundol - Patan Access

unit : vehicle / hour

Figure 5.5 DESIGN - HOURLY TRAFFIC VOLUMES (1997)

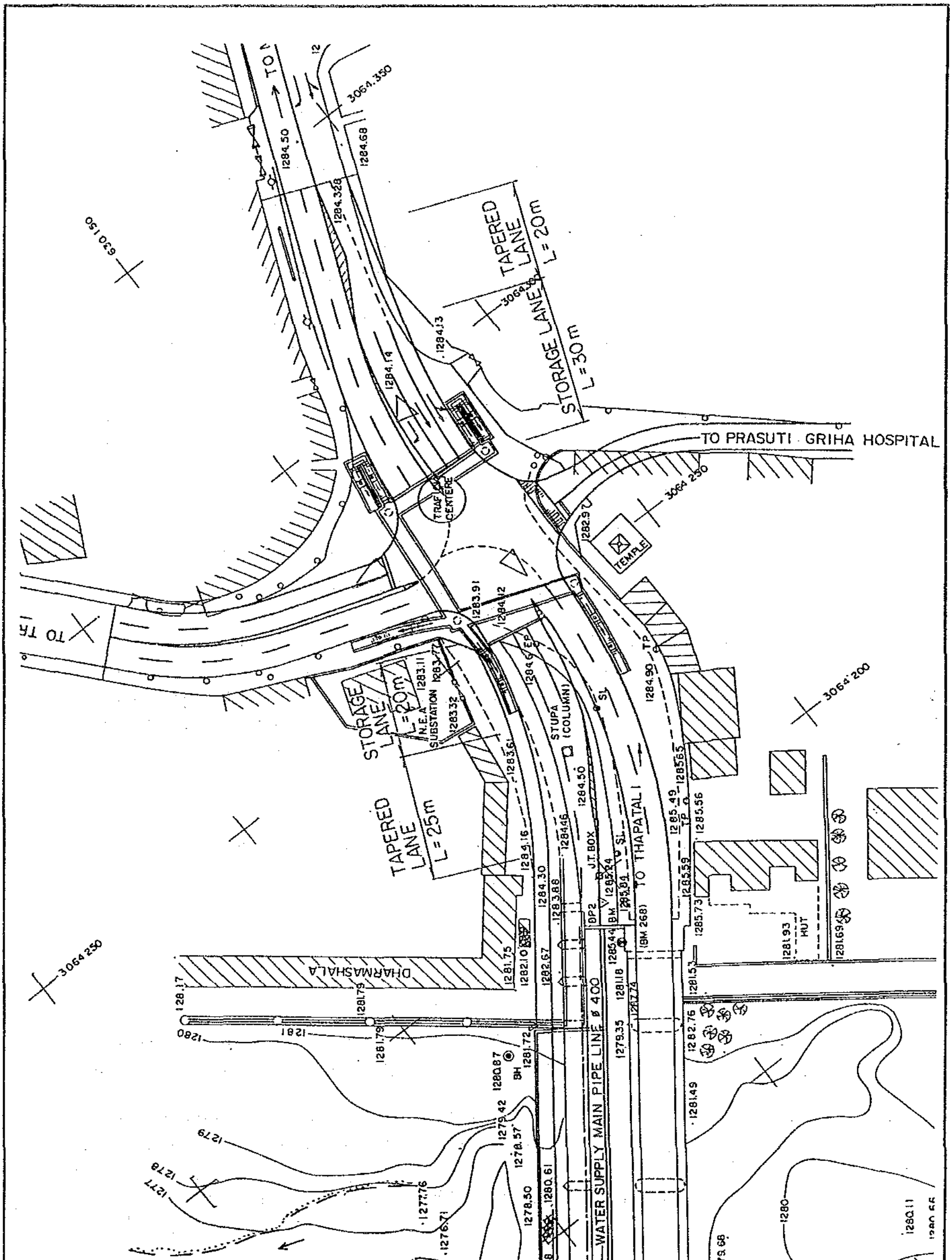


Figure 5.6 Proposed New Intersection at Thapathali

5.3 Bridge Design

5.3.1 Bagmati Bridge No.1 (Kalimati Bridge)

(1) General plan

The section of Bagmati river varies from 110 m to 150 m. There is a slight change of river course at the proposed site according to the aerial photos of 1987 and survey map of about 1974. The length of the proposed bridge was determined taking into account of the existing gabion wall located at the right bank.

Span arrangement of the proposed Bridge No. 1 was determined as shown below:

A multiple span composite steel girder bridge 5@ x 30.6 m = 153 m

(2) Clearance

High water level at the proposed site of Bridge No.1 was calculated at 1276.5 m assuming the maximum discharge of 1,300 m3/sec. According to Japanese Bridge Standards, the minimum clearance required in case that the discharge of river is expected to be 500 - 2,000 m^3/sec is 1.0 m. The elevation of proposed Bridge No.1 was determined on the basis of high water level with some allowance of steel girder. A clearance was determined to be 3.0 m above water level, that is about E.L.=1274 m.

(3) Layout Plan

Layout plan including typical section is presented in Fig. 5.7.

5.3.2 Bagmati Bridge No.2 (New Bagmati Bridge)

(1) General Plan

The proposed bridge will be constructed after demolishing the existing old steel truss bridge, which is located about 10 m downstream of the existing Bagmati bridge. Span arrangement was determined on the same line as on existing bridge considering smooth flow of river. The right abutment of existing bridge is set back about 20 m from the river bank, however, this set back might be not necessary from the view point of present river condition. It is therefore that new bridge could be shortened by 15 m approx.

Span arrangement of the proposed Bridge No.2 (New Bagmati Bridge) is determined as follows:

Composite steel girder bridge   17 m + 4@ x 30 m = 137 m

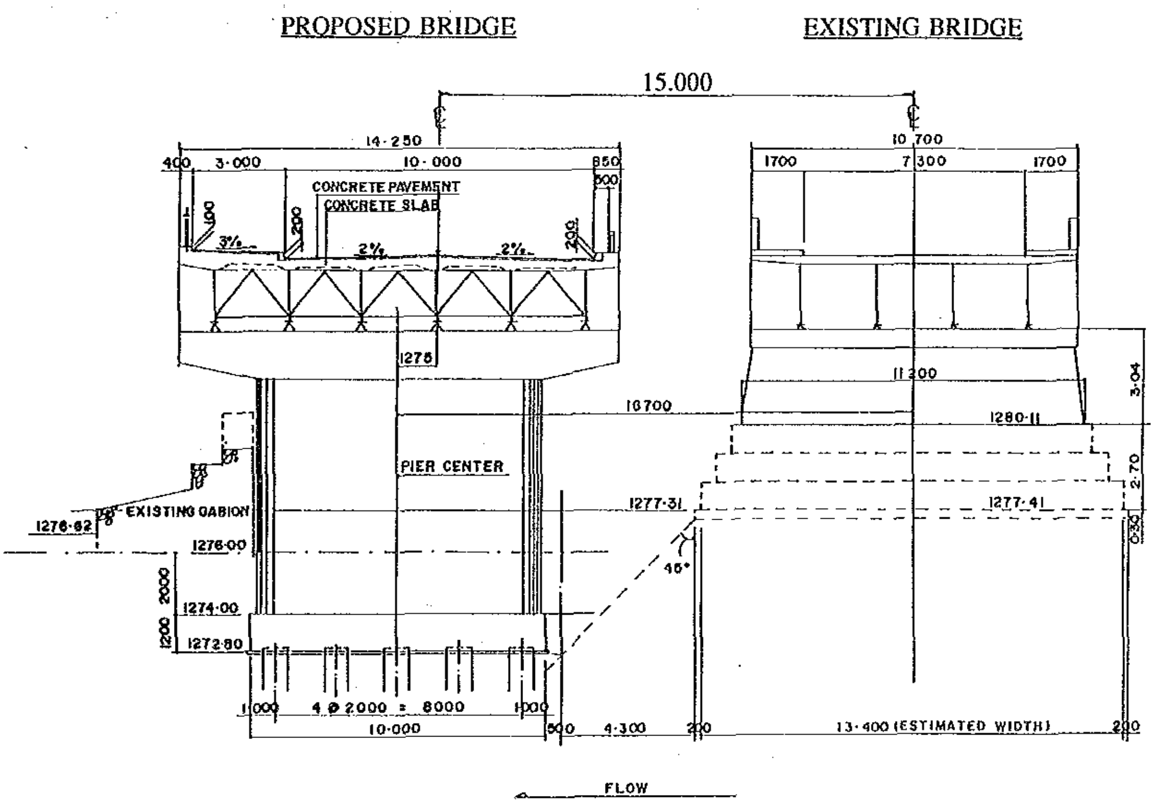
Formation level of the proposed bridge should be the same as the existing bridge. The vertical clearance has a sufficient against the calculated high water level.

(2) Covering Depth of Foundation

The covering depth of foundation is determined to be 2.0 m taking into consideration the lowering of river bed.

(3) Distance from existing bridge to new bridge

It is observed that the existing bridge was constructed on black cotton soil. This material generally has a high cohesion value and stand almost vertically when it is dry. The earth looseness will not be much during excavation. The looseness of soil during excavation is calculated to determine distance between the adjacent foundations. Assuming the distribution angle of 45°, the distance between center lines of the two bridges was determined to be 15.5 m.



DISTANCE FROM EXISTING BRIDGE TO NEW BRIDGE

(4) Protection of Existing Bridge

Alternative study on protection work for the existing bridge was conducted, result of which is presented in Appendix 5.3.1.

A firm checkdam (ground sill) might be necessary on downstream to maintain the river bed level and prevent it's further erosion. The check-dam made of reinforced concrete should be provided as the permanent structure.

In addition to the check-dam, the scour protection around the existing piers should be constructed. The elevation of this protection should be the same as that for the ground sill. From hydrological considerations, the top of ground still should be 1.5 m below the top of existing pier footing.

(5) Demolishment of Existing Old Truss Bridge

There is an old truss bridge where new Bagmati Bridge will be constructed. It is not being used for vehicular at present. This old truss bridge should be demolished however water main, telephone and electric line equipped with old truss bridge must be relocated to the new Bagmati Bridge.

(6) Layout Plan

Fig. 5.8 shows the general layout plan of New Bagmati Bridge at Thapathali.

BAGMATI BRIDGE No.1 SKETCH
Multiple Span Composite Steel Girder Bridge

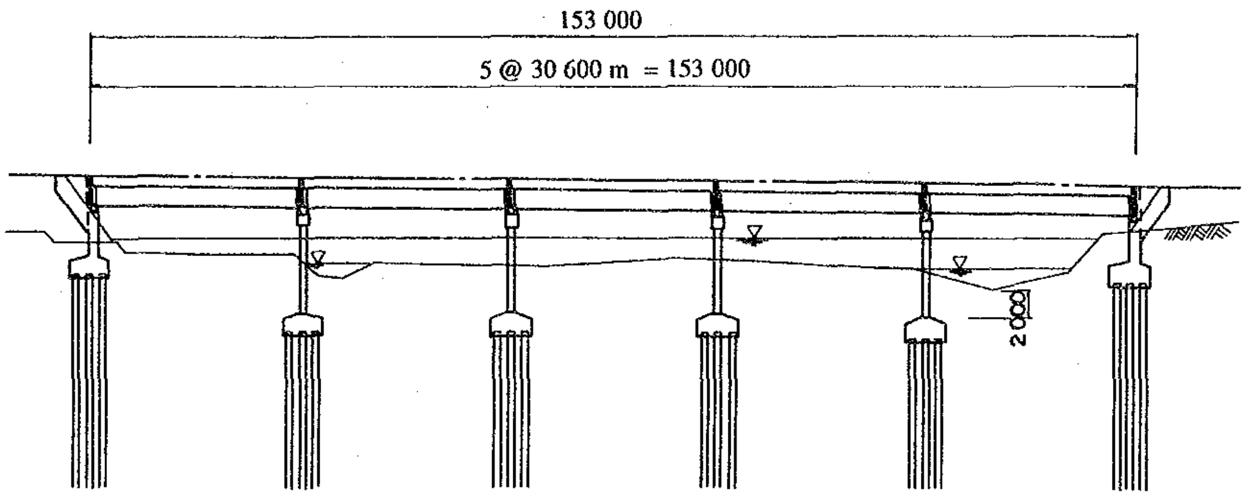


Figure 5.7

BAGMATI BRIDGE No.2 SKETCH
Composite Steel Girder Bridge

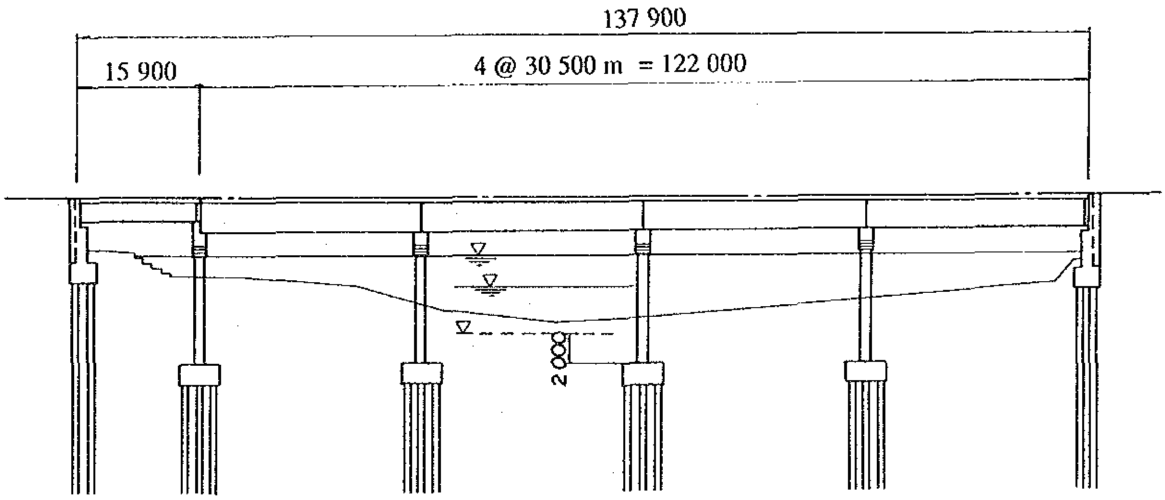


Figure 5.8

5.3.3 Bagmati Bridge No.3 (Chakupat Bridge)

(1) General Plan

Aerial photos prepared in 1987 and survey map in 1974 indicate a change of river course. It can be seen that the existing left bank has shifted about 45 m from the old position while the right bank shifted back about 25 m. The width of the river has narrowed from about 145 m to 120 m. The right side abutment is planned to be located behind the existing old gabion wall while the left side abutment behind the existing river bank line. The total length of the bridge will be 120 m.

Span arrangement of the proposed Bridge No. 3 is determined as shown below:

A multiple span composite steel girder bridge 4@ x 30 m = 120 m

(2) Clearance

High water level of Bridge No.3 is calculated at 1283.7 m assuming the maximum discharge of 1,030 m^3/sec. The required minimum clearance is 1.0 m in case that the discharge of river is expected to be 500 - 2,000 m^3/sec according to the Japanese Standards. The elevation of proposed Bridge No.3 is determined on the basis of high water level taking into account the estimated height of steel girder of the bridge.

(3) Layout Plan

Layout plan including typical section is presented in Fig. 5.9.

5.3.4 Bagmati Bridge No. 4 (Koteswor Bridge)

(1) General Plan

This bridge is located before its confluence with Manohara river. Aerial photos of 1987 indicates a shift of the river to the right side by 7 - 8 m. The left side abutment is planned behind the old river bank while the right side abutment behind the existing bank. The total length of the bridge is 60 m.

Span arrangement of the proposed Bridge No.4 was determined as shown below:

Composite steel girder bridge 2@ x 30 m = 60 m

(2) Clearance

High water level of Bridge No.4 is calculated at 1286.5 m assuming the maximum discharge of 210 m^3/sec. The required minimum clearance is 0.8 m in case that the discharge of river is expected to be 200 - 500 m^3/sec according to the Japanese Standards. The elevation of proposed Bridge No.4 was determined on the basis of high water level taking into account the estimated height of steel girder of the bridge.

(3) Layout Plan

Layout plan including typical section is presented in Fig. 5.10.

5.3.5 Pedestrian Bridge

The pedestrian bridges are planned at intersections located at both end of New Bagmati Bridge.

Design was conducted in accordance with the Pedestrian Crossing Bridge Design Manual published by Japan Road Association employing following design condition:

Live Load (pedestrian load)	350 kg/sq.m
Seismic Load (seismic coefficient)	0.14

BAGMATI BRIDGE No.3 SKETCH
Multiple Span Composite Steel Girder Bridge

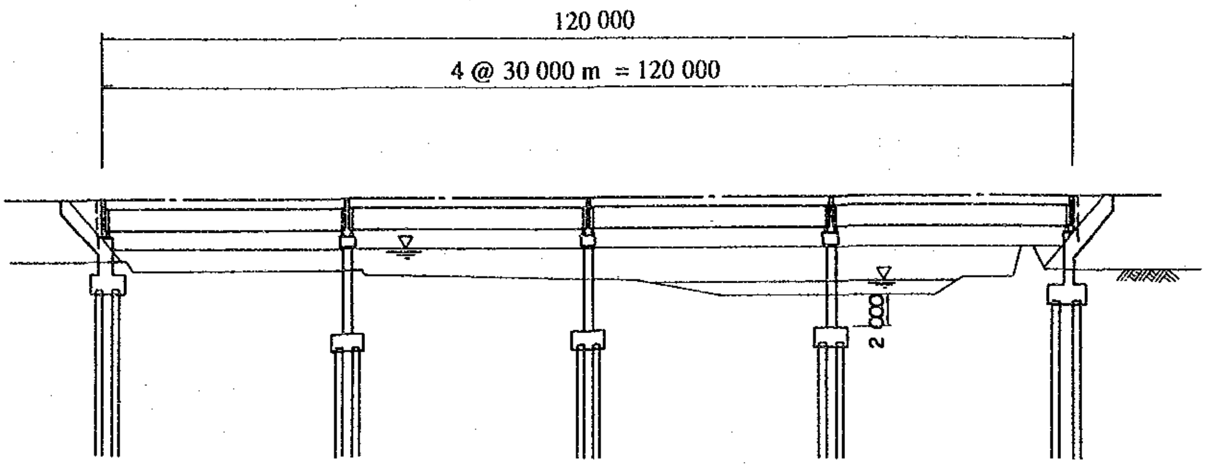


Figure 5.9

BAGMATI BRIDGE No.4 SKETCH
Composite Steel Girder Bridge

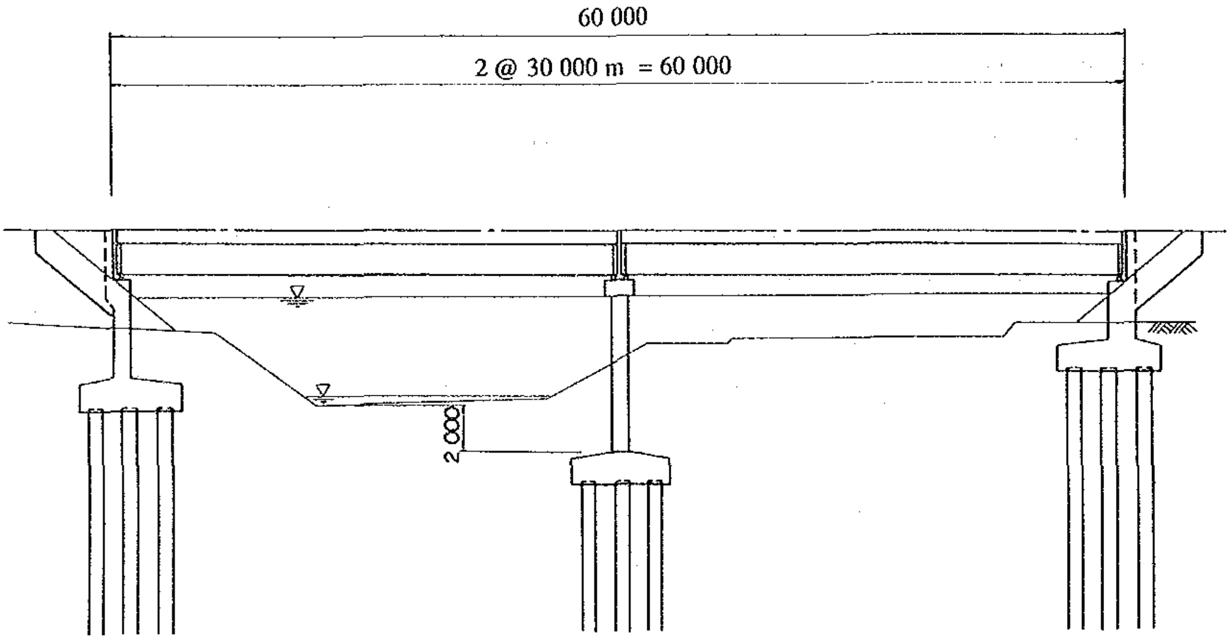


Figure 5.10

The type of pedestrian bridge was determined taking into account construction and maintenance costs, availability of materials either concrete or steel, the span length, functional requirement of substructure, construction method and period, and environmental requirements.

Steel girder type was selected for the proposed pedestrian bridge because of the following reasons:

(i) The width of road over which the bridges are required to pass is wide ranging from 21.0 m to 37.0 m, for which steel bridge is suitable.

(ii) Proposed bridge is located on the ground with soft soil and black cotton so that light weight superstructure (steel) is preferable to reduce a reaction of foundation.

(iii) Proposed bridge is required to pass over the road carrying heavy traffic, for which steel bridge is superior to minimize the disturbance of existing traffic during construction.

(iv) Steel girder bridge is adopted for all other proposed bridges across Bagmati river (Bridge No. 1, No.2, No.3 and No.4) so that selection of steel bridge for the pedestrian bridge is reasonable in terms of construction cost, ease of construction, etc.

The following is the main feature of proposed pedestrian bridge:

(1) Pedestrian Bridge at Thapathali on Kathmandu side

Width	:	3.0 m
Span Length	:	72.0 m (24.0 m + 26.0 m + 22.0.m)
Type of Bridge	:	Steel Girder
Width of Staircase	:	1.5 m

(2) Pedestrian Bridge at Kopundor on Patan side

Width	:	3.0 m
Span Length	:	116.0 m (21.0 m + 37.0 m + 26.0 m + 37.0 m)
Type of Bridge	:	Steel Girder
Width of Staircase	:	1.5 m

Minimum vertical clearance below the bridge was determined to be 6.5 m taking into consideration the trolleybus operating on the proposed road.

General plan of pedestrian bridges is shown in Fig. 5.11.

<u>Alternative of Pedestrian Crossing</u>

Under-pass is considered to be an alternative of pedestrian crossing at Thapathali intersection. The following are the results of comparative study:

<u>Pedestrian Over-bridge</u>

Pedestrian overbridge might affect on the scenery of Kathmandu Valley so that it should be planned paying due attention to bridge type and materials to harmonize with the surrounding area. It is apparent that over-bridge is inferior to underpass in scenery, however, it is superior in maintenance and operation costs, sanitary, safety or public piece problem, construction period, etc.

Steel girder bridge was planned taking into consideration construction cost, construction period, traffic management during the construction, road width to be overpassed, etc. though PC bridge is superior to steel girder bridge in terms of scenery.

<u>Underpass</u>

Underpass will not spoil the scenery of Kathmandu Valley, however, it may have issues and problems to be solved as shown below:

(i) It must be equipped with lighting and drainage facilities which require electricity for its operation and maintenance. Kathmandu Valley, however, has a serious shortage of electricity at present, so that these facilities might not be operated and maintained unless the shortage of electricity is solved.

(ii) There is an idea to furnish the underpass with a underground shopping arcade to impose the operation and maintenance costs on the shops. It may, however, require a sufficient space for providing shops and stalls inside the underpass and the construction cost will be increased twice or three times of over-bridge.

(iii) Moreover, should the shopping arcade be included in the construction of underpass, it would be difficult to have a subsidy or official development assistance from the foreign countries for its implementation.

(iv) The underpass near Ratna Park in the central Kathmandu, which is the only underpass of pedestrian crossing in Kathmandu, has not been utilized effectively due to sanitary and public peace problems. The proposed underpass at Thapathali may have the same problems unless it is maintained cleanly and safely by DOR or agencies concerned.

(v) The construction of underpass requires the traffic control or restriction during the construction because of the limited space for providing detour roads in the intersection so that it may cause serious traffic disturbance during the construction

Summarizing the above, it is concluded that the underpass is superior to the overbridge in scenery, however, it is not recommendable for a pedestrian crossing at Thapathali intersection from the view point of economy, maintenance and operation, sanitary and safety, less of implementation and construction.

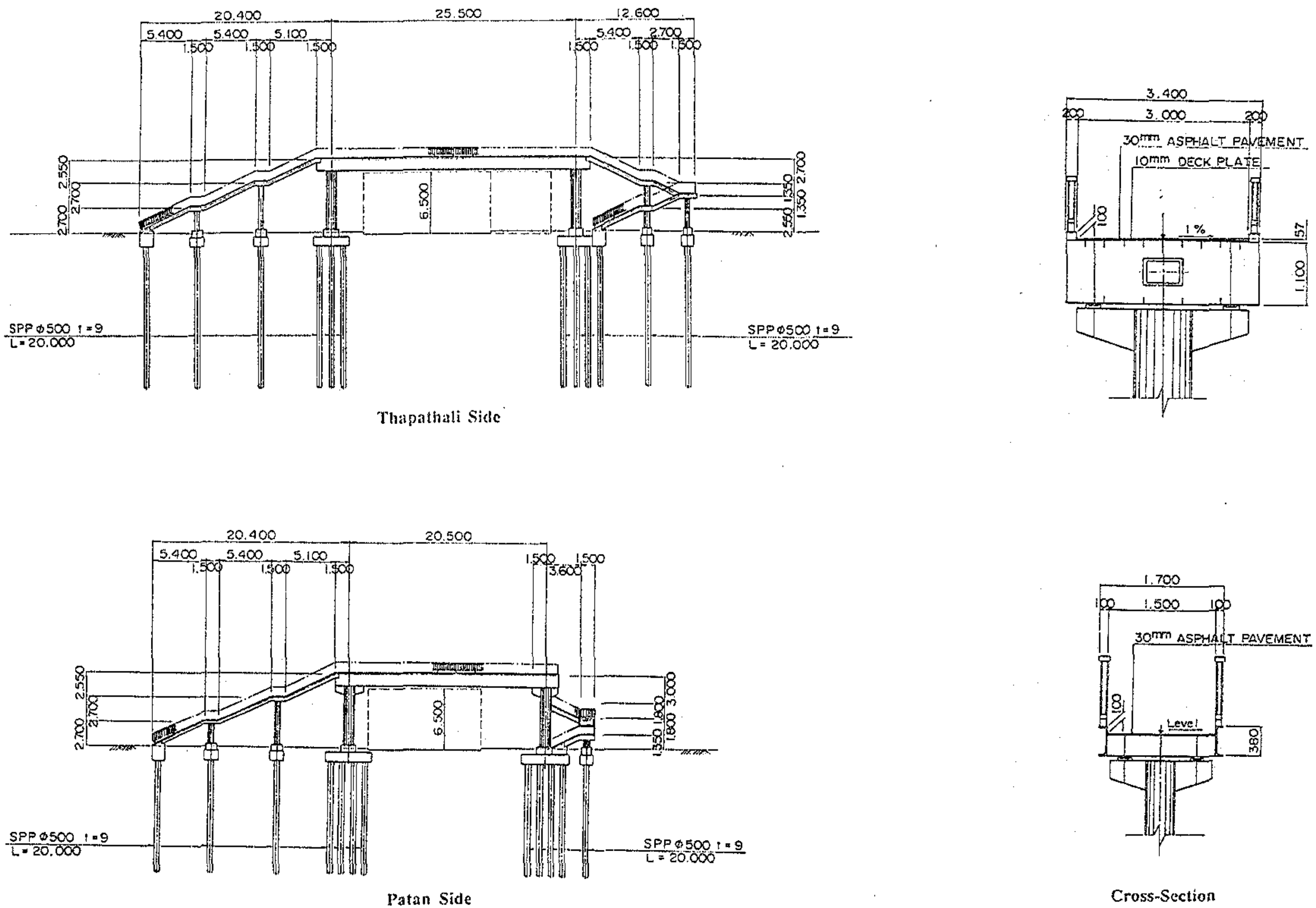


Figure 5.11 General Plan of Pedestrian Bridge

5.4 Drainage Design

Since the project road is running on relatively flat terrain with a slight slope, there would be no much problems on setting of drainage structures. The drainage system consists of road surface drainage and road side drainage as follows:

5.4.1 Road Surface Drainage

Road surface drainage will be constructed at the following locations:

(i) The sag points on the road profile,

(ii) The crossing points of existing rivers and drainage structures,

(iii) The points accessible to the existing waterway.

Fig. 5.11 shows the proposed road surface drainage system of which design criteria is described as follows:

(i) Outer shoulders and sidewalks which have more than 2.0 m width will be utilized for the location of road gutter, and

(ii) Catch pit with grating covers will be placed at interval of not more than 100 m.

5.4.2 Road Side Drainage

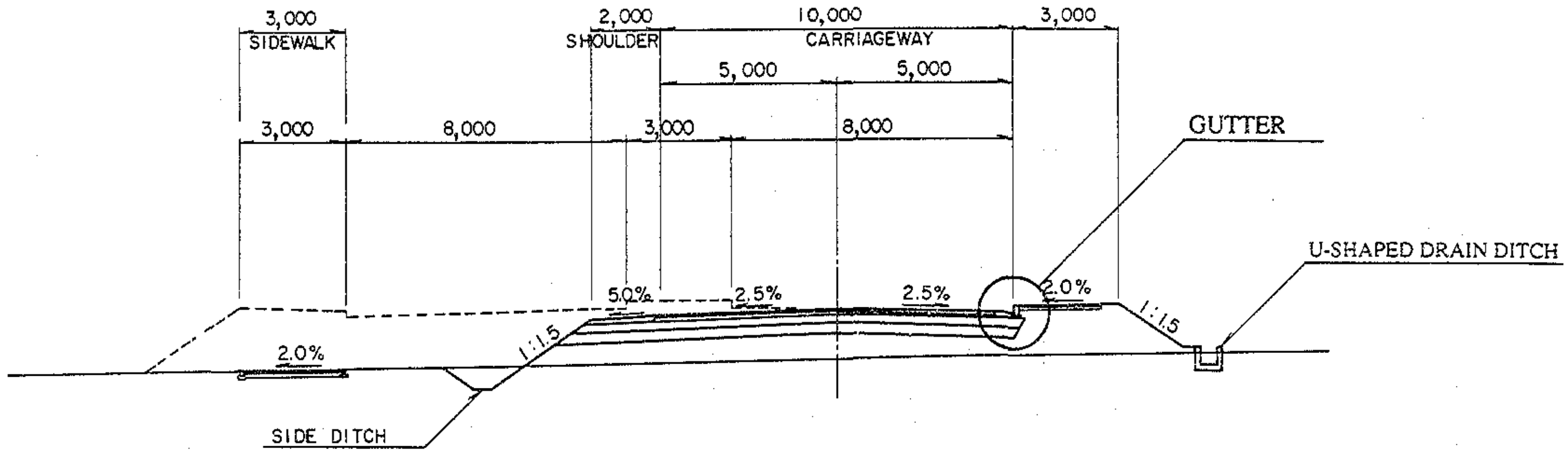
The road side drainage is to protect the road structures and adjacent areas from floods caused by rainfall on roads and surrounding areas.

Road side drains, which should have enough discharge capacity for the above purpose, will be provided outside the toe of embankment and connected to the existing main drain, canal and river properly with the following conditions:

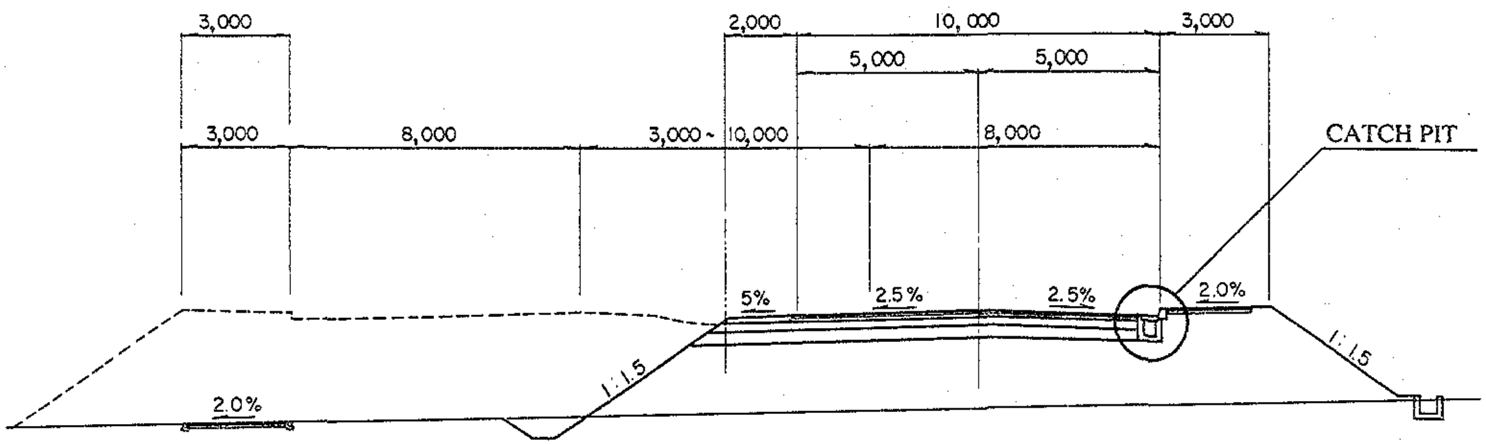
(i) Pipe culvert with more than 60 cm in diameter should be used for this purpose taking into account ease of maintenance;

(ii) The minimum allowable velocity should be 0.8 m/sec. to prevent silutation and the maximum 3.0 m/sec. to avoid excess scour; and

(iii) All culverts should be designed to free outlet conditions.



To be adopted in Open Area



To be adopted in Open Area beside the River

Figure 5.12 Proposed Road Surface Drainage System

5.5 Pavement Design

5.5.1 Selection of Pavement Type

Pavement structures is broadly divided into two types namely, flexible pavement (asphalt pavement) and rigid pavement (concrete pavement). Type of pavement is determined on the basis of its characteristics of flexible and rigid pavement taking into account the following factors:

(i) Construction practices in terms of design life (10 years for flexible pavement and 20 - 30 years for rigid pavement)

(ii) Construction economy (cost of rigid pavement is higher that of flexible pavement)

(iii) Ground Condition (normally rigid pavement is not adopted in soft ground area because of unequal settlement of embankment)

(iv) Local conditions (availability of materials, government policy, etc.)

Considering the construction economy, ground condition in the Valley and local condition, the flexible pavement is recommended for the proposed roads.

5.5.2 Alternative Study of Flexible Pavement

Two types of flexible pavement is considered for the alternative study namely, Double Bitumen Surface Treatment (DBST) and Asphalt Mixed Concrete (AMC).

(1) Double Bitumen Surface Treatment (DBST)

This method is very common in Nepal because of its easy maintenance and low construction cost if compared with asphalt mixed concrete. However, this type of pavement is not recommendable to adopt for the arterial urban road with heavy traffic volume because of its short design life and unreliable quality.

Durability, waterproofing and stability of DBST will be not reliable unless the work is constructed by the skilled labor with experience because of difficulty of materials control during the construction, though it can be maintained by relatively unskilled labor.

DBST, therefore, will not perform satisfactorily throughout even its design life unless regular maintenance in the form of re-sealing or patching work would be conducted properly and periodically.

DBST is recommended to adopt for low standard road with a narrow carriageway less than 5.5 m but not for high standard road as such proposed road.

(2) Asphalt Mixed Concrete (AMC)

AMC pavement is currently used on urban road, particularly on arterial and highway with heavy traffic.

Initial cost of AMC is higher than that of DBST since it requires asphalt mix plant and high skilled engineer and labour for operating the plant and quality control at construction site.

However, ACM has longer design life than DBST and quality of the pavement, such as durability, waterproofing and stability, is superior to DBST pavement, since it is mixed up with and measured properly in the mechanical plant.

ACM is particularly suited to the urban road carrying heavy traffic since it can be opened to traffic immediately after laying pavement so that traffic congestion could be minimized during the construction.

Although it is necessary to spend more initial investment, it is recommended to adopt AMC pavement for the proposed road taking into account the function of proposed road expected as arterial urban road with heavy traffic as well as the smaller maintenance cost if compared with DBST pavement.

5.5.3 Thickness Design of AMC Pavement

The preliminary thickness design of flexible pavement was carried out in accordance with the "MANUAL FOR ASPHALT PAVEMENT, 1989" published by Japan Road Association. The Japanese method of asphalt pavement design is largely on the basis of domestically developed technology incorporated with principles of AASHO Road Test and the CBR Design Curve method.

Traffic load estimates were based on the result of traffic study in Main Report (Part A: Master Plan Study). Design inputs including effective modules of subgrade reaction were estimated by referring available data and information obtained through the engineering survey.

The thickness and the structure of individual layers of pavement are designed based on a comprehensive judgment of various factors including subgrade, traffic and climate conditions as well as economic aspects. The pavement design was conducted as follow:.

(1) Classification of Roads by Traffic

The one-way daily traffic volume of heavy vehicles in 5th year after opening the road to public is first estimated to determine the pavement standard from among the five grades shown in Table 5.3.

Table 5.3 Traffic Classification

Traffic Classification	One-way Daily Traffic of Heavy Vehicles
L	Less than 100
A	100 to 250
B	250 to 1,000
C	1,000 to 3,000
D	More than 3,000

One-way daily traffic volume of heavy vehicles in 5th year, which is the year of 2002 assuming the completion of the project in 1997, was calculated for each road section using the basic traffic data obtained through traffic survey. The summary of estimated traffic volume by road section as well as the traffic classification are summarized in Table 5.4.

Table 5.4 Estimated Traffic Volume and Traffic Classification

Road Section	One-way Daily Traffic Volume of Heavy Vehicles in 2002	Traffic Classification
South Link of Inner Ring Road	1,150	C
Patan Access	500	B
New Bagmati Bridge	2,450	C
Koteswor Access	850	B
New Bus Terminal Access	650	B

Heavy vehicles refers to cargo trucks, buses and special vehicles, etc.

(2) Design CBR Value

For the design of pavement thickness, subgrade soils are sampled to determine the design CBR. According to the soil tests conducted by the Study Team, soil samples obtained from Thimi borrow pit showed the good result for subgrade soil, and design CBR was determined to be 4 %.

(3) Design of Pavement Thickness

Pavement thickness is designed based on the design CBR as well as the road classification given in Table 5.3 such that each individual course does not fall below the target value of T_A shown in Table 5.5, and that the total pavement thickness does not become smaller than the target total thickness in Table 5.5 by 1/5 or more.

T_A represents the pavement thickness which would be required if the entire depth of the pavement were to be constructed of hot asphalt mixed concrete for binder and surface courses.

Table 5.5 Target Values for TA and Total Pavement Thickness

Design CBR	Road Classification									
	L		A		B		C		D	
	Ta	H	Ta	H	Ta	H	Ta	H	Ta	H
2	17	52	21	61	29	74	39	90	51	105
3	15	41	19	48	26	58	35	70	45	83
4	14	35	18	41	24	49	32	59	41	70
6	12	27	16	32	21	38	28	47	37	55
8	11	23	14	27	19	32	26	39	34	46
12	-	-	13	21	17	26	23	31	30	36
20 or more	-	-	-	-	-	-	20	23	26	27

Based of the traffic classification as well as the design CBR of subgrade of embankment, thickness of pavement structure for each proposed road was estimated as shown in Table 5.6.

Table 5.6 Pavement Thickness Required for Proposed Road

Type	The Desirable T_A	Total Thickness of Pavement (cm)	Proposed Road
Type-I	23.5	50	Sanepa Access
			Patan Access
			Koteswor Access
			New Bus Terminal Access
Type-II	31.0	61	South Link of Inner Ring Road
			New Bagmati Bridge

(4) Alternative design of Pavement Structure

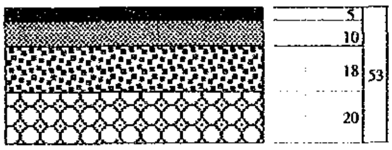
In determining the pavement structure, the following formula is applied for the calculation of T_A:

$$T_A = a_1T_1 + A_2T_2 + \dots\dots\dots a_nT_n$$

Where $a_1, a_2, \dots\dots, a_n$: Coefficient of relative strength given in Table 5.7
$T_1, T_2, \dots\dots, T_n$: Thickness of individual layers of pavement, (cm)

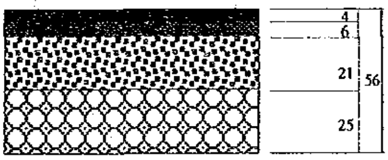
Coefficients of relative strength in Table 5.7 indicate in cm the thickness of hot asphalt mix used in constructing binder and surface courses, having a strength equivalent to 1 cm layer of pavement of other materials and method of construction. For example, the coefficient being 0.35 for mechanically stabilized materials indicates that the strength of a 1 cm layer of such material is equivalent to that of a 0.35 cm layer of hot asphalt mixes used in binder and surface courses.

As the result of calculation, Two (2) alternative pavement structure have been considered for the each type of pavements as shown in Fig. 5.13. Cement or lime stabilized base course is not recommendable for the project road because of limited construction period and weather condition.



Surface course (Hot asphalt mix)
Base course (Bituminous stabilization, Stability>350kgf)
Base course (Crushed stone for mechanical stabilization, CBR>80)
Subbase course (Crusher-Run,CBR>30)

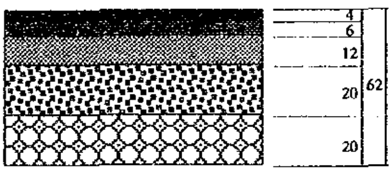
Type I-1



Surface course (Hot asphalt mix)
Binder course (Hot asphalt mix)
Base course (Crushed stone for mechanical stabilization, CBR>80)
Subbase course (Crusher-Run, CBR>30)

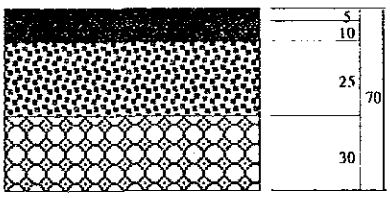
Type I-2

Pavement Type I



Surface course (Hot asphalt mix)
Binder course (Hot asphalt mix)
Base course (Bituminous stabilization, Stability>350kgf)
Base course (Crushed stone for mechanical stabilization, CBR>80)
Subbase course (Crusher-Run, CBR>30)

Type II-1



Surface course (Hot asphalt mix)
Binder course (Hot asphalt mix)
Base course (Crushed stone for mechanical stabilization, CBR>80)
Subbase course (Crusher-Run, CBR>30)

Type II-2

Pavement Type II

Unit : centimeter

Figure 5.13 Alternative Pavement Structure

Table 5.7 Coefficient of Relative Strength for Calculating TA

Pavment Course	Method and Materials of Construction Used	Conditions	Coefficients
Binder and Surface Courses	Hot asphalt mix for binder and surface courses		1.00
Base course	Bituminous stabilization	Hot mixed, Marshall stability: 350 kg or more	0.80
		Cold mixed, Marshall stability: 250 kg or more	0.55
	Cement stabilization	Unconfined compressive strength(7 days): 30kg/m2	0.55
	Lime stabilization	Unconfined compressive strength(10 days): 10kg/m2	0.45
	Mechanically stabilized Gravel and Slag	Modified CBR: 80 or more	0.35
	Hydraulic mechanically stabilized slag	Modified CBR: 80 or more	0.55
	Penetration macadam	Unconfined compressive strength(14 days): 12kg/m2	0.55
Subbase course	Crusher-run, Slag	Modified CBR: 30 or more	0.25
	Sand	Modified CBR: 30 or more, less than 30	0.20
	Cement stabilization	Unconfined compressive strength(7 days): 10kg/m2	0.25
	Lime stabilization	Unconfined compressive strength(10 days): 7kg/m2	0.25

(5) Optimum Pavement Structure

Type I-1 and Type II-1 was designed to obtain high quality pavement in terms of durability, waterproofing and stability, however, the construction cost of these type is much higher than that of Type I-2 and Type II-2 which were designed to utilize cheaper materials of crushed stone and crusher-run for base course and subbase course.

It is recommended to adopt Type I-2 and Type II-2 for the proposed road taking into account the lesser construction cost.

5.5.4 Pavement Structure for Side-walk

Pavement structure for side-walk was determined as shown in Fig. 5.14 according to the manual.

Figure 5.14 Pavement Structure of Side-Walk

5.6 Road Facilities Design

5.6.1 Utilities Space for Public Services

Public services utilities either underground or overhead are planned to be set at either sidewalk or shoulder.

The 3.0 m wide shoulder and sidewalk will provide space to contain the following public utilities:

(i) Water main and distribution pipes

(ii) Electric power ducts

(iii) Telecommunication line

(iv) Sanitary sewers

5.6.2 Bus Bays

Proposed roads will be bus routes and the provision of bus bays will become necessary exclusive spaces for buses to stop.

Bus bay consists of a stopping bay with taper at booth ends. Normally a stopping bay is 15.0 m long and 3.0 m wide which is sufficient to one large bus. 20 m length of taper minimize the disturbance to other vehicles on the through lanes.

Proposed location of bus bays are marked with circle as shown in Fig. 5.15, however, final location shall be determined in accordance with the following criteria after discussions:

(i) The locations of bus bays shall avoid as much as possible places where the stopping and starting movement of buses is likely to be interfered with by vehicles from other roads,

(ii) They shall be close to the pedestrian crossing facilities and bridges and at-grade crossings planned, and

(iii) They shall be placed where sufficient spaces are remained within the given ROW.

A shelter is provided at each bus bays.

5.6.3 Pedestrian Crossing Facilities

There are two types of crossing facilities planned for this project namely, at-grade crossing painted on the pavement surface and elevated pedestrian bridges with staircase. No underpasses by box culverts are planned because of the problems on security and drainage.

The exact type and location of at-grade crossings should be determined at the detailed design stage.

Pedestrian over bridge of the type of shown in the "Drawings - Part B" in this study will be provided at the both end of New Bagmati Bridge at Thapathali in order to flow a large numbers of traffic focusing on the intersection smoothly and efficiently as well as to secure the safety of pedestrian crossing the intersection at Thapathali.

Type of pedestrian over bridges was discussed in the study on Bridge Design.

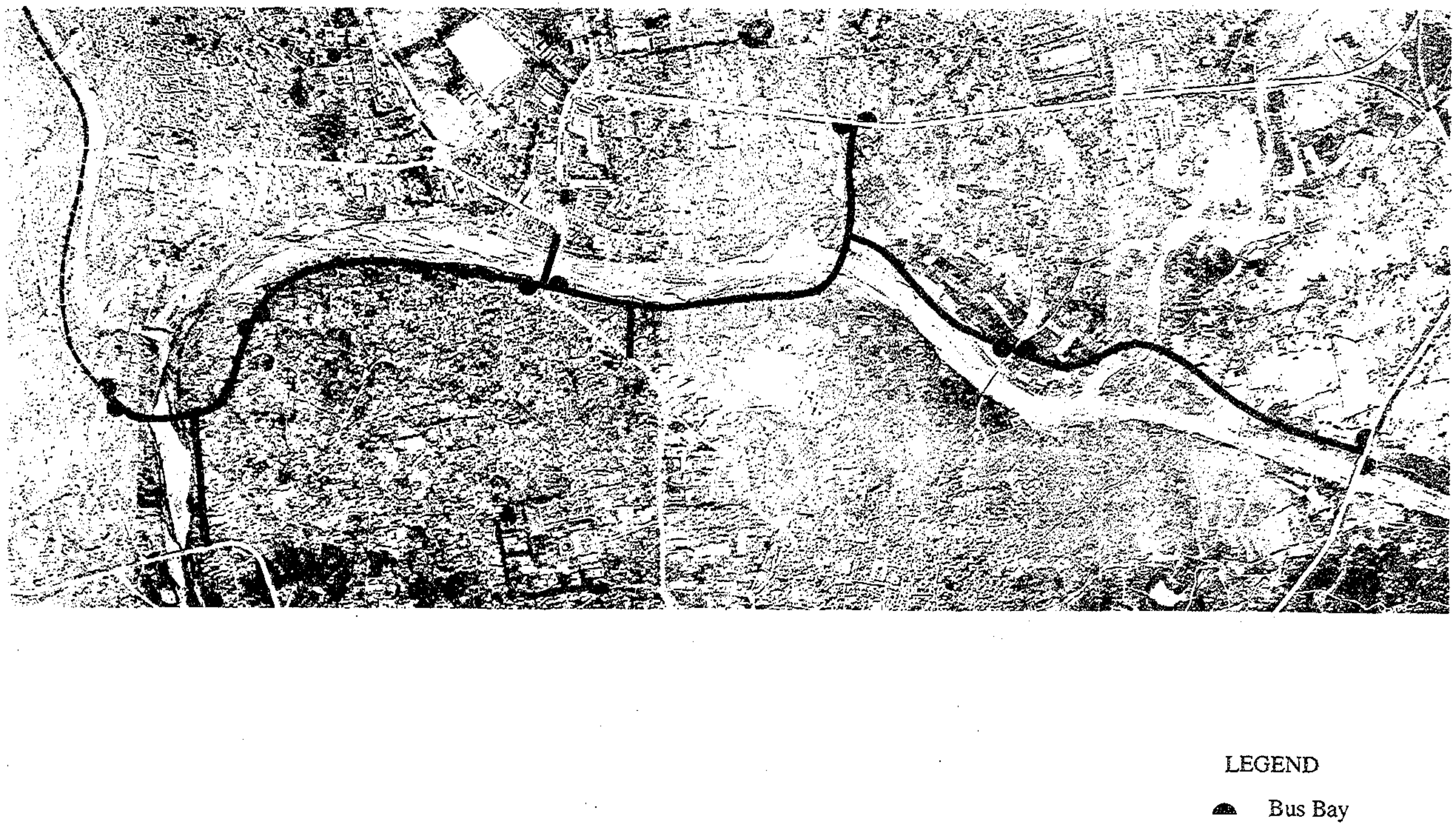


Figure 5.15 Proposed Location of Bus Bays

5.6.4 Street Lighting

The objectives of the lighting facilities is to maintain good driving conditions of drivers, to reduce the number of traffic accidents during the night time and to make the road and bridge structures more attractive to potential users.

Lighting facilities should be provided with the South Link of Inner Ring Road and New Bagmati Bridge at Thapathali including both intersections. No lighting facilities is recommended on Access Roads taking into account the road function, the traffic volume anticipated on the roads and operation and maintenance costs of lighting facilities.

Numbers of lighting columns, mounting position and height of luminaries should be determined by the degree of road surface luminance.

5.6.5 Traffic Signal

Traffic signals shall be installed at at-grade intersections for traffic control, safety of drivers and smooth handling of traffic flow.

Detailed elements to be considered in the study on traffic signal are as shown below, however, they must be conducted in the detailed design stage.:

- Signal installation,
- Signal equipment, and
- Signal control system.

Traffic signal having standard lenses with red, armor and green coloured is recommended. It should be installed on overhanging tapered poles with arm at a height of 6 m.

Signal for pedestrian, which is a signal head covered with a symbol of a person and standard red and green coloured, is also recommended to install at the top of a 3.5 m high pole in each direction at intersection.

5.7 Relocation and Protection of Public Utilities

Relocation of existing utilities is one of the most awkward aspects of the road construction in urban areas due to involvement of many authorities or agencies who have different policies, development time schedules and technical standards.

The existing utilities were investigated by the Study team, however, detailed data showing the location and dimension could not be obtained from the authorities and agencies concerned, especially no data is available regarding underground utilities, such as water main and distribution. The detailed investigation should be conducted in the detailed design stage prior to the commencement of construction.

The inventory of the existing utilities is shown in the "Drawings--Part B" and summarized below:

(i) South Link of Inner Ring Road

Several numbers of a low (220V) and middle(20KV) voltage overhead power lines with poles cross the proposed road. Overhead telephone cable lines also exists along the road, but not many.

Water main and distribution line might cross the proposed road in certain section of the proposed road but it is impossible to identify their exact location.

(ii) New Bagmati Bridge

There exists old truss bridge where New Bagmati Bridge is planned to be constructed. This old truss bridge is now used by pedestrian only, however, it should be demolished prior to commencing the construction of New Bagmati Bridge.

Water main (600 mm in diameter), low voltage electric power cables and telephone cables are hanged on this bridge, so that these utilities should be totally relocated.

(iii) New Bus Terminal Access

A high voltage (150KV) electric transmission line crosses the proposed Access to the New Bus Terminal on its halfway, however, it will not directly affect the construction of the Access since sufficient clearance is maintained in the route selection.

(iv) Other Access

Low and middle electric line and telephone cables are installed along the proposed route, however, the relocation of these facilities might be not difficult.

All utilities to be affected by the construction of proposed roads must be relocated and replaced or protected. Normally the authorities or agencies concerned are responsible for the relocation and replacement works of electric facilities, telephone cable, water main at their own cost.

5.8 Preliminary Right-of-way Plan

The right-of-way (ROW) limit lines for the proposed roads were indicated in the plan showing alignment of road.

The width of ROW strip was determined in accordance with the Nepal Road Standards as stated in Chapter 3 as follows:

	ROW Width	
	Standard(m)	Minimum(m)
South Link of Inner Ring Road	50	30
New Bagmati Bridge	50	30
Sanepa Access	30	20
Koteswor Access	30	20
Patan Access	30	13
New Bus Terminal Access	30	20

5.9 Traffic Management at Intersections

Traffic management at intersections is important so as not to cause the road congestion's as well as the traffic accidents in nearby area. Intersections to be improved have been identified in paragraph 8.2.2 of Text, "Master Plan Study".

Out of the intersections identified in the Master Plan Study, following three (3) location of the intersections are selected to be improved as a model case:

(1) Intersection of Maitighar which is the beginning point of Arniko Highway

(2) Intersection of Tripureswar near national Stadium

(3) Intersection of Koteswor connecting Arniko Highway with Ring Road

Fig. 5.16 shows the layout of the improvement plan on intersections.

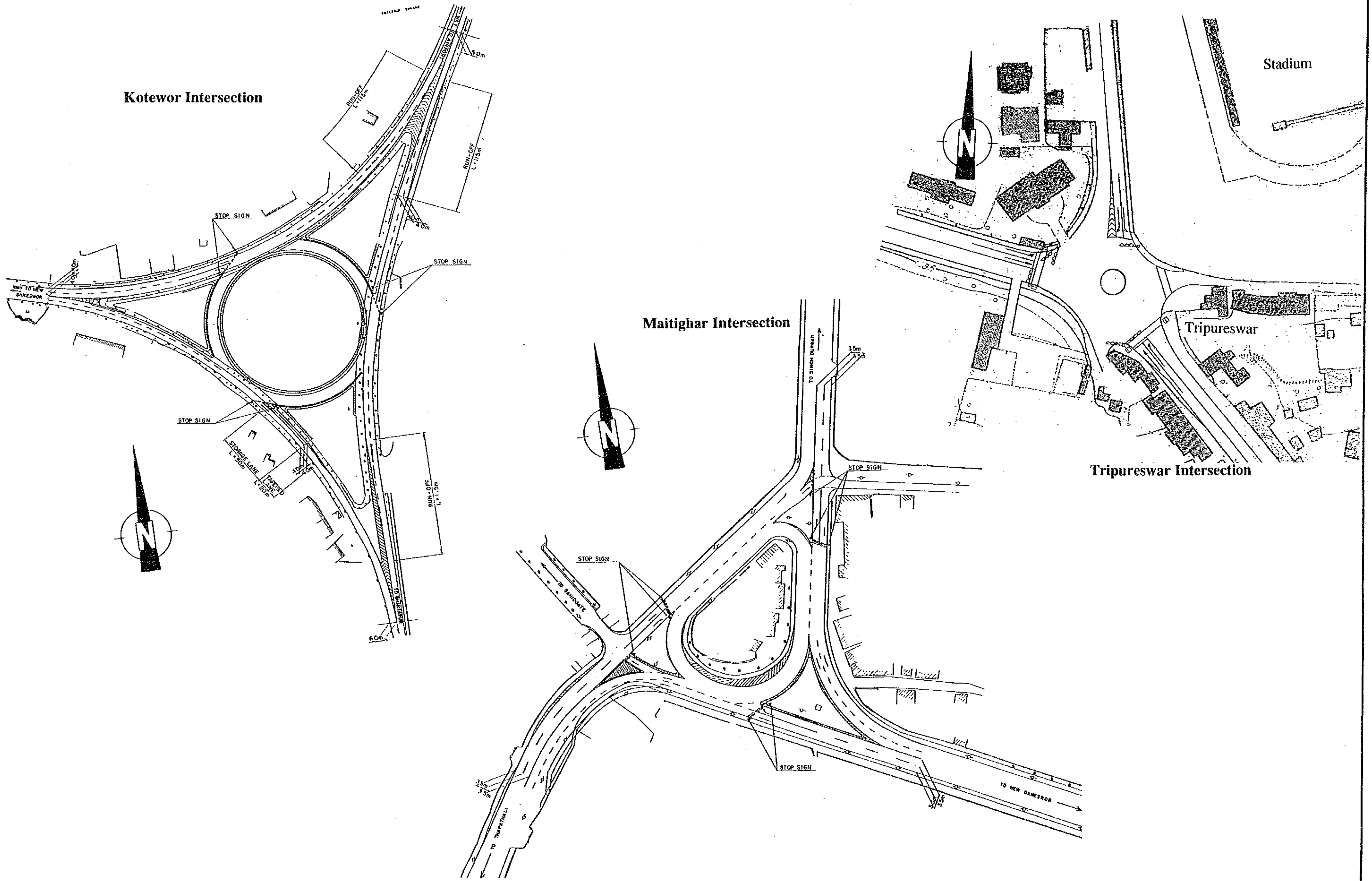
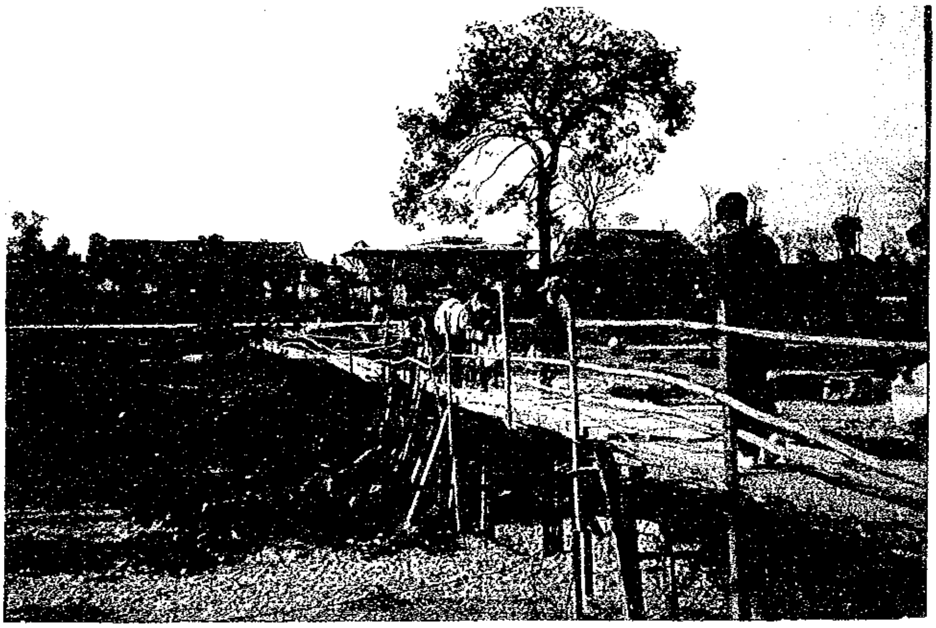


Figure 5.16 Traffic Management at Intersections

CHAPTER 6

CONSTRUCTION PLAN AND COST ESTIMATES



CHAPTER 6 CONSTRUCTION PLAN AND COST ESTIMATES

6.1 General

The project comprises three projects, namely "Improvement of Bagmati Transport Corridor" dividing into five (5) construction sections, "Construction of New Bus Terminal Access" and "Improvement of Traffic Management at Intersections (3 Places)" as follows:

(A) : Improvement of Bagmati Transport Corridor, dividing into;
- (1) South Link of Inner Ring Road
- (2) New Bagmati Bridge
- (3) Koteswor Access
- (4) Sanepa Access
- (5) Patan Access

(B) : Construction of New Bus Terminal Access at Balaju

(C) : Improvement of Traffic Management at Intersections (3 Places)

The project cost, which consists of construction cost, land acquisition and compensation costs, physical contingency, cost of engineering services and consulting supervisory services, etc. was estimated.

6.2 Availability of Local Materials and Equipment

6.2.1 Local Materials

Materials Sources of Aggregates and Fill Materials

As stated in paragraph 4.2.5, the following materials sources are identified suitable for producing concrete and pavement aggregates and the location of these sources are shown in Appendix 4.2.1.

Materials		Materials Sources (Borrow Pits and Quarry Sites)
Soil	;	Kapan, Thimi and Gokarna Ban
Gravel	;	Chuninikhel
Sands	;	Pikhel, Kapan and Basundhara
Crushed Stone	;	Jhalungtar, Godawari and Thankot

6.2.2 Local Plant and Equipment

Some kind of construction equipment are available on rental basis from the local in Kathmandu, such as National Construction Corporation (NCC), Department of Roads (DOR) and local contractors. However, according to the survey made by the Study Team these equipment are mostly old model in poor condition and capacity and numbers of equipment are small and insufficient. Equipment available in Kathmandu are only those which are used for land preparation and hauling of the construction materials, such as, sand, stone and bricks as follows:

Major equipment available in Kathmandu;

- Tipper Truck (6 - 8 ton)
- Dump Truck (8 - 11 ton)
- Bulldozer (16 - 21 ton)

6. 3 Conditions of Project Cost Estimate

The project construction cost is estimated on the basis of the preliminary design and construction plan and schedule. The unit prices are computed in accordance with the following basic assumptions and conditions:

(1) The project cost is estimated assuming that all construction works will be executed on turn key basis by an international contractor.

(2) Unit prices of labour, materials and equipment are computed under the economic conditions or on the basis of market prices prevailing in November, 1992.

(3) The exchange rate used to convert the US$ to Japanese yen and Nepalese Rupees are as follows:

US$ 1.0 = 123.8 yen = NRs. 46.57 (NRs.1.0 = ¥ 2.659)
As of end of November, 1992

(4) The unit price is divided into foreign currency (indicated in Yen) and local currency (indicated in NRs.) portion. The foreign and local component consists of the following items:

(a) Foreign currency component;

- Imported equipment, materials and supplies,
- Imported materials in the local market,
- Wages of expatriate personnel, and
- Overhead and profit of the contractor.

(b) Local currency component;

- Domestic materials and supplies,
- Wages of local personnel,
- Indirect local cost including temporary facilities, and
- Duties and tax

(5) Constitution of the Project Cost

The project cost consists of the following:

- Construction cost,
- Engineering cost including detailed design and construction supervision,
- Physical contingency and price contingency,
- Land/house acquisition cost including the relocation cost of existing utilities
- Government Administration Expanses

(6) Constitution of the Construction Cost

Construction cost constitutes of the following work items:

- Direct construction cost
- Direct cost for temporary works
- General cost for temporary works
- Transportation cost and packing cost
- Site operation and administration cost
- Contractors general expenses

(7) Imported equipment and materials with the exception of fuel are assumed to be exempted from tax and duties by Nepalese government. Fuel including tax and duties is estimated in terms of local currency portion.

(8) Land and house compensation and acquisition costs are estimated on the basis of current unit rate applied by Kathmandu Urban Development Project conducted by ADB.

(9) 25% of overhead including profit is considered in the unit costs.

(10) Contingency including physical contingency and price escalation is estimated to be 15 % of the total of construction cost.

(11) The fee for engineering services is estimated at 10 % of the total construction cost.

6.4 Unit Costs

6.4.1 Unit Price of Materials/Labour/Equipment

(1) Materials

Construction materials are mostly imported from other countries. The materials are assumed to be imported from the following countries:

- Cement ; Indonesia
- Reinforcement ; Korea
- Asphalt Bitumen ; Singapore
- Explosive ; Japan
- Structural steel ; Japan
- Gabion mesh ; Japan
- Traffic Signal ; Japan

The unit price is estimated on the basis of the above assumption and CIF Calcutta price. It includes the inland transportation between Calcutta and Kathmandu, as a local component.

Table 6.1 shows the unit price of materials by material source.

(2) Labour

The unit price of labour is estimated on the basis of the average daily wages applied for works conducted by an international contractor working in Nepal. Daily wages includes the allowance for overtime.

Table 6.2 shows the average daily wage by labour classification.

(3) Equipment

Unit price of equipment is developed using FOB price at shipping port of foreign country (tentatively Tokyo port, Japan was used for estimation purpose). The purchasing prices of equipment, which is used for calculating depreciation cost of equipment, are the prevailing prices in Japan in November, 1992.

The foreign currency portion of unit price includes the depreciation cost, spare parts and consumable item cost, while the local portion mechanic cost for repairing and administration expenses.

Unit price of plant operation cost is presented in Table 6.3.

6.4.2 Unit Cost of Work Items

The unit cost of each work item was calculated on the basis of materials cost, labour cost, operation cost of equipment and contractor's overhead and profit. The calculation was made taking into consideration the local conditions as well as the availability of the local product.

The unit cost of each work item is presented in Table 6.4.

Table 6.1 Unit Cost of Major Construction Material

Unit: NRs.

Materials	Unit	Unit Cost
Cement (Local)	ton	4,400
Cement (Imported)	ton	5,280
Reinforcement	ton	30,000
Fuel (Diesel)	lit	10
Petrole (Gasolin)	lit	25
Lubricant	lit	150
Grease	kg	125
Asphalt bitumen	ton	22,000
Bitumen emalusion	lit	14
Timber	m3	37,400
Plywood	m2	583
Strucutral steel	ton	28,100
Gabion wire mesh	kg	35
Fine agggregate	m3	850
Corse aggregate	m3	725
Crushed stone	m3	575
Boulder	m3	575

Table 6.2 Unit Cost of Labor (Wage Rate)

Unit : NRs.

Description	Unit	Wage Rate
Foreman	Man Day	100
Skilled labour	Man Day	85
Unskilled labour	Man Day	45
Operator, light	Man Day	75
Operator, heavy	Man Day	75
Assist. operator	Man Day	65
Driver, dump truck	Man Day	70
Driver, vehicle	Man Day	55
Assist. driver	Man Day	45
Electrician	Man Day	80
Assist. electrician	Man Day	45
Mechanic	Man Day	60
Assist. mechanic	Man Day	45
Carpenter	Man Day	80
Concrete worker	Man Day	80
Reinforcement worker	Man Day	75
Masonry worker	Man Day	80
Pavement worker	Man Day	50
Driller	Man Day	80
Blaster	Man Day	80

Source: DOR, Patan District Office
for Fiscal Year 047/48 (1991/92)

Table 6.3 Unit Cost of Major Equipment

Unit: NRs.

Description	Unit	Unit Cost
Bulldozer, 21 ton	hr	4,230
Backhoe, 0.6m3	hr	1,990
Backhoe, 0.35m3	hr	1,340
Tractor shovel, 2.1 m3, wheel	hr	1,970
Dump truck, 11 ton	hr	1,210
Dump truck, 4 ton	hr	590
Truck, 4 ton	hr	560
Truck, 4 ton , with crane 2ton	hr	680
Truck crane, 20 ton	hr	2,490
Truck crane, 40 ton	hr	5,690
Vibro-pile driver	hr	18,170
Road sprinkler, 5.5 ton	hr	780
Motor grader, 3.1 m	hr	1,720
Macadam roller, 10 ton	hr	1,260
Tire roller, 8-20 ton	hr	1,320
Vibratating roller, 0.8-1.1 ton	hr	400
Asphalt finisher, 2.4-4.5m	hr	4,180
Asphalt finisher, 40ton	hr	8,860

Table 6.4 Unit Cost for Work Items

Unit : NRs.

Description	Unit	Foreign Portion	Local Portion	TOTAL
Clear site and stripping	m2	16	4	20
Removal of existing pavement material	m3	308	77	385
Removal of existing bridge at Thaphatali	L.S	4,802,398	1,200,600	6,002,998
Removal of existing structures	m3	1,566	392	1,958
Fill in soft material	m3	335	84	419
Spoil in soft material	m3	241	60	301
Sodding	m2	156	39	195
Plant selected trees	no.	1,292	0	1,292
Gabion	m3	1,957	345	2,302
Stone Masonry	m2	4,885	1,221	6,106
Excavation in soft material for structures	m3	40	10	50
Backfilling with selectedmaterials for structures	m3	36	9	45
Side block	m	558	239	797
Kerb stone (A)	m	1,352	580	1,932
Kerb stone (B)	m	2,668	1,143	3,811
Kerb stone for bridge	m	570	244	814
Pipe culvert D300	m	2,110	904	3,014
Pipe culvert D600	m	3,720	1,594	5,314
Pipe culvert D1000	m	7,445	3,191	10,635
U shaped drain ditch (0.3 x 0.3m)	m	1,384	593	1,977
U shaped drain ditch (0.5 x 0.5m)	m	1,912	820	2,732
U shaped drain ditch (1.0 x 1.0m)	m	4,624	1,982	6,606
Side drain with stone pitching	m	1,373	343	1,716
Catch pit	no.	6,811	2,919	9,730
Manhole	no.	11,379	4,877	16,256
Subbase course	m3	648	162	810
Base course	m3	1,173	293	1,466
Prime coat, 1.0 litre/m2	m2	33	1	34
Tack coat, 0.4litre/m2	m2	11	0	11
Asphalt concrete binder course t=6cm	m2	577	86	663
Asphalt concrete binder course t=10cm	m2	968	145	1,113
Asphalt concrete surfase course t=4cm	m2	415	62	477
Asphalt concrete surfase course t=5cm	m2	512	77	589
Side walk t=13cm	m2	402	60	462
Road lighting	no.	269,413	5,498	274,911
Traffic signal	portion	4,598,410	93,845	4,692,255
Lane marking 15cm	m	54	1	55
Information sign	no.	222,546	4,542	227,088
Steel pile D800	m	22,121	451	22,572
Steel pile D500		11,060	226	11,286
Concrete class-A, 240kg	m3	4,598	94	4,692
Concrete class-C, 180kg	m3	3,627	74	3,701
Formwork for superstructures	m2	632	271	903
Formwork for all structures other than superstructur	m2	408	175	583
Reinforcement	ton	37,914	774	38,688
Prate girder (material,assemble,transportation,electi	ton	488,414	25,706	514,120
Bridge railing	m	21,742	1,144	22,886
Excavation for diversion of the river	m3	40	10	50
Construction and removal of temporary road	m3	335	84	419
Temporary bridge	m	52,156	2,745	54,901
Steel sheet pile	m	2,673	141	2,814