7.2 Highway Study based on Route Alternatives

7.2.1 Traffic Capacity and Required Number of Lanes

To determine the required number of traffic lanes, the capacity of project road was analyzed based on future traffic characteristic factors and proposed typical cross sections (inception analysis, refer to Section 10.1.2 for final traffic capacity analysis in step-by-step detail).

The concept and methodology used for the analysis were based on the "Highway Capacity Manual" of the Highway Research Board, USA. Some adjustments were made to reflect local conditions based on the results of studies accomplished by "Road Design Standard" of Japan. These studies were used because similar operating conditions were found in Vietnam and Japan.

The design capacity of 4-lane SHTRR capacity is presented in Table 7.2.1.

Table 7.2.1 Inception Traffic Capacity Analysis

Description		Unit	Throughway
Design Speed		Km/h	100
Terrain or Grade		-	Flat
Capacity under Ideal Condition		PCU/Hr/Lane	2,200
Design Level of Service		-	C
Coefficient of Service Level		-	0.77
Maximum Service Flow Rate		PCU/Hr/Lane	1,870
Width of Lane		m	3.75
Lateral Clearance	Outer	m	3.0
	Inner	m	1.5
Coefficient	Width of Lane	-	1.0
	Lateral Clearance	-	1.0
	Driver Population	-	1.0
	Total	-	1.0
Service Flow Rate		PCU/Hr/Lane	1,870
Peak Factor		%	8
Directional Distribution Ratio		%	55
Design Capacity		PCU/Day/Lane	21,250
4-Lane SHTRR Capacity		PCU/Day	77,000

7.2.2 Interchanges

(1) General Concept

An interchange is a system of intersecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways or highways on different levels. Although an interchange is a useful and adaptable solution for many intersection problems, only access-controlled highways or terminus of freeway warrant justifying an interchange at a given intersection because of high initial cost. Any one type of interchange can vary extensively in shape and scope, and there are numerous combined types of directional and semi-directional ramps.

The basic types of interchanges for the Study are shown in Figure 7.2.1. In 3-leg interchanges, a trumpet type interchange has a single structure with loop, and Y-type interchange has three structures with semi-directional ramps.

In 4-leg interchanges, a diamond type interchange has a single and the simplest structure with at-grade intersection. In case of existent of parallel railway or river, a half cloverleaf type interchange is adaptable instead of a diamond type interchange. To eliminate at-grade intersections to attain higher efficiency, safety and capacity, a double trumpet type or a cloverleaf type interchange is to be selected.

(2) Location of Interchanges (Concept in the Phase of Formation of Alternative Plans)

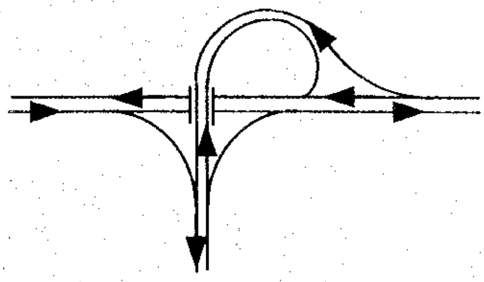
Figure 7.2.2 shows possible location of interchanges on SHTRR. NH-1 IC was located in the vicinity of Linh Dam lake to connect NH-1 with the frontage road of SHTRR.

New NH-1 IC was located 3 km east of NH-1 IC, which becomes the terminus of the southern section of New NH-1 and connects to through traveled carriageway of SHTRR.

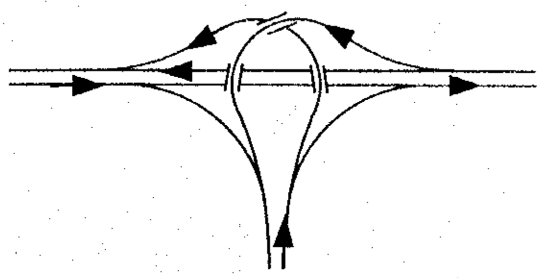
NH-5 IC was located at the beginning points of the northern section of New NH-1 to connect National Highway No. 5 with the frontage road of SHTRR.

Railway runs besides both intersecting points of the SHTRR with NH-1 (Phap Van) and NH-5 (Sai Dong). SHTRR is planned to fly over NH-1 and NH-5 as well as railway.

3-leg Interchanges

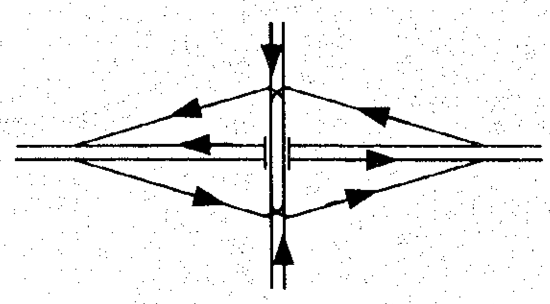


Trumpet Type

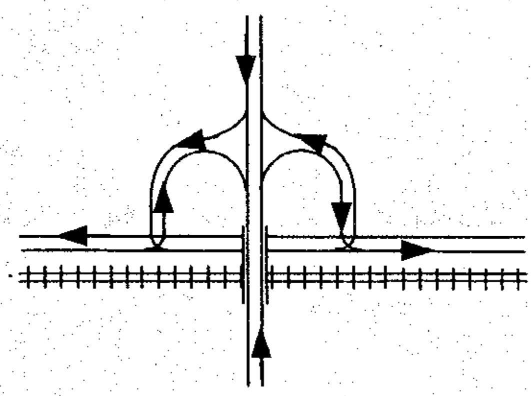


Y-Type

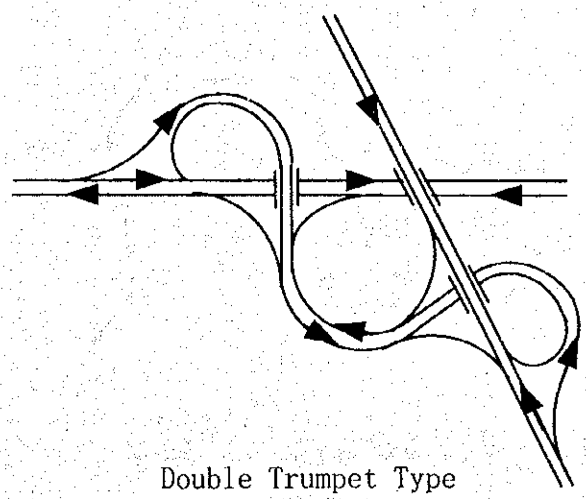
4-leg Interchanges



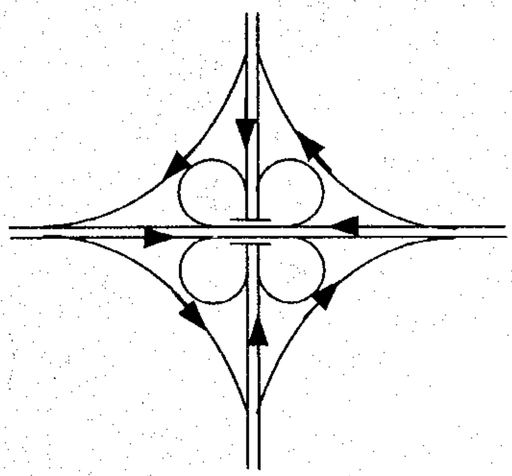
Diamond Type



Half Cloverleaf Type



Double Trumpet Type



Cloverleaf Type

Figure 7.2.1 Typical Types of Interchanges

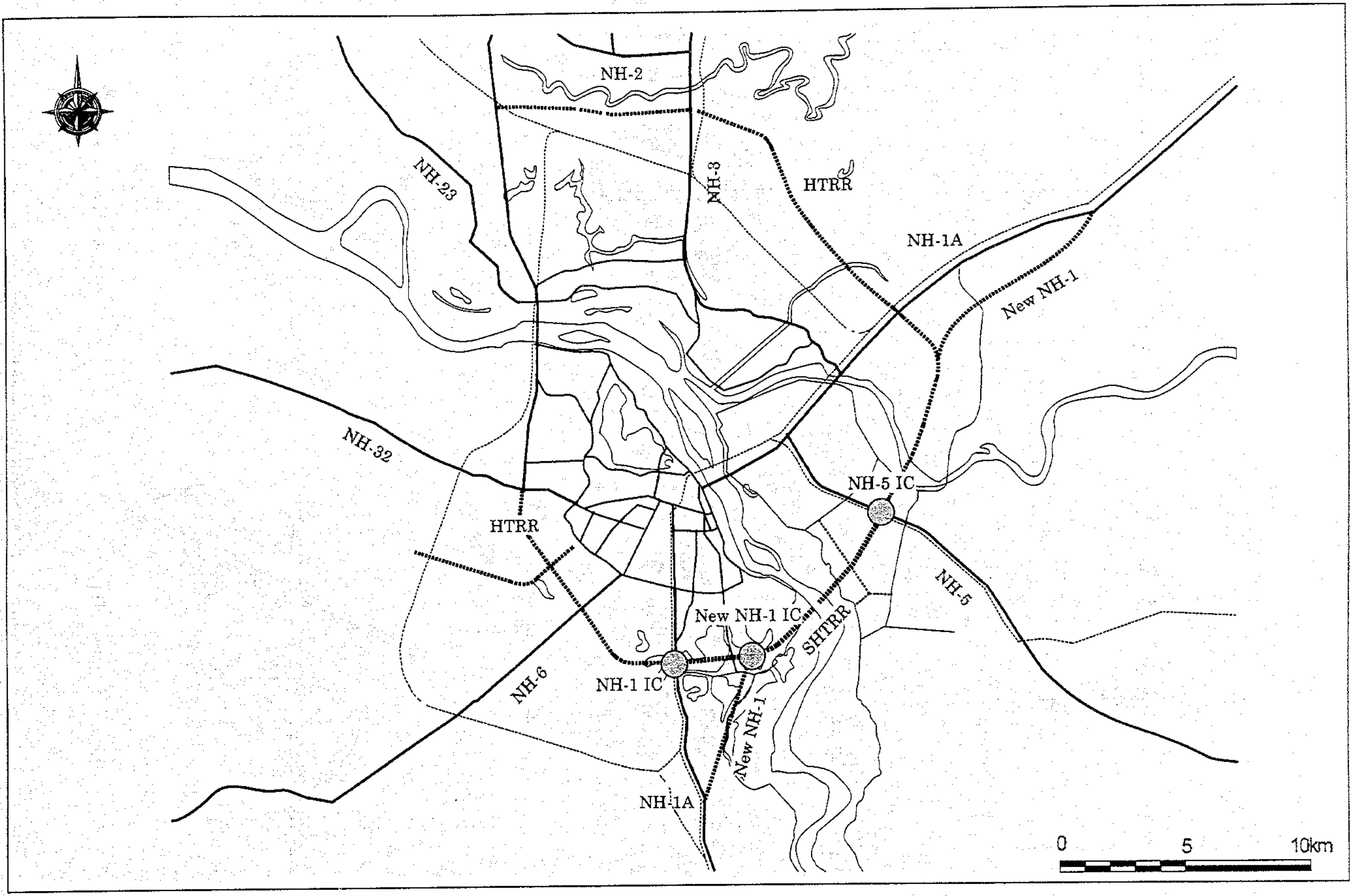


Figure 7.2.2 Possible Location of Interchanges on SHTRR

(3) Type of Interchanges

To avoid serious traffic problems on ramps brought about by at-grade railway crossing at NH-1 IC and NH-5 IC, a half cloverleaf type interchange as shown in Figures 7.2.3 and 7.2.4 was taken into consideration instead of a diamond type interchange. Semi-directional ramps will be added in future to cope with increase of directional traffic.

Enough space for interchange including future expansion should be reserved from an initial land acquisition.

7.2.3 Traffic Manouvering Plan in Thanh Tri and Gia Lam Area

(1) Traffic Manouvering Plan

A barrier type toll plaza was planned to be installed on the throughway of SHTRR to levy a toll from whole stretch users. According to the development plan of Gia Lam Industrial Estate, city planning roads are planned to form road network in Gia Lam area as shown in Figure 7.2.5.

It is likely possible that some links of road network in Thanh Tri and Gia Lam may be improved to maneuver local traffic of bridge use only as shown in Figure 7.2.6.

(2) Location of Toll Plaza

The city planning road planned in the development plan of Gia Lam Industrial Estate is located 1.2 km far from the eastern dike of the Red river. SHTRR was planned to fly over the dyke road and descend on downgrade slope. Approximately 200 m long toll plaza was planned before the city planning road and heavy trucks on the downgrade slope must decelerate their speed sufficiently prior to end of waiting queue. Accordingly, the location of toll plaza should be studied carefully taking these factors into account in detailed design stage.

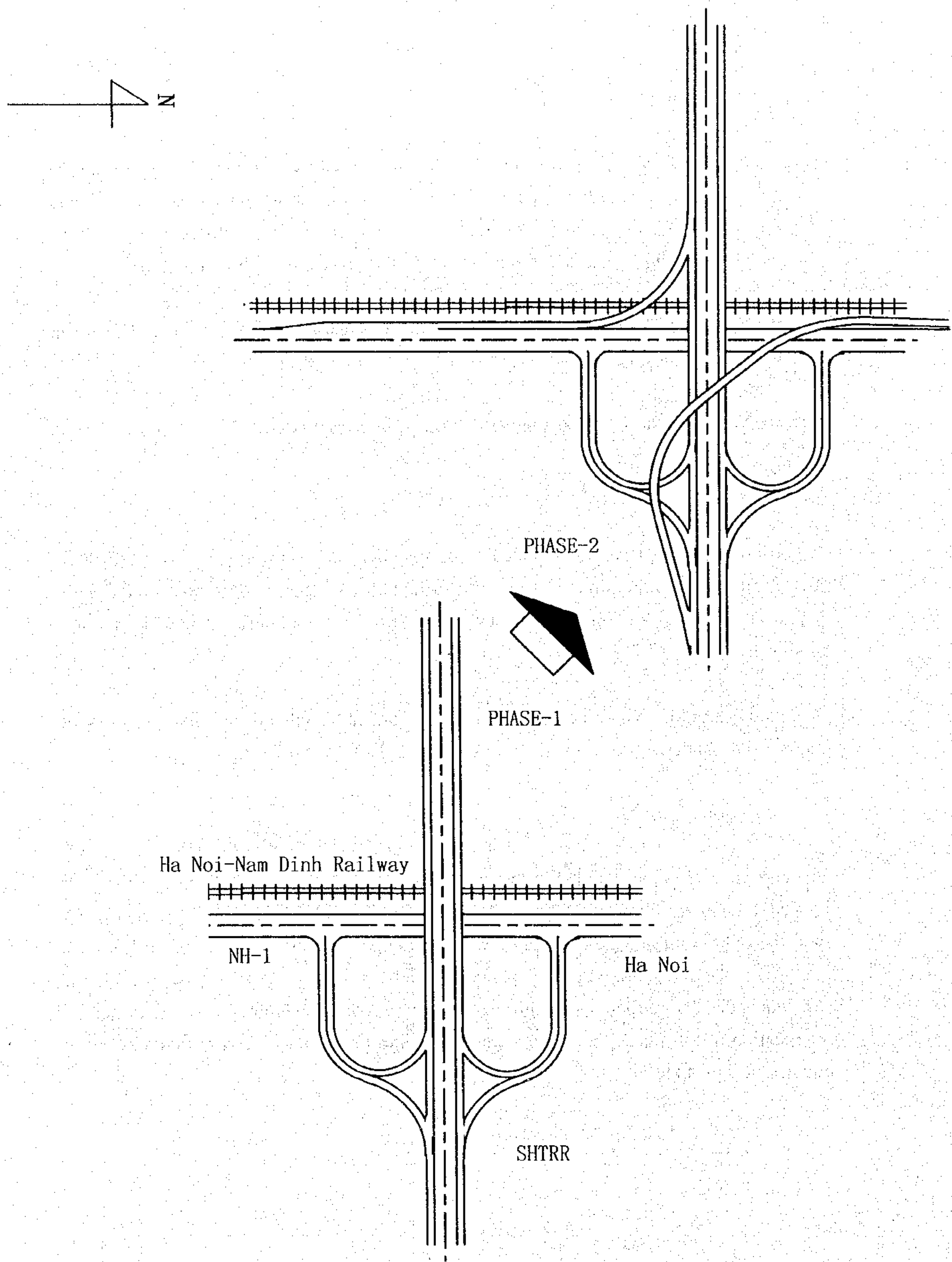


Figure 7.2.3 Interchange Layout between SHTRR and NH-1

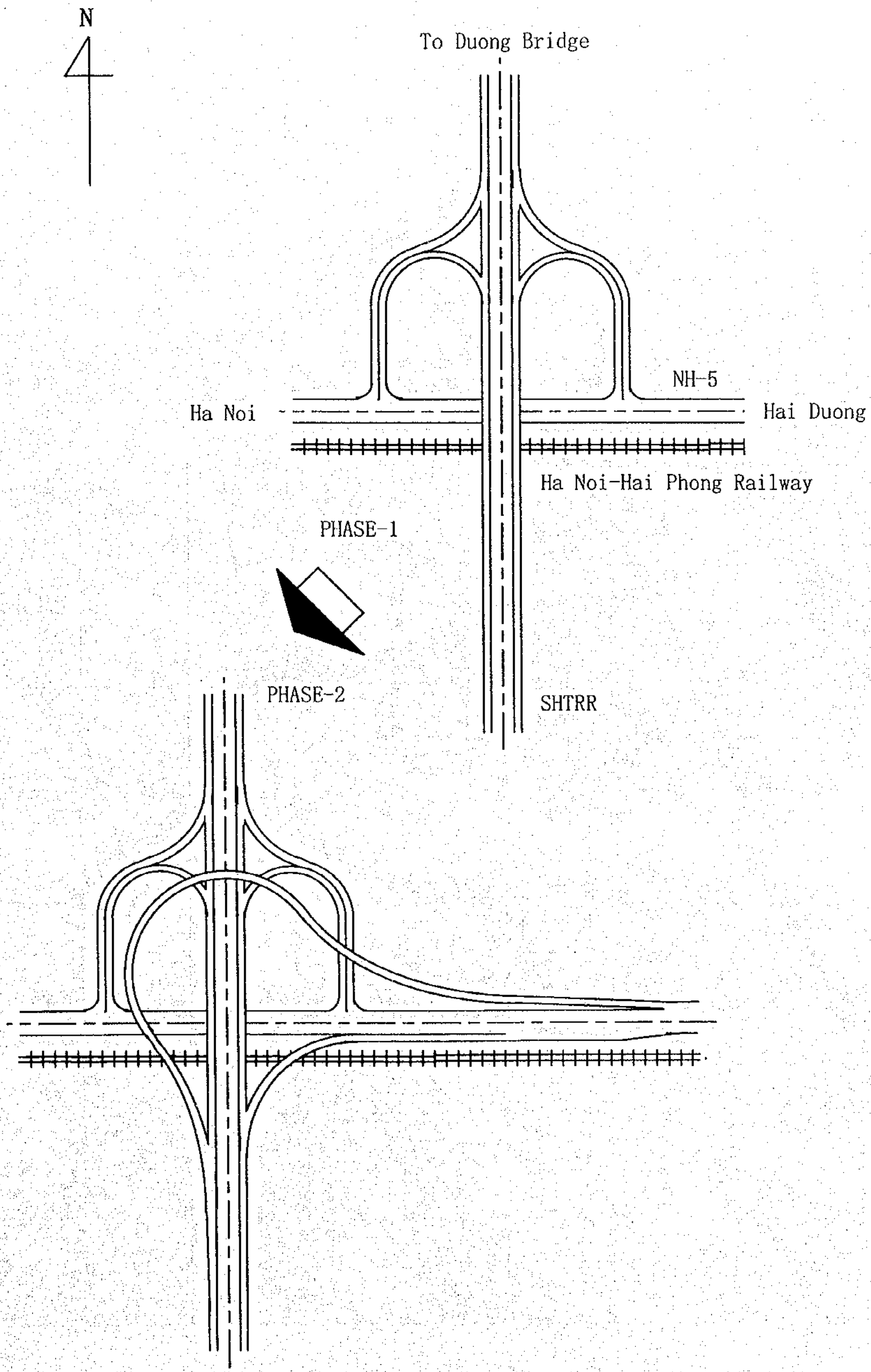


Figure 7.2.4 Interchange Layout between SHTRR and NH-5

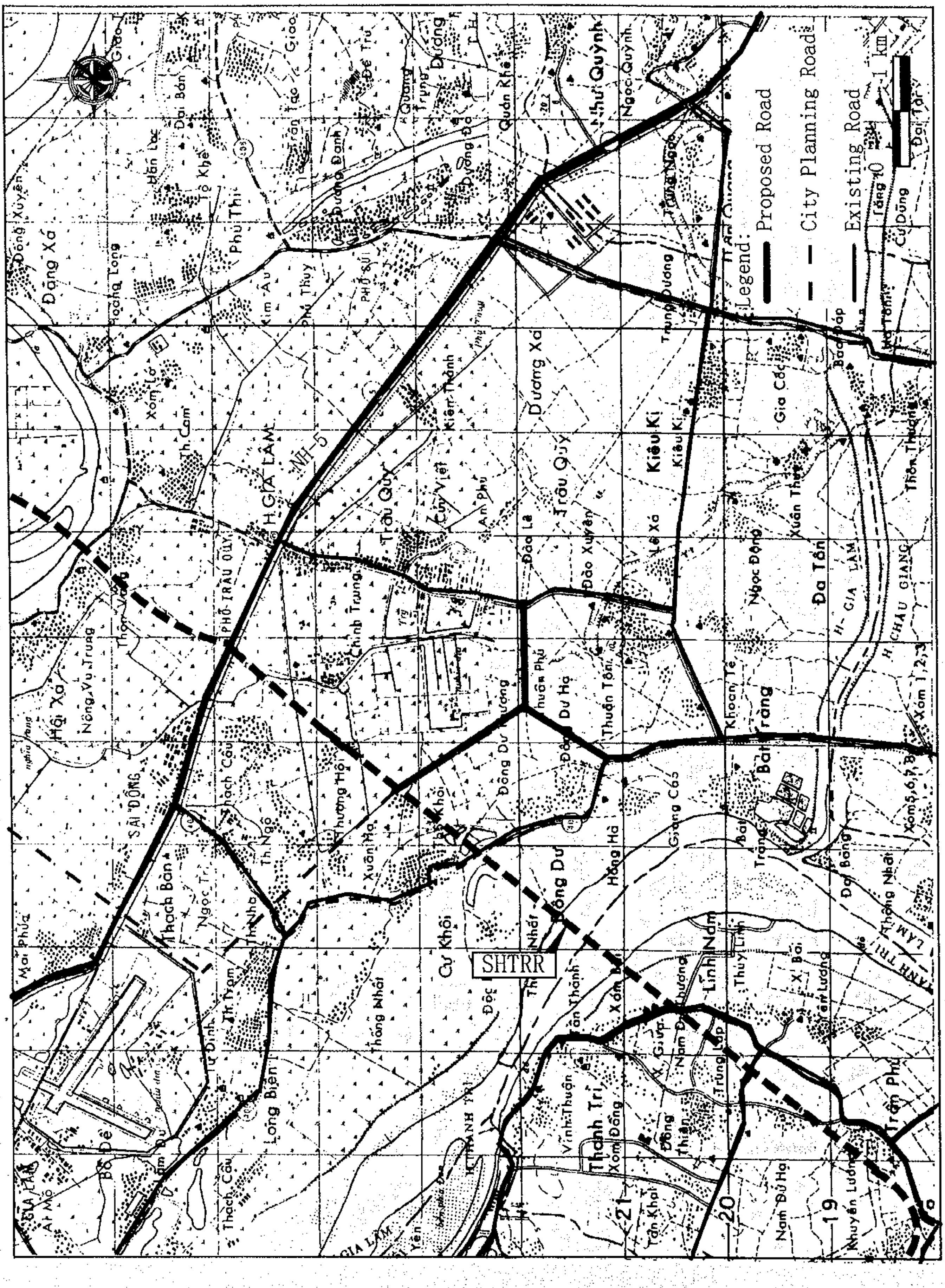


Figure 7.2.5 Proposed Future Road Network in Gia Lam Area

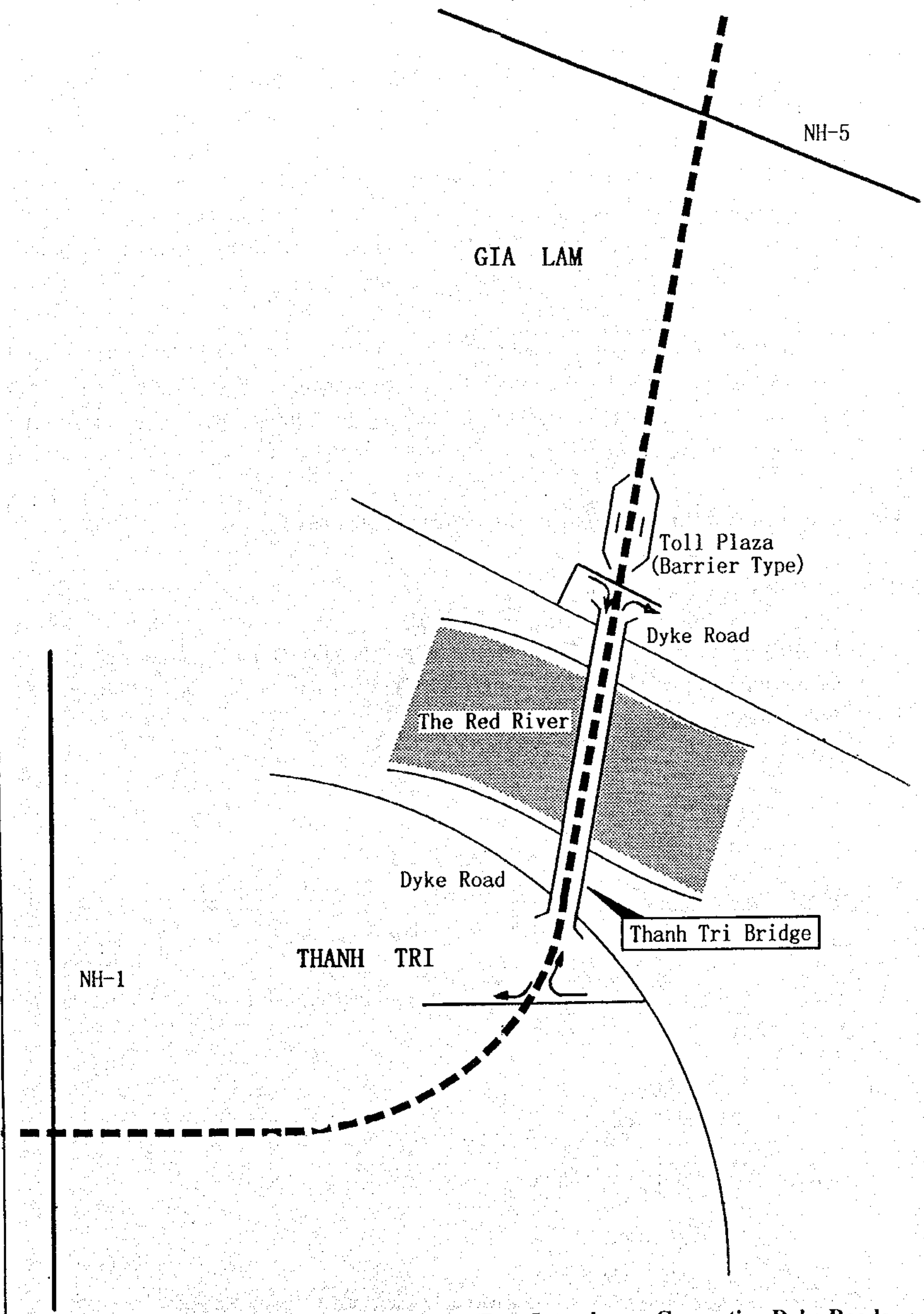


Figure 7.2.6 Half-Diamond Type Interchange Connecting Dyke Roads

7.2.4 Location of New NH-1 IC and Urban Drainage and Wastewater Disposal Project in Thanh Tri District

SHTRR should coordinate with the drainage project to find a way to avoid flood regulating reservoirs planned in Thanh Tri area. One practical measure in Alternative-3 is that the through traveled way of SHTRR get across the reservoirs on the existing road at Yen So to mitigate physical influence, as shown in Figure 7.2.7.

It is also practical measures in Alternative-1 and 2b that the through traveled way of SHTRR shall get across their reservoirs by viaduct to mitigate physical influence, where the frontage road of SHTRR shall be apart from the throughway and utilize existing road as far as the drainage project concerns.

7.3 Bridge Study and Formation of Alternative Bridge Planning

7.3.1 Introduction

The route study in Section 7.1 has identified two possible crossings of the Red River; Alignment 1 and 3. For each alignment the Study Team has identified the following bridge structure types;

i) River crossing,
ii) Interchange structures,
iii) Flyovers,
iv) Drainage structures, and other bridges

(1) River Crossing

The bridge structures of river crossing has been separated into two types, as shown in Figure 7.3.1.

i) Main Bridge
ii) Approach Bridge

Approach Bridge is defined as follows:

a. Approach Bridge (1)
b. Approach Bridge (2)
c. Dyke Bridge

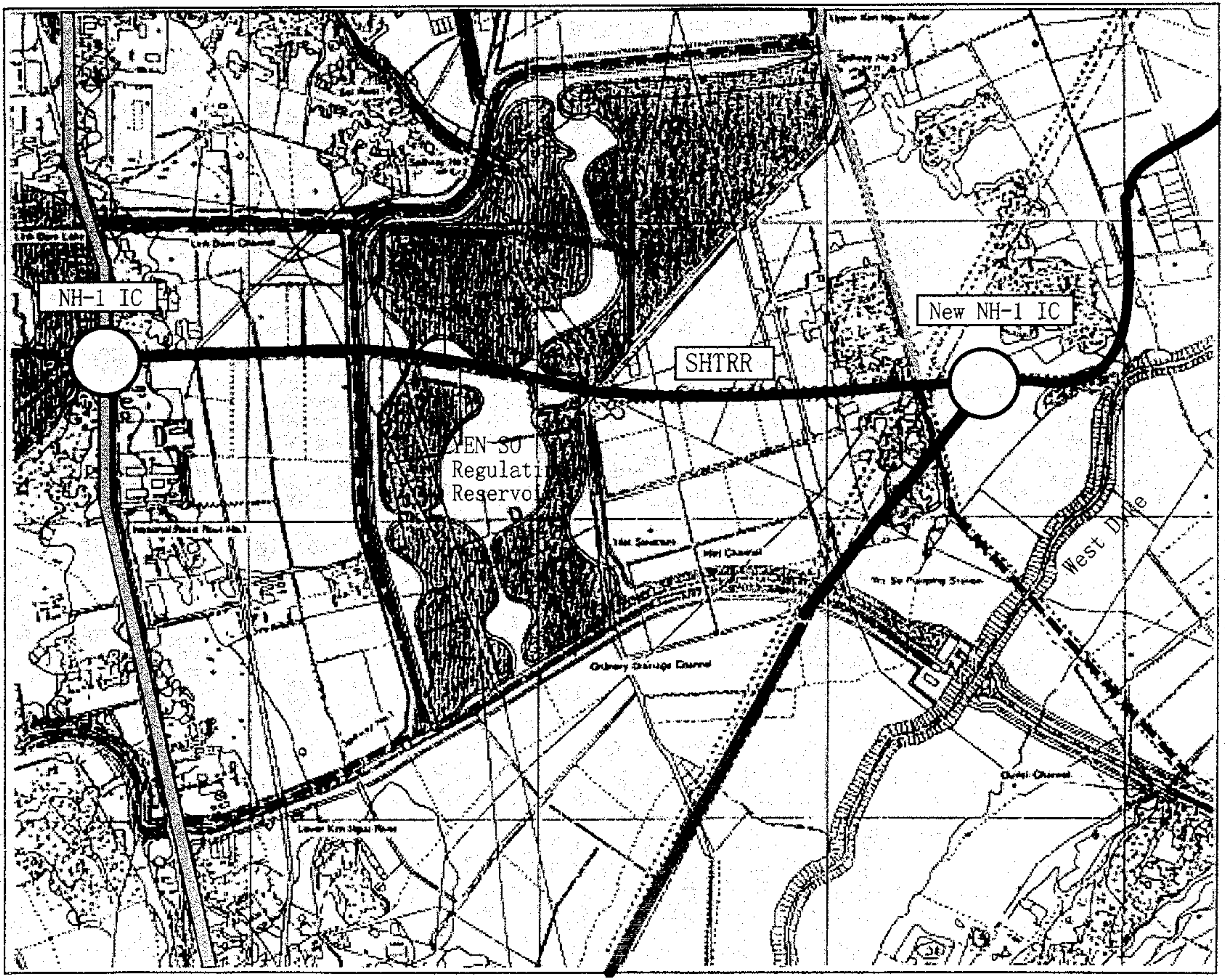


Figure 7.2.7 Location of New NH-1 IC and YEN SO Regulating Reservoir

(2) Interchange structures

The requirements for three interchanges have been identified, namely;

a. At the intersection of the existing NH-1
b. At the intersection of the new NH-1
c. At the intersection of the existing NH-5

The road layouts for these interchanges have been discussed in Section 7.2.2.

(3) Flyover

The alignment traverses a number of local roads and public footpaths and flyovers were proposed to allow the public to traverse the highway in a safe manner.

(4) Drainage and other bridges

The area of the study requires drainage across the line of the carriageway and at the eastern end of the study area, Thanh Tri district, there are proposals for the location of a flood relief reservoir. The Study Team proposed that drainage structures are incorporated within the highway embankments to accommodate these requirements.

7.3.2 Preliminary Study of Bridge Type

(1) Criteria on the selection

1) Main Bridge

The final recommendation for pier locations of the main bridge and consequently the length of the spans will be dependent on the following criteria;

- structural form,
- topography,
- number of piers in the normal water course,
- aesthetics,
- constructability,

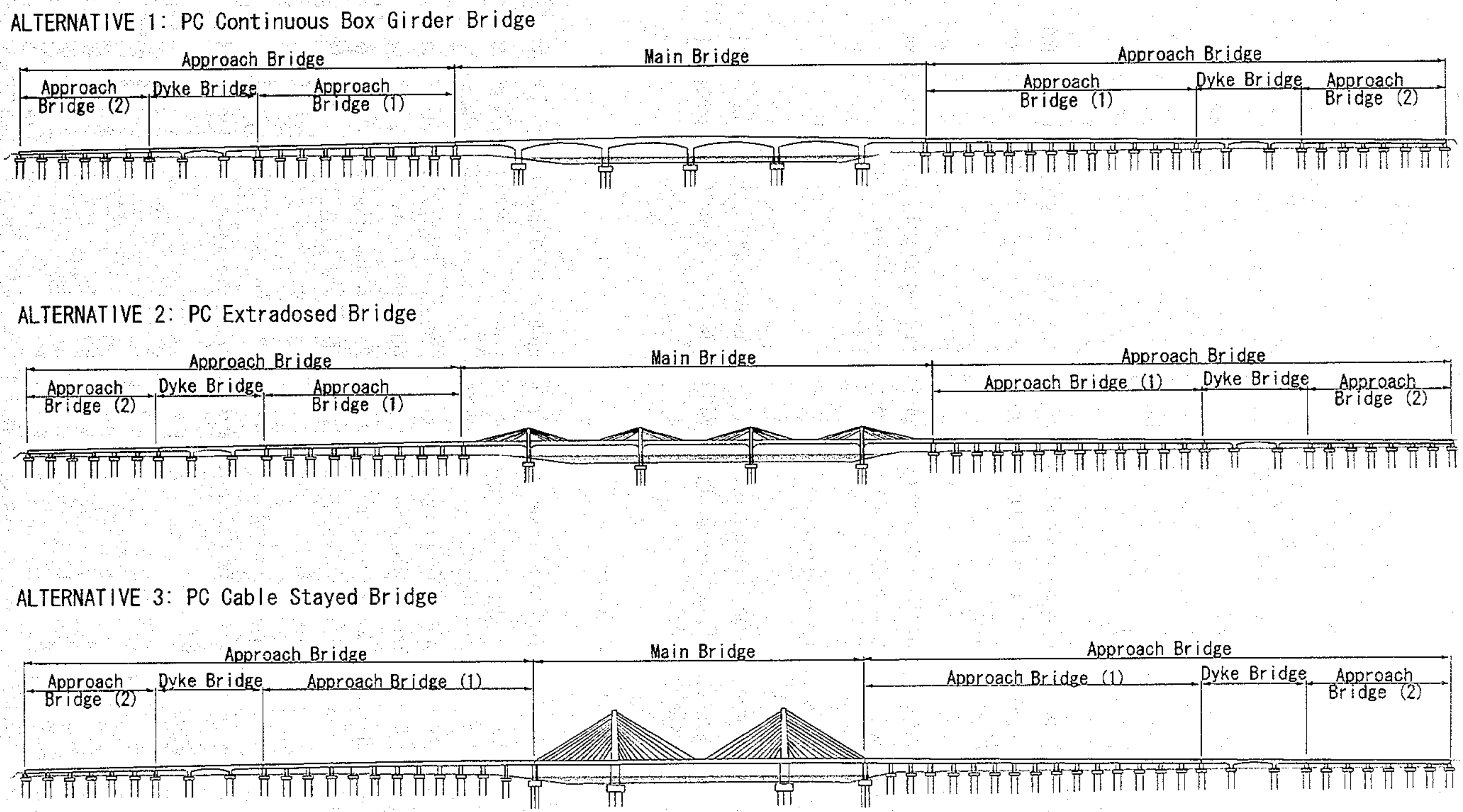


Figure 7.3.1 River Crossing Structure

- construction cost,
- construction period,
- maintenance & operation, and
- technology transfer.

2) Approach Bridge

a. Approach Bridge (1)

Approach Bridges (1) are located between two dykes out of the normal water course of the Red River. The piers are not located in the normal water course in the dry season.

The criteria for the selection of the bridge type are almost as same criteria as Main Bridge, because of the continuity to the Main Bridge.

b. Approach Bridge (2)

Approach Bridge (2) are located on the non-river side of the dykes. The bridge type of Approach Bridge (2) will be selected from the economical point of view.

c. Dyke Bridge

The Study Team had made enquiries, through PMU Thang Long, with the Dyke Control Department of Ministry of Agriculture and Rural Development to ascertain whether the dyke control authority would permit any temporary works within the dyke embankments. They were unable to give a categorical statement but would review this request following the development of the scheme. Following this statement, the Study Team has decided not to allow for any works, including temporary, within the dyke embankments.

The Study Team has made an allowance of 4.5 metres, for vehicular traffic, between the soffit of the bridge and the top of the dyke embankment, as shown in Figure 7.3.2.

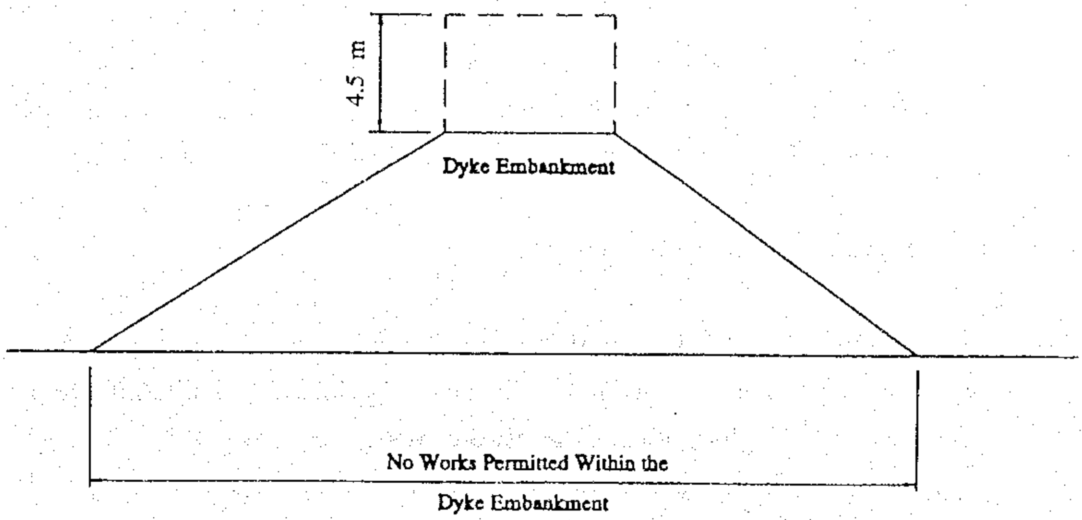


Figure 7.3.2 Dyke Road Clearance

(2) Preliminary Selection of Bridge Types (Superstructure, Substructure and Foundation)

1) Main Bridge

a. Materials

Materials for modern bridge construction are usually concrete (either reinforced or prestressed) or structural steel. For the Thanh Tri Bridge and its approach structures both materials are suitable. The main factors which have influenced the adoption of concrete as the structural element are:

- Structural steel will require importation.

- There is insufficient experience in Vietnam in the use of structural steel for medium to long span bridges. However, an educational programme could be instigated for site construction techniques in using steelwork such as welding. This may be considered beneficial to Vietnam should similar bridges be under consideration in the near future.

- The nature of steelwork requires high periodic maintenance and inspection costs, i.e., repainting of the steelwork every 10 - 15 years. Also suitable protective treatment to the steelwork may not be available in Vietnam.

- Concrete is a local material to Vietnam and the labour force is sufficiently experienced using this material. Recently a 120 metres prestressed concrete bridge has been constructed in Vietnam using the cantilever erection method. However, overseas labour and material will be required for specialist material such as prestressing and stay erection.

b. Determination of Span Arrangement

Referring to section 6.2.1 the horizontal navigation clearance has been defined by the Inland Waterway Bureau of Vietnam as 80 metres. The Study Team considers that further allowance of 30 metres be provided for future navigational requirements. If the dimension of coffer dam for the construction of footing is B m, the required span length shall be 80 m + 15 m x 2 + B/2 x 2 = 110 m + B m (Figure 7.3.3).
If B is determined as 20 m, the span length shall be 130 m.

c. Preliminary Selection of Bridge Types

Figures 7.3.4 and 7.3.5 show the relationship between bridge types and applicable span lengths for prestressed concrete bridges and for steel bridge. These figures are made based on the analyses for the many projects which were implemented in the past. A number of structural types exists for spans in excess of 130 metres. Referring to Figures 7.3.4 and 7.3.5, the following bridge types were selected:

<u>PC Bridge</u>

- Continuous Box Girder (Cantilever Erection Method);
- Rigid Frame Bridge (Cantilever Erection Method);
- Truss Bridge;
- Arch Bridge;
- Cable Stayed Bridge; and
- Extradosed Bridge.

<u>Steel Bridge</u>

- Steel Box Girder with Steel Orthotropic Deck;
- Lohse Bridge;

- Adversed Lohse Bridge;
- Langer Bridge;
- Truss Langer Bridge;
- Nielsen Bridge;
- Cable Stayed Bridge; and
- Suspension Bridge.

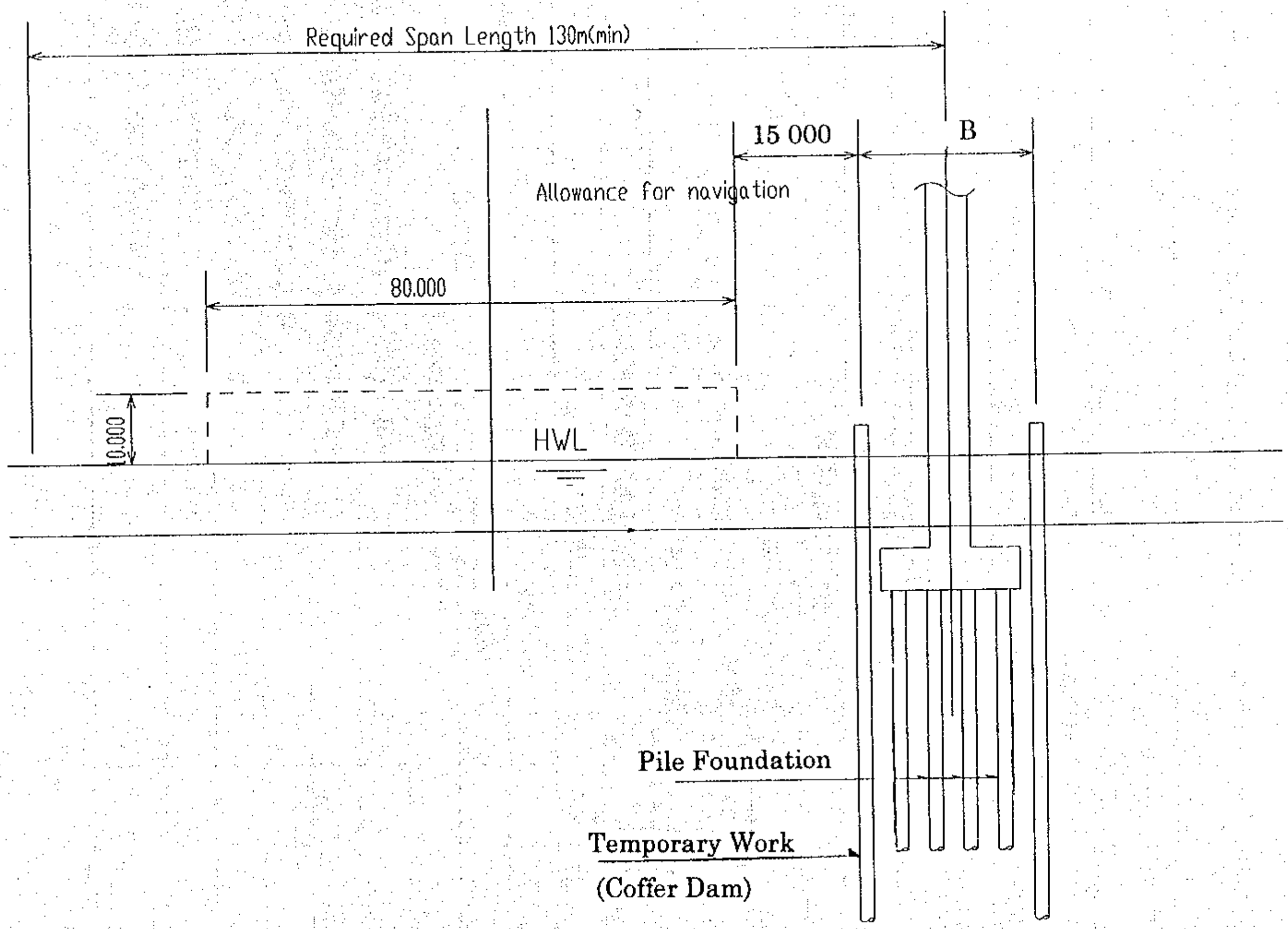


Figure 7.3.3 Determination of Span Length (Main Bridge)

Figure 7.3.4 Relationship Between Bridge Types and Applicable Span Length for Prestressed Concrete Bridges

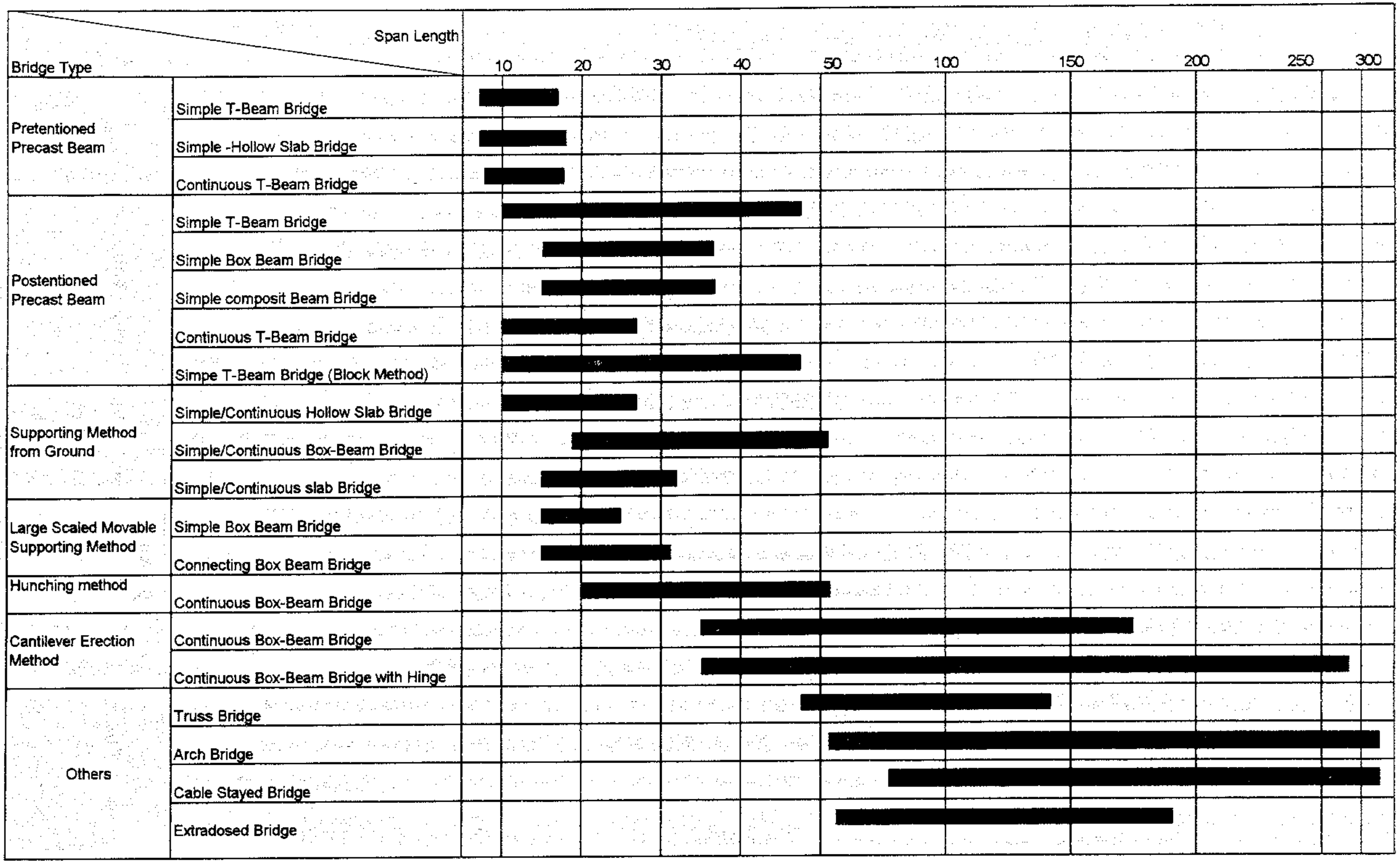
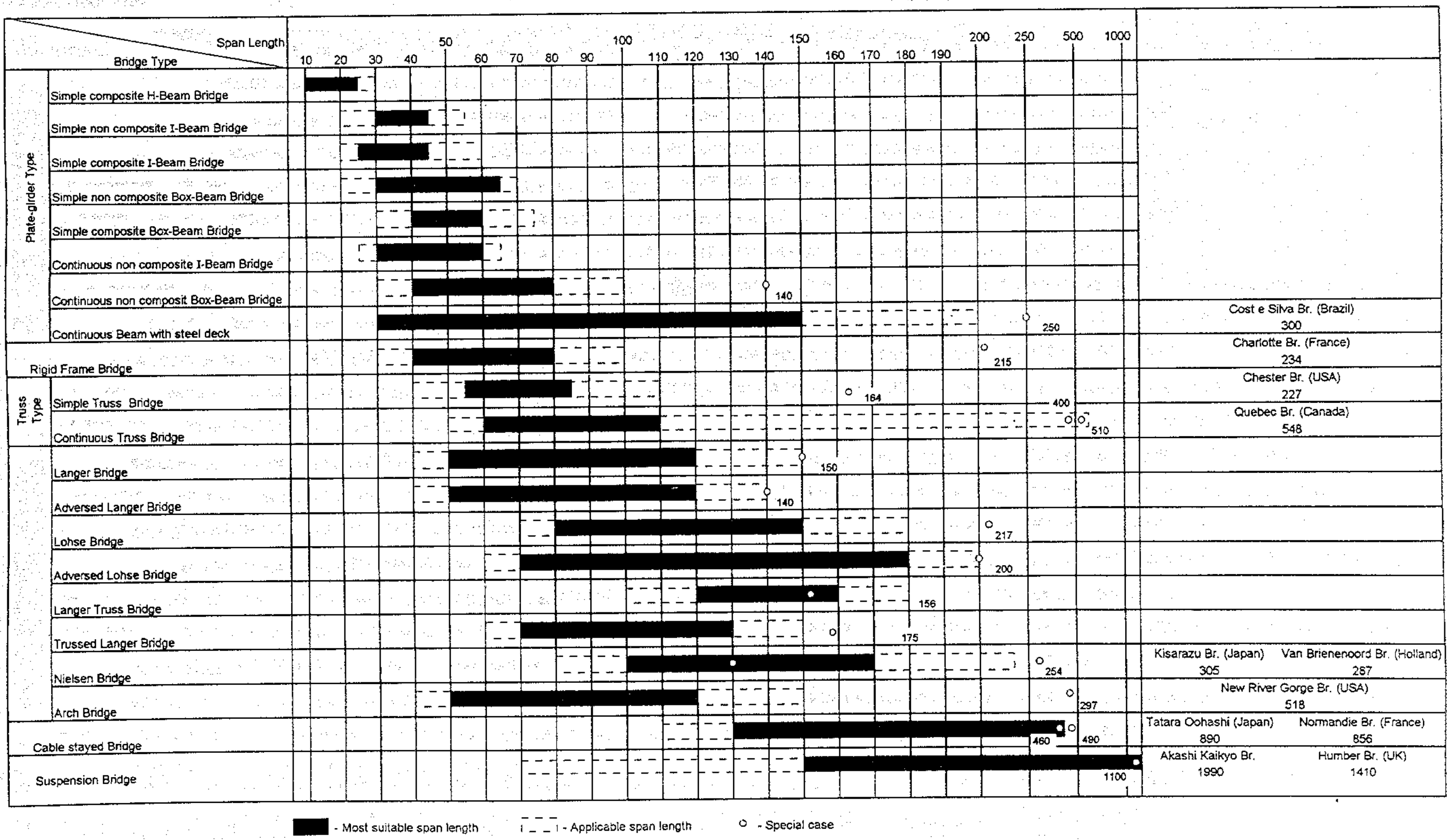


Figure 7.3.5 Relationship Between Bridge Types and Applicable Span Length for Steel Bridges



The comparison study was carried out for the preliminary selection of the bridge types regarding the above-listed bridge types, indicated in Table 7.3.1.

Considering the conditions surrounding the project, the following bridge types were selected as the preliminary selection:

- PC Continuous Box Girder Bridge (Cantilever Erection Method);
- PC Extradosed Bridge; and
- PC/Steel Cable Stayed Bridge.

2) Approach Bridge

Investigations into the structural form of the approach bridges have considered the following options;

a. The use of precast post-tensioned concrete beams, either simple supported or formed into a continuous deck by constructing an in-situ section at the piers. A span range of 20 - 40 metres has been considered in the magnitude cost estimate. There is recent experience of this type of construction in the Hanoi region of Vietnam.

b. Post-tensioned box girders in the span rang of 30 - 50 metres formed using either the balanced cantilever or span by span techniques. In the case of the span by span technique the post-tensioning will be continuous with the vertical position of the cable varying to suit the sagging and hogging moment conditions.

3) Bridge Substructure and Foundation Type

a. Pier Types

<u>Classification of Pier Types</u>

In general, the types of piers can be classified as shown in Table 7.3.2 Classification of Pier Types.

Table 7.3.1 Selection of Bridge Types (Alternatives)

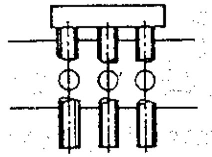
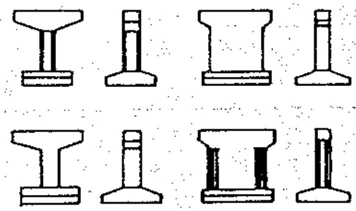
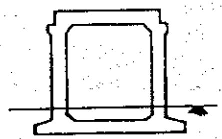
Comparison Table

Main Bridge

		Bridge Type	Construction cost	Constructability	Construction period	Aesthetic poin (Symbolism)	Maintenance & Operation	Technology Transfer	Total Evaluation
PC Bridge	1	Continuous Box-Girder (Cantilever Erection Method)	○	○	○	Δ	○	○	○
	2	Rigid Frame Bridge (Cantilever Erection Method)	○	○	○	Δ	○	○	○
	3	Truss Bridge	X	X	X	Δ	○	○	X
	4	Arch Bridge	X	X	X	○	○	○	X
	5	Cable stayed Bridge	Δ	○	○	○	○	○	○
	6	Extra dosed Bridge	○	○	○	○	○	○	○
Steel Bridge	1	Steel Box Grider with steel deck	X	Δ	○	Δ	X	Δ	X
	2	Lohse Bridge	X	Δ	Δ	Δ	X	Δ	X
	3	Adversed Lohse Bridge	X	Δ	Δ	Δ	X	Δ	X
	4	Langer Bridge	X	Δ	Δ	Δ	X	Δ	X
	5	Truss Langer Bridge	X	Δ	Δ	Δ	X	Δ	X
	6	Nielsen Bridge	X	Δ	Δ	○	X	Δ	X
	7	Cable stayed Bridge	X	○	○	○	X	Δ	X
	8	Suspension Bridge	X	Δ	Δ	○	X	Δ	X

○: Good Δ: Fair X: Poor

Table 7.3.2 Classification of Pier Types

Type	Shape	Characteristics
Pile- Bent		• Pile heads are connected by the cross beam • Flexible in bridge axle direction • Not applicable to the large scaled structures
Wall Type	(1) Rectangular column  (2) Ellipse shape column	• Generally applicable to normal structures
Adversed T-Type with Cantilever Beam	(3) Circular column (6) Rectangular column  (4) Rectangular column (7) Ellipse shape column	• Pier type with cantilever beams in perpendicular direction to bridge axle • (3) Circular column: advantage in the water which does not flow in one direction
Ridged Frame Type (2-Columns)	(5) Two column 	• Rigid frame structure in perpendicular direction to bridge axle
Ridged Frame Type (Box)		• It is possible to construct by the slender member, therefore, this type can be applied to the grade separation or viaduct in the big city in order to avoid the dusburbance of sight.

Criteria for selection of pier locations and types

The locations and the structural types of piers were selected according to the following criteria.

- Selection from structural point of view (relation to superstructure);
- Topography / soil and other natural conditions;
- Constructability;
- Maintenance and operation;
- Piers within normal water course;
- Aesthetics;
- Cost (economical point of view); and
- Others.

Construction conditions in the normal water course of the river differ from the raised flood plain where it is possible to proceed with work above water level outside the rainy season. The main bridge construction will be carried out over the river and the approach bridge will be carried out on the land outside of the rainy season.

Particular attention was paid to the selection of pier and foundation types for the main bridge.

Selection of Pier Types

Main Bridge:

Piers located in the normal water course will be circular or elliptical in shape in order to minimise the influence of stream flow.

Approach Bridge:

The candidates for pier types of dyke bridges were almost as same as the main bridges for 130 m span bridge.

b. Selection of Abutment Types

Abutment type was be selected according to the abutment height.

Generally, the relationship between the abutment type and the height are shown in Table 7.3.3 Classification of Abutment Types.

The abutment height of this project in the approach sections was estimated from 5 m - 6 m at this stage.

The candidate abutment type was adversed T-Type.

c. Foundation Types

Classification of Foundations

Generally, the foundation types can be classified according to the construction conditions shown in Table 7.3.4 Classification of Foundation Types.

Conditions for the Selection of Foundations

The following conditions for the selection of foundations were revealed following field investigation; according to the results of the topographic survey, hydrological survey and soil investigation.

Conditions for Main Bridge:

- Construction on the river;
- Stream water velocity is between 0.8 and 1.5 m/s at time of survey;
- Maximum water depths are approximately 15 m at Alignment 1 and 10 m at Alignment 3;
- Soil condition of river bed is fine sand; and
- The bearing stratum appears approximately 40 m below sea water.

Table 7.3.3 Classification of Abutment Types

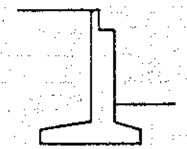
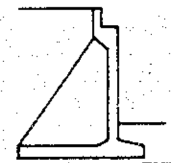
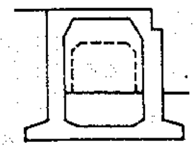
Type	Shape	Applicable Height
Gravity Type		$H \le 4 - 5m$
Semi-Gravity		$4m \le H \le 6m$
Adversed T-Type		$5m \le H \le 11m$
Butressed Type		$H \ge 10m$
Ridged Frame Types		$H \ge 10m$

Table 7.3.4 Classification of Foundation Types

Conditions for selection \ Foundation Type					Driving Pile			Driving pile with diging inside of pile		Cast in situ Conorete pile			Caisson			
				Spread Footing	Reinforced concret pile (RC pile)	Prestressed concrete pile (PC pile)	Steel pipe pile	PC Pile	Steel pipe pile	All casing method	Reverse circulation method	Earth Drill Method	Pneumatic caisson	Open caisson	Permanent Steel Pipe Pile Cofferdam	Cast-in-situ-slurry wall method
Ground conditions	Existance of very soft layer in the middle			X	O	O	O	O	O	O	O	O	O	O	O	O
	Conditions up to bearing stratum	Existance of gravel layer in the middle	Diameter of gravel: less than ϕ 5 cm	O	Δ	Δ	O	O	O	O	O	O	O	O	O	O
			" : ϕ 5cm - ϕ 10cm	O	X	Δ	Δ	Δ	Δ	O	O	Δ	O	O	Δ	O
			" : ϕ 10cm- ϕ 50cm	O	X	X	X	X	X	Δ	X	X	O	Δ	X	Δ
	Conditions of the bearing stratum	Depth up to bearing stratum	less than 5m	O	X	X	X	X	X	X	X	X	X	X	X	X
			5m - 15m	Δ	O	O	O	O	O	O	Δ	O	O	O	Δ	Δ
			15m - 25m	X	Δ	O	O	O	O	O	O	O	O	O	O	O
			25m - 40m	X	X	O	O	O	O	O	O	Δ	O	O	O	O
			40m - 60m	X	X	Δ	O	Δ	O	Δ	O	X	Δ	O	O	O
			more than 60m	X	X	X	Δ	X	X	X	Δ	X	X	Δ	Δ	Δ
		Soil condition of bearing stratum	Cohehive soil (20 ≤ N)	O	O	O	O	O	O	O	O	O	O	O	O	O
			Sandy or gravel (30 ≤ N)	O	O	O	O	O	O	O	O	O	O	O	O	O
		Bearing stratum level inclines (30°< θ)		O	X	Δ	O	Δ	O	O	Δ	Δ	O	Δ	Δ	Δ
	Conditions of ground water	Ground water level is near ground surface		Δ	O	O	O	O	O	O	O	Δ	O	O	O	O
		Resurgent water is large		Δ	O	O	O	O	O	O	O	Δ	O	O	O	Δ
		Artestian head water exits (h>2m)		X	O	O	O	X	X	X	X	X	Δ	Δ	O	X
		Velocity of ground water is more than 3m/min		X	O	O	O	O	O	X	X	X	O	Δ	O	X
Structural feature	Magnitute of load	Vertical load is low (span< 20m)		O	O	O	O	O	O	O	O	O	X	Δ	X	X
		Vertical load is medium (span 20m - 50m)		O	Δ	O	O	O	O	O	O	O	O	O	O	O
		Vertical load is large (span > 50m)		O	X	Δ	O	Δ	O	O	O	Δ	O	O	O	O
		Horizontal load is comparatively low againt vertical load		O	O	O	O	O	O	O	O	O	Δ	Δ	Δ	Δ
		Horizontal load is comparatively large againt vertical load		O	X	Δ	O	Δ	O	O	O	O	O	O	O	O
	Support system	Bearing pile		-	O	O	O	O	O	O	O	O	-	-	-	-
		Friction pile		-	O	O	O	Δ	-	O	O	O	-	-	-	-
Construction condition	Construction over water	Water depth is less than 5m		O	O	O	O	Δ	Δ	Δ	O	Δ	Δ	Δ	O	X
		Water depth is more than 5m		X	Δ	Δ	O	Δ	Δ	Δ	O	X	Δ	Δ	O	X
	Working space is narrow			O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	X	Δ
	Inclined pile construction			-	Δ	O	O	X	Δ	Δ	X	X	-	-	-	-
	Environment		Required measures for vibration and noise	Δ	O	X	X	Δ	Δ	Δ	O	O	O	O	X	O
			Influence to adjusment structures	O	O	X	Δ	Δ	Δ	O	O	O	Δ	Δ	Δ	O

O: Suitable Δ: Applicable X: Not suitable

Conditions for Approach Bridge

- It is possible to construct the foundation in dry condition except during the flood period;
- The topographic conditions are almost flat at the levels of between 4 m and 6 m within the dykes and the level between 6 m and 8 m beyond the dykes; and
- The bearing stratum appears at the same depth as main bridge.

Selection of Foundation Types

Considering the above-mentioned conditions (Table 7.3.4), the candidate foundation types were narrowed own to the followings:

Bridge Category	Type of Foundation
Main Bridge	• Driving Pile • Cast-In-Situ Concrete Pile • Caisson Foundation • Permanent Cofferdam
Approach Bridge including Dyke Bridge	• Cast-In-Situ Concrete Pile • Driving Pile

Design features of each type of foundation are shown as follows:

Main Bridge:

Driving Pile	Steel Pipe Pile	ϕ2000
Cast-In-Situ Concrete Pile	Reverse Circulation Drill Method	ϕ1500
		ϕ2000
		2500
Caisson Foundation	Open Caisson	–
Permanent Steel Pipe Pile Cofferdam	–	ϕ1000

Approach Bridge:

Compared with the main bridge, the scale of the structure is small, therefore, the foundation of the approach bridges will be smaller.

Driving Pile	Precast Concrete Pile	□ 400 x 400
Cast-In-Situ Concrete Pile	Reverse Circulation Drill Method	ø1000
		ø1500

7.3.3 Formation of Bridge Planning (Route Alternative-3)

(1) Site Review

From the alignment survey the total distance between dyke embankments is approximately 2.03 km with the normal water course situated closer to the mid point of this distance. The width of the normal water course is approximately 633 metres.

The height of the dyke embankments are:

Hanoi side	14.03 metres
Gia Lam side	13.30 metres

The flood plain varies between 5.21 and 10.96 metres on the Hanoi side and 5.05 and 9.12 metres on the Gia Lam side.

The lowest level of the river bed is -3.80 metres and is situated towards the centre of the normal water course.

(2) Main Bridge

Based on the relationship between bridge type and applicable span length (Tables 7.3.4 and 7.3.5) the following candidate bridge types were selected.

1) Option 1 – PC Box Girder Type (Separate River and Dyke Structures)

This option separates the main river bridge from the Hanoi dyke structure. Two span arrangements have been considered, namely 130 metre and 150 metre spans. The last arrangement is identical to the internal span required for the dyke structure. The span arrangement require five and four piers within the normal water course.

For this option the Study Team proposed to form the deck from a continuous prestressed concrete box girder with a maximum depths of approximately 7.0 and 8.5 metres respectively.

2) Option 2 – PC Box Girder Type (Combined River and Dyke Structures)

This option is similar to option 1 except the main bridge is combined with the Hanoi dyke structure to form a viaduct.

3) Option 3 - 180 metre span Extradosed Type

To reduce the river piers to three the spans are required to be increased to 180 metres. The Study Team considers that box girder bridges may result in construction difficulties in Vietnam and the Study Team proposes that an extradosed type structure could be used for this span arrangement with a maximum depth of approximately 9.25 metres.

4) Option 4 - 260 metre span Cable Stay Type

The overall layout of the proposed bridge is shown in Figure 9.4.2 in Chapter 9. The span shown in the figure is considered to be close to the upper limit for a concrete cable stay bridge using either of the structural forms proposed. The height of the towers is approximately 91 metres above sea level at Hanoi side. The height of the towers are within the limits defined by the Vietnam Aviation Dept.

(4) Approach Bridges

The Study Team considered three options for bridge planning, namely;

- Extend the structural form of the main river crossing,
- Use of simple supported or continuous precast post-tensioned concrete beams with a span of 30 - 50 metres (Table 7.3.4); there is recent experience of this type of construction in Vietnam.
- Use of precast post-tensioned concrete beams with an in-situ deck section over the pier to form a continuous deck.

(5) Dyke Bridges

The alignment across the Hanoi dyke at a skew of approximately 50° and requires a bridge to span a distance of approximately 130 metres, along the line of the alignment. The Study Team has adopted a span over the dyke of 130 metres with side spans of 90 metres.

The Gia Lam dyke spans a distance of approximately 90 metres, along the line of the alignment, between existing ground levels. The span of the bridge over the dyke is 105 metres with side spans of 70 metres.

For both of these locations the Study Team considers that the structural form of the deck should be a prestressed concrete box girder constructed using temporary formwork to support the deck during construction.

7.3.4 Formation of Bridge Planning (Route Alternative-1)

(1) Site Review

From the alignment survey the total distance between dyke embankments is approximately 1.96 km with the normal water course situated close to the Hanoi dyke. The width of the normal water course is approximately 510 metres.

The height of the dyke embankments are:

Hanoi side	14.45 metres
Gia Lam side	13.50 metres

The flood plain level varies between 5.04 and 10.25 metres on the Gia Lam side.

The lowest level of the river bed is -8.30 metres and is situated on the Gia Lam side of the normal water course.

(2) Main Bridge

The Hanoi dyke is located close to the normal water course which leads to a preferred option of a single structure traversing both obstacles. The Study Team has considered a number of span options which progressively reduce the number of piers within the normal water course, namely;

i) Option 1 - 130 metre span

The overall layout of the proposed bridge shows four piers within the normal water course. The layout of the spans results in a end span over the Hanoi dyke of 100 metres. For this span arrangement the Study Team proposes to form the deck from a continuous prestressed concrete box girder using the balanced cantilever method of construction with a maximum depth of approximately 7.0 metres.

ii) Option 2 - 150 metre span

The overall layout of the proposed bridge shows three piers within the normal water course. This option has the advantage of reducing the amount of construction work within the normal water course. However, this must be offset against an increased depth of construction which for the proposed prestressed concrete box girder would be approximately 8.5 metres.

iii) Option 3 - 180 metre span

The 180 metre span option still requires three piers within the normal water course and will require a concrete box girder of 10.5 metres in depth. This depth of construction may cause construction difficulties in Vietnam and the Study Team therefore proposes to use a hybrid concrete box girder (known as 'extradosed' in Japan) which incorporates low level cable stays to increase the effective section at the piers. The overall depth of the box girder at the piers would be approximately 9.0 metres with concrete towers of approximately 20.0 metres above the deck. For this option the requirements of the Vietnam Aviation Dept. do not restrict the height of the towers.

iv) Option 4 - 260 metre span

Following discussions and correspondence with the Vietnam Aviation Dept. which limits the height of the towers at the bridge site to a maximum height of 53 metres above sea level, the Study Team has eliminated the cable stay option at this location in accordance with the instruction of Vietnam side steering committee.

(3) Approach Bridges

Refer to Alignment 3.

(4) Dyke Bridges

The Hanoi dyke is situated close to the normal water course and so has been incorporated into the main river crossing.

The Gia Lam dyke spans a distance of approximately 65 metres, along the line of the proposed alignment, between existing ground levels. The span of the bridge over the dyke is 65 metres with side spans of 45 metres. For this span arrangement the Study Team proposes to form a continuous prestressed concrete box girder constructed using temporary formwork to support the deck during construction.

CHAPTER 8

SELECTION OF THE OPTIMUM ALTERNATIVE ROUTE

CHAPTER 8 SELECTION OF THE OPTIMUM ALTERNATIVE ROUTE

8.1 General

For the purpose of evaluation of alternative plans, the study flow is given in Figure 8.1.1.

The main focus of evaluation at this step is to select an optimum route among three route alternatives, study flow is shown in Figure 8.1.1.

The concept of selection is that each alternative plan deemed feasible is compared to others based on the evaluation criteria as well as the pre-determined comparison basis.

Any practical countermeasures to facilitate or expedite its implementation which are assumed through comparison and evaluation of each alternative plan are supposed to be preconditions for subsequent preliminary design.

8.2 Evaluation of Route Alternatives

For the purpose of comparison of each alternative, the following criteria were taken into account in descending order:

- i) Land Availability;
- ii) Impact on the Social Environment;
- iii) Construction Economy;
- iv) Road user Benefits; and
- v) River Morphology.

(1) Land Availability

Since the salient features of land acquisition for road as well as railway or river are that they require not only spot but long strip make alignment, it is quite usual that an agency concerned is forced to long negotiations with a number of land owners and inhabitants. Even though right-of-way (ROW) acquisition procedure necessitates endorsement by the government's prerogative, high availability of ROW acquisition surely facilitates realization of a road project.

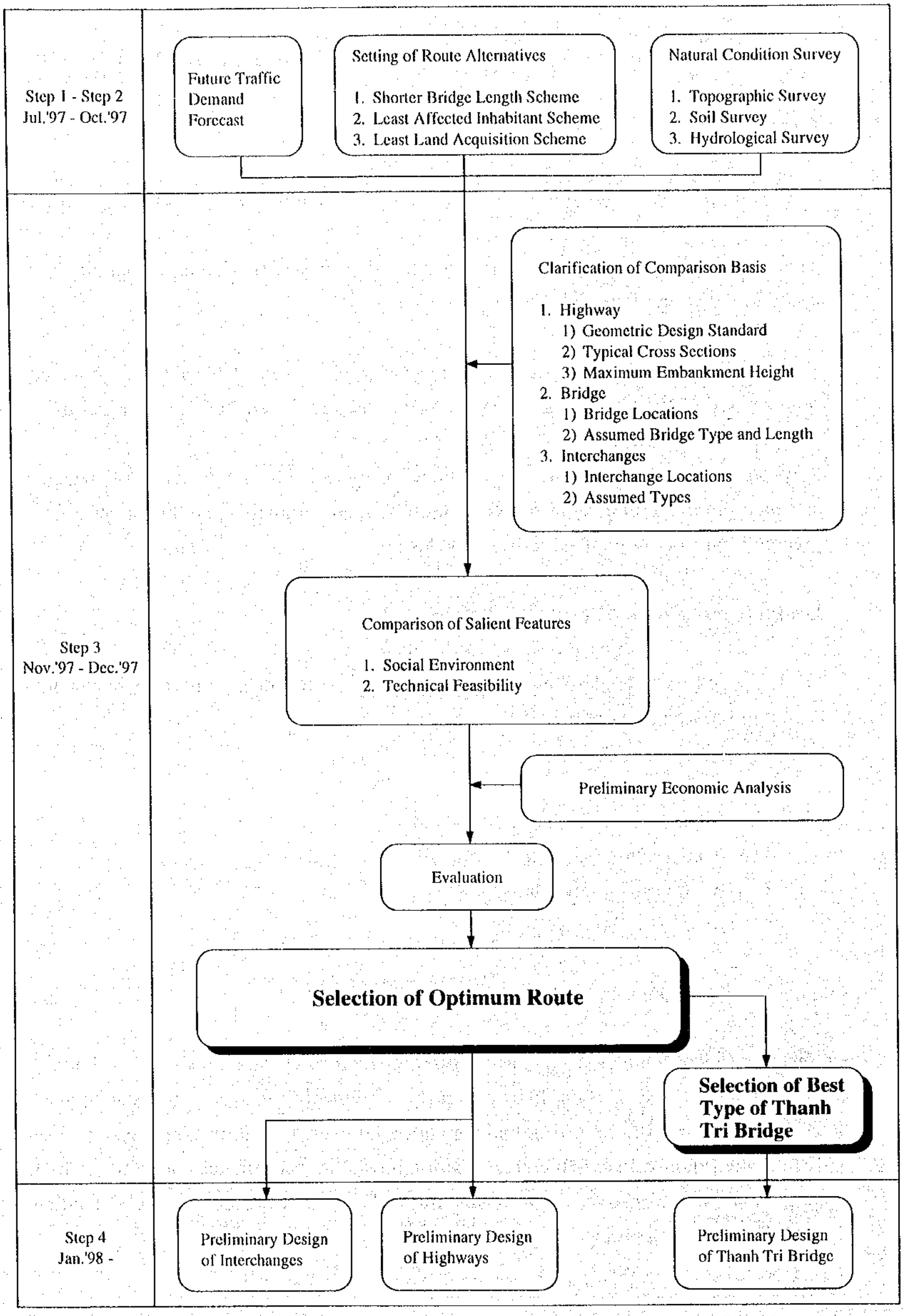


Figure 8.1.1 Study Flow for Selection of Optimum Route

If the ROW acquisition problems are solved in an early stage it may fairly be said that the urban road development is successfully completed for the most part.

However, ROW acquisition in urban areas is one of the most difficult problems as the following problems are always associated with vast amount of cost and influence to the social environment.

(2) Impact on the Social Environment

Good social environment should be maintained, otherwise the project road can not be acceptable to the public.

Community severance such as disruption of built-up area and eviction of inhabitants or tombs is considered to be a serious problem to the social environment.

When developing an urban road network, not only reducing traffic congestion but also promoting high amenity in an urban area are the main focus.

(3) Construction Economy

Cheaper construction cost and better performance including lower maintenance cost are regarded as having high construction economy over project life. Ease of construction and shorter construction period are also important factors.

However, since the investment of road transport has close relationship to other transport modes to accommodate traffic demand, due investment should be made adequately to achieve the designated roles and functions of project road.

(4) Road User Benefits

The enhancement of functional road network to meet future traffic demand is one of the most practical solutions to maintain an urban activities at a preferable level without excessive transport costs. Furthermore, an efficient road network can encourage urban activity to induce desirable economic growth through promoting commercial and institutional development.

In general the following traffic aspects are acceptable:

i) Shorter connection for bigger traffic has advantages such as reducing vehicle operating cost and travelling time;
ii) Sharper horizontal curve under 500m has significantly higher rate of traffic accident; and
iii) Steeper downward slope more than 4% also has higher rate of traffic accident.

(5) River Morphology

Few records and information are found concerning the stability of river course of the Red River. However, 40-year operating record of Thanh Tri sanitary factory proves the river course around the proposed crossing point stable.

Right angle crossing river flow and longer center span have superiority in river morphology.

The comprehensive comparison and evaluation of each alternative are summarized in Table 8.2.1.

It was concluded that Route Alternative-3 is recommended assuming that SHTRR on the existing road at Yen So in Thanh Tri district should be constructed 4-lane carriageway with frontage road.

Table 8.2.1 Comparison of Route Alternatives and its Evaluation

Items		ALT-1:Shorter Bridge Length Scheme		ALT-2b:Least Affected Inhabitant Scheme		ALT-3:Least Land Acquisition Scheme
Major Indices						
Route Length		11.6 Km		12.05 Km		12.3 Km
Thanh Tri Bridge Length		1,860 m		2,340 m		2,340 m
Construction Cost Indices		0.95		1.01		1.00
Land Acqusition & Compensation						
Acquired Land Area		68.3 ha		70.7 ha		61.7 ha
Affected Houses		315		225		422
Affected Inhabitants		1,400		1,000		1,900
Evaluation						
Social Environment						
Land Availability	○	It is necessary to acquire 3.6 ha inhabited lands along NH-1, NH-5 and both dyke roads, and a pottery factory and a warehouse at Nam Du Ha will be affected. However, no protected or environmentally sensitive area is found because the route passes open spaces such as pond, arable land and undeveloped area.	○	It is necessary to acquire 3.0 ha inhabited lands along NH-1, NH-5, and a cement warehouse of Chinfon factory at Linh Nam will be affected. However, no protected or environmentally sensitive area is found because the route passes open spaces such as pond, arable land and undeveloped area. The route will manage to pass beside the Hero's cemetery of Linh Nam commune just in case of required ROW of 50 m wide.	○	It is necessary to acquire 9.6 ha inhabited lands along NH-1, NH-5 and 4 km long existing road at Yen So in Thanh Tri. However, since wide open space behind the existing road is available for relocation of affected inhabitants, 7.6 ha land acquisition itself has no difficulty in this stretch. A cement warehouse of Chinfon factory at Linh Nam will be affected, but the route in the remaining section passes open spaces such as pond, arable land and undeveloped area.
Impact on Social Environment	△	Since the route passes beside cemetery at Phap Van and Yen Duyen in Thanh Tri, some practical countermeasures against community severance are deemed necessary. Several tombs are required to be relocated at Tho Khoi in Gia Lam. 230 of 315 affected houses and several tombs are deemed necessary to be relocated elsewhere.	○	Since the route passes beside cemetery at Phap Van and Yen Duyen in Thanh Tri, some practical countermeasures against community severance are deemed necessary. 155 od 225 affected houses are deemed necessary to be relocated elsewhere.	○	Since the route passes build-up area at Yen So and Pagoda at Xa Tran Phu in Thanh Tri, some practical countermeasures against community severance are deemed necessary. 162 of 422 affected houses are deemed necessary to be relocated elsewhere.
Technical Feasibility						
Construction Economy	○	The length of route is the shortest, and Thanh Tri bridge becomes shorter as well. However, the route passes many water reservoirs and ponds where soft soil treatment is required in case of embankment. New NH-1 IC is located 1.25 km north from ALT-3 to increase relative cost on comparison basis. Construction cost is lower but higher maintenance cost and longer construction period are expected.	△	The route passes several water reservoirs and ponds where soft soil treatment is required. 1.25 km farther New NH-1 IC from ALT-3 and longer Thanh Tri bridge length than ALT-1 increase relative cost on comparison basis. Construction cost is higher and higher maintenance cost and longer construction period are expected.	○	Although the route is the longest and has longer Thanh Tri bridge length than ALT-1, relative cost on comparison basis is the same level of ALT-2b because of shorter length crossing over water reservoirs and ponds where soft soil treatment is required. Lower maintenance cost and shorter construction period are expected.
Road User's Benefits	○	The shorter scheme has advantages of considerable travel time and vehicle operating cost savings.	△	Sharper horizontal curve less 500m which has significant higher rate of traffic accident will be applied to avoid violation of inhabited area.	△	The longer route has disadvantages of travel time and vehicle operating cost for through-travelling users who will occupy half of total users in 2010.
River Morphology	△	Surveyed river cross sections imply slight presence of inbalanced scouring force at river bed rather than ALT-2b and 3.	○	Surveyed river cross sections ascertain balanced scouring force at both sides of river bed.	○	Surveyed river cross sections ascertain balanced scouring force at both sides of river bed.
Planning Consistency	△	The route should coordinate with the Hanoi Master Plan to find a way how to cross their Yen So regulating reservoirs planned in Thanh Tri area.	△	The route should coordinate with the Hanoi Master Plan to find a way how to cross their Yen So regulating reservoirs planned in Thanh Tri area.	○	This alternative has the same route as the city planning road shown in the Hanoi Master Plan.
Comprehensive Evaluation		This scheme has advantages in the aspects of construction cost and road user's benefits. However, it is inferior in the aspects of stability of river morphology, planning consistency and social environment, especially for relocation of inhabitants and tombs.		This scheme is superior in the aspect of social environment, especially smaller number of affected persons. However, it is inferior to horizontal alignment, construction economy and planning consistency.	◎	It apparently is bigger number of affected persons, but most of them are along existing road at Yen So, and they are easily set back in the same way as NH-5 widening. However, it has advantages of stability of river morphology, construction economy and planning consistency.

Notes:

○ Fair or Superior

△ Poor or Inferior