社会開発調査部報告書

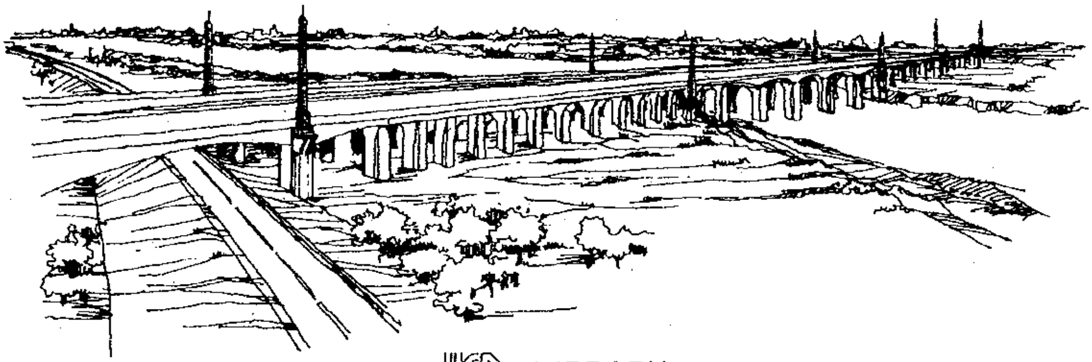
No. 32

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
PROJECT MANAGEMENT UNIT THANG LONG
MINISTRY OF TRANSPORT
THE SOCIALIST REPUBLIC OF VIET NAM

THE DETAILED DESIGN OF THE RED RIVER BRIDGE (THANH TRI BRIDGE) CONSTRUCTION PROJECT IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

VOLUME II : MAIN REPORT



June 2000

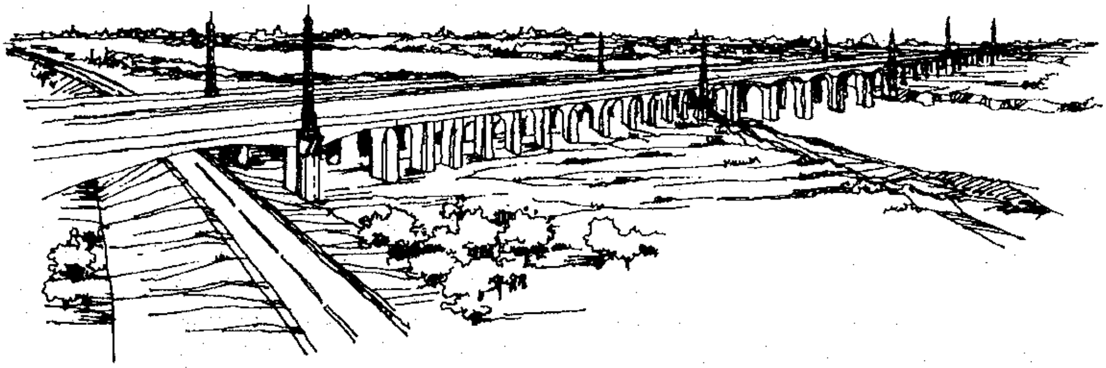
PACIFIC CONSULTANTS INTERNATIONAL

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
PROJECT MANAGEMENT UNIT THANG LONG
MINISTRY OF TRANSPORT
THE SOCIALIST REPUBLIC OF VIET NAM

THE DETAILED DESIGN OF THE RED RIVER BRIDGE (THANH TRI BRIDGE) CONSTRUCTION PROJECT IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

VOLUME II : MAIN REPORT



June 2000

PACIFIC CONSULTANTS INTERNATIONAL

NOTE

The following exchange rate is applied

US$ 1.00 = VN Dong 14,000
VN Dong 1.00 = JP Yen 0.01
(as of February 2000)

PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a detailed design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam and entrusted to study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Satoshi Watabe of Pacific Consultants International (PCI) to the Socialist Republic of Viet Nam, several times between April 1999 and March 2000.

The team held discussions with the officials concerned of the Government of the Socialist Republic of Viet Nam and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Socialist Republic of Viet Nam for their close cooperation extended to the study.

June 2000

Kimio Fujita
President
Japan International Cooperation Agency

June 2000

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir:

We are pleased to submit herewith the Final Report of Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your agency as well as the formulation of the above mentioned project.

This report presents the result of detailed design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam.

We would like to express our sincere gratitude to your agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the officials concerned of Project Management Unit Tang Long, Ministry of Transport of the Socialist Republic of Viet Nam, the Japanese Embassy in the Socialist Republic of Viet Nam for close cooperation and assistance extended to us during our investigation and design.

Very truly yours,

Satoshi Watabe
Team Leader
The Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project
In the Socialist Republic of Viet Nam

EXISTING LANDSCAPE ALONG THE PROJECT SITE OF THE RED R


Townscape at National Highway No.1 Intersection

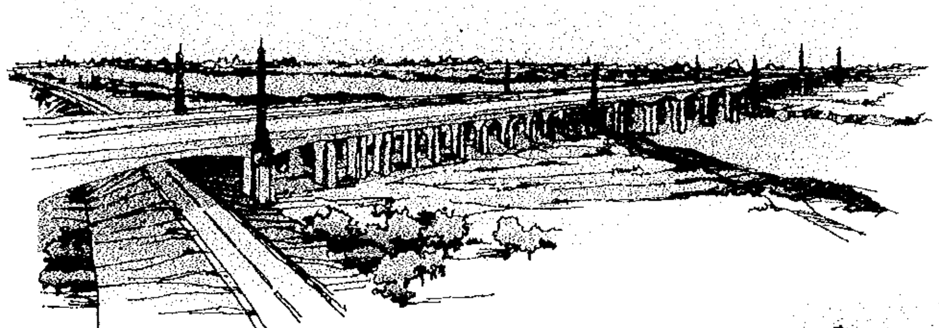


Image of the Red River Bridge


Town Silhouette and Water Front


Pond and Old Townscape


Levee and Pond along the Proposed Route

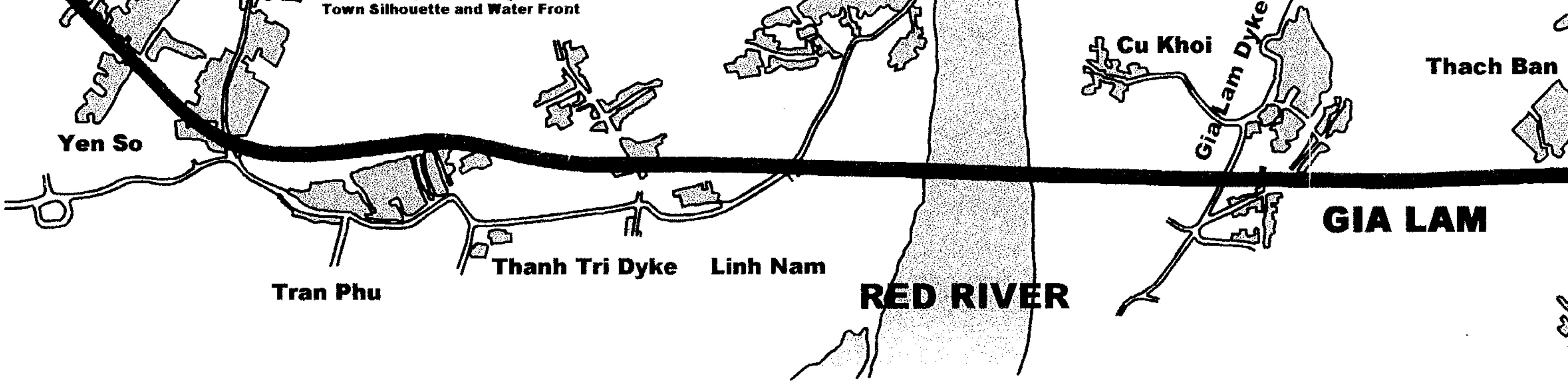
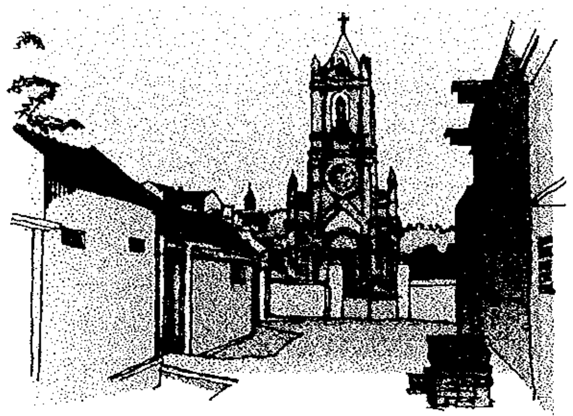


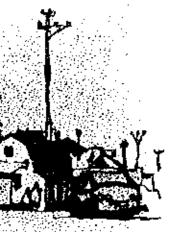

Image of the Expressway with Frontage Road


Old Church within a Village


Factory of Secondary Concrete Products


Townscape expansion from the Thanh Tri Dyke

APE ALONG THE PROJECT SITE OF THE RED RIVER BRIDGE



Intersection

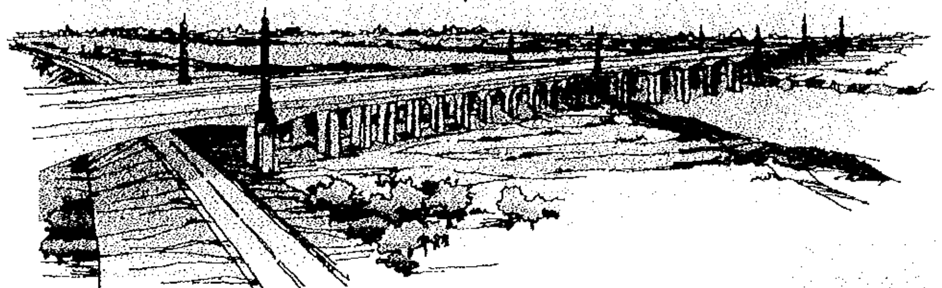
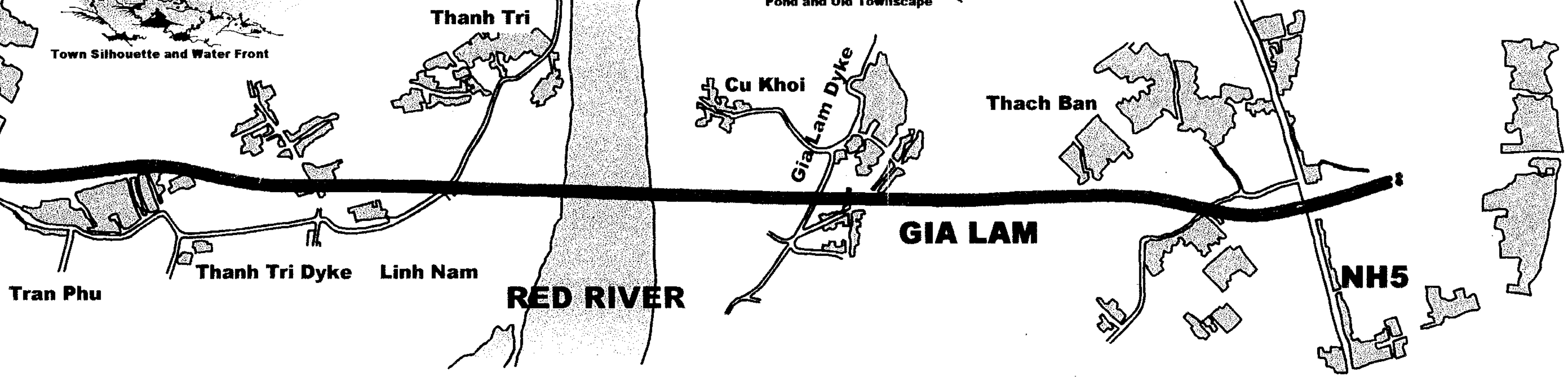


Image of the Red River Bridge

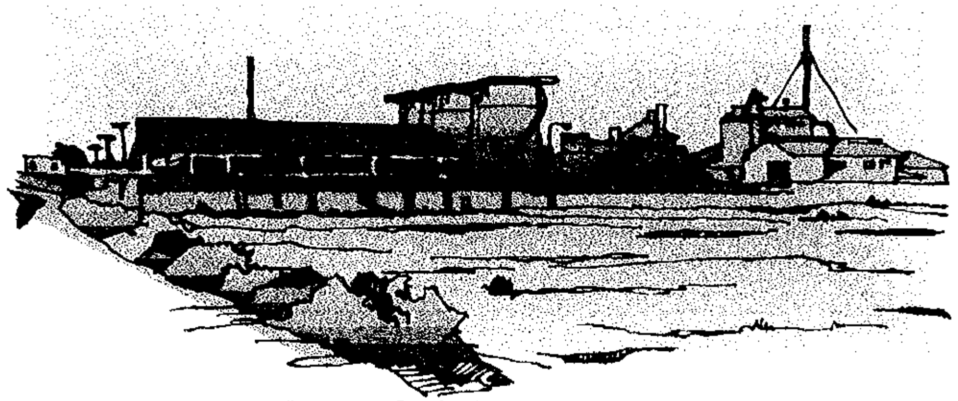
Town Silhouette behind Rice Paddy

Town Silhouette and Water Front

Pond and Old Townscape

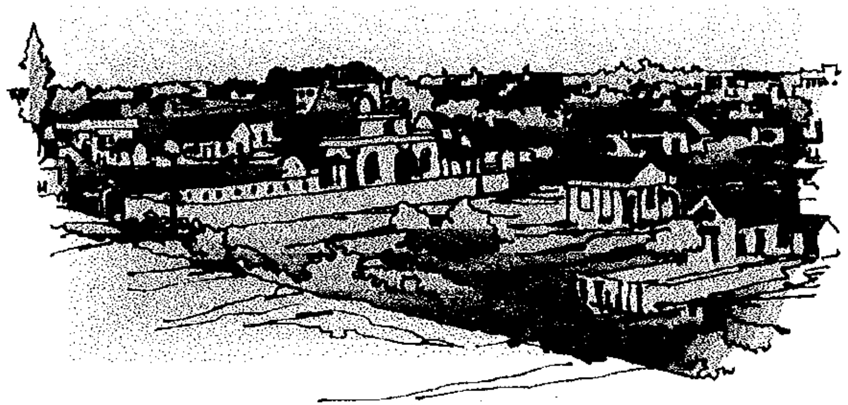


e



Factory of Secondary Concrete Products

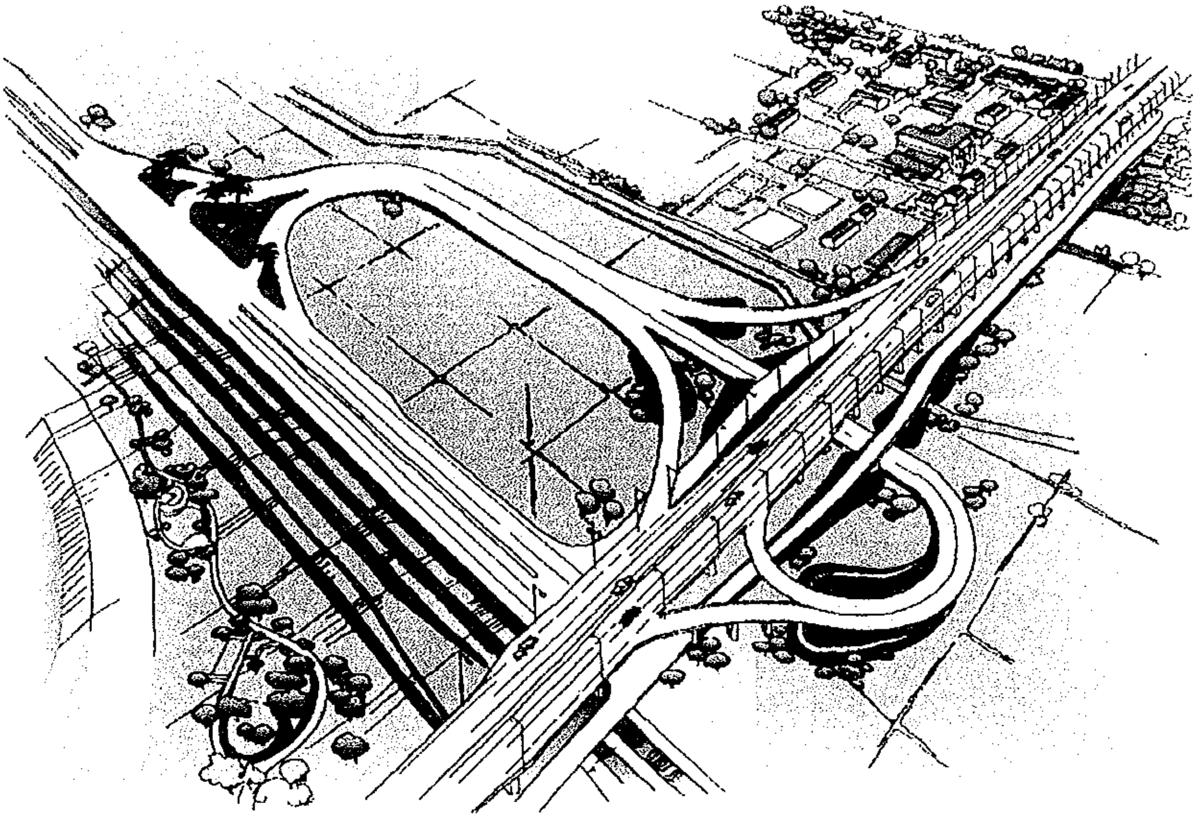
Townscape expansion from the Thanh Tri Dyke



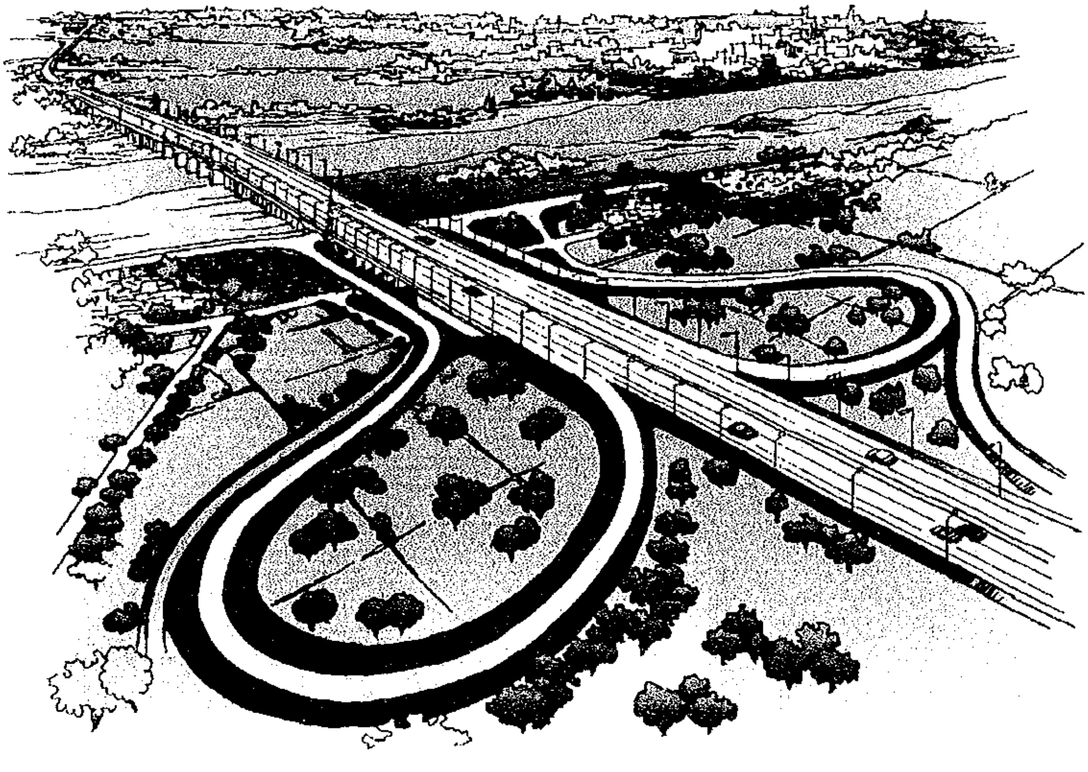
Panoramic view from Gia Lam Dyke

LIST OF FINAL REPORT

Volume I : Summary
Volume Ⅱ: Main Report
Volume Ⅲ: Appendix
Volume Ⅳ: Design Report
Volume V : Tender Documents (Draft)
Volume Ⅵ: Engineer's Cost Estimates
Volume Ⅶ: Drawings <Package-1>
Volume Ⅷ: Drawings <Package-2>
Volume Ⅸ: Drawings <Package-3> (1 of 2)
Volume X : Drawings <Package-3> (2 of 2)
Volume XI: Drawings <Package-4>

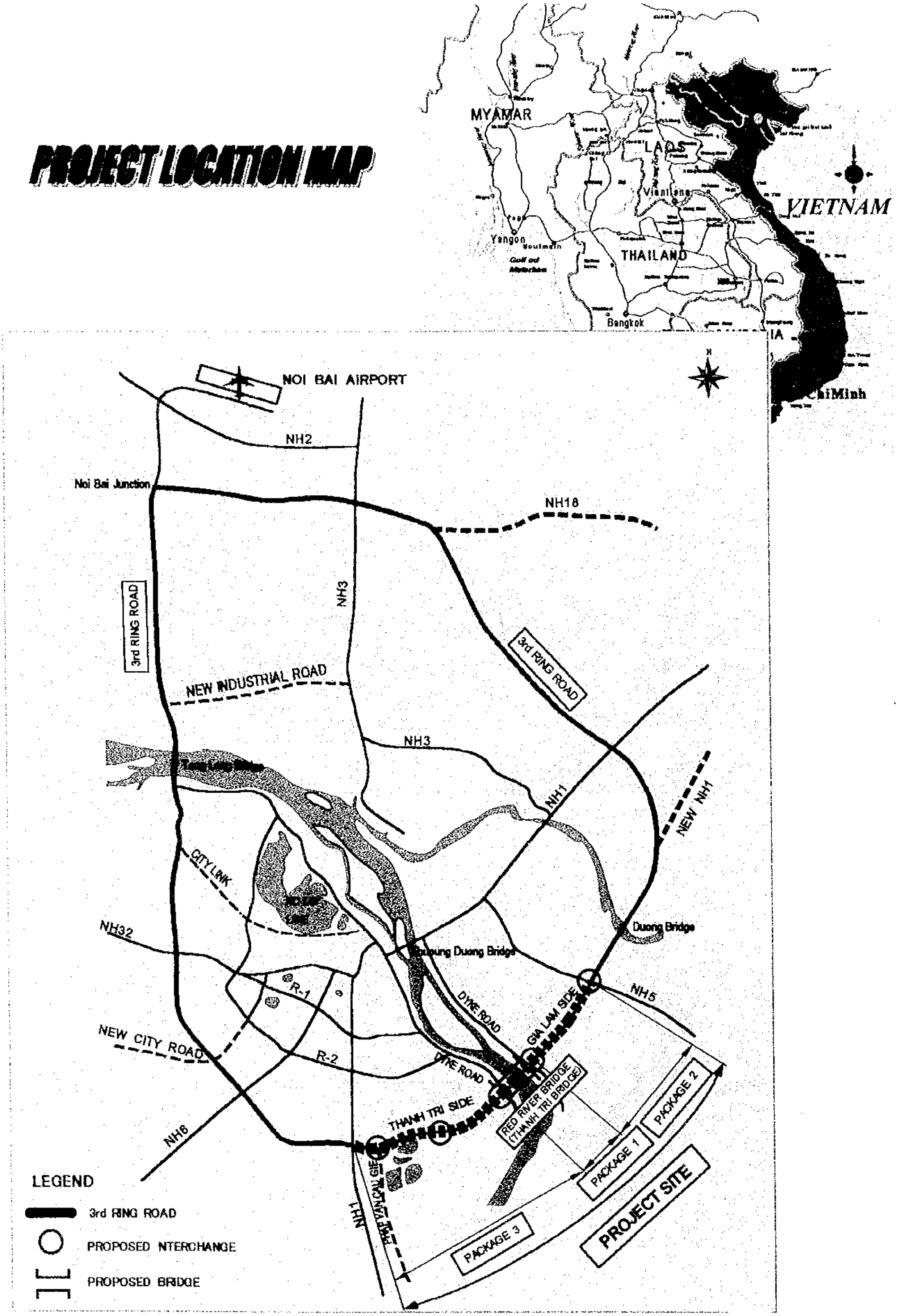


PHAP VAN CAU GIE INTERCHANGE

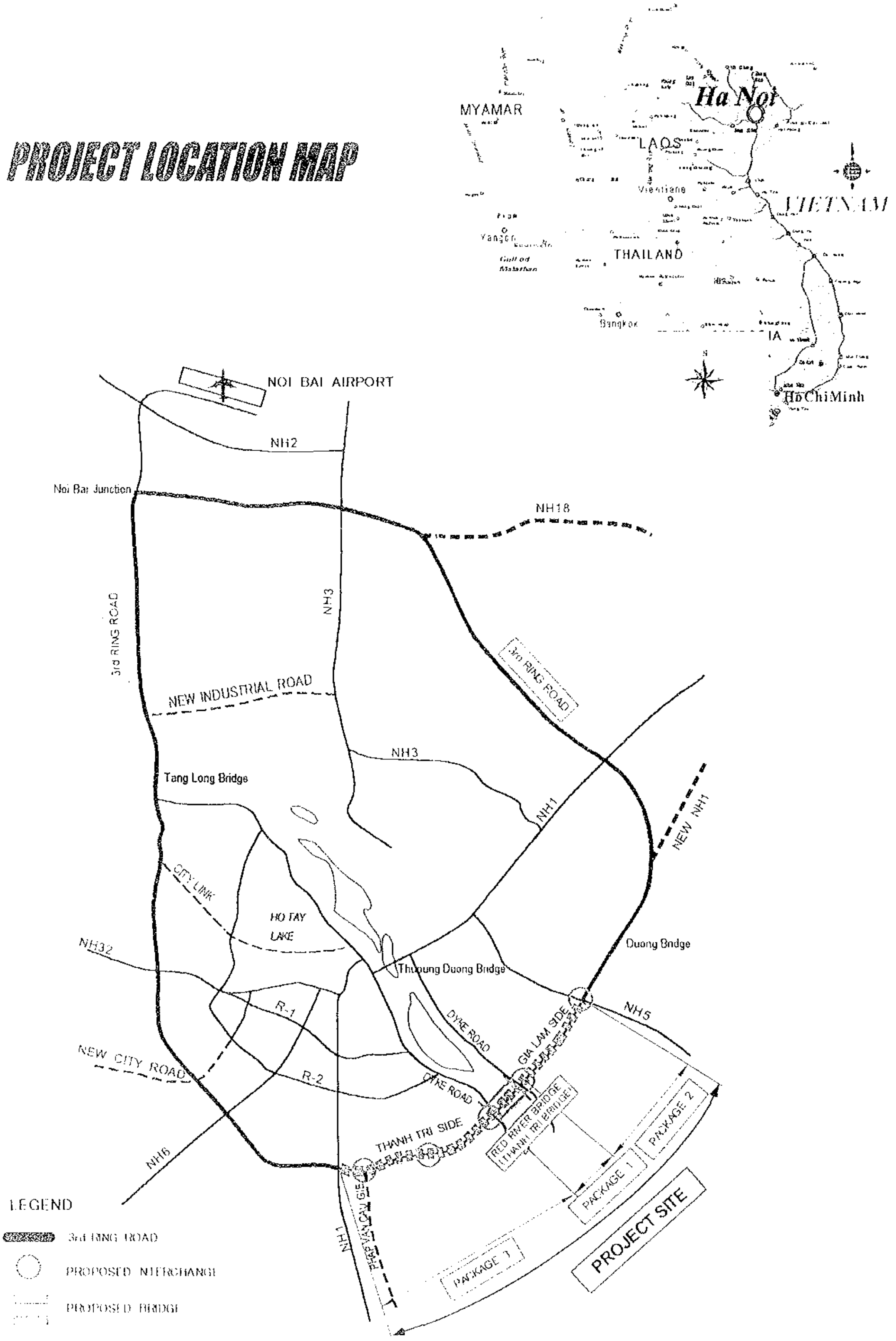


RED RIVER BRIDGE and GIA LAM INTERCHANGE

PROJECT LOCATION MAP



PROJECT LOCATION MAP



ABBREVIATION AND GLOSSARY

(1) Agencies

AASHTO	American Association of State Highway and Transportation
ASTM	American Society for Testing and Materials
ADB	Asian Development Bank
CBD	Central Business District
CPCs	Commune's People's Committees
DOSTE	Hanoi Department of Science Technology and Environment
DLACRCs	District's Land Acquisition, Compensation and Resettlement Committees
DPCs	District's People's Committees
GOJ	Government of Japan
HPC	Hanoi People's Committee
HWBC	Hanoi Water Business Company
HCEC	Hanoi Civil Engineering College
IBRD/WB	International Bank for Reconstruction and Development/ World Bank
JICA	Japan International Cooperation Agency
JBIC	Japan Bank for International Cooperation
JHPC	Japan Highway Public Corporation
MOSTE	Ministry of Science and Technology and Environment
MOT	Ministry of Transport
MOF	Ministry of Finance
MOC	Ministry of Construction
NEA	National Environmental Agency
OMD	Operation and Maintenance Division
PMU Thang Long	Project Management Unit Thang Long
PCs	People's Committees
PED	Executive Division for Implementation of APCRs in PMU Thang Long
PIU	Project Implementation Unit
RMD	Road Management Division
TEDI	Transport Engineering Design Incorporation
TUPWS	Transport and Urban Public Works Services, HPC
UNDP	United Nations Development Program
VRAB	Vietnam Road Administration Bureau, Ministry of Transport

(2) Technial, Traffic and Economic Terms

AADT	Average Annual Daily Traffic
AC	Asphaltic Concrete
ADT	Average Daily Traffic
APCRs	Action Plans for Compensation and Resettlement
B/D	Basic Design
BOD	Biological Oxygen Demand
BP	By-Pass
BH	Bore hole
CBR	California Bearing Ratio
°C	Degree(s) Celsius

CEPT	Center for Environmental Protection in Transportation
DHV	Design Hourly Volume
DPEIH	Drainage Project for Environment Improvement in Hanoi
D/D	Detailed Design
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EIRR	Economic Internal Rate of Return
ESAL	Equivalent Standard Axle Load
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GDP	Gross Domestic Product
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
HCM	Highway Capacity Manual of Transportation Research Board, USA
HTRR	Hanoi Third Ring Road
HUTMP	Hanoi Urban Transport Master Plan Study (The Master Plan of Urban Transport for Hanoi City in Vietnam, JICA)
HWL	High Water Level
H/L	Height/span length
IC	Interchange
IP	Intersection Point
ICB	International Competitive Bid
I/L	International Launching
JIS	Japan Industrial Standards
JSHB	Japanese Specifications for Highway Bridges, or DOURO-KYO SHIHOUSHO
kgf	kilogram-force = 9.8 Newton (approximately)
LWL	Low Water Level
LCB	Local Competitive Bid
LPR	Lane Printer
LRFD	Load and Resistance Factor Design
MSL	Mean Sea Level
NH	National Highway
NR	National Route
NPV	Net Present Value
O-D	Origin - Destination
O/M	Operation and Maintenance
Pass. or Pas.	Passenger
PC	Prestressed Concrete
PCU	Passenger Car Unit
PAPs	Project-Affected Persons
P/Q	Pre-Qualification
PSI	Pound(s) per square inch (=lb./in.^{2})
RR	Ring Road
RC	Reinforced Concrete
ROW	Right-Of-Way
SCPT	Static Core Penetration Test
SHTRR	Southern Section of Hanoi Third Ring Road
SPT	Standard Penetration Test
SPM	Suspended Particulate Matter

SMS	Surface-water Modeling System
Sta.	Station
STRADA	System for Traffic Demand Analysis
TCVN	Standard of Vietnam
TCT	Toll collector's terminal
Tf	Ton-force = 9.8 kilo Newton (approximately)
US$/USD	US Dollar
VND	Vietnam Dong
VNBDC	Vietnamese Bridge Design Codes 22TCN 018-79
VOC	Vehicle Operation Cost
WGS	World Geodetic System

(3) Definition

Auxiliary Lane	An auxiliary lane is defined as the portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through traffic movement.
Base	The layer or layers of material placed on a subbase or subgrade to support a surface course.
Bridge	A structure more than 6m long, including supports, spanning and providing passage over a depression, waterway, railroad, highway, or other obstruction.
Capacity	The term "capacity" is used to express the maximum number of vehicles that have a reasonable expectation of passing over a given section of a lane or a roadway during a given time period under prevailing roadway and traffic conditions.
Expressway	The highest type of arterial highway is the expressway which is defined as an express highway fully controlled access. Essential expressway elements include medians, grade separations at cross roads, ramp connections for entrance to and exit from the through pavements for interchange of traffic and (in some cases) frontage roads.
Frontage Road	Frontage roads may be used to function as a street facility serving adjoining property, and to maintain circulation of traffic on each side of the expressway. Frontage roads generally are, but need not be, parallel to the roadway for through traffic, they may or may not be continuous, and they may be provided on one or both sides of the expressway.
Full Control of Access	Full control of access means that preference is given to through traffic by providing access connections only with selected public roads and by prohibiting crossing at grade.

Interchange	An interchange is a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways on different levels.
Intersection	An intersection is defined as the general area where two or more highways join or cross, including roadway and roadside facilities for traffic movements within it.
Median	A median is defined as the portion of divided highway separating the traveled way for traffic in opposing directions.
Ramp	The term "ramp" includes all types, arrangements, and turning roadways that connect two or more legs at an interchange.
Roadbed	The graded portion of a highway prepared as a foundation for the pavement structures.
Roadside	All area within the right-of-way excluding the traveled way and shoulders.
Roadway	The portion of a highway within the limits of construction.
Shoulder	A shoulder is the portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use and for lateral support of pavement.
Subbase	The layer or layers of material placed on a subgrade to support a base.
Subgrade	The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.
Substructure	All of the bridge below the bearings of simple and continuous spans; pier(s) and abutments including wingwalls.
Superstructure	The entire bridge except the substructure.
Surface Course	The top layer or layers of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering.
Throughway or Through Pavement	Roadway for the movement of through - traffic, inclusive of shoulders.
Traveled Way	Traveled way is the portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

PROJECT SUMMARY

1. COUNTRY	The Socialist Republic of Viet Nam
2. NAME OF STUDY	The Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project
3. COUNTERPART AGENCY	Project Management Unit Thang Long, Ministry of Transport
4. OBJECTIVE OF STUDY	The Detailed Design and Preparation of Draft Tender Documents for the Project

1. STUDY AREA: The Study area covered Hanoi City and its vicinity where the influence of the Project will be expected.

2. FUTURE TRAFFIC VOLUME

Package No.		1	2	3
Section		Red River Bridge	Gia Lam Section	Thanh Tri Section
Road/Bridge Length		3.1 km	3.5 km	6.2 km
Traffic Volume	Year 2010	73,100	73,100	57,600／73,100 *
(PCU／day)	Year 2020	111,700	111,700	86,400／111,700 *

Note) * Traffic volumes indicate (section between NH1 and Phap Van Road)／(section between Phap Van Road and the Red River Bridge).

3. DESIGN SPEED, NUMBER OF LANE AND TYPICAL CROSS SECTION

Package No.	Section	Design Speed	Number of Lane	Typical Cross Section*2
1	Red River Bridge	100 km／hr	4 (6 *1)	TypeA
2	Gia Lam Section	100 km／hr	4	Type B or C
3	Thanh Tri Section	100 km／hr	4	Type C or D
4	Resettlement Area	—	—	—

Note) *1: The Red River Bridge will be constructed with 6-lane width for future widening, even though 4 lanes will be operated initially.

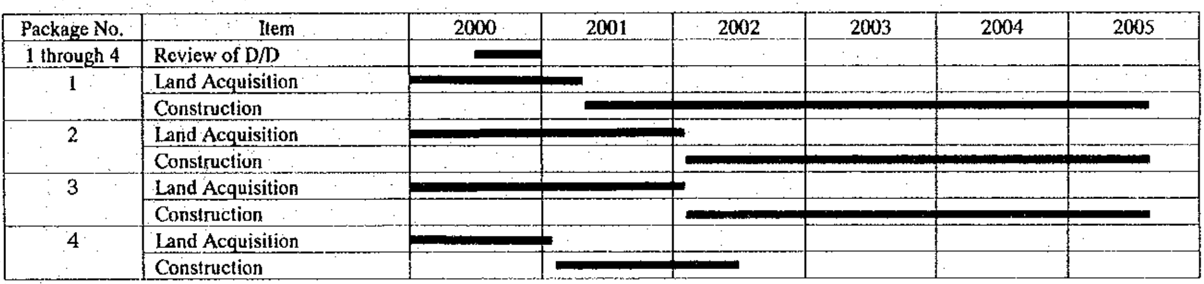
*2: See Figure 1.

4. CONSTRUCTION COST

- February 2000 Prices
- 1 US$ = 14,000 Dong
- 1 Dong = 0.01 Yen

Pckage No.	Section	Road /Bridge Length	Construction Cost		
			F.C (Mill.¥)	L.C(Mill. D)	Total (Mill.¥)
1	Red River Bridge	3.1 km	12,059	714,437	19,203
2	Gia Lam Section	3.5 km	3,397	252,498	5,922
3	Thanh Tri Section	6.2 km	6,304	417,519	10,479
4	Resettlement Area	—	374	37,400	748
	TOTAL	12.8 km	22,134	1,421,854	36,352

5. IMPLEMENTATION SCHEDULE



6. ECONOMIC INDICATORS

Economic Indicators	Project as a whole
EIRR(%)	13.49
NPV(Million Dong)	594,800
B/C Ratio	1.18

Note) NPV and B/C ratio were calculated based on a discount ratio of 12% p.a.

7. RECOMMENDATIONS

1. The results of the Study indicate that the Project is technically sound (no serious technical difficulty is anticipated for the construction) and economically feasible. Taking into account the direct and enormous indirect benefits towards regional development other than the quantified savings in travel costs, the Project should be implemented at the earliest opportunity.
2. Delay of implementation would entail increasingly difficult land acquisition and resettlement due to the rapid development of the region, especially in Thanh Tri area. Arrangement of land acquisition and resettlement should commence immediately.
3. Proposed implementation schedule is to emphasize simultaneous commencement of services in all three construction sections, subject to due consideration on inevitable lead-time for land acquisition and resettlement, to optimize investment schedule.
4. A stage construction scheme such as widening from four lanes to six lanes in the future will entail immense technical difficulties when applied to Thanh Tri Bridge, Pahp Van – Cau Gie Interchange and National Highway No.5 Interchange. Thus it is recommended to provide a six-lane width in the initial stage to avoid this problem, even though only four lanes will be required initially.

OUTLINE OF THE STUDY

The Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam

- Study Period: April, 1999 - June, 2000
- Counterpart Agency: Project Management Unit Thang Long,
  Ministry of Transport

1. Background

Since an effective transport system is a basic requirement to achieve the future socio-economic development of the Hanoi region, a number of transport infrastructures improvement projects are either planned or under construction.

Many industrial zones are now either in operation or in the construction stage around Hanoi and along the major transport arteries. The traffic entering and originating from Hanoi will increase drastically in the near future.

In Hanoi, the total length of the road network is not sufficient for this increased usage. No adequate ring road system has been implemented, road widths are insufficient to allow for heavy vehicles and bridges are deteriorating.

2. Study Objectives

The Objectives of the Study were to carry out necessary engineering and environmental surveys, to complete a detailed design and to prepare draft tender documents of the Project, agreed on between the governments and to pursue technology transfer to the Government counterpart personnel in the course of the Study.

3. Study Area

The Study area covered Hanoi City and its vicinity where the influence of the Project will be expected.

4. Project Outline

4.1 Basic Policy

The detailed design and preparation of draft tender documents are carried out for the construction of required facilities which are proposed for the target year of 2010.

4.2 Content

The detailed design work for the construction of the Red River Bridge (Thanh Tri Bridge) and the Southern section of Hanoi Third Ring Road (SHTRR) were made within reference to the basic policy and study results as stated above.

(1) Future Traffic Volume

A forecast of future traffic volume based on present volume and the future socio-economic framework of the Study Area is shown in Table 1.

Table 1 Future Traffic Volume

Package No.		1	2	3
Section		Red River Bridge	Gia Lam Section	Thanh Tri Section
Road / Bridge Length		3.1 km	3.5 km	6.2 km
Traffic Volume	Year 2010	73,100	73,100	57,600 / 73,100 *
In PCU / day	Year 2020	111,700	111,700	86,400 / 111,700 *

Note) *: Traffic Volumes of Thanh Tri section indicate (section between NH1 and Phap Van Road) / (section between Phap Van Road and Thanh Tri Bridge).

(2) Design Speed, Number of Lanes and Typical Cross Sections

The number of lanes required was based on the expected traffic volume and traffic capacity. The road geometric standards, which includes design speed and cross-section structure, were determined in consideration of the characteristics of each Package and are given in Table 2.

Table 2 Number of Lanes and Typical Cross Sections

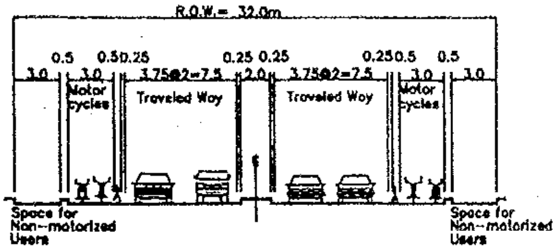
Package No.	Section	Design Speed	Number of Lanes	Typical Cross Section *2
1	Red River Bridge	100 km/hr	4 (6 *1)	Type A
2	Thanh Tri Section	100 km/hr	4	Type B or C
3	Gia Lam Section	100 km/hr	4	Type C or D

Note) *1: The Red River Bridge will be constructed with 6-lane width for future widening, even though 4 lanes will be initially operated as shown in Figure 1 - Type A.

*2: See Figure 1.

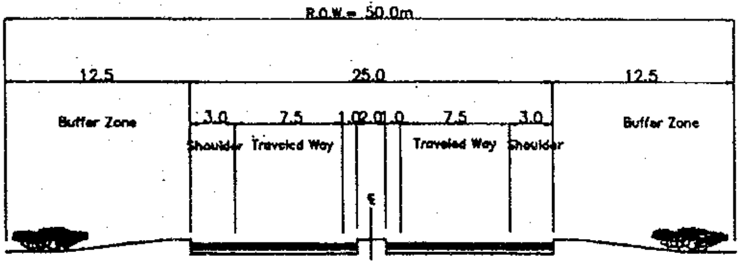
Type A

The Red River Bridge will be constructed with 6-lane width for future widening. However, the bridge will be initially operated as shown in Type A.



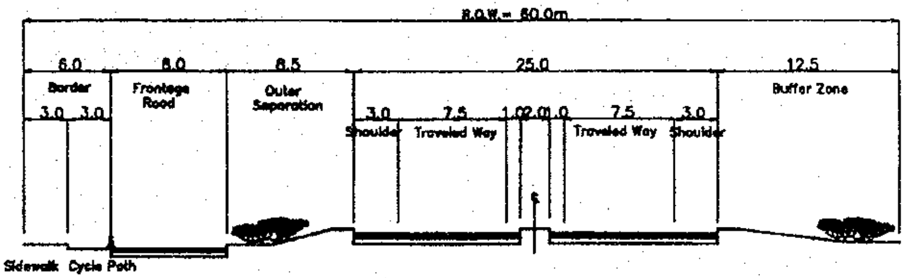
Motor Cycle Separation Scheme

Type B



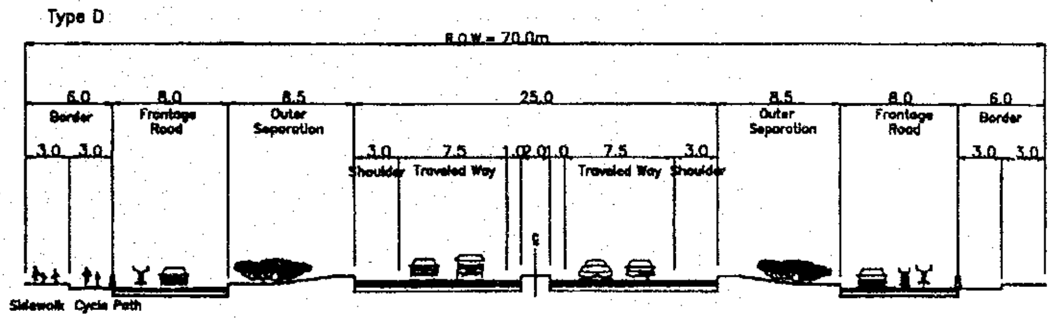
Through Traveled Ways with Buffer Zone

Type C



Through Traveled Ways with Frontage Road and Buffer Zone

Type D



Through Traveled Ways with Frontage Road on Both Sides

Figure 1 Typical Cross Sections

(3) Detailed Design, Cost Estimates and Preparation of Tender Documents

Based upon the highway's geometric standards the route selection was decided with efforts made to keep the influence on the human and natural environments to a minimum. At the same time, detailed design and construction planning were conducted. The project cost estimates and draft bidding documents were prepared based on these results.

(4) Outline of Project

- Package 1: Red River Bridge (Thanh Tri Bridge)

  This bridge which crosses the Red River has a total length of 3,084 m and consists of seven parts.

- Package 2: Gia Lam Section

  Package 2 is 3.5 km in length and the main works are the construction of:

  - Four lane throughways, frontage roads and border facilities;
  - One partial cloverleaf type interchange to connect SHTRR and National Highway No.5 including flyover bridge;
  - One half-diamond type interchange to connect the Red River Bridge and Gia Lam Dyke road; and
  - Three throughway bridges and two ramp way bridges by the prestressed concrete girder.

- Package 3: Thanh Tri Section

  Package 3 is 6.2 km in length and the main works are the construction of:

  - Four lane throughways, frontage roads and border facilities;
  - One single trumpet interchange to connect SHTRR and National Highway No.1 including viaduct;
  - One full-diamond type interchange to connect the Red River Bridge and Thanh Tri Dyke road;
  - One half-diamond type interchange to connect SHTRR and Nguyen Tam Trinh road;
  - One barrier type toll plaza; and
  - Four throughway bridges and three ramp way bridges by the prestressed concrete girder.

- Package 4: Construction of Resettlement Area

Main construction works in Package 4 are the construction of:

- Access roads and internal roads in the resettlement areas
- Water supply and drainage
- Public space and park

5. Project Costs

The estimated project costs for each Package at the exchange rates effective in February 2000 (1 US$ = 14,000 Dong) are shown in Table 3.

Table 3 Estimated Construction Cost in 2000 Prices

Package No.	Section	Road / Bridge Length	Construction Cost		
			Foreign Currency (Million Yen)	Local Currency (Million Dong)	Total (Million Yen)
1	Thanh Tri Bridge	3.1 km	12,059	714,437	19,203
2	Gia Lam Section	3.5 km	3,397	252,498	5,922
3	Thanh Tri Section	6.2 km	6,304	417,519	10,479
4	Resettlement	-	374	37,400	748
Total		12.8 km	22,134	1,421.854	36,352

6. Project Evaluation

6.1 Economic Analysis

The economic indicators for the project are shown in Table 4 and from these it can be seen that the Project is deemed economically feasible.

Table 4 Results of Economic Analysis

Economic Indicators	Project as a whole
EIRR (%)	13.49
NPV (Million Dong)	594,800
B/C Ratio	1.18

Note: NPV and B/C ratio were calculated based on a discount rate of 12 % p.a.

6.2 Financial Analysis

- Implementation of project by 100% of private sector is judged to be financially unfeasible since FIRR is less than 6%

- For implementation by the government, the fund combination with interest on the government loan and bank loan is not feasible because of the shortage of revenue, which cannot cover the repayment of principle and interest.

- There is a need to increase toll charge when the project is implemented by the fund resources with soft loan and government financing.

- Private concessionaire needs to participate in the project when the government cannot prepare the 20 % of project cost of without interest. In this case, the government needs to prepare soft loan of 70% of the project cost based on government guarantee to the soft loan provider.

- Implementation by private concessionaire is not easy to participate with 30% of equity of the project cost since FIRR is very low and not profitable. In this case, the Government needs to consider to give some considerations such as tax exemption or increase of toll fee.

6.3 Environmental Aspects

The construction of Thanh Tri Bridge and SHTRR will result overall in a large favorable impact on society and the economy of the people along the highway as well as the state. However, consideration must be given to minimize any adverse environmental effects and appropriate compensation should be made for land and properties affected by the Project.

7. Implementation Schedule

Project implementation time schedule is prepared as shown in Figure 2.

Package	Item	2000	2001	2002	2003	2004	2005
1 to 4	Review of D/D	▬					
1	Land Acquisition	▬	▬				
	Construction		▬	▬	▬	▬	▬
2	Land Acquisition	▬	▬	▬			
	Construction			▬	▬	▬	▬
3	Land Acquisition	▬	▬	▬			
	Construction			▬	▬	▬	▬
4	Land Acquisition	▬	▬				
	Construction		▬	▬			

Figure 2 Project Implementation Schedule

As shown in Figure 2, the completion of the construction in all packages will be set at the same time of the middle of 2005 to attain the optimum investment schedule and to consider the time required for land acquisition and resettlement.

8. Recommendations

(1) Implementation of the Project

The results of the Study indicate that the Project is technically sound (no serious technical difficulties are anticipated for the construction) and also economically feasible. Taking into account the direct and enormous indirect benefits towards regional development other than the quantified savings in travel costs, the Project should be implemented at the earliest opportunity.

(2) Land Acquisition and Resettlement

Delay of implementation would entail increasingly difficult land acquisition and resettlement due to the rapid development of the region, especially in Thanh Tri area. Arrangement of land acquisition and resettlement should commence immediately.

(3) Project Implementation Schedule

Proposed implementation schedule is to emphasize simultaneous commencement of services in all three construction sections, subject to due consideration on inevitable lead-time for land acquisition and resettlement, to optimize investment schedule.

(4) Construction Scheme for the Future Widening

A stage construction scheme such as widening from four lanes to six lanes in the future will entail immense technical difficulties when applied to Thanh Tri Bridge, Pahp Van – Cau Gie Interchange and National Highway No.5 Interchange. Thus it is recommended to provide a six-lane width in the initial stage to avoid this problem, even though only four lanes will be required initially.

THE DETAILED DESIGN
OF
THE RED RIVER BRIDGE (THANH TRI BRIDGE) CONSTRUCTION PROJECT
IN
THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT – Volume II: Main Report

TABLE OF CONTENTS

CHAPTER 4 DESIGN STANDARDS

CHAPTER 5 DETAILED DESIGN OF HIGHWAY

CHAPTER 6 DETAILED DESIGN OF BRIDGES

CHAPTER 7 DETAILED DESIGN OF BOX CULVERT AND RETAINING WALL

CHAPTER 8 DETAILED DESIGN OF DRAINAGE SYSTEM

CHAPTER 9 DETAILED DESIGN OF ELECTRICAL FACILITIES

CHAPTER 10 LAND ACQUISITION, COMPENSATION AND RESETTLEMENT IMPLEMENTATION PROGRAM

CHAPTER 11 DETAILED DESIGN OF RESETTLEMENT SITES

CHAPTER 12 CONSTRUCTION PLANNING

CHAPTER 13 MANAGEMENT AND MAINTENANCE PLAN

CHAPTER 14 COST ESTIMATES

CHAPTER 15 PROJECT IMPLEMENTATION PLAN

CHAPTER 16 TENDER AND CONTRACT DOCUMENTS

CHAPTER 17 ENVIRONMENTAL IMPACT STUDY

CHAPTER 18 LANDSCAPES

CHAPTER 19 ECONOMIC AND FINANCIAL ANALYSIS

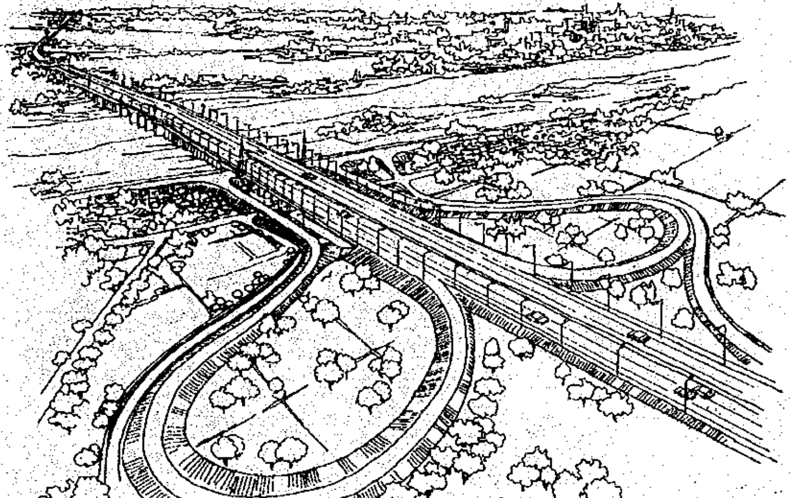
CHAPTER 20 CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF PICTURES

CHAPTER 1 INTRODUCTION



CHAPTER 1 INTRODUCTION

1.1 Project Background

The urban area in Hanoi, the capital city of the Socialist Republic of Viet Nam, has rapidly developed under the " Doi Moi " policy started from 1986. Hanoi is expected to keep on developing in future but traffic congestion is estimated to be one of the most serious problems. Measures to minimize traffic congestion is therefore a most important task but the existing road network is not sufficient. Accordingly it is important that the trunk road network be improved in the first place without further delay.

Hanoi is the main focus of human activities of the nation and the centre of commerce, finance, industry and transportation in the Red River Delta and Northern Focal Economic Area. The population of Hanoi was estimated at approximate 2.3 million people in 1994 and a sharp increase of population in Hanoi is expected based on the previous trends.. Increase of population is mainly caused by moving from the surrounding area due to imbalance of income and this trend is expected to continue in future. The present rate of increase in the central Hanoi is more than 3% a year

Under such increase of population and high economic growth, motorization that is from bicycle to motor bike and from motorbike to car is increasing dramatically and this will further increase in future.

National Highways No.1A, No.1B, No.3, No.5, No.6 and No.18 are the existing radial trunk roads in the Hanoi area but only Thang Long Bridge and Chuong Duong Bridge are available for crossing the Red River. Vehicles passing over bridges are concentrated at a part of the radial trunk roads and this causes traffic congestion. Furthermore, the mixed road usage by cars, motorbikes, bicycles and pedestrian also increases the problem.

As a result of the above-mentioned traffic conditions, Japan International Cooperation Agency (hereinafter referred as "JICA") has carried out the following projects in response to the request of the Government of the Socialist Republic of Viet Nam (hereinafter referred as "the Government"):

- The Study on Traffic System in Northern Area (1994)
- The Master Plan of Urban Transport for Hanoi City (1996)
- The Feasibility Study on Thanh Tri Bridge and Southern Section of Ring Road No.3 in Hanoi (1998)

In order to build the framework to solve the above-mentioned problems, the Master Plan of Urban Transport for Hanoi City was formulated by JICA in 1996. According to results of the study, the existing bridges over the Red River have not enough traffic capacity to correspond with the future increase in traffic volume. The concept of the Hanoi Third Ring Road (hereinafter referred to as "HTRR") to collect and distribute all incoming and outgoing traffic was therefore proposed.

Under such circumstances, the Government has decided to construct the most urgent section of HTRR that is the Southern Section of Ring Road No. 3 in Hanoi including Thanh Tri Bridge (hereinafter referred to as "the Project"). In the Feasibility Study on Thanh Tri Bridge and Southern Section of Ring Road No.3 in Hanoi, it was recommended the Project should be implemented as soon as possible.

Considering the background mentioned above, in July 1998 the Government requested the Government of Japan to implement the Project by ODA loans and in October 1998 they further requested to implement the detailed design of the Project by JICA. The Government of Japan sent an appraisal mission from the Japan Bank for International Cooperation (hereinafter referred as "JBIC") and gave a pledge on the ODA loans for the Project. The JICA preparatory study team for this detailed design was dispatched in December, 1998 and agreed the scope of work after confirmation of an exemption clause from responsibility of the result of detailed design.

1.2 Study Objective

The Objectives of the Study were to carry out necessary engineering and environmental surveys, to complete a detailed design and to prepare draft tender documents of the Project, agreed on between the governments and to pursue technology transfer to the Government counterpart personnel in the course of the Study.

1.3 Study Area

The Study area covered Hanoi City and its vicinity where the influence of the Project will be expected.

1.4 Scope of the Study and Work Flow

The Study was divided into four steps that were executed in a sequential manner:

- Step [1]: Review of the existing data. (April 1999)
- Step [2]: Data collection, natural condition survey, basic design and survey on environment. (April through June 1999)

- Step [3]: Detailed design, environmental impact assessment, construction planning, cost estimate, implementation planning and preparation of draft tender documents. (August 1999 through March 2000)
- Step [4]: Preparation and submission of final report. (May 2000)

The basic flow diagram, which identifies major work items to be carried out in each step, is indicated in Figure 1.4.1, and a work flow chart of the Study, which indicates also the approximate timing to carry out each work item and their relation, is shown in Figure 1.4.2.

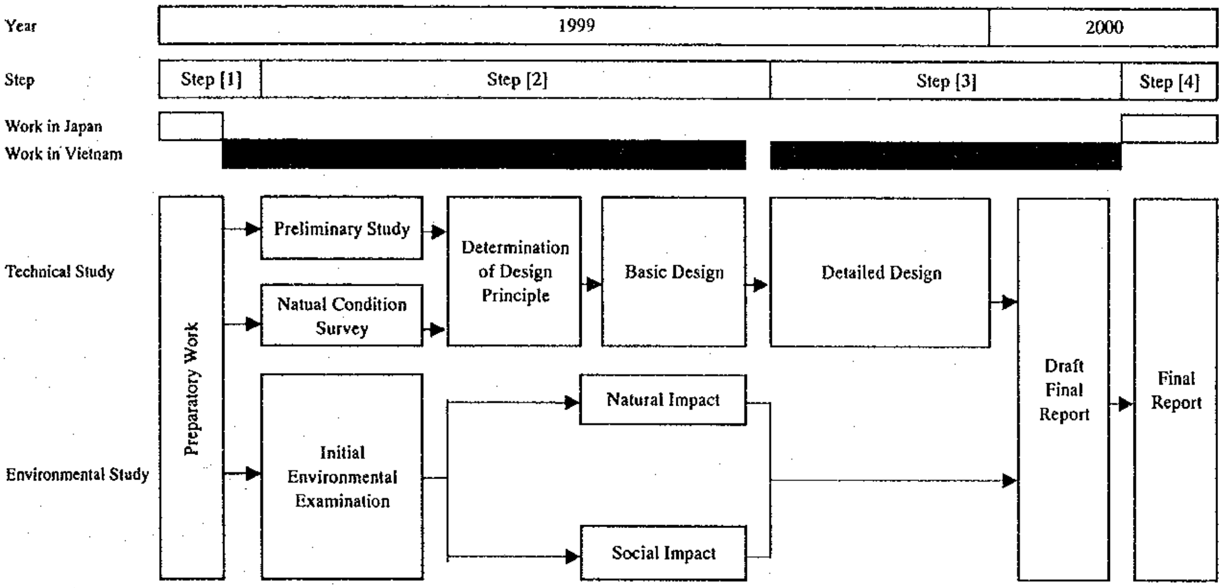
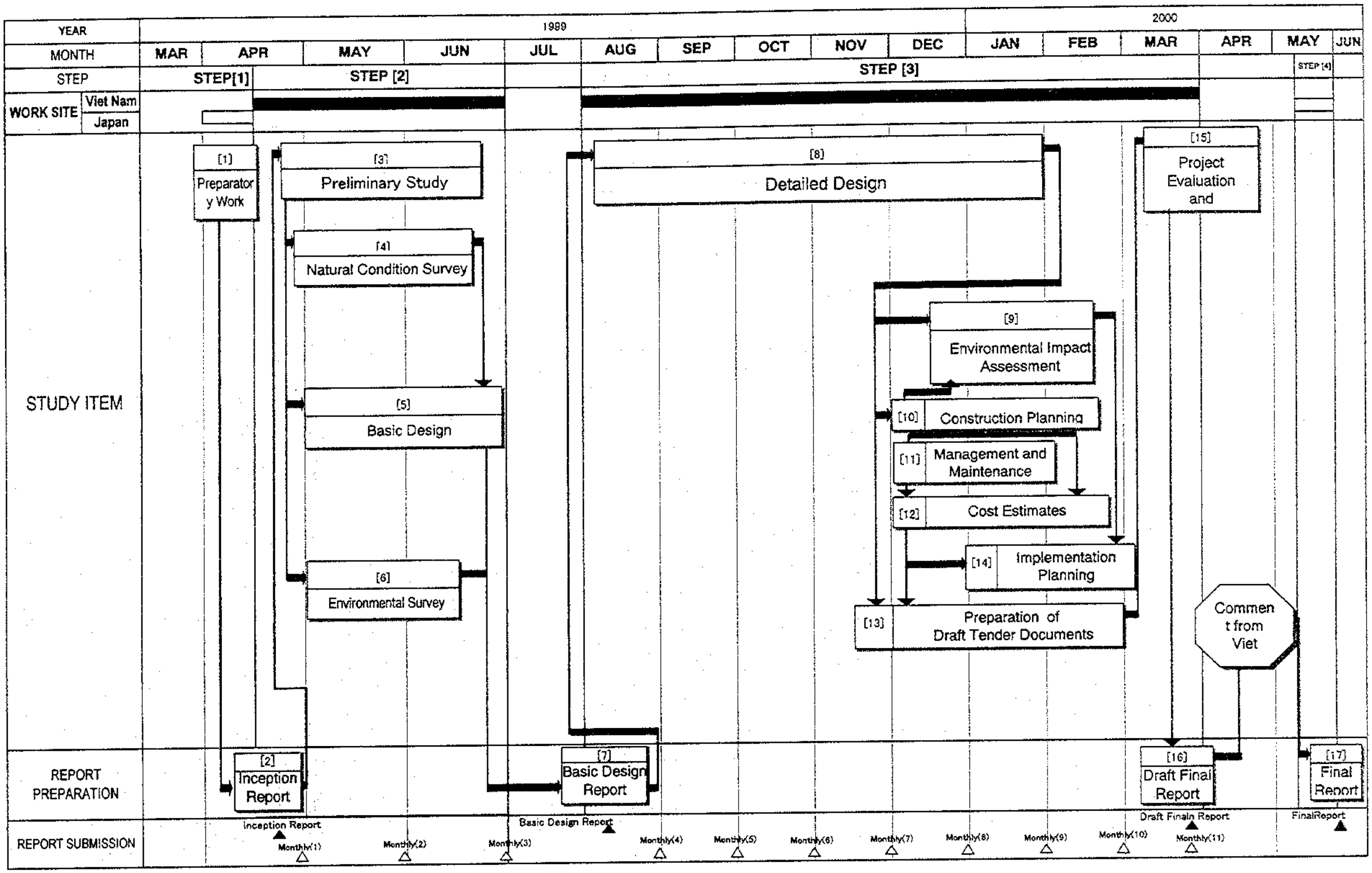


Figure 1.4.1 Basic Flow of the Study

1.5 Study Organization

The JICA Study Team carried out the Study closely collaborating with the Vietnamese counterpart personnel, who were arranged by the Government. A Steering Committee was set up by the Government and a Technical Evaluation and Examination Consultant was employed by JICA, for the duration of the Study. The study organization is shown in Figure 1.5.1.



△ : Report submission ▲ :Report submission and work shop

Figure 1.4.2 Work Flow Chart

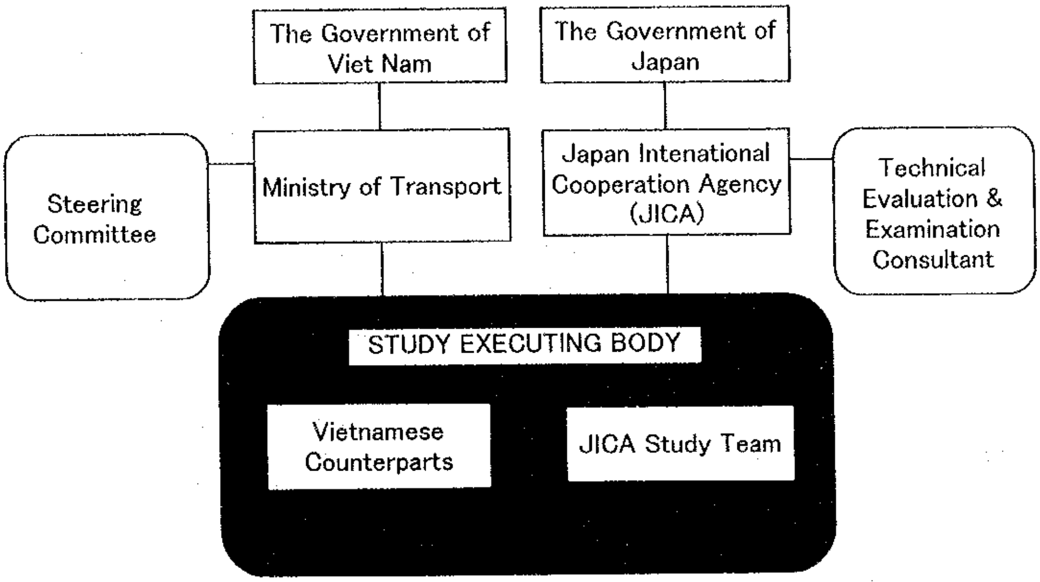


Figure 1.5.1 Study Organization

The members of the Government's steering committee (Vietnamese Steering Committee) and counterparts (Vietnamese Counterparts), technical evaluation and examination consultant and JICA Study Team, for execution of the study were as follows:

(1) Vietnamese Steering Committee

1) Mr. Pham Quang Tuyen	Vice Minister, Ministry of Transport
2) Mr. Nguyen Ngoc Nhat	General Director of Infrastructure Department, Ministry of Planning and Investment
3) Mr. Vu Van Tri	Deputy General Director of Transport Construction Quality and Management Control Bureau, Ministry of Transport
4) Mr. Tran Quang Minh	Deputy General Director of Planning and Investment, Ministry of Transport
5) Mr. To Anh Tuan	Deputy Chief Architect, Hanoi Chief Architect Office
6) Mr. Do Huu Tri	General Director of Science and Technology Department, Ministry of Transport

7)	Mr. Tran Trung Tru	General Director of Project Management Unit Thang Long

(2) Vietnamese Counterparts

1)	Mr. Tran Trung Tru	General Director of Project Management Unit Thang Long
2)	Mr. Vu Dinh Hoa	Deputy General Director of Project Management Unit Thang Long
3)	Mr. Vu Hoc Le	Senior Engineer of Project Management Unit Thang Long

(3) Technical Evaluation and Examination Consultant

1)	Mr. Tomoaki Murakami	Infrastructure Development Institute
2)	Mr. Tsuyoshi Matsumoto	Infrastructure Development Institute
3)	Mr. Toshiyuki Kano	Infrastructure Development Institute
4)	Mr. Hiroo Oda	Infrastructure Development Institute
5)	Mr. Minoru Hujiwara	Infrastructure Development Institute

(4) JICA Study Team

1)	Mr. Satoshi Watabe	Team Leader/Bridge Planning
2)	Mr. Jiro Koyama	Bridge Design (Superstructure 1)
3)	Mr. Teruhisa Iwabuchi	Bridge Design (Superstructure 2)
4)	Mr. Kazuo Moriya	Bridge Design (Superstructure 3)
5)	Mr. Hiroshi Minamiguchi	Bridge Design (Superstructure 4)
6)	Dr. Takayuki Ishizuka	Bridge Design (Substructure 1)
7)	Mr. Shunji Yoshihara	Bridge Design (Substructure 2)
8)	Mr. Kunio Takahashi	Bridge Design (Substructure 3)
9)	Mr. Tadahiko Akiyama	Highway Design 1
10)	Mr. Akihiko Kitayama	Highway Design 2
11)	Mr. Jinnosuke Otoguro	Highway Design 3
12)	Mr. Shogo Shibata	Soils and Materials Survey
13)	Mr. Hiroyuki Watanabe	Electrical Facility Design
14)	Mr. Keiji Nakaoka	Drainage Design
15)	Dr. Chaisak Sripadungtham	Hydraulic/Hydrological Survey
16)	Mr. Sadahiko Akiyoshi	Geological Survey
17)	Mr. Masamitsu Toriyama	Economic/Financial Analysis

18)	Mr. Akira Shikichi	Cost Estimates and Tender Documents
19)	Mr. Tsuyoshi Ito	Environmental Assessment
20)	Mr. Takeshi Omura	Resettlement Planning
21)	Mr. Hidenori Okazaki	Computer System
22)	Mr. Hiroshi Tamaka	Landscape

CHAPTER 2 REVIEW OF THE FEASIBILITY STUDY

CHAPTER 2 REVIEW OF THE FEASIBILITY STUDY

2.1 Transport Profile and Future Development Plans

(1) General Road Transport Condition in the Study Area

The transport network in the region consists of three modes; road, railway and inland waterway but road transport plays a very dominant role for both inter-regional and intra-regional transportation. Arterial roads run to and from Hanoi City in radial directions, connecting to all major cities in the country and to the surrounding provinces. An analysis on the general transport condition in the Study Area was carried out based on the existing data and this confirms:

- Increasing transport volume for both freight and passengers; and
- Road transport plays a dominant role in passenger transport, however inland water transport has a certain role in freight transport.

(2) Road Network

The city of Hanoi, with a population of approximately 2.3 million people, is the center of politics, culture, commerce, finance, and the industrial areas which are concentrated in the Red River plain. A complete and effective transport network is a basic need for the socio-economic development in this area.

Transport network in this region consists of three modes: road, railway and inland waterways, of which road transport plays a dominant role for both inter-regional and intra-regional transportation. Arterial roads run to and from the city in radial directions, connecting it with all major cities in the country as well as the surrounding provinces. Road lengths within Hanoi are summarized in Table 2.1.1 according to administrative authority.

Table 2.1.1 Road Length According to Administrative Authority

Road type	Road length (km)			
	VRA	TUPWS	District	Total
National road	71.7	28.4	-	100.1
Special (State)	12.3	14.0	-	26.3
Provincial	-	134.6	-	134.6
Special(TUPWS)	-	90.5	-	90.5
District	-	19.8	-	19.8
District/municipal	-	-	427.0	427.0
Total	84.0	287.3	427.0	798.3

Note : VRA: Vietnam Road Administration, MOT
TUPWS : Transport and Urban Public Works Services, HPC

However, in Hanoi, the total length of the road network is not sufficient for the presently increasing usage. No ring road system has been implemented, road widths are insufficient for heavy vehicles, and bridges are deteriorating.

In 1996, JICA conducted a new Transport Master Plan named "The Study on Urban Transportation for Hanoi City in Vietnam, 1996" . The plan emphasized the need for a coordinated and integrated transportation vision for Hanoi. It also highlighted the rapidly changing pace of development - reflected in urbanization and motorization - and the need to review and refine existing plans for transport.

HPC's Transport and Urban Public Works Services (TUPWS) presented the proposed investment plan for the following five years(1996-2000). Notwithstanding resettlement difficulties, it planned to complete the First, Second and Third Ring Roads (including Thanh Tri Bridge). Five major radial roads into the city are also to be upgraded, including:

- Mai Dich/Cau Giay/Hung Vuong, Nghia Do and Thang in the west
- National Route 23,(NR23), Nhat Tan to Phap Van(SHTRR)) and Nria(S) to Le Duan in the south;
- Upgrading and constructing near roads in Ba Dinh and Dong Da Districts along the Second Ring Road (2RR) in the west and southwest.

Several junctions are also targeted for improvement including ;

- Cau Giay, Nga Tu So and Nga Tu Vong on the 2RR;
- Le Duan/Nguyen Khuyen and Le Duan/Tham Tien on the Le Duan Corridor to NR1A(S);

- O Cho Dua on the Tay Son Corridor at the First Ring Road (1RR);
- The Tran Quang Khai/Long Bien Bridge and Tran Quang Khai/Chuong Duong Bridge.

(2) Future Railway Network

Vietnamese National Railway (VNR) has links from Hanoi to major regional centres of the whole country such as Hai Phong (102 km), Ho Chi Minh City (1,726 km), Thai Nguyen (75 km), Lang Son (148 km) and Lao Cai (283 km). Also, there are 11 stations in Hanoi City.

The future railway development plan for the development target year 2020 was carried out by Vietnam National Railway Authority. The planned railway network consists of an outer-ring and a radial pattern from the center of Hanoi City. Problems related with SHTRR are as follows:

Existing railway along the NH1 between Giap Bat and Gia Lam station is to be improved by elevated system to prevent traffic congestion. However, SHTRR is not involved as the elevated system is adapted 1.2 km away from the intersection between it and the railway, though it is necessary for architecture clearance to take double-deck trucks and electrification into consideration for the plan.

The railway planned parallel to SHTRR between Thanh Tri Dyke and Gia Lam Dyke is shifted to the north-east from Gia Lam Dyke, therefore it is therefore not necessary for SHTRR alignment to take railway location into consideration.

Existing railway along NH5 will be removed to the southern side of Duong Bridge in the future. Therefore, existing railway will not be improved.

(3) Regulating Reservoir and Park Development Plan in Yen So area

A regulating reservoir to control flooding in the area north of Thanh Tri Dyke is planned at 800m (3.2 ha) along the Phap Van road from NH1. The Hanoi Planning Institute under the Hanoi People's Committee is implementing the project, the target year for completion being 2002.

The regulating reservoir area is divided into a north area and south area. There are two lakes in the north area and three in the south area. The north area and the south area are

connected by channels and underpasses for pedestrian. In addition, this area is developed as Yen So Recreational Park area.
It is necessary for SHTRR alignment to be planned so as to be effective for the regulating reservoir facilities. The Regulating Reservoir plan is shown in Figure 2.1.1.

2.2 Present Condition of Right-of-way Acquisition

Present land-use configuration of the SHTRR roadside area includes paddy fields, ponds, industrial areas, monument, factories, densely inhabited residential areas, historical churches and graveyards; as shown in Table 2.2.1. Existing facilities crossing the SHTRR are local roads, footpaths, rivers, and waterways, including a drainage and an irrigation channel as shown in Table 2.2.1.

There are very many houses in the Thanh Tri area which is from National Highway No.1 to Thanh Tri Dyke and sufficient attention should be paid to the resettlement in this area. In the Red River area which is between Thanh Tri and Gia Lam Dykes there are few houses but the flood plain is used for cultivation and therefore land acquisition is still necessary for this area. Land use in the Gia Lam area from Gia Lam Dyke to National Highway No.5 is mostly rice field. There are some houses along National Highway No.5, so that a resettlement should be still considered in this area.

Table 2.2.1 Existing Crossing Facilities & Roadside Land Use (1)

Station(STA)	Crossing facilities	Roadside land use	Remark
0+000	National Highway No.1	Residential area &Commercial area	
0+510	Drainage cannel: B = 10.0m	Paddy field &pond	
0+600	Intersection of Planned Local road	Residential area & Commercial area	
0+760	Planned reservoir cannel	Paddy field &pond	
0+760 1+600	-	Planned reservoir area	
0+970	Local road: w=6.0m	Residential area	
1+690	River, length:l=53m	Residential area	
1+890	High voltage power line	Residential area	
1+960	High voltage power line	Residential area	
2+400	Waterway, w=10m	Residential area	
2+590	Footpath, w=5.0m	Residential area	
2+790	Local road, w=9.0m	Residential area	
3+080	PHAP VAN-CAUGIE ROAD B=7.0M	Residential area & Commercial area	
3+140	Footpath, w=2.5m	Residential area	

Note ; Intersection to NH1is the beginning point: STA =0+000 of SHTRR

Table 2.2.1 Existing Crossing Facilities & Roadside Land Use (2)

3+440	Local road, w=8.0m	Residential area	
3+530	Local road, w=6.0m	Paddy field & pond, graveyard	
3+900	Existing pond levee	Paddy field & pond	
3+960	Local road, w= 3.5m Waterway, w= 4.0m	Paddy field & pond	
4+110	Footpath, w=2.0m	Paddy field & pond	
4+150	Footpath, w=1.8m	Paddy field & pond	
4+200	Footpath, w= 2.0m	Paddy field & pond	
4+250	Footpath, w=2.0m	Paddy field & pond	
4+300	Footpath, w=2.5m	Paddy field & pond	
4+360	Footpath, w= 1.5m	Paddy field & pond	
4+420	Footpath, w=2.0m	Paddy field & pond	
4+470	Footpath, w=1.5m	Paddy field & pond	
4+500	Footpath, w=2.0m	Paddy field & pond	
4+550	Footpath, w=1.5m	Paddy field, pond & Pagoda	
4+680	Local road, w= 5.0m Waterway, w= 4.0m	Paddy field & pond	
4+880	Local road, w= 4.0m Waterway, w= 4.0m	Warehouse, school & planned chemical factory	
4+950	Local road, w= 3.0m	Residential area	
5+030	Local road, w= 3.0m	Residential area	
5+070	Local road, w= 5.0m	Residential area	
5+650	Local road, w= 8.5m Waterway, w= 1.5m	Residential area	
6+170	Local road, w= 3.0m	Linh Namn monument, cement concrete factory & field	
6+590	Local road, w=14.0m	Field	dyke
8+950	Local road, w= 6.0m	Residential area	dyke
9+190	Local road, w= 4.0m	Residential area	
9+240	Local road, w= 4.0m	Residential area	
9+370	Footpath, w= 1.5m Waterway, w= 3.0m	Paddy field	
9+530	Footpath, w= 1.0m Waterway, w= 1.0m	Paddy field	
9+900	Footpath, w=1.5m	Residential area	
10+300	Footpath, w=1.0m Waterway, w= 1.0m	Paddy field	
10+520	Local road, w= 5.0m Waterway, w= 5.0m	Residential area	
10+600	Local road, w= 5.0m	Residential area	
10+700	Footpath, w= 1.0m Waterway, w= 3.0m	Paddy field	
10+920	Footpath, w=1.0m Waterway, w= 3.0m	Paddy field	
11+010	Footpath, w= 1.0m Waterway, w= 1.5m	Paddy field	
11+230	Footpath, w=1.0m Waterway, w= 2.0m	Paddy field	

Note ; Intersection with NH1 is the beginning point: STA=0+000 of SHTRR

Table 2.2.1 Existing Crossing Facilities & Roadside Land Use (3)

11+440	Footpath, w= 5.0m Waterway, w= 6.0m	Paddy field	
11+550	River, w=50.0m Pd road, w= 2.0m Waterway, w= 5.0m	Paddy field	
11+600	Footpath, w= 1.0m Waterway, w= 5.0m	Paddy field	
11+820	Waterway, w= 5.0m	Paddy field	
12+060	Waterway, w= 3.0m Footpath, w=3.0m	Paddy field	
12+180	National highway No.5	Residential area & commercial area	
12+320	Footpath, w= 4.0m Waterway, w= 7.0m	Paddy field	
12+580	Footpath, w= 3.0m Waterway, w= 5.0m	Paddy field	

Note ; Intersection with NH1 is the beginning point: STA=0+000 of SHTRR

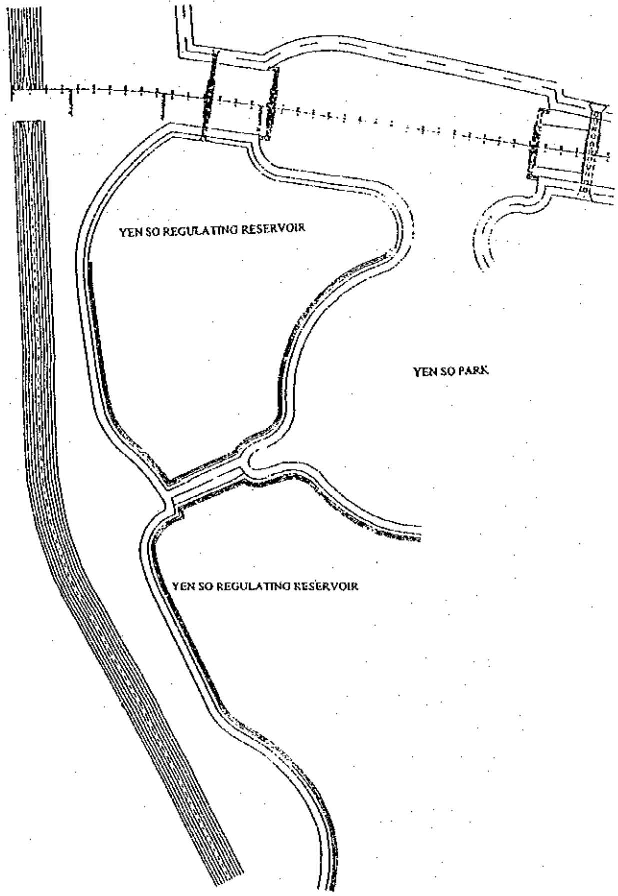


Figure 2.2.1 Regulating Reservoir Plan

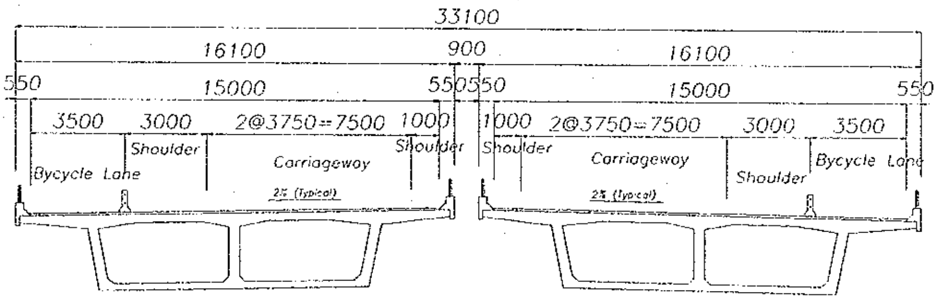
2.3 Construction Scheme for the Red River Bridge

Regarding the construction scheme for the Red River Bridge, following scheme was recommended in the Feasibility Study.

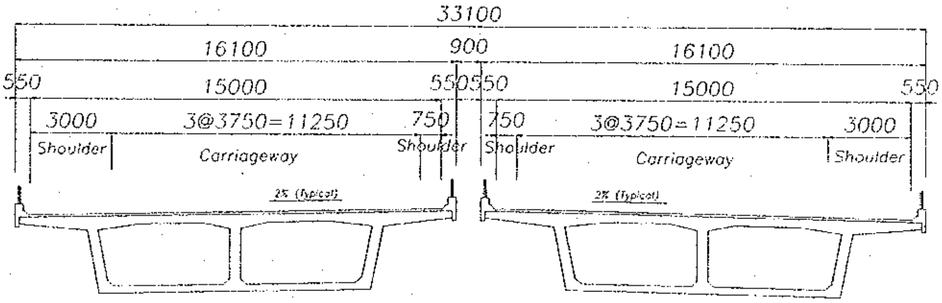
☐ Such a stage construction scheme as widening from four lanes to six lanes in due time will entail diverse technical difficulties when applied to the Red River Bridge. Therefore it is recommendable to provide whole six-lane width in the initial and single construction stage.

The Detailed Design was carried out for the construction of required facilities which were proposed for the target year of 2010. Concerning the number of road lanes, the traffic capacity of 4-lane road will satisfy the requirements for the traffic volume in the year 2010, however in the year 2020, 6 lanes will be required as explained in Chapter 5. Therefore the same construction scheme as in the Feasibility Study was adopted in the Detailed Design.

Operation of road lanes was considered as shown in Figure 2.3.1.



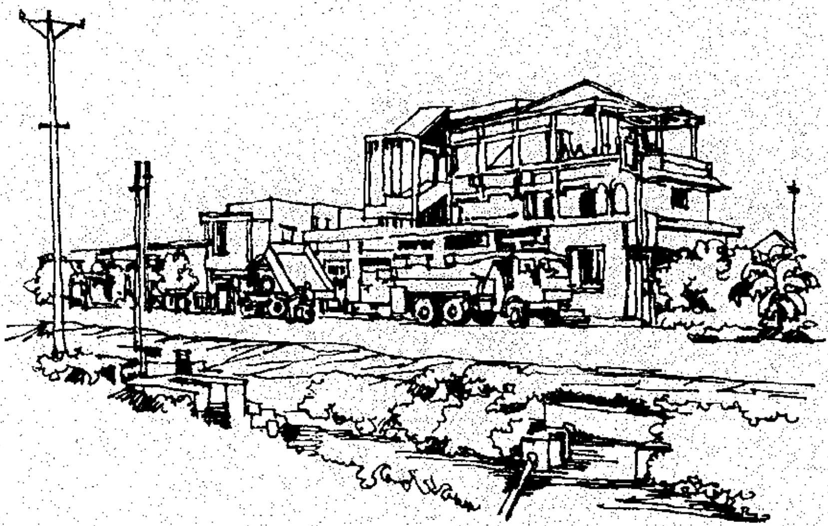
(a) 4-lane Operation



(b) 6-lane Operation

Figure 2.3.1 Road Lane Operation of the Red River Bridge

CHAPTER 3 PHYSICAL CONDITIONS SURVEY



CHAPTER 3 PHYSICAL CONDITIONS SURVEY

3.1 Physical Conditions of Study Area

3.1.1 Topography

The topography is favorable throughout the entire Project Site. Flat land spreads out over the Red River delta with elevations of under 10 m. The open area is mainly utilized for rice cultivation.

3.1.2 Geology

Geologically, the flat terrain in the Red River delta area is of alluvium or diluvium formation of Holocene or Pleistocene Ages, composed of alluvial or diluvial soils of gravel, sand, loam, silt, and clay.

3.1.3 Climate

Annual average rainfall in Hanoi is about 1,700 mm, of 80 - 85 % of which falls in the rainy season. The annual average number of rainy days is 140. Annual average temperature in Hanoi is 23.6 °C with a minimum of 4 °C and maximum of 39.4 °C ; mean humidity is 82 %.

3.2 Topographic Survey

3.2.1 General

The topography in the project area was surveyed by dividing the area into three sections: the Thanh Tri side, the Red River Bridge section and the Gia Lam side. The project area in the Thanh Tri side and the Gia Lam side are flat with a ground level of about +5.0 m in the residential area and about +3.0 to +4.0 m. among the paddy fields and fish ponds. On the Thanh Tri side, the ground level is about +4.0 m. On the Gia Lam side, the flood plain area is rather flat with a comparatively low ground elevation of less than +4.0 m. The riverbed along the centerline has the deepest point at about -3.0 m. The flood plain area is mainly used for the cultivation of corn.

3.2.2 Purpose of the Survey

The purpose of the survey was mainly to obtain the topographical data for the detailed design of the project.

3.2.3 Scope of the Survey

(1) Stage 1: Location Survey
- Primary control survey
- Secondary control survey
- Leveling
- Mapping

(2) Stage 2: Detailed Survey
- Centerline survey
- Profile survey
- Cross- section survey
- River bed survey

The surveyed areas in each section are shown in the following table:

Section No	Section No. I	Section No. II	Section No. III	
	Thanh Tri side	Bridge section	Gia Lam side	Total
Surveyed area	140 ha	50 ha	80 ha	270 ha
	Housing, mostly ponds and paddy fields	Red River	Housing, mostly paddy fields	

3.2.4 Basic Datum

The following basic datum are applied for the survey.

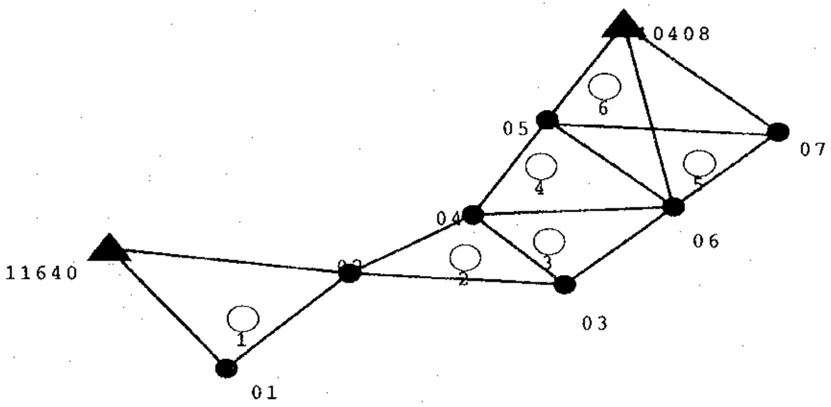
- Projection : Gauss-Kruger Grib System
- Scale factor : 1.000 on the central meridial
- Ellipsoid : Kva sowskian
- Vertical datum : Mean sea level at t/m Dau island
- Horizontal datum : HN - 72 (National bench mark system)
- Symbols of topographical map : VN -Standard

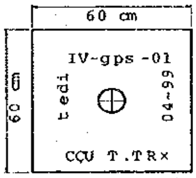
3.2.5 Survey Method

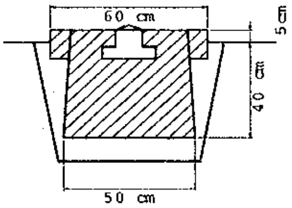
(1) Primary Control Survey

The primary control survey was performed based on the Global Positioning System (GPS). After completion of the field work, the primary control survey for seven (7) new GPS points was established in each section. The configuration of the ground network for the project is referred to the "Network Configuration".

The observations using GPS receivers were linked with the national triangulation points by the differential positioning and simultaneous observation. Furthermore, the observed data on the World Geodetic System (WGS-84) ellipsoid and geographic coordinates (B,L,H) were also computed and adjusted with the final transfer to the national coordinates system in Vietnam. A permanent concrete monument, 60 cm x 60 cm x 40 cm, set in a concrete foundation, was placed for each primary control point.





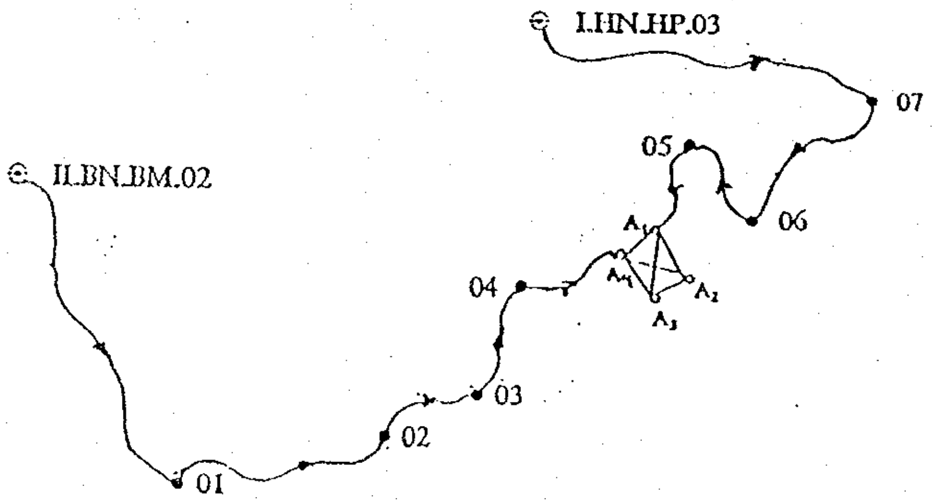


(2) Secondary Control Survey

The secondary control survey was carried out by applying the traverse survey method with the total station instrument SET ZB in order to provide the reference points for the forthcoming topographical survey and the construction of the project bridges. The same concrete monuments and foundations, as mentioned above, for the primary control points (together with bench mark) were used for the secondary control points.

(3) Leveling

A leveling loop was established, starting from the bench mark network connecting the local geological height to the control point, GPS 01-07. The leveling scheme is referred to as the "Leveling Loop".



Leveling loop

(4) Mapping

The mapping methods were conducted by a total station system which used the "Auto Cad" program for the mapping of the topography.

The mapping area included the surrounding areas of the existing bridges, the possible realigned approach roads and the proposed project bridges. A scale of 1:500 or 1:1,000 was adapted for the mapping. The symbols used for the mapping were mainly based on the Vietnam standard.

The mapping included the following additional or supplemental measurements on the existing bridges:

- Precise individual span length
- Dimension of riverbed survey

(5) Centerline Survey

a) Alignment Data

The horizontal alignment of the proposed roads was determined by the highway engineer and then handed over to the surveyors with the alignment data.

b) Plotting of the Alignment on the Ground

The plotting of the proposed centerline of the expressway on the ground (i.e.: setting out) has been carried out.

i) Thanh Tri Side

Beginning Point (STA 0+000) was set on the centerline of the existing National Highway No. 1.
There are 5 IPs in this highway section and centerline setting was carried out together with the establishment of two GPS monuments.

- IP-1 Curve radius = 1,300 m
- IP-2 Curve radius = 1,200 m
- IP-3 Curve radius = 900 m

- IP-4 Curve radius = 900 m
- IP-5 Curve radius = 1,000 m
- GPS 01 and 02 (concrete monuments).

ii) Red River Bridge Section:

Two reference points (concrete monuments, CC-1 and CC-2) have been set on the straight centerline of Red River Bridge. Thanh Tri side centerline point (CC-1) and Gia Lam side centerline point (CC-2) are set on the top of Dykes.

- CC-1 Thanh Tri side
- CC-2 Gia Lam side
- GPS 03 and 04 (concrete monuments) are set on the existing stone masonry wall of Thanh Tri side dyke.

iii) Gia Lam Side

There are three IPs in this highway section

- IP-6 Curve radius = 5,000 m
- IP-7 Curve radius = 1,900 m
- IP-8 Curve radius = 1,000 m
- The end point is set on the centerline of the National Highway No. 1 (Duong Bridge site) under construction.

The above mentioned markers were set with steel bar Ø 12 mm x 30 cm long or permanent concrete monuments.

c) Abbreviations and Symbols Used in the Centerline Survey (Principle Points)

The abbreviations and symbols used in the curve setting are based on the AASHTO standard as follows:

- BP : Beginning point of construction limit
- EP : End point of construction limit
- TS : Tangent to spiral (clothoid) curve

- SC : Spiral (clothoid) to circular curve
- CS : Circular Curve to spiral (clothoid) curve
- ST : Spiral (clothoid) curve to tangent
- PC : Point of curve (beginning of simple curve)
- PT : Point of tangent (end of simple curve)
- IP : Intersection point

d) Bridge Markers

The bridge markers were established on a suitable line at both ends of each proposed bridge in accordance with the Vietnamese Specification (refer to the following subsection).

e) Materials Used for Marking of Monuments and Pegs

Principle and chainage points are marked by using the following materials:

- Intersection point(IP) : Concrete with steel bar or nail
- Bridge marker (Br.M) : Same as above
- Other principle points : Wooden peg protected by concrete or nail
- Chainage points : Wooden peg or nail (20m on center)

(6) Profile Survey

The profile survey along the proposed highway centerline was carried out within the construction limit with extension of 500m from the beginning and end points. The profile survey was linked with the control points and the seven (7) GPS bench marks chainage points and additional ground levels along the proposed centerline were also taken.

Profiles were prepared to the following scales:

- Horizontal scale : 1:500 or 1:1,000
- Vertical scale : 1:100 or 1:200

(7) Cross-section Survey

The elevation to prepare cross-sections along the centerline was calculated using a computer system. Elevation data were obtained from the three- dimensional elements (x,y,z) which had been computed based on the spot heights of the prepared topographic maps.

The scales of cross-section were:

- Horizontal scale : 1:200
- Vertical scale : 1:200

(8) Riverbed Survey

The cross-sections of the riverbed were taken at the proposed bridge site. In general, the survey locations were at the upstream and downstream sides paralleled to the proposed bridge centerline, approximately 100 m on either side.
The scales of riverbed cross- sections were as follows:

- Horizontal scale : 1:200
- Vertical scale : 1:200

3.3 Soil and Material Investigations

The soil and material investigations mostly consist of site reconnaissance, analysis of soft soil layer and detailed design. The field investigation and laboratory test were carried out by a Vietnamese consulting firm. The analysis of soft soil layer was calculated consolidation settlement and ground stability. The detailed design is implemented mainly recommendation of comprehensive pretreatment for soft soil, subsidiary works for pretreatment and prevention works for stability.

This detailed design report concerning soil and material investigations is made based on the investigations reports which was submitted from the Vietnamese consulting firm and another investigation report on the Feasibility Study stage partially.

The detailed design report was also described concerning soil and material matters which include site reconnaisance, general evaluation of stratification, geotechnical conditions of foundations relating structure and embankment, materials, consolidation settlement and ground stability for soft soil layer, recommendation of comprehensive pretreatment for soft soil, recommendation of pretreatment method, method of subsidiary works for pretreatment and method of prevention works for stability.

3.3.1 Purpose of Soil and Material Investigations

The purpose of the soil investigation is to obtain engineering design data for the geotechnical matters which include bearing strata for structure, embankment foundation, settlement and stability analysis of soft soil layer.

The purpose of the material investigation is to obtain engineering design data on the material for embankment which include soil and quarry materials, water for making concrete and ready- mixed concrete.

3.3.2 Scope of Site Reconnaissance

(1) Soil Investigation

The site reconnaissance of soil investigation consists of field investigations along the proposed route and laboratory tests of the collected samples.

The field investigations mainly dealt with borehole drilling with standard penetration test (SPT) and static cone penetration tests (SCPT). Borehole drilling was carried out at 33 locations and SCPT was carried out 47 locations. All boreholes were taken to 50 meters in depth with standard penetration test at 1-meter intervals. All static cone penetration tests were carried out every 0.2 m up to 20 meters in depth.

The quantities of borehole drilling and SCPT are shown in Appendix 3.3.1 and 3.3.2 respectively. The locations with national co-ordinates of borehole drilling and SCPT are shown in Appendix 3.3.3 and 3.3.4 respectively. The location maps of borehole drilling and SCPT are shown in Appendix 3.3.5.

Twelve boreholes were conducted for the road section of Thanh Tri side, five boreholes for the road section of Gia Lam side and sixteen boreholes for the bridge section respectively.

The static cone penetration tests were carried out at 35 locations along the road section on the Thanh Tri side and at 12 locations along the road section on the Gia Lam side.

Pressuremeter tests (lateral loading test in borehole) were carried out at four boreholes in bridge section at depth of 5 m and 15 m from the ground. The locations of pressuremeter tests are shown in Appendix 3.3.6.

Laboratory tests required that undisturbed samples be obtained from the boreholes. The tests include natural water content test, specific gravity test, wet density test, grain size analysis with hydrometer, liquid and plastic limit test on the plasticity index, unconsolidated-undrained triaxial compression test, consolidation test, and permeability of saturation test.

Undisturbed samples and laboratory testing of physical properties and mechanical properties are shown in Appendix 3.3.7.

(2) Material Investigation

The site reconnaissance of material investigation consists of field sampling and laboratory tests on the collected samples.

The field sampling mainly dealt with soil and quarry material, water for making concrete and ready-mixed concrete.

Samples on soil materials, quarry materials, water for making concrete and ready mixed concrete were shown in Appendix 3.3.8, Appendix 3.3.9, Appendix 3.3.10 and Appendix 3.3.11 respectively.

The laboratory tests on soil material included sieve analysis, compaction test and California bearing ratio test. The laboratory tests on quarry material included sieve analysis, abrasion resistance test, chloride content test and alkali-silica reactivity test. The laboratory tests on water for making concrete included pH test and chloride content test. The laboratory test of ready-mixed concrete carried out compression test.

3.3.3 Result of Site Reconnaissance

Geological analysis and geological evaluation of stratification is based on a report on geotechnical investigation which had been submitted from a Vietnamese consulting firm at the detailed design (D/D) stage.

(1) Geology

The study area is located in the southeastern part of Hanoi, is located in the Red River Delta. Geologically, the Red River Delta is composed of Quaternary formations which consist of Alluvium (Holocene Age) and Diluvium (Pleistocene Age).

The alluvial soils of the Red River Delta are bright red-brown in color, with medium clay content (20 to 25 %) and an appropriate proportion of silt, about 50 % in the form of grains 0.05 to 0.001 mm in size.
Alluvium deposits are mainly composed of top soil, cohesive soil and sandy soil. Diluvium deposits are mainly composed cohesive soil, sandy soil and gravelly soil.

(2) Geological Division in the Study Area

The study area is divided into the following sections based on the viewpoint of the geotechnical engineering and road engineering.

- Road section on Thanh Tri side; STA: 0-375 - 6+218
- Bridge section; STA: 6+218- 9+302
- Road section on Gia Lam side; STA: 9+302- 12+832

The road section on the Thanh Tri side is located approximately from National Highway No. 1 to the west side (Hanoi side) of the Red River dike. The road section of Gia Lam side is located approximately from the east side (Gia Lam side) of the Red River dike to National Highway No. 5. The bridge section is located between the above two road sections.

Soil profiles along the planned center line described on the investigation report which had been submitted from the Vietnamese consulting firm are shown in Appendix 3.3.12.

The report described the stratification into eight main layers.

(3) General Evaluation of Stratification

Layer 1: This layer was divided into two sub-layers as follows:

Sub-layer 1a: Filling soil, medium-stiff to stiff.
This layer was found on the ground surface with a discontinuous distribution at high area (dykes, bank of rivers - canals). The thickness of this layer ranges from 10 (Gia Lam dyke) to 0.5 m (BH-R4).

Sub-layer 1b: Cultivated land, in some places muddy soil of bed of lakes - canals - ponds, soft to very soft, dark brown.
It is distributed sporadically along the alignment. The thickness of this layer is very thin.

Layer 2: Medium-stiff to stiff lean clay, in some places sandy clay, silty clay (especially, in borehole BH-B15, very soft). The color is dark gray, brownish gray in some places yellowish gray, whitish gray. This layer was found under Layer 1, in some places on the ground surface with sporadic distribution.

Along the road section on the Thanh Tri side, its thickness ranges from 7.4 m (SCPT30) to 1.9 m (BH-R3). At borehole BH-R4, the thickness is 9.3 m; a special case.
Along the road bridge section, the thickness ranges from 7.6 m (BH-B15) to 2.0 m (BH-B5).
Along the road section Gia Lam side, its thickness ranges from 7.6 m (SCPT46) to 2.4 m (SCPT 40).

According to the results that were obtained from SPTs and laboratory soil tests, the characteristics of this layer are as follows:
The SPT value is 0 to 11, with an average of 7.
The compression index is 0.12 to 0.30.
The coefficient of consolidation is 0.99 x 10-3 to 9.34 x 10-3 cm^2/s
The coefficient of permeability is 0.21 x 10-7 to 1.95 x 10-7 cm/s.
The coefficient of compressibility is 0.35 x 10-1 to 0.87 x 10-1 cm^2/kg

Layer 3: Very loose to medium-dense silty fine sand, in some places fine to medium sand with silt, low to no plasticity. The color of this layer is dark gray, brownish gray.

This layer was encountered in all boreholes at the main bridge section (except borehole BH-B16) and in four boreholes at Thanh Tri side (BH-R11, BH-R12, BH-B1, BH-B2). It lies under Layer 2 and in some places under Layer 1 or on the ground surface. The elevation of the top of this layer ranges from 7.58 m (BH-B13) to -3.42 m (BH-B9) and the bottom elevation ranges from -0.96 m (SCPT 35) to -20.81 m (BH-B10). Its thickness ranges from 23.3 m (BH-B12) to 1.08 m (SCPT 35) at an average of 13.0 m.
The N values range from 1 to 21, with an average of.

Layer 4: Clay, in some places clay with organic matter, intermediate to high plasticity. The color is dark gray, brownish gray.

This layer was found along the road section on the Thanh Tri side and the road section on the Gia Lam side (not along main bridge section). It lies under Layer 1, Layer 2, and in some places directly on the ground surface.

Along the Thanh Tri section, its state is very soft to soft and along the Gia Lam section, its state is very soft to medium-stiff.
Along the road section on the Thanh Tri side, this layer is distributed continuously. From 0+184.5 km to 3+550 km, 3+800 km to 4+500 km, 4+650 km to 4+800 km, 4+900 km to 5+050 km, the thickness of this layer ranges from 30.5 m (BH-R8) to 13.6 m (SCPT10, SCPT 12) with an average thickness of 19.0 m and at other areas, the thickness of this layer is very thin (about 1.60 m to 2.60 m). The elevation of bottom of layer ranges from
-1.15 m (SCPT 27) to -27.31 m (BH-R8).

According to the results that were obtained from SPTs and laboratory soil tests, the characteristics of this layer are follows:
The SPT value is 0 to 3 blows.
Compression index is 0.31 to 0.73.
The coefficient of consolidation is 0.57×10^{-3} to 2.11×10^{-3} cm^2/s.
The coefficient of permeability is 0.46×10^{-7} to 1.01×10^{-7} cm/s.
The coefficient of compressibility is 0.90×10^{-1} to 1.77×10^{-1} cm^2/kg.

Along the road section on the Gia Lam side: it is distributed continuously. The thickness of this layer is rather small, from 5.50 m (BH-R15) to 2.20 m (SCPT 42). Especially, in the three SCPT locations (SCPT 38, SCPT 39, SCPT 41), the thickness of layers are rather high (from -11.4 m to 11.60 m). The elevation of layer ranges from -12.2 m (SCPT 39) to +2.3 m (BH-R16).

According to the results that were obtained from SPTs and laboratory soil tests, the characteristics of this layer are as follows:
The SPT value is 1 to 4 blows.
Compression index is 0.11 to 0.56.
The coefficient of consolidation is 0.34×10^{-3} to 1.77×10^{-3} cm^2/s.
The coefficient of permeability is 0.24×10^{-7} to 0.27×10^{-7} cm/s.
The coefficient of compressibility is 0.32×10^{-1} to 1.62×10^{-1} cm^2/kg.

Layer 5: Medium-stiff to stiff SANDY LEAN CLAY, LEAN CLAY, low to intermediate plasticity. The color of this layer is dark gray- brownish gray.

Along the road section on the Thanh Tri Side, it was found in almost all boreholes (except boreholes BH-R8, BH-R11, BH- R12) with the thickness ranges from 19.3 m (BH-R3) to 2.8 m (BH-R4). The elevation of top of this layer ranges from -7.10 m (BH-R3) to -22.39 m (BH-R4). The elevation of bottom layer ranges from -25.19 m (BH-R4) to -27.93 m (BH-R5). In this layer, in some places there is alternation of lenses (Clay, soft, silty fine sand, medium dense).

According to results that were obtained from SPTs and laboratory soil tests, the characteristics of this layer are as follows:
The SPT value is 4 to 13, 7 on average.
Compression index is 0.11 to 0.25.
The coefficient of consolidation is 1.89 x 10^{-3} to 4.23 x 10^{-3} cm^2/s
The coefficient of permeability is 0.51 x 10^{-7} to 0.79 x 10^{-7} cm/s.
The coefficient of compressibility is 0.32 x 10^{-1} to 0.73 x 10^{-1} cm^2/kg.

Along the road section on the Gia Lam side, this layer was found in boreholes BH-R13, BH-R14, BH- R15 with the thickness ranges from 9.40 m (SCPT 47) to 3.00 m (SCPT-46). The top elevation of layer ranges from 1.0 m (BH-R16) to -12.20 m (SCPT 39). The bottom elevation of layer ranges from -7.20 m(BH-R16) to -5.56 m (SCPT 37).

The q_c value ranges from 10 to 48 kg/cm^2, 22 on average.
According to the results that were obtained from the SPTs and laboratory soil test, the characteristics of this layer are as follows:
The SPT value is 5 to 11, which is 7 on average.
Compression index is 0.10 to 0.11.
The coefficient of consolidation is 1.09 x 10^{-3} to 7.28 x 10^{-3} cm^2/s.
The coefficient of permeability is 0.21 x 10^{-7} to 1.36 x 10^{-7} cm/s.
The coefficient of compressibility is 0.29 x 10^{-1} to 0.32 x 10^{-1} cm^2/kg.

Along the main bridge section, this layer was found in two boreholes; BH-R15 and BH-R16. The thickness of this layer is 11.5 m on average and ranges from 8.60 m (BH-B15) to 14.40 m (BH-B16). The top elevation of this layer ranges from -0.75 m (BH-R15) to -10.37 m (BH-B16).

The SPT value is 5 to 20, 9 on average.
Compression index is 0.09.
The coefficient of consolidation is 1.33×10^{-3} to 2.37×10^{-3} cm^2/s.
The coefficient of permeability is 0.20×10^{-7} to 0.35×10^{-7} cm/s.
The coefficient of compressibility is 0.26×10^{-1} cm^2/kg.

Layer 6: Stiff to very stiff clay, in some places lean clay with sand, intermediate plasticity. The color is brownish gray, greenish, gray, yellowish gray.

This layer was encountered in almost all boreholes along the road section Thanh Tri side (except boreholes BH-R11, BH-R12) and two boreholes along the road section Gia Lam side (BH-R16, BH-R17). It is not found along the main bridge section.

Layer 6 lies under Layer 5 (except in borehole BH-R7, where it lied under the layer 4) and upper of the layer 7. The N-value ranges from 9 to 21, 11 on average.

Along the road section on the Thanh Tri side, the top of elevation of this layer ranges from -25.19 m (BH-R4) to -30.54 m (BH-R10) and the bottom elevation of layer ranges from -31.50 m (BH-R9) to -33.79 m (BH-R6). The thickness of layer ranges from 6.40 m (BH-R4) to 1.70 m (BH-R9), 4.30 m on average.

According to the results that were obtained from SPT and laboratory tests, the characteristics of this layer one as follows:
The SPT value is 9 to 26, which is 17 on average.
Compression index is 0.06 to 0.22.
The coefficient of consolidation is 2.38×10^{-3} to 9.14×10^{-3} cm^2/s.
The coefficient of permeability is 0.32×10^{-7} to 1.73×10^{-7} cm/s.
The coefficient of compressibility is 0.17×10^{-1} to 0.64×10^{-1} cm^2/kg.

Along the road section on the Gia Lam side, this layer was found in two boreholes (BH-R16 and BH-R17). The thickness of this layer ranges from 5.50 m (BH-R16) to -6.70 m (BH- R17). The top elevation of the layer ranges from -7.20 m (BH-R16) to -6.23 m (BH-R17).

The N value ranges from 11 to 28, 18 on average.

Layer 7: This layer is an alternation of medium-dense to very dense silty fine sand, fine to medium sand with silt in some places mixed with small gravel and intercalation with some lenses of clay, zero to low plasticity. The color of this layer is gray, yellowish gray, brownish gray, pinkish gray, whitish gray. This layer was encountered in all of boreholes of the study area.

Along the road section on the Thanh Tri side, the top elevation of layer ranges from -0.03 m (SCPT 21) to -33.79 m (BH-R6), especially at area near main bridge section, the top elevation of layer is from -2.31 m (BH-B1) to -17.3 m (BH-R12). The bottom elevation of layer ranges from -33.50 m (BH-R12) to -42.07 m (BH-B2). The thickness of the layer ranges from 9 to 31, 20 on average.

Along the main bridge section, the top elevation of the layer ranges from -6.92 m (BH-B4) to -20.81 m (BH-B10) and the bottom elevation of the layer ranges from -26.25 m (BH-B14) to -39.72 m (BH-B9). The thickness of the layer ranges from 20.30 m (BH-R16) to 10.6 m (BH-B12), 21.00 m on average.
The N value ranges from 10 to 48, 22 on average.

The road section Gia Lam side, the top elevation of layer ranges from -3.85 m (SCPT 44) to -15.60 m (SCPT 39) and the bottom elevation of layer ranges from -33.0 m (BH-R16) to -38.59 m (BH-B13). The thickness of layer ranges from 20.30 m (BH-R16) to 26.60 m (BH-R13) which is 24.50 on average.
The N value ranges from 5 to 56, 25 on average.

Layer 8: Very dense gravel with sand, in some places coarse sand with gravel, no plasticity, the color is whitish gray, yellowish gray, gray.

Layer 8 is distributed over all of the study area. The top of elevation of this layer ranges from -26.25 m (BH-B14) to -42.17 m (BH-B16).

The thickness of layer is more than 5.0 m (except borehole BH-B6, BH-B1, BH-B2, BH-B4).

1) Road Section of Thanh Tri Side

Based on the data of this investigation and the borehole drilling log, the soft soil layer of under 5 N-value was found to depths of 0 to -33 m and the bearing layer 50 N-value or over was found at depths of -39 to -44 m, within the road section of Thanh Tri side.

The results of standard penetration tests in the road section of Thanh Tri side are shown in Table 3.3.1.

Table 3.3.1 Result of SPT in the Road Section of Thanh Tri Side

Name of borehole	STA	Elevation of borehole	0≤N-value≤4 (depth)	50≤N-value (depth)
BH-R1	0-184.5	4.83	0m to -19m	-43m
BH-R2	0+020	5.60	-2m to -27m	-44m
BH-R3	0+116.15	6.40	-4m to -26m	-43m
BH-R4	0+371	6.31	0m to -27m	-43m
BH-R5	0+540	3.67	-2m to -21m	-40m
BH-R4b	0+600	3.52	0m to –20m	-41m
BH-R7	0+720	3.16	0m to –13m	-41m
BH-R6	0+930	3.21	0m to -26m	-40m
BH-R8	1+100	4.99	0m to -31m	-41m
BH-R9	1+660	4.00	-4m to -18m	-39m
BH-R10	1+720	5.46	0m to –33m	-41m
BH-R11	5+608.63	5.53	-14m to -15m	-41m
BH-R12	5+676.1	6.20	-17m to -23m	-40m

2) Road Section of Gia Lam Side

Based on the data of this investigation and the borehole drilling log, the soft soil layer of under 5 N-value was found to depths of 0 to -9 m and the bearing layer 50 N-value or over was found at depths of -36 to -42 m, within the road section of Gia Lam side.

The tentative results of standard penetration tests in the road section of Gia Lam side are shown in Table 3.3.2.

Table 3.3.2 Result of SPT in the Road Section of Gia Lam Side

Name of borehole	STA	Elevation of borehole	0≤N-value≤4 (depth)	50≤N-value (depth)
BH-R13	11+400	3.91	0m to -8m	-42m
BH-R14	11+590	3.75	0m to -9m	-36m
BH-R15	11+930	2.90	0m to -6m	-40m
BH-R16	12+210	3.80	0m to -9m	-31m
BH-R17	12+380	3.77	0m to -3m	-39m

3) Bridge Section

Based on the data of the soil investigation and the borehole drilling log, the soft soil layer of under 5 N-value was found to depths of 0 to -12 m and the bearing layer 50 N-value or over was found at the depth of -32 to -54 m, within the bridge section.

The tentative results of standard penetration tests in the bridge section, are shown in Table 3.3.3.

Table 3.3.3 Result of SPT in the Bridge Section

Borehole No.	STA	Elevation of borehole	0≤N-value≤4	50≤N-value
BH-B2	6+240	5.53	not found	-48m
BH-B1	6+340	5.69	0m to -3m	-47m
BH-B4	6+810	6.68	not found	more than -50m
BH-B5	6+960	6.02	-2m to -4m	-46m
BH-B6	7+160	9.37	not found	-54m
BH-B7	7+340	6.49	0m to -4m	-41m
BH-B8	7+470	0.02	0m to -12m	-36m
BH-B9	7+730	-3.42	0m to -10m	-41m
BH-B10	7+860	-1.81	0m to -6m	-36m
BH-B11	8+040	9.24	-3m to -8m	-44m
BH-B12	8+380	4.21	not found	-36m
BH-B13	8+540	8.78	-2m to -4m	-42m
BH-B14	8+720	5.05	0m to -8m	-32m
BH-B15	8+880	6.85	0m to -7m	-41m
BH-B16	9+070	4.03	not found	-47m

(4) Results of Laboratory Tests on Soil Samples

Results of laboratory tests of physical and mechanical properties on soil samples are shown in Appendix 3.3.13 and Appendix 3.3.14, respectively.

(5) Results of Laboratory Tests on Material Samples

Results of laboratory tests on soil material, quarry material, water for making concrete and ready mixed concrete are shown in Appendix 3.3.15, Appendix 3.3.16 Appendix 3.3.17 and Appendix 3.3.18, respectively.

3.3.4 Geotechnical Conditions Relating to the Bridge Foundation Design

Geotechnical conditions relating to the bridge foundation can be applied to foundations of other important structures. Generally, it is sufficient that a bearing strata has not less than 50 N-value. Based on the data of the soil investigation and the borehole drilling log, the forecast strata which can be recommended as bearing layer for bridges is found at depths of -39 to -44 m within the road section of Thanh Tri side; at depths of -36 to -43 m within the road section of Gia Lam side; and at the depth of -33 to -54 m within the bridge section. These are non-cohesive and low-deformation soil layers which are called gravelly sand or sandy gravel.

The forecast bearing layer is located deep underground and it is recommended that the bridge foundations are made with pile foundation on this layer.
The forecasted depth of the bearing layers are shown in Table 3.3.4.

Table 3.3.4 Forecasted Depth of Bearing Layers for Bridge

Section	Location (STA)		Depth of bearing layer top
Road section of Thanh Tri side	0-184.5	6+218	-39m to -44m
Bridge section	6+218	9+302	-32m to -54m
Road section of Gia Lam	9+302	12+832	-36m to –42m

Pressuremeter tests (lateral loading test) were carried out at four boreholes in the bridge section at depths of 5 m and 15 m. The results of pressuremeter tests are shown in Table 3.3.5.

Table 3.3.5 Result of Pressuremeter Tests

Name of Section	No.	Name of Borehole	Station	Elevation of Borehole	Depth of the test	Elevation of the test	Modulus of deformation (kPa)
Bridge Section	1	BH-B2	6+240	5.53	-5.5	0.03	1211
	2			5.53	-15.5	-9.97	4454
	3	BH-B8	7+470	0.02	-5.5	-5.48	281
	4			0.02	-15.5	-15.48	4602
	5	BH-B9	7+730	-3.42	-5.5	-8.92	697
	6			-3.42	-15.5	-18.92	4242
	7	BH-B14	8+720	5.05	-5.5	-0.45	510
	8			5.05	-15.5	-10.45	4479

3.3.5 Geotechnical Conditions Relating to the Embankment Foundation Design

Generally, the embankment foundation should be a layer of low deformation, such as sandy soil.

According to the data of the soil investigation borehole drilling log, a soft soil layer was found along the road sections. The soft soil layer was found to depths of 0 to -33 m along the road section on the Thanh Tri side, to depths of 0 to -12 m along the bridge section and to depths of 0 to -9 m along the road section on the Gia Lam side. These are cohesive and fairly compressible layers known as clay or lean clay.

The soft soil layer is located deep underground and the settlement and stability analyses are shown in other paragraphs based on the investigation report. The forecast depths of soft soil layers are shown in Table 3.3.6.

Table 3.3.6 Forecasted Depths of Soft Soil Layers

Section	Location (STA)		Depth of soft layer top	Depth of soft layer bottom
Road section of Thanh Tri side	0+000	6+214	0m to -17m	-13m to -33m
Bridge section	6+214	9+401	0m to -3m	-3m to -12m
Road section of Gia Lam side	9+401	12+388	0m	-3m to -9m

3.3.6 Materials

(1) Soil Materials

Soil materials were taken in four (4) sources, located on both sides of Red River. "Soil materials" indicate sand materials for the purposes of this report. In the results of laboratory tests of CBR, the CBR value is from 9.0 to 32.5 % in this stage and the value is from 11.5 to 21.5 % in the F/S stage.

The result of laboratory tests on soil materials are shown in Appendix 3.3.15.

1) Linh Nam Sand Pit

This is the quarrying site, near alignment of main bridge section (at the Thanh Tri side). The sand material is quarried by pumping from the bed of the Red River. In this sand pit, there are two pumping machines, each with a capacity 200 tons/hour. The quarrying, supply and transportation conditions are very convenient.

From the laboratory test results, some characteristics of this sand material are shown as follows:

Description: Poorly graded SAND, no plasticity, dark gray (SP).

The maximum dry density ranges from 1.58 to 1.59 t/m^3.

The optimum moisture content ranges from 17.5 to 18.0 %.

The California bearing ratio (CBR) ranges from 9 to 20 %.

2) Waterway Repair Enterprise Sand Pit

This sand pit is located near the main bridge section (on Thanh Tri side). The distance from the main bridge is about 1.5 km on the left. In this sand pit, there are two types of sand materials as follows:

Sand material is quarried by pumping from the bed of the Red River. Thus, its characteristics are similar to the Linh Nam sand pit.

Sand material is quarried by pumping from Lo river bed and transported to the waterway repair enterprise via the waterway. In this sand material type, two samples were taken for laboratory testing.

From the laboratory test results, some characteristics of this sand material source are shown as follows:

Description: Well graded SAND, no plasticity, yellow (SW).

The maximum dry density ranges from 1.80 to 1.81 t/m^3.

The optimum moisture content ranges from 12.0 to 12.2 %.

The California bearing ratio (CBR) ranges from 20.5 to 31.0 %.

The conditions for quarrying, supply and transportation are very convenient. The quantity of its sand is not precisely estimated but is sufficient for the project.

3) Duong Ha Sand Pit

This is located in Duong Ha - Gia Lam - Ha Noi and near Duong River. The distance from the Gia Lam side of the project is about 12.0 km. The sand material is quarried by pumping from the Duong River bed. There are three pumping machines, each with the capacity 150 tons/hour. The exploitation, supply and transportation conditions are very convenient. In this sand pit, four sand samples were taken for laboratory testing.

From the laboratory test results, this sand material shows the following characteristics:

Description: Poorly-graded SAND with silt, no plasticity, dark gray (SP-SM).

The maximum dry density ranges from 1.63 to 1.65 t/m^3.

The optimum moisture content ranges from 15.2 to 15.7 %.

The California bearing ratio (CBR) ranges from 11 to 21 %.

4) Anh Dinh Sand Pit

This sand pit is located in Conh Thon - Cau Duong - Gia Lam-Ha Noi and near Duong Ha sand pit. The distance from the project site is about 10 km. In this sand pit, there are two types of sand materials:

One type consists of sand material quarried by pumping from the Duong River bed. Thus, its characteristics are similar to the Duong Ha sand pit.

Another is sand material pumped from the Lo River bed and transported to the Anh Dinh sand pit by waterway. One sample of this sand material type was taken for the laboratory testing.

From laboratory test results, this sand material has shown the following characteristics:

Description: Well-graded SAND with gravel, no plasticity, greenish yellow (SW).

The maximum dry density is 1.84 t/m^3.

The optimum moisture content is 10 %.

The California bearing ratio (CBR) ranges from 20.5 to 32.5 %.

(2) Quarry Material.

Quarry materials were taken from two sources, namely Mieu Mon Quarry and Kien Khe Quarry.

The result of laboratory tests on quarry materials is shown in Appendix 3.3.16.

1) Mieu Mon Quarry

This quarry is located in Tan Vinh - Luong Son - Hoa Binh and managed by Thai Thinh Rock Enterprise. The distance from the project site is about 45 km (along the NH6). The rock is limestone, dark gray. In this quarry, there are five stone crushers each with a capacity of 100-200 m^3/day. Around this area, there are many small rock quarries which supply similar type of rock.
The volume of rock is ample.
In this quarry, five aggregate samples were taken for laboratory testing.
From laboratory test results, the rock of this quarry has shown the following characteristics:
Water-soluble chloride content ranges from 0.65 to 0.72 mg/g
Abrasion resistance ranges from 17.3 to 19.7 %
Alkali-Silica reactivity of aggregate:

- Dissolved Silica ranges from 5.0 to 6.0 mMol/l
- Reduction in alkalinity ranges from 100 to 170 mMol/l.

The exploitation and transportation conditions are very convenient.

2) Kien Khe Quarry

This quarry is located in Chau Son - Kim Bang - Phu Ly - Ha Nam (near But Son Cement Corporation) and managed by Phu Ly Rock Enterprise under Viet Nam Railway Union. The distance to the project site is about 67 km (along to the NH1). The rock is limestone, dark gray. In this quarry, there are four stone crushers each with a capacity of 200 tons/day. The volume of rock quarry is ample.
In this quarry, five aggregate samples were taken for laboratory testing.
From laboratory test results, the rock of this quarry has shown the following characteristics:

Water-soluble chloride content ranges from 0.68 to 0.71 mg/g
Abrasion resistance ranges from 17.6 to 20.0 %
Alkali-Silica reactivity of aggregate:

- Dissolved Silica ranges from 0.0 to 0.3 mMol/litter
- Reduction in alkalinity ranges from 270 to 300 mMol/litter

The quarrying and transportation conditions are very convenient.

(3) Water for Making Concrete

Ten (10) water samples were taken at six locations (Red River, ponds and lakes) to carry out pH tests and chloride content tests. The laboratory test result of pH value is 7.0 to 7.2 and of chloride contents value is approximately 10 to 67 mg/liter.

The results of laboratory tests of water for making concrete are shown in Appendix 3.3.17.

(4) Ready-mixed Concrete

Ten (10) ready-mixed concrete samples were taken to carry out compression tests. The testing cylinder was 30 cm in height and 15 cm in diameter. The type of cement used was Portland cement and quick strength Portland cement which was produced by CHINGFONG Factory.
The admixtures for ready-mixed concrete used SIKA NN or RHEOBUILD R716-MBT and the ratios used to cement are 1.5 % and 1.2 %, respectively.

The compression test result exceeded the target value by far.

The results of laboratory tests of ready-mixed concrete are shown in Appendix 3.3.18.

(5) Recommendation of Materials

All of the material locations which were sampled have very convenient conditions for quarrying and transportation to the project site. In addition, the quantities are large enough for construction of the project. According to the specifications of AASHTO, quality of material is sufficient, and can be used for project construction.

For construction of embankment on the Thanh Tri side, Linh Nam sand pit materials are recommended for use as filling (reference with the F/S stage, can add sand material from Bai Bac sand pit) and aggregate materials from two rock quarries as base, sub-base materials.
For construction of embankment on the Gia Lam side, Duong Ha sand pit materials are recommended for use as filling (reference with the F/S stage, can add sand material from Phu Dong sand pit) and aggregate materials from two rock quarries as base, sub-base materials.

For construction of bridges, making concrete and asphalt concrete, rock from above two quarries and sand (SW) from Anh Dinh and waterway repair enterprise sand pits should be used.

Above water samples can be used for making concrete, except for water samples from Red River, for which should be carried out more tests to determine other chemical properties before using.

3.3.7 Analysis of Soft Soil Layer

Calculation of consolidation settlement and ground stability were carried out by site reconnaissance data. But the actual construction process sometimes differs in calculation results. Therefore, observation of embankment management is required to ensure safety in construction of embankment.

(1) General Countermeasure Method for Soft Soil

Foundation strata settling and failure are caused when the load of embankment exceeds the bearing capacity of soft soil layer. Countermeasures for pre-treatment method against soft soil layers are classified as follows:

1) Replacement of soft soil layer
2) Consolidation by removal of excess pore water
3) Solid column by compaction
4) Chemical soil stabilization
5) Reinforcement

The outline of above methods are presented below:

1) Replacement of Soft Soil Layer

This method is applicable in places where the soft soil layer is shallow (2 m to 3 m). This is because all unsuitable soft layers are replaced with suitable sand or other material and this may be expensive when the method is applied to deep soft soil.

2) Consolidation by Drainage Water

This method is applicable to clay or organic soft soil, whose permeable coefficients are very low and the period of consolidation by natural drainage is very long. The principle of this method is to accelerate drainage from soil by a) application of surcharge load on the soft soil to increasing the pore water pressure and b) by inserting permeable material into soft soil layer vertically.

a) Pre-loading Method or Surcharge Method

By constructing an extra layer of temporary embankment on the soft soil layer, the pore water pressure in the soft soil and effective stress increase, which results in accelerating consolidation.

b) Vertical Drain Method

Vertical drain covers 3 major construction methods namely, sand drain, packed drain and fiber drain. The basis of all these methods is that permeable materials are inserted vertically into soft soil layer to accelerate consolidation by draining water from the clay soil by providing a short-cut vertical permeable column. Clay is a soil which has very low permeability and it takes time for water to be drained through the normal path. Inserting a vertical permeable material prepares a short-cut path for water and accelerates consolidation.

3) Solid Column by Compaction

Sand compaction pile is the represented method of this principle. Vibrated sand is inserted into the soft soil, forming sand columns which resist sliding and settlement.

4) Chemical Soil Stabilization

This is a method to form vertical columns in a soft soil layer by inserting chemical or thermo-chemical material. The mixture builds up solid columns by chemical reaction with water in the soil and the columns supporting the load of the embankment.

5) Reinforcement

By construction of concrete piles in a soft soil layer, the load of the embankment is transferred to the foundation of the soil. The top of the piles is connected by a grid of concrete slab and the slab distributes the load of embankment to the piles.

Sand drain, fiber drain (plastic board drain) and sand compaction pile foundation are the applicable methods in this study. The analysis of soft soil layer is implemented above three method in this stage.

(2) Geological Conditions for Soft Soil Analysis

1) Combined Drawings for Soft Soil Analysis

The soil profiles of Thanh Tri road section and Gia Lam road section which are submitted from the Vietnamese consulting firm are combined with traffic plans with longitudinal profile for analysis of soft soil layer. The combined drawings of 50 % reduced are shown in Appendix 3.3.19. The drawings are according to station. The original scale of the combined drawings and descriptions are as follows:

-	Traffic plan with longitudinal profile:	Horizontal:	1/2,500
		Vertical:	1/500
-	Soil profile:	Horizontal:	1/2,500
		Vertical:	1/500

- He: Height of embankment
  (from existing ground to top of embankment)
- Ts: Thickness of soft soil layer estimated settlement

2) Geological Conditions

Geological conditions of this project have soft soil layers along the route. In particular the road section of Thanh Tri side has soft soil layers, total thickness of 32 m to 16 m at analyzed locations and the road section of Gia Lam side has soft layers total thickness of 18 m to 16 m at analyzed locations.

a) Division Model of Geological Sections for Soft Soil Analysis

For soft soil analysis, the road section of Thanh Tri side had been divided into two geological sections named T-1 and T-2, and the road section of Gia Lam side had been divided into two geological sections named G-1 and G-2. Furthermore T-1 section had been divided into two subsections named T-1-a and T-1-b, and G-1 section had been divided into two subsections named G-1-a and G-1-b. The T-1-a section has two special sections near ponds, as the ponds are near to the right of way on both sides. Division model of geological sections is shown in Table 3.3.7.

Table 3.3.7 Division Model of Geological Sections

Name of section	from	to	Length (m)	Analysis location
T-1-a	1+030	2+600	1,032	1+400
Near pond-1	1+109	1+300	191	1+114
Near pond-2	1+300	1+647	347	1+560
T-1-b	2+600	3+300	700	2+740
T-2	3+330	6+214	2,914	4+740
G-1-a	9+298	10+920	1,622	9+920
G-1-b	10+920	12+060	1,140	11+360
G-2	12+060	12+868	808	12+400

b) Reasoning for Division Model of Geological Sections

- Boundary at STA2+600 (T-1-a and T-1-b)
  The boundary of T-1-a and T-1-b is due to thickness of soft layer equal to more than 30 m or less than 30 m.

- Boundary at STA3+300 (T-1-b and T-2)
  The boundary of T-1-b and T-2 is due to thickness of soft layer equal to more than 20 m or less than 20 m, and Layer-5 is existent or not visible.

- Boundary at STA10+920 (G-1-a and G-1-b)
  The boundary of G-1-a and G-1-b is due to the planned frontage road.

- Boundary at STA12+060 (G-1-b and G-2)
  The boundary of T-1-b and T-2 is due to the existence of layer-6.

3) Selection of Pretreatment Method in the Project

The following items are recommended as general countermeasures for soft soil:

- Sand drain
- Fiber drain (plastic board drain)
- Sand compaction pile

Consolidation by drainage water methods and solid column by compaction (sand compaction) method were generally recommended in Vietnam due to stability, construction cost, construction period, ease of construction and viable experience.

Rough comparisons of the above methods are shown in Table 3.3.8. Sand compaction method is excepted due to high cost and construction difficulty. Sand drain method and plastic board drain method were examined.

Table 3.3.8 Comparison of Pretreatment Method

Items	Plastic board drain	Sand drain	Sand compaction pile
Diameter (m)	0.1	0.4	0.7
Available depth (m)	20	30	35
Unit cost / m (1,000 VD)	800	1,185	4,000
Ease of construction	○	○	×
Adaptation to analysis	○	○	×

4) Analysis Conditions

a) Embankment Formation

Embankment formation of traffic lanes with frontage road is shown in Figure 3.3.1.

The shoulders of the traffic lanes have 26.5 m in width and its slope gradient is 1 (vertical) to 2 (horizontal). Shoulder of the frontage way is 14 m in width and height of frontage way is approximately EL 6.0, and its slope gradient is also 1 (vertical) to 2 (horizontal).

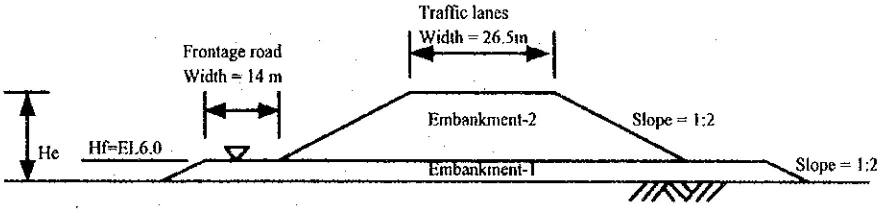


Figure 3.3.1 Embankment Formation of Traffic Way with Frontage Way

Maximum height of embankment and average existing ground level of traffic lanes with frontage road are shown in Table 3.3.9.

Table 3.3.9 Maximum Height of Embankment and Average Ground Level of Traffic Lanes with Frontage Road

Geological section	Typical location (STA)	Maximum height of embankment : He (m)	Average existing ground level (EL)
T-1-a	1+040	7.0	5.1
T-1-b	2+740	11.0	2.0
T-2	4+740	9.0	2.8
G-1-a	9+920	8.0	3.2
G-1-b	11+360	9.0	4.0
G-2	12+400	9.0	3.7

Embankment formation of ramp way is shown in Figure 3.3.2.

Shoulder of the ramp way is 10 m in width and its slope gradient is 1 (vertical) to 2 (horizontal).

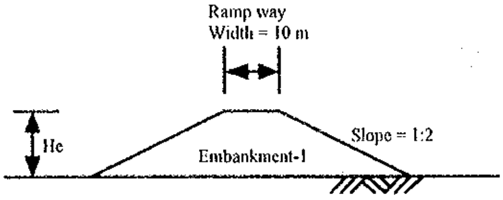


Figure 3.3.2 Embankment Formation of Ramp Way

Maximum height of embankment and average existing ground level of rampway are shown in Table 3.3.10.

Table 3.3.10 Maximum Height of Embankment and Average Ground Level of Rampway

Geological section	Typical location (STA)	Maximum height of embankment : He (m)	Average existing ground level (EL)
T-1-a	1+040	8.0	5.1
G-1-a	9+920	9.0 & 8.0	3.2
G-2	12+400	8.0	3.7

The details of embankment formation and layer for soft soil analysis are shown in Appendix 3.3.20.

b) Embankment Index

Embankment indices for soft soil analysis are shown in Table 3.3.11.

Table 3.3.11 Embankment Indices

Items	Unit	Indexes
Velocity of banking	cm/day	5.0
Wet density	Ton/m^3	1.88
Cohesion	Ton/m^2	0
Internal friction angle	Degree	27

c) Soil Index

Thickness of soft soil layer in each geological sections which is estimated from site reconnaissance are shown in Table 3.3.12. Adopted general soil indices for soft soil analysis are shown in Appendix 3.3.21.

Table 3.3.12 Thickness of Soft Soil Layer

Geological section	Typical location (STA)	Thickness of soft soil (m)
T-1-a	1+040	32.0
T-1-b	2+740	26.2
T-2	4+740	16.0
G-1-a	9+920	18.0
G-1-b	11+360	16.0
G-2	12+400	16.7

General soil index table of the road sections and the bridge section are shown in Appendix 3.3.22 and Appendix 3.3.23, respectively.

d) Pre-treatment Indices

Pre-treatment indices which are used in calculation for soft soil analysis are shown in Table 3.3.13.

Table 3.3.13 Calculated Indices of Pretreatment

Items	Plastic board drain	Sand drain
Diameter of drain (m)	0.10	0.40
Minimum interval (m)	0.75	1.00
Variable interval (m)	0.25	0.25
Placement of drain	square	square
Available depth (m)	20	30

Limits of adapted indices of pre-treatment for selection of comprehensive pre-treatment method are shown in Table 3.3.14.

Table 3.3.14 Limit of Adapted Indices of Pre-treatment

Items	Plastic board drain	Sand drain
Diameter of drain (m)	0.10	0.40
Minimum interval (m)	1.25	2.00
Available depth (m)	20	30
Placement of drain	square	square

(3) Consolidation Settlement

1) Settlement Analysis Conditions

Calculation indices of consolidation settlement is shown in Table 3.3.15.

Table 3.3.15 Calculation Indices of Consolidation Settlement

Items	Unit	Indices
Velocity of banking	Cm/day	5.0
Period of keeping embankment	days	450
Permissible residual settlement	cm	2.0

Soil consolidation indices which are used calculation for consolidation settlement are shown in Appendix 3.3.24.

2) Results of Calculation for Consolidation Settlement

Detailed calculation sheets regarding consolidation settlement are attached in a supplemental volume.

Results of settlement analysis are shown in Appendix 3.3.25. The calculation of consolidation settlement used case 2 indices in T-1-a section.

Summary of settlement analysis on traffic lane center is shown in Table 3.3.16.

Sand drain method is recommended at the sections of T-1-a, near pond-1, near pond-2 and at T-1-b. The interval of the sand drain varies from 2.25 m to 2.75 m.

Plastic board drain method is recommended at sections T-2, G-1-a, G-1-b and G-2. The interval of the plastic board drain varies from 1.50 m to 2.75 m.

Final settlement on the traffic way center varies from approximately 1.14 m to 1.84 m in Thanh Tri side and varies from approximately 0.80 m to 1.20 m in Gia Lam side.

The residual settlement after 450 days of the embankment completion are less than 2 cm.

Table 3.3.16 Summary of Settlement Analysis on Traffic Way

Geological section	Analysis location (STA)	Height of embankment	Final settling (m)	Sand drain		Plastic board drain		Residual settlement (cm)
				Interval (m)	Depth (m)	Interval (m)	Depth (m)	
T-1-a	1+040	7.0	1.504	2.50	30.0			1.840
Near pond-1	1+114	5.5	1.242	2.25	30.0			1.366
Near pond-2	1+560	4.1	0.983	2.25	30.0			1.024
T-1-b	2+740	11.0	1.842	2.75	26.2			0.996
T-2	4+740	9.0	1.137			1.50	16.0	0.935
G-1-a	9+920	8.0	1.216			2.00	18.0	0.900
G-1-b	11+360	9.0	1.031			2.00	16.0	1.544
G-2	12+400	9.0	0.929			2.75	16.7	1.984
		8.0	0.868			2.50	16.7	1.014
		7.0	0.801			2.50	16.7	0.978
		9.0 (CW6)	0.922			2.50	16.7	1.583
		8.0 (CW6)	0.861			2.50	16.7	1.531
		7.0 (CW6)	0.795			2.50	16.7	1.455

Summary of settling analysis at rampway center is shown in Table 3.3.17.

Sand drain method is recommended at the section of T-1-a. The interval of the sand drain is 2.50 m.

Plastic board drain method is recommended at sections G-1-a, and G-2. The interval of the plastic board drain varies from 2.25 m to 2.50 m.

Final settling at the rampway center varies from approximately 1.00 cm to 1.92 cm. The residual settlement after 450 days of the embankment completion is also less than 2 cm.

Table 3.3.17 Summary of Settling Analysis on Rampway

Geological section	Analysis location (STA)	Height of embankment	Final settling (m)	Sand drain		Plastic board drain		Residual settlement (cm)
				Interval (m)	Depth (m)	Interval (m)	Depth (m)	
T-1-a	1+040	8.0	1.459	2.50	30.0			1.462
G-1-a	9+920	9.0	1.240			2.25	18.0	1.906
		8.0	1.139			2.25	18.0	1.921
G-2	12+400	8.0	0.831			2.50	16.7	0.995
		7.0	0.762			2.50	16.7	0.957
		8.0 (CW6)	0.814			2.50	16.7	1.476

(4) Ground Stability

1) Stability Analysis Conditions

Calculation indices of stability analysis are shown are Table 3.3.18.

Tables of strength increased for calculation of ground stability is shown in Appendix 3.3.26.

Table 3.3.18 Calculation Indices of Stability Analysis

Items	
Calculation method	Circular sliding
Calculation period	At the time of completion of embankment construction
Increasing internal strength by consolidation	Considered
Permissible safety factor	1.2

2) Results of Calculation Regarding Ground Stability

Detailed calculation results (calculated drawings) of ground stability are attached in a supplemental volume.

Results of calculation for ground stability are shown in Appendix 3.3.27. The calculations of ground stability used case 2 indices in T-1-a section.

Summary of ground stability of traffic lanes is shown in Table 3.3.19.

Sand drain method is recommended at the sections of T-1-a, near pond-1, near pond-2 and T-1-b. The interval of the sand drain varies from 2.00 m to 2.25 m. Plastic board drain method is recommended at the sections T-2, G-1-a, G-1-b and G-2. The interval of the plastic board drain varies from 0.75 m to 1.50 m.

Minimum safety factor of stability on the traffic lane on the Thanh Tri side varies from approximately 0.98 to 1.23. Minimum safety factor of stability on the traffic way in Gia Lam side varies from approximately 1.05 to 1.29.

Residual settling at that time is less than 2 cm.

At the section near pond-1 and near pond -2, the minimum safety factors are less than 1.2. Preventative works are required for increasing safety factor in these sections. The preventative works are described in the detailed design paragraph.

At the G-2 section, embankment heights of 9 m and 8 m are not recommended as safety factors are less than 1.2.

Table 3.3.19 Summary of Stability Analysis for Traffic Lanes

Geological section	Analysis location (STA)	Height of embankment	Sand drain		Plastic board drain		Minimum safety factor	Residual settling (cm)
			Interval (m)	Depth (m)	Interval (m)	Depth (m)		
T-1-a	1+040	7.0	2.25	30.0			1.230	1.648
Near pond-1	1+114	5.5	2.25	30.0			0.977	1.366
Near pond-2	1+560	4.1	2.25	30.0			1.023	1. 024
T-1-b	2+740	11.0	2.00	26.2			1.203	0.001
T-2	4+740	9.0			1.50	16.0	1.201	0.935
G-1-a	9+920	8.0			1.50	18.0	1.290	0.018
G-1-b	11+360	9.0			1.50	16.0	1.215	0.031
G-2	12+400	9.0			0.75	16.7	1.048	0.000
		8.0			0.75	16.7	1.118	0.000
		7.0			1.50	16.7	1.211	0.001
		9.0 (CW6)	1.75	16.7			1.202	0.000

Summary of ground stability on rampway is shown in Table 3.3.20.

Sand drain method is recommended at the sections of T-1-a. The interval of the sand drain varies from 2.50 m.
Plastic board drain method is recommended at sections G-1-a and G-2. The interval of the plastic board drain varies from 0.75 m to 1.50 m.

Minimum safety factor of stability on the rampway of the Thanh Tri side is 1.22. Minimum safety factor of stability on the rampway on the Gia Lam side varies from approximately 1.04 to 1.25.

Residual settling at that time are less than 2 cm.

At the G-2 section, embankment height of 8 m is not recommended as safety factors are less than 1.2.

Table 3.3.20 Summary of Stability Analysis on Rampway

Geological section	Analysis location (STA)	Height of embankment	Sand drain		Plastic board drain		Safety factor	Residual settling (cm)
			Interval (m)	Depth (m)	Interval (m)	Depth (m)		
T-1-a	1+040	8.0	2.50	30.0			1.215	1.462
G-1-a	9+920	9.0			1.25	18.0	1.209	0.000
		8.0			1.50	18.0	1.254	0.003
G-2	12+400	8.0			0.75	16.7	1.040	0.000
		7.0			1.50	16.7	1.212	0.000
		8.0 (CW6)			1.00	16.7	1.208	0.000

Ground stability during embankment construction was calculated in T-1-a section as an example. Summary of the ground stability in the process of embankment is shown in Table 3.3.21.

The degree of consolidation varies from 0.30 to 0.69 and minimum safety factor are varies from 2.23 to 1.23.

In consequence, final stage has a minimum safety factor in the process of embankment construction.

Table 3.3.21 Summary of Ground Stability in the Process of Embankment

Geological section	Analysis (STA)	Stage of embankment construction (height: m)	Passage of days	Sand drain		Degree of consoli-dation	Rate of strength increased	Minimum safety factor
				Interval (m)	Depth (m)			
T-1-a	1+040	3	60	2.25	30.0	0.30	0.25	2.32
		4	80	2.25	30.0	0.37	0.25	1.79
		5	100	2.25	30.0	0.46	0.25	1.50
		6	120	2.25	30.0	0.57	0.25	1.33
		7	140	2.25	30.0	0.69	0.25	1.23

3.3.8 Detailed Design

(1) Recommendation of Comprehensive Pre-treatment

The recommendation of comprehensive pre-treatment for soft soil is shown in Appendix 3.3.28. The comprehensive pre-treatment was compared with the pre-treatment of consolidation settlement and the pre-treatment of ground stability. The pre-treatment of ground stability is a strict than the pre-treatment of consolidation settlement in all the geological sections. The recommended comprehensive pre-treatment should be equal to the pre-treatment of ground stability.

Summary of comprehensive pre-treatment on traffic lanes is shown in Table 3.3.22.

Consequently, the sand drain method is recommended for the comprehensive pre-treatment in the sections of T-1-a, near pond-1, near pond-2 and T-1-b. The interval of the sand drain should vary from 2.00 m to 2.25 m and the depth of sand drain should very from 26.2 m to 30.0 m.
The plastic board drain method is recommended for comprehensive pre-treatment in the sections T-2, G-1-a, G-1-b and G-2. The interval of the plastic board drain is 1.50 m and the depth of plastic board drain should be varied from 16.0 m to 18.0 m.

Minimum safety factors are above 1.2 except in the sections near pond-1 and near pond -2. Preventative works are needed for increasing safety factors to 1.2. The prevention works are described in section (4) regarding method of prevention works for stability.
Residual settling at that time is less than 2 cm.

Table 3.3.22 Summary of Comprehensive Pre-treatment on Traffic Lanes

Geological Section	Analysis location (STA)	Maximum height of embankment	Sand drain		Plastic board drain		Minimum safety factor	Residual settling (cm)
			Interval (m)	Depth (m)	Interval (m)	Depth (m)		
T-1-a	1+040	7.0	2.25	30.0			1.230	1.648
Near pond-1	1+114	5.5	2.25	30.0			0.977	1.366
Near pond-2	1+560	4.1	2.25	30.0			1.023	1. 024
T-1-b	2+740	11.0	2.00	26.2			1.203	0.001
T-2	4+740	9.0			1.50	16.0	1.201	0.935
G-1-a	9+920	8.0			1.50	18.0	1.290	0.018
G-1-b	11+360	9.0			1.50	16.0	1.215	0.031
G-2	12+400	7.0	1.75	16.7	1.50	16.7	1.211	0.001
		9.0 (CW6)	1.75	16.7	1.50	16.7	1.202	0.000

Summary of comprehensive pre-treatment on rampway is shown in Table 3.3.23.

Consequently, the sand drain method is recommended as comprehensive pre-treatment in the section of T-1-a. The interval of the sand drain should be 2.50 m and the depth of sand drain should be 30.0 m.

The plastic board drain method is recommended as comprehensive pre-treatment in the sections G-1-a and G-2. The interval of the plastic board drain should vary from 1.00 m to 1.50 m and the depth of plastic board drain should vary from 16.7 m to 18.0 m.
Residual settling at that time is less than 2 cm.

Table 3.3.23 Summary of Stability Comprehensive Pre-treatment on Rampway

Geological Section	Analysis location (STA)	Height of embankment	Sand drain		Plastic board drain		Safety factor	Residual settling (cm)
			Interval (m)	Depth (m)	Interval (m)	Depth (m)		
T-1-a	1+040	8.0	2.50	30.0			1.215	1.462
G-1-a	9+920	9.0			1.25	18.0	1.209	0.000
		8.0			1.50	18.0	1.254	0.003
G-2	12+400	7.0			1.50	16.7	1.212	0.000
		8.0 (CW6)			1.00	16.7	1.208	0.000

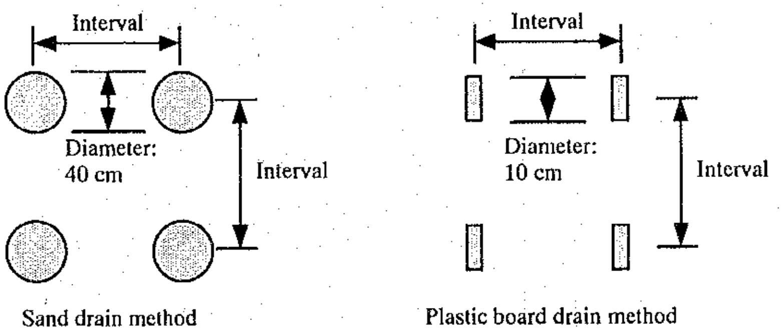
Quantities of comprehensive pre-treatment are shown in Appendix 3.3.29. Summary of total quantities of the comprehensive pre-treatment are shown in Table 3.3.24. Total number is 49,717 and length of sand drain 1,441,271 m. Total number of plastic drain board is 270,410 and length is 4,518,616 m.

Table 3.3.24 Summary of Total Quantities of the Comprehensive Pre-treatment

Geological section		Length of section (m)	Area of section (m^2)	Sand drain		Plastic board drain	
				Number	Total length (m)	Number	Total length (m)
Road section: Thanh Tri	Traffic lanes	4,892	405,094	31,493	894,551	106,369	1,701,904
	Rampway	3,270	87,420	13,560	406,800	0	0
Road section: Gia Lam side	Traffic lanes	2,556	143,989	0	0	63,921	1,114,672
	Counter weight	372	14,136	4,664	139,920	0	0
	Rampway	2,570	100,120	0	0	100,120	1,702,040
Grand total		13,660	750,759	49,717	1,441,271	270,410	4,518,616

(2) Method of Comprehensive Pre-treatment

Placement of comprehensive pre-treatment should be square, as shown in Figure 3.3.3



Sand drain method

Plastic board drain method

Figure 3.3.3 Pre-treatment Method on Traffic Lanes

Area of comprehensive pre-treatment should encompass the total width of embankment and an additional 4 meters on both sides, in both the coses of traffic lanes and rampway. General figures of comprehensive pre-treatment for traffic lanes and rampway are shown in Figures 3.3.4 and 3.3.5 respectively.

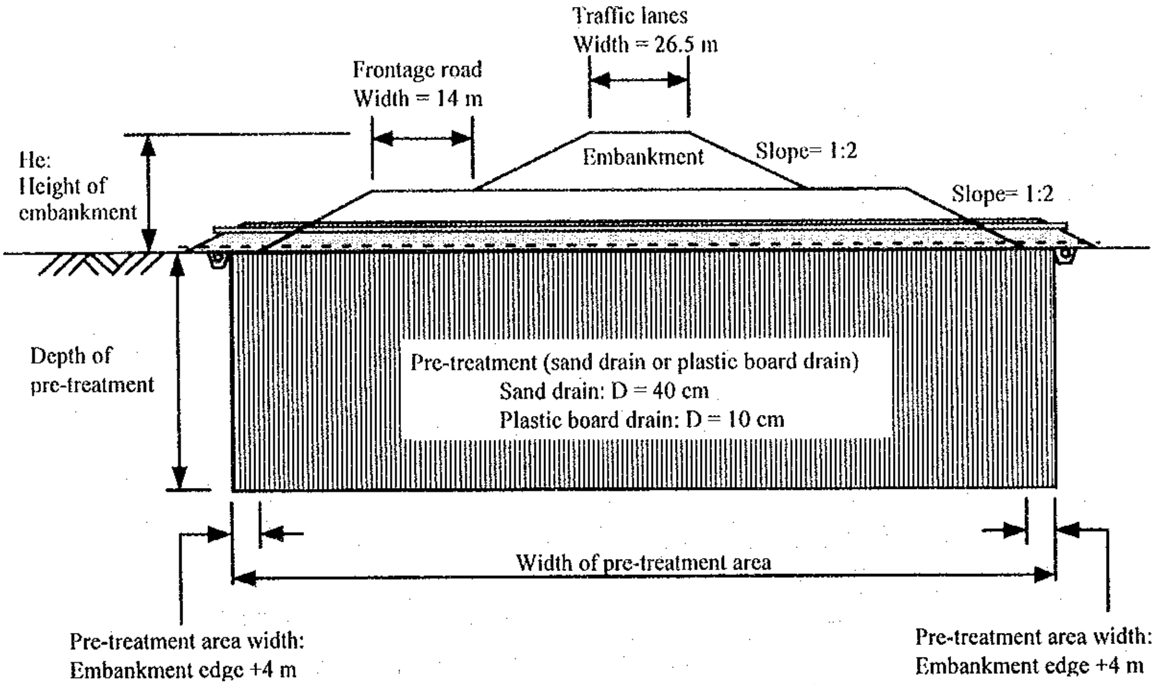


Figure 3.3.4 Comprehensive Pre-treatment on Traffic Lanes

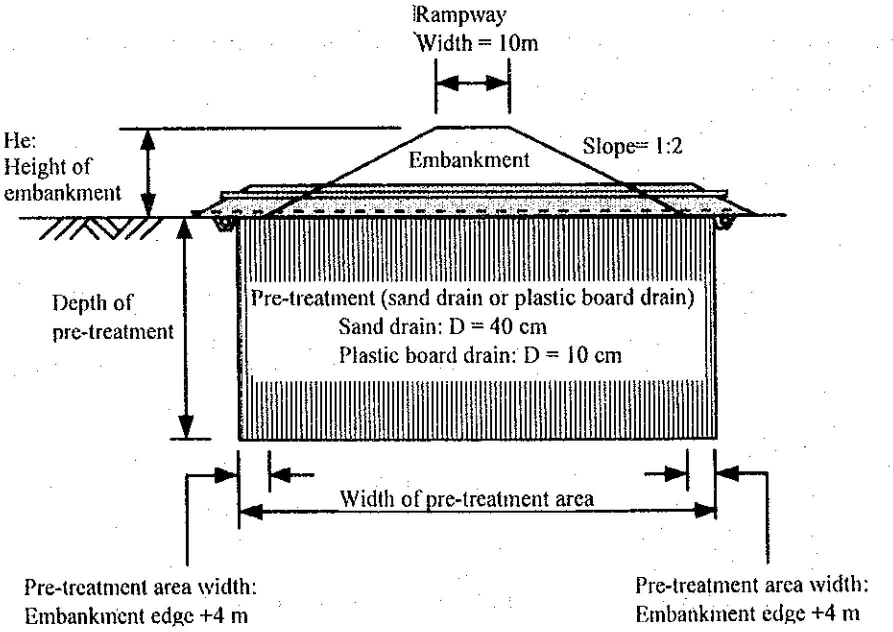


Figure 3.3.5 Comprehensive Pre-treatment on Rampway

The material of sand drain consists of sand material with good permeability, well-graded with less than 3 % passing a 0.075 mm sieve. Furthermore, the ratio of sieve more than 0.5 mm should be more than 50 % and the ratio of sieve less than 0.5 mm should not be exceed 10 %.

The material of plastic board drain consists of band with polypropylene core according to ASTM-D4632 and ASTM-D4716.

(3) Method of Subsidiary Works for Comprehensive Pre-treatment

The subsidiary works for comprehensive pre-treatment consist of installation of sand mat, fabric sheet, cross drainage and longitudinal drainage.

The thickness of sand mat should exceed final settling value by 50 cm. The material of sand mat should consist of well-graded sand with less than 3 % passing a 0.075 mm sieve.

The fabric sheet (geotextile) should be installed under the sand mat structure complying with ASTM-D4632, BS-9606-3 and BS-9606-4. Summary of roughly-estimated area where fabric sheets should be installed is shown in Table 3.3.25.

Table 3.3.25 Summary of Roughly Estimation Area of Fabric Sheets

Section	Item	Installation area (m^2)
Thanh Tri side	Traffic lanes	405,094
	Rampway	87,420
Gia Lam side	Traffic lanes	143,989
	Rampway	14,136
	Counter weight	100,120
Total		750,759

Cross drainage should be installed every 10 m to 20 m. The material of cross drainage should consist of flexible porous pipe.
Longitudinal drainage should be installed as drain ditch or drain pipe.

Roughly-estimated earth work volume is shown in Appendix 3.3.30. Summary of the same is shown in Table 3.3.26.

Table 3.3.26 Roughly Estimation of Earth Work Volume

Section	Item	Embankment (m^3)	Reform of settling (m^3)
Thanh Tri side	Traffic way	1,216,410	282,405
	Ramp way	537,380	91,409
Gia Lam side	Traffic way	438,068	95,162
	Ramp way	310,240	48,355
	Counter weight	30,690	4,945
Total		2,532,788	522,276

General figures of subsidiary works on traffic lanes and rampway are shown in Figure 3.3.6 and Figure 3.3.7, respectively.

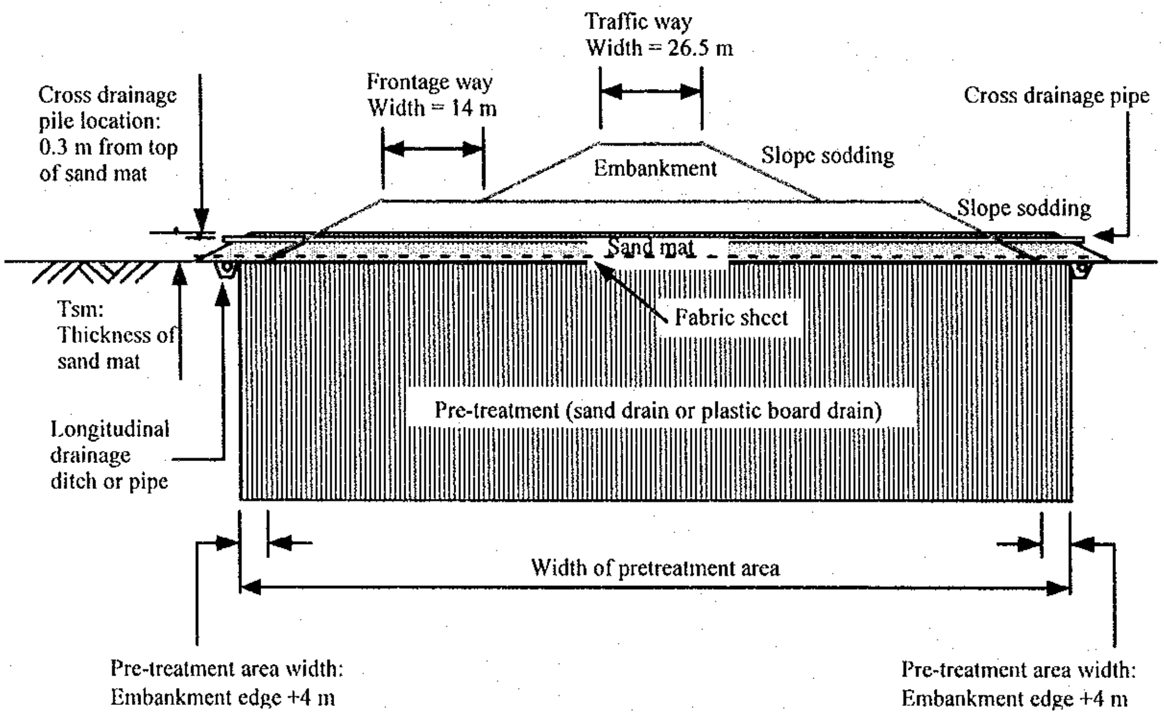


Figure 3.3.6 Subsidiary Work of Pre-treatment on Traffic Lanes

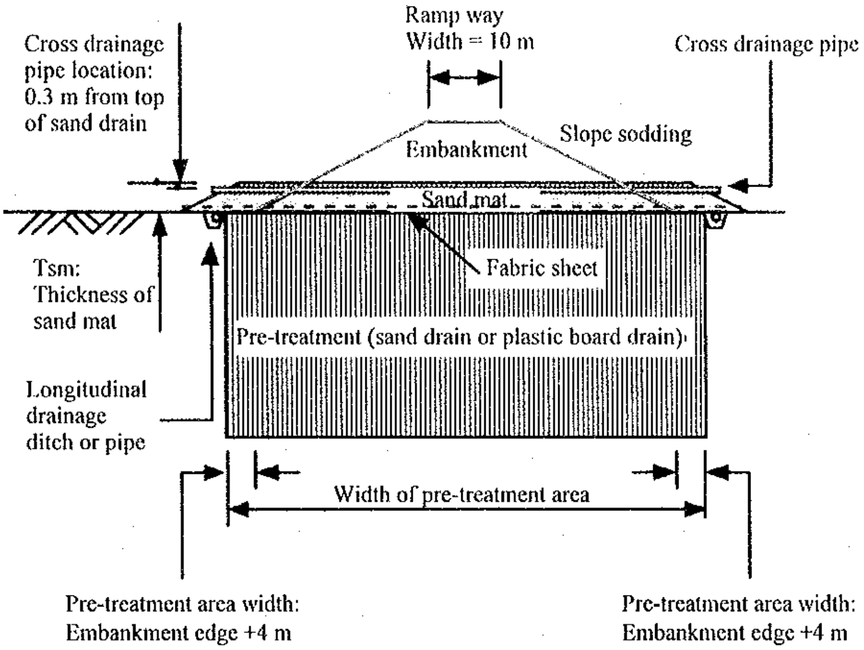


Figure 3.3.7 Subsidiary Work of Pre-treatment on Ramp Way

(4) Method of Preventative Works for Stability

For increased stability, preventative works should be implemented in the sections near pond-1 (from STA 1+114 to STA 1+300) and near pond-2 (from STA 1+300 to STA 1+647).

Sheet pile method is recommended and IA type steeled sheet piles. The preventing force should be shear force of sheet pile. Results of preventing force near pond sections are shown in Table 3.3.27.

Table 3.3.27 Stability Analysis Near Pond Sections

Sections	Length	Sand drain method		Stability analysis					
		Interval	Depth	Fs	Moment (tfm)		Arm	Permissible	Prevention
	(m)	(m)	(m)		Resisted	Sliding	(m)	FS	force (t/m)
1+114 - 1+300	186	2.25	30.0	0.977	17,643	18,050	68.94	1.200	60.00
1+300 - 1+647	347	2.25	30.0	1.0 23	11.259	11,003	52.25	1.200	38.88

The results of examination relating to preventative works are shown in Table 3.3.28. Consequently, maximum prevention force per meter of width (60.0 ton/m) is less than allowable shear force of sheet pile per meter of width (67.8 ton/m).

Table 3.3.28 Result of Examination Relating Prevention Work

Sheet pile type	IA
Cross section per meter width	113 cm^2/m
Corrosion thickness	1 mm both sides
Allowable thickness	8-1-1 = 6 mm
Allowable cross section per meter width	113*6/8 = 84.75 cm^2/m
Allowable shear stress	800 kg/cm^2
Allowable shear force per meter width	84.75*800 = 67.8 ton/m

General figure of preventative work near pond-1 and near pond-2 are shown in Figures 3.3.8 and 3.3.9, respectively.

Preventative works should be implemented outside of pre-treatment area. The distance of prevention work and pre-treatment is 1 m as recommended.
The length of prevention work should be 32 m as the bottom of sliding arc is 30 m in depth.

Rough estimation of quantity of the prevention work is shown in Table 3.3.29.

Table 3.3.29 Rough Estimation of Sheet Pile

Sections	Section length	Numbers	Total length (m)
1+114 - 1+300	186	186*2/0.4 = 930	29,760
1+300 - 1+647	347	347*2/0.4 = 1,735	55,520
Grand total	533	2,665	85,280

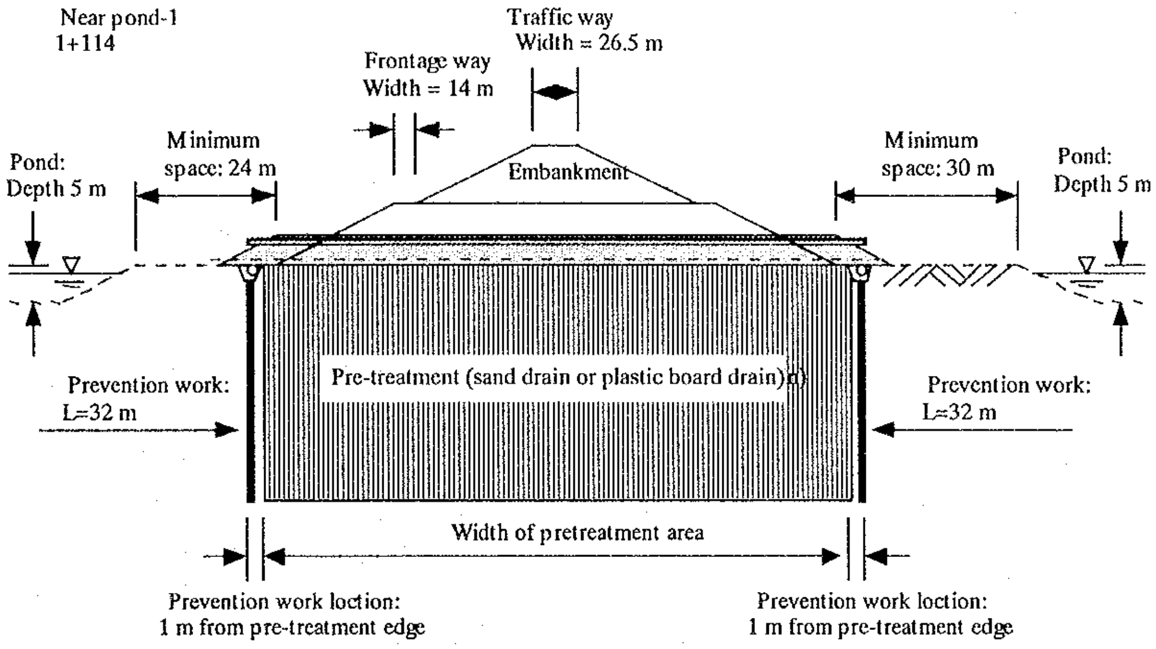


Figure 3.3.8 Preventative Work Method at Near Pond-1

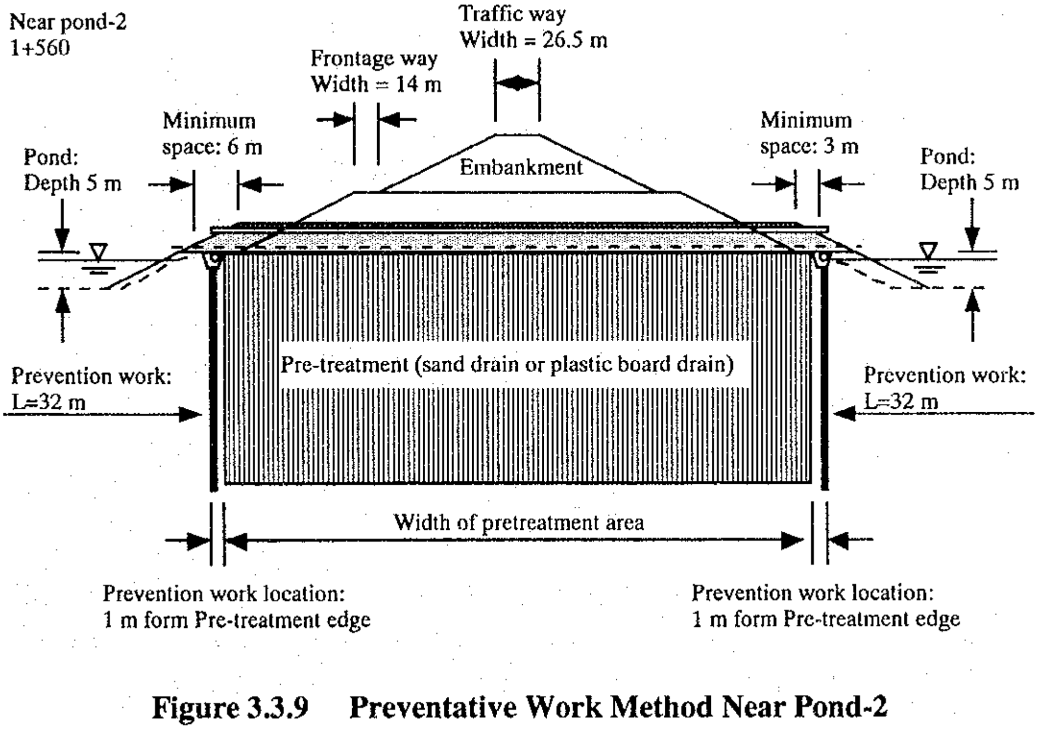


Figure 3.3.9 Preventative Work Method Near Pond-2

3.4 Hydrological Analysis

3.4.1 General

The proposed Red River Bridge (Thanh Tri Bridge) connects National Highway No.1 on the Thanh Tri or Hanoi side to National Highway No. 5 on the Gia Lam side crossing the Red River southeast of the city.

This hydrological analysis is conducted for the Basic Design and Detailed Design on the Red River Bridge (Thanh Tri Bridge) Construction Project.

3.4.2 Objectives and Scope

The objective of the hydrological analysis is to clarify the flow characteristics at the project site and the interaction between the bridge and river. The analysis is focuses on the determination of high water level and flow rate at the design return period, the simulation of flow along the river nearby the bridge, the verification of the impact of the bridge to the river and dykes, and the calculation of the potential scour at bridge piers.

3.4.3 The Red River

The Red River originates in the Nguy Son mountains in China, where it has a different neme. The river then branches into several tributaries and flows through Laos and Vietnam. The main tributaries which flow through the northwest of Hanoi are: the Da River, the Thao River, the Chay River, the Lo River and the Gam River. The Red River takes its name after the confluence of these tributaries at Viet Tri city. In midstream, north of Hanoi, the river is diverted to the west in the Day River and to the east in the Thai Binh River through the Duong River. The river then flows eastwards through the city to the sea at Ba Lat. The river pattern is shown in Fig. 3.4.1.

The overall drainage basin occupies a total drainage area of about 155,000 km^2 in Vietnam, Laos, and China. The drainage area of the main tributaries upstream from Viet Tri city is approximately 143,700 km^2.

Since 1988, the flow in the Da River has been regulated by the Hoa Binh reservoir. The portion of the regulated flow is reported to be more than 50% of the total flow of the Red River.

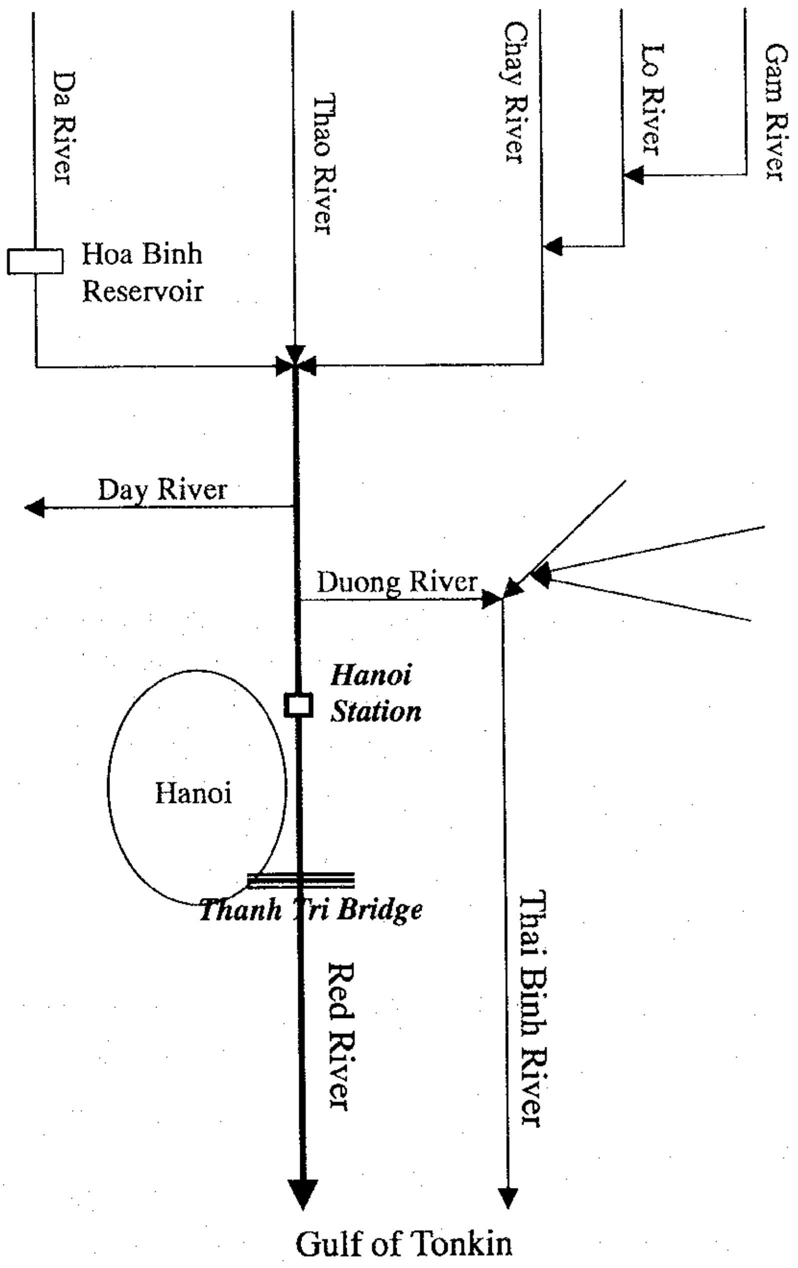


Figure 3.4.1 Flow Pattern of the Red River

In combination with the reservoir, a diversion at Day River has also been used to regulate the flow. The excess water during flood period will be diverted to this river.

Therefore, flow in the Red River at Hanoi is at present regulated by the Hoa Binh reservoir and the diversion at Day River.

3.4.4 Available Data

(1) Water Level and Velocity

Data on water level, velocity and cross sections in the Red River are available from Hanoi station, the nearest measuring station to the Thanh Tri Bridge in the upstream area. Water level and velocity have been measured regularly by this station nearby the Chuong Duong Bridge.

The water level is normally at its maximum in the rainy season in August and minimum in the dry season in March. The seasonal average maximum and minimum water levels measured at Hanoi Station are as follows:

Average maximum and minimum water level in the Red River

Average	Water level (m, msl)		
	Rainy Season (August)	Dry Season (March)	Average
Maximum	11.44	4.18	6.67
Minimum	6.04	2.01	3.57

It is reported that there is no tidal effect from the sea.

Flow rate is calculated from the measured water level by the summation of the sub-sections of the velocity multiplied by the cross sectional area.

(2) Maximum Water Level and Velocity

Annual maximum water level recorded at the Hanoi Station is shown in Table 3.4.1. The water level in 1971 is recorded as the highest of all at 13.97 m (msl).

However, in 1988, the Hoa Binh reservoir was completed. This reservoir is reported to regulate more than 50% of the flow rate in the Red River. In addition, the diversion at the Day River has been set to bypass the excess flow from the Red River for flood mitigation in Hanoi City. The maximum water level in the Red River now is controlled at 13.4 m (msl).

The annual maximum velocity recorded since 1988 after the operation of the reservoir and the diversion was also collected as shown in Table 3.4.2.

The recorded major floods are shown in the following table. The most severe floods before and after the operation of the reservoir and the diversion are the floods in August 1971 and August 1996, respectively.

Major recorded floods in the Red River

Year	Max Water Level		Max Discharge		Max Vel.	
	WL (m)	Date	Q (m^3/s)	Date	V (m/s)	Date
1969	13.06	Aug, 18	17,800	Aug, 18	2.62	Aug, 14
1971	13.97	Aug, 22	22,200	Aug, 20	2.81	Aug, 21
1986	12.19	Jul, 29	14,600	Jul, 28	2.28	Jul, 26
1996	12.43	Aug, 21	14,800	Aug, 21	2.23	Jul, 26

(3) River Profile

Cross section along the Red River has been measured regularly by Hanoi Station and Department of Dyke Management and Flood Control.

The river profile data along the river are collected from the Department of Dyke Management and Flood Control. The profile at Station Mc 48 is focused upon as it provides the nearest available data upstream from project site. Location of Station Mc 48 is as follows:

The profile, as shown in Figure 3.4.2, is divided mainly into three periods as follows:

1) Before the completion of Hoa Binh reservoir (1981 - 1988)
2) Transition period after the completion of Hoa Binh reservoir (1988 - 1991)
3) After the completion of Hoa Binh reservoir (1991 - 1998)

The profile at this station shows that the river course has been stable during 1981 - 1998.

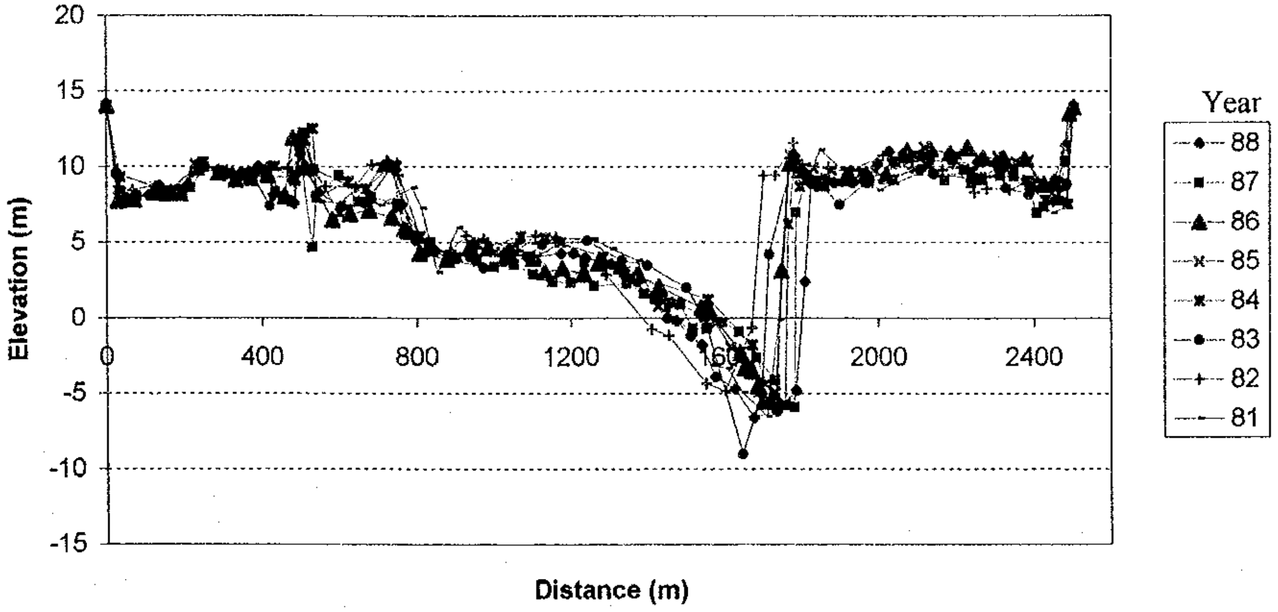
Table 3.4.1 Maximum Annual Water Level at Hanoi Station

Unit : m, msl

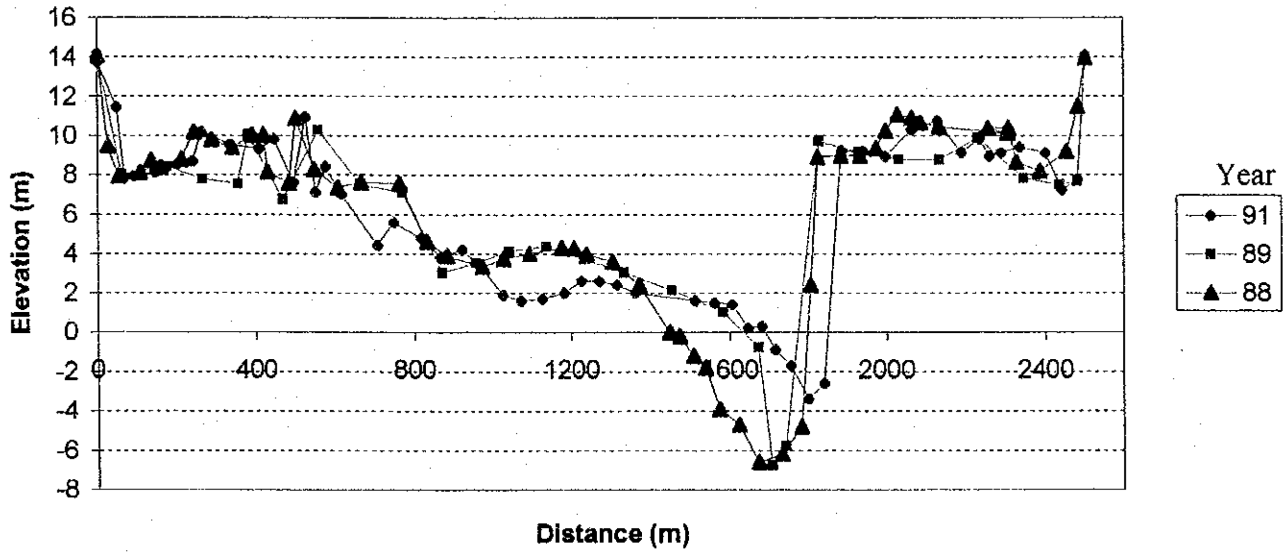
Year	Max WL	Year	Max WL	Year	Max WL
1945	12.52	1963	9.51	1981	10.90
1946	9.89	1964	11.42	1982	11.06
1947	12.08	1965	9.47	1983	11.91
1948	10.57	1966	11.62	1984	10.32
1949	10.72	1967	10.64	1985	11.80
1950	10.83	1968	11.07	1986	12.19
1951	10.12	1969	13.06	1987	10.02
1952	9.69	1970	11.89	1988	9.99
1953	10.44	1971	13.97	1989	10.07
1954	11.26	1972	9.81	1990	11.78
1955	9.89	1973	11.00	1991	11.33
1956	10.52	1974	9.76	1992	11.32
1957	10.04	1975	10.06	1993	9.46
1958	10.26	1976	10.73	1994	10.57
1959	10.22	1977	11.07	1995	11.73
1960	10.21	1978	11.26	1996	12.43
1961	10.81	1979	11.53	1997	11.07
1962	9.81	1980	11.65	1998	11.00

Table 3.4.2 Annual Maximum Velocity at Hanoi Station

Year	Vel. (m/s)	Year	Vel. (m/s)
1988	1.85	1994	1.97
1989	1.98	1995	2.11
1990	2.09	1996	2.23
1991	1.82	1997	2.09
1992	2.11	1998	2.25
1993	1.72		



River Profile at Station Mc 48
(Before the completion of Hoa Binh Dam)



River Profile at Station Mc 48
(Transition period after the completion of Hoa Binh Dam)

Figure 3.4.2 (1) River Profile at Station Mc 48
(nearby the Project Site)
(Left side : Hanoi, Right side : Gia Lam)

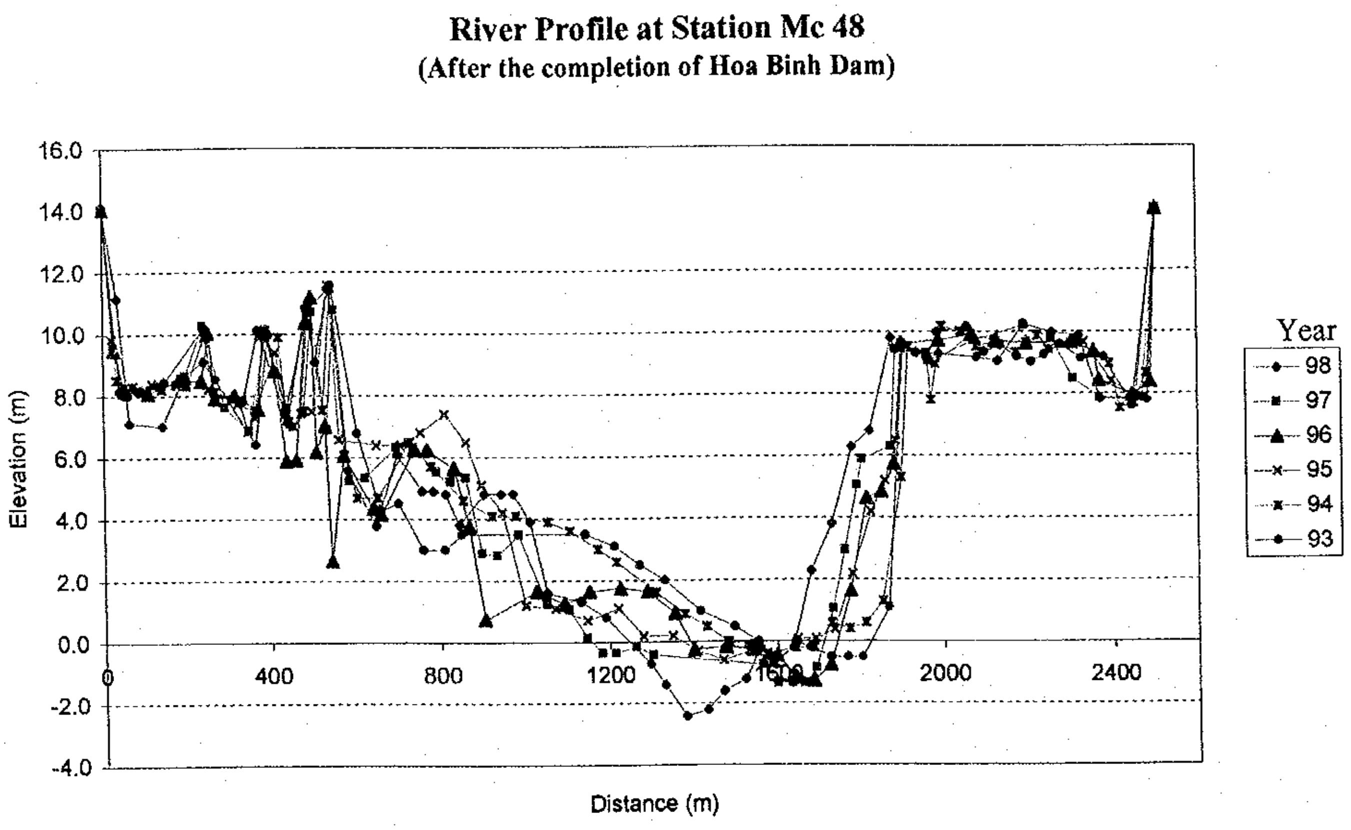


Figure 3.4.2 (2) River Profile at Station Mc 48
(nearby the Project Site)
(Left side : Hanoi, Right side : Gia Lam)

(4) Landsat Images

Landsat images on November 30, 1989 and October 16, 1996 were collected from the Meteorological Division as shown in Figure 3.4.3. From the digital data of the images and the reproduced figures as shown, there is found a slight difference of the river course in the main channel at the project site. This difference can be possibly attributed to the following reasons:

- Subtle river course changes occurring every yearly,
- Water level during the time of image taking was different, causing an error in the interpretation of the boundary of river course.

As a result, it can be summarized that the change of river course at the project site between 1989 and 1996 is negligible.

3.4.5 Hydrological Survey

In order to obtain additional information on the river characteristics between Hanoi Station and the project site for the hydraulic simulation, hydrological surveys were conducted twice in 1999; during the dry period in June and flood period in August.

(1) Survey in Dry Period

A survey of the Red River along the center-line over a width of about 2.5 km and nearby sections was conducted in order to obtain the following information:

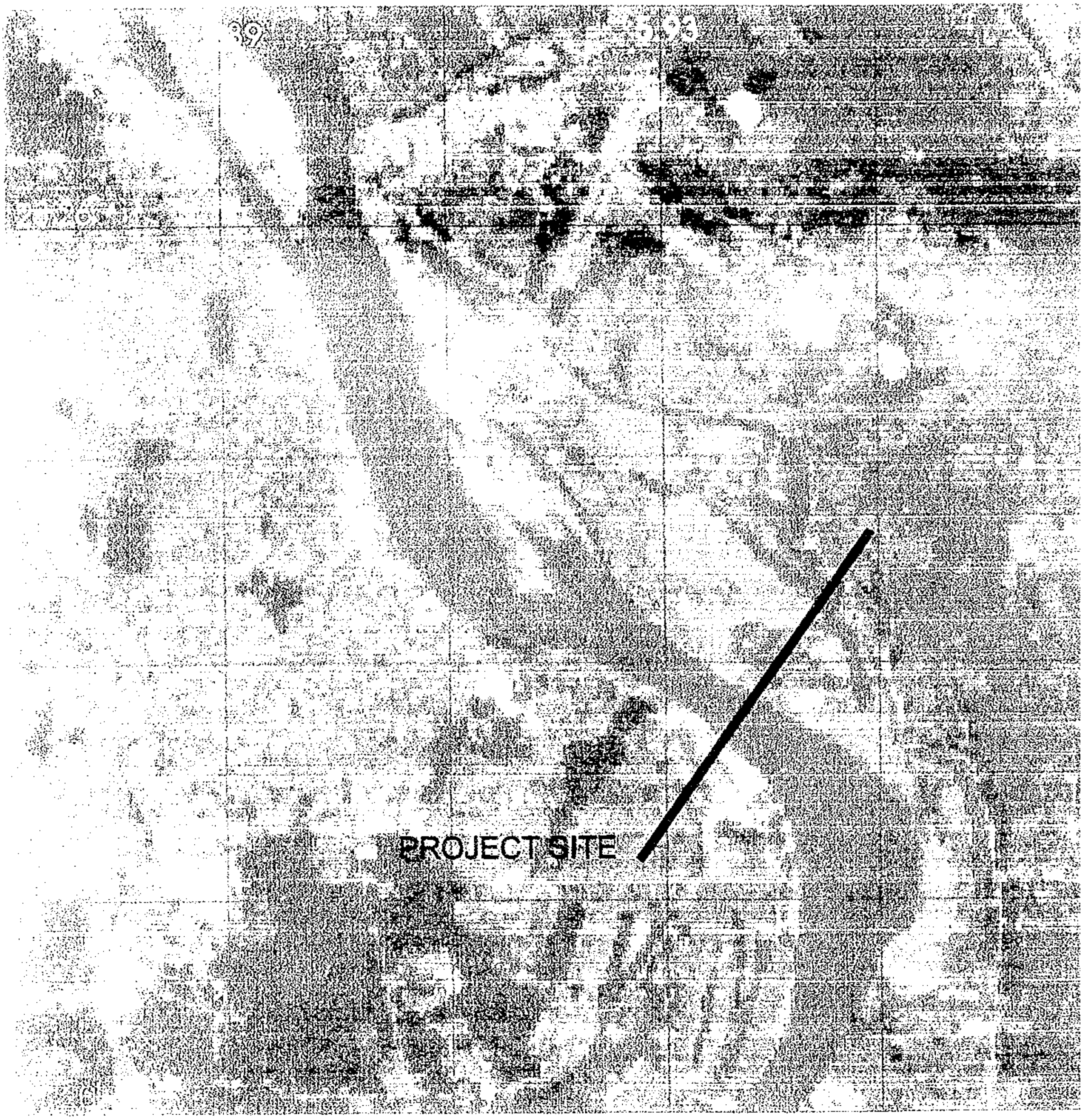
- The gradient of water surface between Hanoi Station and the project site,
- The cross sectional profile in the upstream and downstream of the project area,
- The simultaneous velocity and water level.

River profile and water level were measured by sonar method along the river in the wet land and leveling method along the flood plain in the dry land.

Velocity was measured by a current meter at the project site and nearby sections in the upstream and downstream of the project site simultaneously. Details of the survey are shown in the Report on Hydrological Survey, June 1999. The river profile at the project site is shown in Figure 3.4.4.

Scale of picture 1:50,000 - UTM Projection

Figure 3.4 (1) Landsat Image at the Project Site in 1996



Scale of picture 1:50,000 - UTM Projection

Figure 3.4 (1) Landsat Image at the Project Site in 1996

Scale of picture 1:50,000 - UTM Projection

Figure 3.4 (2) Landsat Image at the Project Site in 1989

Scale of picture 1:50,000 - UTM Projection

Figure 3.4 (2) Landsat Image at the Project Site in 1989

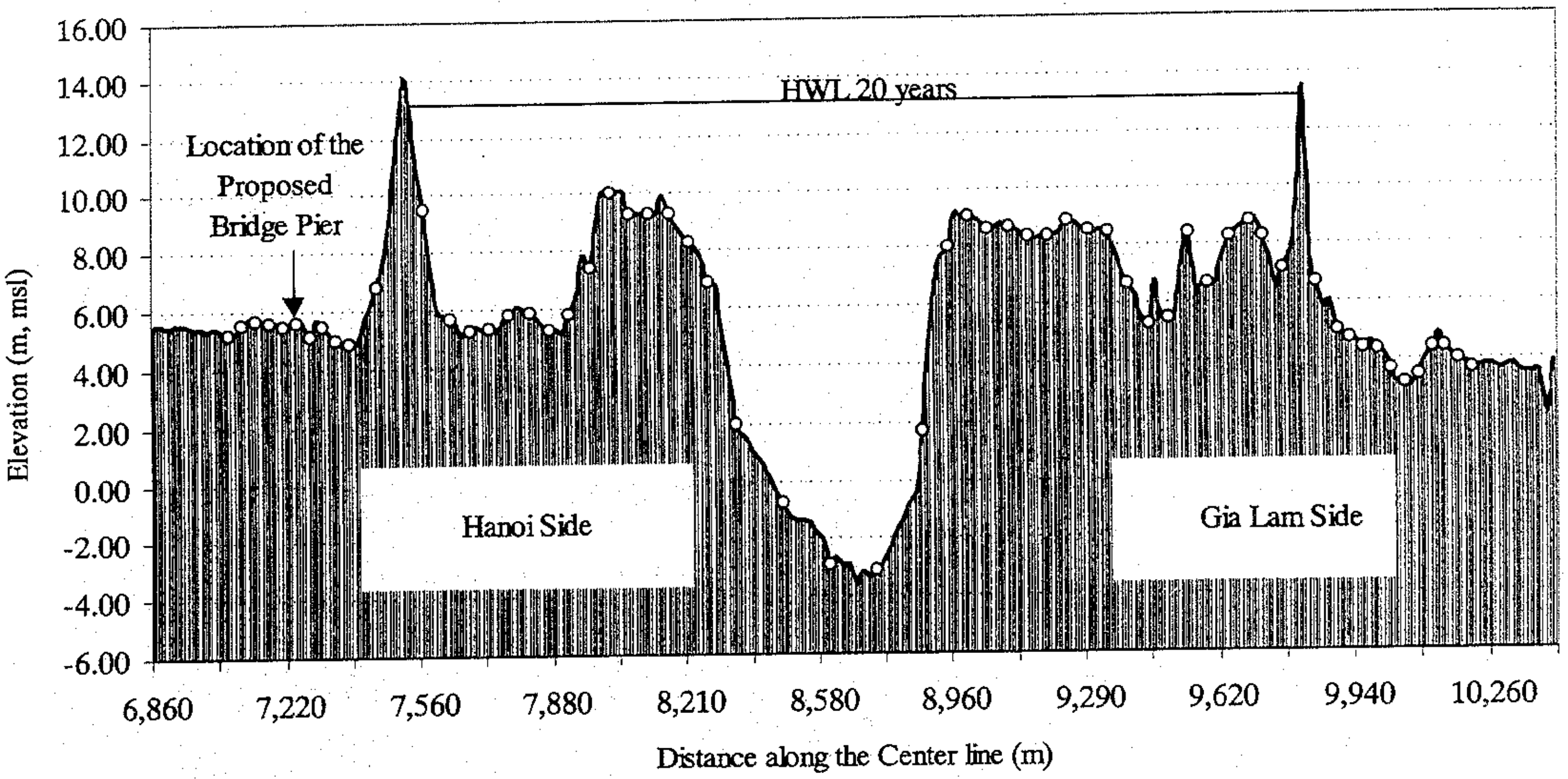


Figure 3.4.4 River Profile at Thanh Tri Bridge

Measured velocity and water level can be summarized as follows:

Measured Water Level in Dry Period

Date		Water Level (m)		
		Hanoi Station	Project Site	Diff.
12-Jun-99	morning	4.98	4.33	0.65
	afternoon	5.11	4.33	0.78
13-Jun-99	morning	5.24	4.56	0.68
	afternoon	5.26	4.56	0.70
14-Jun-99	morning	5.35	4.68	0.67
	afternoon	5.39	4.71	0.68
15-Jun-99	morning	5.41	4.75	0.66
	afternoon	5.45	4.77	0.68
Average		5.27	4.59	0.69

(2) Survey in Flood Period

The survey was conducted again during August – September 1999. The range of the survey was from Hanoi Station in the upstream to Khuyen Luong port downstream of the project site.

The information needed from this survey was basically the same as that in the dry period. However, all data were taken when water level rose up to the flood plain in order to obtain the additional information during flood period for the hydraulic simulation.

The survey was conducted along the river with a total of 28 river profiles as shown in Figure 3.4.5. The distance interval within 1 km in the upstream and downstream of the project site was 200 m, while that out of this range was about 500 m.

River profile and water level were measured by a sonar method along the river in the wet land and leveling method along the flood plain in the dry land.

Velocity was measured by a current meter at the first, last section, project site and 1 km in the upstream and downstream of the project site simultaneously. Details of the survey are shown in the Report on Hydrological Survey, September 1999. Cross sections from the survey are shown in the Hydrological Report, a supplementary report for this Study.

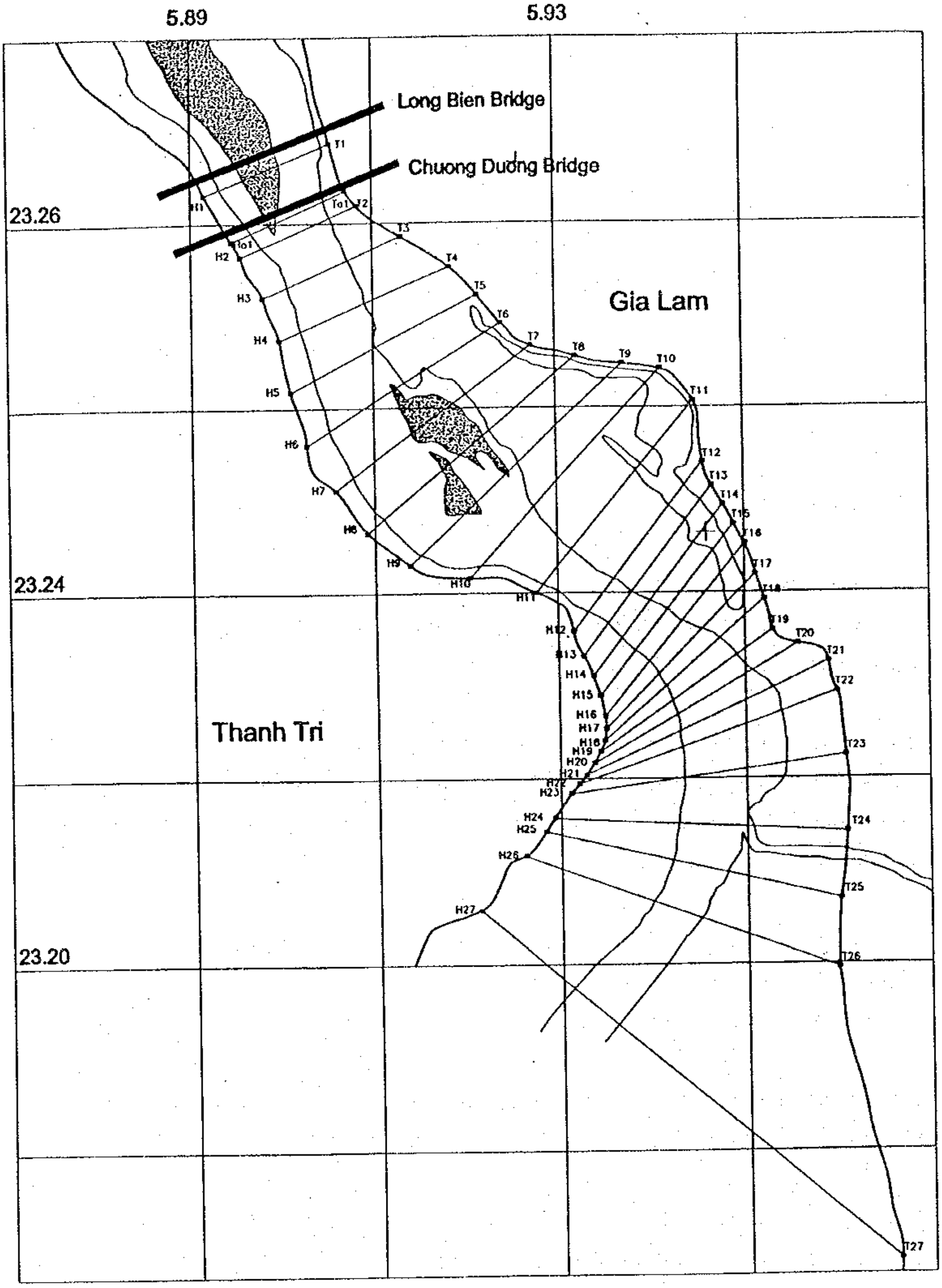


Figure 3.4.5 Location of Sections in the Hydrological Survey in 1999

A summary of the key sections is as follows:

Measured Water Level and Velocity in Flood Period

Section	Location	Date	Average Water Level (m)	Average Velocity (m/s)	Max. Section Velocity (m/s)
T-1	Hanoi Station	Sept. 1, 99	10.25	1.14	1.43
		Sept. 2, 99	10.63	1.26	1.57
T-12	1 km upstream of Project Site	Sept. 1, 99	9.55	1.62	2.38
		Sept. 2, 99	9.89	1.78	2.54
T-17	Project Site	Sept. 1, 99	9.50	1.67	1.81
		Sept. 2, 99	9.83	2.23	2.29
T-27	Khuyen Luong Port	Sept. 1, 99	9.22	1.53	2.04
		Sept. 2, 99	9.53	1.58	2.18
Water level difference (Hanoi Sta. - Project Site)		Sept. 1, 99	0.75	m	
		Sept. 2, 99	0.80	m	
		Average	0.78	m	

(3) Comparison of River Profile at the Project Site

In order to verify the river profile change at the project site, the measured cross section at the project site in this Study is compared with those measured in the Feasibility Study as shown in Figure 3.4.6. Due to the short period of measurement, any conclusion on the long-term change cannot be drawn from these data.

However, the figure shows no significant change of the bed profile. A variation of about 3 m can be found during those 2 years after 2 moderate floods. This magnitude is also about the same as the bed change at Hanoi Station.

3.4.6 Frequency Analysis

(1) Design Water Level

The frequency of the recorded data at Hanoi Station was analyzed by using the standard Gumbel method for the maximum water level. The analysis was divided into three periods, the period from 1945 to 1987, from 1988 to 1998 and the whole period from 1945 to 1988 by considering the flow change after the operation of the Hoa Binh reservoir and the diversion of discharge to the Day River in 1988.

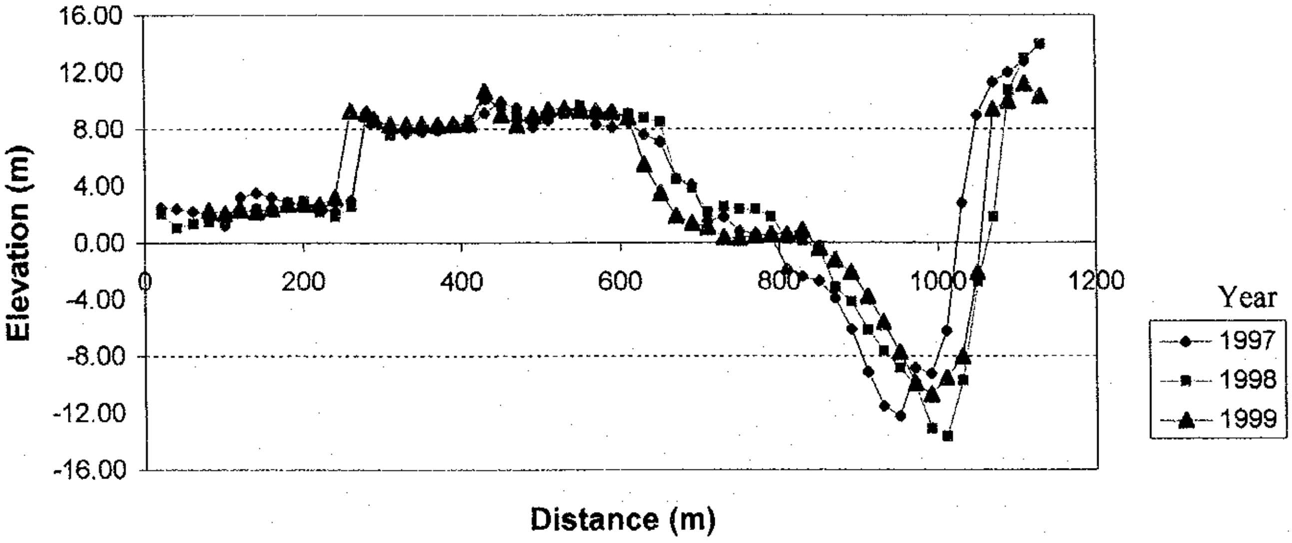


Figure 3.4.6 Comparison of the River Bed Profile at the Project Site

(Measured in 1997, 19998 and 1999)

Result of the analysis is shown in Table 3.4.3 and the plotting of the frequency is shown in Figure 3.4.7. It can be seen that the fitted curves for these three periods show no significant difference in comparison with the clearance depth of the bridge for navigation purpose at the project site (with the order of height of 10 m).

It should be noted that the frequency analyzed by the Hydro-meteorology Forecast and Service Division is slightly different, not in the fitted curve.

The ranges of the design high water level (HWL) at 20-year and 100-year return period are as follows:

20-year : HWL = 12.88 - 13.13 m.
100-year : HWL = 14.21 - 14.55 m.

Results of the hydrological surveys and hydraulic simulation (as also explained in the latter section) revealed the water level difference (Δh) between Hanoi Station and the project site as follows:

In June 1999,	Δh (Hanoi Station - Project Site)	=	0.69 m.
In August 1999,	Δh(Hanoi Station - Project Site)	=	0.75 m.
From simulation,	Δh (Hanoi Station - Project Site)	=	0.71 - 0.79 m
	Average Δh	=	0.72 m

Therefore the range of design water level (HWL) at the project site calculated by taking into consideration of the water surface gradient is as follows:

20-year : HWL = 12.16 - 12.41 m.
100-year : HWL = 13.49 - 13.83 m.

Thus, the proposed water level at a 20-year return period in the design is 12.50 m. This is also same as the value recommended by the Ministry of Transport. The HWL at 100-year return period from the above figure should be about 13.90 m.

Proposed Design Flood Water Level at Project Site

Return Period	Design Water Level (m)	Remark
20 year	12.50	from water surface gradient and MOT's recommendation
100 year	13.90	from rating curve (for reference only)

Table 3.4.3 Maximum Water Level at Each Return Period

(calculated before and after the reservoir, and overall period)

Return Period (year)	Max. Water Level (m, msl)		
	1945-1987	1988-1998	1945-1998
2	10.72	10.86	10.75
3	11.18	11.33	11.18
4	11.47	11.63	11.46
5	11.69	11.85	11.67
6	11.86	12.03	11.83
7	12.00	12.17	11.97
8	12.12	12.30	12.09
9	12.23	12.41	12.19
10	12.32	12.51	12.28
15	12.68	12.87	12.63
20	12.94	13.13	12.87
25	13.13	13.33	13.06
30	13.29	13.49	13.21
40	13.54	13.75	13.44
50	13.73	13.94	13.63
60	13.88	14.11	13.78
80	14.13	14.36	14.02
100	14.32	14.55	14.20
150	14.67	14.91	14.53
200	14.91	15.16	14.77

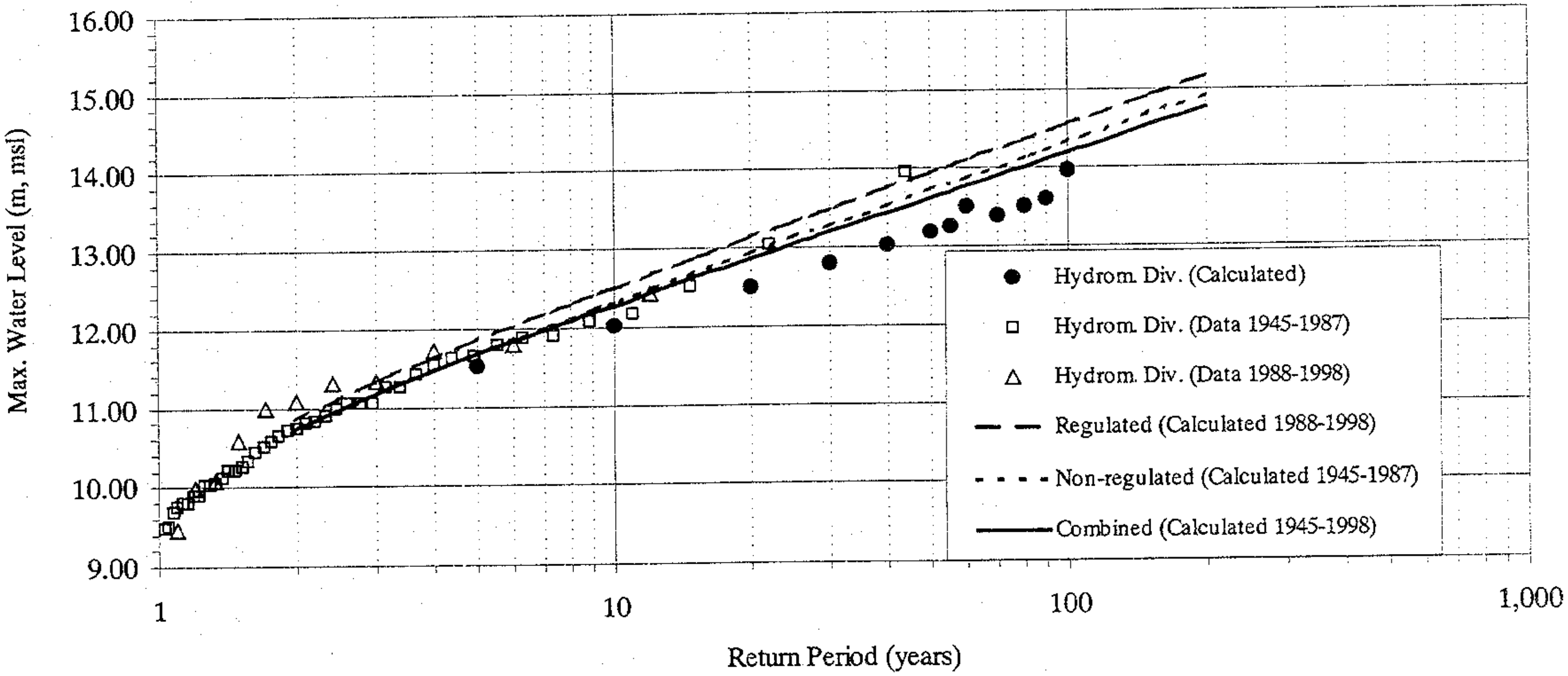


Figure 3.4.7 Relationship between Maximum Water Level and Return Period at Hanoi Station

However, it should be noted that since the maximum water level is controlled at 13.40 m according to the flow regulation in the Red River by Hoa Binh reservoir and the diversion, the HWL at 100-year return period is shown herein for reference.

(2) Design Flood Discharge

The floods in 1971 and 1996 are considered as the most severe floods before and after the flow regulation. The hydrograph as in Figure 3.4.8, shows a remarkable reduction of the flood peak discharge and water level after the flow regulation, but negligible change in the flood duration time.

The rating curve (H-Q curve) is formulated, as shown in Figure 3.4.9. The design discharge can be calculated from this rating curve. By considering this curve in combination with the rating curve from Hanoi Station and the UNDP report, the proposed design flood discharges are as follows:

Proposed Design Flood Discharge

Return Period	Design Flood Discharge (m^3/s)	Remark
20 year	17,900	from rating curve and references
100 year	22,200	equivalent to flood in 1971 (for reference only)

It should be noted that due to the flow regulation by the Hoa Binh reservoir, the maximum water level in the Red River is controlled as mentioned above. This controlled water level is equivalent to the flow of about 19,000 m^3/s according to the rating curve from Hanoi Station and the UNDP report.

3.4.7 Hydraulic Simulation

Hydraulic simulation is divided into three parts as follows:

1. Simulation of hydrograph along the river from Hanoi Station to the project site using an unsteady flow program so-called MIKE11 developed by the Danish Hydraulic Institute,

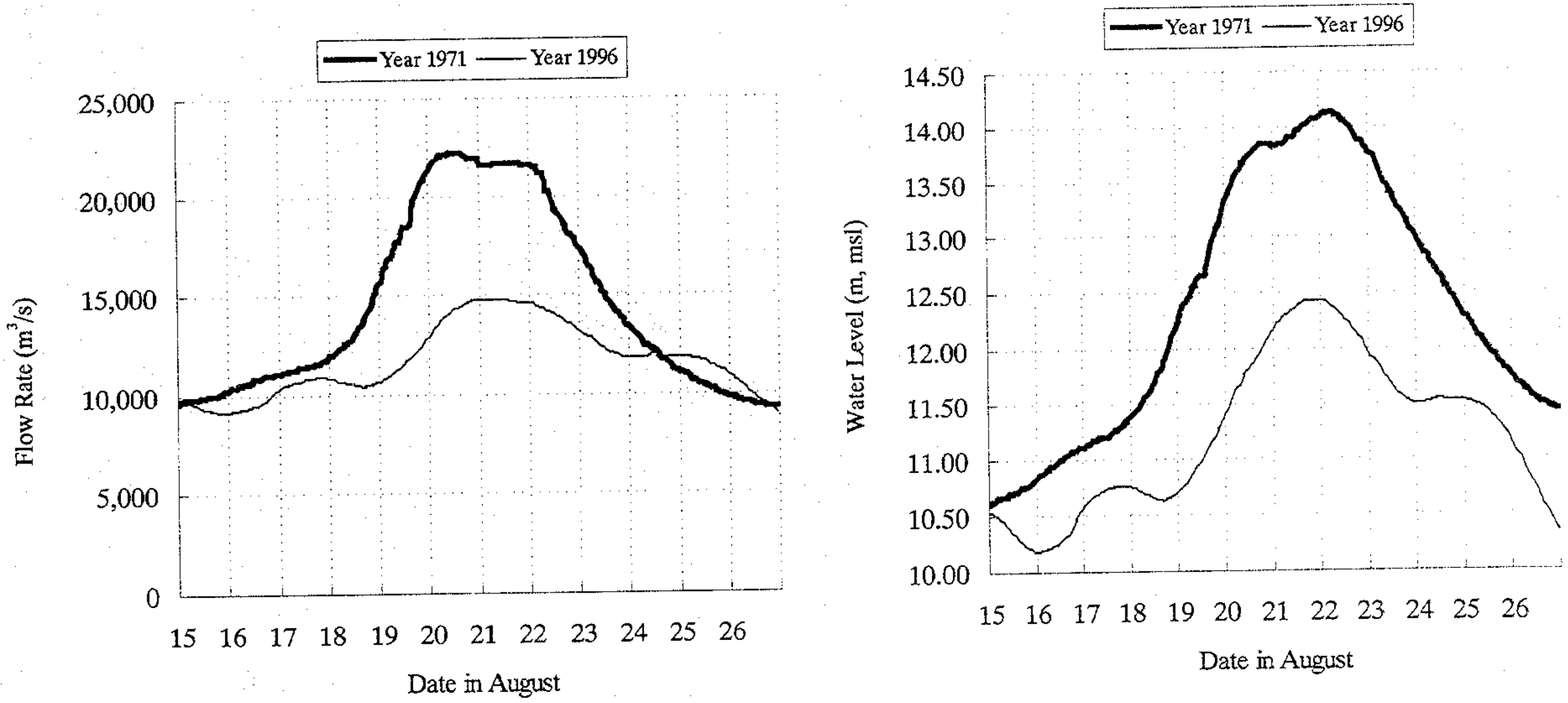


Figure 3.4.8 Discharge Hydrograph and Water Level at Hanoi Station During Flood in August 1971 and 1996

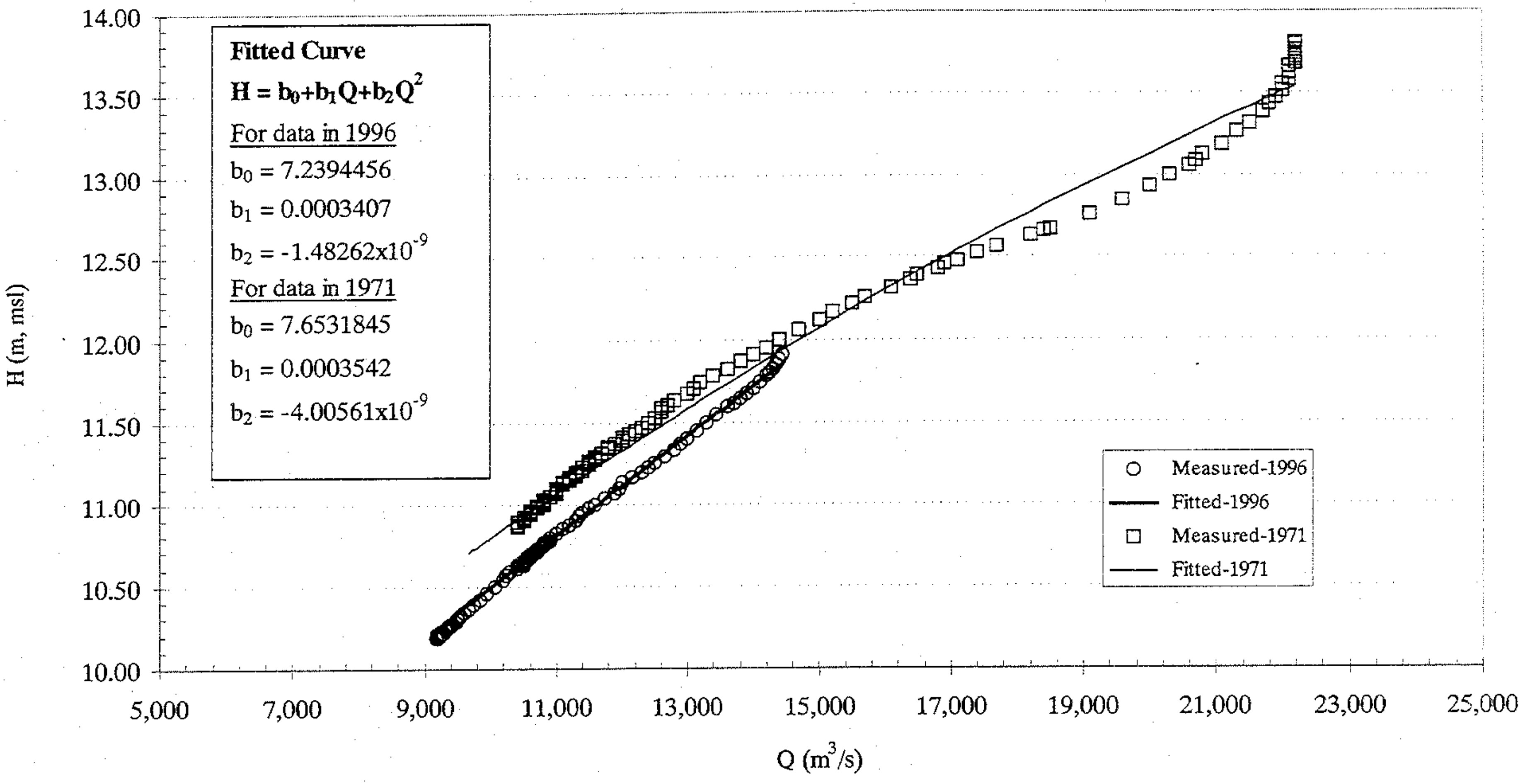


Figure 3.4.9 Relationship between Water Level (H) and Discharge (Q) at Hanoi Station

2. Simulation of surface-water velocity along the river from Hanoi Station to Khuyen Luong Port without and with the existence of bridge piers using a two-dimensional flow program so called FESWMS module of Surface-water Modeling System (SMS) developed by the Brigham Young University Environmental Modeling Research Laboratory based on the guidelines of the Federal Highway Administration, US Department of Transportation, in combination with simulation results from MIKE11 and

3. Calculation of scour at the design bridge piers using a scour computation program so called WSPRO module of Surface-water Modeling System (SMS) developed by the Brigham Young University Environmental Modeling Research Laboratory based on the guidelines of the Federal Highway Administration, US Department of Transportation.

(1) Simulation of Hydrograph

1) River Network

The river network model was set up from the river coordinate and the cross sections along the river from the river survey. Input of digitized cross section data from the river survey was conducted for the program. The controlled sections are as follows:

Controlled Cross Sections in the River Survey

Location	Sta. name	Hanoi side N	Hanoi side E	Gialam side N	Gialam side E	Width m (Dyke to Dyke)
Hanoi Station	T-1	2,327,659	588,543	2,328,214	589,924	1,489
Chuong Duong Bridge	Ta-1	2,327,180	588,868	2,327,687	590,074	1,308
Thanh Tri Bridge	T-17	2,321,860	593,037	2,323,671	594,534	2,349
Bac Hung Hai River	T-25	2,320,733	592,473	2,320,030	595,549	3,156
Khuyen Luong Port	T-27	2,319,771	591,693	2,315,962	596,282	5,964

The observed velocity and water level in June and August, 1999, at the controlled sections were used to calibrate the model. The grids controlled nodes have been set up in accordance with the river survey.

Theoretical consideration of the model is shown in the Hydrological Report, a supplementary report for the Study.

2) Simulation Results

In the calibration process, the hourly discharge hydrograph at Hanoi Station during August - September 1999, was input as the boundary condition. Water level and velocity at all sections were calculated. Water level at Station T-1 (Hanoi Station), Station T-12 (1 km upstream from the project site) and Station T-17 (the project site) were used to compare with the observed ones. Parameters in the model were adjusted for minimum error. Simulation then was performed for the three cases of design discharge as follows:

Simulation of Hydrograph

Case	Condition	Design flow Q (m^3/s)
I	Flood in 1971 (equivalent to 100-year return period)	22,200
II	Design flow at 20-year return period	17,900
III	Design equivalent flow at maximum water level controlled by Hoa Binh reservoir (maximum regulated flow)	19,000

The pattern of flood in 1971 was used to create the design hydrograph. The water level at the project site then was simulated from the design hydrograph. The maximum water level at the project site can be summarized as follows:

Simulated Water Level

Case	Water Level at Project Site(m)
I	13.42
II	12.50
III	12.75

The time duration of the flood was approximately 5 - 6 days.

(2) Simulation of Surface-water Velocity

1) River Network

The river model set up in the previous section was used in this calculation. The input coordinates and cross-sections were transferred to a finite element scheme.

The model was divided into two parts:

I) Model without the Bridge
II) Model with the Bridge

A series of 37 bridge piers was set up in the model. Nodes, elements and bridge piers are shown in Figure 3.3.10. Details are shown in the Hydrological Report, a supplementary report for this Study.

2) Simulation Results

Simulation was performed for the six cases, as follows:

Simulation of Surface-water Velocity

Case	Condition	
I	Flood in 1971	Without bridge
I-B	Flood in 1971	With bridge
II	Design flow at 20-year return period	Without bridge
II-B	Design flow at 20-year return period	With bridge
III	Design equivalent flow at maximum regulated flow	Without bridge
III-B	Design equivalent flow at maximum regulated flow	With bridge

Results of the simulation in each case are also shown in the Hydrological Report.

Variation of the bed elevation is shown in Figure 3.4.11. The beds are comparatively low in the Section T-2 to T-4 and T-9 to T-11 with a range of -12.0 to -15.7 m.

Variation of the water level and velocity without and with bridge at the dyke and flood plain in Hanoi and Gai Lam, and the main channel are shown in Figure 3.4.12, Figure 3.4.13 and Table 3.4.4. It can be summarized briefly as follows:

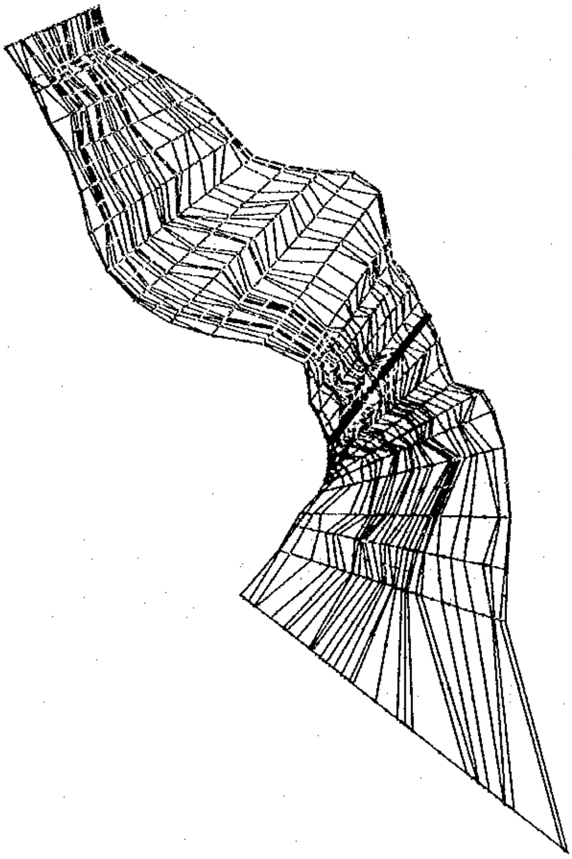


Figure 3.4.10 Nodes and Elements in the River Network for the Simulation of Surface-water Velocity

(For description of the Figure, refer to Figure 3.3.5)

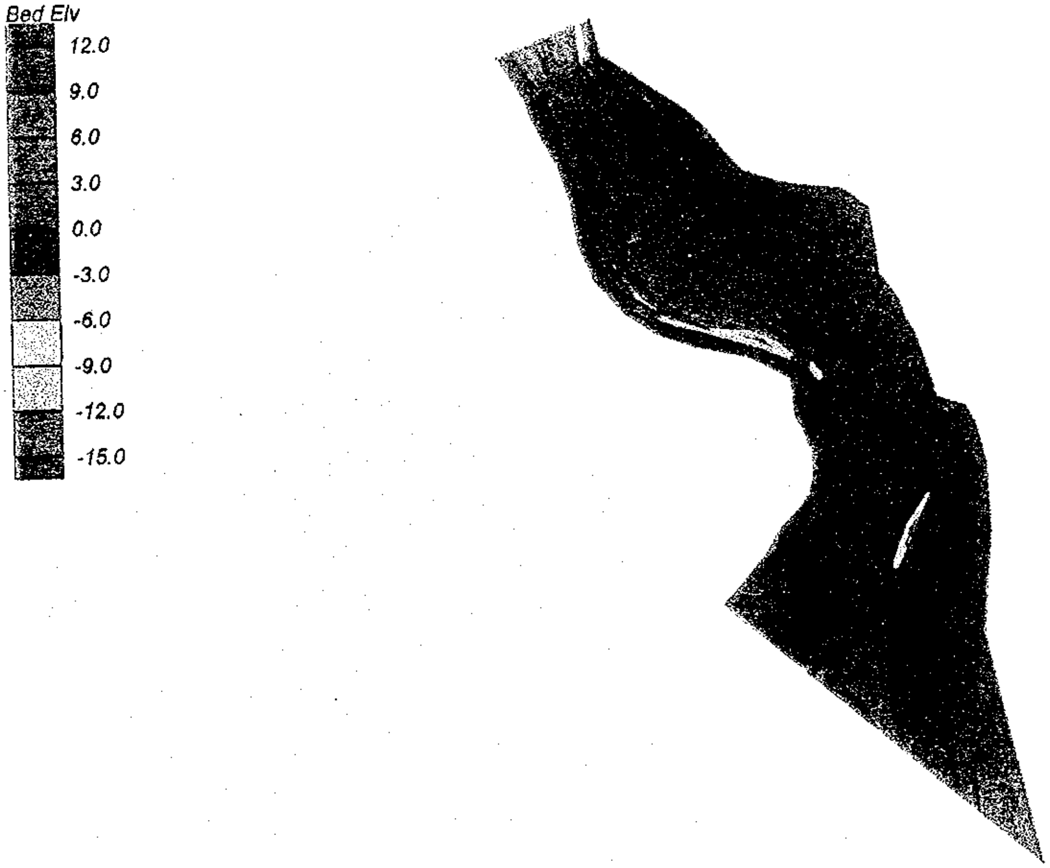


Figure 3.4.11 Bed Elevation of the River
(Bed Elevation Unit: m, msl)

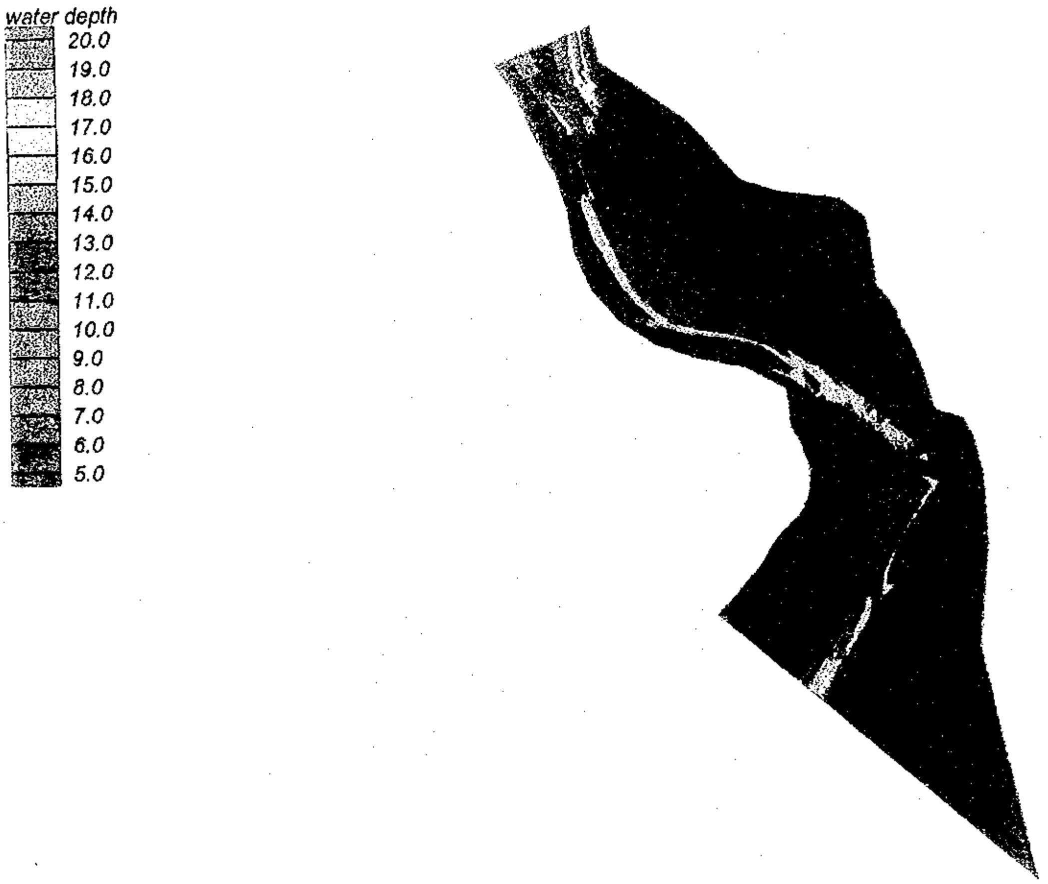


Figure 3.4.12 Simulated Water Depth at 20-year Return Period

(Water Depth Unit : m)

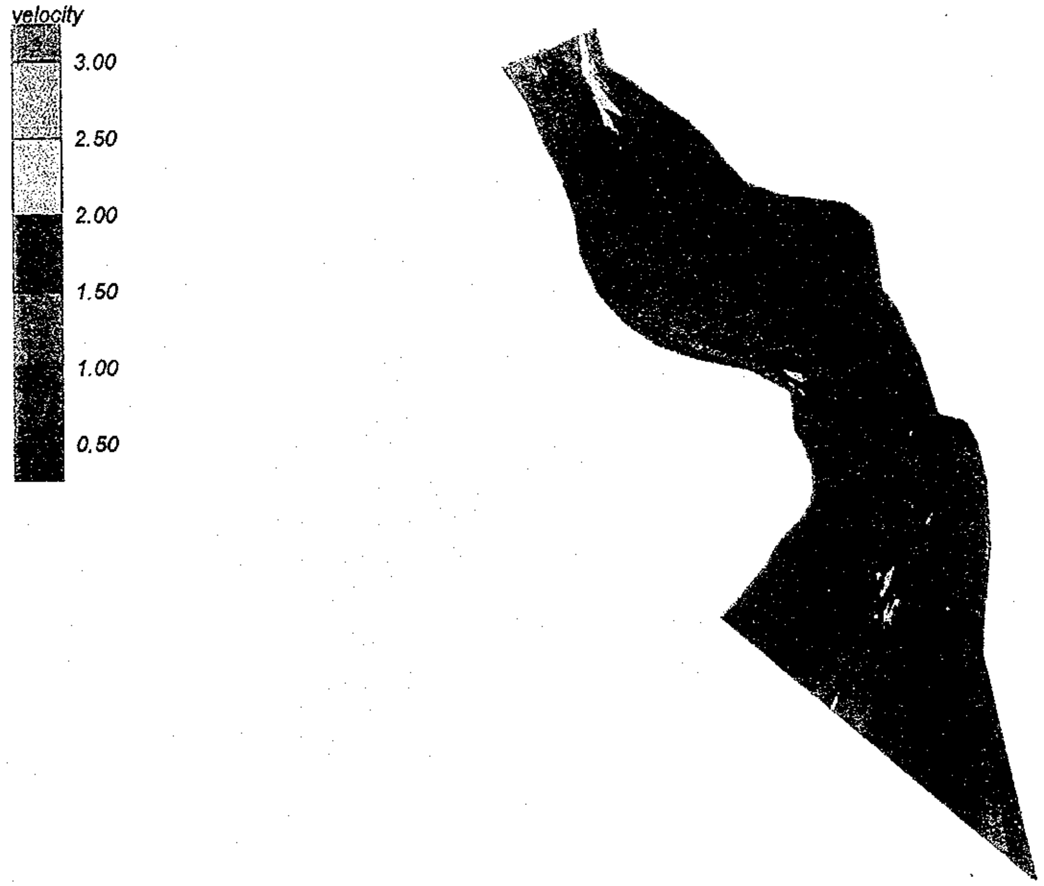


Figure 3.4.13 (1) **Simulated Velocity at 20-year Return Period, Without Bridge**
(Velocity Unit: m/s)

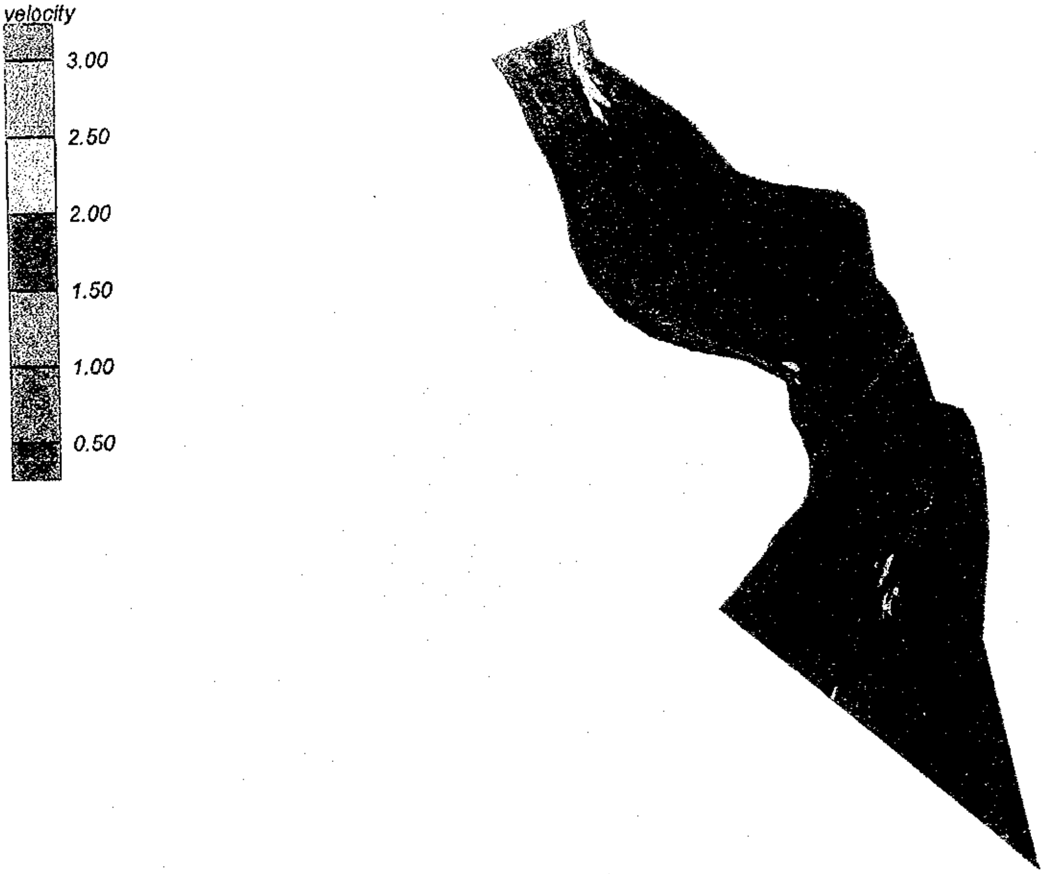


Figure 3.4.13 (2) Simulated Velocity at 20-year Return Period, With Bridge
(Velocity Unit : m/s)

Table 3.4.4 Simulated Water Level and Velocity at Nodes along the Bridge

Case	Node No.	Water Level (m)	Water Depth (m)	Velocity (m/s)	Froude No.	Energy Grade Line (m)	Bed Shear Stress (N/m2)	Vorticity (Rad/s)
I (Without Bridge) (flood in 1971)	887	13.66	7.56	0.76	0.09	13.68	2.60	-0.0041
	903	13.70	4.43	1.42	0.22	13.80	10.80	-0.0103
	922	13.74	13.04	2.12	0.19	13.97	16.80	0.0002
	1461	13.80	7.64	0.55	0.06	13.82	1.37	0.0020
	2431	13.83	6.93	0.96	0.12	13.88	4.29	0.0017
I-B (With Bridge) (flood in 1971)	887	13.65	7.55	0.85	0.10	13.69	3.25	-0.0044
	903	13.70	4.43	1.17	0.18	13.77	7.29	-0.0203
	922	13.77	13.07	2.10	0.19	13.99	16.40	0.0013
	1461	13.83	7.67	0.54	0.06	13.85	1.28	-0.0008
	2431	13.85	6.95	0.80	0.10	13.89	2.97	0.0023
II (Without Bridge) (20-year)	887	12.78	6.68	0.62	0.08	12.80	1.80	-0.0039
	903	12.81	3.54	1.21	0.21	12.88	8.50	0.0050
	922	12.85	12.15	1.99	0.18	13.06	15.20	-0.0007
	1461	12.91	6.74	0.38	0.05	12.91	0.66	-0.0030
	2431	12.93	6.03	0.60	0.08	12.95	1.74	0.0003
II-B (With Bridge) (20-year)	887	12.78	6.68	0.67	0.08	12.80	2.08	-0.0041
	903	12.82	3.55	1.05	0.18	12.87	6.37	-0.0047
	922	12.88	12.18	1.96	0.18	13.07	14.70	0.0000
	1461	12.93	6.76	0.38	0.05	12.93	0.68	-0.0042
	2431	12.95	6.05	0.52	0.07	12.97	1.29	0.0003
III (Without Bridge) (maximum regulated flow)	887	12.96	6.86	0.68	0.08	12.99	2.12	-0.0038
	903	13.00	3.73	1.32	0.22	13.08	9.86	0.0001
	922	13.05	12.35	2.07	0.19	13.26	16.30	-0.0006
	1461	13.10	6.94	0.39	0.05	13.11	0.71	-0.0101
	2431	13.13	6.23	0.60	0.08	13.15	1.72	-0.0005
III-B (With Bridge) (maximum regulated flow)	887	12.96	6.86	0.75	0.09	12.99	2.59	-0.0043
	903	13.00	3.73	1.07	0.18	13.06	6.45	-0.0148
	922	13.07	12.37	2.05	0.19	13.28	16.00	0.0001
	1461	13.13	6.96	0.37	0.05	13.13	0.63	-0.0128
	2431	13.15	6.25	0.46	0.06	13.16	1.03	0.0004

where Node 887 : Hanoi Dyke,

Node 903 : Flood plain in Hanoi side,
between pier no. 7 and 8,

Node 926 : Main channel, between pier no. 15 and 16,

Node 1461 : Flood plain in Gia Lam side,
between pier no. 26 and 27,

Node 2431 : Gia Lam Dyke.

Simulated Water Level and Velocity along the Bridge (Project Site)

Case	Location	Water Level (m)	Velocity (m/s)
I (without Bridge) (flood in 1971)	Dyke in Hanoi	13.66	0.76
	Dyke in Gia Lam	13.83	0.96
I-B (with bridge) (flood in 1971)	Dyke in Hanoi	13.65	0.85
	Dyke in Gia Lam	13.85	0.80
II (Without Bridge) (20-year)	Dyke in Hanoi	12.78	0.62
	Flood Plain in Hanoi	12.81	1.21
	Main Channel	12.85	1.99
	Flood Plain in Gia Lam	12.91	0.38
	Dyke in Gia Lam	12.93	0.60
II-B (With Bridge) (20-year)	Dyke in Hanoi	12.78	0.67
	Flood Plain in Hanoi	12.82	1.05
	Main Channel	12.88	1.96
	Flood Plain in Gia Lam	12.93	0.38
	Dyke in Gia Lam	12.95	0.52
III (without Bridge) (max. regulated flow)	Dyke in Hanoi	12.96	0.68
	Dyke in Gia Lam	13.13	0.60
III-B (with Bridge) (max. regulated flow)	Dyke in Hanoi	12.96	0.75
	Dyke in Gia Lam	13.15	0.46

Because the bridge is designed at a 20-year return period, the summary in the above table is focused on only Case II and Case II-B. However, all the results from the calculation are shown in the Hydrological Report.

For Case II and II-B (without/with bridge at 20-year return period), the maximum velocity is also found at the location about 100 - 200 m downstream of the pier no. 14 and 15 (node 1153) at 1.99 m/s.

Velocity is somewhat high at the Section T-2 to T-4 and T-11 where the river width is apparently narrow. This narrow width causes an immediate cross-sectional area reduction and results in the higher velocity.

Variation of the velocity at the project site is in a range between 0.4 to 2.0 m/s for the simulated Case II and II-B (20-year return period). This is considered as in a moderate velocity range compared to the other sections.

Water level in the case with bridge is slightly lower than that without bridge within a range of 5 %; on the other hand its velocity is higher, within a range of 10%. As a result, this variation leads to a conclusion that the bridge will have no significant impact to dykes both in Hanoi and Gia Lam.

Fluctuation of the water level and velocity due to the impact of the bridge piers is negligibly small at all controlled nodes about 100 m in the upstream and downstream of the bridge piers.

It should be noted that the outflow at Bac Hung Hai River is not taken into consideration in the calculation because its location is somewhat far from the project site and expected to have no interaction with the project site. There is also no available or reliable data on the flow in this river. Therefore, the result of simulation from the Section T-24 to T-26 (nearby the Bac Hung Hai River) is not recommended for any use.

(3) Calculation of Scour

1) River Network

The river model was also used for the calculation of scour. The sections in the upstream and downstream of the bridge were used to calculate the energy grade line and water level. A series of 7 bridge piers in the main channel with a total bridge span of 680 m (80 + 130×4 + 80) was focused upon. The calculation of scour depth and water level change between the front and back of the piers were performed based on the energy loss due to the existence of bridge piers.

2) Simulation Results

Simulation was performed for the three following cases:

Calculation of Scour

Case	Condition	
I-B	Flood in 1971	With bridge
II-B	Design flow at 20-year return period	With bridge
III-B	Design equivalent flow at maximum regulated flow	With bridge

The input data and results of the calculation are shown in the Hydrological Report, a supplementary report for this Study.

The results reveal the water surface difference and velocity at the section upstream, downstream and bridge section as shown in Table 3.4.5, and can be summarized as follows:

Bridge Draw Down Depth and Total Scour

Case	Bridge Draw Down Depth (m)	Total Scour (m)
I-B	0.50	9.87
II-B	0.12	8.35
III-B	0.13	8.49

The bridge draw down depth is the water level difference between the point in front of and behind a bridge pier. The total scour is the summation of live-bed and local scour.

Water level change resulting from the bridge is somewhat high for Case I-B, but negligible for Cases II-B and III-B.

The calculated total scour at the bridge pier at 20-year return period or Case II-B is about 8.35 m. Therefore, the proposed scour depth in the design is 8.50 m.

It should be noted that this scour depth is greater than that in the Feasibility Study at 6.0 m as the proposed value in the Feasibility Study is an average maximum value.

Fluctuation of the water level and velocity due to bridge piers is expected to be in a range of about twice the scour depth, according to the "Evaluating Scour at Bridges, 3rd Edition, by the US Department of Transportation, the Federal Highway Administration, 1995, as shown in the Hydrological Report, a supplementary report for this Study.

Thus, the horizontal diameter of the flow fluctuation around a bridge pier should be approximately 17 m (8.50×2 = 17.0 m).

3.4.8 Conclusion and Recommendation

From the results of calculation, it can be concluded that

- Historical records of river profile nearby the project site (section 48) show no significant change of the river bed and flood plain during 1981 - 1998. The river course in this part is stable.

Table 3.4.5 Water Level, Velocity and Scour at the Bridge Piers

Water Level and Velocity

Case	Section	Symbol in Program	Water level (m)	Velocity (m/s)	Froud Number	Bridge Draw Down (m)
I-B	Unconstricted Flow					0.50 (FULLV-BR2)
	1. Upstream of bridge	APPR	13.61	1.62	0.21	
	2. Bridge section	FULLV	13.50	1.44	0.18	
	3. Downstream of bridge	EXIT	13.42	1.29	0.15	
	Constricted Flow					
	1. Bridge section	BR2	13.00	2.60	0.33	
	2. Upstream of bridge	APPR	14.13	1.48	0.19	
II-B	Unconstricted Flow					0.12 (FULLV-BR2)
	1. Upstream of bridge	APPR	12.70	1.54	0.22	
	2. Bridge section	FULLV	12.58	1.34	0.18	
	3. Downstream of bridge	EXIT	12.50	1.19	0.15	
	Constricted Flow					
	1. Bridge section	BR2	12.46	2.17	0.20	
	2. Upstream of bridge	APPR	12.78	1.52	0.22	
III-B	Unconstricted Flow					0.13 (FULLV-BR2)
	1. Upstream of bridge	APPR	12.95	1.56	0.22	
	2. Bridge section	FULLV	12.83	1.37	0.18	
	3. Downstream of bridge	EXIT	12.75	1.22	0.15	
	Constricted Flow					
	1. Bridge section	BR2	12.70	2.26	0.21	
	2. Upstream of bridge	APPR	13.03	1.53	0.21	

Live Bed Scour and Local Scour

Case	Scour Depth (m)		
	Live Bed	Local	Total
I-B	0.73	9.14	9.87
II-B	0.02	8.33	8.35
III-B	0.02	8.48	8.49

Note : Unconstricted flow is the flow condition without the bridge piers, Constricted flow is the flow condition with the bridge piers.

- The simulated water level at the project site (Station T-17) during flood in 1971 (13.42 m), 20-year return period (12.50 m) and maximum regulated flow (12.75 m) are lower than the height of dyke in Hanoi (14.26 m) and Gia Lam (13.95 m).

- The surface-water velocity is apparently very high at Station T-4 to T-6 (3.0 - 4.0 m/s), and somewhat high at Station T-10 to T-12 and T-24 to T-26 (2.5 - 3.0 m/s).

- The surface-water velocity at and nearby the project site varies from 1.0 - 2.0 m/s and the maximum value is found at the location behind the pier no. 14 and 15.

- Maximum scour depth at a bridge pier is about 8.50 m at 20-year return period.

- Fluctuation of water level and velocity due to the nearest bridge pier (about 70 m away from the dyke) at the dyke in Hanoi and Gia Lam is negligible.

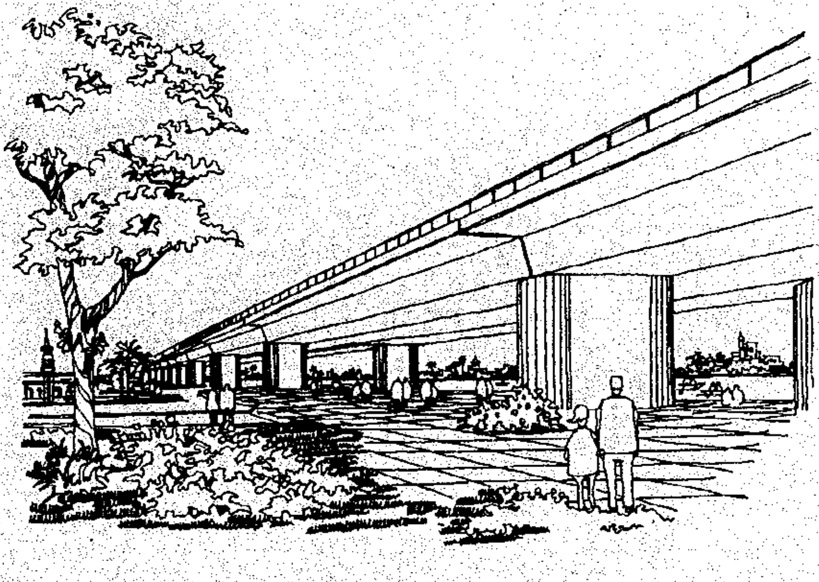
- The bridge piers may have impact to the flow within the distance of about 17 m in the upstream and downstream of the bridge piers.

- It is evident that the river course at the project site is stable. The velocity is not so high compared with the other sections.

- It is recommended that revetment should be constructed on the flood plain and main channel under the bridge to protect the flow disturbance and erosion at a distance of at least 17 m in the upstream and downstream.

- It is also recommended that monitoring of the flow and river morphology change should be conducted after the completion of the bridge.

CHAPTER 4 DESIGN STANDARDS



CHAPTER 4 DESIGN STANDARDS

4.1 Highway Design Standard

Expressways and highways in the Vietnam road standard TCVN 5729-1997 and TCVN 4054-85 are based on AASHTO due to lack of design standard for arterial roads. Therefore, Vietnam road standards, especially for road geometric design and pavement design is closer to that of AASHTO. On the other hand, local roads are still based on the Russian standard.

Generally, lane width is decided according to design speed and vehicle type is larger than that of Japanese Standard (for instance, 100 km/hr: Vietnam 3.75 m, Japan 3.50 m), and vertical clearance of expressway is higher than that of Japan (Vietnam: 4.75 m, Japan: 4.5 m), though vertical clearance of highway is the same as that of Japan (Vietnam 4.5 m, Japan 4.5 m).

4.1.1 Design Standard of Expressways and Highways

Highway design criteria was established for the Detailed Design of the Red River Bridge Construction Project (hereinafter referred to as " the project"). The design criteria are decided based on Vietnamese standards with reference to Japanese standard and design policy of highway and streets in the USA (AASHTO). In addition, the design criteria are considered based on the concept of the feasibility study by JICA.

(1) Classification of Expressway

Expressway classification based on the Vietnamese standard is divided into three categories depending on median type (mounted-up type without location pier of bridge, mounted-up type and locating pier of bridge, no mounted-up type), and further is divided into three classes according to design speed (Grade 80: 80 km/h, Grade100 :100 km/h and Grade120 :120 km/h).

For the project, the following warrant the design speed of 100 km/h (Grade 100) applied to the throughway of the project :

- to install a toll plaza of barrier-gate type on the throughway where all vehicles stop to pay toll;

- to avert excessive eviction of local inhabitants by applying sharper curves;
- to accommodate the entire scheme of Hanoi Third Ring Road with reasonable construction economy yet high level of service.

Grade100 was selected from the viewpoint of future traffic demand, terrain, state development plans and cost/benefit.

(2) Classification of Highway and Other Roads

Highway classification is divided into five classes according to road function as shown in Table 4.1.1. The number of lanes, design speed and future traffic volume are decided according to the each classification.

Table 4.1.1 Highway Classification

Classification	Function	Design Speed Km/h	Number of Lanes
I	Link to the important economic and political cultural centers	80 or 60	6
II			4
III			2
IV	Link to the economic and political cultural centers, and link with the main truck road or expressway	60 or 40	2
V	Link to the distribution centers and resident areas	40 or 20	2 or 1

National highways (NH1 and NH5) and urban arterial roads (Phap Van Cau Gie Road, Nguyen Tam Trinh Road and Thanh Tri Dyke Road, and Gia Lam Road in the future plan) crossing the project road are applied to Categories I and II. The frontage roads' access between throughway the above roads are applied to Category IV.

(3) Consideration for Geometric Design Criteria

The geometric design criteria in the project are studied and decided based on the following standards:

a) Expressway standard in Vietnam (TCVN 5729 : 1997)
b) Highway standard in Vietnam (TCVN 4054 - 1998)
c) Design standard of rural road (22-TCN-210-92)
d) Japanese standard (256 - 1983)
e) Policy on geometric design of highway and streets in USA (AASHTO, 1994)

However, the geometric design criteria adopted will be based on the Vietnamese standards as much as possible, using other standards as reference.

(4) Design Criteria

1) Lane width

Lane width is fixed according to the design speed and vehicle type. Table 4.1.2 shows the lane width for each design speed. Generally, 3.0 m to 3.75 m lane widths are used, and 3.75 m lane width is internationally accepted as the widest possible lane width as lanes wider than 3.75 m cause difficulty in regulating traffic flow. In case a design speed of more than 100 km/h is applied to a highway, 3.75 m lane width (12ft in AASHTO) is desirable for both rural and urban facilities.

Table 4.1.2 Lane Width

Design Speed	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	3.75	3.5	3.6	3.75
80 km/hr	3.5	3.5	3.6	3.5
60 km/hr	3.5	3.25	3.6	3.5
40 km/hr	3.0	3.5	2.7	3.5
20 km/hr	3.5 (1 lane)	4.0 (1 lane)	3.6	4.0

Note: The above figures are indicated in meters

2) Median width

In order to insure smooth flow of traffic and safety, a median is adapted to a highway with than four lanes or more. Table 4.1.3 shows the comparison of the minimum median width.

Table 4.1.3 Minimum Median Width

Design Speed	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	1.0 m - 3.0 m	3.0 m	2.0 m	2.0 m
80 km/hr	0.5 m - 3.0 m	1.25 m	1.2 m	1.0 m
60 km/hr	0.5 m - 3.0 m	1.25 m (*0.5 m)	1.2 m	1.0 m
40 km/hr	0.5 m - 3.0 m	1.0 m	1.2 m	1.0 m
20 km/hr	-	-	-	-

3) Shoulder

Shoulders shall be provided for not only keeping side clearance to ensure smooth traffic flow and increase traffic safety but also protecting for pavement edge of the carriageway. Table 4.1.4 shows the comparison for minimum shoulder width.

Table 4.1.4 Minimum Shoulder Width

Design Speed	Location	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	Outer	3.0 m	2.5 m	3.0 m	3.0 m
	Inner	0.75 m	1.25 m	1.2 m	1.0 m
80 km/hr	Outer	**2.5 m	1.25 m	2.4 m	1.0 m
	Inner	0.5 m	0.5 m	1.2 m	0.5 m
60 km/hr	Outer	**2.0 m	0.75 m (*0.5 m)	2.4 m	1.0 m
	Inner	0.5 m	0.5 m	1.2 m	0.5 m
40 km/hr	Outer	1.5 m	0.5 m	-	0.5 m
	Inner	1.5 m	0.5 m	-	0.5 m
20 km/hr	Outer	1.5 m	0.5 m	-	0.5 m
	Inner	1.5 m	0.5 m	-	0.5 m

Note : (*) is in urban area.   ** includes width of bicycle lane

4) Bicycle lane width

Cyclists should be protected from motorized vehicles. One of most practical measures is to separate cyclists from fast-moving motorized vehicles. The separation contributes to increase traffic capacity of carriageway and enhances traffic safety as well.

The minimum width of bicycle lanes adopted on a highway are shown in Table 4.1.5

Table 4.1.5 Minimum Width of Bicycle Lane

Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
1.5 m	2.0 m	-	3.0 m

Since horizontal clearance of a bicycle is 1.0-1.5 m, the minimum width of the bicycle lane is to be 3.0 m so that two bicycles can pass simultaneously. The bicycle lane is to be separated from the carriageway by a guardrail or other facility.

5) Cross slope (cross-fall)

Cross slope on the highway pavement is required to divert rainwater into the side drainage. For the project, a cross slope of 2 % is adopted from the viewpoint of convenience to traffic.

6) Vertical and horizontal clearance

The vertical clearance of the expressway and the highway is shown in Table 4.1.6.

Table 4.1.6 Vertical Clearance of Expressway/Highway

Classification	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
Expressway	4.75	4.5	4.9	4.75
Highway	4.5	4.5	4.9	4.5

(Railway)
As train car size differs by country, the railway vertical clearance is to be set at 6.80 m in accordance with the Vietnamese standard. In the fourth project working meeting held on 23rd September 1995, it was decided that vertical and horizontal railway clearance are to be 6.80 m and 25 m respectively for the future electric rail.

(Navigation)
Navigation water level is set at 12.50 m in accordance with the requirements by the Waterway Management Department. Navigation vertical clearance is 10 m.

7) Horizontal Curve

The Vietnamese standard and AASHTO use the same value. Therefore, the Vietnamese Standard shall be applied as shown in Table 4.1.7.

Table 4.1.7 Minimum Radius of Curve in Vietnamese Standard

Design Speed					Super-elevation
100 km/hr	80 km/hr	60 km/hr	40 km/hr	20 km/hr	
2,000 m	500 m	250 m	100m	-	2 %
1,550 m	350 m	200 m	75m	50 m	3 %
1,100 m	300 m	175 m	75m	50 m	4 %
650 m	275 m	150 m	60m	14 m	5 %
550 m	250 m	125 m	60m	14 m	6 %
450 m	-	-	-	-	7 %

8) Vertical Curve

Vertical curves are to be provided at the changing point of vertical gradient on the carriageway to ensure comfort in travelling and ample sight distance. Therefore, the radius of vertical curves are to be of the greatest value possible. Table 4.1.8 shows the minimum radius of vertical curve.

Table 4.1.8 Minimum Radius of Vertical Curve

Design Speed		Vietnamese Standard	Japanese Standard	Adopted Value
100 km/hr	Crest	6,000	6,500	6,500
	Sag	3,000	3,000	3,000
80 km/hr	Crest	4,000	3,000	3,000
	Sag	2,000	2,000	2,000
60 km/hr	Crest	1,500	1,400	1,500
	Sag	1,000	1,000	1,000

9) Vertical Gradient

The design of vertical gradient on the section with same design speed is to be executed to maintain traffic conditions. However, the grade design can not provide for all traffic conditions as the performance of vehicles differ. Therefore, the vertical gradient is to be designed according to the design speed and hill climbing performance of the vehicle.

Table 4.1.9 shows the maximum vertical gradient for each design speed.

Table 4.1.9 Maximum Vertical Gradient

Design Speed	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	5 %	3 % (*5 %)	5 %	4 %
80 km/hr	6 %	4 % (*7 %)	6 %	6 % (**4 %)
60 km/hr	7 %	5 % (*8 %)	7 %	7 %

Note : (*) is applied for special sections. (**) is for flat sections.

10) Transition Curve

Transition curves are to be located between straight curved sections, or two or more curved sections to make for a smooth shift. Table 4.1.10 shows the comparison for the length of transition curve for minimum radius.

Table 4.1.10 Length of Transition Curve for Minimum Radius

Design Speed	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	100	85 m	-	100
80 km/hr	90	70 m	-	90

For the transition curve in both Vietnamese and Japanese standards, the clothoid curve is used. The length of transition curve for minimum radius is to be based on the Vietnamese standard.

11) Super-elevation

Traffic on the curved section of the road is subject to centrifugal force. Centrifugal forces must be resisted by the adhesion between the road surface and vehicle tires unless superelevation of the road surface is provided to ensure equalized action of the force and smooth running of the vehicle.

Table 4.1.11 shows the comparison of maximum superelevation of Vietnam, Japanese and AASHTO standard for expressway and highway and the value to be adopted for the project.

Table 4.1.11 Maximum Super-elevation

Unit : %

Categories	Vietnam Standard	Japanese Standard	AASHTO	Adopted Value
Highway	6	10	12	6
Expressway	7	10	8 - 12	7

The project area is expected to be developed in the future, the maximum superelevation is to be 6 %.

12) Sight Distance

a) Stopping Sight Distance

Table 4.1.12 shows the comparison of minimum stopping sight distance of Vietnam, Japanese, and AASHTO standards and the value to be adopted for the project.

Table 4.1.12 Minimum Stopping Sight Distance

Design Speed	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	160 m	160 m	-	160 m
80 km/hr	100 m	110 m	139 m	100 m
60 km/hr	75 m	75 m	85 m	75 m

b) Travelling Sight Distance

Two-direction and two-lane highways are considered to ensure smooth and safe travel. Table 4.1.13 shows the comparison of maximum travelling sight distance of Vietnam, Japanese and AASHTO standard and the value to be adopted for the project.

Table 4.1.13 Travelling Sight Distance

Design Speed	Vietnamese Standard	Japanese Standard	AASHTO	Adopted Value
100 km/hr	-	700 m	-	700 m
80 km/hr	600	550 m	580 m	550 m
60 km/hr	250	350 m	315 m	350 m

A four-lane highway requires 100 km/hr design speed, travelling sight distance is not indicated.

(5) Summary of Design Criteria

- Throughway (expressway) -

Table 4.1.14 shows the summary of the design criteria for the throughway (expressway).

Table 4.1.14 Summary of Design Criteria for Throughway

Item	Unit	Adopted Value
Class Road		Class I-II
Design Speed	Km/h	100
Cross Section Elements	Lanes	
Number of Lanes	m	4
Lane Width	m	3.75
Median Width	m	2.0
Inner Shoulder Width	m	1.0
Outer Shoulder Width	m	3.0
Cross-fall of Carriageway	%	2.0
Cross-fall of Shoulder	%	2.0
Maximum Super-elevation	%	7.0
Horizontal Alignment		
Minimum Radius	m	450
Length of transition curve for minimum radius	m	100
Minimum radius without super-elevation	m	3,000
Vertical Alignment		
Maximum Grade	%	4
Minimum Radius of Vertical Curve		
Crest	m	6,000
Sag	m	3,000
Minimum Stopping Sight Distance	m	160
Minimum Passing Sight Distance	m	700
Vertical Clearance	m	4.75

- Frontage Road -

Table 4.1.15 shows the summary of the design criteria for the throughway (expressway)

Table 4.1.15 Summary of Design Criteria for Frontage Road

Item	Unit	Adopted Value
Class Road		Class IV
Design Speed	Km/h	60
Cross Section Elements		
Number of Lanes	Lanes	2
Lane Width	m	3.5
Median	m	-
Inner Shoulder Width	m	0.5
Outer Shoulder Width	m	0.5
Crossfall of Carriageway	%	2
Crossfall of Shoulder	%	2
Maximum Super-elevation	%	6
Horizontal Alignment		
Minimum Radius	m	150 (125)
Critical curve radius with transition curve	m	500
Minimum curve radius without super-elevation	m	500
Vertical Alignment		
Maximum Grade	%	6
Minimum Radius of Vertical Curve		
Crest	m	1,500
Sag	m	1,000
Minimum Stopping Sight Distance	m	75
Minimum Passing Sight Distance	m	350
Vertical Clearance	m	4.5

4.1.2 Design Standard of Interchange

(1) Standard for the throughway in the Vicinity of Interchange

As the road's design speed is 100 km/h, the interchange must be located at an appropriate point along the main road so as to provide adequate sight distance for traffic safety. Thus when the interchange has more lanes and allows for speed changes, vehicles may enter/exit at high speed from/to the main road. The geometric standard to be applied is the Japanese standard for interchanges of the recommended main road that is shown in Table 4.1.16.

Table 4.1.16 Throughway Standard in the Vicinity of Interchange

Item	Unit	Requirement
Design Speed of Main Road	Km/h	100
Minimum Radius	m	1500 (* 1000)
Minimum Vertical Curve (Crest)	m	25,000 (* 15 000)
Minimum Vertical Curve (Sag)	m	12,000 (* 8000)
Maximum Gradient	%	2 (* 3)

Note : (*) is special case

(2) Design Speed of Interchange Ramp

Generally, ramp design speed is decided based on the class of each connected road, design speed of the throughway, and traffic volume on the interchange ramp.

With reference to Table 4.1.17, a design speed of 50 km/h for junction ramp (expressway to high speed road) and 40 km/h for the interchange ramp (expressway to arterial road) are recommended in Japanese Standard. For the project, 40 km /h is adopted.

Table 4.1.17 Design Speed of Interchange

Unit : km/h

Vietnamese Standard	AASHTO	Japanese Standard	Adopted Value
45-70	40-60	40-60	40

Note: Design Speed of the throughway : 100 km/h

(3) Geometric Design Criteria

The geometric design standard and typical cross section proposed are to use AASHTO standard, as the geometric design standard and typical cross section are not so different from AASHTO.

Adopted geometric design standard (AASHTO) for interchange ramps are shown in Table 4.1.18.

Table 4.1.18 Geometric Design Criteria for Interchange Ramps

Item	Unit	Japanese Standard	AASHTO	Adopted Standard
Design Speed	Km/h	40	40	40
Sight Distance	m	40	44.4	40
Two-Lane Inner Shoulder Width	m	0.75	0.6-1.2	1.0
Two-Lane Outer Shoulder Width	m	0.75	2.4-3.0	1.0
Single-Lane Inner Shoulder Width	m	1.00	0.6-1.2	1.0
Single-Lane Outer Shoulder Width	m	2.50	2.4-3.0	2.5
Minimum Radius	m	50	55	50
Minimum Grade	%	6 (8)	5(7)	6
Minimum Vertical Curve Length	m	40	-	40
Maximum Super-elevation	%	9	6	9

(4) Super-Elevation for Rampway

Values of the super-elevation of the rampway were decided according to the Japanese and AASHTO standards as shown in Table 4.1.19.

Table 4.1.19 Super-Elevation for Ramp

Type	Radius of Circular Curve		Super-elevation
	More than	Less than	
Interchange	-	50	10
	50	70	9
	70	90	8
	90	130	7
	130	160	6
	160	210	5
	210	280	4
	280	400	3

(5) Length of Speed Change Lane

Length of Speed Change Lane was decided according to the Japanese and AASHTO standard as shown in Table 4.1.20.

Table 4.1.20 Length of Speed Change Lane

Items	Design Speed : 100 km/h	
	One Lane	Two Lane
Length of Deceleration	90	130
Length of Acceleration	180	260
Taper Length	60	
Exit Angle	1/25	
Entrance Angle	1/40	

(6) Summary of Design Criteria for Ramp-way

Tables 4.1.21 and 4.1.22 show the summary of the design criteria for the rampways.

Table 4.1.21 Summary of Design Criteria for Interchange Ramps
(Two-lane , one-way)

Item	Unit	Proposed Value
Design Speed	Km/h	40
Cross Section Elements		
Number of Lanes	Lanes	2
Lane Width	m	3.5
Median	m	-
Inner Shoulder Width	m	1.0
Outer Shoulder Width	m	1.0
Protective Shoulder	m	0.75
Crossfall of Carriageway	%	2.0
Crossfall of Shoulder	%	2.0
Maximum Super-elevation	%	10
Composite gradient	%	11
Horizontal Alignment		
Minimum Radius	m	50.0
Critical curve radius with transition curve	m	140
Minimum curve radius without super-elevation	m	600
Vertical Alignment		
Maximum Grade	%	6.0
Minimum Radius of Vertical Curve		
Crest	m	900
Sag	m	900
Minimum Stopping Sight Distance	m	40
Length of Deceleration lane		
Two-lane	m	130
Length of Acceleration lane		
Two-lane	m	260
Exit Angle		
Two-lane		1/25
Entrance Angle		
Two-lane		1/40
Vertical Clearance	m	4.75

Table 4.1.22 Summary of Design Criteria for Interchange Ramps (One-lane , one-way)

Item	Unit	Proposed Value
Design Speed	Km/h	40
Cross Section Elements		
Number of Lanes	Lanes	1
Lane Width	m	3.5
Median	m	-
(Non-motorcycle Width)	m	(3.0)
Inner Shoulder Width	m	2.5
Outer Shoulder Width	m	1.0
Protective Shoulder	m	0.75
Crossfall of Carriageway	%	2.0
Crossfall of Shoulder	%	2.0
Maximum Super-elevation	%	10
Composite gradient	%	11
Horizontal Alignment		
Minimum Radius	m	50.0
Critical curve radius with transition	m	140
Minimum radius without super-elevation	m	600
Vertical Alignment		
Maximum Grade	%	6.0
Minimum Radius of Vertical Curve		
Crest	m	900
Sag	m	900
Minimum Stopping Sight Distance	m	40
Vertical Clearance	m	4.5
Length of Deceleration Lane		
Single-lane	m	90
Length of Acceleration		
Single-lane	m	180
Taper Length		
Single-lane	m	60
Exit Angle		
Single-lane		1/25
Entrance Angle		
Single-lane		1/40

4.1.3 Pavement Design Standard

(1) Adopted Standard

Pavement design criteria was considered and decided based on the following standards:

- Vietnam Pavement Standard (Guide for design of flexible pavement structures 22-TCN 211-93)
- American Association of State Highway and Transportation Officials (AASHTO) guide for design of pavement structures, 1986)
- Japanese Pavement Standard (Asphalt pavement outline published by Japan Road Association, 1992)

Table 4.1.23 shows the summary of the characteristics for each standard.

Table 4.1.23 Comparison for Each Standard

Standard Name:	Vietnamese Standard	AASHTO Standard	Japanese Standard
Basic concept:	Based on Russian Standard.	Based on result of AASHTO Road Test	Refer to results of AASHTO Road Test
Design Target Year:	5 to 15 years	20 years	10 years
Traffic Volume:	Estimated traffic volume at target year	Total traffic volume for 20 years	Average traffic volume of heavy vehicle for 10 years
Design Load:	10 ton single axle load	18 kips (8.2 ton) equivalent single axle load (ESAL)	Japanese standard has two design methods. 1) Divided into five categorized traffic volumes, up to large-sized vehicle. 2) 5 ton of conversion into number of wheels. In generally, 1) method is applied.

As result of comparison, AASHTO Standard shall be applied from the following reasons:

- Design target year in the Vietnamese standard is from 5 to 15 year and AASHTO Standard is 20 years.
- It was been used for international bidding projects and in the F/S by JICA.

(2) Design Formula

The design formula from the AASHTO Guide for Design of Pavement Structure is indicated in the following 1) and 2), and is also indicated in Figure "Nomogram for flexible pavement" and Figure "Nomogram for rigid pavement(1),(2),(3).

1) Asphalt cement concrete

$$\log_{10}(W_{18}) = Z_R x S_0 + 9.36x\log_{10}(SN+1) - 0.2 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.4+\frac{1094}{(SN+1)^{5.19}}} + 2.32x\log_{10}(M_R) - 8.07$$

Where,

W18= Predicted number of 18-kip equivalent single axle load applications
Z_R = Standard normal deviate
S_O= Combined standard error of the traffic prediction and performance prediction
ΔPSI= Difference between the initial design serviceability index, Po, and design terminal serviceability index, P_t, and
M_R= Resilient modulus (psi)
SN=Σ a^i d^i m^i

Where,

SN = Structural Number
a^i = i-th layer coefficient
d^i = i-th layer thickness (inches)
m^i = i-th layer drainage coefficient

2) Cement Concrete Pavement

$$\text{Log } W_{18} = 7.35 \log (D+1) - 0.06 + \frac{Gt}{1 + \frac{1.624x10^{7}}{(D+1).8.46}} + (4.42 - 0.32\ Pt)x$$

$$\log\left[\left(\frac{ft}{690}\frac{D^{0.75} - 1.132}{D^{0.75} - \frac{18.42}{\left(EC/_{K}\right)^{0.25}}}\right)\right]$$

Where:

W18 = Total load applications
D = Thickness of slab (inch)
Ft = Working stress in concrete (= 428 psi)
Gt = log (4.2- Pt)/(4.2-1.5) = - 0.2

Ec = Modulus elasticity of concrete(= 4.98 x 106 psi)
K = Modulus of subbase reaction(= ***pci)

(3) Design Criteria

The criteria for the design variables, performance, material pro to estimate thickness of the pavement design are summarized as follows

Table 4.1.24 Design Criteria for Pavement Design

Design Input Requirements		Value
1 Design Variables	Performance Period (years)	15
	Analysis Period (years)	15
	Traffic	-
	Equivalent Single Axle Load (ton)	8.2
	Directional Distribution Factor, $D_{D,}$ Single-way:1.0, Two-way:0.5	0.5-1.0
	Lane Distribution Factor, $D_{L,,}$ One-lane: 1.0, More than lanes: 0.8	0.8-1.0
	Reliability	90
	Overall Standard Deviation	0.5
2 Performance Criteria	Initial Serviceability Index, Po	4.2
	Terminal Serviceability Index, P_t	2.5
	Design Serviceability Loss, ΔPSI	Po - P_t
	Load Distribution Coefficient, J	2.8
3 Material Properties	Effective Road Soil Resilient Modulus M_R (psi)	1500 x CBR
	Layer Coefficient for AC, a_1	0.37
	Layer Coefficient for ATB, a_1	0.33
	Layer Coefficient for Base Course Concrete, a_3	0.14
	Layer Coefficient for Subbase Course Concrete, a_3	0.11
	Elastic Modulus for AC Surface (psi)	200,000
	Elastic Modulus for AC Binder (psi)	200,000
	Elastic Modulus for Asphalt treated Base Course (psi)	100,000
	Elastic Modulus for Stabilized Aggregate Base (psi)	40,000
	Elastic Modulus for Crusher-run Aggregate Subbase (psi)	30,000
	Elastic Modulus, Ec for Concrete (psi)	4,200,000
	Bending Intensity, Sc for Concrete (psi)	578
4 Pavement Characteristics	Drainage Coefficient for Base Course and Subbase Course, m_2, m_3(m_1=1)	1.0
	Drainage Coefficient for rigid pavement, Cd	1.0

4.2 Bridge Design Standard

Structural design standards were basically agreed upon in the Feasibility Study (F/S) stage. Some of the conditions proposed in the F/S have been reviewed with reference to the updated information. In this section, the design conditions considered in the Detailed Design are described.

4.2.1 Design Codes

AASHTO Standard Specifications for Highway Bridges, 16th edition, 1996 (hereinafter called "AASHTO standard"), and other AASHTO specifications shall be adopted for design of all structures in this project. Ship collision force, which is not speculated in AASHTO standard, is calculated in accordance with the requirements specified in AASHTO LRFD Bridge Design Specifications, 2nd edition, 1998 (hereinafter called "AASHTO LRFD specification").

Vietnamese Bridge Design Codes 22TCN 018-79 (herein after called "VNBDC") and Japanese Specifications for Highway Bridges, the 1996 edition (hereinafter called "JSHB"), shall be used as reference. AASHTO requirements will be modified or supplemented by VNBDC and/or JSHB where appropriate.

4.2.2 Loads

(1) Dead Load

The following weights are to be used in computing dead load:

material	unit weight (kg/m^3)
Steel and Cast Steel	7,850 kgf/m^3
Cast Iron	7,250 kgf/m^3
Plain Concrete	2,350 kgf/m^3
Reinforced Concrete, Pre-stressed Concrete	2,500 kgf/m^3
Compacted Sand, Earth, Gravel, or Ballast	1,920 kgf/m^3
Loose Sand, Earth, and Gravel	1,600 kgf/m^3
Pavement	2,300 kgf/m^3
Railing	50 kgf/m

(2) Live Load

1) For Girder Design and Substructure Design

It is common practice in Vietnam to magnify the standard AASHTO HS20-44 truck or lane loads by a factor of 1.25 with considerations on H30 and XB80 live loads specified in VNBDC. The same condition shall be applied to the design.

The HS20-44 loads are specified in Article 3.7 of the AASHTO standard. As is prescribed in Article 3.6, the lane loading and the standard truck shall be placed in 12-foot wide, or 3.6-meter wide, design traffic lanes spaced across the entire bridge roadway width measured between curbs.

Where maximum stresses are produced in any members by loading a number of traffic lanes simultaneously, the following percentages of the live loads shall be used in view of the impossibility of coincident maximum loading (AASHTO Article 3.12.1):

	Percent
One or two lanes	100
Three lanes	90
Four lanes or more	75

When XB80 load, which is an infrequent truck load specified in Appendix 9 of VNBDC, is considered, it shall be assumed that one unit of XB80 is loaded in the transverse direction and that the spacing of a unit in the longitudinal direction is not less than 20.0 meters.

2) For Slab Design

125% of standard HS20-44 truck shall be loaded to produce maximum stresses in the slab.

The XB80 load shall be also considered for the slab design. Since this is a special infrequent live load, allowable stresses shall be increased by 25% for reinforced concrete a slab. Increase of load intensity due to impact effect is considered to be zero in accordance with the note of VNBDC Article 2.22.

(3) Impact

Article 3.8 of the AASHTO standard shall be applied. The amount of the impact allowance or increment is expected as a fraction of the live load stress, and shall be determined by the formula:

$I = 50 / (L_f + 125)$ --- in US units, Eq. 3-1 of AASHTO standard
$= 15.24 / (L + 37.8)$ --- in metric

in which

I = impact fraction (maximum 30 percent)
$L (L_f)$ =length in meters (feet) of the portion of the span that is loaded to produce the maximum stress in the member

(4) Logitudinal Force

Five percent of the live load, without impact, in all lanes carrying traffic headed in the same direction shall be applied as specified in Article 3.9 of the AASHTO standard. The center of gravity of the longitudinal force shall be assumed to be located 6 feet, or 1.8m, above the floor slab and to be transmitted to the substructure through the superstructure.

(5) Shaking Force

Although the AASHTO standard and JSHB do not specify this shaking force, VNBDC Article 2.19 shall be applied. The shaking force shall be 0.4 t/m (without impact) irrespective of the number of traffic lanes to be used. The center of gravity of the shaking force shall be assumed to be located at the top of the floor slab and to be transmitted to the substructure through the superstructure.

(6) Centrifugal Force

Article 3.10 of the AASHTO standard shall be applied. Structures on curves shall be designed for a horizontal radial force equal to the following percentage of the live load, without impact, in all traffic lanes:

$C = 0.00117\ S_m^2\ D = 6.68\ S_m^2\ /\ R_f$ --- in US units, Eq. 3-2 of AASHTO standard
$= 0.79\ S^2\ /\ R$ --- in metric

where

C = the centrifugal force in percent of the live load, without impact;
S (S_m) = the design speed in kilometers (miles) per hour;
D = the degree of curve;
R (R_f) = the radius of the curve in meters (feet).

(7) Effect of Temperature

1) Air Temperature Variation

The maximum and minimum air temperature shall be assumed to be 5°C and 45°C respectively.

2) Temperature Variation in the Structural System

Table 4.2.1 Average Highest and Lowest Monthly Temperatures in Hanoi

Year	Monthly Average				Year	Monthly Average			
	Highest		Lowest			Highest		Lowest	
	°C	Month	°C	Month		°C	Month	°C	Month
1957	28.9	Jul.	14.3	Mar.	1978	29.0	Jul.	16.1	Jan.
1958	28.7	Jul.	15.4	Jan.	1979	29.7	Jul.	17.3	Jan.
1959	29.3	Jun.	14.9	Jan.	1980	28.7	Jul.	15.1	Feb.
1960	29.5	Jun.	16.9	Dec.	1981	29.5	Aug.	16.8	Dec.
1961	29.4	Jul.	15.5	Jan.	1982	29.4	Jul.	15.7	Dec.
1962	29.0	Jul.	14.3	Jan.	1983	30.0	Jul.	14.4	Jan.
1963	28.6	Jul.	14.6	Feb.	1984	29.6	Jul.	13.5	Jan.
1964	29.0	Jul.	14.9	Feb.	1985	29.4	Jun.	14.1	Jan.
1965	29.0	Jul.	17.4	Dec.	1986	29.0	Jul.	16.2	Feb.
1966	29.2	Jul.	18.1	Jan.	1987	29.6	Jun.	16.2	Dec.
1967	29.5	Jul.	14.9	Feb.	1988	29.5	Jul.	16.3	Feb.
1968	29.5	Jul.	12.0	Feb.	1989	29.1	Jul.	15.2	Jan.
1969	29.2	Jul.	16.4	Feb.	1990	30.2	Aug.	17.3	Jan.
1970	29.0	Jul.	15.1	Jan.	1991	29.3	Jul.	17.5	Jan.
1971	29.1	Jun.	14.6	Jan.	1992	29.6	Aug.	15.8	Jan.
1972	29.3	Jun.	16.6	Jan.	1993	30.2	Jun.,Jul.	16.2	Jan.
1973	29.2	Jun.	16.2	Jan.	1994	28.7	Jun.	17.8	Jan.
1974	28.8	Jun.	15.6	Feb.	1995	29.8	Jul.	15.7	Jan.
1975	29.3	Jul.	15.1	Dec.	1996	29.6	Jul.	16.2	Jan.
1976	29.2	Jul.	15.9	Jan.	1997	29.8	Jun.	17.0	Feb.
1977	29.6	Jun.	13.1	Jan.	1998	30.7	Jul.	17.9	Feb.

Note: Data source --- Meteorology and Hydrology Document Centre

Temperature conditions considered in F/S have been reviewed based on the additional local information. According to Meteorology and Hydrology Document Centre, average highest and lowest monthly temperatures recorded from 1957 to 1998 are tabulated in Table 4.2.1.

Based on these data and the consideration on the lag between air temperature and the temperature of structural members, the range of temperature change to be used for the structural analysis shall be 20±10°C.

3) Temperature Difference between Deck Slab and Other Members

The sectional force due to the difference of temperature between deck slab and other members shall generally be calculated with assumption that temperature variation in deck slab and other members is respectively uniform. The temperature difference of 5°C shall be used for the design as speculated in Article 2.1.11 of JSHB, Vol. I.

4) For Calculation of the Movement at Movable Bearings

Range of temperature for calculation of the movement at movable bearings shall be taken from 5°C to 45°C.

5) Coefficients of Thermal Expansion

Following values shall be used for the design:

- for steel in steel structure: 12 x 10-5 /°C
- for reinforcing bars and concrete in concrete structure: 10 x 10-5 /°C

(8) Effect of Creep and Shrinkage

Effects of creep and shrinkage of concrete on the structural system is not specifically described in the AASHTO standard. Provisions of JSHB shown below shall be applied:

Article 2.1.6 Effects of Creep and Shrinkage of Concrete

Effects of creep and shrinkage of concrete to be considered in designing concrete members shall be as follows:

(1) Strain due to creep of concrete shall be given by equation (2.1.1).

$$\varepsilon_{cc} = \sigma_c \text{ x } \varphi / E_c \qquad (2.1.1)$$

where; ε_{cc} : strain due to creep of concrete

σ_c : stress of concrete due to sustained load (kg/cm^2)

E_c : Young's modulus of concrete (kg/cm^2)

φ : creep coefficient of concrete

(2) For the calculation of the pre-stress loss and the statically indeterminate force, the creep coefficient of concrete shall generally be as given in Table 2.1.8.

Table 2.1.8 Creep Coefficient of Concrete

age of concrete when sustained load is applied (days)		4 to 7	14	28	90	365
creep coefficient	for high early strength concrete	2.6	2.3	2.0	1.7	1.2
	for ordinary concrete	2.8	2.5	2.2	1.9	1.4

(3) When the pre-stress loss is calculated, the shrinkage strain of concrete shall be given in Table 2.1.9.

Table 2.1.9 Shrinkage Strain of Concrete

age of concrete when pre-stress is introduced (days)	4 to 7	28	90	365
shrinkage of strain	$20 \text{ x } 10^{-5}$	$18 \text{ x } 10^{-5}$	$16 \text{ x } 10^{-5}$	$12 \text{ x } 10^{-5}$

(4) When Article (2) or (3) is not suitable, the creep coefficient or the shrinkage strain of concrete shall alternatively be determined with consideration of the ambient relative humidity, the geometric dimension of cross section of concrete, the age of concrete at loading, etc.

(5) The statically indeterminate force due to the effects of creep and shrinkage of concrete shall be calculated in accordance with the followings:

1) In case the structural system does not change

When the structural system does not change between construction stage and completion stage since the whole structure is constructed on the shore at a time, the creep effect of concrete may generally be ignored. When the statically indeterminate force due to the shrinkage of concrete is calculated, the shrinkage strain shall be $15x10^{-5}$. However, when the amount of the longitudinal reinforcement is less than 0.5% of the area of the cross section of the member, the shrinkage strain shall be $20x10^{-5}$.

2) In case the structural system changes

When the structural system changes between construction stage and completion stage since the whole structure is not constructed on the shore at a time, the statically indeterminate force due to the creep of concrete shall be calculated in accordance of concrete. The statically indeterminate force due to the effect of shrinkage of concrete shall be calculated in accordance with Article (4).

(9) Earthquake Load

As proposed in F/S, a seismic acceleration coefficient of 0.17 shall be used. The value of 0.17 was also used for the design of New Ham Rong Bridge of National Highway No.1 and Duong Bridge of the No.3 Hanoi Ring Road. The use of the coefficient of 0.17 has been recommended by Institute of Geophysics of Vietnam National Center for Natural Science and Technology[Note)].

Note) "The Red River Bridge Construction Project, Assessment of Seismic Hazard in Bridge Area," completed by The Department of Seismology, Institute of Geophysics, June 1999.

(10) Wind Load

The requirements of AASHTO standard Article 3.15 shall be adopted to the design. As confirmed in F/S, the maximum wind velocity observed in the period from 1956 through 1996 is 122 km/hr. The AASHTO requirements, which are for a base wind velocity of 100 miles per hour (160 km/hr), are conservatively appropriate for the design.

1) For Superstructure Design

a) Group II and Group V Loadings

For girders and beams the design force shall be greater than;

(i) a pressure of 245 kg/m^2 (50 psf), or
(ii) a total force not less than 447 kg/m (300 pounds per linear foot)

b) Group III and Group VI Loadings

(i) The loads used for Group II and Group V loadings shall be reduced by 70 %, and
(ii) a load of 100 pounds per linear foot shall be applied at right angles to the longitudinal axis of the structure and 6 feet above the deck as a wind load on a moving live load.

2) For Substructure Design

Article 3.15.2 of AASHTO standard shall be applied.

(11) Vessel Collision Force

Technical specifications of vessels considered in the design are shown in Table 4.2.2. This information has been provided by Vietnam Inland Waterway Administration, Ministry of Transport, correspondence No.831/CDS-QLDS dated 15 June 1999.

Table 4.2.2 Specifications of Vessels

Item	Ship	Barge Convoy
maximum length (m)	54.9	102.6
maximum width (m)	15.2	16.4
full loaded draft (m)	2.38	1.85
maximum DWT (tons)	1,242	1,200
maximum water displacement (tons)	1,864	1,712

Transport Construction Quality Control and Management Bureau of the Ministry of Transport has agreed to use the design conditions as follows (Refer to the letter No.1031/TD from MOT dated July 2, 1999):

1) Provisions of AASHTO shall be allied for calculation of ship collision force,
2) Vessel sizes to be considered are as follows:
   (i) Ship : maximum DWT = 1,242 tons
   (ii) Barge : maximum water displacement = 1,712 tons,
3) Design collision velocity shall be assumed to be equal to the yearly mean velocity of Red River.

The velocity of 0.80m/sec shall be used for the design. The velocity is the yearly mean velocity of Red River monitored at Hanoi Station.
Vessel collision forces calculated by the above-mentioned conditions are as follows:

1) In the direction parallel to the navigation channel
   (i) Ship collision force = 345 tf
   (ii) Barge collision force = 631 tf
2) 50 % of the above

(12) River Flow Force

Article 3.18.1 of the AASHTO standard shall be applied.

$P_p = K\,V_m^2$ --- in US units, Eq. 3-4 of the AASHTO standard
$P = 52.5\,K\,V^2$ --- in metric

where:

$P\ (P_p)$ = pressure in kgf/m^2 (lbs/ft^2)
$V\ (V_m)$ = velocity of water in meters (feet) per second
K = a constant being 1-3/8 for square ends, 1/2 for angle ends where the

angle is 30 degrees or less, and 2/3 for circular piers

(13) Earth Pressure

Earth pressure shall be calculated by Coulomb's equation.

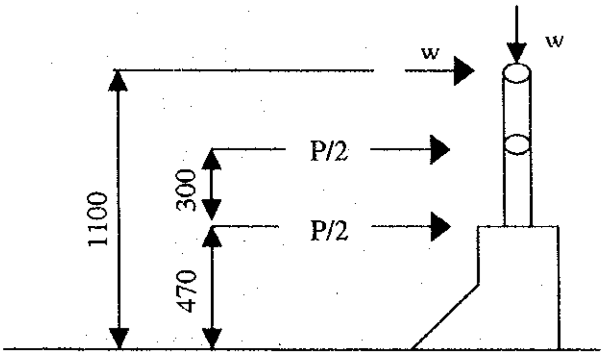
(14) Buoyancy

Buoyancy shall be considered where it affects the design of either substructure, including piling, or the superstructure.

(15) Loads on Curb and Railing

The railing shall be designed for combination traffic and pedestrian loading. Article 2.7 of the AASHTO standard shall be applied.

P = highway design loading
  = 10 kips = 4.54 t
w = pedestrian loading
  = 100 kgf/m



4.2.3 Combinations of Loads

Combinations of loads shall be considered in accordance with Section 3, Part B of the AASHTO standard. The requirements specified in Article 3.22 have been modified with considerations on the conditions of the Red River Bridge. Some loads have been deleted or added as appropriate for the project bridges. These modifications are;

(i) The $(L+I)_p$ load, rib shortening (R) and ice pressure (ICE) have been deleted because these loads are not applicable,

(ii) Shaking force (SH), for which a load factor is assumed to be the same for rib shortening (R), has been added,

(iii) Ship collision force (CO) has been added.

Article 3.22 of the AASHTO standards has been modified relevantly as follows:

$$\text{Group (N)} = \gamma\,[\beta_D D + \beta_L(L+I) + \beta_C CF + \beta_E E + \beta_B B + \beta_S SF + \beta_W W \;\; + \beta_{WL} WL$$
$$+ \beta_L LF + \beta_{SH}(SH+S+T) + \beta_{EQ} EQ + \beta_{CO} CO]$$

where,

N = group number;
γ = load factor, see Table 4.2.4;
β = coefficient, see Table 4.2.4;
D = dead load;
L = live load;
I = live load impact;
E = earth pressure;
B = buoyancy;
W = wind load on structure;
WL = wind load on live load;
LF = longitudinal force from live load;
CF = centrifugal force;
SK = shake force;
S = shrinkage;
T = temperature;
EQ = earthquake;
SF = stream flow pressure;
CO = ship collision force;

Combinations of loads and the gamma and beta factors are given in Table 4.2.3.

Table 4.2.3 Combinations of Loads and Coefficients γ and β

Col. No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
GROUP		γ	β FACTORS												%	
			D	L+I	CF	E	B	SF	W	WL	LF	SK+ S+T	EQ	CO		
SERVICE LOAD	I	1.0	1	1	1	β_E	1	1	0	0	0	0	0	0	100	
	IA	1.0	1	2	0	0	0	0	0	0	0	0	0	0	150	
	IB	Not Applicable													-	
	II	1.0	1	0	0	1	1	1	1	0	0	0	0	0	125	
	III	1.0	1	1	1	β_E	1	1	0.3	1	1	0	0	0	125	
	IV	1.0	1	1	1	β_E	1	1	0	0	0	1	0	0	125	
	V	1.0	1	0	0	1	1	1	1	0	0	1	0	0	140	
	VI	1.0	1	1	1	β_E	1	1	0.3	1	1	1	0	0	140	
	VII	1.0	1	0	0	1	1	1	0	0	0	0	1	0	133	
	VIII	1.0	1	1	1	1	1	1	0	0	0	0	0	1	150	
	IX	Not Applicable													-	
	X	1.0	1	1	0	1	0	0	0	0	0	0	0	0	100	Culvert
LOAD FACTOR DESIGN	I	1.3	β_D	1.67	1	β_E	1	1	0	0	0	0	0	0	Not Applicable	
	IA	Not Applicable														
	IB	Not Applicable														
	II	1.3	β_D	0	0	β_E	1	1	1	0	0	0	0	0		
	III	1.3	β_D	1	1	β_E	1	1	0.3	1	1	0	0	0		
	IV	1.3	β_D	1	1	β_E	1	1	0	0	0	1	0	0		
	V	1.25	β_D	0	0	β_E	1	1	1	0	0	1	0	0		
	VI	1.25	β_D	1	1	β_E	1	1	0.3	1	1	1	0	0		
	VII	1.3	β_D	0	0	β_E	1	1	0	0	0	0	1	0		
	VIII	1.3	β_D	1	1	β_E	1	1	0	0	0	0	0	1		
	IX	Not Applicable														
	X	1.3	1	1.67	0	β_E	0	0	0	0	0	0	0	0		Culvert

For service load design;

(i) "%" in Column 14 represents percentage of basic unit stress, i.e.;

$$\text{Percentage} = \frac{\text{Maximum Unit Stress (Operating Rating)}}{\text{Allowable Basic Unit Stress}} \times 100$$

(ii) No increase in allowable unit stresses shall be permitted for members or connections carrying wind loads only.

(iii) Culvert loading specifications comply with Article 3.24.2.2 of the AASHTO standards.

4.2.4 Flood and Navigation Clearance

(1) Navigation Clearance

At the commencement of the study, the Vietnamese side confirmed that the navigation clearance should be 10 meters above the high water level (HWL) and that this should be maintained over a length of 80 meters. In addition, the value of the HWL should be considered as the predicted level of the river for a return period of 20 years. The Study Team predicted the HWL at 12.50 meters for a return period of 20 years. Please refer to Article 3.4 "Hydraulic and Hydrological Investigation" of this report for details.

Proposed navigation clearance is shown in Figure 4.2.1.

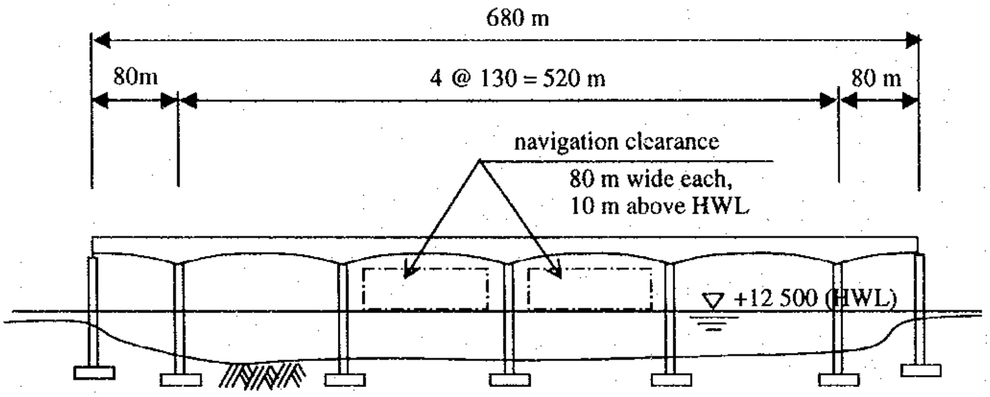


Figure 4.2.1 Navigation Clearance

(2) Flood

For rivers without navigation, flood clearance for bridges will be provided to the values given in Table 4.2.4.

Table 4.2.4 Flood Clearance

Structure			Minimum clearance above design flood level (m)	
			For Highway Bridges	For Railway Bridges
Girder	Water level rising by influence of piers	less than 1 m	0.50	0.50
		over 1 m	0.50	0.75
	Flooded material	Wooden logs and debris	1.00	1.50
		Roll stone	1.00	-
Bearing plate			0.25	0.25

Notes: From Article 1.27 of Vietnamese Bridge Design Codes 22TCN 018-79.
Water level rising by piers is taken into account in flood level in the area;
where there is stagnant water or reservoir, minimum clearance is 3/4 of wave depth.

4.2.5 Materials and Strengths

(1) General

The strength of materials to be used for the structural design shall comply with the latest versions of AASHTO, ASTM or JIS.

(2) Concrete

Classes, the use and the design strengths of the concrete are shown in Table 4.2.5.

Table 4.2.5 Concrete Classes and Design Strengths

Class of Concrete	Use of Concrete	Design Strength f'_c (kg/cm^2)
A-1	cast-in-place pre-stressed concrete (PC) box girders for cantilever erection	400
A-2	cast-in-place PC box girders (girder height = 2.75m)	400
A-3	PC I-girders	400
C-1	reinforced concrete (RC) deck slabs, diaphragms of PC I-girder, parapet and foundation of lighting poles excluding those for RC hollow slab	290
C-2	pre-cast RC panels	290
C-3	pre-cast RC piles	290
C-4	RC piers (including cantilevered pier heads, pier columns and footings), RC abutments (including wind walls), RC retaining walls, box culverts	290
C-5	RC hollow slab, parapet and foundation of lighting poles for RC hollow slab	290
E-1	approach	210
E-2	pipe culverts	210
E-3	slab for foundation (piled) below pipe and box culvert	210
E-4	pre-cast concrete curbs	210
G	lean concrete, leveling concrete	-
P	concrete pavement	-
Y	cast-in-place reinforced concrete piles	290

Allowable basic stresses of concrete for pre-stressed concrete structures and reinforced concrete structures are shown in Tables 4.2.6 and 4.2.7 respectively.

Table 4.2.6 Allowable Concrete Stresses for Pre-stressed Concrete Structures

unit in kgf/cm^2

Description	Class of Concrete
	A-1, A-2 and A-3
(1) Compressive Stress	
- Temporary stress before losses due to creep and shrinkage	$0.55f'_{ci}$
- Stress at service load after losses have occurred	160 ($=0.4f'_c$)
(2) Tensile Stress	
- Temporary stress before losses due to creep and shrinkage	$0.794(f'_{ci})^{1/2}$
- Stress at service load after losses have occurred	
except slab	31.8 ($=1.59(f'_c)^{1/2}$)
slab	15.8 ($=0.79(f'_c)^{1/2}$)
(3) Bearing Stress	120

Note: f'_{ci} : compressive strength at time of initial pre-stress (kgf/cm^2, by cylinder specimen)
f'_{ci} shall be not less than 360kgf/cm^2.

Table 4.2.7 Allowable Concrete Stresses for Reinforced Concrete Structures

unit in kgf/cm^2

Description	all classes except Type Y	Type Y
(1) Compressive Stress	$0.40f'_c$	96.0
(2) Shear Stress	$0.25(f'_c)^{1/2}$	3.9

(3) Reinforcing Steel

Reinforcing steel for concrete shall conform to the standard specified in Table 4.2.8 or equivalent:

Table 4.2.8 Reinforcing Steel

Type	JIS G3112	
	Designation	Yield Strength (kgf/cm^2)
Round Bar	SR 235	2,400
Deformed Bar	SD 295A	3,000

Allowable basic stresses of reinforcing steel are shown in Tables 4.2.9.

Table 4.2.9 Allowable Stresses of Reinforcing Steel

unit in kgf/cm^2

Allowable Tensile Stress	Designation	
	Round Bar (SR 235)	Deformed Bar (SD295A)
- general members	1,400	1,800
- reinforce concrete slab	1,400	1,400

(4) Pre-stressing Steel

Pre-stressing steel shall conform to the standard specified in Table 4.2.10 or equivalent thereof:

Table 4.2.10 Pre-stressing Steel

Type	Designation		Yield Strength (kgf/cm^2)	Tensile Strength (kgf/cm^2)
A	JIS G3536, SWPR7BL	12T15.2	16,000	19,000
B	JIS G3536, SWPR7BL	4T15.2	16,000	19,000
C	JIS G3536, SWPR7BL	3T15.2	16,000	19,000
D	JIS G3536, SWPR7BL	12T12.7	16,000	19,000
E	JIS G3536, SWPR7BL	7T12.7	16,000	19,000
F	JIS G3112, SBPR930/1180	ϕ 32	9,500	12,000

Allowable basic stresses of pre-stressing steel are shown in Tables 4.2.11.

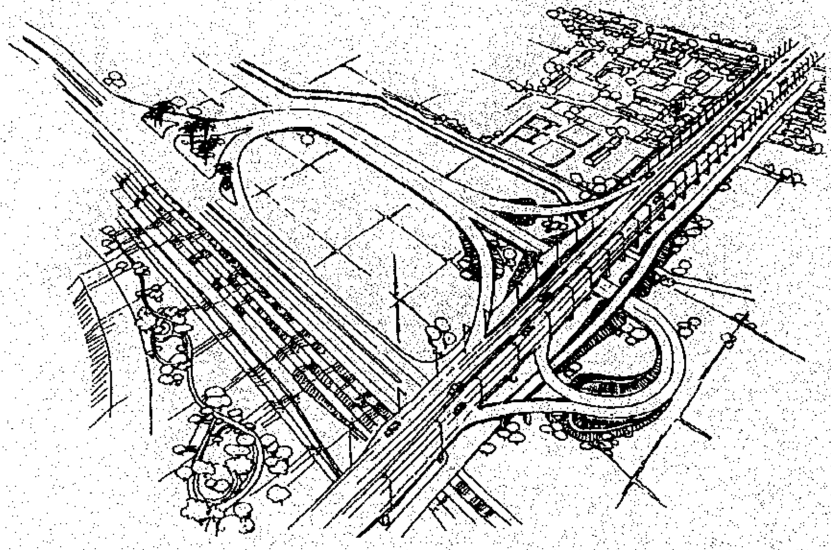
Table 4.2.11 Allowable Stresses of Pre-stressing Steel

Refer to AASHTO standard Article 9.15.1, unit in kgf/cm^2

Allowable Tensile Stress	Designation	
	7 wire strands (JIS G3536)	bars (JIS G3112)
- during pre-stressing work : $0.90f^*_y$	14,400	8,350
- immediately after pre-stressing : $0.70f'_s$	13,280	8,070
- at service load : $0.80f^*_y$	12,800	7,120

Note: f^*_y = yield stress of pre-stressing steel, f'_s = ultimate strength of pre-stressing steel

CHAPTER 5 DETAILED DESIGN OF HIGHWAY



CHAPTER 5 DETAILED DESIGN OF HIGHWAY

5.1 Traffic Capacity and Required Number of Lanes

5.1.1 Throughway

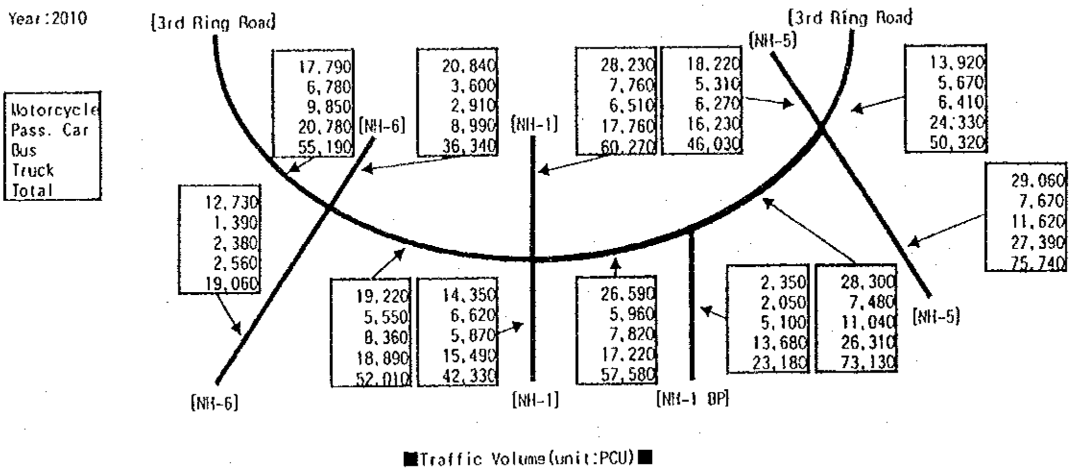
The concept and methodology used for the highway capacity analysis are based on the "Highway Capacity Manual of Highway Research Board, U.S.A.". However, some adjustment is made to reflect local conditions base on the results of studies undertaken by the "Highway Research Board, Japan (Japanese Standard)", due to the fact that much resemblance is found in type and size of vehicles and in operating conditions in Vietnam and Japan.

(1) Traffic Capacity Analysis

Table 5.1.1 shows summary of traffic capacity analysis with brief notes in each calculation step. The traffic demand forecast is shown in Figures 5.1.1 and 5.1.2.

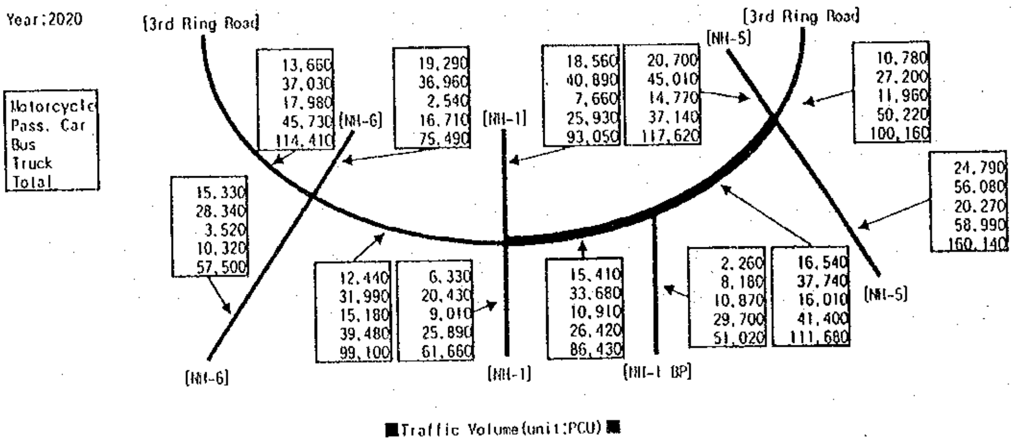
(SHTRR)
The number of lanes for the throughway is recommended at four (4) for both the Thanh Tri and Gia Lam sections of SHTRR. Total capacity of four-lane throughway (18,900 x 4 = 75,600 PCU/day) contains certain allowance compared with the maximum daily traffic volume forecast for 2010 (73,200 PCU/day).

(Thanh Tri Bridge)
The number of lanes of the throughway is recommended to be basically a total of six lanes (motorcycle lanes separated in initial stage) for the Thanh Tri Bridge. Total capacity of a six-lane bridge (18,900 x 6 = 113,400 PCU/day) has slight allowance even if compared with daily traffic volume for 2020 (111,700 PCU/day).



Source : JICA study, September 1988

Figure 5.1.1 Forecast Traffic Demand for 2010



Source : JICA study, September 1988

Figure 5.1.2 Forecast Traffic Demand for 2020

Table 5.1.1 Summary of Capacity Analysis for Throughway

Description		Symbol	Unit	Adopted	Remarks
Highway Type		-	-	-	Urban Expressway
Landuse/Terrain		-	-	Urban/Flat	-
Design Speed		-	Km/hr	100	-
Lane Width		-	m	3.75	-
Lateral Clearance	Outer	-	m	3.00	-
	Inner	-	m	1.00	-
Basic Capacity		C_B	PCU/hr/lane	2200	-
Adjustment Factor	Lane Width	γL	-	1.00	-
	Lateral Clearance	γC	-	1.00	-
	Roadside Development	γI	-	1.00	
	Large Vehicles	γT	-	1.00	
	Driver Population	γD	-	1.00	
	Planning Level-2	γP	-	0.85	
Possible Capacity per Hour		C_L	PCU/hr/lane	2,200	$C_L = C_B \cdot \gamma L \cdot \gamma C \cdot \gamma I \cdot \gamma T \cdot \gamma D$
Design Capacity per Hour		C_D	PCU/hr/lane	1,870	$C_D = C_L \gamma P$
K-Factor		K	%	9	Highway capacity Manual
D-Factor		D	%	55	Highway capacity Manual
Design Average Annual Daily Traffic Volume		D_{AADT}	PCU/day/lane PCU/day/4lane	18,900 75,600	Design AADT= $C_D \times 5{,}000 / (K \times D)$

5.1.2 Rampway

The operation of the ramp-freeway terminals is often the determinant factor influencing ramp operations. The capacity of ramps at the terminal is affected by the highway lane adjacent to the ramp, the volume of traffic on the ramp, the distance to the adjacent ramp and type of ramp. The methodology for ramp capacity calculation based on the H.C.M., 1985 and "Highway Research Board, Japan" and "Japan Highway Public Corporation".

(1) Design Traffic Capacity

The design traffic flow volume of the single-lane ramp is 1,200 pcu/hour. In case of a two-lane ramp, double the single-lane ramp capacity is considered in the case that the vehicles with two lanes available are able to enter or exit a throughway, at the entry and exit terminals. For the traffic capacity estimation of the ramp, the following points are taken into consideration:

- The capacity of the connecting section between the ramp and throughway.
- The capacity of main body of the ramp.
- The capacity of the connecting section between the ramp and the approach road.

Normally, the capacity of the connecting section between the ramp and throughway is smaller than that of the ramp itself. Therefore, the ramp capacity is determined by the capacity of the ramp terminal. Even if it is necessary for the capacity to have a two-lane, the traffic capacity at the exit and entrance terminal should be carefully evaluated, if the number of lanes of throughway remains unchanged at the exit and entrance terminal.

(2) Traffic Volume (PCU/day) According to Direction

Traffic volume (PCU/day) according to direction is indicated in Table 5.1.2. Interchange types are indicated in Table 5.3.2.

Table 5.1.2 Traffic Volume by Each Direction

(PCU/day)

Lamp location	Phan Van Cau Gie Interchange		NH5 Interchange	
	2010	2020	2010	2020
1	11,708	22,714	28,639	41,267
2	11,751	22,612	14,167	31,330
3	12,001	23,791	19,863	24,164
4	14,170	22,536	9,245	11,813
5	26,194	49,383	39,241	58,799
6	25,818	49,713	33,890	52,882
7	29,578	43,326	24,769	48,862
8	14,163	43,105	19,502	51,295
9	-	-	24,484	63,703
10	-	-	21,550	53,920
11	-	-	42,405	89,137
12	-	-	33,338	71,004

Source: JICA study, 1998

(3) Required Number of Lane

From the above results on the traffic demand for 2010 and 2020, for the required lane numbers of the rampway, two lanes are adapted to the Phap Van Cau Gie and NH5 interchange respectively. The results of the traffic capacity analysis are shown in the following Table 5.1.3 and Table 5.1.4.

Table 5.1.3 Traffic Capacity Analysis

(NH5 Interchange)

Ramp location		Entrance		Exit	
		(1)	(4)	(3)	(2)
Traffic capacity (PCU/hour)	Vr (1)	2,720	2,365	2,882	2,843
	Vr (2)	4,033	3,026	-	-
Traffic volume (2020) (PCU/hour)		41,267*0.09= 3,714	11,813*0.09= 1,063	24,164*0.09= 2,174	31,330*0.09= 2,819

Table 5.1.4 Traffic Capacity Analysis

(Phap Van Cau Gie Interchange)

Ramp location		Entrance		Exit	
		(3)	(4)	(1)	(2)
Traffic capacity (PCU/hour)	Vr (1)	1,780	1,900	2,830	2,762
	Vr (2)	2,202	2,400	-	-
Traffic volume(2020) (PCU/hour)		17,310*0.09= 1,557	20,992*0.09= 1,889	21,848*0.09= 1,966	24,052*0.09= 2,164

(Two-lane entrance ramp connected with a single-direction three-lane throughway)

$Vr(1) = 1.739Vd - 357 - 0.499Vf$

$Vr(2) = 3Vd-Vf$

where;

Vf : Total traffic flow volume of one side of throughway(PCU/hour)

Vr : Traffic flow volume of the ramp entrance section (PCU/hour)

Vd : Design traffic capacity per lane of throughway (PCU/lane/hour)
(1,870 PCU/hr/lane is estimated from the feasibility study 1998)

(Two-lane exit ramp connected with a single-direction three-lane)

$Vr\,(1) = 1.76Vd - 279 - 0.06Vf$

5.1.3 Frontage Road

The forecast traffic volume on the frontage road in both directions is 16,936 PCU/day for 2010 and 21,518 PCU/day for 2020. Traffic capacity for two-lane frontage road is 30,900 PCU/day. From this result, design traffic capacity is sufficient for traffic demand for 2010 and 2020.

Table 5.1.5 Traffic Capacity for Frontage Road

Description		Symbol	Unit	Adopted	Remarks
Highway Type		-	-	-	Arterial road
Landuse/Terrain		-	-	Flat	-
Design Speed		-	Km/hr	60	-
Lane Width		-	m	3.5	-
Lateral Clearance	Outer	-	m	0.5	-
	Inner	-	m	3.5	-
Basic Capacity		C_B	PCU/hr/2 lane	3,600	-
Adjustment Factor	Lane Width	γL	-		-
	Lateral Clearance	γC	-	1.00	-
	Roadside Development	γI	-	1.00	
	Large Vehicles	γT	-	1.00	
	Driver Population	γD	-	1.00	
	Planning Level-2	γP	-	0.85	
Possible Capacity per Hour		C_L	PCU/hr/2 lane	3,600	$C_L = C_B \cdot \gamma L \cdot \gamma C \cdot \gamma I \cdot \gamma T \cdot \gamma D$
Design Capacity per Hour		C_D	PCU/hr/2 lane	3060	$C_D = C_L \gamma P$
K-Factor		K	%	9	Highway capacity Manual
D-Factor		D	%	55	Highway capacity Manual
Design Daily Traffic Volume		D_{AADT}	PCU/day/2 lane	30,900	C_D H5,000 / (KHD)

5.2 Design of Throughway/Frontage Road

5.2.1 Alignment Feature

Horizontal and vertical alignment detail design was carried out based on the socialenvironment, hydrology /drainage and geological results surveyed by the project, in addition to the traffic flow and road geometric structure aspect. For the detail design, the project discussed the urban plan (Socio-Economic Master Plan for Hanoi City by the Years 2010 and 2020) and the future railway plan with the related agencies such as the Hanoi People's Committee and the Vietnam Railway Association.

Association.

Figure 5.2.1 shows the outline of the horizontal alignment indicating land use and the existing facilities in the vicinity of the project area. Conception for an alignment selection is based on the JICA Feasibility Study Report, September 1998. Especially, for the detail design, the following conditions are carefully studied.

(Horizontal Alignment)

- To minimize the need for resettlement, alignment is considered so as to utilize the existing road and avoid densely populated areas as much as possible.

- To minimize social and socio-economic isolation in densely populated areas divided by the project road.

- To avoid the disturbance of other projects such as industrial areas both under construction and planned, such as the Yen So Reservoir area, planned chemical factory, cement concrete factory, pagoda, Linh Nam monument, cemeteries, etc.

- To maintain to the highway standards mentioned in Chapter 4.1

(Vertical Alignment)

- Elevation of the road surface should surpass that required based on the probable flood water level in the project area.

- To maintain and enhance the existing railways and the existing roads' accessibility where crossing the project road, in terms of vertical/horizontal clearance.
- To install underpass facilities in order to prevent adverse effects to adjacent areas, especially where disrupting communities in urban areas.

- To keep embankment height as low as possible from the point of view of the stability and settling of the embankment.

- To keep embankment height as low as possible for the reduction of the countermeasures in the soft ground area.

- To pay attention to the highway standard mentioned in Chapter 4.1.

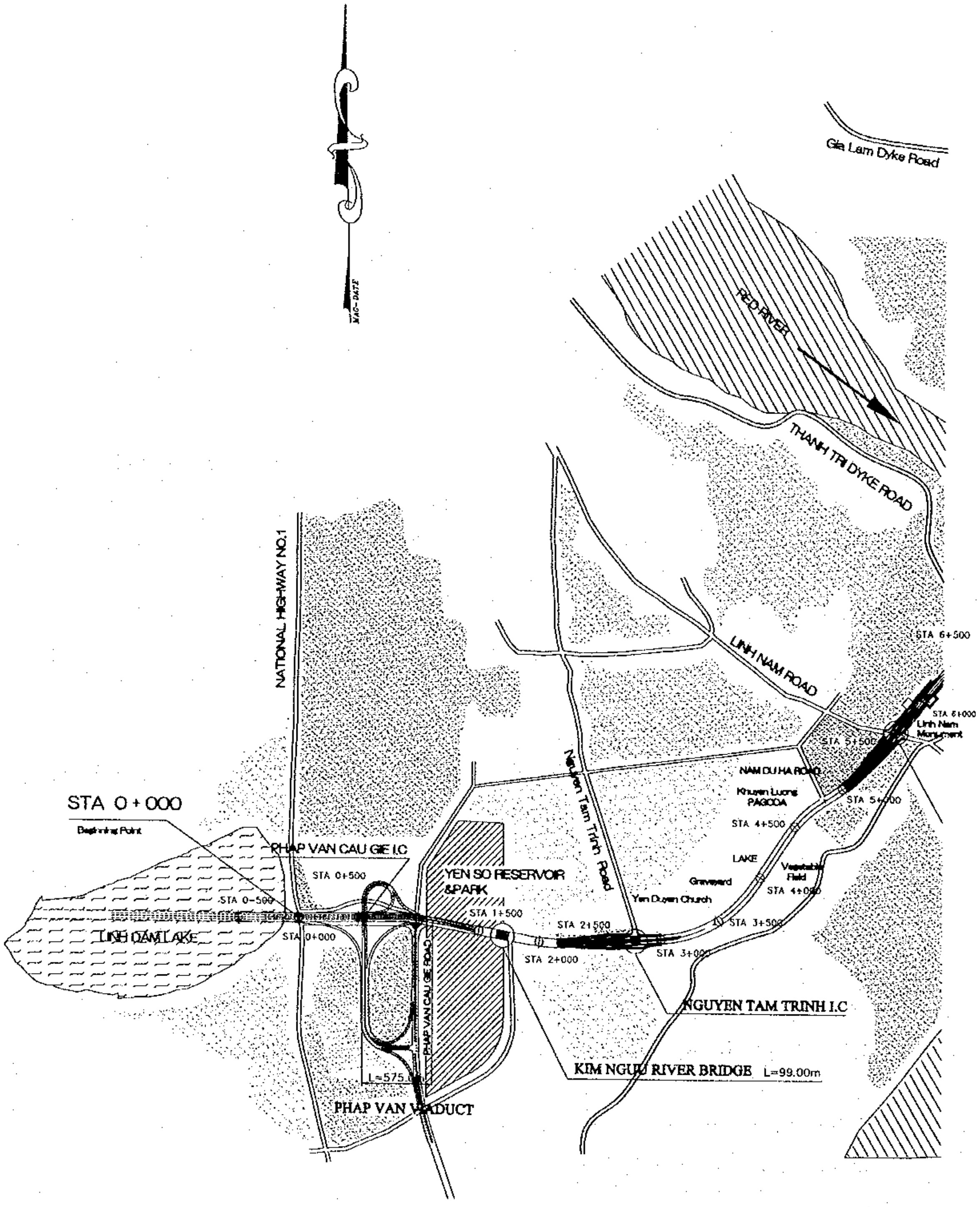


Figure 5.2.1 Project Area (1)

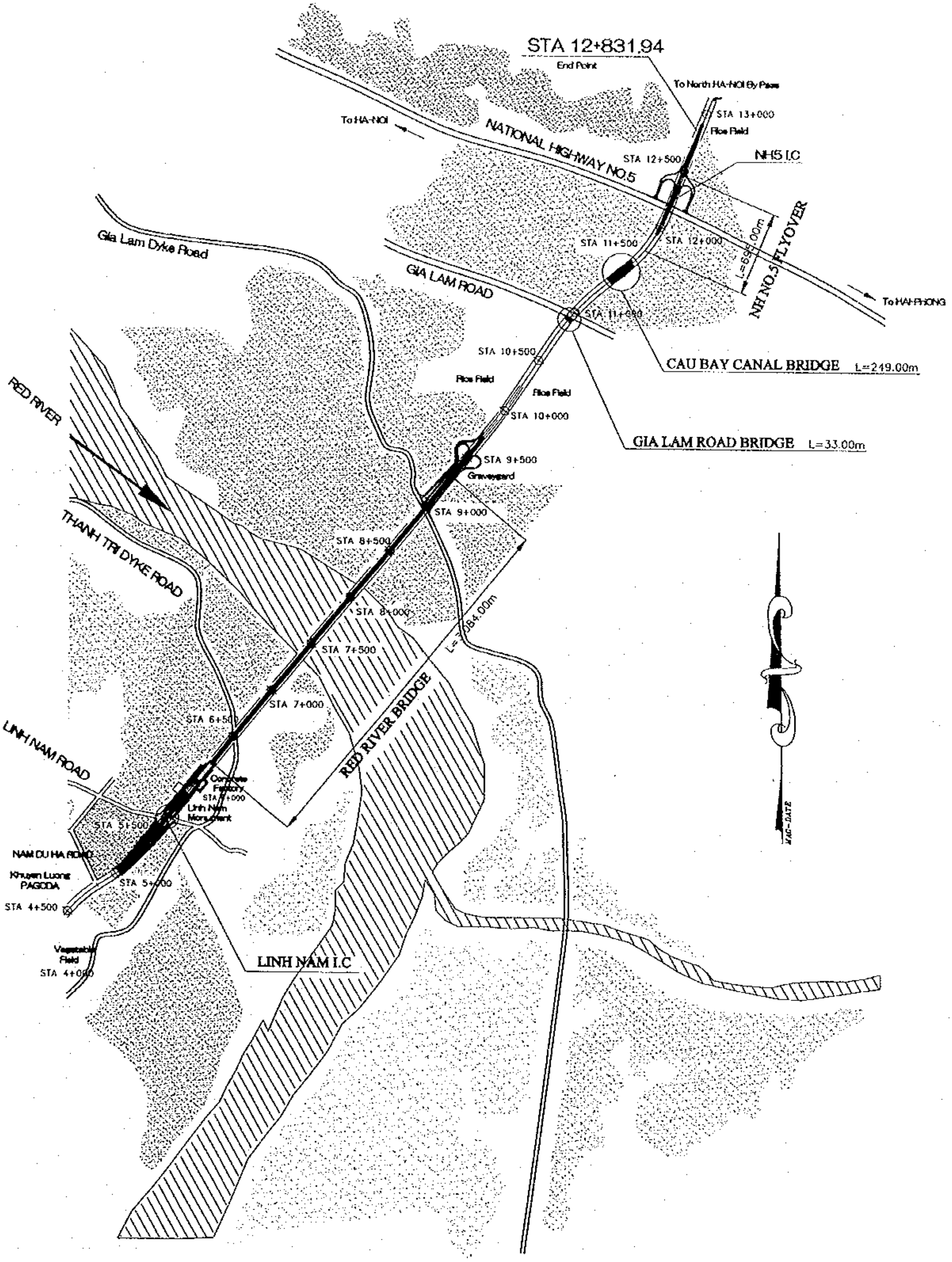


Figure 5.2.1 Project Area (2)

5.2.2 Horizontal Alignment

(1) Re-Alignment

For the project, the design of horizontal alignment as compared with the previous basic design was revised as follows:

(a) Re-Alignment (STA0++000 - STA 1+800, L=1,800 m)

In the section between STA0+000 and STA 1+800, alignment is shifted 20 m to the Hanoi side from the center of the existing Phap Van road owing to the following reasons:

To avoid the reservoirs and the crossing structures in the Yen So area, which are planned by Transportation & Urban Public Works Project Management Board under Hanoi's People Committee, as shown in Figure 5.5.2

To minimize compensation for the houses in the substantial resident area on the right side between STA 0+000 and STA 0+600, and to minimize influence to the facilities of Phap Van Water Supply Company, which supplies the overall Phap Van area with treated water service.

(b) Re-Alignment (STA 1+800 - STA 3+600, L= 1,800 m)

In the section between STA 1+800 and STA 3+600, alignment is shifted 20 m to the south side from the center line fixed at the basic design stage, owing to the following reasons:

To minimize compensation for the substantial residential area located at the left side of the Phap Van road between Kim Nguu River and Yen Duyen village (STA 1+800 - STA 3+600).

(c) Re-alignment (STA4+400 - STA 5+300, L=900 m)

In the section between STA4+400 and STA 5+300, alignment is shifted 35 m to the south side from the center line fixed in the basic design stage to minimize house compensation for the substantial residential area (NAM DU village).

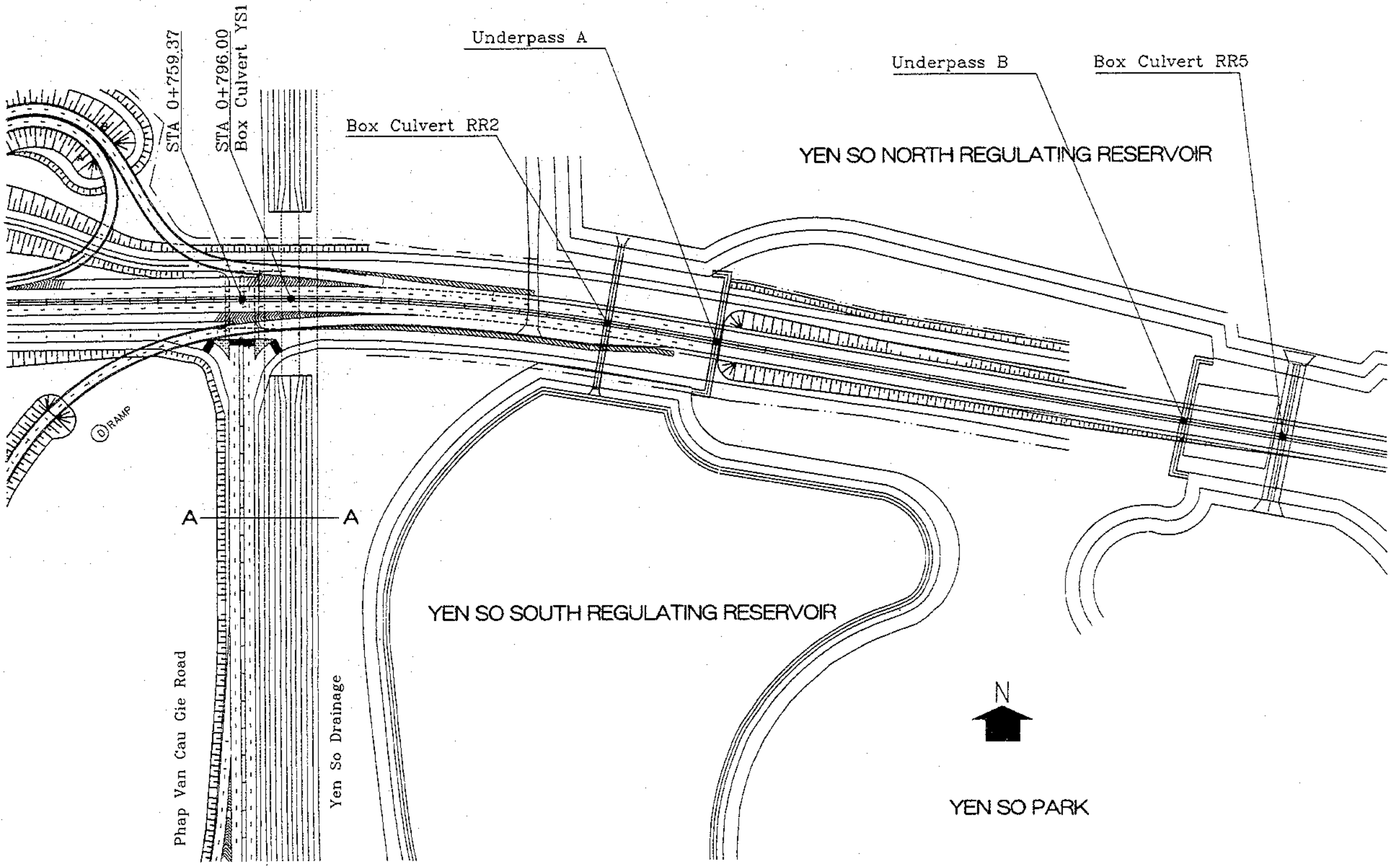


Figure 5.2.2 Yen So Park Area (1)

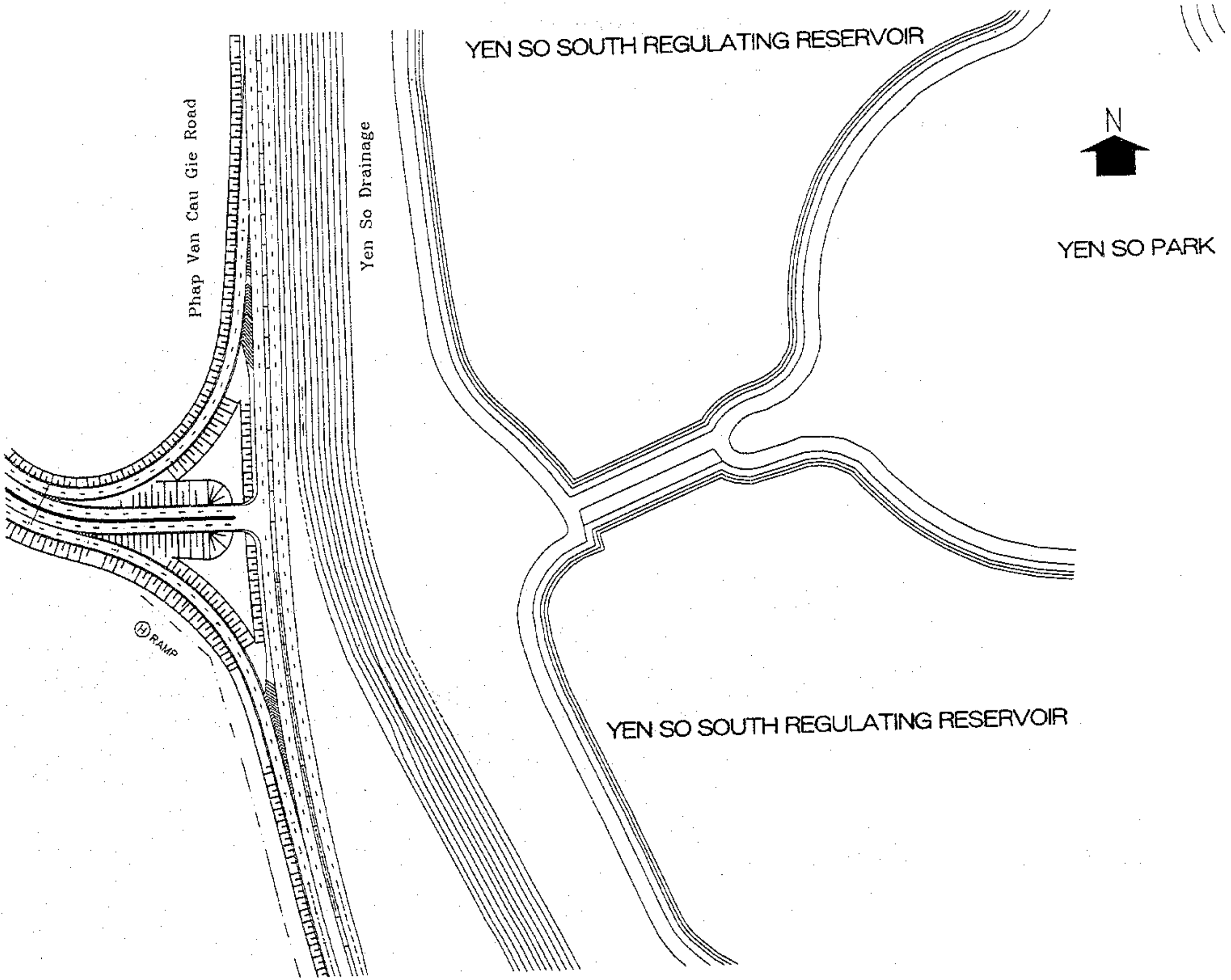


Figure 5.2.2 Yen So Park Area (2)

(2) Important Facilities

Facilities regarded as important such as the Treated Water Supply Company, Yen So Reservoir, Cement Concrete Factory, pagoda, Linh Nam Monument, cemeteries, etc., as shown in Table 5.2.1 are not to be affected.

(3) Gia Lam side (STA 11+000-STA12+000, L=1,000 m)

Beginning alignment to Gia Lam Dyke from Thanh Tri Dyke is set based on the following reasons:

a) Location of at least riverbed fluctuation
b) Possibility of straight alignment for the bridge

On the other hand, SHTRR alignment must be consistent with the alignment from Duong Bridge. In this condition, alignment between STA 9+000 - STA 12+000 was set for the following reasons:

a) Easy access between residential areas by using frontage road.
b) Utilization of existing local road decreases land acquisition
c) Residential area exists near NH5
d) Pump station exists near NH5
e) Curve setting is based on the Geometric Standard.

(4) Connection to the northern new NH No.1 (Hanoi Bypass)

The project road links Hanoi Bypass. Road development plan for Hanoi Bypass between NH5 and the Duong Bridge are as follows;

First phase : two-lane carriageway 2@3.5m
Second phase : four-lane carriageway 4@3.5m
Third phase : six-lane carriageway 6@3.5m

At present, construction for the first phase is under way. The center line of the project agrees with that of the third phase for the future Hanoi bypass (6 lanes). Design limit is the end of the acceleration lane of the NH5 interchange, namely at approximately 652 m from Duong Bridge from the center of the NH5.

(5) Alignment Setting

Horizontal alignment consists of straight lines, circularcurves and clothoidcurves as shown in Table 5.2.2. The highway standard decided in Chapter 4.1 is applied to the decision of geometric structure for the horizontal alignment. Table 5.2.2 shows horizontal alignment elements of the throughway.

Table 5.2.1 Existing Land Use and Facilities

Section		Land Use & Facilities
Than Tri Side	STA 0+000 STA 0+000 -TA 0+500 STA 0+450	- NH1 - Dense Residential Area - Treated Water Supply Company
	STA 0+759.37 STA 0+740 - STA 1+600	- Phap Van Cau Gie Road - Regulating Reservoir Area &Yen Park Area
	STA1+600 - STA 2+800	- Dense Residential Area
	STA 2+800 STA 2+800 - STA 3+600 STA 3+460	- Nguyen Tam Trinh road - Dense Residential Area - Yen Duyen Church
	STA 3+700 STA 4+520 STA 4+800	- Cemetery - Khuyen Luong PAGODA - Were House
	STA 4+820 - STA 5+630	- Dense Residential Area
	STA 5+630 STA 5+630 - STA 5+800 STA 5+760 STA 6+100	- Linh Nam road - Dense Residential Area - Linh Nam Monument - Concrete Factory
Gia Lam Side	STA 8+958 STA 9+000- STA 9+400 STA 9+340	- Gia Lam Dyke road - Residential Area - Cemetery
	STA 10+920 - STA 12+150	- Rice Field
	STA 12+179.59 STA 12+190 - STA 12+200 STA 12+831.94	- NH5 - Dense Residential Area - North Hanoi Bypass

Table 5.2.2 Horizontal Alignment Elements

IP No.	Station	R (m)	A1	A2	L1 (m)	CL (m)	L2 (m)
1	TS=0+727.358 SC=0+850.435 CS=0+968.990 ST=1+092.068	1,300	400	400	123.077	118.556	123.077
2	TS=1+886.414 SC=2+019.747 CS=2+146.412 ST=2+279.745	1,200	400	400	133.333	126.664	133.333
3	TS=2+800.355 SC=3+160.355 CS=3+746.274 ST=4+106.274	1,000	360	360	360.000	585.919	360.000
4	TS=4+324.134 SC=4+501.912 CS=4+699.122 ST=4+876.900	900	400	400	177.778	197.211	177.778
5	TS=4+876.900 SC=5+027.890 CS=5+184.608 ST=5+335.598	1,000	388.574	388.574	150.990	56.717	150.990
6	SC=9+718.176 CS=10+246.962	5,000	-	-	-	528.786	-
7	TS=10+543.619. SC=10+801.514 CS=11+148.911 ST=11+406.806	1,900	700	700	257.895	347.397	257.895
8	TS=11+406.806 SC=11+738.012 CS=11+927.243 ST=12+258.449	1,000	575.505	575.505	331.206	189.230	331.206

Note: R: Circular radius, A1,A2: Clothoid parameter, L1,L2: Clothoid length, CL: Circular curve length, TS: Beginning clothoid curve, SC: Beginning of circular curve, CS: End of circular curve, ST: End of clothoid curve.

5.2.3 Vertical Alignment Design

(1) Floodwater Level

The project area is often flooded at low elevations and there is high ground water level outside of the residential areas. Hydraulic survey was conducted by the project to provide basic data to decide the formation level of the throughway, frontage road and crossing roads.

The formation level of the throughway and the other roads should surpass that of the high water level at the 100-year return period and that of the high water level at the 25-year return period respectively. On the Thanh Tri Side, probable flood levels of the throughway and the other roads are 6.0 m and 5.5 m respectively. Therefore, minimum design formation level including freeboard of the throughway and the other roads are 7.0 m and 6.0 m respectively, as shown in Table 5.2.3.

At the Gia Lam side, probable flood levels of the throughway and the other roads are 5.5 m and 5.0 m, respectively. Therefore, minimum design formation level including freeboard of the throughway and the other roads are 7.0 m and 5.5 m, respectively, as shown in Table 5.2.4.

According to the above formation level, the embankment height of the frontage road approximately is 0.5-1.0 m above the existing ground line. Therefore, the frontage road should be designed so as to be able to ensure accessibility to the crossing roads and to be able to preserve the existing irrigation system. The embankment height of the throughway should also be kept as low as possible to reduce foundation treatment requirements.

Table 5.2.3 Minimum Design Formation Level at Thanh Tri Side

Name of road	Probable flood level (m)	Freeboard (m)	Design Minimum Formation Level (m)
Throughway	6.00	1.00	7.00
Interchange ramp	5.50	0.50	6.00
Frontage road	5.50	0.50	6.00
Urban road	5.50	0.50	6.00

Source: JICA Study Team

Table 5.2.4 Minimum Design Formation Level at Gia Lam Side

Name of road	Probable flood level (m)	Freeboard (m)	Design Minimum Formation Level (m)
Throughway	5.50	1.00	7.00
Interchange ramp	5.00	0.50	5.50
Frontage road	5.00	0.50	5.50
Urban road	5.00	0.50	5.50

Source: JICA Study Team

(2) Vertical and Horizontal Clearance

Vertical alignment design is especially influenced by the vertical and horizontal clearance of the rivers and existing facilities (i.e., roads and railways). The following basic rules are established for the vertical alignment design:

(a) NH1 and NH5 Crossing the Project Road

At the fly-over section of the project road crossing the NH1 and NH5 with railway line, it is necessary to ensure vertical clearances for NH1 and NH5, and the railway adjoining them. Required vertical clearance of NH1, NH5 and the railways are 4.5 m, 4.5 m and 6.8 m respectively. Figures 5.2.3 and 5.2.4 indicate vertical and horizontal clearances of NH1, NH5 and the railways taking account of the future highway and railway plans.

The project agreed the following points of the NH1 side with the Vietnam Railway Association:

- Location of pier center set at 6.5 m from the outer rail of the railway to the NH1 side (It is 3.35 m between the fence of the railway and the edge of pier column).
- For the bridge at the railway side, span length: 33 m is changed for 35 m in order to ensure inspection space.

The project agreed upon the future cross section component for NH1 shown in Figure 5.2.3 with the Hanoi Urban Planning Institute.

The project agreed upon the following points of the NH1 side with the Vietnam Railway Association:

- Location of the pier center (diameter: 2 m) set at 7.2 m from the outer rail of existing railway to the NH5 side (It is 6.2 m between the outer rail of the railway and the edge of the pier)
- Span length: 33 m for the bridge at the railway side is changed for 35 m in order to ensure inspection space.
- For the cycle lane interrupted by the pier, the cycle lane is shifted to the railway side.
- For the above section, the existing lined drainage will be exchanged for a small box culvert.

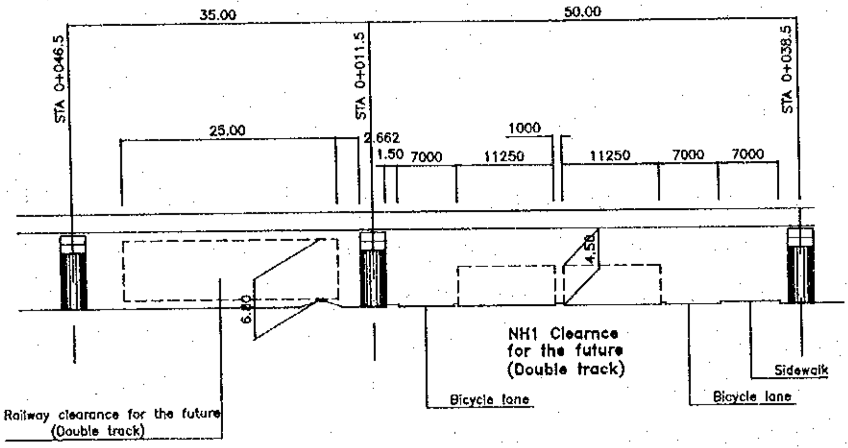


Figure 5.2.3 NH1 Flyover

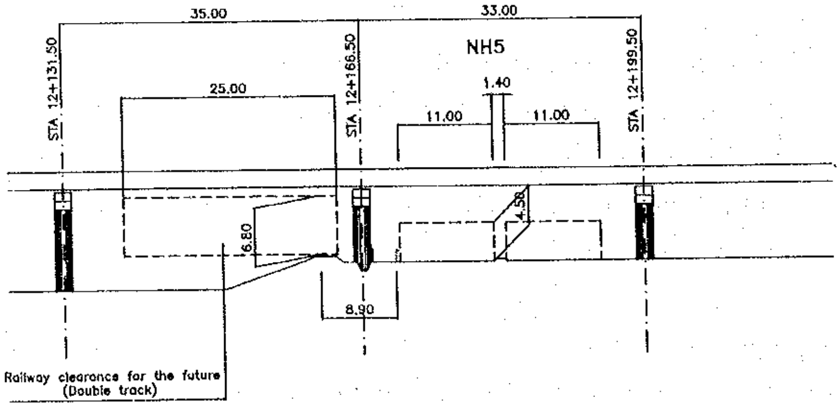


Figure 5.2.4 NH5 Flyover

(b) Main Bridge Section in the Red River Bridge

High water level and clearance greatly influences the vertical alignment of the Red River Bridge. Flood water levels at the main section of the Red River Bridge and clearances were analyzed by the JICA Study Team taking account of the flood return period and vessels. Figure 5.2.5 indicates the high water level at the design return period of 20 years.

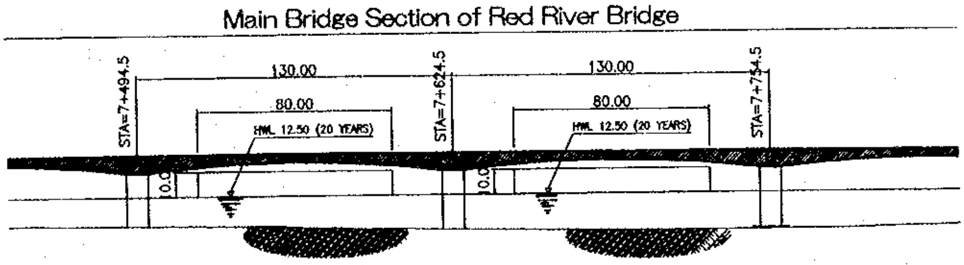


Figure 5.2.5 Navigation Clearance

(c) Urban Roads Crossing the Project Road

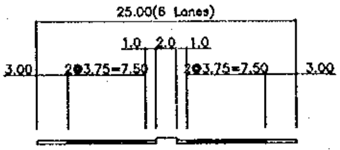
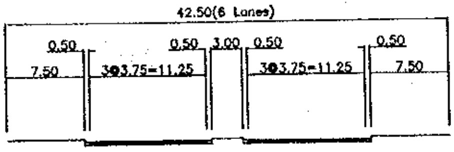
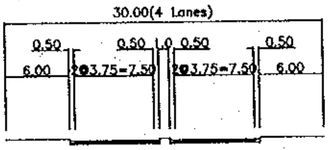
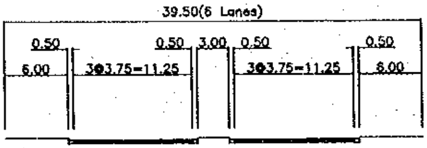
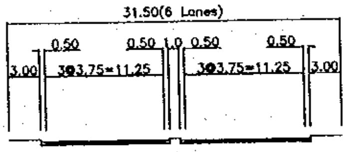
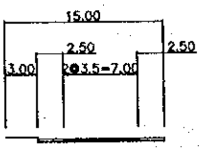
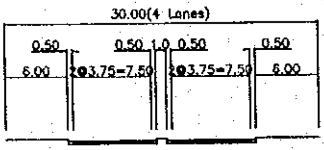
At the sections of the project road crossing the urban road, it is necessary to elevate formation level and to ensure the vertical and horizontal clearance for the urban roads. The urban roads shown in Table 5.2.5 are identified regarding their cross-sectional components and vertical clearances based on the meeting result, September 28th, 1999, with Urban Planning Institute, Hanoi People's Committee, and based on the "Socio-Economic Master Plan of Hanoi City for the Years 2010 and 2020.

(d) Local Road

Local roads crossing the project road should be designed based on the present situation as well as pedestrians' psychology. Local roads are presently divided into two types; vehicle road and pedestrian road. Vertical clearances of the vehicle road and the pedestrian road are 3.5 m and 2.5m respectively. Table 5.2.6 shows the dimension of local/pedestrian roads crossing the project road.

There is a need to provide the pedestrian roads at intervals of five hundred (500) meters to maintain integration of the areas divided by the throughway, since pedestrians are not allowed to cross the expressway except under the fly-over or viaduct at the ground level intersection.

Table 5.2.5 Future Dimension for Urban Road

Urban Road	Function Class	Vertical Clearance (m)	Typical Cross Section
Phap Van Cau Gie STA 0+759.37	Grade III	4.5	
Nguyen Tam Chinh STA 2+800	Grade II		
Nam Du Ha STA 4+820	Grade III		
Linh Nam STA 5+630	Grade II		
Thanh Tri Dyke STA 6+580	Grade III		
Gia Lam Dyke STA8+958	-		
Gia Lam STA10+920	Grade III		

Note: Decision of the above urban road types are based on the meeting result, September 28th, 1999, with Urban Planning Institute, Hanoi People's Committee , and based on the "Social-Economic Master Plan of Hanoi City for The Years 2010 and 2020.

Table 5.2.6 Dimension of Local/Pedestrian Road

Throughway Station	Vehicle(V) or Pedestrian (P)	Clearance (m)	
		Horizontal	Vertical
0+ 984	V	4.0	3.5
1+900	P	3.0	2.5
2+310	P	3.0	2.5
3+439.38	V	4.0	3.5
3+960	V	4.0	3.5
4+503.455	P	3.0	2.5
4+820	V	4.0	3.5
5+120	P	3.0	2.5
6+164.89	V	4.0	3.5
9+900	P	3.0	2.5
10+490	P	3.0	2.5

(3) Soft Ground Area

The project area lies primarily in the soft ground zone. Therefore, in order to fix the vertical alignment, the critical embankment heights at each section of the project road were analyzed to prevent embankment slide, based on the soil survey and the selection of the countermeasures (sand drain and plastic board drain) implanted by the project.

Tables 5.2.7 and 5.2.8 indicate results of the soft ground stabilization analysis. Table 5.2.7 and Table 5.2.8 are the throughway /frontage road and the ramp ways respectively.

As shown in Table 5.2.8, A, B rampways of the NH5 interchange require counter embankment for the stability of the ramp embankment (EL=6.0 m).

Table 5.2.7 Result of Soft Ground Stabilization Analysis (Throughway and Frontage road)

Geological Sections	From/To	Critical Embankment Height (m)	Comprehensive Countermeasure						
			Sand Drain			Plastic Board Drain			Residual Settlement at 450 days
			Interval (m)	Depth (m)	Fs Safety Factor	Interval (m)	Depth (m)	Fs Safety Factor	
T-1-a	1+030 2+600	7.0 (with frontages roads)	2.25	30.0	1.230				1.648
T-1-b	2+600 3+300	11.0 (with frontage roads)	2.00	26.2	1.203				0.001
T-2	3+300 6+214	9.0 (with frontage roads)				1.50	16.0	1.201	0.935
G-1-a	9+298 10+920	8.0 (with one frontage road)				1.50	18.0	1.290	0.018
G-1-b	10+920 12+060	9.0				1.50	16.0	1.215	0.031
G2	12+060 12+868	7.0				1.50	16.7	1.211	0.001
G2	12+060 12+868	* 9.0	1.75	16.7	1.202				0.000

Note: * : Critical embankment height with the counter embankment (h=2.3, EL=3.7m, w=14m)
Source: JICA Study Team

Table 5.2.8 Result of Soft Ground Treatment Analysis (Rampway)

Geological Sections	From/To	Critical Embankment Height (m)	Comprehensive Countermeasure						
			Sand Drain			Plastic Board Drain			Residual Settlement at 450 days
			Interval (m)	Depth (m)	Fs Safety Factor	Interval (m)	Depth (m)	Fs Safety Factor	
T-1-a	1+030 2+600	8.0	2.50	30.0	1.215				1.462
G-1-a	9+298 10+920	9.0 8.0				1.25 1.50	18.0 18.0	1.209 1.254	0.000 0.003
G2	12+060 12+868	8.0 7.0				1.50	16.7	1.211	0.000
G2	12+060 12+868	* 8.0				1.00	16.7	1.208	0.000

Note: * : Critical embankment height with the counter embankment (h=2.3, EL=3.7 m, w=14m)
Source: JICA Study Team

(4) Selection of Viaduct Type between STA 0+ 000 and STA 1+300

In the section between STA 0+000 and STA 1+300 in the Phap Van area, both at-grade type and viaduct type are considered as shown in Figure 5.2.6. They were examined from the standpoint as shown in Table 5.2. 9. As the result of the study, the viaduct was recommended for the following reasons:

(a) Construction Cost

Construction cost of the viaduct type is lower than that of at-grade type, as this section is in the softest ground area in the project. Therefore, in the earthwork section of the at-grade type, considerable expense must be spent for soft-ground treatment. In addition, in the case of the at-grade type, two bridges (Girder height: 3 m, center span: 40 m, total length for two bridges: 240 m) overpass for the ramp diverging from Phan Van-Cau Gie road to the SHTRR and for Phap Van-Cau Gie road need to be newly constructed.

(b) Land/House Compensation:

The at-grade type would occupy portion of the facilities for the Yen So Reservoir area, which is planned and to be constructed by Hanoi Transportation and Urban Public Works Project Management Board. In addition, parts of its designed facilities such as box culverts must be changed.

(c) Road Stability in the Softest Ground Area

For road stability in the softest ground area, the viaduct type (bridge method) is superior to the at-grade type (earthwork method).

(d) Landscaping and Environment

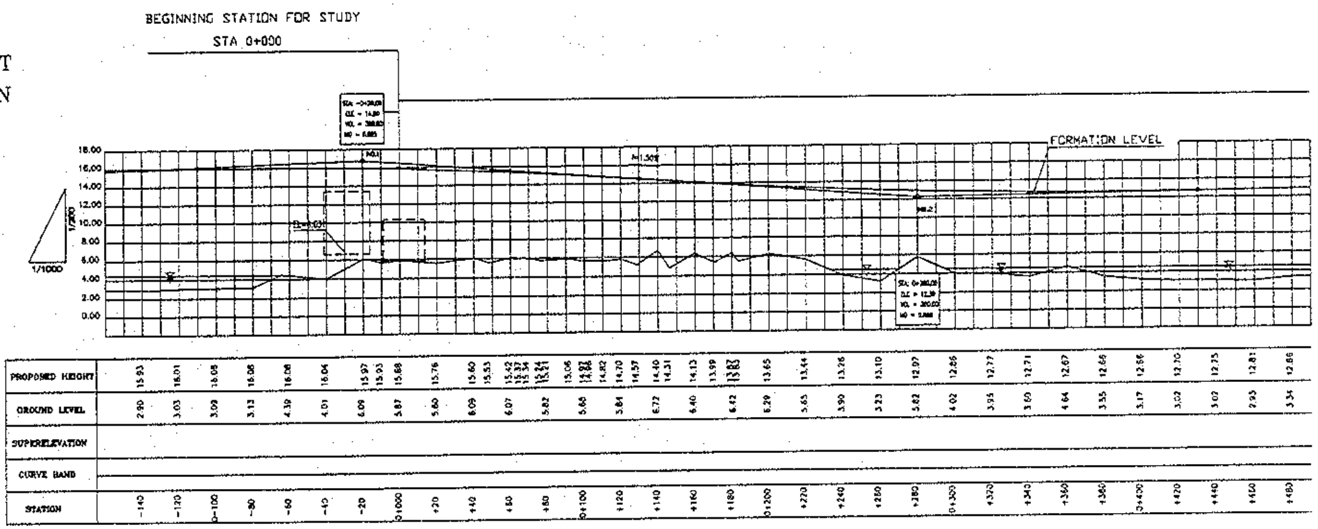
SHTRR section in Yen So park and adjoining Linh Dam lake takes the aspect of landscaping and environment into serious consideration. From this standpoint, the viaduct type is superior to the at-grade type.

Table 5.2.9 Comparison for at-grade and elevated type
STA 0+000 - STA 1+300 (1.3 km)

Item	At-grade Type	Grade	Elevated (viaduct) Type	Grade
Traffic Flow	Validity for interchange of trumpet type was studied	○	Validity for interchange of trumpet type was studied	○
Running Stability	Vertical grade 2%	△	Vertical grade 0.87-0.2%	○
Construction Cost	5.996×10^{11} Dong Breakdown is shown in the attachment	△	5.447×10^{11} Dong Breakdown is shown in the attachment	○
Land / House Compensation	A part of Yen So Park area is occupied	△	Planning Facilities of Yen So Park area maintained	○
Landscaping (scenery) /Land use	Inferior to elevated type for Yen So Park area	△	Land use under the girder	○
Road Stability on the Soft Ground Area	Inferior to bridge foundation	△	Stabilized by the bridge foundation	○
Environment (Noise ,Vibration)	Noise and vibration are greater than the elevated type	△	Noise and vibration are less than the at-grade type	○

COMPARISON FOR THE VIADUCT
AND AT-GRADE TYPE BETWEEN
STA 0+000 AND STA 0+550

PROFILE FOR
VIADUCT TYPE



PROFILE FOR
AT-GRADE TYPE

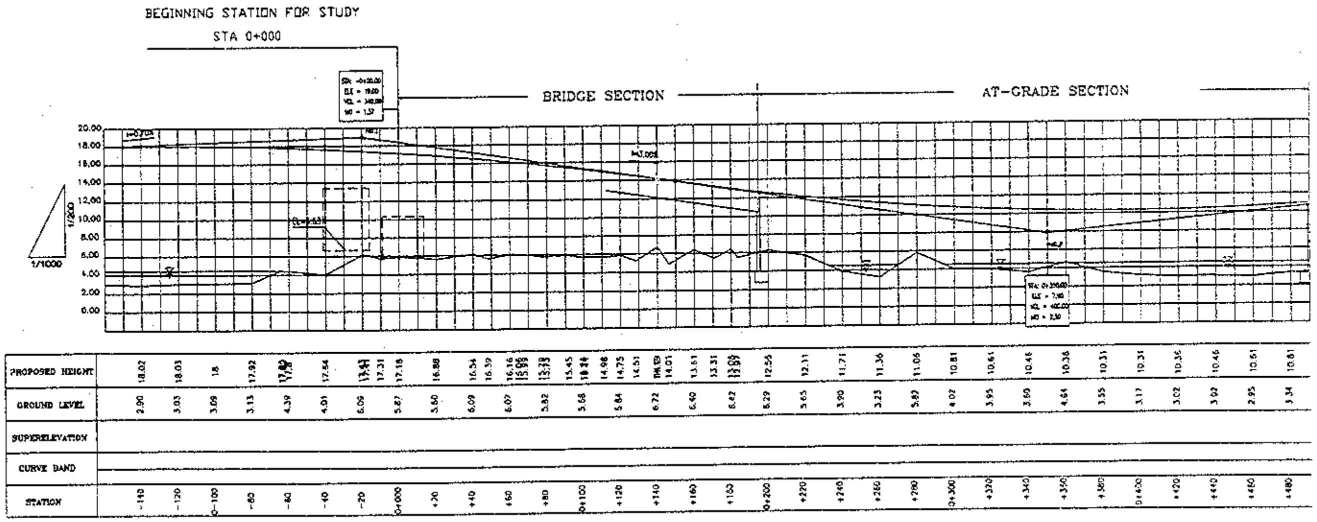


Figure 5.2.6 Profile of At-grade and Viaduct Type (1)

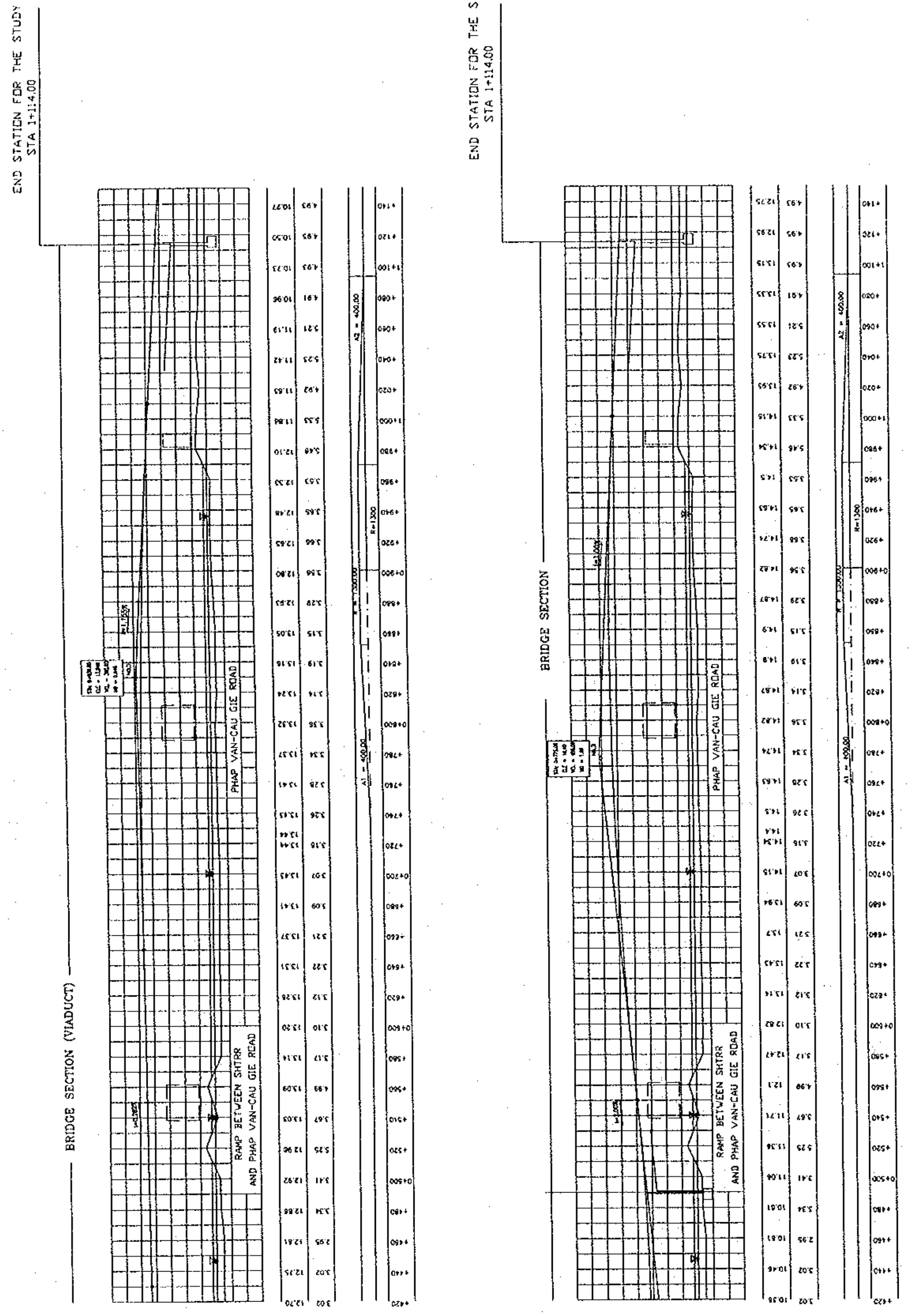


Figure 5.2.6 Profile of Viaduct and At-grade Type (2)

5.3 Interchange Design

5.3.1 Selection of Interchange

The project defined two types of interchanges based on their function. A system interchange connects two access-controlled highways with each other to maintain high mobility and safety (Junction), while a service interchange connects an access-controlled highway to a standard road where it may allow the stopping of traffic by traffic signals according to volume of traffic (Interchange). Accordingly, in case of the project, a service interchange connecting the project road (expressway "South Hanoi Third Ring Road") with the national highways and the urban roads was adopted.

(1) Design Notice

Attention to the following points was especially paid to the design of the interchanges:

(a) Onramp and Offramp

Many traffic accidents occur at the sections of the exit and entrance of the rampway where traffic flow easily falls out line. The provision of smooth traffic flow at the ramp sections is therefore considered to be extremely important. The following ramp elements were fixed to meet the design standards indicated in the Chapter 4.4.1 and to ensure security and comfort of the expressway users:

- Traffic capacity of the offramp/onramp
- Length of deceleration and acceleration lanes
- Length of taper
- Offramp angle and onramp angle
- Stopping sight distance
- Shape of speed change lane

The design for the deceleration lane on the offramp and acceleration lane on the onramp was set taking into account the future increase to six lanes on the throughway, and to therefore avoid difficulty of additional work.

(b) Relation to the Adjoining Interchanges

Minimum interval between interchanges is fixed from the point of view of driving operation and traffic management in addition to those of socio-economic and natural conditions. From the above points, minimum interval between interchanges is set as follows:

- Minimum interval: 1 km is required in order to ensure entrance and exit ramp length, and to ensure weaving length.
- To give effective information to drivers, it is necessary to notify by traffic sign board from at least 2 km before of the interchange.

The shortest interval between the planned interchanges in the project road is 2 km, between Phan Van Cau Gie road and the Nguyen Tam Trinh road.

(2) Location and Type of Interchange

The location and the type of the interchanges on the project road are decided from the social-economic and technical point. In addition, these are decided based on the consultation with the PMU Thang Long and Hanoi Chief Architect Office, Hanoi People's Committee. Table 5.3.1 indicates location and function of each interchange. And Figure 5.3.1 shows each interchange type.

In principal, parallel type of the auxiliary lane is adopted to the onramp, and taper type of the auxiliary lane is adopted to the offramp.

(Phap Van Cau Gie Interchange)

The Phap Van Cau Gie interchange is provided at 550 m east of the existing NH1 to link the Phap Van Cau Gie road, which functions as an urban arterial road and the NH1 bypass, with the throughway and to link the NH1 with the throughway. In addition, the Phap Van Cau Gie interchange was provided so as to avoid the reservoirs and the crossing structures in Yen So area, which are planned by Transportation & Urban Public Works Project Management Board under Hanoi's People Committee.

(Nguyen Tam Trinh Interchange)

The Nguyen Tam Trinh Interchange was provided to link the Nguyen Tan Trinh road, which functions as an urban arterial road leading to the center of the Hanoi by the throughway. Onramp A from the Nguyen Tan Trinh road access to NH1 or Phap Van Cau Gie road, and offramp B from the throughway access to Nguyen Tan Trinh road are provided. The interchange type is a half-diamond type.

(Linh Nam Interchange)

The Linh Nam Interchange is provided to link the Linh Nam road, which functions as an urban road leading to the center of the Hanoi city, with the throughway. Onramp/offramp A, B links NH1or Phap Van Cau Gie road and Linh Nam road. Onramp/offramp C, D link the Linh Nam road and Tan Trinh bridge with bicycle lanes for community service. The interchange is a full-diamond type.

(Gia Lam Dyke Interchange)

The Gia Lam Dyke Interchange is provided to link the Gia Lam Dyke Road, which functions not only as an urban road but also as a service road for the residents, with the throughway. Onramp B accesses to the Thanh Tri Bridge with bicycle lanes for community service, and offramp A accesses from the Thanh Tri Bridge to the Gia Lam side with bicycle lanes for community service. The interchange is a half-diamond type.

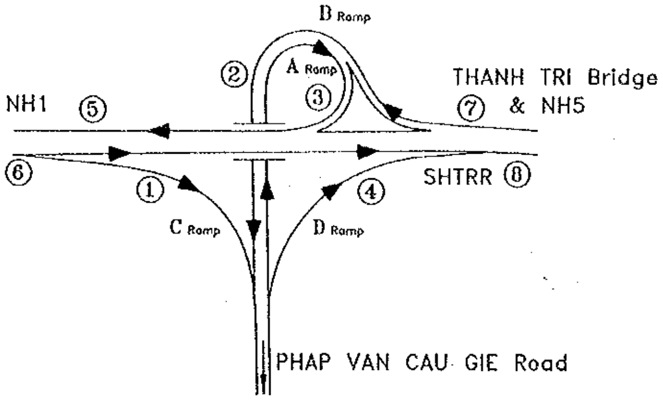
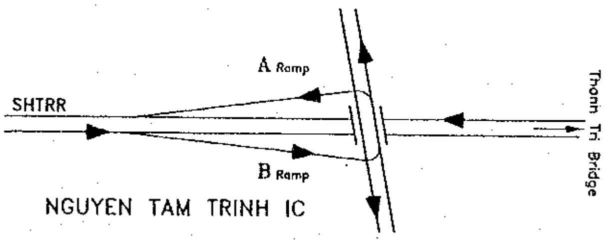
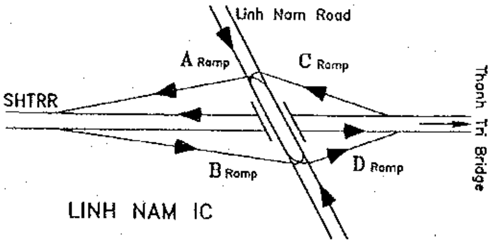
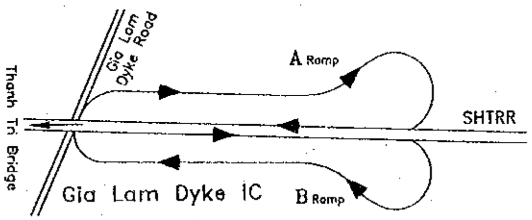
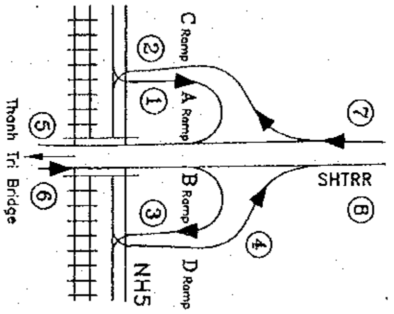
(NH5 Interchange)

The NH5 Interchange is provided to link the NH1, which functions as a national highway leading to the center of the Hanoi or Hai Phong, with the throughway.
Onramp/offramp A,B access between Thanh Tri Bridge and NH5 is provided. Onramp/offramp C,D access between the Duong Bridge and the NH5. The interchange is a half-cloverleaf type.

Table 5.3.1 List of Interchanges (I.C)

I.C. Name	I.C. Type	Linking Road	Function
Phap Van Cau Gie STA 0+550	Single Trumpet	Phap Van Cau Gie Road	Access from Phap Van Cau Gie Road to the project road and access from the project road to Phap Van Cau Gie Road. Access from NH1 to the project road and access from the project road to NH1.
Nguyen Tam Trinh STA 2+800	Half Diamond	Nguyen Tam Trinh Road	Access between Nguyen Tan Trinh Road and the project road. Onramp A access to NH1 or Phap Van Cau Gie Road, and offramp B access to Nguyen Tan Trinh Road.
Linh Nam STA 5+630	Full Diamond	Linh Nam Road	Access between Linh Nam Road and the project road. On/off-ramp A,B access between NH1or Phap Van Cau Gie road and Linh Nam Road. On/off-ramp C,D access between Linh Nam Road and Tan Trinh Bridge with bicycle lane for community service.
Gia Lam Dyke STA 8+958	Half Diamond	Gia Lam Dyke Road	Access between Gia Lam Dyke Road and Gia Lam side. Onramp A access to Thanh Tri Bridge and offramp B access from Thanh Tri Bridge to Gia Lam side with bicycle lane for community service.
NH5 STA 12+179.59	Half Cloverleaf	NH 5	Access between NH5 and the project road. On/off-ramp A,B access between Thanh Tri Bridge and NH5. On/off-ramp C,D access between Duong Bridge.

Table 5.3.2 Interchange Type

Interchange Name	Configuration
Phap Van Cau Gie	
Nguyen Tam Trinh	
Linh Nam	
Gia Lam	
NH5	

5.3.2 Design of Phap Van Cau Gie I.C.

NH1 interchange was planned in the vicinity of Linh Dam Lake to connect NH1 with the throughway in the basic design. However, since the Phap Van Cau Gie Interchange (called "New NH1 interchange" in the basic design) was situated at STA 0+550 m, the interval between NH1 Interchange and the Phap Van Cau Gie Interchange is too short. Only in Phap Van Cau Gie Interchange made the function between the NH1 and the throughway fulfill.

Minimum interval between interchanges is decided from the point of view of driving operation and traffic management, in addition to socio-economic and natural conditions. From the above points, minimum interval between interchanges is figured as follows:

- Minimum interval of 1 km is required in order to ensure entrance and exit ramp length and weaving length.
- To give effective information to drivers, it is necessary to notify by traffic sign board from at least 2 km before the interchange.

(1) Selection of Interchange Type

Two types (cloverleaf type and trumpet type) for the interchange between STA 0+000 and STA 0+ 800 were considered to manage the traffic flow between the Phap Van Cau Gie Road and the project road, and between the NH1. Trumpet type was recommended for the following reasons:

- Construction cost of the trumpet type is almost the same as that of the cloverleaf type. But in the case of the cloverleaf type, total project cost including land acquisition / compensation is increased.

- In case of the trumpet type, owing to the extension to the northern side of the Phap Van Cau Gie Road in the future (according to the Social-Economic Master Plan of Hanoi), the Phap Van Cau Gie Road functions as not only an urban arterial road but also as a bypass connecting NH1 with the project.

- In case of the trumpet type, land acquisition and/compensation cost is smaller than that of the cloverleaf type. In particular, it is possible to avoid the Phap Van Water supply company, which supplies the overall Phap Van area with water service. On the other hand, for the cloverleaf type, it is impossible to avoid the Phap Van water supply area.

- In case of the cloverleaf type, traffic flow from the ramp loop and the frontage road shows a tendency of rushing into the center of this interchange. Such a characteristic causes weaving, bringing about traffic congestion.

- In case of the trumpet type, the future traffic volume (2020) estimated from NH1 to the throughway and from the throughwayy to NH1 are 22,411 and 21,518 PCU / day respectively for the traffic capacity of the frontage road (35,000 PCU / day / 2 lane). Therefore, traffic capacity for the frontage road is sufficient for the future traffic volume (2020). The at-grade intersection between NH1 and the throughway, is manageable by a traffic signal system. Left-turn hourly traffic volume from Hanoi to the throughway for the NH1 and right-turn hourly traffic volume from the throughway to Hanoi for the NH1 are 2,016/2-lane/PCU/h and 1,936/2-lane/PCU/h respectively. In either case, these are less than the possible saturation flow rate: 1,800 × 2 = 3,600 PCU/green hour.

(2) Adoption of Single Trumpet Type

Trumpet type is divided into single and double trumpet. Single trumpet type is adopted for the project from the following reasons.

- For the traffic management on the intersection connecting with the Phap Van Cau Gie Road, it is sufficient to adapt to no-signal at-grade intersection for Stage 1 (up to 2010).

- Double-trumpet type should be adopted for the increase of traffic volume caused by linking the Phap Van Cau Gie Road to the center of Hanoi in the future.

Table 5.3.3 Comparison of Interchange
STA 0+400 - STA 1+040

Items	Type of Interchange	
	Cloverleaf	Trumpet
ROW Area (m^2)	20 ha (approximately)	17 ha (approximately)
Land acquisition and compensation (ha)	6.26 ha	2.25 ha
Ramp Length (km)	3.6 km	4.3 km
Traffic flow and Future traffic volume (PCU/day) (2020)	This type functions for the traffic flow between SHTRR and the northern side of NH1, and between Phan Van Cau Gie Road and SHTRR. It is necessary to study carefully for weaving occurring between loop ramp and frontage road.	This type functions for the traffic flow between SHTRR and NH1crossing Phan Van Road, and between Phan Van Cau Gie Road and SHTRR for the year 2010.
Accessibility (Detour distance) SHTRR-Bypass NH1-SHTRR	0.6 km (average) (0.4 km) (0.9 km)	1.6 km (average) (1.1 km) (2.0 km)
Utilization for Phap Van - Cau Gie Road	Section (600m) from diverging point to SHTRR to Hanoi, which is under-construction , is not revived.	Owing to the extension to the north of the Phap Van Cau Gie Road in the future, the Phap Van Cau Gie Road functions as not only an urban arterial road but also the bypass for the NH1 like the cloverleaf type.
Construction Cost (x million dong)	815200 (Bridge, box culverts, pavement, embankment)	811400 (Bridges, box culverts, pavement, embankment)

Note: Construction Cost does not include land compensation, soft ground treatment and frontage roads

5.4 Pavement Design

5.4.1 Selection of Pavement Type

Detailed pavement design is carried out for the throughway, ramps and the frontage roads in the project road. Characteristics of flexible pavement and rigid pavement were compared together with local situations as summarized in Table 5.4.1.

Table 5.4.1 Comparison of Flexible and Rigid Pavement

Item	Flexible Pavement	Rigid Pavement
Stage construction	Two stages for 20 years	Single stage for 20 years
Maintenance	Periodic maintenance	Limited maintenance
Quality control	Sensitive to temperature	Easy
Sensitivity to overloaded trucks	Sensitive	Not sensitive
Main material source	Imported asphalt	Locally produced cement
Adaptability to maintenance	Easy for repair	Careful traffic management is needed

Both flexible and rigid pavement types are available for the construction of roads, however, the adoption of flexible pavement is recommended for the following reasons:

- Rigid pavement is very sensitive on soft ground flood plain area. The soil investigation results pointed out that the project area is mostly in a weak soil area and requires soil stabilization at high embankment stretches.
- The project highway is defined as urban toll road, therefore riding condition is an important design factor.

As a result of study, the asphalt concrete pavement is to be employed in consideration of:

- The fact that the asphalt concrete pavement can attain smoother riding conditions.
- The fact that flexible design will ensure more speedy construction.
- Lower initial cost

For the toll plaza area, Portland cement concrete pavement will be used.

5.4.2 Design Condition

"Chapter 4. Pavement Design Standard" is used to determine the thickness of pavement layers. The asphalt pavement requires a sufficient layer thickness for design traffic load and all pavement layers, from the subbase course to the surface course must be functional and well-balanced. The most important consideration in the asphalt pavement structures is cost-saving in maintenance work after construction. It is therefore recommended that sufficient allowance be considered in the thickness design. The design condition is presented as follows;

(1) Daily Traffic Volume

The forecast daily traffic volumes are described in "Feasibility Study report". The forecast daily traffic volumes for the years 2003, 2018 and 2020 are reference years adopted for SHTRR.

1) Year 2003 assumes the beginning of operation year.
2) Year 2018 is analysis and performance period.
3) Year 2020 is reference year.

(2) Estimation of Equivalent 18-kip Single Axle Load (ESAL)

Equivalent standard axle load (ESAL) is expressed in terms of the cumulative single axle load of 8,200kg(18kip), over the analysis period; 15 years, of the project road. Vehicle types such as passenger cars, buses and trucks are adapted to pavement design.

For estimation of equivalent 18-kip single axle load, daily average traffic volume is converted into truck load factor. The truck load factor is determined based on "AASHTO Guide for Design of Pavement Structure, 1986" as shown in Table 5.4.2.

Table 5.4.2 Truck load factor

Vehicle Type	Truck Load Factor
Passenger car	0.008
Bus	0.681
Truck (1)	0.189

Notes: (1) 2 axle /6-tire trucks

Equivalent 18-kip single axle load for the each road and the growth rate per year of traffic volume is shown in Table 5.4.3.

(2) Strength of Sub-Grade

The strength of sub-grade will govern the thickness design of the pavement. Commonly, the strength is expressed by California Bearing Ratio (CBR) value determined by laboratory testing. A CBR value of 6.0% is adopted in the computation of pavement thickness.

Table 5.4.3 Initial Year (2003) 18-kip ESAL and Growth Rate

Location		Type of Vehicle	2003			Growth Rate of Traffic Volume
			ADT (Vehicle /day)	ESAL		
				/day	/year	
Throughway		Passenger car	9,120	73		18.75 %/year
		Bus	1,920	1,307		
		Truck	4,940	934		
		Total	16,000	2,314	844,610	
Phap-Van Cau Gie Interchange	Ramp A,C	Passenger car	961	8		
		Bus	198	135		
		Truck	523	99		
		Total	1,682	242	88,330	
	Ramp B,D	Passenger car	2,242	18		
		Bus	462	315		
		Truck	1,220	231		
		Total	3,924	564	205,860	
NH5 Interchange	Ramp A,B	Passenger car	3,030	24		
		Bus	624	425		
		Truck	1,649	312		
		Total	5,303	761	277,765	
	Ramp C,D	Passenger car	1,463	12		
		Bus	301	205		
		Truck	796	150		
		Total	2,560	367	133,955	
Linh Nam Interchange	Ramp A,B,CD	Passenger car	961	8		
		Bus	198	135		
		Truck	523	99		
		Total	1,682	252	91,980	
Nguyentan Trnh &Gia Lam Dyke Interchange	Ramp A,B	Passenger car	961	8		
		Bus	198	135		
		Truck	523	99		
		Total	1,682	252	91,980	
Frontage Road	Phap Van Section	Passenger car	2,107	17		
		Bus	434	296		
		Truck	1,147	217		
		Total	3,688	530	193,450	
	Other Section	Passenger car	1,463	12		
		Bus	301	205		
		Truck	796	150		
		Total	2,560	367	133,955	

Note: Truck Factor : Passenger 0.008, Bus 0.681, Truck 0.189

5.4.3 Required Structure Type and Thickness

Using the DNPS86/PCTM of Computer Soft program AADHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURE - 1986 issued by American Association of State; pavement type and thickness for each road are summarized as shown in Table .

(1) Throughway/Frontage Road

Table 5.4.4 Pavement Structure for Throughway/Frontage Road

Material	Throughway	Pavement Thickness (cm)	
		Frontage Road	
		F-1	F-2
Asphalt Concrete Surface Course	5	5	5
Asphalt Concrete Binder Course	5	5	-
Asphalt Treated Base Course	10	10	10
Stabilized Aggregate Base Course	15	15	15
Crusher-run Aggregate Sub-base	40	30	35
Total	75	65	65

Note: F-1: Phap Van Cau Gie Section of frontage road
(Right side: STA 0+000-STA 0+7590.256, Left side: STA 0+000-STA 0+770.646)
F-2: Other frontage road section

(2) Rampway

Table 5.4.5 Pavement Structure for Ramp-way

Material	Pavement Thickness of Interchange Ramp		
	Phap Van Cau Gie	NH5	Other
Asphalt Concrete Surface Course	5	5	5
Asphalt Concrete Binder Course	5	5	-
Asphalt Treated Base Course	10	10	10
Stabilized Aggregate Base Course	15	15	15
Crusher-run Aggregate Sub-base	30	35	35
Total	65	70	65

Note: Others: Nguyen Tan Trinh Interchange, Ramp A,B
Linh Nam Interchange, Ramp A,B,C,D
Gia Lam Dyke Interchange, A,B

(3) Toll Plaza (Cement Concrete Pavement)

Table 5.4.6 Pavement Structure for Toll Plaza

Material	Thickness (cm)
Cement Concrete	25
Sub-base Thickness	25

5.5 Cross Section

Cross section for the project road and width are indicated in Section 4.4.1, and traffic analysis in Section 5.5.1. The component of the cross section for the throughway, frontage road and rampways applied for the project road is as follows:

5.5.1 Throughway and Frontage Road

(1) Throughway

The throughway accommodates fast-moving vehicles, motorcars and high-capacity motorcycles. Non-motorized vehicles should be prohibited to enter except on the Red River Bridge, where a non-motorized lane is installed as a countermeasure for the community between Thanh Tri side and Gia Lam. Since motorcycles presently dominate traffic, and motorized traffic and motorcar ownership is very limited in Metropolitan Hanoi, the throughway will be tentatively used by both motorcars and motorcycles.

The recommended number of lanes for the throughway is four for both the Thanh Tri and Gia Lam sections of the project road. The design for the deceleration and acceleration lane on the interchange section of the throughway is set taking into account the future six lanes, to avoid difficulty of the additional work.

Cross-section component for the each throughway type is as follows:

Table 5.5.1 Cross Section Component for the Each Throughway Type

(unit: m)

Throughway Type	Cross Section Component		
Embankment (Ordinary section):	Protected shoulder: Outer shoulder : Carriageway : Inner shoulder : Median :	2 x 0.75 2 x 3.00 2 x 2x3.75 2 x1.00 2.00	Total width 26.50 m
Embankment (Interchange section)	Protected shoulder : Outer shoulder : Carriageway : Inner shoulder : Median :	2 x0.75 2 x6.50 2 x2x3.75 2 x 1.00 2.00	Total width 33.50 m
Red River Bridge	Curbs : Non motercycle lanes Outer shoulders : Carriageways : Inner shoulders : Curbs : Side clearance :	2 x0.55 2 x3.5 2 x3.00 2 x2 x3.75 2x1.00 2 x0.55 0.9	Total width 33.10 m

(2) Frontage Road

There are two types, both one way and two ways, of the carriageway due to the situation of the land use along the project road. Both the walk side for pedestrian and bicycle lanes are accommodated. The walk side and bicycle lane provide important space for drainage structures, street lighting, regulatory/warning and guide signs as well as underground or aerial public utilities.

Cross section component for the each frontage road type is as follows:

Table 5.5.2 Cross Section Component for the Each Frontage Road Type

Frontage Road Type	Cross Section Component		
One-way/Two-lane (Type F-1, TypeF-2)	Protected shoulder : Sidewalk : Non-motorcycle lane : Shoulder : Carriageway :	0.50 3.00 3.00 2 x0.50 2 x3.50	Total Width 14.50
Two-way/Two-lane (TypeF-3, TypeF-4)	Protected shoulder: Sidewalk : Shoulder : Carriageway :	0.50 2 x3.00 2 x0.50 2 x3.50	Total Width 14.50

Cross-sections for the throughway and frontage road are adopted in the following sections of the project road:

Table 5.5.3 Application of the Rampway Type

Sections	Section (STA)	Throughway Cross Section Type
Thanh Tri Side	0+000 - 1+112	with viaduct and both side frontage road (TypeF-1,2)
	1+112 - 5+630	with both side frontage (Type F-2)
	5+630 - 6+160	with one side the frontage road (Type F-3,4)
Thanh Tri River	6+160 - 9+302	(Bridge)
Gia Lam Side	9+302 - 10+920	with one side frontage road (Type F3,4)
	10+920 - 12+831	without frontage road

Note: The above sections include bridge sections.

5.5.2 Rampway

There are three types; one-way/single-lane with parking shoulder (R-3), one-way/single-lane with parking shoulder and non-motorcycle lane (R-5), and one-way/two-lane without parking shoulder (R-1,R-2).

Rampway for the one-way/single-lane is installed at right side parking shoulder so as to be able to park a vehicle in an emergency. Rampways with non-motorcycle lane are adopted at the C,D rampways of the Linh Nam Interchange and at the A,B rampways of the Gia Lam Dyke Interchange, to preseve/enhance local communities between Thanh Tri side and Gia lam side.

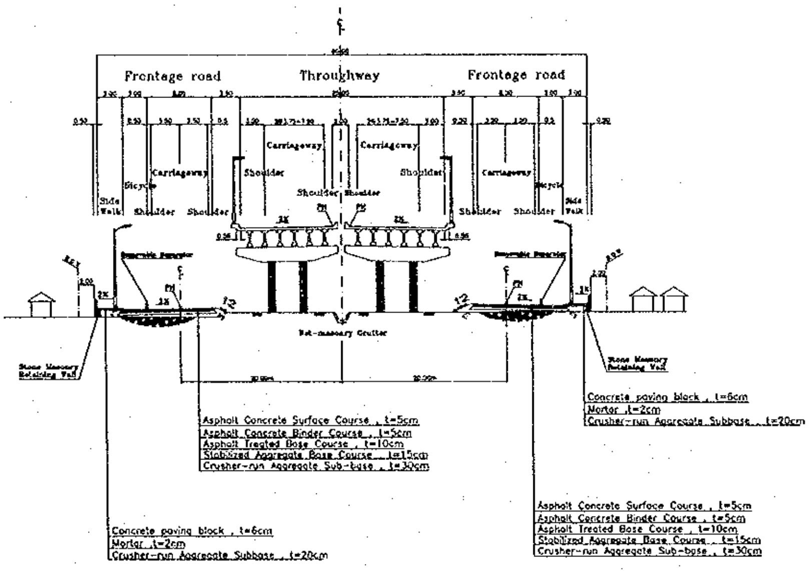
Table 5.5.4 Application of the Rampway Type

(unit: m)

Rampway Type	Cross-section Component		Application
One-way/single-lane, with paking shoulder	Protected shoulder : Min. : Shoulder : Carriageway : Parking shoulder : Protected shoulder :	0.50 1.00 3.50 2.50 0.75	Nguyen Tam Trinh Interchange, A, B ramps. Lin Nam Interchange, A, B ramps.
One-way/single-lane, with paking shoulder and non-motorized	Protected shoulder : Min. : Non-motorcycle lane : Carriageway : Parking shoulder : Protected shoulder :	0.50 3.00 3.50 2.50 0.75	Lin Nam Interchange, C, D ramps. Gia Lam Interchange, A, B ramps.
One-way/two-lane	Protected shoulder : Shoulder : Carriageway :	2 x 0.75 2 x 1.00 2 x 3.50	Phap Van Cau Gie Interchange, A, B, C, D, G, H ramps. NH5 Interchange, A, B, C, D ramps.
Two-way/four-lane	Protected Shoulder Outer shoulder Inner shoulder Carriageway	2 x 0.75 2 x 1.00 2 x 0.50 4 x 3.50	Phap Van Cau Gie Interchange, A, B, E, F ramp

STA0+100

(PHAP VAN VIADUCT)



STA1+060

(PHAP VAN VIADUCT)

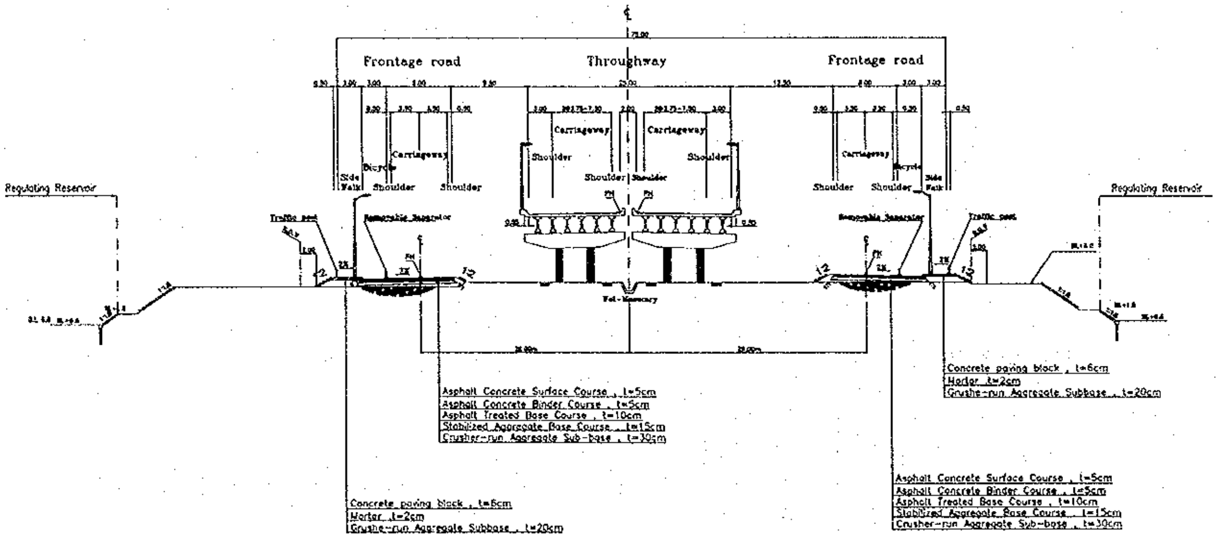
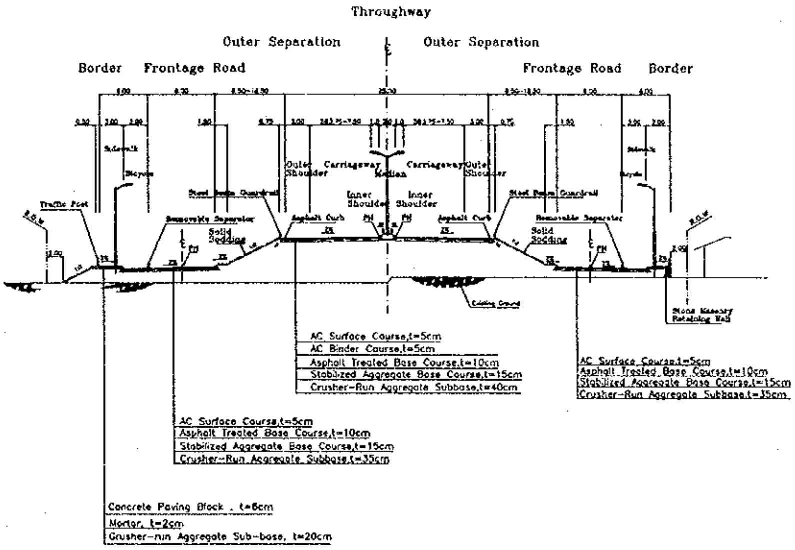


Figure 5.5.1 Typical Cross Section (1)

STA3+340
(THOUGHWAY WITH BOTH SIDE FRONTAGE ROAD)



STA7+620
(MAIN BRIDGE)

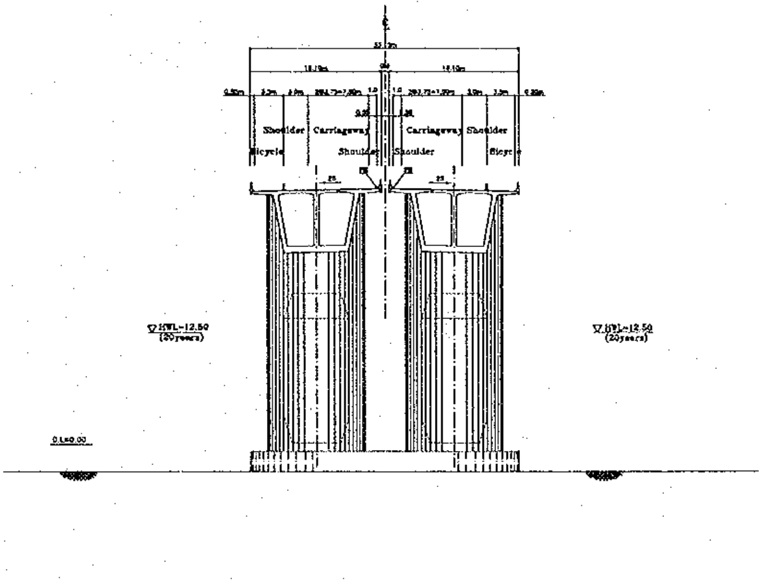
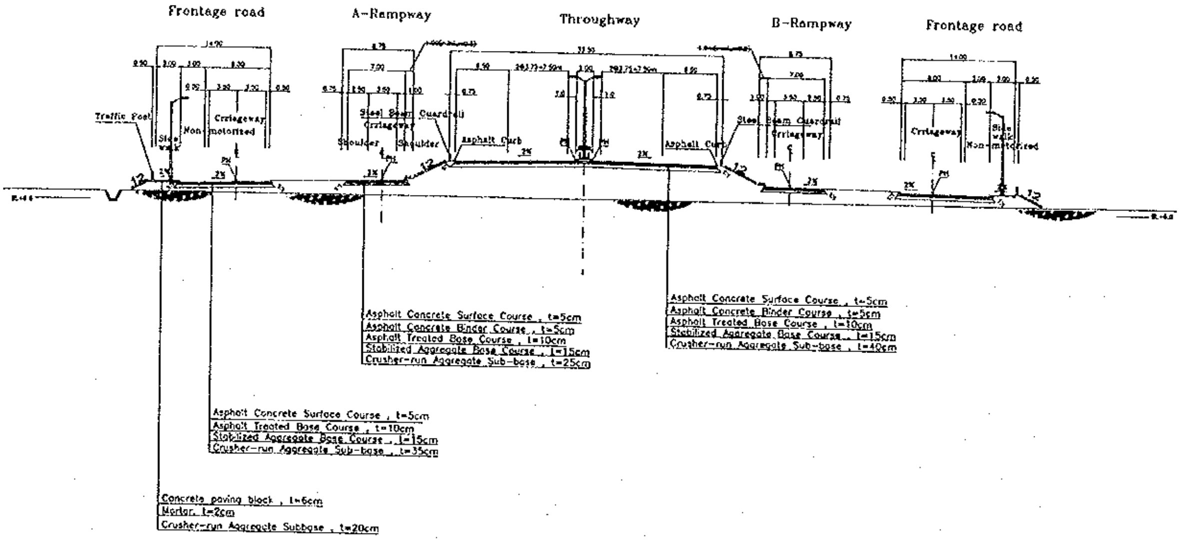


Figure 5.5.1 Typical Cross Section (2)

STA2+600
(NGUYEN TAM TRINH INTERCHANGE)



STA5+800
(LINH NAM INTERCHANGE)

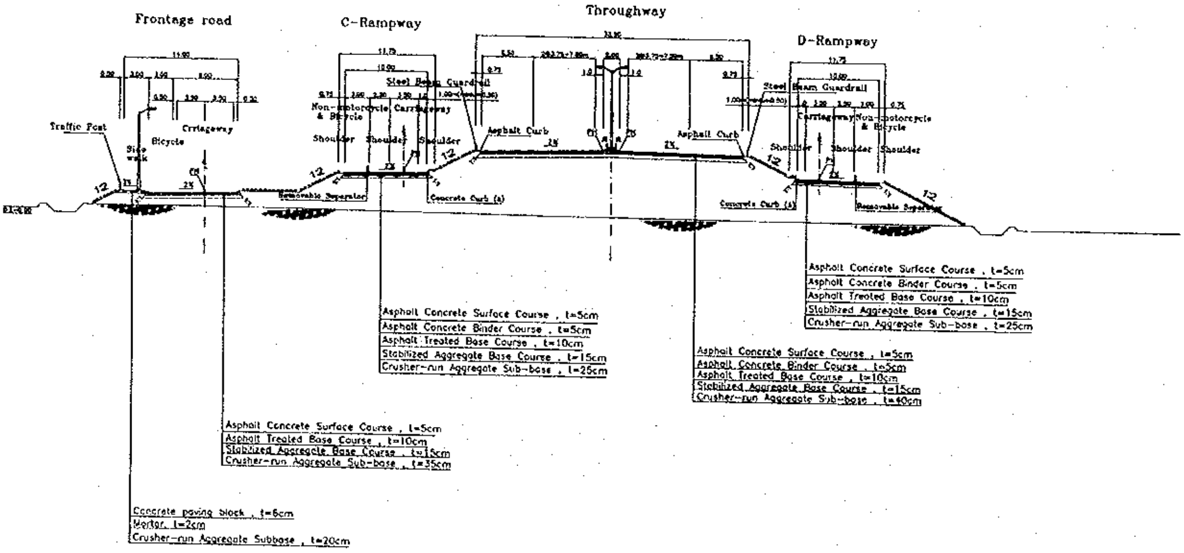
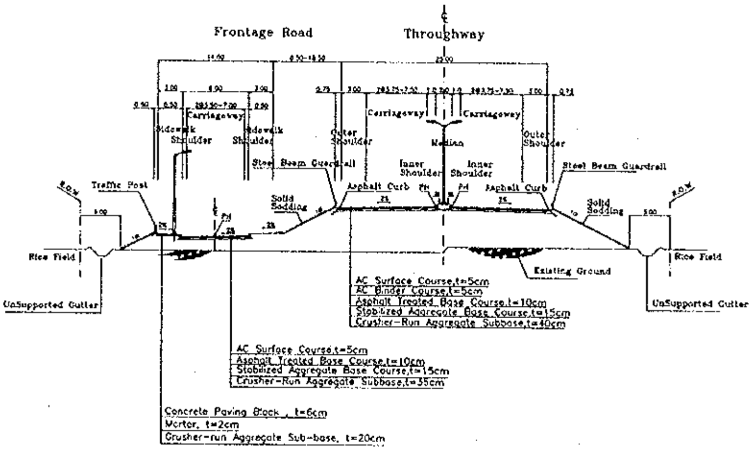


Figure 5.5.1 Typical Cross Section (3)

STA10+340
(THOUGHWAY WITH ONE SIDE FRONTAGE ROAD)



STA11+160
(THOUGHWAY WITHOUT FRONTAGE ROAD)

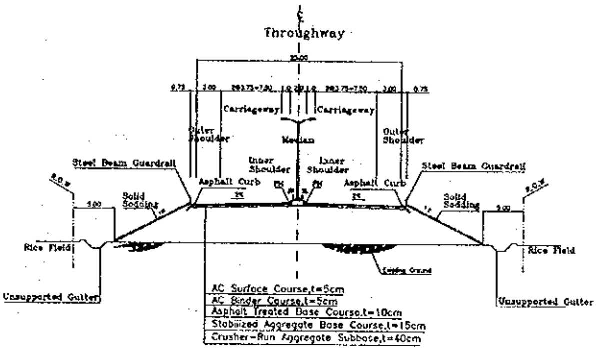
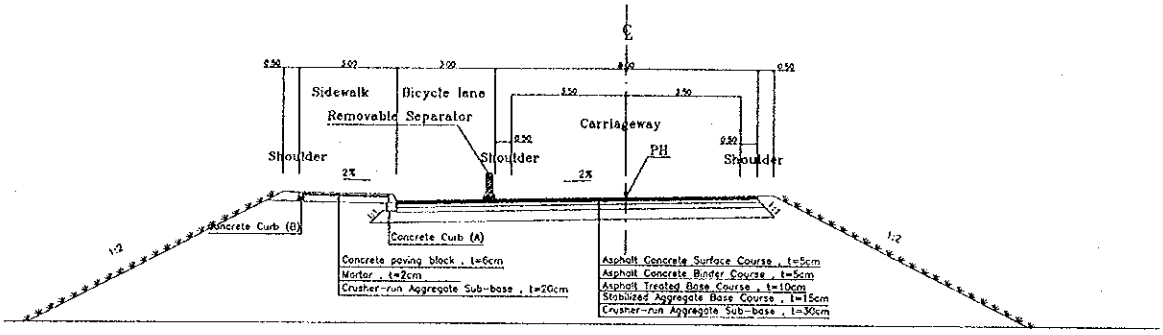
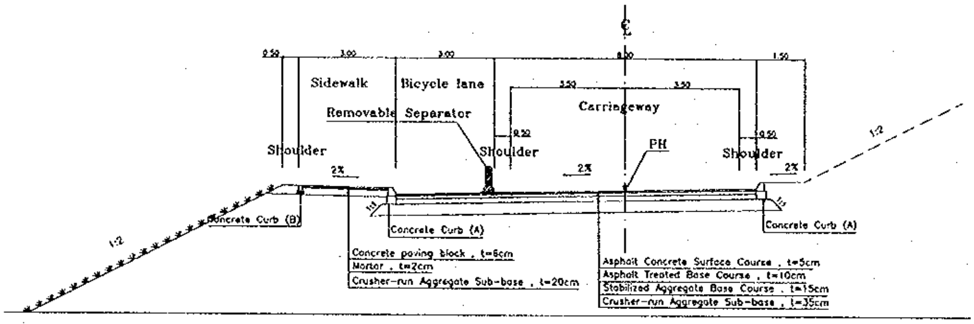


Figure 5.5.1 Typical Cross Section (4)

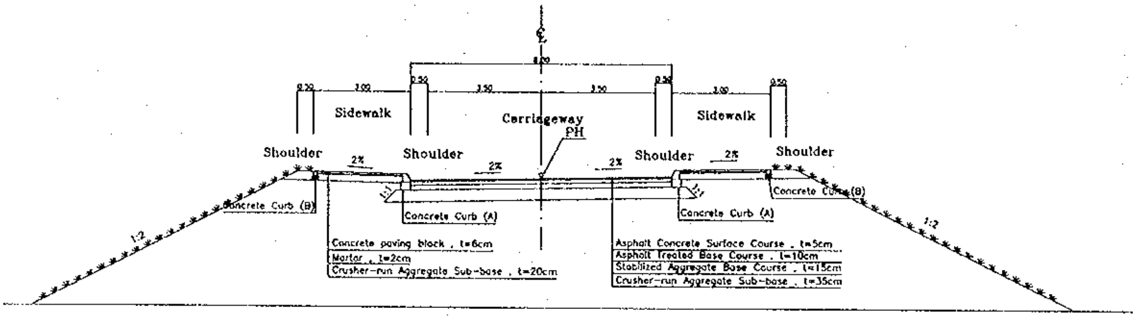
FRONTAGE ROAD (TYPE F-1)



FRONTAGE ROAD (TYPE F-2)



FRONTAGE ROAD (TYPE F-3)



FRONTAGE ROAD (TYPE F-4)

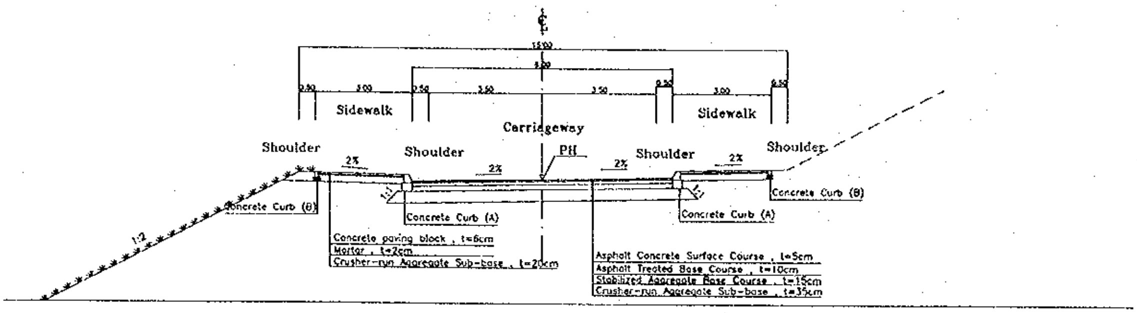
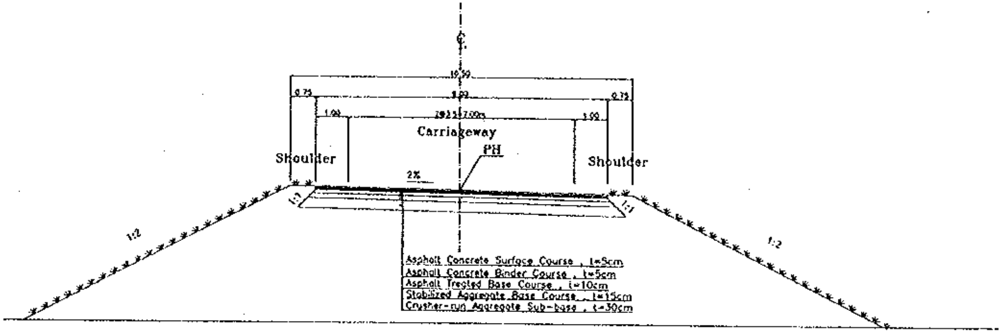
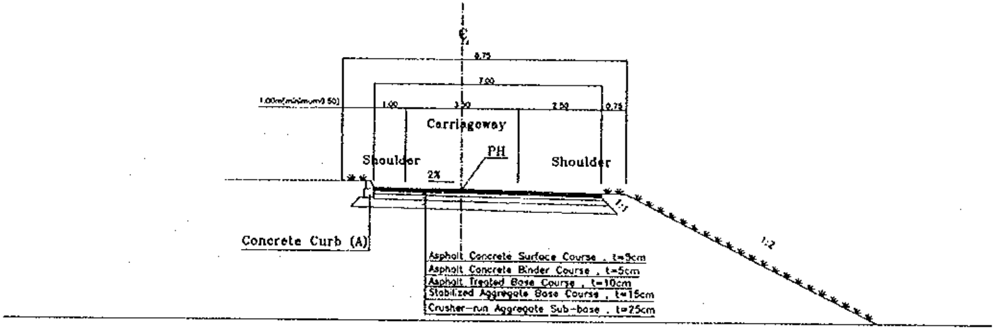


Figure 5.5.1 Typical Cross Section (5)

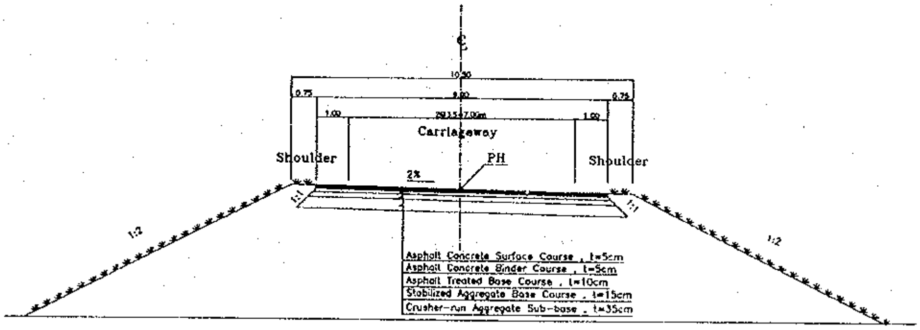
RAMPWAY (TYPE R--1)



RAMPWAY (TYPE R–3)



RAMPWAY (TYPE R2)



RAMPWAY (TYPE R5)

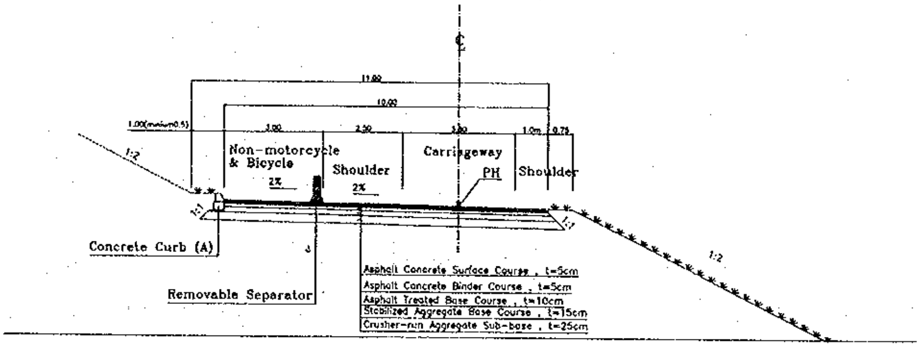


Figure 5.5.1 Typical Cross Section (6)

5.6 Toll Barrier

Since an expressway is a toll road, it is necessary to install a facility to collect fees from the vehicles which use it. The toll barrier is the facility for this purpose. The toll barrier is composed of toll office, toll gate (island, booth, gate, building) and plaza.

Location of the toll plaza was designed between Linh Nam Interchange and Thanh Tri Dyke Road (STA 6+060 at the center of the booth).

5.6.1 Structure of Toll Barrier

Design of the toll barrier was conducted taking account the following points:

- The distance between the gate and the throughway should allow smooth passage of through traffic. For the project, the distance was applied at 120 m at the both sides from the center of the gate, excepting the transition section.

- The alignment of the toll gate and its vicinity should be along a flat and straight line. For the project road, 2 % is applied to the gradient of the vertical alignment, and a straight line is applied to the horizontal alignment.

- Cement concrete pavement is laid for 40 m on both sides from the center of the gate to prevent pavement aging around the gate and its vicinity.

- The toll gate lanes consist of the car and truck/bus lane: 3.20 m, heavy vehicle : 4.50 m, bicycle lane: 3.0 m and access lane for maintenance vehicle: 6.0 m.

5.6.2 Required the Number of Lanes (Gates) at the Toll Gate

The number of lanes at a toll gate can be determined from traffic volume (vehicle entry interval). When directional separation (exit and entrance) is made, the number of lanes is to be determined in accordance with peak-hour traffic volume in each direction. Traffic flow volume, and average service time and standard are based on the following standards:

(1) Design Hourly Volume (DHV)

Design traffic flow volume shall be based on designed hourly traffic volume or 30^{th} highest hourly traffic flow volume. 30th highest hourly traffic flow volume is calculated from average daily traffic volume (ADT) using the formula (DHV = ADT × k × D).

K (ratio of 30th highest hourly traffic flow volume to ADT) : 0.09

D (ratio of traffic flow volume in a direction with larger traffic flow volume in both directions) : 0.55

(2) Service time

Service time of 6 seconds at entry and 14 seconds at exit in case of variable rate system. 8 seconds in case of flat rate are used to calculate the number of lanes.

(3) Service level

Service standard measured by average number of waiting vehicles shall be 1.0 vehicles. If no disturbance to traffic is expected, the number of lanes on the basis of 0.5, 1.5 and 2.0 vehicles is used.

(4) Required Number of Lane

Number of lanes is estimated at 4 lanes for the vehicles except for motorcycle based on following estimation and traffic demand 2010. For motorcycles, one lane is provided.

Table 5.6.1 indicates calculation result with brief notes in the each calculation step. And Figure 5.6.1 shows Front View of Thanh Tri Dyke Toll Plaza.

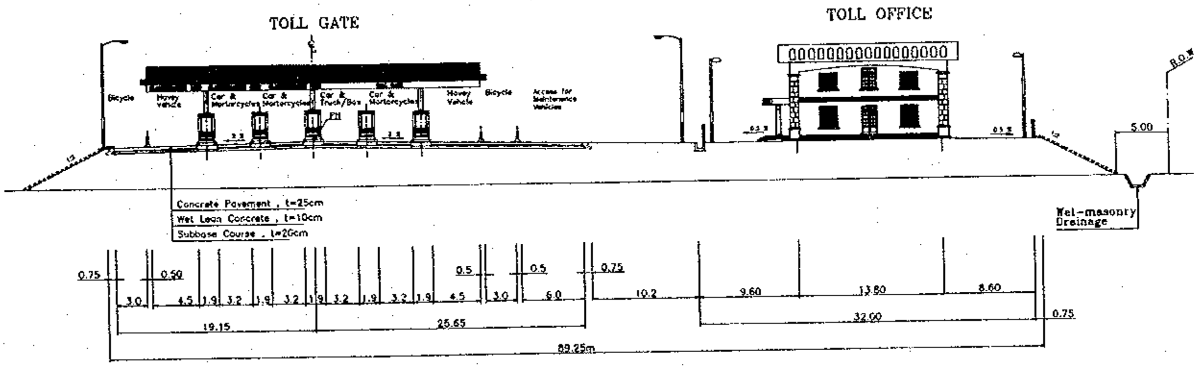


Figure 5.6.1 Front View of Thanh Tri Dyke Toll Plaza

Table 5.6.1 Number of Gate for Than Tri Dyke Toll Gate

Probability Year	2010	2020
Traffic volume (vehicle/day	26,160 vehicle/day	66,440 vehicle/day
Daily hourly volume (DHV)	1,295 vehicles/hour	3,288 vehicle/hour
Average service time (b)	8 seconds	8 seconds
Number of lanes (s) (gate number)	4 lanes	8 lanes
Average vehicle entry interval (a)	2.78 seconds	1.09seconds
Traffic intensity (p)	2.877	7.306
Traffic intensity for one lane (u)	0.719	0.913
Probability to have no vehicle at the toll gate (k)	0.04549	0.0003165
Average waiting time (w)	3.28 seconds	8.42 seconds
Average waiting vehicle (q)	1.64 vehicles	8.42 vehicles
Average waiting vehicle for one lane (u)	0.41 vehicles	1.05 vehicles

Note: As one lane is set up for motorcycles, the above vehicle volume excepts motorcycles.

Table Saturation & Saturation Flow Rate for NH5 at-grade Intersection

(Hanoi side: 2010)

Flowed in the at-grade Intersection		A		B		C	
Lane		Straight	Left-turn	Straight	Right-turn	Left-turn	Right-turn
Number of lane		3	1	3	2	1	1
Basic value for saturation flow rate		2,000× 3	2,000	2,000× 3	2,000×2	2,000	2,000
Revision for carriage way width		1.0 (3×3.6)	1.0 (3.6)	1.0 (2×3.6)	1.0 (3.6+3.75)	1.0 (3.5)	1.0 (3.5)
Revision for vertical gradient (Gradient) %		1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)
Revision to be mixed with right-turn vehicle		-	-	-	-	-	-
Revision to be mixed with left turn vehicle		-	-	-	-	-	-
Saturation flow rate		6,000	2,000	6,000	4,000	2,000	2,000
Traffic volume (PCU/h)		1,603	336	1,369	2,241	834	440
Authorized traffic volume		0.24		0.35		0.31	
Required Phase ratio	1 ϕ	0.24					
	2 ϕ			0.35			
	3 ϕ					0.31	

$\lambda = \rho1 + \rho2 + \rho3$: 0.24+0.35+ 0.31= 0.90 $\leq$ 0.90

λ : Saturation at the at -grade intersection

ρi : Maximum of the authorized traffic volume

Note: Traffic volume (PCU/h) for the each direction was estimated by JICA Study Team, 1998

Table Saturation & Saturation Flow Rate for NH5 at-grade Intersection

(Hai Hung side: 2010)

Flowed in the at-grade Intersection		A		B		C	
Lane		Straight	Left-turn	Straight	Right-turn	Left-turn	Right-turn
Number of lane		3	1	3	2	1	1
Basic value for saturation flow rate		2,000× 3	2,000	2,000× 3	2,000×2	2,000	2,000
Revision for carriage way width		1.0 (3×3.6)	1.0 (3.6)	1.0 (2×3.6)	1.0 (3.6+3.75)	1.0 (3.5)	1.0 (3.5)
Revision for vertical gradient (Gradient) %		1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)
Revision to be mixed with right-turn vehicle		-	-	-	-	-	-
Revision to be mixed with left turn vehicle		-	-	-	-	-	-
Saturation flow rate		6,000	2,000	6,000	2,000	2,000	2,000
Traffic volume (PCU/h)		771	831	1,030	544	1,787	336
Authorized traffic volume		0.20		0.19		0.51	
Required Phase ratio	1 φ	0.20					
	2 φ			0.19			
	3 φ					0.51	

$\lambda = \rho 1 + \rho 2 + \rho 3$: $0.20+0.19+0.51=0.90 \leq 0.90$

λ : Saturation at the at -grade intersection

ρi : Maximum of the authorized traffic volume

Note: Traffic volume (PCU/h) for the each direction was estimated by JICA Study Team, 1998

Table Saturation & Saturation Flow Rate for NH5 at-grade Intersection

(Hanoi side: 2020)

Flowed in the at-grade Intersection		A		B		C	
Lane		Straight	Left-turn	Straight	Right-turn	Left-turn	Right-turn
Number of lane		3	1	3	2	1	1
Basic value for saturation flow rate		2,000× 4	2,000	2,000× 4	2,000×2	2,000	2,000
Revision for carriage way width		1.0	1.0	1.0	1.0	1.0	1.0
Revision for vertical gradient (Gradient) %		1.0	1.0	1.0	1.0	1.0	1.0
Revision to be mixed with right-turn vehicle		-	-	-	-	-	-
Revision to be mixed with left turn vehicle		-	-	-	-	-	-
Saturation flow rate		6,000	2,000	8,000	4,000	2,000	2,000
Traffic volume (PCU/h)		3,533	1,319	4,658	2,395	1,745	1,075
Authorized traffic volume		0.58		0.58		0.51	
Required Phase ratio	1 ϕ	0.60				0.51	
	2 ϕ			0.58			

$\lambda = \rho 1 + \rho 2$: $0.60+0.58= 1.18 \leq 0.90$

λ : Saturation at the at -grade intersection

ρi : Maximum of the authorized traffic volume

Note: Traffic volume (PCU/h) for the each direction was estimated by JICA Study Team, 1998

Table Estimation of the Green Time for Each Phase

(NH5 at-grade intersection :2010)

Signal Phase	Green Time (second)	
	Hanoi Side	Hai Hung Side
1ϕ	17.1	14.2
2ϕ	24.8	13.5
3ϕ	22.1	36.3

ϕi : $Gi = (C-L) \rho i / \lambda$

Gi : Green time for each phase
C : Signal cycle length (70 second)
L : Loss time of signal (6 second)
λ : Saturation
ρi : Maximum of authorized traffic volume
ϕ : Signal phase

Table Saturation & Saturation Flow Rate at NH1 Grade Intersection

(Hanoi side: 2020)

Flowed in the at-grade Intersection		A	B	C	
Lane		Straight	Straight	Left-turn	Right-turn
Number of lane		3	3	1	2
Basic value for saturation flow rate		2,000 ×3	2,000× 3	2,000	2,000× 2
Revision for carriage way width		1.0 (3×3.5)	1.0 (2×3.5)	1.0 (3.5)	1.0 (3.5)
Revision for vertical gradient (Gradient) %		1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)
Revision to be mixed with right-turn vehicle		-	-	-	-
Revision to be mixed with left turn vehicle		-	-	-	-
Saturation		6,000	6,000	2,000	2,000
Traffic volume (PCU/h)		3,472	1,027	200	1,936
Authorized traffic volume		0.37		0.53	
Required Phase ratio	1 ϕ	0.37		-	
	2 ϕ	-		0.53	

$\lambda = \rho 1 + \rho 2$: $0.37+0.53= 0.90 \leq 0.90$

λ : Saturation at the at -grade intersection

ρi : Maximum of the authorized traffic volume

Note: Traffic volume (PCU/h) for the each direction was estimated by JICA Study Team, 1998

Table Saturation & Saturation Flow Rate at NH1Grade Intersection

(Hai Hung side: 2020)

Flowed in the at-grade Intersection		A		B	
Lane		Straight	Left-turn	Straight	Right-turn
Number of lane		2	2	2	1
Basic value for saturation flow rate		2,000× 2	2,000× 2	2,000× 2	2,000
Revision for carriage way width		1.0 (2×3.5)	1.0 (2×3.5)	1.0 (2×3.5)	1.0 (3.5)
Revision for vertical gradient (Gradient) %		1.0 (0.4)	1.0 (0.4)	1.0 (0.4)	1.0 (0.4)
Revision to be mixed with right-turn vehicle		-	-	-	-
Revision to be mixed with left turn vehicle		-	-	-	-
Saturation		4,000	4,000	4,000	2,000
Traffic volume (PCU/h)		1,455	2,016	1,027	342
Authorized traffic volume		0.36	0.50	0.25	0.17
Required Phase ratio	1 φ	0.36		0.26	
	2 φ		0.50		0.17

$\lambda = \rho 1 + \rho 2$: 0.36+0.50=0.86 ≤ 0.90

λ : Saturation at the at -grade intersection

ρi : Maximum of the authorized traffic volume

Note: Traffic volume (PCU/h) for the each direction was estimated by JICA Study Team, 1998

Table Estimation of the Green Time for Each Phase

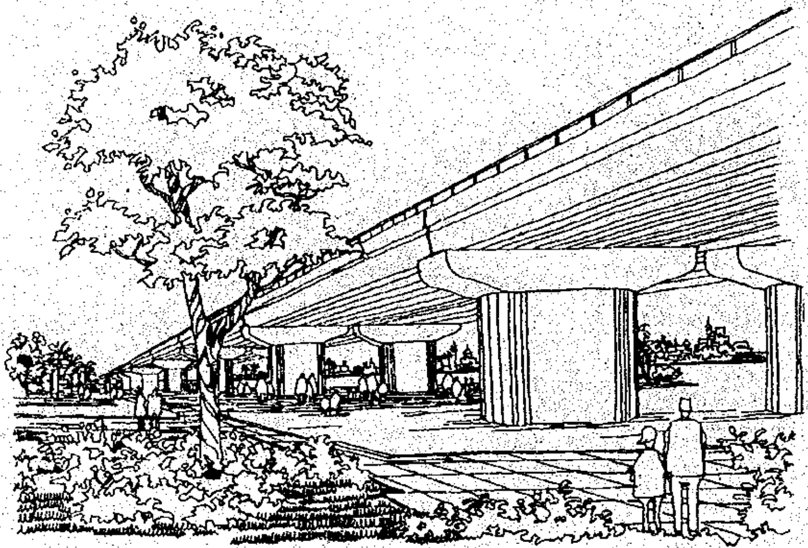
(NH1 at-grade intersection)

Signal Phase	Green Time (second)	
	Hanoi Side	Hai Hung Side
1ϕ	26.3	26.8
2ϕ	37.7	37.2

ϕi : $Gi = (C-L)\, \rho i / \lambda$

Gi : Green time for each phase
C : Signal cycle length (70 second)
L : Loss time of signal (6 second)
λ : Saturation
ρi : Maximum of authorized traffic volume
ϕ : Signal phase

CHAPTER 6 DETAILED DESIGN OF BRIDGES



CHAPTER 6 DETAILED DESIGN OF BRIDGES

6.1 General

Some structures are proposed as highway facilities in the project area. These structures should be installed in order to ensure continuous through traffic or to avoid separation of communities. Structures in this project are roughly classified into two types by scale. One type consists of large-scale structures, namely bridges and the other type consists of small-scale structures such as box culverts and retaining walls. Discussion on proposed bridges is conducted in this chapter and box culverts and retaining walls are discussed in Chapters 7 and 8.

The total number of locations of proposed bridges in this project is eight (8) (shown in Figure 6.1.1). The longest bridge in this project is the Red River Bridge (Thanh Tri Bridge) in Package 1, which is crosses the Red River. This bridge has a total length of 3,084 m and consists of seven parts.

There are three bridges in Package 2. The Gia Lam Road Bridge is proposed at an intersection point where the throughway goes over a newly proposed road. The Cau Bay Canal Bridge is located at a location where the alignment of throughway crosses an existing irrigation canal to the adjacent agricultural area. The last bridge in Package 2 is the National Highway No. 5 Flyover, which is proposed for crossing over the existing National Highway No. 5 and railway. Furthermore, two ramp bridges are arranged in this area since an interchange system which will connect National Highway No. 5 and Hanoi Third Ring Road is proposed.

In Package 3, four bridges are proposed. The Phap Van Viaduct is a viaduct which crosses the Phap Van Cau Gie Road and existing National Highway No. 1 and lands in the Linh Dam Lake area. An interchange is proposed to connect the Hanoi Third Ring Road and the Phap Van Cau Gie Road under construction in this area. Therefore, four connecting rampway bridges of to the throughway are proposed. The secondary listed bridge is the Kim Nguu River Bridge, which is to be located over the existing Kim Nguu River. Bridge of throughway and bridges of frontage road on both sides of the throughway are to be separately constructed in this section. The Nguyen Tam Trinh Bridge is proposed at the Nguyen Tam Trinh Interchange. This bridge is to cross over the Nguyen Tam Trinh Road and is only composed of a throughway bridge. The fourth bridge in Package 3 is proposed in order to ensure future traffic of the Linh Nam Road under the throughway and named the Linh Nam Bridge.

LOCATION MAP OF PROPOSED BRIDGES

LIST OF PROPOSED BRIDGES

Construction Package	Name of Bridge		Length (m)	Location	
				Beginning	End
Package 1	Red River Bridge (Thanh Tri Bridge)	S	3084.0	STA 6+218.5	STA 9+302.5
		N	3084.0	STA 6+218.5	STA 9+302.5
	Approach Bridge 2 (T) Thanh Tri side	S	246.0	STA 6+218.5	STA 6+464.5
		N	226.0	STA 6+218.5	STA 6+444.5
	Thanh Tri Dyke Bridge	S	290.0	STA 6+464.5	STA 6+754.5
		N	290.0	STA 6+444.5	STA 6+734.5
	Approach Bridge 1 (T) Thanh Tri side	S	530.0	STA 6+754.5	STA 7+284.5
		N	550.0	STA 6+734.5	STA 7+284.5
	Main Bridge	S	680.0	STA 7+284.5	STA 7+964.5
		N	680.0	STA 7+284.5	STA 7+964.5
	Approach Bridge 1 (G) Gia Lam side	S	850.0	STA 7+964.5	STA 8+814.5
		N	850.0	STA 7+964.5	STA 8+814.5
	Gia Lam Dyke Bridge	S	290.0	STA 8+814.5	STA 9+104.5
		N	290.0	STA 8+814.5	STA 9+104.5
	Approach Bridge 2 (G) Gia Lam side	S	198.0	STA 9+104.5	STA 9+302.5
		N	198.0	STA 9+104.5	STA 9+302.5
Package 2	Gia Lam Road Bridge	S	33.0	STA 10+903.5	STA 10+936.5
		N	33.0	STA 10+903.5	STA 10+936.5
	Cau Bay Canal Bridge	S	249.0	STA 11+382.0	STA 11+631.0
		N	233.0	STA 11+382.0	STA 11+615.0
	National Highway No.5 Flyover	S	695.0	STA 11+768.5	STA 12+463.5
		N	695.0	STA 11+768.5	STA 12+463.5
Pckage 3	Phap Van Cau Gie Viaduct	S	575.0	STA 0+536.5	STA 1+111.5
		N	575.0	STA 0+536.5	STA 1+111.5
	Kim Guu River Bridge	S	99.0	STA 1+647.0	STA 1+746.0
		N	99.0	STA 1+647.0	STA 1+746.0
	Nguyen Tam Trin Bridge	S	50.0	STA 2+775.0	STA 2+825.0
		N	50.0	STA 2+775.0	STA 2+825.0
	Linh Nam Bridge	S	50.0	STA 5+605.0	STA 5+655.0
		N	50.0	STA 5+605.0	STA 5+655.0

Note: S and N in the above Table shows South Bound and North Bound respectively.

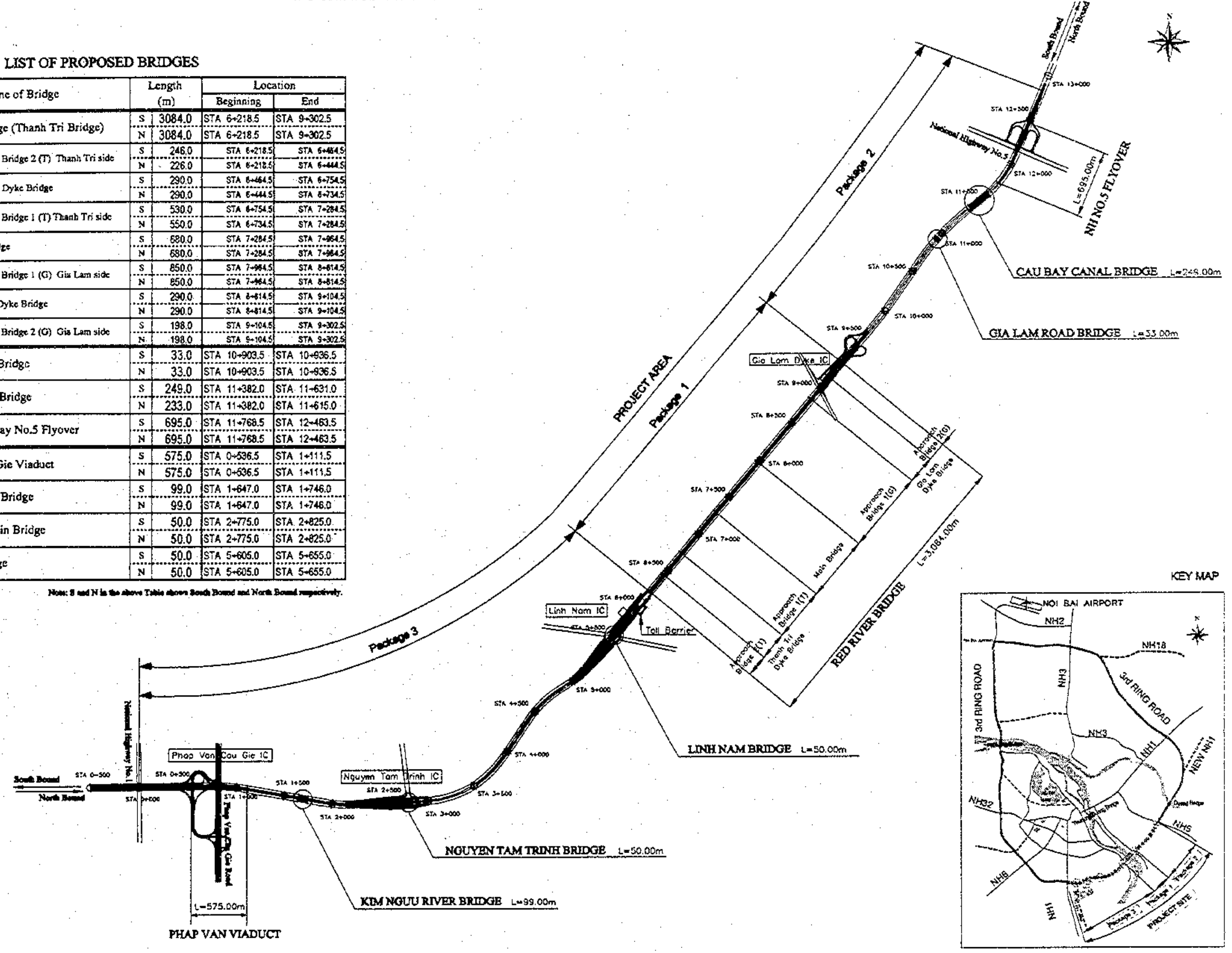


Figure 6.1.1 Location Map of Proposed Bridges

LOCATION MAP OF PROPOSED BRIDGES

LIST OF PROPOSED BRIDGES

Construction Package	Name of Bridge		Length (m)	Location	
				Beginning	End
Package 1	Red River Bridge (Thanh Tri Bridge)	S	3084.0	STA 6+218.5	STA 9+302.5
		N	3084.0	STA 6+218.5	STA 9+302.5
	Approach Bridge 2 (T) Thanh Tri side	S	246.0	STA 6+218.5	STA 6+464.5
		N	226.0	STA 6+218.5	STA 6+444.5
	Thanh Tri Dyke Bridge	S	290.0	STA 6+464.5	STA 6+754.5
		N	290.0	STA 6+444.5	STA 6+734.5
	Approach Bridge 1 (T) Thanh Tri side	S	530.0	STA 6+754.5	STA 7+284.5
		N	550.0	STA 6+734.5	STA 7+284.5
	Main Bridge	S	680.0	STA 7+284.5	STA 7+964.5
		N	680.0	STA 7+284.5	STA 7+964.5
	Approach Bridge 1 (G) Gia Lam side	S	850.0	STA 7+964.5	STA 8+814.5
		N	850.0	STA 7+964.5	STA 8+814.5
	Gia Lam Dyke Bridge	S	290.0	STA 8+814.5	STA 9+104.5
		N	290.0	STA 9+814.5	STA 9+104.5
	Approach Bridge 2 (G) Gia Lam side	S	198.0	STA 9+104.5	STA 9+302.5
		N	198.0	STA 5+104.5	STA 9+302.5
Package 2	Gia Lam Road Bridge	S	33.0	STA 10+903.5	STA 10+936.5
		N	33.0	STA 10+903.5	STA 10+936.5
	Cau Bay Canal Bridge	S	249.0	STA 11+382.0	STA 11+631.0
		N	233.0	STA 11+382.0	STA 11+615.0
	National Highway No.5 Flyover	S	695.0	STA 11+768.5	STA 12+463.5
		N	695.0	STA 11+768.5	STA 12+463.5
Pckage 3	Phap Van Cau Gie Viaduct	S	575.0	STA 0+536.5	STA 1+111.5
		N	575.0	STA 0+536.5	STA 1+111.5
	Kim Guu River Bridge	S	99.0	STA 1+647.0	STA 1+746.0
		N	99.0	STA 1+647.0	STA 1+746.0
	Nguyen Tam Trin Bridge	S	50.0	STA 2+775.0	STA 2+825.0
		N	50.0	STA 2+775.0	STA 2+825.0
	Linh Nam Bridge	S	50.0	STA 5+605.0	STA 5+655.0
		N	50.0	STA 5+605.0	STA 5+655.0

Note: S and N in the above Table shows South Bound and North Bound respectively.

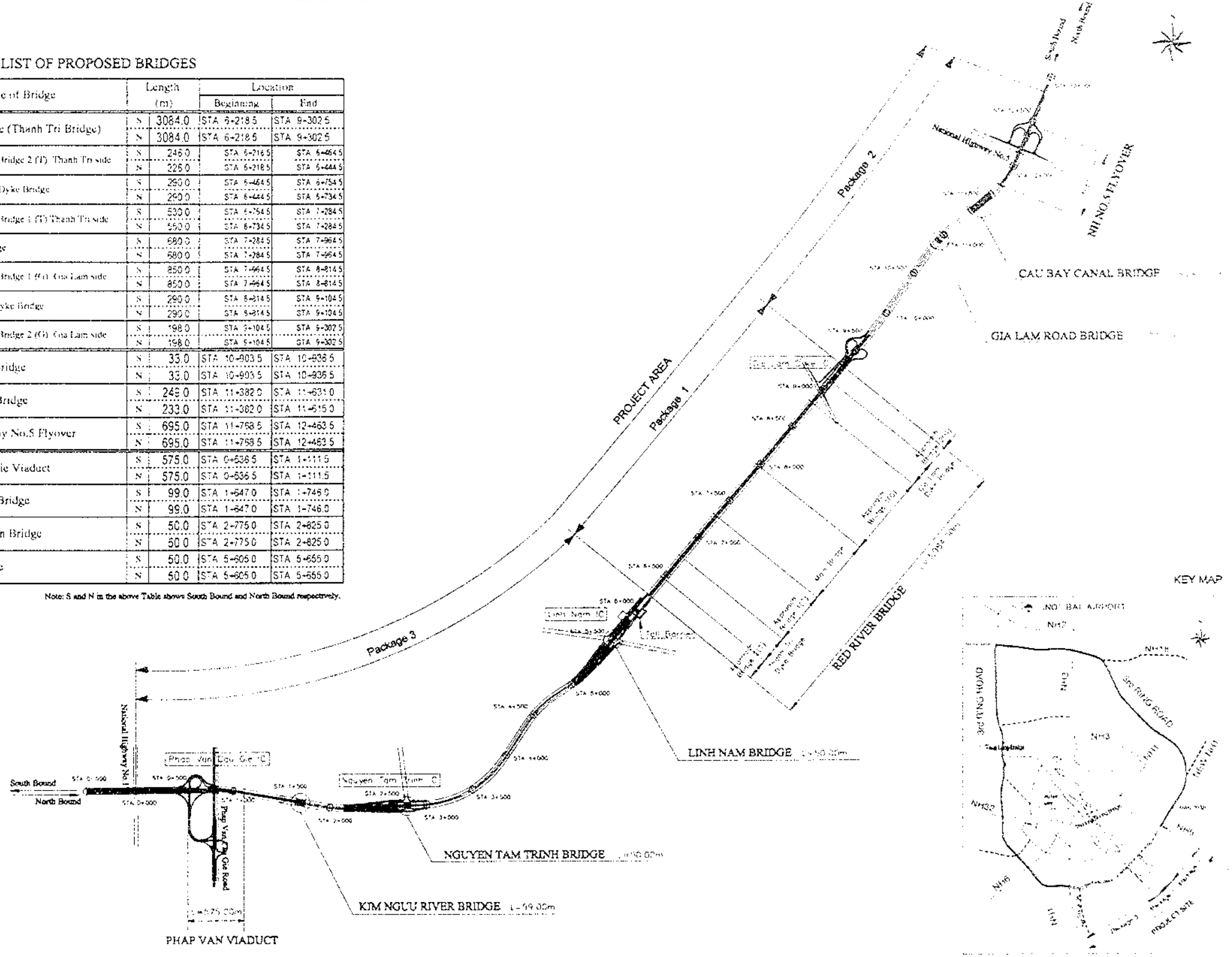


Figure 6.1.1 Location Map of Proposed Bridges

Table 6.1.1 List of Superstructures in the Project

PACKAGE	LOCATION	BRIDGE NAME	BOUND	STATION		EFFECTIVE WIDTH	BRIDGE LENGTH & AREA									
							CANTILEVER		PC BOX		PC I-GIRDER		RC HOLLOW		TOTAL	
							Length	Area	Length	Area	Length	Area	Length	Area	Length	Area
				Beginning	End	(m)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)
Package 1 from ST.6+218.5 to ST.12+931.9	Throughway	Approach Bridge 2 (T)	N	6+218.5	6+444.5	15.000	-	-	-	-	226.00	3,390	-	-	226.00	3,390
			S	6+218.5	6+464.5	15.000	-	-	-	-	246.00	3,690	-	-	246.00	3,690
		Thanh Tri Dyke Bridge	N	6+444.5	6+734.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	6+464.5	6+754.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 1 (T)	N	6+734.5	7+284.5	15.000	-	-	550.00	8,250	-	-	-	-	550.00	8,250
			S	6+754.5	7+284.5	15.000	-	-	530.00	7,950	-	-	-	-	530.00	7,950
		Main Bridge	N	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
			S	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
		Approach Bridge 1 (G)	N	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
			S	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
		Gia Lam Dyke Bridge	N	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 2 (G)	N	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
			S	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
	RED RIVER BRIDGE TOTAL (TOTAL OF PACKAGE 1)		N	-	-	-	1,260.00	18,900	1,400.00	21,000	424.00	6,360	0.00	0	3,084.00	46,260
			S	-	-	-	1,260.00	18,900	1,380.00	20,700	444.00	6,660	0.00	0	3,084.00	46,260
			all	-	-	-	**2,520.00**	**37,800**	**2,780.00**	**41,700**	**868.00**	**13,020**	**0.00**	**0**	**6,168.00**	**92,520**
Package 2 from ST.9+302.5 to ST.12+831.9	Throughway	Gia Lam Road Bridge	N	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
			S	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
		Cau Bay Canal Bridge	N	11+382	11+615	11.500	-	-	200.00	2,300	33.00	380	-	-	233.00	2,680
			S	11+382	11+631	11.500	-	-	150.00	1,725	99.00	1,139	-	-	249.00	2,864
		NH No.5 Flyover	N	11+768.5	12+463.5	11.50 - 26.91	-	-	-	-	695.00	10,027	-	-	695.00	10,027
			S	11+768.5	12+463.5	11.50 - 30.26	-	-	-	-	695.00	10,985	-	-	695.00	10,985
		SUBTOTAL	N	-	-	-	0.00	0	200.00	2,300	761.00	10,786	0.00	0	961.00	13,086
			S	-	-	-	0.00	0	150.00	1,725	827.00	12,503	0.00	0	977.00	14,228
			N + S	-	-	-	**0.00**	**0**	**350.00**	**4,025**	**1,588.00**	**23,289**	**0.00**	**0**	**1,938.00**	**27,314**
	Others	Ramp Bridge	-	-	-	9.990 - 10.268	-	-	-	-	-	-	119.00	1,197	119.00	1,197
		SUBTOTAL	-	-	-	-	0.00	0	0.00	0	0.00	0	119.00	1,197	119.00	1,197
	TOTAL (PACKAGE 2)		**all**	-	-	-	**0.00**	**0**	**350.00**	**4,025**	**1,588.00**	**23,289**	**119.00**	**1,197**	**2,057.00**	**28,511**
Package 3 from ST.0+000 to ST.6+218.5	Throughway	Phap Van Viaduct	N	0+536.5	1+111.5	11.50 - 26.87	-	-	-	-	575.00	10,421	-	-	575.00	10,421
			S	0+536.5	1+111.5	11.50 - 30.43	-	-	-	-	575.00	9,975	-	-	575.00	9,975
		Kim Nguu River Bridge	N	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
			S	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
		Nguyen Tam Trinh Bridge	N	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		Linh Nam Bridge	N	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		SUBTOTAL	N	-	-	-	0.00	0	100.00	1,150	674.00	11,560	0.00	0	774.00	12,710
			S	-	-	-	0.00	0	100.00	1,150	674.00	11,114	0.00	0	774.00	12,264
			N + S	-	-	-	**0.00**	**0**	**200.00**	**2,300**	**1,348.00**	**22,674**	**0.00**	**0**	**1,548.00**	**24,974**
	Others	Kim Nguu River Bridge (F)	N	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
			S	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
		Ramp Bridge	-	-	-	9.00 - 10.00	-	-	-	-	-	-	357.00	3,315	357.00	3,315
		Phap Van - Cau Gie Flyover	-	-	-	18.000	-	-	-	-	132.00	2,376	-	-	132.00	2,376
		SUBTOTAL	all	-	-	-	0.00	0	0.00	0	330.00	5,040	357.00	3,315	687.00	8,355
	TOTAL (PACKAGE 2)		**all**	-	-	-	**0.00**	**0**	**200.00**	**2,300**	**1,678.00**	**27,714**	**357.00**	**3,315**	**2,235.00**	**33,329**
GRAND TOTAL (PACAKGES 1 through 3)			all of all	-	-	-	2,520.00	37,800	3,330.00	48,025	4,134.00	64,023	476.00	4,512	10,460.00	154,360

Table 6.1.1 List of Superstructures in the Project

PACKAGE	LOCATION	BRIDGE NAME	BOUND	STATION		EFFECTIVE WIDTH	BRIDGE LENGTH & AREA									
							CANTILEVER		PC BOX		PC I-GIRDER		RC HOLLOW		TOTAL	
							Length	Area	Length	Area	Length	Area	Length	Area	Length	Area
				Beginning	End	(m)	(m)	(m²)	(m)	(m²)	(m)	(m²)	(m)	(m²)	(m)	(m²)
Package 1 from ST 6+218.5 to ST 12+931.9	Throughway	Approach Bridge 2 (T)	N	6+218.5	6+444.5	15.000	-	-	-	-	226.00	3,390	-	-	226.00	3,390
			S	6+218.5	6+464.5	15.000	-	-	-	-	246.00	3,690	-	-	246.00	3,690
		Thanh Tri Dyke Bridge	N	6+444.5	6+734.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	6+464.5	6+754.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 1 (T)	N	6+734.5	7+284.5	15.000	-	-	550.00	8,250	-	-	-	-	550.00	8,250
			S	6+754.5	7+284.5	15.000	-	-	530.00	7,950	-	-	-	-	530.00	7,950
		Main Bridge	N	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
			S	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
		Approach Bridge 1 (G)	N	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
			S	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
		Gia Lam Dyke Bridge	N	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 2 (G)	N	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
			S	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
	RED RIVER BRIDGE TOTAL (TOTAL OF PACKAGE 1)		N	-	-	-	1,260.00	18,900	1,400.00	21,000	424.00	6,360	0.00	0	3,084.00	46,260
			S	-	-	-	1,260.00	18,900	1,380.00	20,700	444.00	6,660	0.00	0	3,084.00	46,260
			all	-	-	-	**2,520.00**	**37,800**	**2,780.00**	**41,700**	**868.00**	**13,020**	**0.00**	**0**	**6,168.00**	**92,520**
Package 2 from ST 9+302.5 to ST 12+831.9	Throughway	Gia Lam Road Bridge	N	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
			S	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
		Cau Bay Canal Bridge	N	11+382	11+615	11.500	-	-	200.00	2,300	33.00	380	-	-	233.00	2,680
			S	11+382	11+631	11.500	-	-	150.00	1.725	99.00	1,139	-	-	249.00	2,864
		NH No 5 Flyover	N	11+768.5	12+463.5	11.50 - 26.91	-	-	-	-	695.00	10,027	-	-	695.00	10,027
			S	11+768.5	12+463.5	11.50 - 30.26	-	-	-	-	695.00	10,985	-	-	695.00	10,985
		SUBTOTAL	N	-	-	-	0.00	0	200.00	2,300	761.00	10,786	0.00	0	961.00	13,086
			S	-	-	-	0.00	0	150.00	1.725	827.00	12,503	0.00	0	977.00	14,228
			N + S	-	-	-	0.00	0	350.00	4,025	1,588.00	23,289	0.00	0	1,938.00	27.314
	Others	Ramp Bridge	-	-	-	9.990 - 10.268	-	-	-	-	-	-	119.00	1,197	119.00	1,197
		SUBTOTAL	-	-	-	-	0.00	0	0.00	0	0.00	0	119.00	1,197	119.00	1,197
	TOTAL (PACKAGE 2)		**all**	-	-	-	**0.00**	**0**	**350.00**	**4,025**	**1,588.00**	**23,289**	**119.00**	**1,197**	**2,057.00**	**28,511**
Package 3 from ST 0+000 to ST 6+218.5	Throughway	Phap Van Viaduct	N	0+536.5	1+111.5	11.50 - 26.87	-	-	-	-	575.00	10,421	-	-	575.00	10,421
			S	0+536.5	1+111.5	11.50 - 30.43	-	-	-	-	575.00	9,975	-	-	575.00	9,975
		Kim Nguu River Bridge	N	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
			S	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
		Nguyen Tam Trinh Bridge	N	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		Linh Nam Bridge	N	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		SUBTOTAL	N	-	-	-	0.00	0	100.00	1,150	674.00	11,560	0.00	0	774.00	12,710
			S	-	-	-	0.00	0	100.00	1,150	674.00	11,114	0.00	0	774.00	12,264
			N + S	-	-	-	0.00	0	200.00	2,300	1,348.00	22,674	0.00	0	1,548.00	24,974
	Others	Kim Nguu River Bridge (F)	N	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
			S	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
		Ramp Bridge	-	-	-	9.00 - 10.00	-	-	-	-	-	-	357.00	3,315	357.00	3,315
		Phap Van - Cau Gie Flyover	-	-	-	18.000	-	-	-	-	132.00	2,376	-	-	132.00	2,376
		SUBTOTAL	all	-	-	-	0.00	0	0.00	0	330.00	5,040	357.00	3,315	687.00	8,355
	TOTAL (PACKAGE 3)		**all**	-	-	-	**0.00**	**0**	**200.00**	**2,300**	**1,678.00**	**27,714**	**357.00**	**3,315**	**2,235.00**	**33,329**
GRAND TOTAL (PACAKGES 1 through 3)			all of all	-	-	-	2,520.00	37,800	3,330.00	48,025	4,134.00	64,023	476.00	4,512	10,460.00	154,360

Table 6.1.2 List of Substructures in the Project

PACKAGE 1
(Red River Bridge)
STA 6+218.5 to STA 9+302.5

RED RIVER BRIDGE

		Approach Bridge 2(T)								Thanh Tri Dyke Bridge				Approach Bridge 1(T)											Main Bridge				
South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7aL	P7bL	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	P22L	P23L	P24L	P25L	P26L
	Type	⊥	T	T	T	T	T	T	T	T	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
	Height	10.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	15.5	14.0	16.0	21.0	20.0	20.0	20.0	21.0	21.0	19.0	18.0	19.0	19.0	34.0	34.0	32.5	33.0	33.0	33.0	32.5
North Bound	Name	▨	P1R	P2R	P3R	P4R	P5R	P6R	▨	P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	P22R	P23R	P24R	P25R	P26R
	Type	▨	T	T	T	T	T	T	▨	T	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
	Height	▨	9.0	10.0	11.0	12.0	13.0	14.0	▨	15.0	14.0	16.0	21.0	20.0	20.0	20.0	21.0	21.0	19.0	18.0	19.0	19.0	34.0	34.0	32.5	33.0	33.0	33.0	32.5
		Approach Bridge 1(G)																	Gia Lam Dyke Bridge				Approach Bridge 2(G)						
South Bound	Name	P27L	P28L	P29L	P30L	P31L	P32L	P33L	P34L	P35L	P36L	P37L	P38L	P39L	P40L	P41L	P42L	P43L	P44L	P45L	P46L	P47L	P48L	P49L	P50L	P51L	P52L	A2	
	Type	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	T	T	T	T	T	T	⊥	
	Height	35.0	34.5	21.0	20.0	20.0	20.0	20.0	20.0	23.0	23.0	18.0	18.0	18.0	18.0	20.0	20.0	17.0	17.0	14.0	16.0	13.0	14.0	11.0	10.0	9.0	9.0	11.0	
North Bound	Name	P27R	P28R	P29R	P30R	P31R	P32R	P33R	P34R	P35R	P36R	P37R	P38R	P39R	P40R	P41R	P42R	P43R	P44R	P45R	P46R	P47R	P48R	P49R	P50R	P51R	P52R	▨	
	Type	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	T	T	T	T	T	T	▨	
	Height	35.0	34.5	21.0	20.0	20.0	20.0	20.0	20.0	23.0	23.0	18.0	18.0	18.0	18.0	20.0	20.0	17.0	17.0	14.0	16.0	13.0	14.0	11.0	10.0	9.0	9.0	▨	

PACKAGE 2
(Gia Lam Section)
STA 9+302.5 to STA 12+831.9

GIA LAM ROAD BRIDGE

South Bound North Bound	Name	A1	A2
	Type	⊥	⊥
	Height	11.7	11.7

CAU BAY CANAL BRIDGE

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	A2L
	Type	⊥	T	T	T	T	I	⊥
	Height	9.5	7.5	6.1	5.9	6.3	7.8	9.5
North Bound	Name	▨	P1R	P2R	P3R	P4R	▨	A2R
	Type	▨	I	T	T	I	▨	⊥
	Height	▨	5.1	6.2	6.3	7.8	▨	9.5

NH No.5 INTERCHANGE RAMP BRIDGE

Ramp-A	Name	A1A	P1A	P2A	P3A	▨
	Type	⊥	T	T	T	▨
	Height	11.0	11.0	12.0	12.0	▨
Ramp-B	Name	A1B	P1B	P2B	▨	▨
	Type	⊥	T	T	▨	▨
	Height	11.0	11.0	11.0	▨	▨

Note: Height in this table shows height from the bottom of footing to the top of pier.

NATIONAL HIGHWAY NO.5 FLYOVER

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7L	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	A2
	Type	⊥	T	T	T	T	T	T	T	T	TT	TT	TT	TT	TT	TT	TT	TT	TT	TTT	TTT	T	T	⊥
	Height	11.0	9.0	9.0	10.0	11.0	11.0	12.0	12.0	12.0	13.0	13.0	13.0	12.0	10.0	11.0	12.0	11.0	11.0	11.0	10.0	11.0	10.0	12.0
North Bound	Name	▨	P1R	P2R	P3R	P4R	P5R	P6R	P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	▨
	Type	▨	T	T	T	T	T	T	T	T	T	T	T	T	T	TT	TT	TTT	TTT	TTT	T	T	T	▨
	Height	▨	9.4	9.4	10.4	11.4	11.4	12.4	12.4	12.4	13.4	13.4	13.5	12.4	10.4	11.4	12.0	11.0	11.0	11.0	10.2	11.0	10.0	▨

PACKAGE 3
(Thanh Tri Section)
STA 0+000.0 to STA 6+218.5

PHAP VAN VIADUCT

South Bound	Name	P18L	P17L	P16L	P15L	P14L	P13L	P12L	P11L	P10L	P9L	P8L	P7L	P6L	P5L	P4L	P3L	P2L	P1L	A1
	Type	TT	TT	TTT	TTT	T	T	T	TTT	TTT	TTT	TT	T	T	T	T	T	T	T	⊥
	Height	12.8	12.8	12.8	11.8	12.8	12.8	12.8	12.4	12.4	12.8	12.3	11.8	11.3	10.8	8.8	7.8	7.8	6.6	9.0
North Bound	Name	P18R	P17R	P16R	P15R	P14R	P13R	P12R	P11R	P10R	P9R	P8R	P7R	P6R	P5R	P4R	P3R	P2R	P1R	▨
	Type	T	T	T	T	T	T	T	TTT	TTT	TTT	TTT	TT	TT	TT	TT	TT	TT	T	▨
	Height	11.9	12.5	12.8	12.8	12.8	12.8	12.8	12.4	12.4	12.4	11.8	11.3	11.3	11.3	8.3	7.8	7.8	6.6	▨

PHAP VAN CAU GIE INTERCHANGE RAMP BRIDGE

A-Ramp	Name	Aa1	Pa1	Pa2	Pa3	Pa4	Pa5	▨	▨
	Type	⊥	T	T	T	T	T	▨	▨
	Height	11.5	10.3	11.3	11.8	12.3	12.8	▨	▨
C-Ramp	Name	Ac1	Pc1	Pc2	Pc3	Pc4	Pc5	Pc6	Pc7
	Type	⊥	T	T	T	T	T	T	TT
	Height	10.5	8.3	9.0	11.8	12.5	12.9	12.8	11.3

B-Ramp	Name	Ab1	Pb1	Pb2	Pb3	Pb4	Pb5	Pb6
	Type	⊥	T	T	T	T	T	T
	Height	11.5	10.8	11.8	11.8	12.3	12.8	12.8

KIM NGUU RIVER BRIDGE

South Bound	Frontage Road	Name	A1FL	P1FL	P2FL	A2FL	North Bound	Throughway	Name	▨	P1R	P2R	▨
		Type	⊥	T	T	⊥			Type	▨	T	T	▨
		Height	7.8	6.5	6.5	7.8			Height	▨	6.4	6.4	▨
	Throughway	Name	A1C	P1L	P2L	A2C		Frontage Road	Name	A1FR	P1FR	P2FR	A2FR
		Type	⊥	T	T	⊥			Type	⊥	T	T	⊥
		Height	6.5	6.4	6.4	6.5			Height	6.4	6.5	6.5	6.4

NGUYEN TAM TRINH BRIDGE

South Bound North Bound	Name	A1	A2
	Type	⊥	⊥
	Height	11.3	11.3

LINH NAM BRIDGE

South Bound North Bound	Name	A1	A2
	Type	⊥	⊥
	Height	12.0	12.0

Legend: Types of piers and abutments are listed below.
T Hammerhaed pier
TT 2 column pier TTT 3 column pier
I Solid wall pier
⊥ Cantilever wall abutment

The number of Piers and Abutments

Package 1		
Abutment	Cantilever Wall	2
Pier	Hhummer Head	27
	2 Column	-
	3 Column	-
	Solid Wall	78
	Sub-total	105

Package 2		
Abutment	Cantilever Wall	9
Pier	Hhummer Head	37
	2 Column	11
	3 Column	5
	Solid Wall	3
	Sub-total	56

Package 3		
Abutment	Cantilever Wall	14
Pier	Hhummer Head	43
	2 Column	10
	3 Column	9
	Solid Wall	-
	Sub-total	62

TOTAL		
Abutment	Cantilever Wall	25
Pier	Hhummer Head	107
	2-Column	21
	3-Column	14
	Solid Wall	81
	Sub-total	223
GRAND TOTAL		248

LOCATION MAP OF RELATED BORE HOLES

LIST OF BOHE HOLES

Package	Bore Hole No.	Location STA	Existing Ground GL (m)	Under Ground Water	Adjust
Package 3	BH- R1	STA 0 -185.40	GL +4.83	GL +3.73	center
	BH- R2	STA 0 +20.00	GL +5.60	GL +3.70	right 3.00
	BH- R3	STA 0 +161.50	GL +6.40	GL +3.70	right 5.00
	BH- R4	STA 0 +361.50	GL +5.31	GL +3.81	center
	BH- R5	STA 0 +540.00	GL +3.67		center
	BH- R4b	STA 0 +600.00	GL +3.52		left 120.00
	BH- R6	STA 0 +930.00	GL +3.21		center
	BH- R7	STA 0 +720.00	GL +3.16		center
	BH- R8	STA 1 +100.00	GL +4.99	GL +3.30	center
	BH- R9	STA 1 +660.00	GL +4.00	GL +3.35	center
	BH- R10	STA 1 +720.00	GL +5.46	GL +3.30	center
	BH- R11	STA 5 +608.63	GL +5.53	GL +2.50	right 3.88
	BH- R12	STA 5 +676.16	GL +6.20	GL +2.40	left 3.09
Package 1	BH- B1	STA 6 +340.00	GL +5.69		
	BH- B2	STA 6 +240.00	GL +5.53		center
	BH- B4	STA 6 +810.00	GL +6.68		center
	BH- B5	STA 6 +960.00	GL +6.02	GL +2.02	center
	BH- B6	STA 7 +160.00	GL +9.37		center
	BH- B7	STA 7 +340.00	GL +6.49		center
	BH- B8	STA 7 +470.00	GL +0.02		center
	BH- B9	STA 7 +730.00	GL -3.42		center
	BH- B10	STA 7 +860.00	GL -1.81		center
	BH- B11	STA 8 +40.00	GL +9.24		center
	BH- B12	STA 8 +380.00	GL +4.21		center
	BH- B13	STA 8 +540.00	GL +8.78		center
	BH- B14	STA 8 +720.00	GL +5.05	GL +2.55	center
	BH- B15	STA 8 +880.00	GL +6.85		center
	BH- B16	STA 9 +70.00	GL +4.03		left 3.50
Package 2	BH- R13	STA 11 +400.00	GL +3.91		center
	BH- R14	STA 11 +590.00	GL +3.75		center
	BH- R15	STA 11 +930.00	GL +2.90		center
	BH- R16	STA 12 +210.00	GL +3.80		center
	BH- R17	STA 12 +380.00	GL +3.77		center

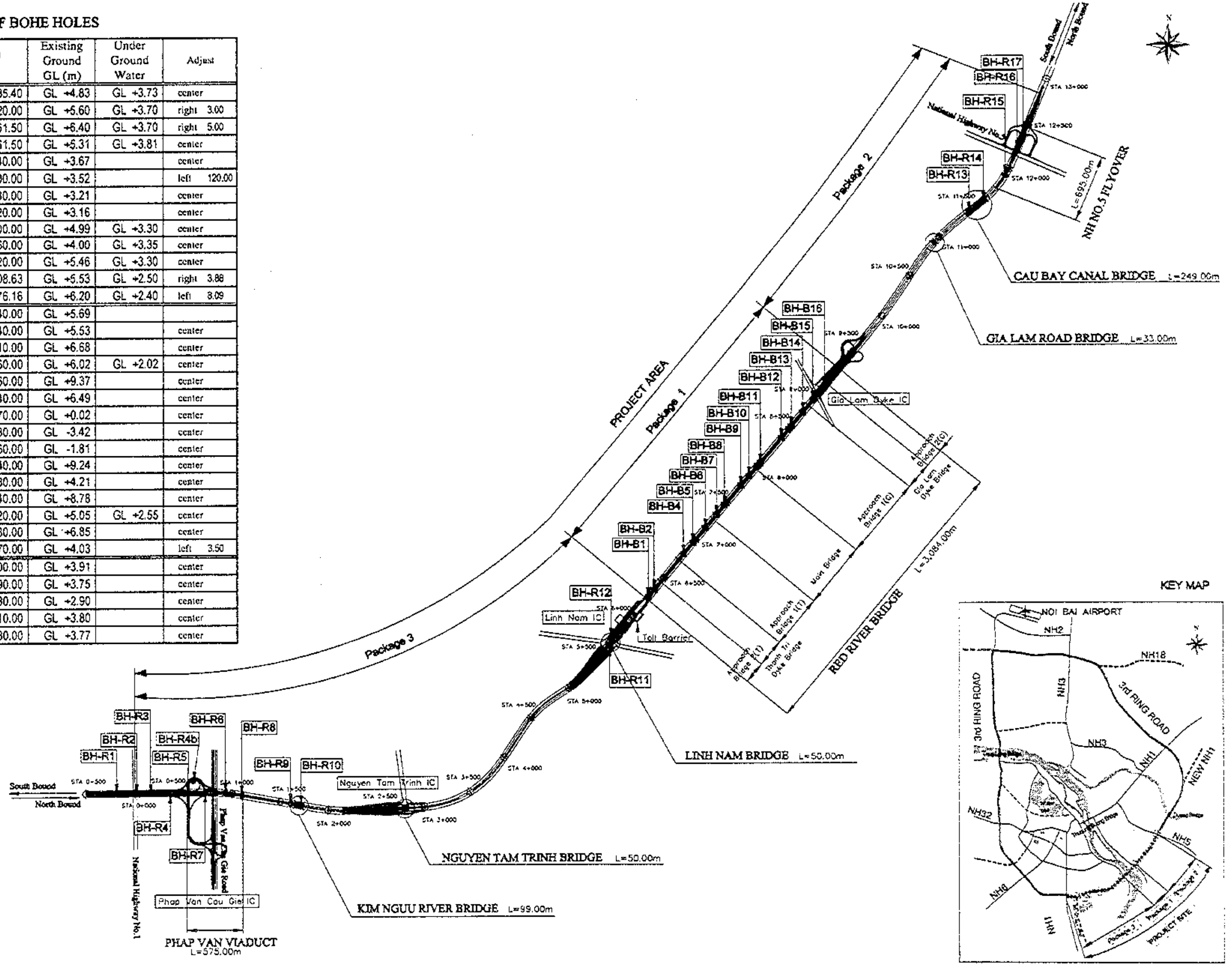


Figure 6.1.2 Location Map of Related Bore Holes

All proposed superstructures in this project are listed in Table 6.1.1 and all proposed substructures are listed in Table 6.1.2. The total length of bridges in Packages 1 through 3 is 10,460 m and the total area of bridges is 154,360 m^2. Regarding substructures, a total of 248 piers and abutments in Packages 1 through 3 were included in design. Here there are 25 abutments and 223 piers. Breakdown of the above-mentioned quantities is referred to in Tables 6.1.1 and 6.1.2.

Soil investigation in this project was sufficiently discussed in Chapter 3. In order to clarify the locating relation between bridges and bore holes, bore holes concerned which are referred for the design calculation of substructures and proposed bridge locations are shown in Figure 6.1.2.

Discussions, studies and results on each bridge are explained in the following section.

6.2 Red River Bridge (Thanh Tri Bridge)

As mentioned above, the Red River Bridge in Package 1, which is to be located in the section across over the Red River has a total length of 3,084 m and is composed of seven following parts:

Part 1: Approach Bridge 2(T): Bridge section from A1 abutment to Thanh Tri Dyke.
Part 2: Thanh Tri Dyke Bridge: Bridge over Thanh Tri Dyke.
Part 3: Approach Bridge 1(T): Bridge section from Thanh Tri Dyke to the Red River.
Part 4: Main Bridge: Bridge over main stream of the Red River.
Part 5: Approach Bridge 1(G): Bridge section from the Red River to Gia Lam Dyke.
Part 6: Gia Lam Dyke Bridge: Bridge over Gia Lam Dyke.
Part 7: Approach Bridge 2(G): Bridge section from Gia Lam Dyke abutment to A2 abutment.

General layout of the Red River Bridge is shown in Figure 6.2.1 and typical cross section of the Red River Bridge is shown in Figure 6.2.2.

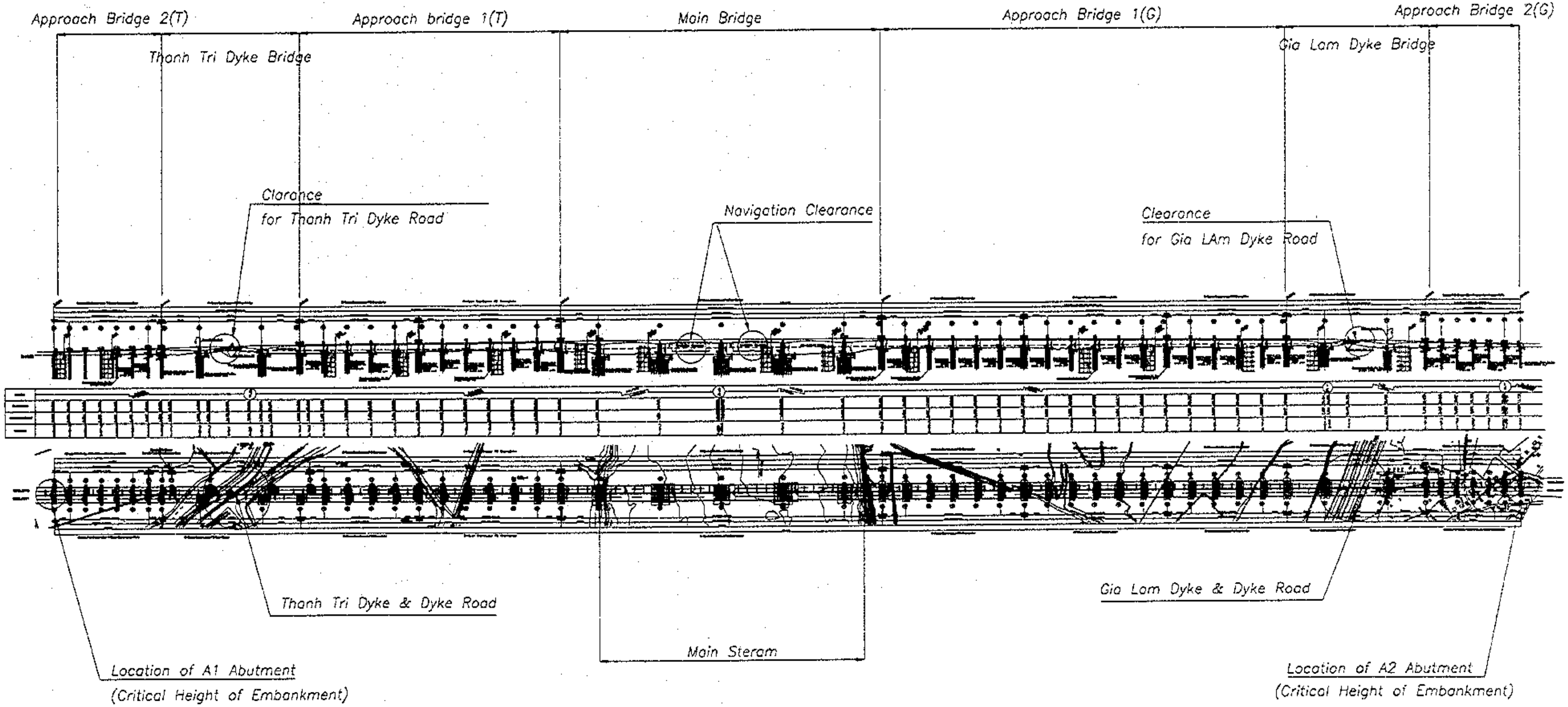


Figure 6.2.1 General layout of the Red RIver Bridge

North-bound and south-bound bridges included in the Red River Bridge are to be separately constructed as shown in Figure 6.2.2.

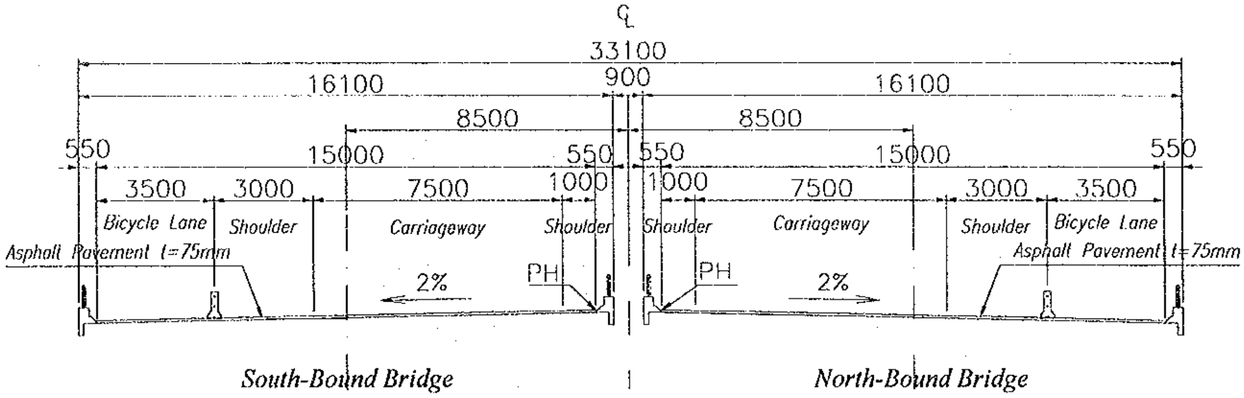


Figure 6.2.2 Typical Cross Section of the Red River Bridge

6.2.1 Main Bridge

(1) General

The main bridge is located in the main stream of the Red River and is the biggest bridge in this project. Continuous PC box-girder with varying girder depth longitudinally due to construction method that the cantilever erection which is appropriate for long span bridge has been proposed for superstructure and piers supported by piles foundation has been proposed as substructures. Figure 6.2.3 shows general view of Main Bridge.

The structural system of Main Bridge, all integrated piers with superstructure, was assumed to reduce future maintenance work for bridge bearing above the river. As a result of structural study, it has become clear that the system could not be realized under the current design conditions. Therefore, the system, which has three intermediate piers integrated with superstructure and two moving bridge bearings on the remaining two piers, has been proposed for Main Bridge. Table 6.2.1 shows the above-mentioned study.

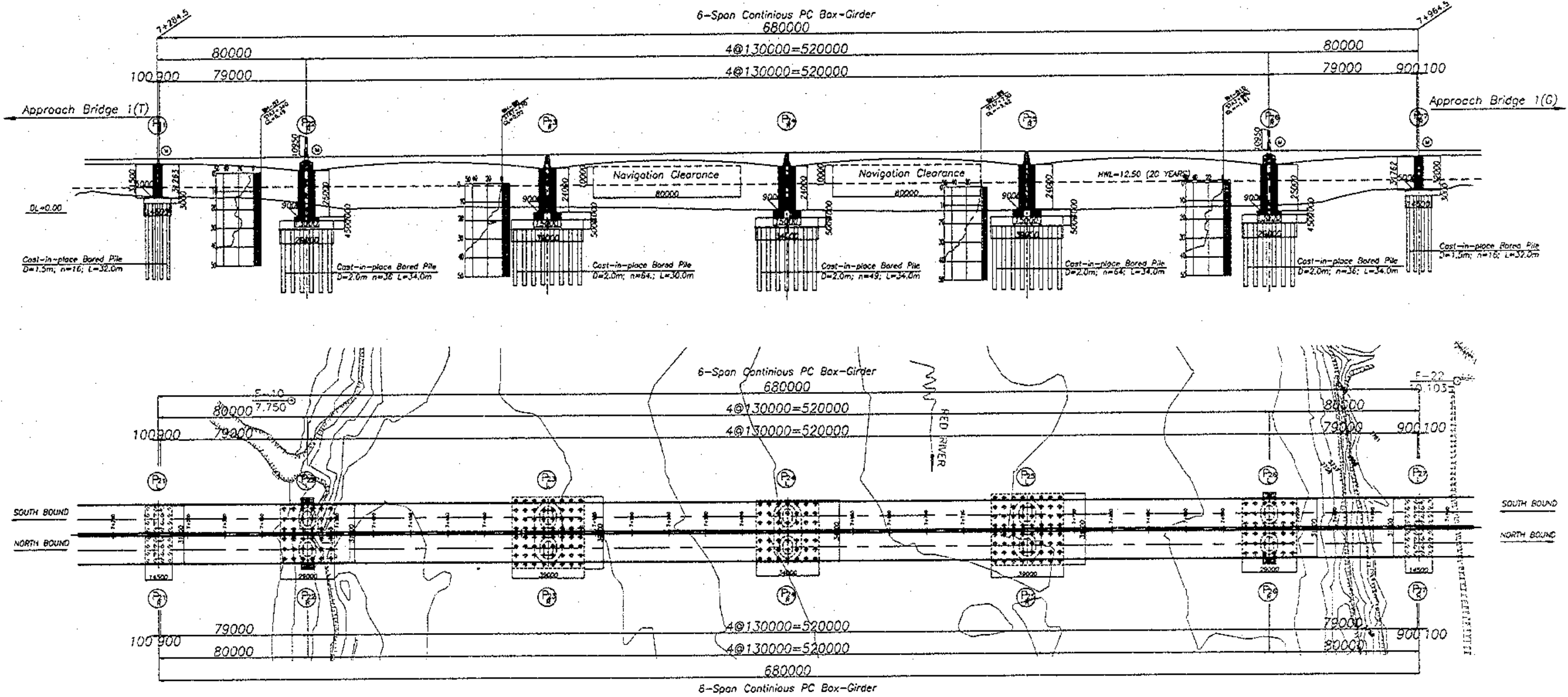
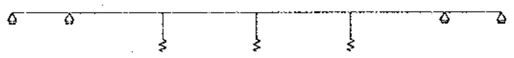
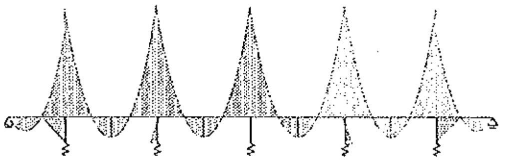
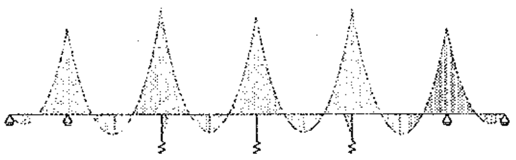
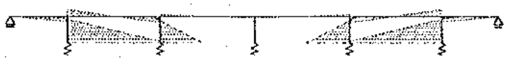
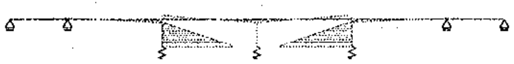
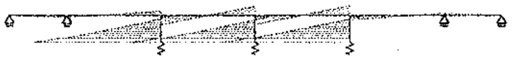


Figure 6.2.3 General Viewof Main Bridge

Table 6.2.1 Comparison of Structural Types for Main Bridge

Alternative	Alt-1 All intermediate piers are integrated	Alt-2 Three intermediate piers are integrated
Structural Model		
Bending Moment Diagram	Dead Load 	Dead Load 
	Temperature Change 	Temperature Change 
	Longitudinal Seismic 	Longitudinal Seismic 
Comparison	- All five intermediate piers are integrated with superstructure. - Maintenance of bridge bearing is not needed. - Magnitude of bending moment due to dead load of Alt-1 is not different from that of Alt-2. - Fixed span length affected with temperature change of Alt-1 (L = 260m) is longer than that of Alt-2 (L = 130m). Therefore, high bending moment at the bottom of pier is generated by temperature change, and this structural system is not realized under current design condition. - Alt-1 is advantageous seismic ally since section force due to seismic force can be dispersed to five piers.	- Three intermediate piers are integrated with superstructure and bridge bearings are installed on the two remaining piers. - Maintenance of bridge bearing is needed. - Magnitude of bending moment due to dead load of Alt-1 is not different with that of Alt-2. - Fixed span length affected with temperature change of Alt-2 (L = 130m) is shorter than that of Alt-1 (L = 260m). Therefore, bending moment at the bottom of pier generated by temperature change is reduced to half of Alt-1. As a result, this structural system is realized under current design condition. - Alt-2 is disadvantageous to the seismic condition since seismic force is to be resisted with only three piers.
Rating		This structural system has been proposed.

(2) Superstructure

1) General

The span arrangement is shown in Figure 6.2.4. The main span length of 130m has been decided upon so as to provide sufficient clearance to the navigation channel described in Section 4.2.4. The side span length of 80 m has been determined in such a manner that it could be kept in balance with the main span length.

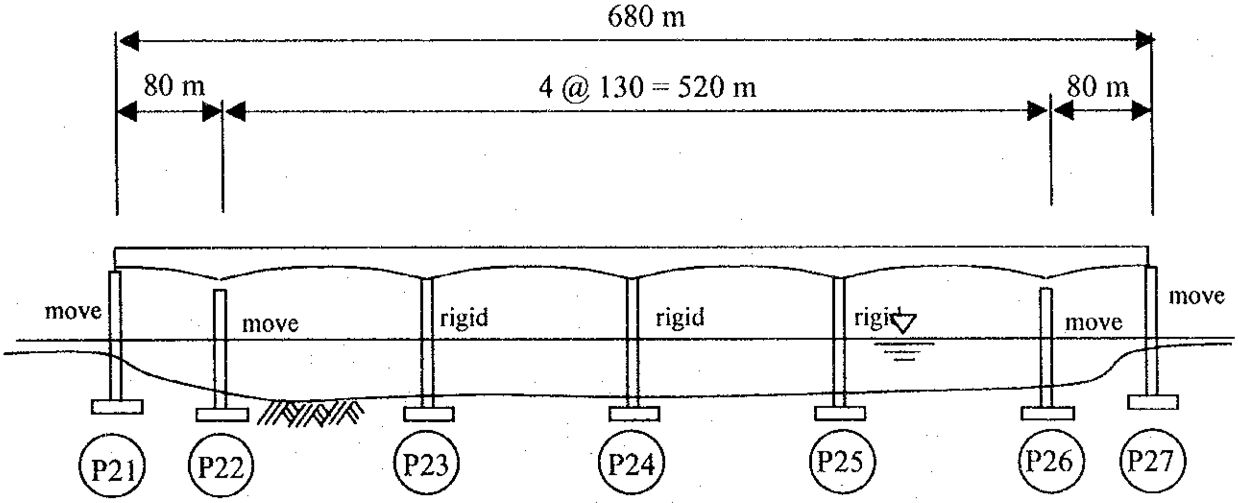


Figure 6.2.4 Span Arrangement of Main Bridge

2) Structural Dimensions

The typical cross-section of the main bridge is shown in Figure 6.2.5. The girder heights at the support, at the center of a span and at the end of bridge are 7.5 m, 3.5 m, and 3.0 m respectively. The varying girder height is achieved by parabolic shape of the side-view profile of the bottom slab.

The trapezoidal cross-section with sloping webs has been selected for the following two reasons.

(i) Aesthetics

The girder height at the support is 7.5 m because of the long span length. The box girder looks very massive if vertical webs are used. It is a commonly accepted concept that the use of sloping web mitigates the massive appearance and therefore aesthetics are improved.

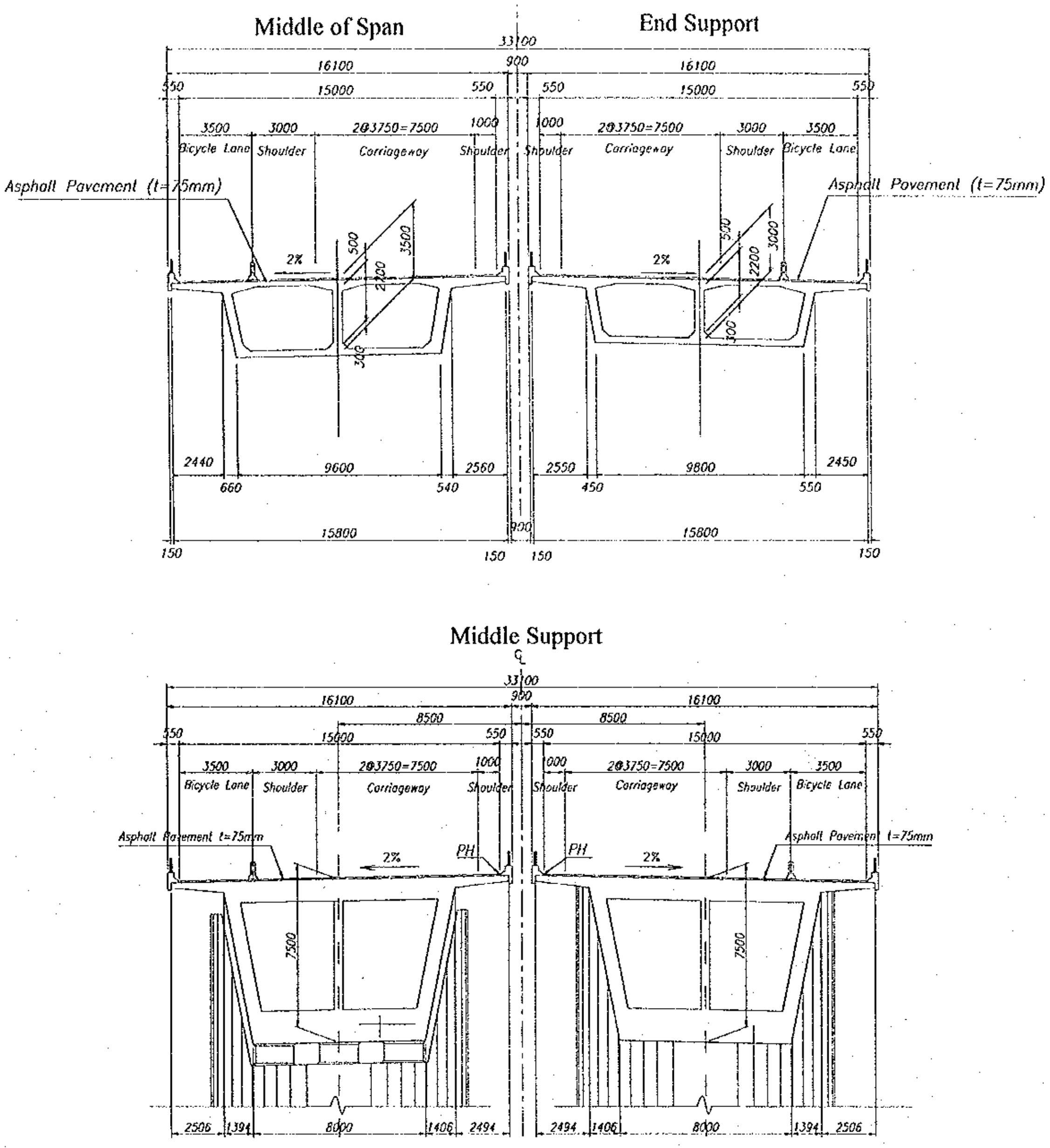


Figure 6.2.5 Typical Cross Sections of Superstructure of Main Bridge

(ii) Economics

The sloping web reduces the width of bottom slab. As a result, less dead load weight acts on the superstructure and the substructure. Therefore, the structural dimensions and/or the amount of reinforcement can be reduced.

The roadway width is the same as that for Approach Bridge 1. Two-cell box girder is adopted. Refer to Section 6.2.2 (2) for the reasons.

3) Design Consideration on Construction Stage

Cast-in-place concrete balanced cantilever construction method is assumed for the design (Refer to Section 12.1.1 (1) for the selection of the method). During the cantilever construction of the bridge, it is necessary to ensure deck stability before the structure is completed.

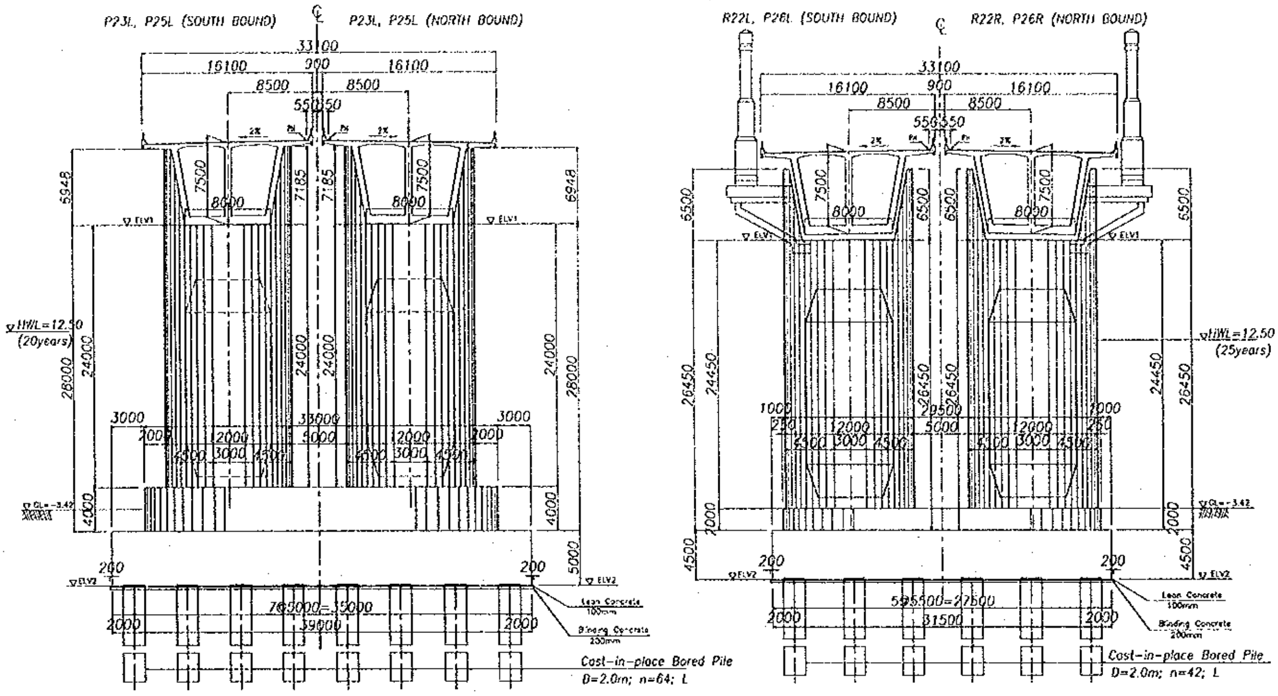
Considering constructibility and economy of a form traveler, the maximum weight of a segment is assumed to be 150 tf which results in the segment lengths varying from 2.5 m to 4.0 m. Segment arrangement in two cantilevers from Pier 22 and Pier 26 is asymmetric as the girder shape of the side span and the internal span are different. Weight of one unit of travelling form is assumed to be 100 tf in the design. The contractor shall recalculate structural stability using an actual traveller's weight.

(3) Substructure

The solid wall piers with oval cross section have been proposed for piers of Main Bridge. Oval cross section, which is an appropriate shape for decreased disturbance of water flow, was selected since all piers of the main bridge are located in the main stream of the Red River. Dimensions of oval cross section were determined based on the result of many trials to find the optimum dimensions which would be fitting to the structural system of the main bridge. Typical front views of the main bridge are shown in Figure 6.2.6

Regarding the bridge foundation, cast-in-place concrete bored pile of 2.0 m was proposed. This pile type is the maximum size of the pile which is commonly constructed in Vietnam and does not require special construction equipment. The main bridge of the Red River Bridge is quite a large bridge. Therefore, the maximum size of pile should be required in order to support it safely.

There are four related boring data for the design of the main bridge. The estimation of pile length and soil properties for the stability calculation for each pier was carried out by use of concerned boring data.

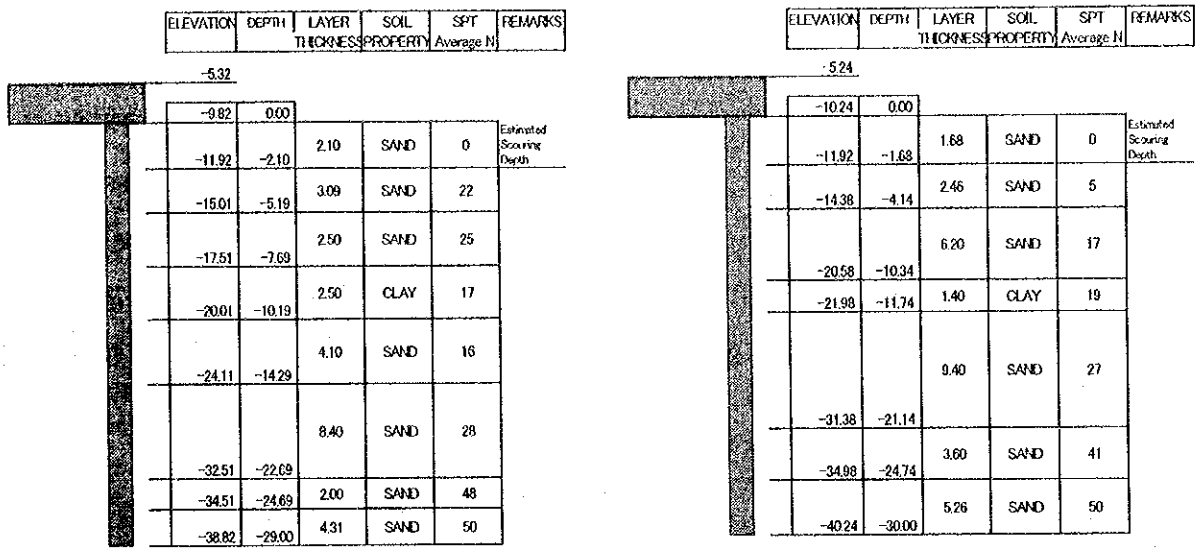


(a) Piers without Towers

(b) Piers with Towers

Figure 6.2.6 Typical Cross Sections of Substructures of Main Bridge

For the design calculation of substructures of the main bridge, influence of scour on piers is considered. Estimated depth of scour based on hydrological study is 8.5 m below the existing river bed, as described in Section 3.4. Maximum scoured depth of EL-11.92 m was estimated based on the lowest river bed elevation of -3.42 m. Piles of the main bridge, therefore, have been designed as projecting piles which have no resistance against horizontal forces between the bottom of footing and EL-11.92. Estimated soil properties for piles are shown in Figure 6.2.7 and calculation result of substructures are summarized in Table 6.2.2.

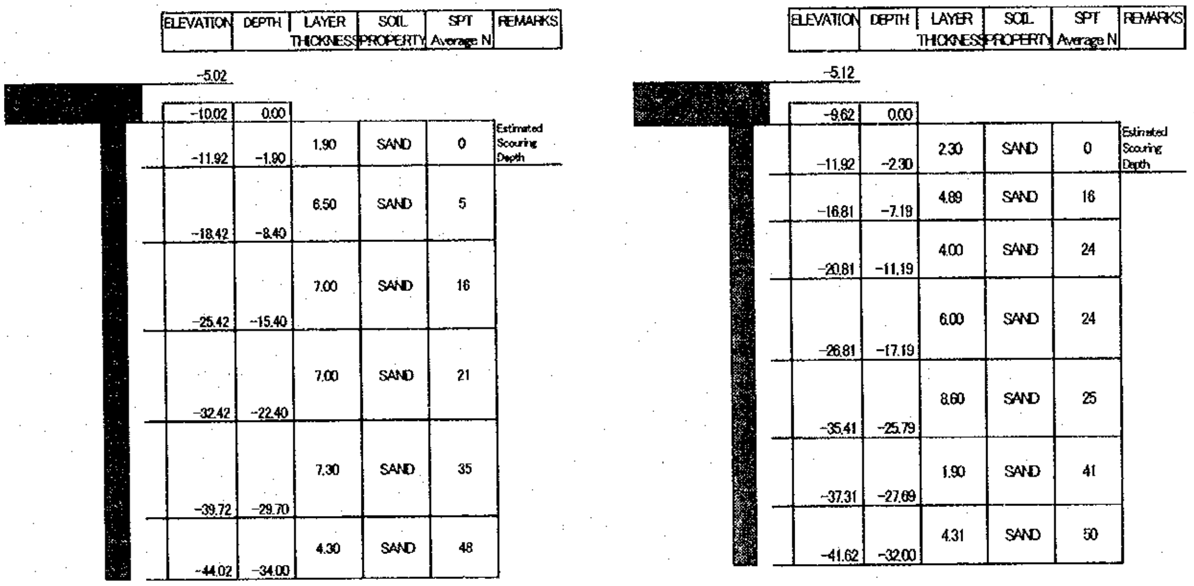


(a) For P22 from BH-B7

ELEVATION	DEPTH	LAYER THICKNESS	SOIL PROPERTY	SPT Average N	REMARKS
-5.32					
-9.82	0.00				
-11.92	-2.10	2.10	SAND	0	Estimated Scouring Depth
-15.01	-5.19	3.09	SAND	22	
-17.51	-7.69	2.50	SAND	25	
-20.01	-10.19	2.50	CLAY	17	
-24.11	-14.29	4.10	SAND	16	
-32.51	-22.69	8.40	SAND	28	
-34.51	-24.69	2.00	SAND	48	
-38.82	-29.00	4.31	SAND	50	

(b) For P23 from BH-B8

ELEVATION	DEPTH	LAYER THICKNESS	SOIL PROPERTY	SPT Average N	REMARKS
·5.24					
-10.24	0.00				
-11.92	-1.68	1.68	SAND	0	Estimated Scouring Depth
-14.38	-4.14	2.46	SAND	5	
-20.58	-10.34	6.20	SAND	17	
-21.98	-11.74	1.40	CLAY	19	
-31.38	-21.14	9.40	SAND	27	
-34.98	-24.74	3.60	SAND	41	
-40.24	-30.00	5.26	SAND	50	



(c) For P24 and P25 from BH-B9

ELEVATION	DEPTH	LAYER THICKNESS	SOIL PROPERTY	SPT Average N	REMARKS
-5.02					
-10.02	0.00				
-11.92	-1.90	1.90	SAND	0	Estimated Scouring Depth
-18.42	-8.40	6.50	SAND	5	
-25.42	-15.40	7.00	SAND	16	
-32.42	-22.40	7.00	SAND	21	
-39.72	-29.70	7.30	SAND	35	
-44.02	-34.00	4.30	SAND	48	

(d) For P26 from BH-B10

ELEVATION	DEPTH	LAYER THICKNESS	SOIL PROPERTY	SPT Average N	REMARKS
-5.12					
-9.62	0.00				
-11.92	-2.30	2.30	SAND	0	Estimated Scouring Depth
-16.81	-7.19	4.89	SAND	16	
-20.81	-11.19	4.00	SAND	24	
-26.81	-17.19	6.00	SAND	24	
-35.41	-25.79	8.60	SAND	25	
-37.31	-27.69	1.90	SAND	41	
-41.62	-32.00	4.31	SAND	50	

Figure 6.2.7 Estimated Soil Conditions of Foundations of Main Bridge

Table 6.2.2 Proposed Pier Types and Other Conditions of Main Bridge

	Name	P22L	P23L	P24L	P25L	P26L
South Bound North Bound	Type	I	I	I	I	I
	Height	32.5	33.0	33.0	33.0	32.5
	Data	BH-B7	BH-B8	BH-B9	BH-B9	BH-B10
	Length	29.0	30.0	34.0	34.0	32.0
	Number	36	64	49	64	36

6.2.2 Approach Bridge 1

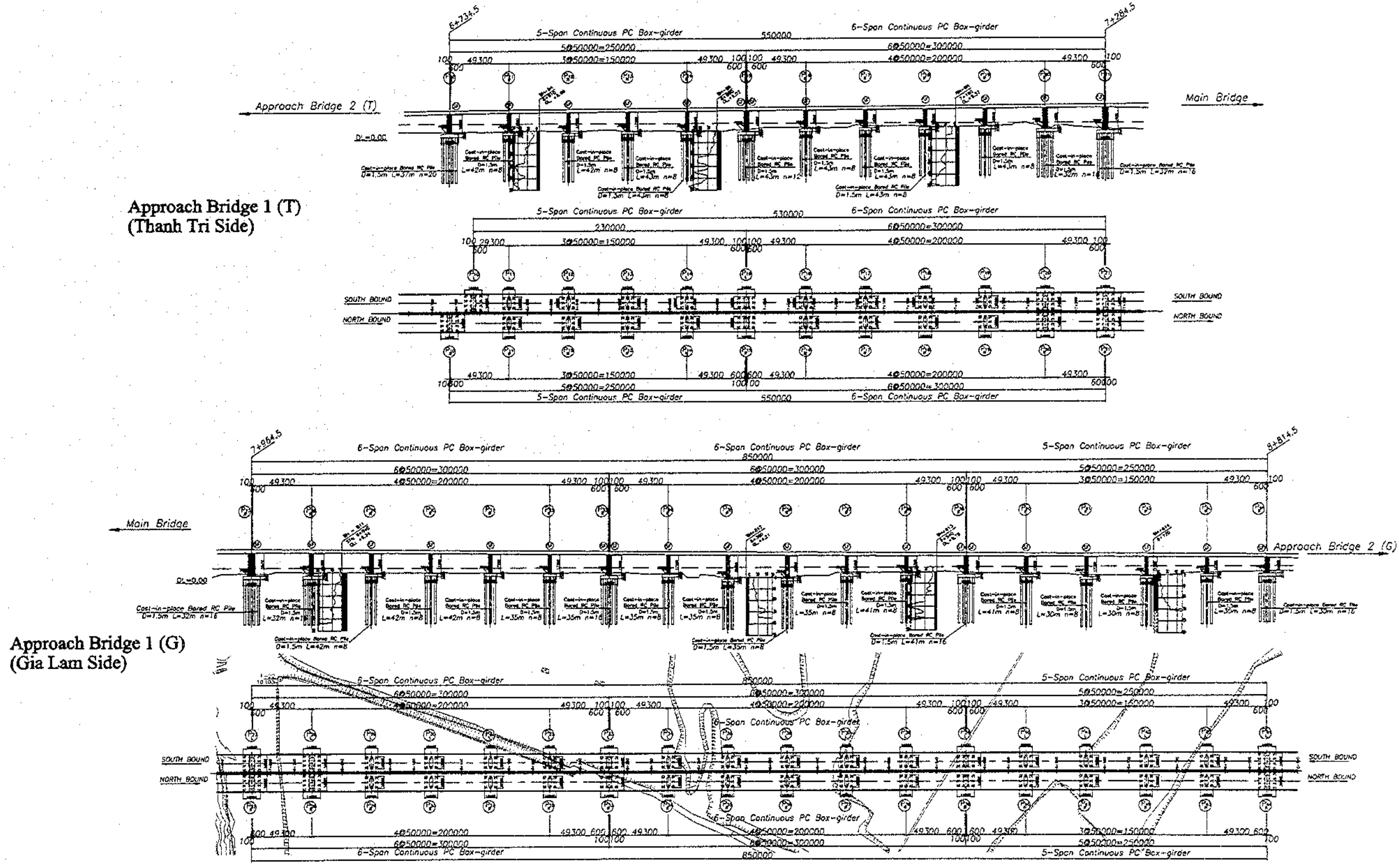
(1) General

As mentioned above, there are two bridges called "Approach Bridge 1". One is proposed on the Thanh Tri side and another on the Gia Lam side. These bridges are proposed based on span lengths of 50 m. General views of these bridges are shown in Figure 6.2.8.

Application of Horizontal Reaction Dispersing Bearing

A recent trend of bridge planning is to propose multi-span continuous bridges for the purpose of reducing the number of expansion joints in consideration of comfort in passage over the bridge. For the approach bridges of the Red River Bridge, multi-span continuous bridges have been proposed. In the case that a bridge bearing is used between the superstructure and the substructure, fixed bearing (no relative displacement between the superstructure and the substructure allowed) and mobile bearing (structural sliding) are applied on piers in order to limit the displacement due to seismic force. In this case, however, imbalance of dimensions of piers is can easily occur, as seismic forces which apply to the piers will concentrate on the fixed piers. Therefore, to the extent that seismic force through the superstructure is dispersed to piers, structural imbalance between piers will be reduced, ensuring safe and economic structures. Application of horizontal reaction dispersing bearing was proposed for Approach Bridge 1. The horizontal reaction dispersing bearing is a kind of elastic bridge bearing composed of natural rubbers and steel plates. The function of the horizontal reaction dispersing bearing is that horizontal reactions applied to piers are dispersed by adjusting the elastic coefficient of the bearing. Basic design flowchart for the case of using the horizontal reaction dispersing bearing is shown in Figure 6.2.9.

Analysis of the frame which is composed of structural members and spring members is generally required to obtain section forces for the structural calculation. Bearings and piles are converted into spring members. Figure 6.2.10 shows a structural model for structural analysis by use of the horizontal dispersing bearing.


Approach Bridge 1 (T)
(Thanh Tri Side)

Approach Bridge 1 (G)
(Gia Lam Side)

Figure 6.2.8 General Views of Approach Bridge 1

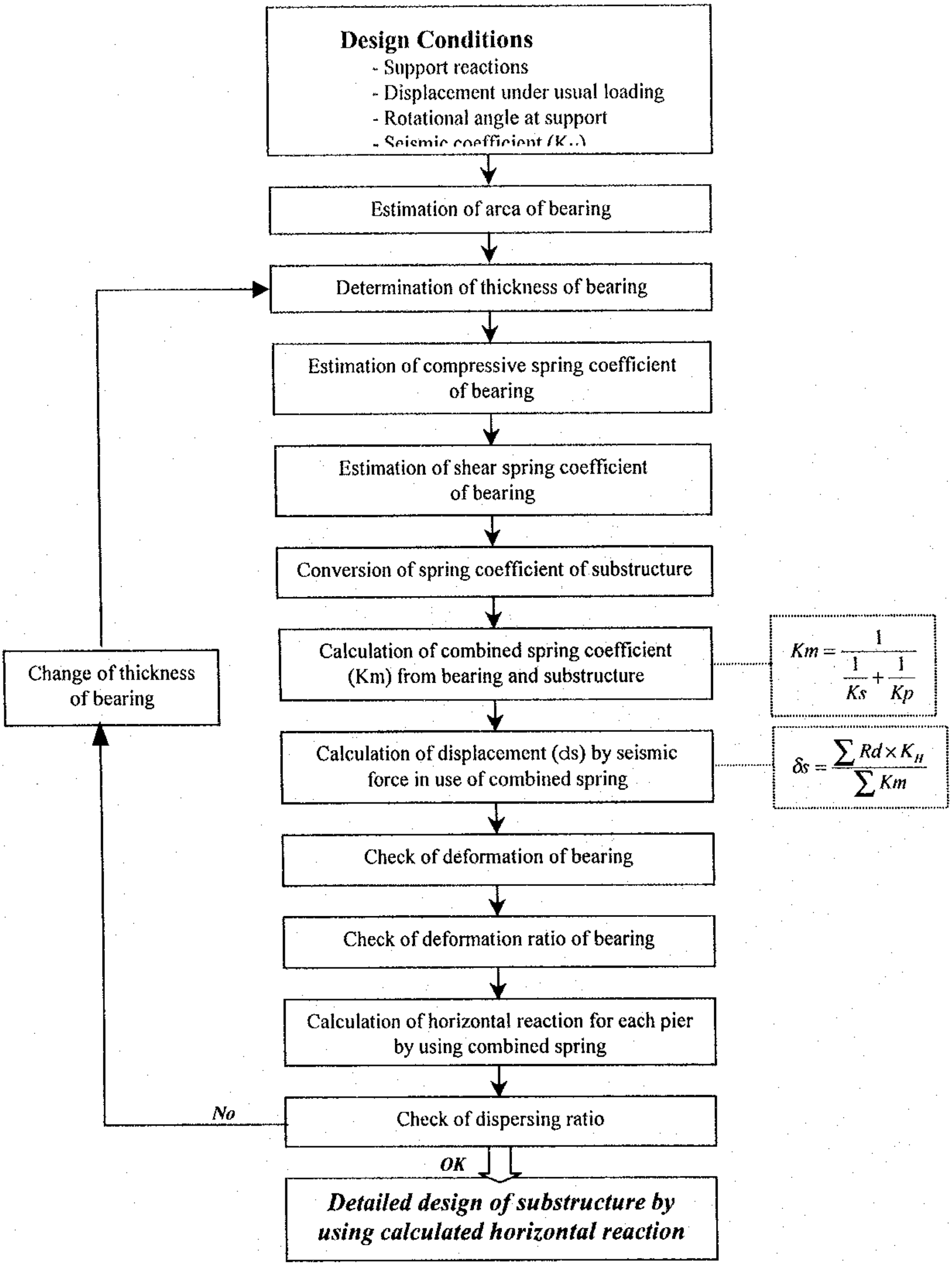
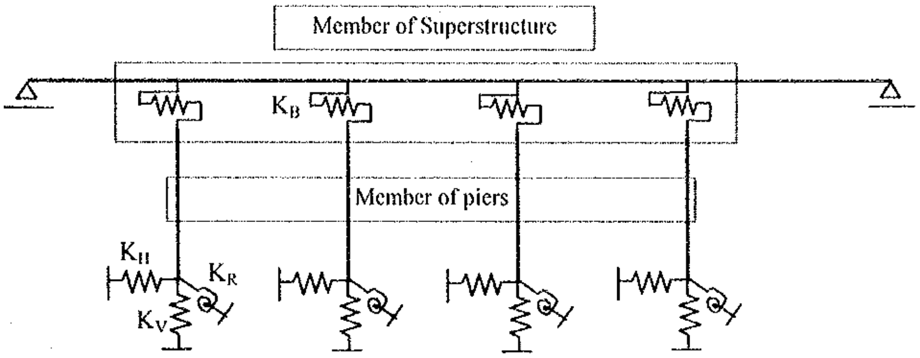


Figure 6.2.9 Design Flowchart for Horizontal Reaction Dispersing Bearing



K_B: Shear spring coefficient of bearing
K_H: Horizontal spring coefficient of piles
K_V: Vertical spring coefficient of piles
K_R: Rotational spring coefficient of piles

Figure 6.2.10 Structural Model of Analysis for Horizontal Reaction Dispersing Bearing

(2) Superstructure

1) Structural Dimensions

As was discussed in the Feasibility Study, Prestressed concrete box girder bridge with span length of 50 m is most appropriate for Approach Bridge 1. The typical cross-section is shown in Figure 6.2.11. The girder height of 2.75 m is constant throughout the bridge. Constant girder depth is generally selected for a box girder bridge with span length up to approximately 55 m.

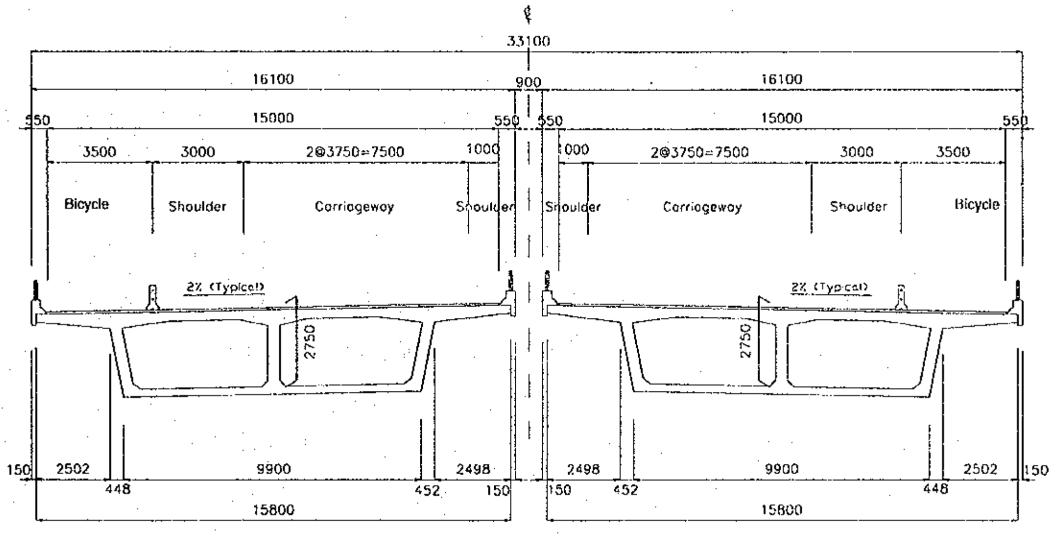


Figure 6.2.11 Typical Cross-section of Approach Bridge 1

The structural dimensions proposed in the Feasibility Study (hereinafter referred to as F/S) have been reviewed. The review focused on the two following items:

i) Girder height (3.20 m in the F/S)
ii) Box type (one-cell box in the F/S)

In the F/S, application of the incremental launching (hereinafter called as I/L) method was considered as one of the applicable construction method. For the I/L method, however, the girder-height/span (herein after called as H/L) ratio is set at approximately 1/16 in order to withstand loading conditions during the construction stage. This was the rationale for the proposed girder height of 3.2 m. After having studied local conditions, it has been concluded that the I/L method is not feasible (Refer to Section 12.1.2 (1) for the detail.). Therefore, the girder height has been reduced to 2.75 m, i.e. the H/L ratio equals to 18.2. Note that the rate of prestressed box girder bridge, except for the I/L method, is in the range of 1/18 to 1/20 in general.

The box type was also reviewed and it has been concluded that two-cell box shall be used because of the relatively wide deck slab width of 15.8 m which is designed as Prestressed concrete (PC) slab provided with transverse Prestressing tendons. Table 6.2.3 shows reference information for selection of two-cell box girder:

Table 6.2.3 Selection of Box Type (for PC deck slab)

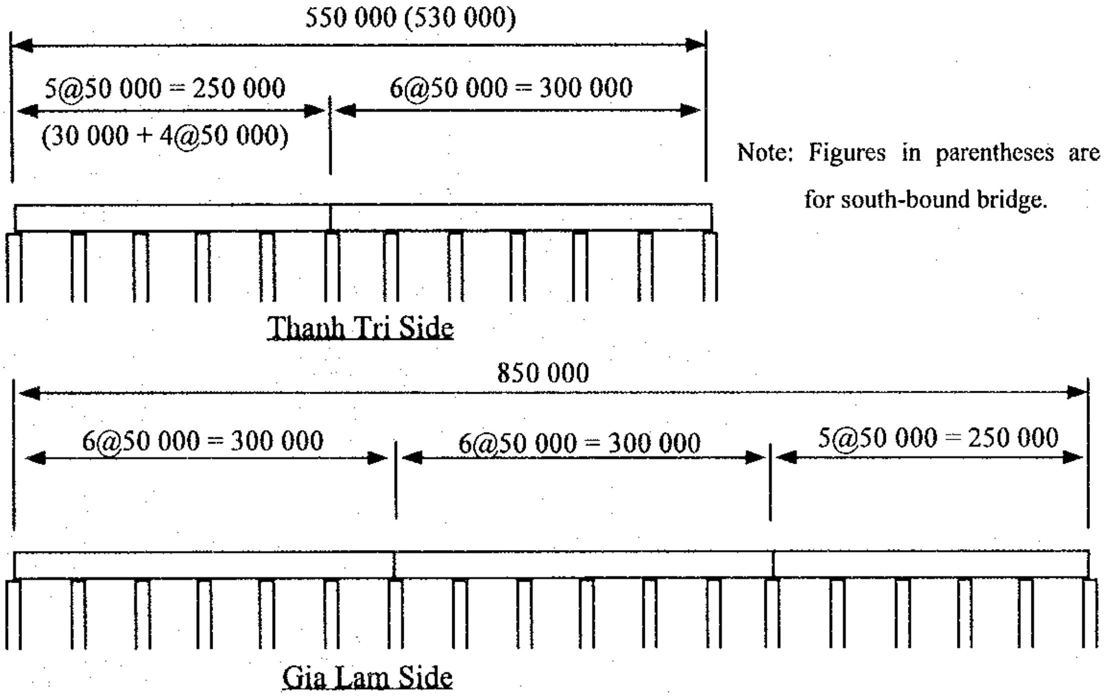
cross-sectional shape	total deck slab width (m)			
	5	10	15	
one-cell box girder		═	═	
two-cell box girder			═	═

The cross-sectional shape of the box girder is a trapezoid with sloping webs. The slope angle (horizontal : vertical = 1:5) is the same as for the main bridge and the dyke bridges so that the outer face of the webs match throughout the Red River Bridge. The use of a trapezoidal shape improve the bridge aesthetic and construction economy as described in Section 6.2.1 (2) 2).

2) Span Arrangement

It is a recent general trend to select a continuous span bridge which provides better riding comfort and is more efficiently maintainable due to the smaller number of number of expansion joints. In order to avoid concentration of horizontal force on a pier, horizontal reaction dispersing bearings are to be used (Refer to Section 6.2.2 (1) for the rationale regarding use of this bearing).

Table 6.2.4 shows a summary of comparison studies on the number of continuous spans. A six-span continuous bridge is selected as the basic bridge unit based on the study. Span arrangements for Approach Bridge 1 situated on the Thanh Tri side and Gia Lam side are shown in Figure 6.2.12.



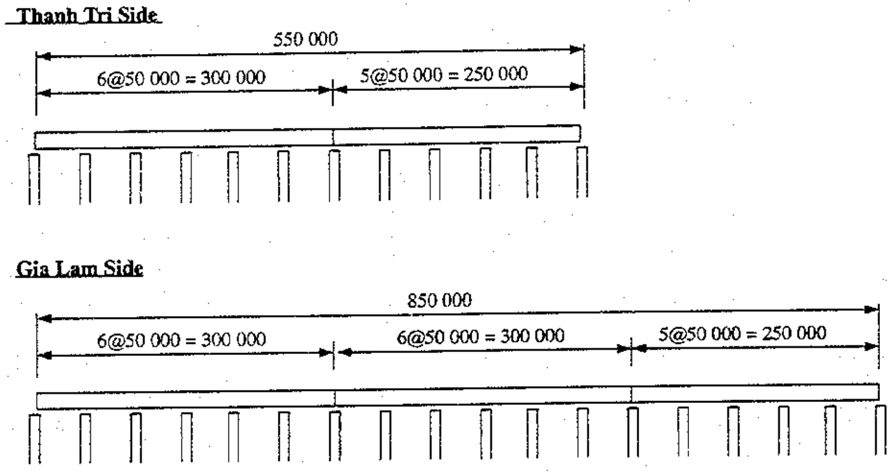
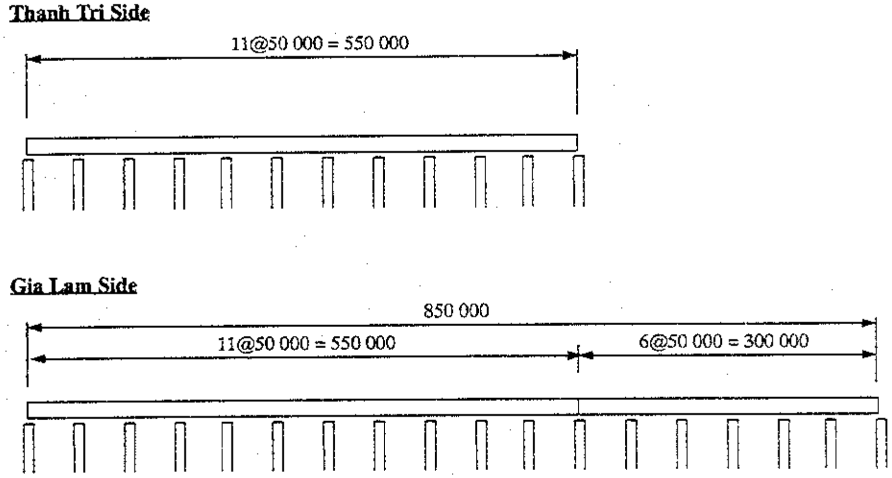
Note: Figures in parentheses are for south-bound bridge.

Figure 6.2.12 Span Arrangement of Approach Bridge 1

3) Structural Model

Forces in the superstructure are transferred to the substructure through the horizontal reaction dispersing bearings. The bearing creates horizontally semi-fixed condition in the longitudinal direction, as the longitudinal displacement of the superstructure causes a shear strain in the bearing. As a result, an axial force is produced in the superstructure. The axial force, however, is small and neglected in the design. Structural models for the design are shown in Figure 6.2.13.

Table 6.2.4 Summary of Comparison Study on Number of Continuous Spans for Approach Bridge 1

		Option I Maximum number of continuous spans = 6 spans	Option II Maximum number of continuous spans = 11 spans
Outline			
structural features	**advantage**	- Required deformability of the bearings is smaller that that for Option-II. Therefore, the cost of bearings is less. - Integrity of the structural system is reliable as many continuous bridges have been constructed in this range of the spans number. - The approach bridge consists of two types of continuous bridges, i.e. 5-span and 6-span. The structural models are similar. Thus the design is consistent through out Approach Bridge 1.	- Better rideability because of less expansion joints. - Reinforcement amount is less than Option-I because of less number of side spans. (Note: Side span requires more reinforcement than internal span.
	disadvantage	- The number of bearings and expansion joints increase.	- A large initial strain occurs due to the creep and shrinkage effect of the concrete. A special adjustment may be required. - A large displacement occurs due to temperature effect in the longitudinal direction. Therefore the size of bearing becomes large and thus not economical. - The design becomes sophisticated because the structural system is less popular.
Construct-ibility		- Option-I is slightly more constructible than Option-II because of less number of bearings and expansion joints. The difference is, however, minimal.	
Construction cost		- The total construction cost of Option-I will be more economical than Option-II due to the high bearing cost for Option-II.	
Recommendation		- There will not be a notable difference in structural system and constructibility. Option-I is, however, recommendable when considering economics of construciton.	
		○	-

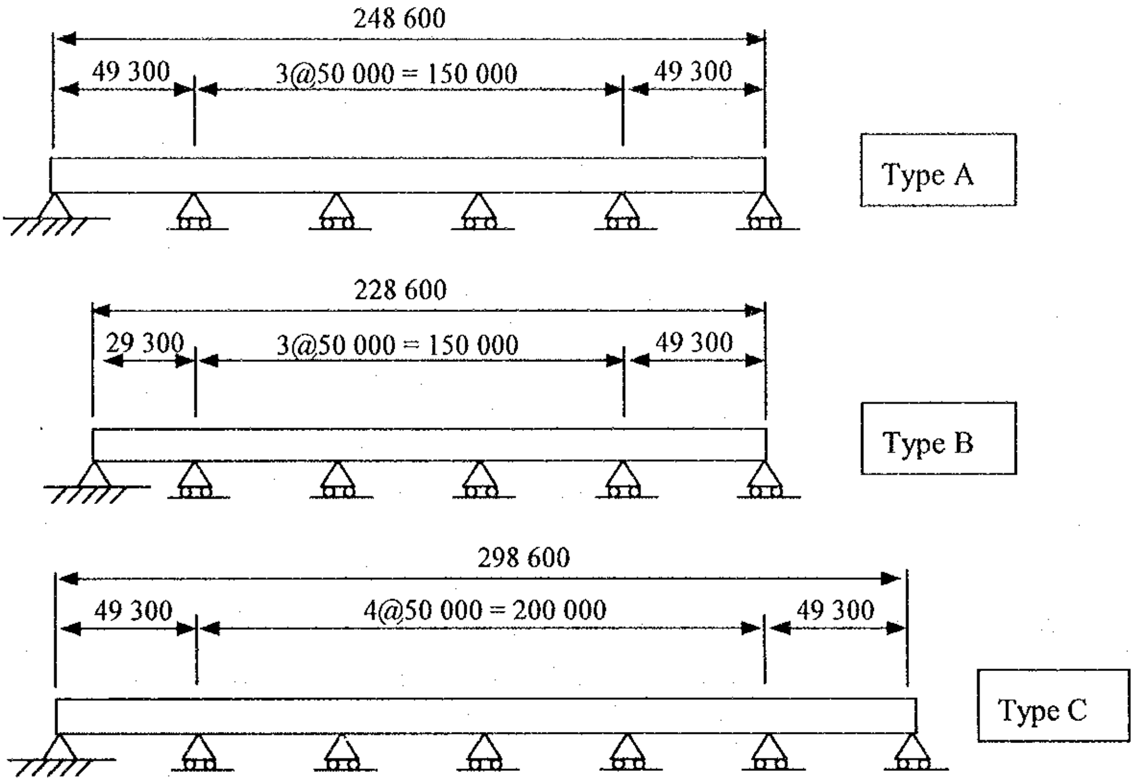


Figure 6.2.13 Structural Model for Design

4) Construction Method Assumed for Design

As discussed in Section 12.1.2 (1) in detail, various construction methods are applicable. The contractor will select the preferable method. Option II, i.e., span-by-span construction on staging with cast-in-place concrete, is assumed in the Detailed Design. The reason is that the design for Option II can be flexibly applied to other construction methods with minimum design changes. The contractor will redesign the bridge in the event that an other method is applied.

Since the structure is structurally indeterminate, produced section forces vary depending the construction sequence. Although the contractor may select a different method, it is assumed in this design that the bridge will be constructed span-by-span on staging. Figure 6.2.14 shows typical construction stage for the assumed construction method.

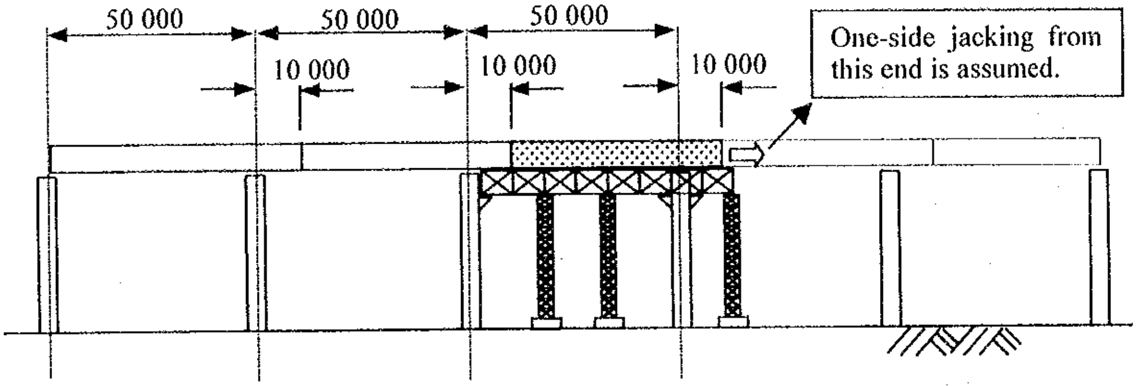


Figure 6.2.14 Assumed Construction Method

It is assumed that Prestressing work of the continuous longitudinal tendons will be done from one side as shown in Figure 6.2.14. These tendons will be connected by couplers at the joint.

5) Structural Analysis

(a) Loads

For some period after the bridge is open to the traffic, the roadway will consist of carriageway, shoulders and a bicycle lane, as shown in Figure 6.2.x. However, in consideration of future use of the bridge, it is assumed in the design that the entire road width between the curbs is to serve vehicular traffic. The number of traffic lanes is four (4) for roadway width of 15.0 m, in accordance with AASHTO standard Article 3.6. The load intensity shall be reduced in accordance with Article 3.12 of the standard.

Refer to Section 4.2.2 for other loads.

(b) Deck Slab

Because of the relatively wide deck slab width, the slab is designed as a Prestressed concrete member.

(c) Check for Construction Stage

A structural member is sometimes exposed to a critical condition during the construction stage. Structural safety is checked for the two construction stages shown in Figures 6.2.15 and 6.2.16. The positive bending moment occurring at the span may create a critical condition for the box girder.

Stage 1: Staging is removed after Prestress is transferred to the first span
Stage 2: Staging is removed after Prestress is transferred to the second span

Since the deck slab is designed as a Prestressed concrete slab, the full strength is achieved after the transverse Prestress is transferred. The slab is, however, exposed to a temporary construction load before the Prestressing work and acts as a reinforced concrete member. The slab is designed to withstand a distributed load of 250 kgf/m^2, but not exceed 1.0 tf/m in average in the longitudinal direction.

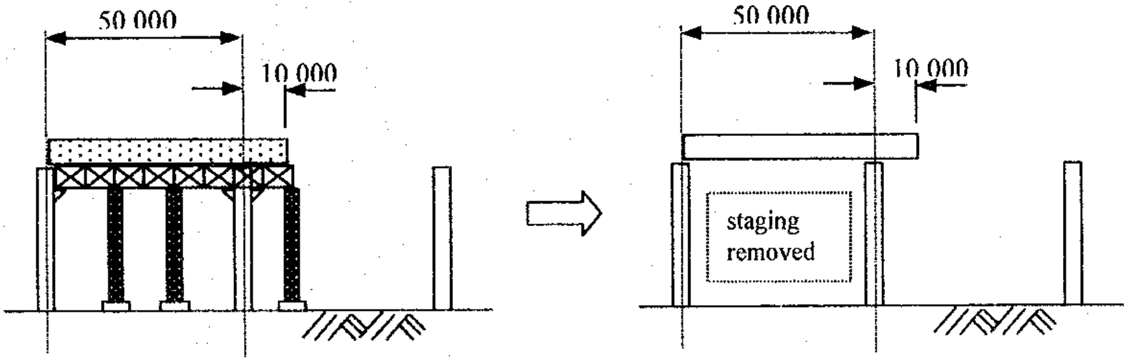


Figure 6.2.15 Construction Stage 1

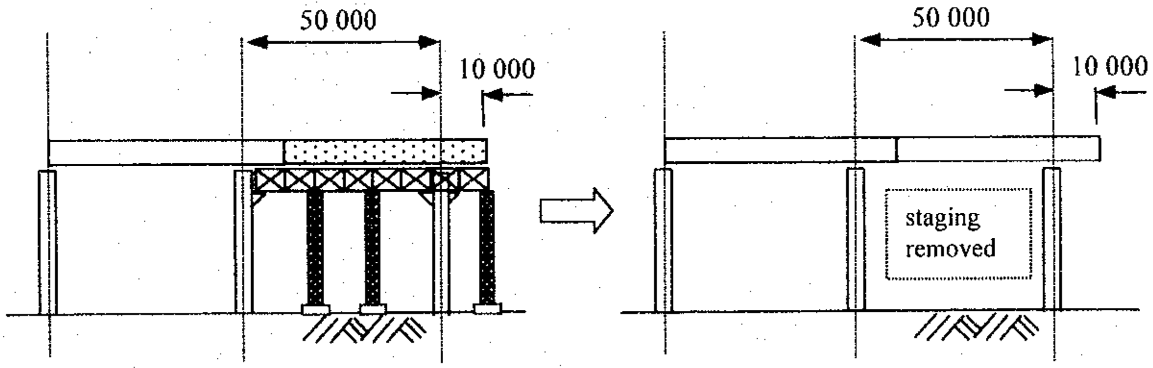


Figure 6.2.16 Construction Stage 2

(3) Substructure

The piers of Approach Bridge 1 are located within the banks of the Red River where river water will flow in the rainy season. Therefore the solid wall piers with oval sections were proposed for the piers of Approach Bridge 1.

The front shape of the top portion of the pier is to be the same cross-sectional shape of PC box-girder on pier, and the transverse width of solid wall has become 8 m. Figure 6.2.17 shows typical front views of piers for Approach Bridge 1.

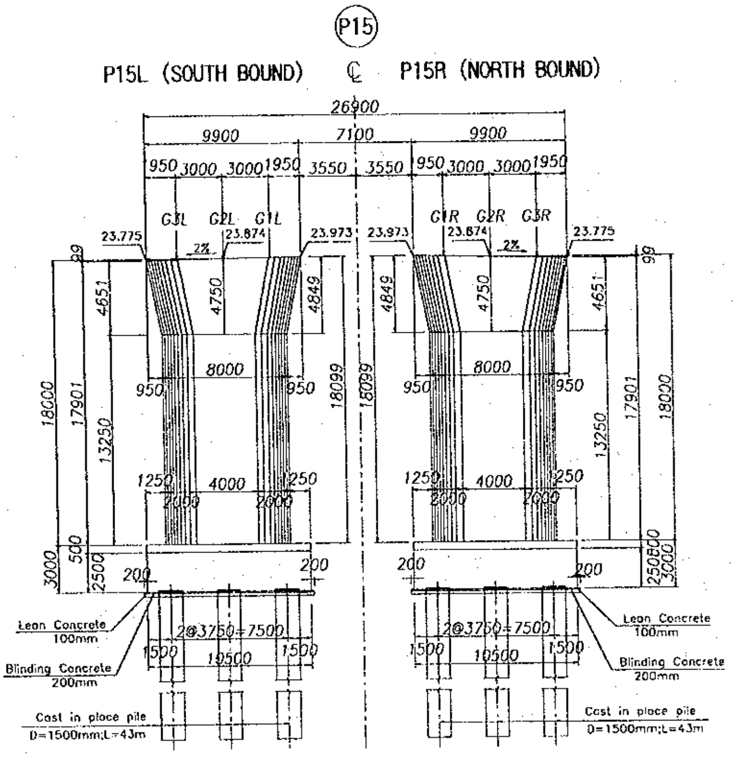


Figure 6.2.17 Typical Front Views of Substructures of Approach Bridge 1

Regarding the bridge foundation, cast-in-place concrete bored pile of 1.5m in diameter was recommended based on the following study.

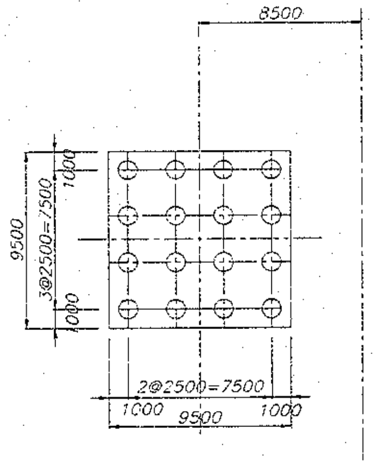
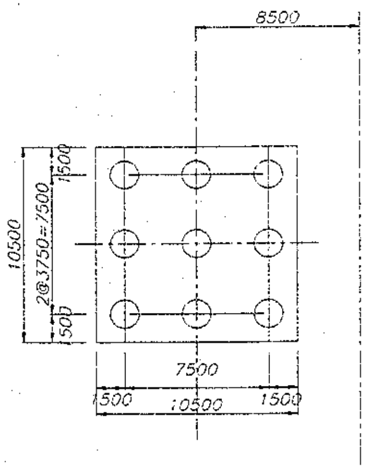
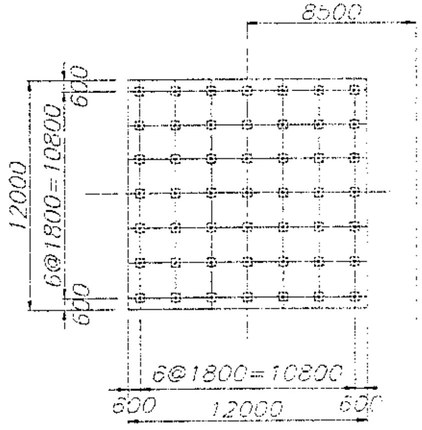
Comparison of Pile Types for PC Box-girder

Compared types of foundation

Case-1: ϕ 1000mm RC bored cast-in-place pile

Case-2: ϕ 1500mm RC bored cast-in-place pile (PROPOSED)

Table 6.2.5 Comparison of Pile Types for Approach Bridge 1

		CASE-1 ϕ =1000mm Borehole Pile	CASE-2 ϕ =1500mm Borehole Pile	CASE-3 □450×450mm Precast Pile
Pile Arrangement				
Bearing Capacity	Pmax (tf)	655 < 961	1,098 < 1,537	206 < 274
	Pmin (tf)	226 < 961	209 < 1,537	53 < 274
Displacement	δx (mm)	5.8 < 15	7.4 < 15	3.6 < 15
Stress	σc (kgf/cm3)	46 < 120	54 < 120	50 < 120
	σs (kgf/cm3)	2,623 < 2,700	2,380 < 2,700	2,444 < 2,700
	As (cm2)	D29−20, D29−10 192.7	D32−24, D32−12 286.0	D32−8 63.5
Construction Cost		1,460,669,000 VND (1.062)	1,374,914,200 VND (1.000)	1,517,952,400 VND (1.104)
Recommendation			○	

Case-3: □450 x 50 mm RC driven pre-cast pile

Compared location
Applied boring data: BH-B6 (km 7+160)

As a result of study, cast-in-place RC bored pile of 1.5 m in diameter was proposed as a bridge foundation for the Approach Bridge 1 due to its economical construction as shown in Table 6.2.5. Furthermore, cast-in-place RC bored piles of 1.5 m I diameter were applied to the other bridges which consist of PC box-girders in this project.

There are three related boring data for the design of the Approach Bridge 1(T) and four boring data for the Approach Bridge 1(G). The estimation of pile length and soil properties for the stability calculation for each pier was carried out by use of boring data concerned. Table 6.2.6 shows the result of foundation design.

Table 6.2.6 Proposed Pier Types and Other Conditions of Approach Bridge 1

(a) Approach Bridge 1(T)

		Approach Bridge 1(T)										
South Bound North Bound	Name	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L
	Type	I	I	I	I	I	I	I	I	I	I	I
	Height	20.0	20.0	20.0	21.0	21.0	19.0	18.0	19.0	19.0	34.0	34.0
	Data	BH-B4			BH-B5				BH-B6			
	Length	42.0	42.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	32.0	32.0
	Number	8	8	8	8	12	8	8	8	8	16	16

(b) Approach Bridge 1(G)

		Approach Bridge 1(G)																
South Bound North aBound	Name	P27L	P28L	P29L	P30L	P31L	P32L	P33L	P34L	P35L	P36L	P37L	P38L	P39L	P40L	P41L	P42L	P43L
	Type	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
	Height	35.0	34.5	21.0	20.0	20.0	20.0	20.0	20.0	23.0	23.0	18.0	18.0	18.0	18.0	20.0	20.0	17.0
	Data	BH-B11					BH-B12						BH-B13			BH-B14		
	Length	32	32	42	42	42	35	35	35	35	35	35	41	41	41	30	30	30
	Number	16	16	8	8	8	8	16	8	8	8	8	8	16	8	8	8	8

6.2.3 Approach Bridge 2

(1) General

There are two bridges called "Approach Bridge 2" as describe before. The bridge on Thanh Tri side is named "Approach Bridge 2(T)" and that on Gia Lam side is "Approach Bridge 2(G)". Locations of abutments was proposed so as to satisfy the following conditions:

a) Construction cost should be reduced by making the bridge length shorter.
b) Height of embankment has been limited due to the soft soil conditions.

As a result of study, location of A1 abutment is to be at STA 6 km + 218.5 m and A2 abutment is located at STA 9 km + 302.5 m. Therefore, the total bridge length of the Red River Bridge has become 3,084 m.

General views of the Approach Bridge 2 are shown in Figure 6.2.18

(2) Superstructure

In designing this bridge, it is not necessary to consider obstruction of the river flow by the piers as the bridge is located outside of the river. The typical girder length of 33.0m was determined for economical reasons. The girder height is 1.65m on which 0.20m thick reinforced concrete deck slab is constructed by cast-in-place concrete.

Typical cross-section is shown in Figure 6.2.19. Precast Prestressed concrete I-girder (PC I-girder) bridge was adopted. The PC I-girder enables utilization of standardized precast girder being used in Vietnam, and is therefore economical and timesaving.

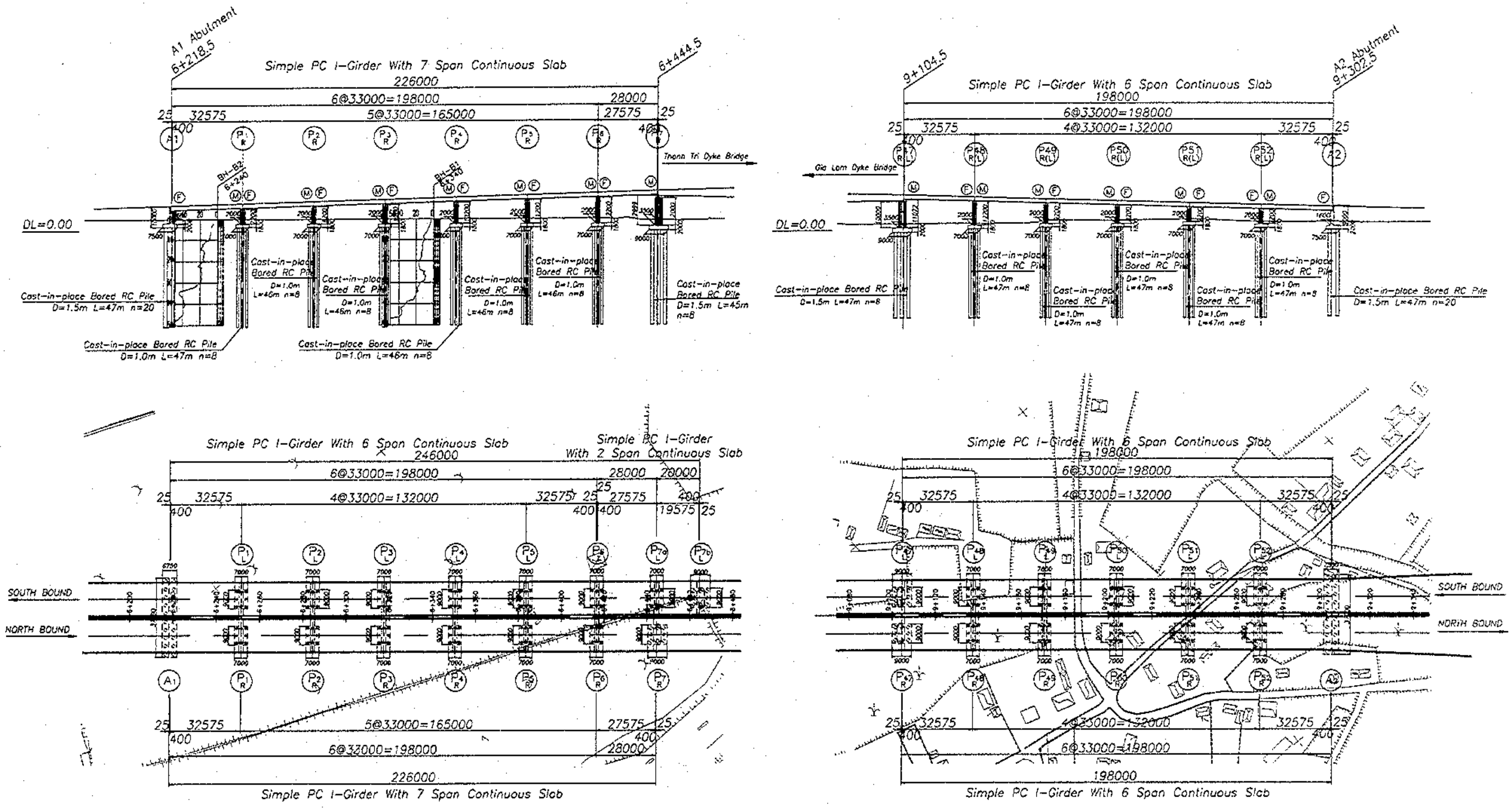


Figure 6.2.18 General Views of Approach Bridge 2

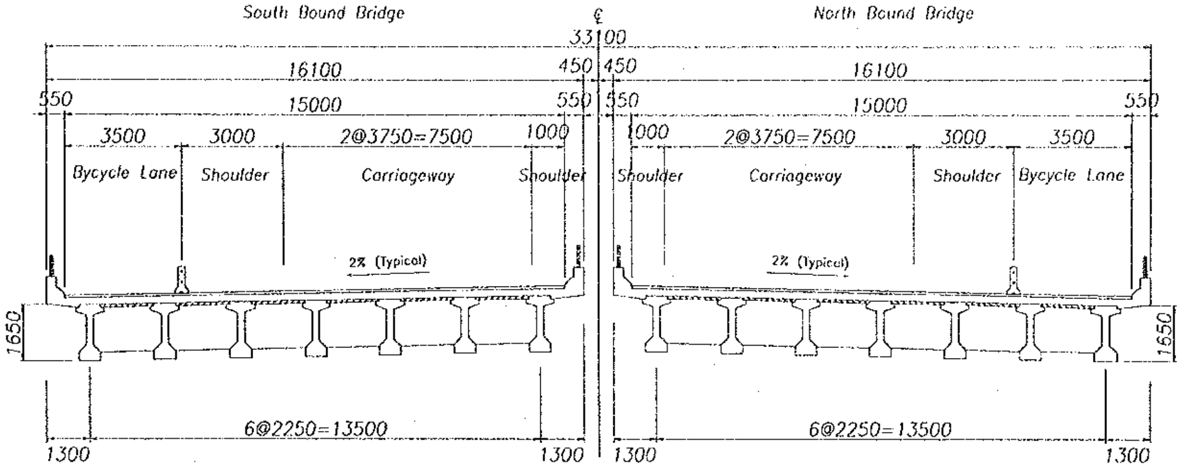


Figure 6.2.19 **Typical Cross-section of Approach Bridge 2**

PC I-girders are designed for a simple span bridge. The deck slab is continuously connected so as to provide improved riding comfort and a higher degree of maintenance efficiency by eliminating expansion joints.

(3) Substructure

The hammerhead pier type was required for the Approach Bridge 2 since ample width is needed to support the PC I-girders. However, the wall part of pier should be solid wall with oval section in the same way as other bridges which make up the Red River Bridge. Therefore, the type of solid wall pier has been proposed for Approach Bridge 2.

Maximum cantilever length of pier head of 4.0 m with 2.0 m in height was calculated considering the position and magnitude of reaction force through superstructure of PC I-girder. The width of wall of hammerhead pier was determined by the total width of superstructure and this cantilever length. Figure 6.2.20 shows typical front views of piers of Approach Bridge 2.

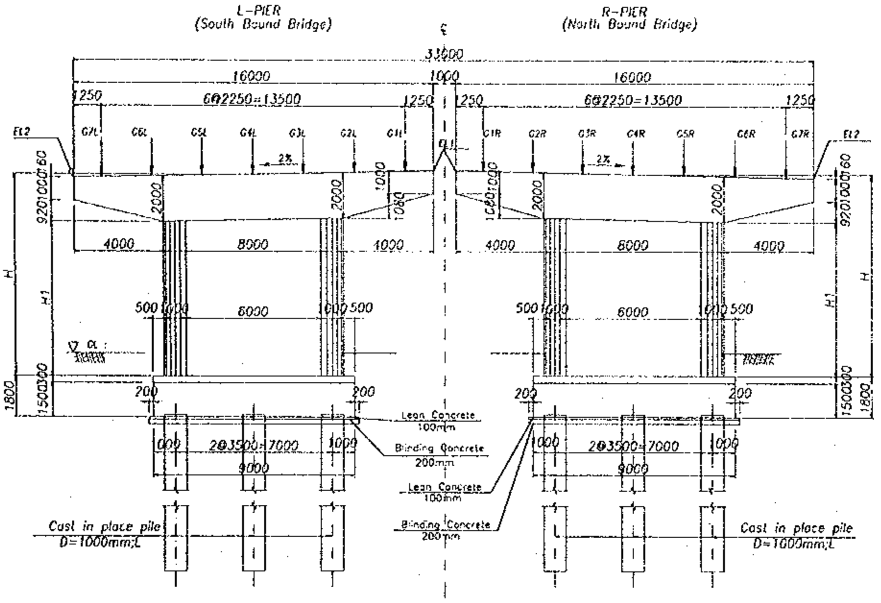


Figure 6.2.20 Typical Cross Sections of Substructures of Approach Bridge 2

Regarding the bridge foundation, cast-in-place concrete bored pile was recommended for both piers and abutment and the diameters of 1.0 m and 1.5 m were proposed for piers and abutment respectively, on the basis of the following study.

Comparison of Pile Types for PC I-girder

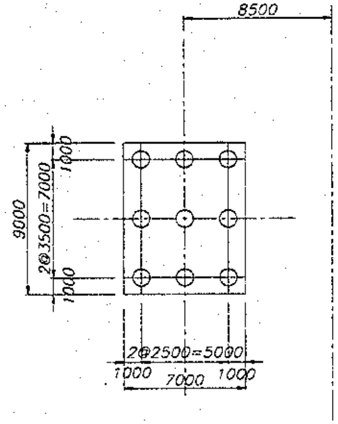
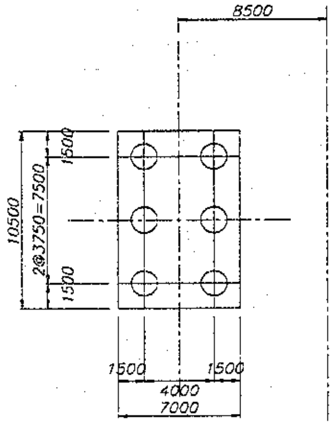
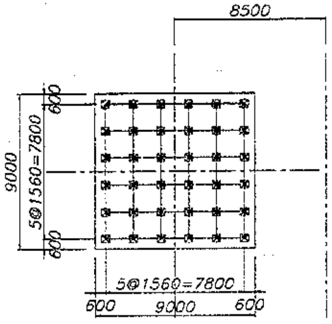
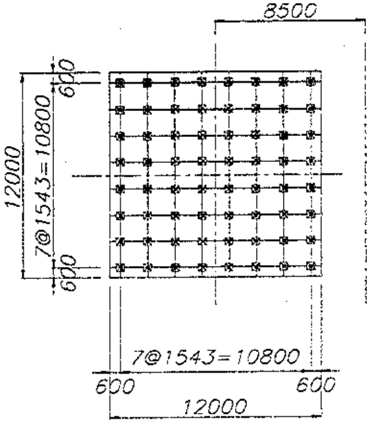
Compared types of foundation

Case-1: ϕ 1000mm RC bored cast-in-place pile (PRPOSED)
Case-2: ϕ 1500 mm RC bored cast-in-place pile
Case-3: □450 x 450 mm RC driven pre-cast pile (bearing pile)
Case-4: □450 x 450 mm RC driven pre-cast pile (friction pile)

Compared location
Applied boring data: BH-B1 (km 6+340)

As a result of study, cast-in-place m RC bored pile of 1.0m in diameter was proposed as a bridge foundation for the Approach Bridge 2 due to the low construction cost as shown in Table 6.2.7. Furthermore, cast-in-place RC bored piles of 1.0 m in diameter were applied to the other bridges which have a type of superstructure of PC I-girder.

Table 6.2.7 Comparison of Pile Types for Approach Bridge 2

		CASE-1 ϕ1000mm Borehole Pile	**CASE-2** ϕ1500mm Borehole Pile	**CASE-3** □450×450mm Precast Pile	**CASE-4** □450×450mm Precast Pile
Pile Arrangement		Bearing Pile 	Bearing Pile 	Bearing Pile 	Fficion Pile 
Pile Length		**44.00** m	**44.00** m	**44.00** m	**27.00** m
Number of Piles		**8** for each Footing	**6** for each Footing	**36** for each Footing	**64** for each Footing
Bearing Capacity	Pmax (tf)	592 < 806	761 < 1,305	147 < 241	83 < 87
	Pmin (tf)	138 < 806	133 < 1,305	40 < 241	9 < 87
Displacement	δx (mm)	10 < 15	7.4 < 15	3.6 < 15	2.8 < 15
Stress	σ C(kgf/cm3)	105 < 120	65 < 120	50 < 120	68 < 120
	σ S(kgf/cm3)	2,100 < 2,700	2,534 < 2,700	2,100 < 2700	2,242 < 2,700
	As (cm2)	D32-20,D32-10 238.3	D29-24,D29-12 231.3	D32-8 63.5	D22-8 31.0
Construction Cost		760,534,600 VND (1.00)	916,113,000 VND (1.20)	986,529,400 VND (1.30)	########## VND (1.50)
Recommendation		○			

In this study, application of RC rectangular driven pre-cast pile as a friction pile was studied. However, advantage of RC driven pile was not recognized since required number of piles increased due to low bearing capacity of friction pile under soft soil conditions in Hanoi area. If a structure has a pile foundation of friction piles, the structure is apt to be affected by settlement of ground. Proportionate to ground settling, the structure will sink since friction pile has no resistance to ground settling. The bearing pile foundation, on the other hand, ensures safety of the structure as the bearing pile supports the structure by a layer which never sinks.

In addition, RC rectangular driven pre-cast pile as a bearing pile is also at a disadvantage due to the high number of piles required since RC rectangular pile has low resistance to horizontal force.

For the abutment structure, the structure receives horizontal earth pressure from the fill behind it at all times. A pile of 1.5 m in diameter was recommended for all abutments in this project since a pile with larger diameter has the advantage of higher resistance against larger horizontal force under the condition that soil properties and depth of bearing layers are not variable.

There are three related boring data for the design of the Approach Bridge 2. Boring data of BH- B2 was applied for the estimation of pile lengths and related soil properties of A1 abutment. BH-B1 and BH-B16 were applied to that of piers and A2 abutment as shown in Table 6.2.8.

Table 6.2.8 Proposed Pier Types and Other Conditions of Approach Bridge 2

		Approach Bridge 2(T)								Approach Bridge 2(G)					
South Bound North Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7aL	P48L	P49L	P50L	P51L	P52L	A2
	Type	⊥	T	T	T	T	T	T	T	T	T	T	T	T	⊥
	Height	10.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	14.0	11.0	10.0	9.0	9.0	11.0
	Data	BH-B2	BH-B1							BH-B16					
	Length	47.0	47.0	46.0	46.0	46.0	46.0	46.0	45.0	47.0	47.0	47.0	47.0	47.0	47.0
	Number	20	8	8	8	8	8	8	8	8	8	8	8	8	20

6.2.4 Dyke Bridges

(1) General

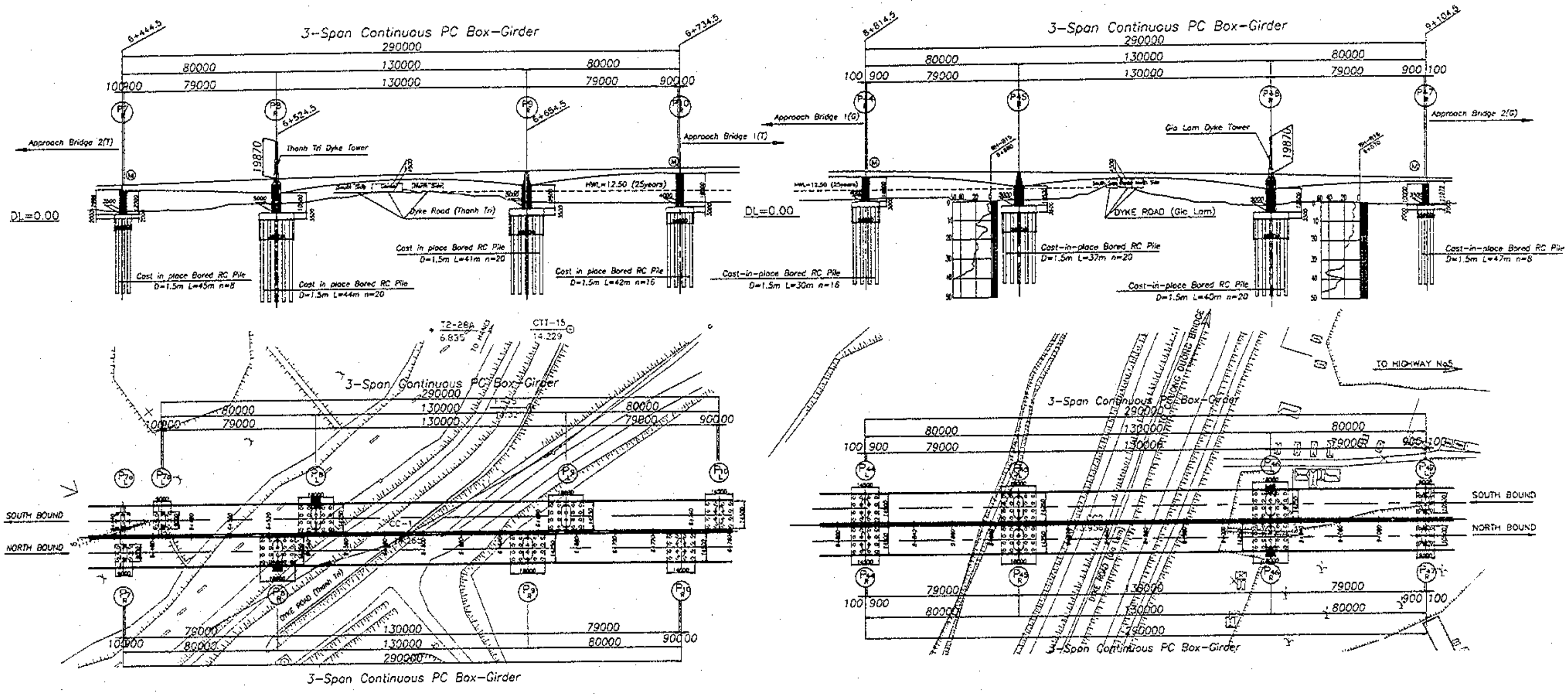
Two bridges with long spans have been proposed in order to cross over Thanh Tri and Gia Lam Dykes.

The primary design criteria to be considered for the dyke bridges was to ensure the road clearance of dyke roads under the proposed bridge and to avoid harmful influence to the dyke systems by construction of piers and foundations. Crossing angle between the Thanh Tri Dyke and the throughway is approximately 40 degrees and that between the Gia Lam Dyke and the throughway is approximately 70 degrees. It is possible to reduce the center span length of bridge on Gia Lam side due to the small crossing angle. However, the same span length as the Thanh Tri side has been required considering future dyke improvement including dyke road development.

As for structural feature, all intermediate piers are to be integrated with the superstructure of PC box-girder. Therefore, there is no bridge bearing on intermediate piers (piers P8, P9, P45 and P46).

From the aesthetic viewpoint, as shown in Chapter 17, the dyke towers are installed on the side piers of dyke bridges. In order to indicate the entrance gate, the Thanh Tri Dyke Towers are located on the outside of pier P8L and P8R, and piers P46L and P46R have the Gia Lam Dyke Towers.

General views of Thanh Tri and Gia Lam Dyke Bridges are shown in Figure 6.2.21.



Thnah Tri Dyke Bridge

Gia Lam Dyke Bridge

Figure 6.2.21 General Views of Dyke Bridges

(2) Superstructure

The span arrangement shown below is adopted for both Thanh Tri side and Gia Lam Side.

Span arrangement for Thanh Tri and Gia Lam Dyke Bridges
= 80.0 + 130.0 +80.0 = 290.0 m

The main span length of 130.0 m has been decided so as not to create hazardous conditios, for the existing dyke. Similar to the main bridge, the side span length of 80 m has been determined in such a manner that balance could be kept with the center span length.

The typical cross-section is the same as for the main bridge as shown in Figure 6.2.22. Refer to Section 6.2.1 (2) for the details.

(3) Substructure

Oval cross-section piers were also adopted for the dyke bridges in the same way as other bridges which compose the Red River Bridge. Dimensions of piers have been determined based on the structural study on these bridges. Figure 6.2.23 shows typical dimension of pier of the dyke bridge.

Regarding the bridge foundation, cast-in-place concrete bored pile of 2.5 m in diameter was recommended for all piers of the dyke bridges based on the following study.

Comparison of Pile Types for the Dyke Bridges

Compared types of foundation
Case-1: ϕ1500 mm RC bored cast-in-place pile (PRPOSED)
Case-2: ϕ2000 mm RC bored cast-in-place pile
Case-3: □450 x 450 mm RC driven pre-cast pile

Compared location
Applied boring data: BH-B1 (km 6+340) (Thanh Tri side)

As a result of study shown in Table 6.2.9, cast-in-place pile RC bored of 1.5 m in diameter was proposed for the Thanh Tri Dyke Bridge due to economical reasons. And this type of pile was also applied to the Gia Lam Dyke Bridge.

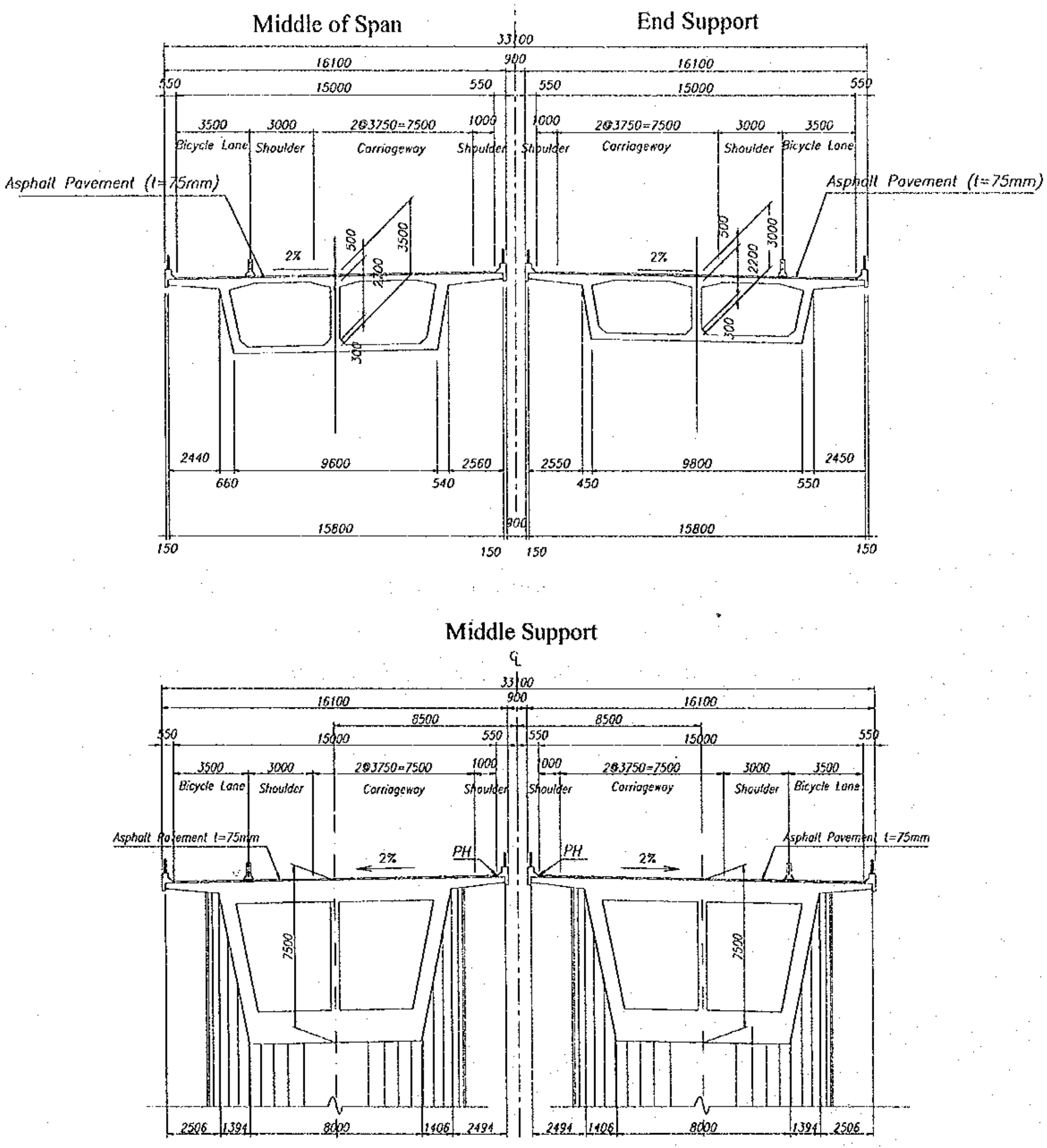
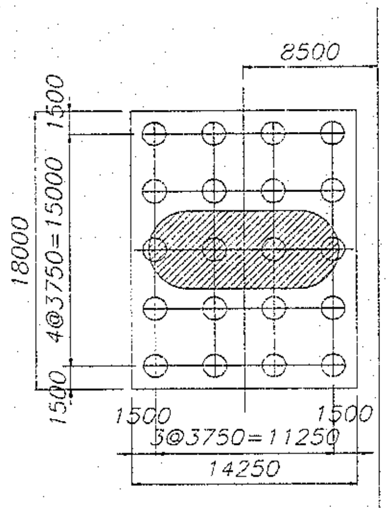
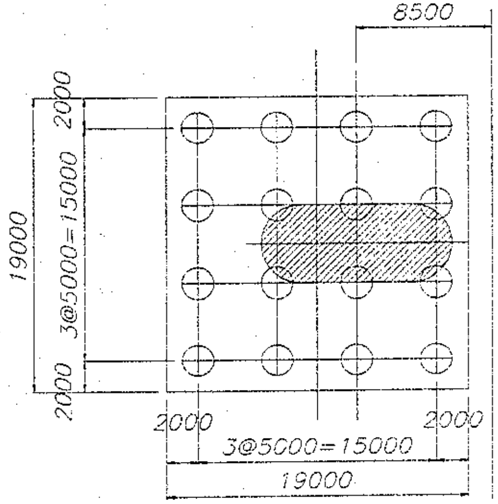
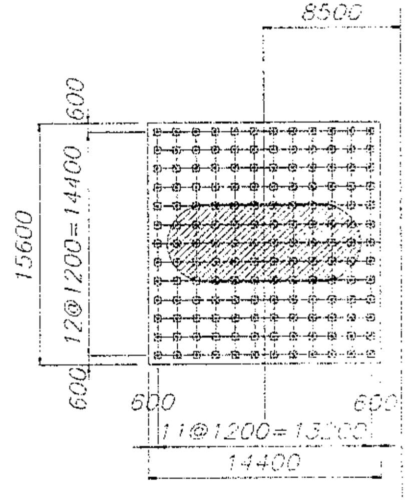


Figure 6.2.22 Typical Cross Sections of Superstructure of Dyke Bridges

Table 6.2.9 Comparison of Pile Types for Dyke Bridges

		CASE-1 ϕ =1500mm Borehole Pile	CASE-2 ϕ =2000mm Borehole Pile	CASE-3 □450×450mm Precast Pile
Pile Arrangement				
Pile Length		44.00 m	44.00 m	44.00 m
Number of Piles		20 nos for each Footing	16 nos for each Footing	156 nos for each Footing
Bearing Capacity	Pmax (tf)	713 (979) < 907 (1385)	858 (1154) < 1156 (1775)	85 (131) < 250 (375)
	Pmin (tf)	273 (-25 < 0 (-925)	482 (153) < 0 (-1174)	39 (-11) < 0 (-152)
Displacement	δx (mm)	7.0 (9.2) < 15 (15)	7.1 (9.1) < 15 (15)	1.9 (3.4) < 15 (15)
Stress	σc (kgf/cm^3)	80 (116) < 80 (120)	74 (97) < 80 (120)	78 (112) < 80 (120)
	σs (kgf/cm^3)	061 (1512) < 1600 (2700)	984 (1293) < 1600 (2700)	991 (1333) < 1600 (2700)
	As (cm^2)	D32-24, D32-24 381.2	D32-32, D32-16 381.2	D32-8 63.5
Construction Cost		2,538,080,000 VND (1.000)	3,260,043,000 VND (1.284)	4,024,900,800 VND (1.586)
Recommendation		○		

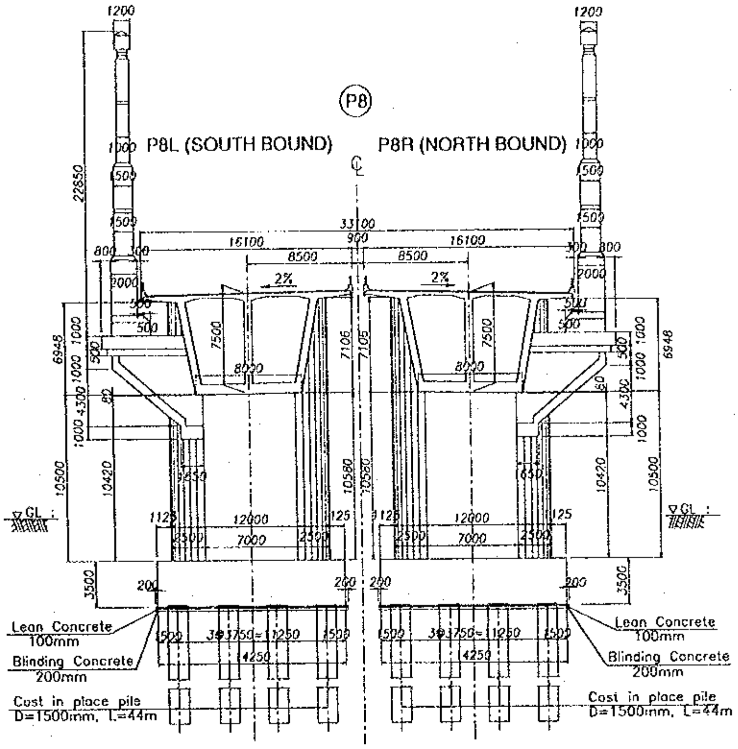


Figure 6.2.23 Typical Dimension of Substructure of Dyke Bridge

There are four boring data for the design of the Dyke Bridges. Boring data of BH- B1, BH-B4, BH-B15 and BH-B16 were applied for the estimation of pile lengths and related soil properties of pier P8, P9, P45 and P46 respectively as shown in Table 6.2.10.

Table 6.2.10 Proposed Pier Types and Other Conditions of Dyke Bridges

		Thanh Tri Dyke Bridge				Gia Lam Dyke Bridge			
South Bound	Name	P7bL	P8L	P9L	P10L	P44L	P45L	P46L	P47L
	Type	T	I	I	I	I	I	I	T
	Height	15.5	14.0	16.0	21.0	17.0	14.0	16.0	13.0
	Data	BH-B1		BH-B4	BH-B5	BH-B14	BH-B15	BH-B16	
	Length	45.0	44.0	41.0	42.0	30.0	37.0	40.0	47.0
	Number	8	20	20	16	16	20	20	8

6.3 Interchange Bridges

6.3.1 Phap Van Viaduct

(1) General

The Phap Van Viaduct is a viaduct which crosses the Phap Van Cau Gie Road and existing National Highway No. 1 and lands in the Linh Dam Lake area. Proposed total bridge length of this viaduct is 1,521 m. It begins at STA 0-409.5 and ends at STA 1+111.5, but this detailed design for 575 m, begins at STA 0+536.5 (P18) and ends at 1+111.5, of bridge section was carried out considering the total project budget.

There are some control points to be considered when the appropriate span arrangement of bridge is studied. Here, control point means the restricted condition on the installation of bridge substructures and on the clearance under bridge superstructure. Major control points on span arrangement of the Phap Van Viaduct are described below and shown in Figure 6.3.1.

- Existing Railway
- National Highway No.1
- Phap Van Cau Gie Road
- Rampway
- Proposed Canal
- Proposed Box Culvert
- Location of Highway-nose

Procedure for determination of the optimum span arrangement of the Phap Van Viaduct is as follows.

1) Location of pier between the existing railway and NH1, proposed P35, was fixed.
2) Span length, 35 m, was decided based on clearance for the future railway and location of pier, proposed P36, was fixed.
3) Span length, 50 m, was decided based on clearance for NH1 and location of pier, proposed P34, was fixed.

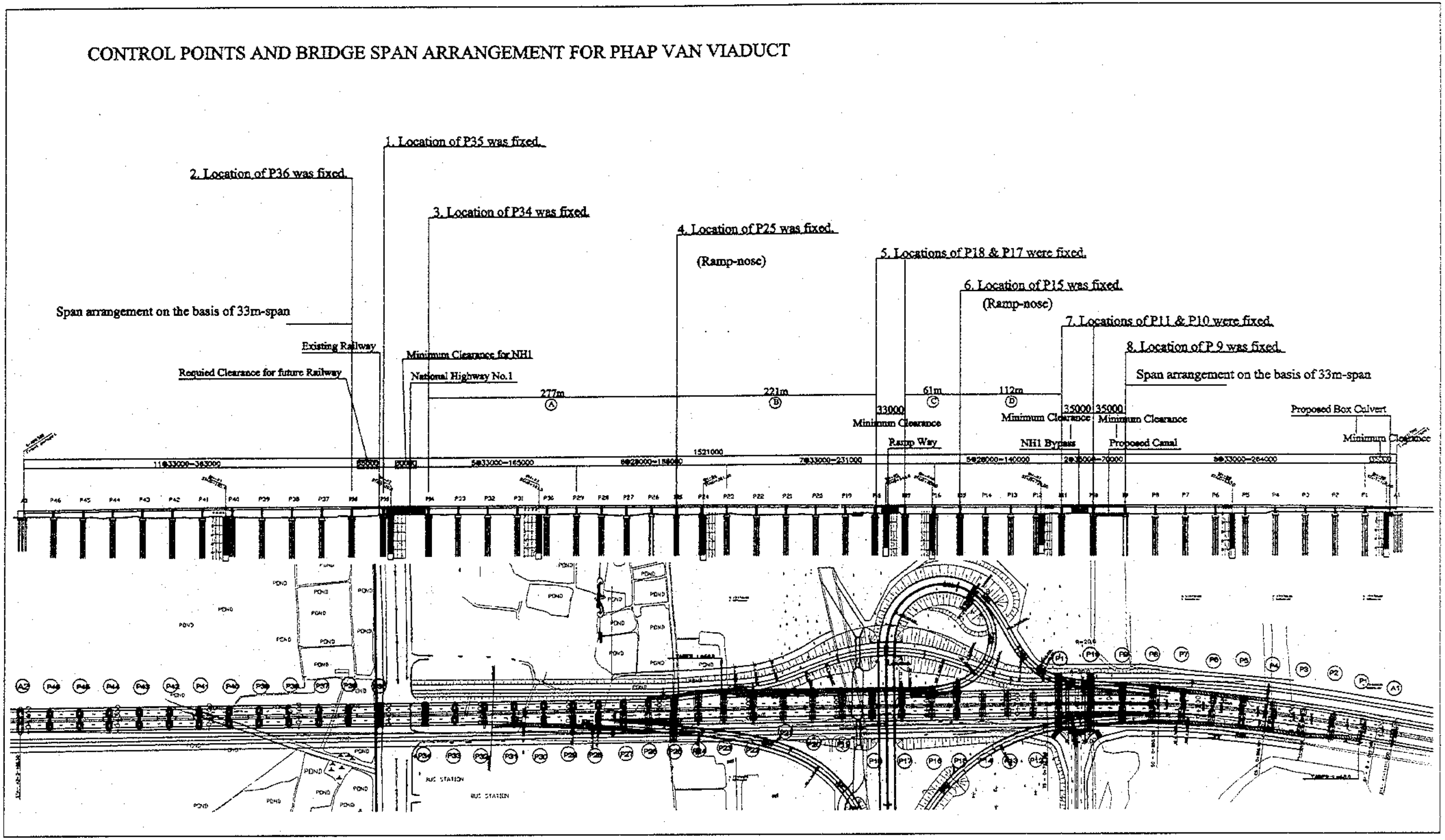


Figure 6.3.1 Span Araangement of PhapVan Viaduct

4) Location of pier, proposed, P25, was fixed based on locations of proposed ramp-nose.

5) Span length, 33 m, was decided based on minimum clearance for rampway and location of piers, proposed P17 and P18, were fixed.

6) Location of pier, proposed, P15, was fixed based on locations of proposed ramp-nose.

7) Span length, 35 m, was decided based on minimum clearance for NH1 bypass and location of piers, proposed P10 and P11, were fixed.

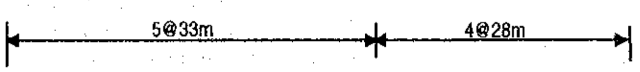
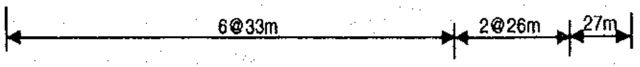
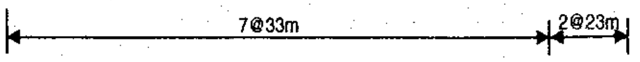
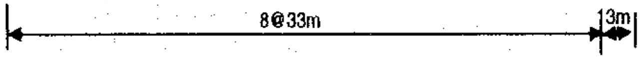
8) Span length, 35 m, was decided based on minimum clearance for proposed canal and location of pier, proposed P9, was fixed.

9) 11Span arrangement from P36 to Lin Dam Lake was carried out on the basis of 33 m-span length and location of abutment, proposed A2, was determined at the location that embankment height is less than 8 m.

10) Span arrangement from P9 to Gia Lam was carried out on the basis of 33 m-span length and location of abutment, proposed A2, was determined in the same way as mentioned above. However, 35 m of span length between proposed P1 and A2 was required to avoid proposed box culvert.

11) Span arrangement between P34 and P25, 277 m long, was studied as shown in Table 6.3.1 and (5x33 m) + (4x28 m) = 277 m span arrangement was finally proposed.

Table 6.3.1 Comparison of Span Arrangement between P34 and P25

Alternative	Span Arrangement	Description	Recommen-dation
ALT-1		There are only two types of girder length. 28m span length is the nearest to 33m span length among alternatives.	○
ALT-2		Three types of girder length make construction works complicated.	
ALT-3		There are two types of girder length. 23 m of span length is not economical span length.	
ALT-4		There are two types of girder length. 13 m of span length is not economical span length.	

12) Span arrangement between P25 and P18, 221 m long, was studied as shown in Table 6.3.2 and (2x28 m) + (5x3 m) = 221 m span arrangement was finally proposed.

13) Span arrangement between P17 and P15, 61 m long, was studied. 33 m + 28 m = 61 m of span arrangement was finally proposed since 61 m can be divided into appropriate spans.

14) Span arrangement between P15 and P11, 112 m long, was studied as shown in Table 6.3.3 and 4x28 m = 112 m span arrangement was finally proposed.

Table 6.3.2 Comparison of Span Arrangement between P25 and P18

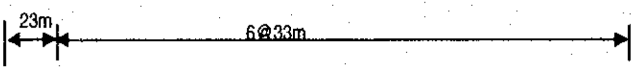
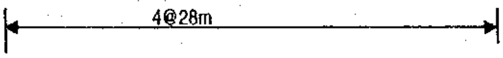
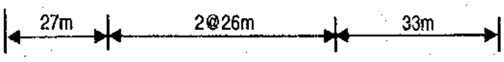
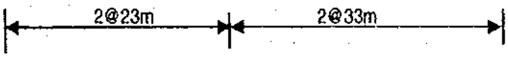
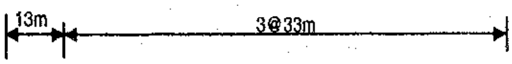
Alternative	Span Arrangement	Description	Recommen-dation
ALT-1		There are only two types of girder length. 28m span length is used in the next span.	○
ALT-2		There are two types of girder length. 23 m of span length is not economical span length.	

Table 6.3.3 Comparison of Span Arrangement between P15 and P11

Alternative	Span Arrangement	Description	Recommen-dation
ALT-1		There are only one types of girder length. 28m span length is the nearest to 33m span length among alternatives.	○
ALT-2		Three types of girder length make construction works complicated.	
ALT-3		There are two types of girder length. 23 m of span length is not economical span length.	
ALT-4		There are two types of girder length. 13 m of span length is not economical span length.	

(2) Superstructure

The typical girder length of 33.0 m was determined for the economical reasons. Due to local land use conditions, the girder lengths of 35.0 m and 28.0 m are used where appropriate. Precast PC I-girder bridge has been selected for the bridge. The girder lengths, span lengths and the heights are shown in Table 6.3.4.

Table 6.3.4 Primary Dimensions of PC I-girders (Phap Van Viaduct)

girder length (m)	span length (m)	girder height (m)*
35.0	34.15	1.75
33.0	32.15	1.65
28.0	27.15	1.50

* : The height does not include 0.2 m-thick deck slab.

The effective width of the roadway varies from 11.50 m to 30.43 m. Number of PC I-girders in a span is adjusted depending on the width as shown in Figure 6.3.2 and Table 6.3.5. Parameters in Table 6.3.3 are shown in Figure 6.3.2.

The structure is simple span bridge with continuously connected deck slab. Refer to Section 6.2.3 (2) for more description.

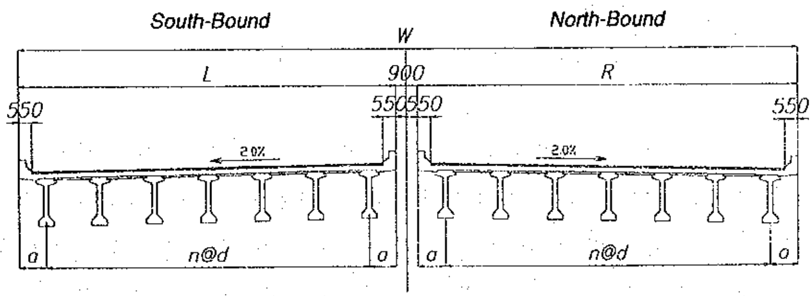


Figure 6.3.2 Typical Cross Section of Superstructure of the Phap Van Viaduct

Table 6.3.5 Dimensions of Superstructure of the Phap Van Viaduct

(a) North-Bound Bridge

LOCATION	DIMENSIONS			
	n	d (mm)	L (mm)	Number of girders
A_1	5	2000	12600	6
$P_1 \sim P_3$	5	2000	12600	6
P_4	6	2267	16100	7
P_5	6	2276	16158	7
P_6	7	2068	16976	8
P_7	8	2028	18727	9
P_8	9	2042	20878	10
P_9	10	2082	23317	11
P_{10}	12	1946	25856	13
P_{11}	6	2250	16100	7
$P_{12} \sim P_{14}$	6	2250	16100	7
P_{15}	11	2434	29272	12
P_{16}	8	2458	22160	9
$P_{17} \sim P_{18}$	8	2325	21100	9

(b) South-Bound Bridge

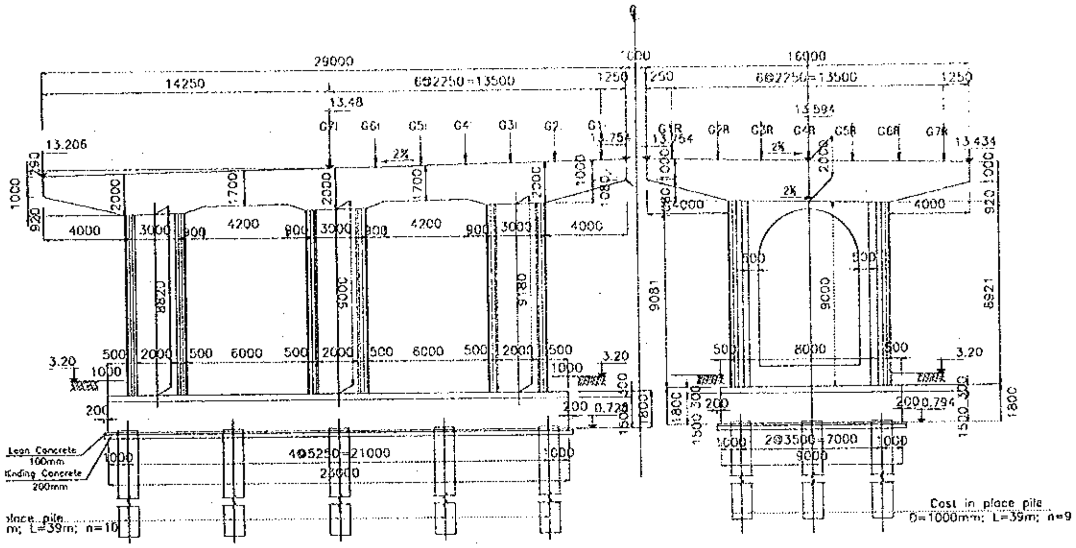
LOCATION	DIMENSIONS				
	n	d (mm)	a (mm)	R (mm)	Number of girders
A_1	5	2000	1300	12600	6
P_1	8	1700	1250	16100	9
$P_2 \sim P_7$	8	2325	1250	21100	9
P_8	8	2380	1250	21541	9
P_9	9	2176	1250	22080	10
P_{10}	11	1933	1250	23762	12
P_{11}	6	2250	1300	16100	7
$P_{12} \sim P_{18}$	6	2413	1300	16100	7

(3) Substructure

The widths of superstructures should be varied in compliance with the proposed width of highway as mentioned above. Some types of pier head width should be prepared in response to the various widths of superstructures so that three types of piers are proposed for substructures of the Phap Van Viaduct:

1) Hammerhead pier (Figure 6.3.3 (b))
2) Two-column hammerhead pier
3) Three-column hammerhead pier (Figure 6.3.3 (a))

Maximum cantilever length of pier head of 4.0 m with 2.0 m in height was calculated considering the position and magnitude of reaction force through superstructure. The width of wall of hammerhead pier was determined by the total width of superstructure and this cantilever length. Hammerhead pier type was applied to the throughway section without widening and two and three columns piers were adopted for piers in the section where the throughway is to be widened due to rampways. Three-column pier was a sufficient type to support simultaneously the throughway and rampway branched off from throughway.



(a) Column Hammerhead Pier (b) Hammerhead Pier

Figure 6.3.3 Typical Dimensions of Substructures of the Phap Van Viaduct

Proposed pier types with their height for Phap Van Viaduct are listed in Table 6.3.6.

Table 6.3.6 Proposed Pier Types of Phap Van Viaduct

South Bound	Name	P18L	P17L	P16L	P15L	P14L	P13L	P12L	P11L	P10L	P9L	P8L	P7L	P6L	P5L	P4L	P3L	P2L	P1L	A1
	Type	TT	TT	TTT	TTT	T	T	T	TTT	TTT	TTT	TT	T	T	T	T	T	T	T	⊥
	Height	12.8	12.8	12.8	11.8	12.8	12.8	12.8	12.4	12.4	12.8	12.3	11.8	11.3	10.8	8.8	7.8	7.8	6.8	9.0
North Bound	Name	P18R	P17R	P16R	P15R	P14R	P13R	P12R	P11R	P10R	P9R	P8R	P7R	P6R	P5R	P4R	P3R	P2R	P1R	▨
	Type	T	T	T	T	T	T	T	TTT	TTT	TTT	TTT	TT	TT	TT	TT	TT	TT	T	▨
	Height	11.9	12.5	12.8	12.8	12.8	12.8	12.8	12.4	12.4	12.4	11.8	11.3	11.3	11.3	8.3	7.8	7.8	6.6	▨

Legend: Types of piers and abutments are listed below.

T	Hammerhead pier
TT	2-column pier
TTT	3-column pier
⊥	Cantilever wall abutment

Cantilever wall abutment was proposed as the type of abutment for A1 abutment. Location of A1 abutment was fixed based on the condition of maximum height of embankment and proposed box culvert.

Regarding the bridge foundation, cast-in-place concrete bored pile was recommended for both piers and abutment and the diameters of 1.0 m and 1.5 m were proposed for piers and abutment respectively on the basis of studies in Section 6.2. There are six boring data concerning the design of this viaduct. Applied boring data and required pile length are listed in Table 6.3.6.

Table 6.3.7 Applied Boring Data and Pile Length of Phap Van Viaduct

South Bound	Name	P18L	P17L	P16L	P15L	P14L	P13L	P12L	P11L	P10L	P9L	P8L	P7L	P6L	P5L	P4L	P3L	P2L	P1L	A1
	Data	BH-R5		BH-R7							BH-R6						BH-R8			
	Length	39.0	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	42.0	38.0	38.0	38.0	38.0	40.0	40.0	40.0	40.0	40.0
North Bound	Name	P18R	P17R	P16R	P15R	P14R	P13R	P12R	P11R	P10R	P9R	P8R	P7R	P6R	P5R	P4R	P3R	P2R	P1R	▨
	Data	BH-R5		BH-R7							BH-R6						BH-R8			▨
	Length	39.0	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	42.0	38.0	38.0	38.0	38.0	40.0	40.0	40.0	40.0	▨

6.3.2 Phap Van Cau Gie Interchange Ramp Bridge

(1) General

An interchange named the Phap Van Cau Gie Interchange is proposed in the area where Hanoi Third Ring Road and the Phap Van Cau Gie Road under construction presently cross each other. There are four rampways named A-ramp and B-ramp which are located on the north side of throughway and C-ramp and D-ramp which are located on the south side of throughway. However, detailed design of D-ramp Bridge has not been carried out considering the total project cost. Horizontal ramp alignments of these rampways are shown in Figure 6.3.4.

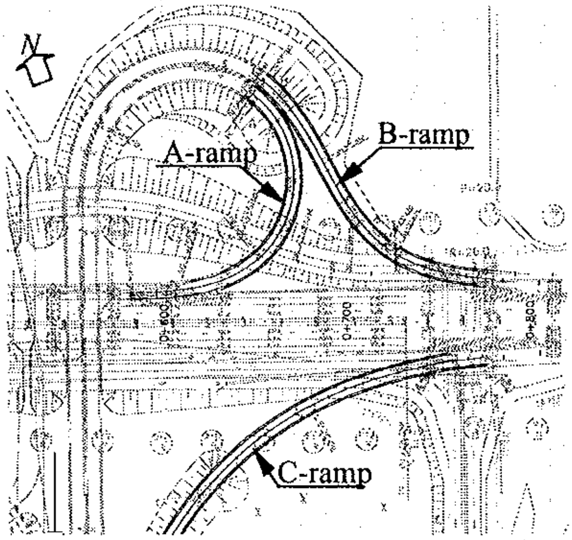
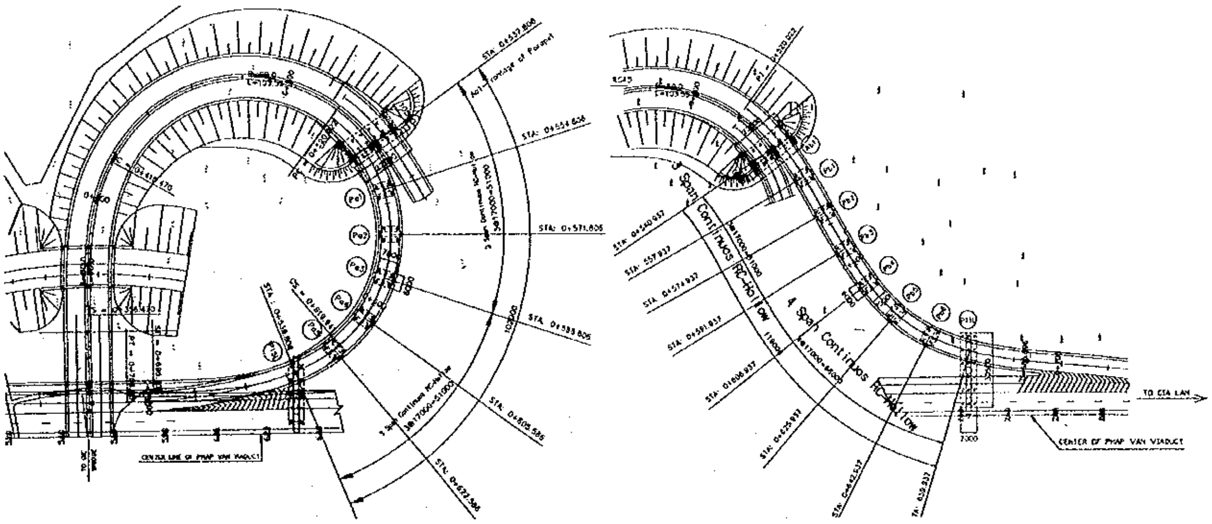


Figure 6.3.4 Horizontal Alignment of Ramps in the Phap Van Cau Gie Interchange

Bridges for part of these rampways are proposed due to the proposed height. The bridge type of reinforced concrete hollow slab bridge is applied to these bridges based on the study described in the following section (2).

Plans of A-Ramp Bridge and B-Ramp Bridge are shown in Figure 6.3.5 and plan of C-ramp Bridge is shown in Figure 6.3.6.



(a) A-ramp **(b) B-ramp**

Figure 6.3.5 Plans of the Phap Van Cau Gie Interchange Ramps

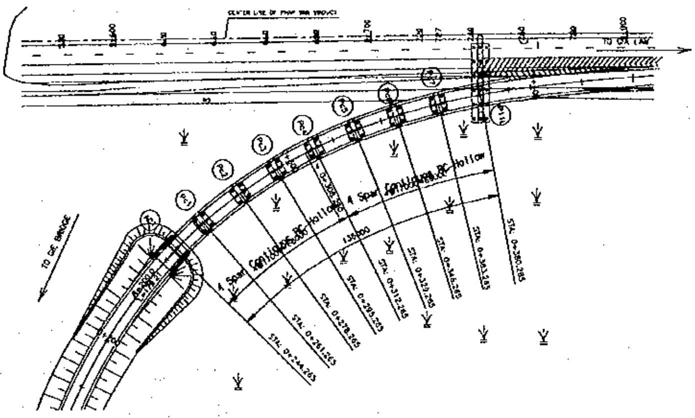


Figure 6.3.6 Plans of the Phap Van Cau Gie Interchange C-Ramp

(1) Superstructure

Design conditions to be considered are as follows:

(i) Small radius, approximately 50 to 60 m, of horizontal road alignment,
(ii) Span length is 15 to 20 m to fit the road alignment, and
(iii) Varying road width

Table 6.3.8 shows typical concrete bridge types and their applicable span lengths. For bridges with the span range of 15 to 20 m, the following types are generally applicable;

(i) RC hollow slab
(ii) Pre-tensioned simple slab
(iii) Pre-tensioned simple T-beam

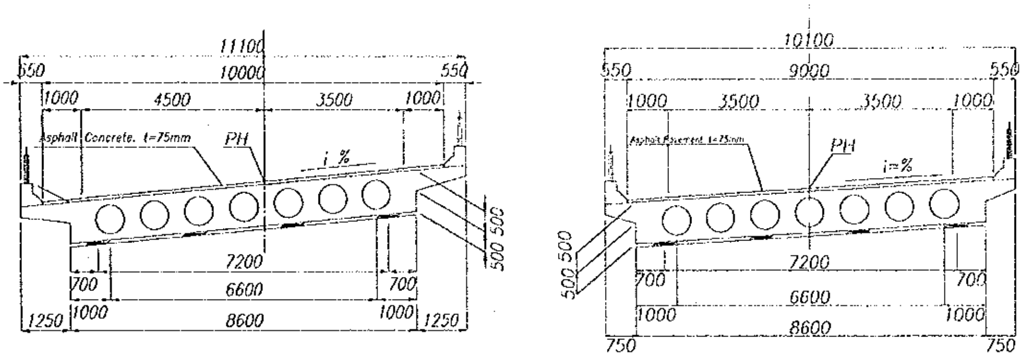
Table 6.3.8 Typical Bridge Types and Applicable Span Length

bridge type		span length					H/L ratio * (approx.)
		10	20	30	40 m		
RC	monolithic slab	═					1/15
	hollow slab		═				1/18
PC	pre-tensioned simple slab	═	═				1/25
	pre-tensioned simple T-beam		═				1/18
	post-tensioned simple hollow slab			═			1/22
	post-tensioned simple T-beam			═	═	═	1/18
	post-tensioned simple box girder			═	═	═	1/20

Note *: H = height of slab, beam or girder, L = span length
(Source: "Design Manual for Concrete Highway Bridges," Ministry of Construction (Japan), 1994)

When a PC bridge is designed, the required pre-stressing force is not large due to its relatively short span length. Therefore, pre-tensioned precast beams are an economical solution for this span range. Erection using precast pre-tensioned beam would be economical if the bridge consists of many structurally-identical beams. For the ramp bridge, however, length of a precast beams differ from each other due to the trapezoidal plan. Therefore, pre-stressed concrete bridge is not suitable. RC hollow slabs, which can be flexibly applied to a curved bridge, have been selected based on the aforementioned considerations. Typical cross section of RC hollow slab of this bridge is shown in Figure 6.3.7.

Design philosophy of reinforced concrete allows occurrence of cracks. However, durable bridge can be designed when measures to avoid deleterious cracks are carefully considered. An example of the important considerations is to reduce the allowable tensile stress in reinforcing bars.



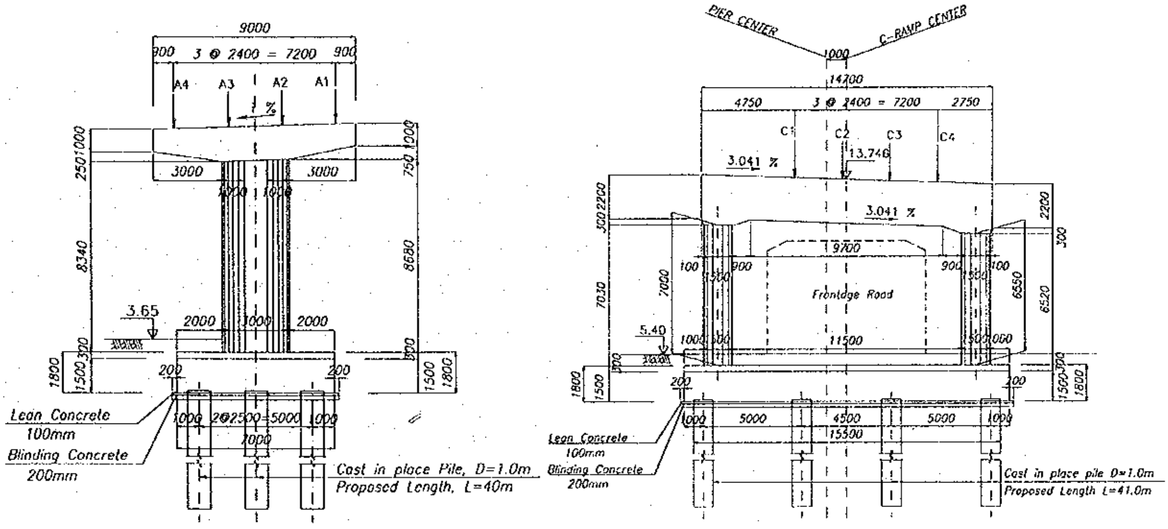
(a) A-ramp Bridge (b) B-ramp and C-ramp Bridges

Figure 6.3.7 Typical Cross Sections of RC Hollow Slabs of Ramp Bridges

As shown in Figure 6.3.7, proposed total widths of superstructure of B-Ramp and C-Ramp Bridge is 10.1 m. On the other hand, proposed total width of superstructure of A-Ramp Bridge is 11.1 m according to the widened rampway due to small radius of horizontal alignment.

(3) Substructure

The hammerhead pier type shown in Figure 6.3.8 (a) was basically approved. However, type Pc7 of C-Ramp Bridge is a two-column bent pier shown in Figure 6.3.8 (b) since the proposed frontage road on south side of throughway passes under the C-ramp Bridge. Abutment of cantilever wall type is to be located at end of each ramp bridge, Aa1, Ab1 and Ac1.



(a) Hammerhead Pier (b) Two-Column Bent Pier

Figure 6.3.8 Typical Cross Sections of Substructure of Ramp Bridges

Foundations by cast-in-place concrete bored piles are installed for all ramp bridges and diameters of piles are 1.0m for piers and 1.5 m for abutments. As listed in Table 6.3.9, applied boring data for these bridges is the data from BH-R7 of bore hole.

Table 6.3.9 shows type of each substructure of ramp bridge, heights of piers, applied boring data for the design and required pile lengths.

Table 6.3.9 Proposed Pier Types and Other Conditions of Ramp Bridges

A-Ramp	Name	Aa1	Pa1	Pa2	Pa3	Pa4	Pa5		
	Type	⊥	T	T	T	T	T		
	Height	11.5	10.3	11.3	11.8	12.3	12.8		
	Data	BH-R7							
	Length	40.0	40.0	40.0	40.0	40.0	40.0		
B-Ramp	Name	Ab1	Pb1	Pb2	Pb3	Pb4	Pb5	Pb6	
	Type	⊥	T	T	T	T	T	T	
	Height	11.5	10.8	11.8	11.8	12.3	12.8	12.8	
	Data	BH-R7							
	Length	40	40	40	40	40	40	40	
C-Ramp	Name	Ac1	Pc1	Pc2	Pc3	Pc4	Pc5	Pc6	Pc7
	Type	⊥	T	T	T	T	T	T	TT
	Height	10.5	8.3	9.0	11.8	12.5	12.9	12.8	11.3
	Data	BH-R7							
	Length	40.0	39.0	39.0	39.0	39.0	39.0	39.0	41.0

Legend: Types of piers and abutments are listed below.

T	Hammerhead pier
TT	2-column bent pier
⊥	Cantilever wall abutment

6.3.3 National Highway No. 5 Flyover

(1) General

The National Highway No. 5 Flyover (hereinafter called "NH5 Flyover") is a flyover which begins at STA 11+768.5 in a rice field on the Gia Lam side and crosses over the existing railway and National Highway No. 5 (hereinafter called "NH5") and ends at STA 12+463.5 in the National Highway No. 5 Interchange. Therefore, proposed total bridge length of this flyover is 695 m.

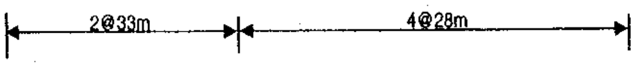
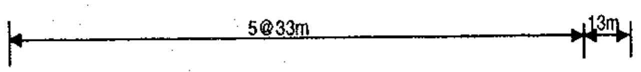
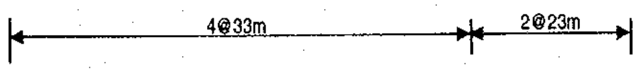
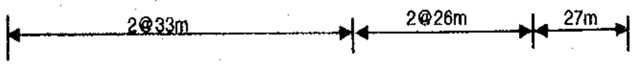
Major control points on span arrangement of the NH5 Flyover are described below and shown in Figure 6.3.9.

- Existing railway
- National Highway No.5
- Location of ramp-nose

Procedure for determination of the optimum span arrangement of this flyover is as follows:

1) Location of pier between the existing railway and NH5, proposed P12, was fixed.
2) Span length, 35 m, was decided based on clearance for the future railway and location of pier, proposed P11, was fixed.
3) Location of piers, proposed P18 and P19, were fixed based on locations of proposed ramp-nose and 20 m long of span length between P18 and P19 was determined.
4) Span arrangement from P11 to Thanh Tri was carried out on the basis of 33 m-span length and location of abutment, proposed A1, was determined at the location that embankment height is less than 8m.
5) Span arrangement of northern part from P18 was carried out on the basis of 33 m-span length and location of abutment, proposed A2, was determined in the same way as above mentioned.
6) Span arrangement between P12 and P18, 178m long, was studied as shown in Table 6.3.10 and (2 x 33 m) + (4 x 28 m) = 178 m of span arrangement was finally proposed.

Table 6.3.10 Comparison of Span Arrangement between P12 and P18

Alternative	Span Arrangement	Description	Recommen-dation
ALT-1		There are only two types of girder length. 28m span length is the nearest to 33m span length among alternatives.	○
ALT-2		There are two types of girder length. 13 m of span length is not economical span length.	
ALT-3		There are two types of girder length. 23 m of span length is not economical span length.	
ALT-4		Three types of girder length make construction works complex.	

(2) Superstructure

The typical girder length of 33.0 m was determined due to economical reasons. Due to local land use conditions, girder lengths of 35.0 m, 28.0 m and 20.0 m are used where appropriate. Precast PC I-girder bridge has been selected for the bridge. The girder lengths, span lengths and the heights are shown in Table 6.3.11:

Table 6.3.11 Primary Dimensions of PC I-girders (NH No.5)

Girder length (m)	Span length (m)	Girder height (m)*
35.0	34.15	1.75
33.0	32.15	1.65
28.0	27.15	1.50
20.0	19.15	1.65

Note *: The height does not include 0.2m thick deck slab.

The 20 m-long girder's height could be structurally reduced. However, the height of 1.65 m was used for aesthetic reasons (matching the adjacent girder height).

The effective width of the roadway varies from 11.50 m to 30.26 m. Number of PC I-girders in a span is adjusted depending on the roadway width as shown in Figure 6.3.10 and Table 6.3.12. Parameters in Table 6.3.12 are shown in Figure 6.3.10.

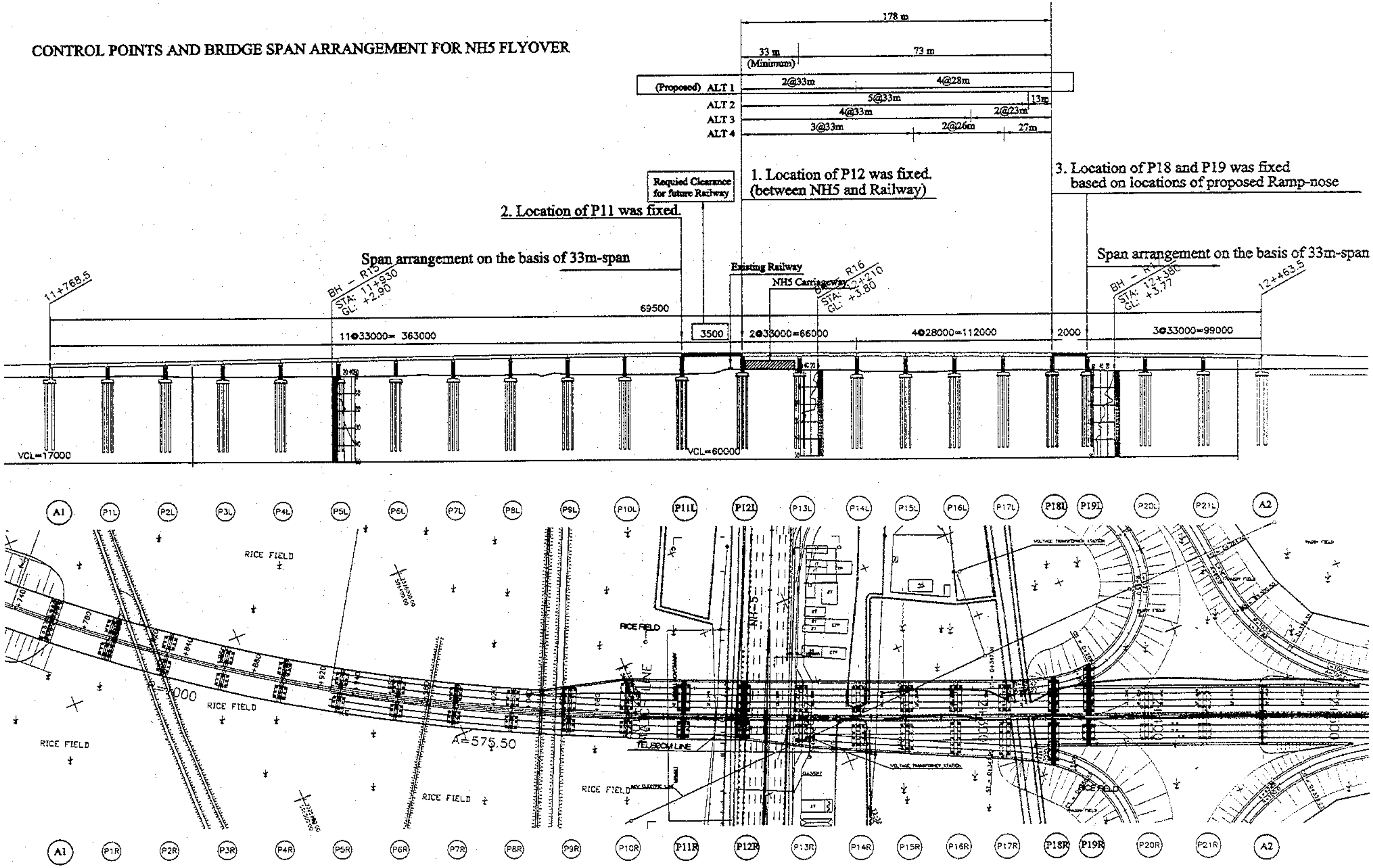


Figure 6.3.9 Span Arrangement of NH5 Flyover

The structure is simple span bridge with continuously connected deck slab. Refer to Section 6.1.3 (2) for further description.

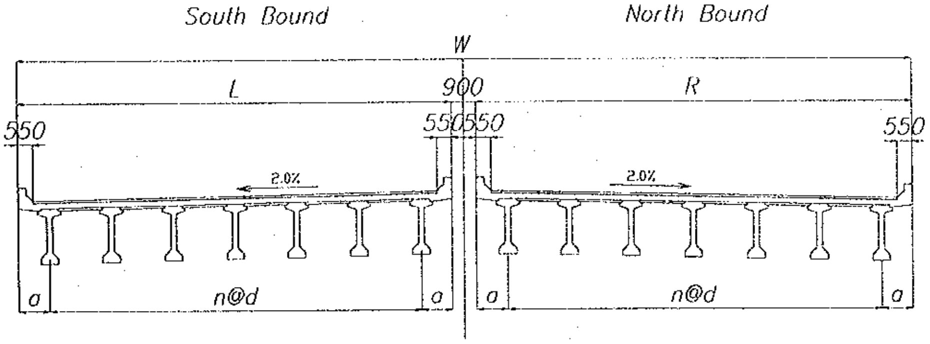


Figure 6.3.10 Typical Cross Section of Superstructure of the NH5 Flyover

Table 6.3.12 Dimensions of Superstructures of the NH5 Flyover

(a) South Bound Bridge

LOCATION	DIMENSIONS				
	n	d (mm)	a (mm)	L (mm)	Number of Girders
A1–P7	5	2000	1300	12600	6
P8	7	1943	1250	16100	8
P9	8	2013	1250	18600	9
P10–P16	8	2325	1250	21100	9
P17	9	2071	1250	21140	10
P18	12	1773	1250	23778	13
P19	6	2250	1300	16100	7
P20–A2	6	2250	1300	16100	7

(b) North Bound Bridge

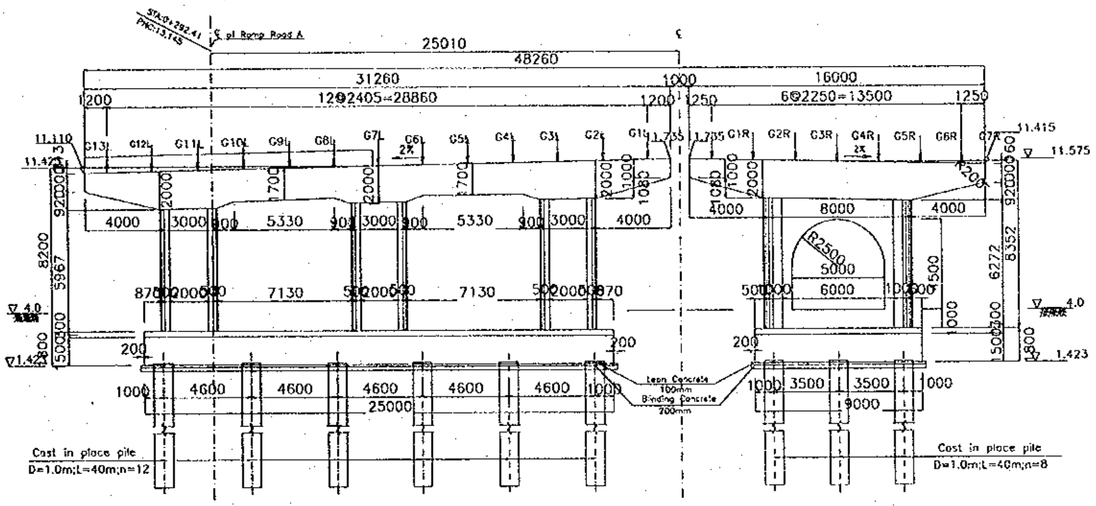
LOCATION	DIMENSIONS				
	n	d (mm)	a (mm)	R (mm)	Number of Girders
A1–P10	5	2000	1300	12600	6
P11	6	2267	1250	16100	7
P12	6	2227	1250	15860	7
P13	7	2070	1250	16991	8
P14	8	2089	1250	19211	9
P15	9	2074	1250	21192	10
P16	10	2062	1250	23122	11
P17	11	2053	1250	25081	12
P18	6	2250	1300	16100	7
P19–A2	6	2250	1300	16100	7

(3) Substructure

The widths of superstructures should be varied in compliance with the proposed width of highway as mentioned above. Some types of pier head width should be prepared in response to the various widths of superstructures so that three types of piers are proposed for substructures in the same way as the Phap Van Viaduct:

1) Hammerhead pier (Figure 6.3.11 (b))
2) Two-column hammerhead pier
3) Three-column hammerhead pier (Figure 6.3.11 (a))

Maximum cantilever length of pier head of 4.0 m with 2.0 m in height, and the width of wall of hammerhead pier were proposed in the same way as for the Phap Van Viaduct. In the same application as the Phap Van Viaduct, hammerhead pier type was applied to the throughway section without widening, and two- and three-column piers were adopted for piers in the section where the throughway is to be widened due to rampways. The three-column pier proved to be a sufficient type to simultaneously support the throughway and rampway branched off from throughway (P18L and P19L of south bound bridge and P16R to P18R of north bound bridge).



(a) Column Hammerhead Pier **(b) Hammerhead Pier**

Figure 6.3.11 Typical Dimensions of Substructures of the NH5 Flyover

Proposed pier types with their height of the Phap Van Viaduct are listed in Table 6.3.13.

Table 6.3.13 Proposed Pier Types of NH5 Flyover

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7L	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	A2
	Type	⊥	T	T	T	T	T	T	T	T	TT	TT	TT	TT	TT	TT	TT	TT	TT	TTT	TTT	T	T	⊥
	Height	11.0	9.0	9.0	10.0	11.0	11.0	12.0	12.0	12.0	13.0	13.0	13.0	12.0	10.0	11.0	12.0	11.0	11.0	11.0	10.0	11.0	10.0	12.0
North Bound	Name		P1R	P2R	P3R	P4R	P5R	P6R	P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	
	Type		T	T	T	T	T	T	T	T	T	T	T	T	T	TT	TT	TTT	TTT	TTT	T	T	T	
	Height		9.4	9.4	10.4	11.4	11.4	12.4	12.4	12.4	13.4	13.4	13.5	12.4	10.4	11.4	12.0	11.0	11.0	11.0	10.2	11.0	10.0	

Legend: Types of piers and abutments are listed below.

T	Hammerhead pier
TT	2-column hammerhead pier
TTT	3-column hammerhead pier
⊥	Cantilever wall abutment

Cantilever wall type abutments were proposed for A1 and A2 abutments. Locations of A1 and A2 abutments were determined considering the maximum height of embankment in each area.

Regarding the bridge foundation, cast-in-place concrete bored piles were recommended for both piers and abutments and the diameters of 1.0 m and 1.5 m were proposed for piers and abutments respectively on the basis of aforementioned study. There are available three boring data for the design of the NH5 Flyover. Applied boring data and designed pile length are listed in Table 6.3.14.

Table 6.3.14 Applied Boring Data and Pile Length of NH5 Flyover

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7L	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	A2
	Data	BH-R15										BH-R16											BH-R17	
	Length	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	40.0	40.0	40.0	40.0	47.0	47.0
North Bound	Name	▨	P1R	P2R	P3R	P4R	P5R	P6R	P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	▨
	Data	▨	BH-R15									BH-R16											BH-R17	▨
	Length	▨	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	40.0	40.0	40.0	40.0	47.0	▨

In addition, a special type of pier was proposed at P12s left and right of the NH5 flyover since footing could not be constructed due to the restriction between the railway and NH5. When the proposed pier P12s were not installed the construction cost of the NH5 Flyover increases as studied in Table 6.3.14. However one-row pile arrangement is allowed in case of the installation of the piers , so that the pile of 2.0m in diameter was applied in order to ensure pier stability. Figure 6.3.12 shows dimensions of P12L and P12R.

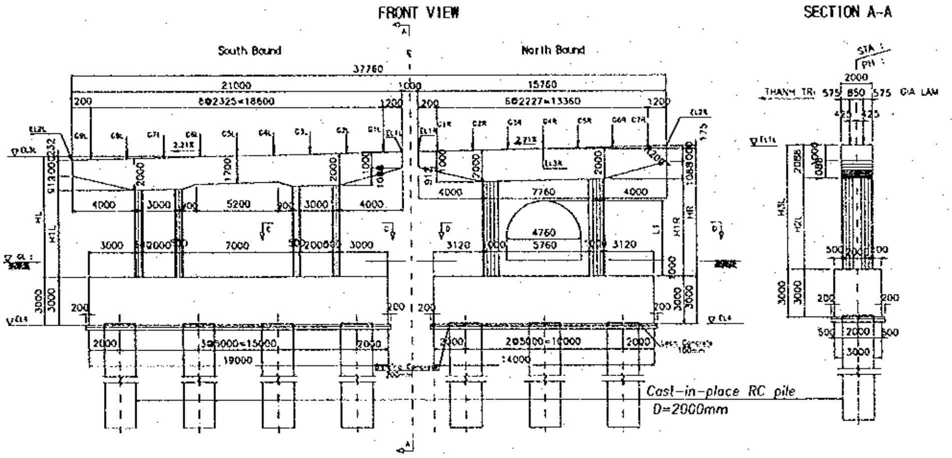
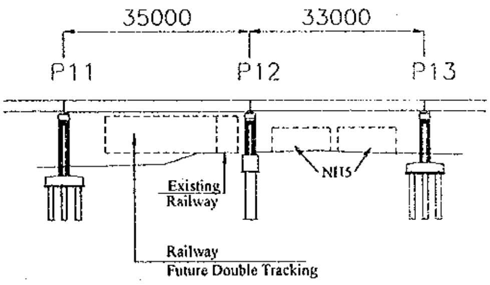
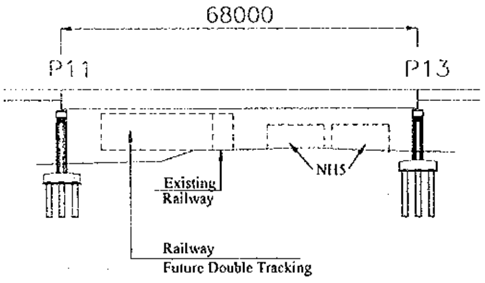


Figure 6.3.12 Dimensions of P12L and P12R of the NH5 Flyover

Table 6.3.15 Study on Span Arrangement of Section over NH5

Alternative	Alt-A Installation of P12	Alt-B Without P12
Views		
Comparison	- Pile of 2.0m in diameter should be applied to P12 due to the restricted construction space. - PC I-girders are available for this span arrangement. - Construction cost of Alt-A is lower than that of Alt-B because of application of PC I-girder. - Construction cost of NH5 Flyover can be reduced in comparison with that of Alt-B since the proposed height of throughway is lowered.	- Span length of 68 m is required without P12. - PC box-girder should be applied due to long span and higher girder height is required. - Construction cost of Alt-B is higher than that of Alt-A because of application of PC box-girder. - Construction cost of NH5 Flyover must be increased in comparison with that of Alt-A since the use of proposed height of throughway is raised. - Construction work over railway and NH5 is quite difficult in the case of the cast-in-place girder.
Recommendation	◎	

6.3.4 National Highway No. 5 Interchange Ramp Bridge

(1) General

An interchange named the NH5 Interchange is proposed in the area passing over the NH5 in order to connect Hanoi Third Ring Road and NH5. There are four rampways named A-ramp and C-ramp which are located north side of throughway and B-ramp and D-ramp which are located south side of throughway (See Figure 6.3.13). Bridges of part of A and B rampways are proposed due to the proposed height. On the other hand C and D ramp are constructed by the embankment structure. A-Ramp Bridge and B-Ramp Bridge are names for proposed bridges of A-rampway and B-rampway respectively. The bridge type of reinforced concrete hollow slab bridge is applied to these bridges based on the reasons described in the following section (2).

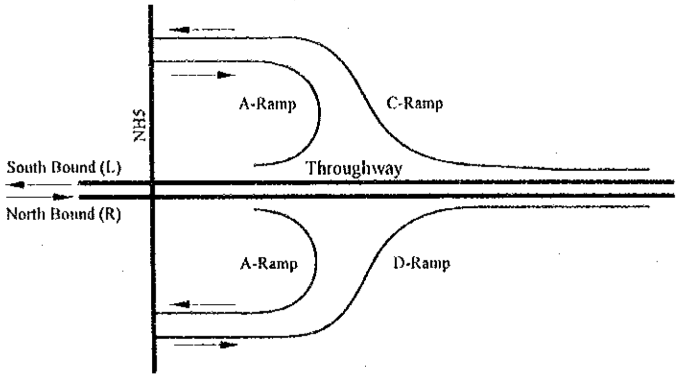
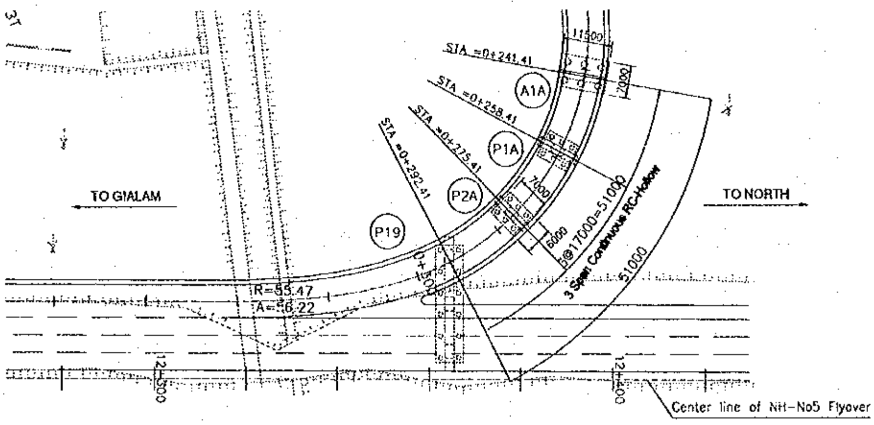
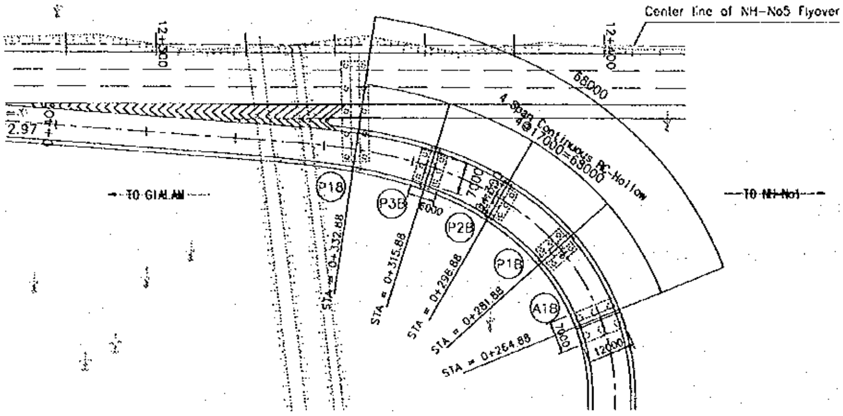


Figure 6.3.13 General Layout of NH5 Interchange

Plans of A-ramp Bridge and B-ramp Bridge are shown in Figure 6.3.14 and typical cross section of these bridges is shown Figure 6.3.15.



(a) Plan of A-ramp Bridge



(b) Plan of B-ramp Bridge

Figure 6.3.14 Plans of A-ramp and B-ramp Bridges

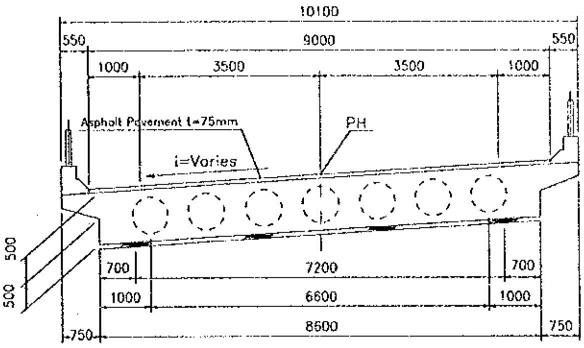


Figure 6.3.15 Typical Cross Section of A-Ramp and B-Ramp Bridges

(2) Superstructure

Rationale for the design of this bridge is the same as for the ramp bridge of Phap Van Cau Gie Interchange. Refer to Section 6.3.2 (2).

(3) Substructure

The hammerhead pier type shown in Figure 6.3.16 was applied to all piers of these ramp bridges. The same superstructures as the Phap Van Cau Gie Interchange are proposed, therefore dimensions of piers are the same. Abutment of cantilever wall type is to be located at end of each ramp bridge (A1A and A1B).

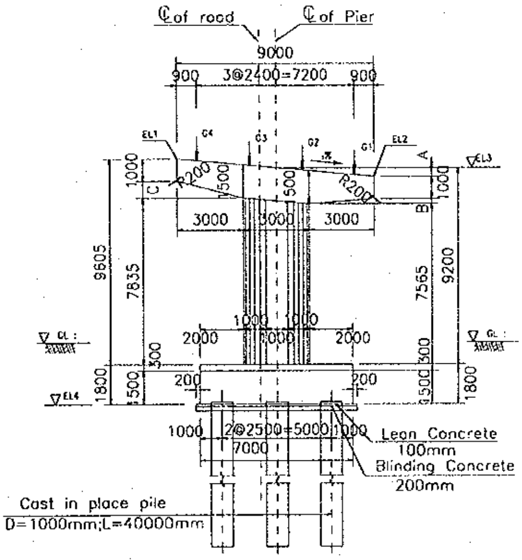


Figure 6.3.16 Typical Dimension of Substructure of A-Ramp and B-Ramp Bridges

Foundations by cast-in-place concrete bored piles are installed for all ramp bridges and diameters of piles are 1.0 m for piers and 1.5 m for abutments. As listed in Table 6.3.9, applied boring data for the design is the data from BH-R17 of bore hole.

Table 6.3.9 shows type of each substructure of ramp bridge, heights of piers, applied boring data for the design and required pile lengths.

Table 6.3.16 Proposed Pier Types and Other Conditions of Ramp Bridges

A-Ramp	Name	A1A	P1A	P2A	P3A	B-Ramp	Name	A1B	P1B	P2B
	Type	⊥	T	T	T		Type	⊥	T	T
	Height	11.0	11.0	12.0	12.0		Height	11.0	11.0	11.0
	Data	BH-R17					Data	BH-R17		
	Length	40.0	40.0	40.0	40.0		Length	40.0	40.0	40.0

Legend: Types of piers and abutments are listed below.

T	Hammerhead pier
⊥	Cantilever wall abutment

6.4 Other Bridges

Sections 6.2 and 6.3 describe the Red River Bridge and bridges at interchanges. Therefore, planning, studies, and design results on remaining proposed bridges in this project are described in following sections.

6.4.1 Kim Nguu River Bridge

(1) General

Kim Nguu River Bridge is proposed for the road section crossing over the existing Kim Nguu River. Throughway bridges composed of north- and south-bound bridges and bridges of frontage roads on both sides of throughway are to be described in this section.

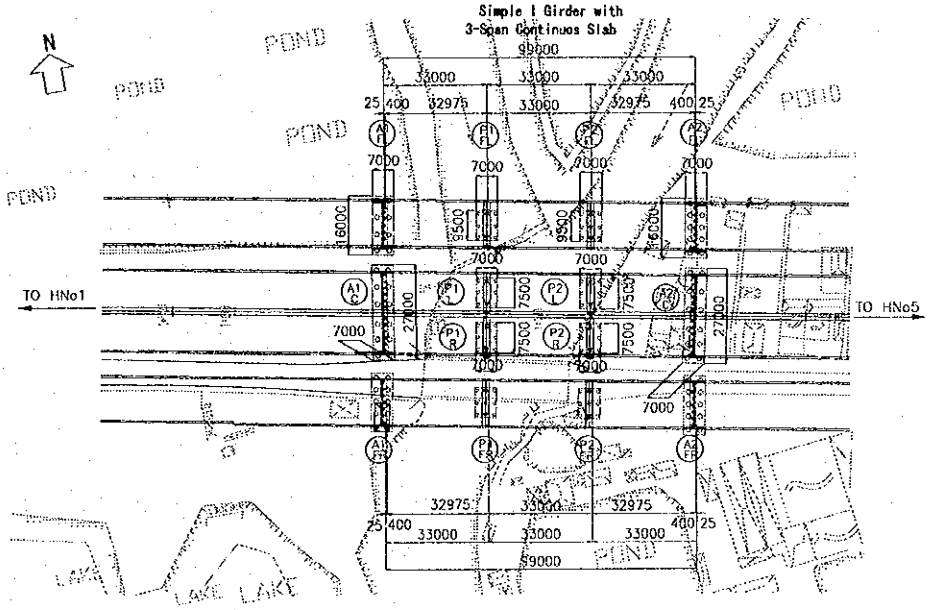


Figure 6.4.1 Proposed Span Arrangement of the Kim Nguu River Bridge

Span arrangement of these bridges is considered based on a 33 m span length as there is no restriction on the span arrangement in the river stream. And 33 m of span length is proposed for all bridges of the Kim Nguu River Bridge. Proposed span arrangement is shown in Figure 6.4.1.

Typical cross sections of the Kim Nguu River Bridge are shown in Figure 6.4.2.

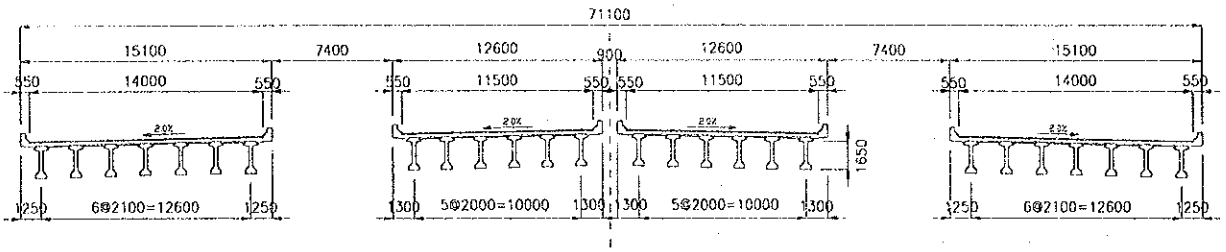


Figure 6.4.2 Typical Cross Sections of Kim Nguu River Bridge

(2) Superstructure

This bridge consists of three (3) spans of 33.0 m. The effective widths are 11.5 m and 14.0 m for the throughway bridge and the frontage road bridge respectively. Precast PC I-girder is adopted because for economical reasons. Refer to Section 6.1.3 (2) for more details.

(3) Substructure

The solid wall hammerhead pier type as shown in Figure 6.4.3 was adopted for substructures of these bridges in order to reduce effect on river stream. Proposed pier height is relatively low (around 6.5 m) due to the low proposed height of throughway and frontage road. Cantilever wall abutment is appropriate for the abutment of these bridges. The number of piers and abutments, including type and height, are listed in Table 6.2.1.

Cast-in-place concrete bored pile was selected for the bridge foundation and diameters of piles are 1.0 m for piers and 1.5 m for abutment. Selection of pile diameter was studied in Section 6.2.3 (3).

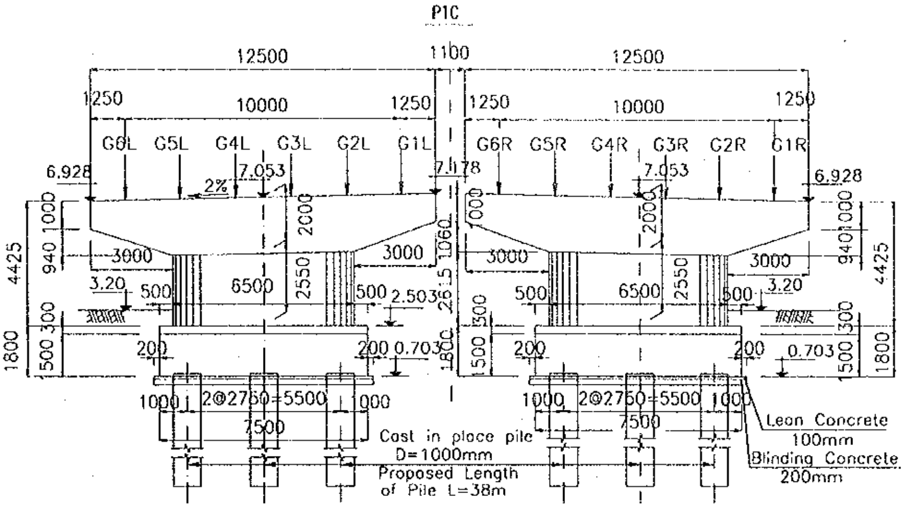


Figure 6.4.3 Typical Dimensions of Substructure of the Kim Nguu River Bridge

6.4.2 Nguyen Tam Trinh Bridge

(1) General

A simple span bridge, named the Nguyen Tam Trinh Bridge, was proposed over the Nguyen Tam Trinh Road which is to be improved in the area of the Nguyen Tam Trinh Interchange, to be located at around STA 2+800. A bridge length of 50 m was decided considering the width and direction of the road. Proposed plan of this bridge is shown in Figure 6.4.4.

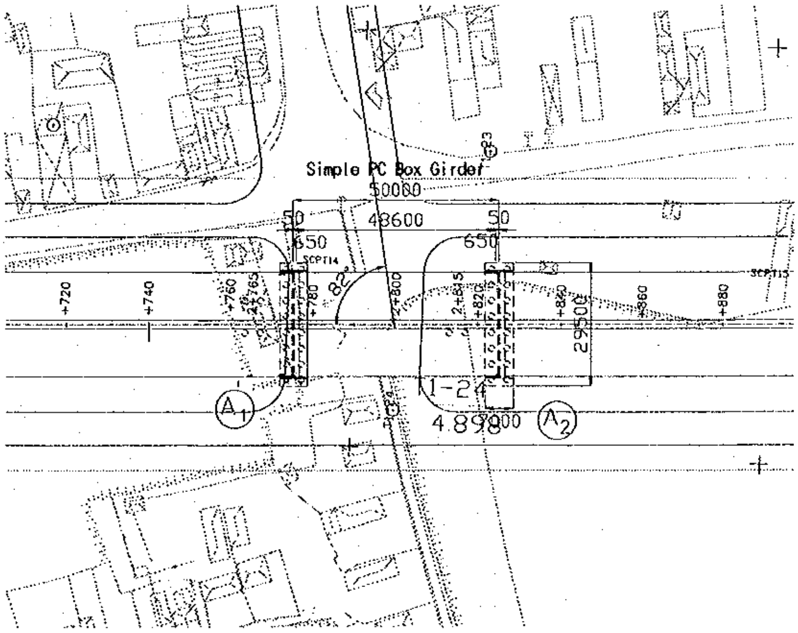


Figure 6.4.4 Proposed Plan of the Nguyen Tam Trinh Bridge

(2) Superstructure

This bridge consists of a simple span with a length of 50.0m. The effective roadway width is 11.5 m, which is the same as that of Cau Bay Canal Bridge. Pre-stressed concrete box girder bridge with a constant height of 2.75m is adopted. Refer to simple span box girder bridge of Cau Bay Canal Bridge (Section 6.4.5 (2) (2B)).

Typical cross section of this bridge is shown in Figure 6.4.5

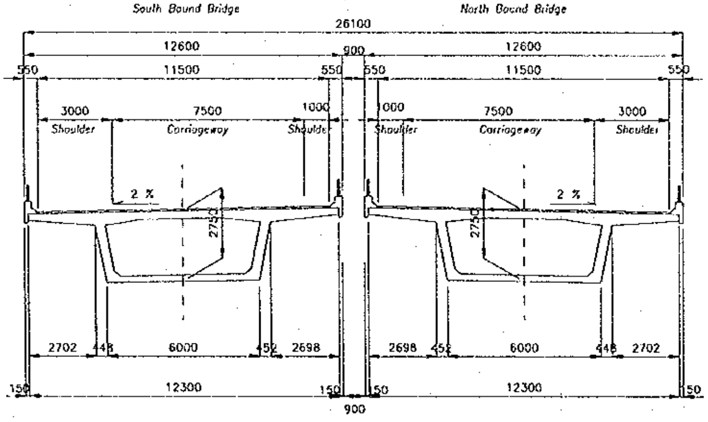


Figure 6.4.5 Typical Cross Section of the Nguyen Tam Trinh Bridge

(3) Substructure

A1 and A2 abutments were designed owing to the simple span. No specific condition for the selection of abutment type was found, so cantilever wall abutment is applied to these abutments. Height of 11m is proposed for both of A1 and A2 abutments. As for bridge foundation, cast-in-place concrete bored pile with the diameter of 1.5m is adopted based on the study mentioned before. BH-R11 of boring data was applied to the design calculation for estimating soil condition, and a pile length of 43 m was adopted.

Typical dimensions of abutment are shown in Figure 6.4.6.

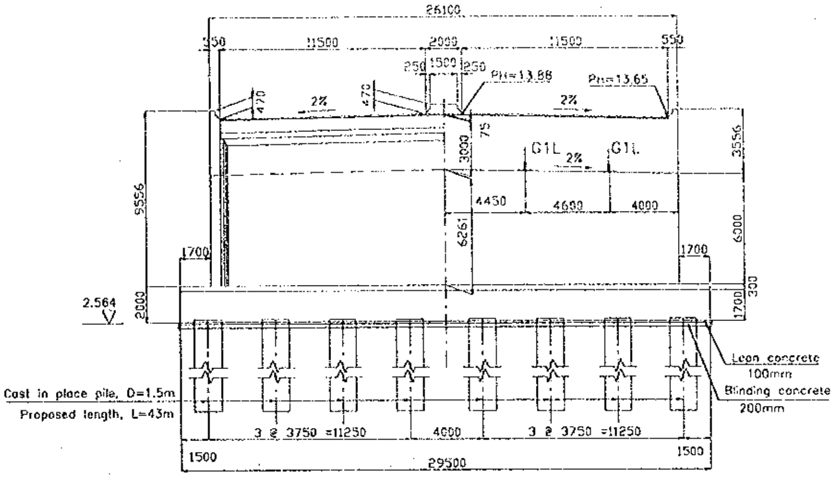


Figure 6.4.6 Typical Dimension of Abutment of the Nguyen Tam Trin Bridge

6.4.3 Linh Nam Bridge

(1) General

The proposed Linh Nam Bridge has a simple span of 50 m long and is at a skew angle of 68 degrees. The existing Linh Nam Road is narrow but this road will be widened in the future. A skew bridge is required in order to propose a simple span bridge of 50 m which is the maximum span length considering appropriate cost and clearance under the bridge.

Plan of the Linh Nam Bridge is shown in Figure 6.4.7

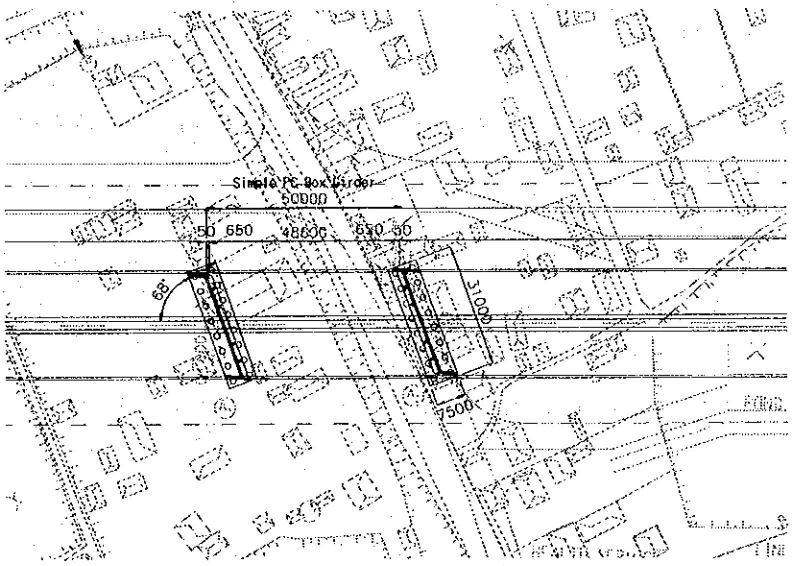


Figure 6.4.7 Proposed Plan of Linh Nam Bridge

(2) Superstructure

The effective roadway width is 11.5 m, which is the same as that of Cau Bay Canal Bridge. Refer to simple span box-girder of Cau Bay Canal Bridge (Section 6.4.5 (2)).

This bridge is also composed of north-bound and south-bound bridges, to be constructed separately.

Typical cross-section of this bridge is shown in Figure 6.4.8.

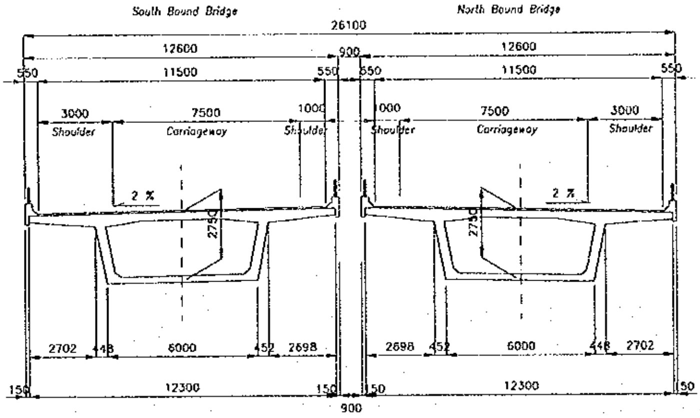


Figure 6.4.8 Typical Cross Section of Linh Nam Bridge

(3) Substructure

The total width of abutment is to be 28.152 m due to the skew. Abutment is of cantilever wall type and the height of abutment is 11.7 m. Cast-in-place concrete bored pile with a diameter of 1.5 m was proposed for foundation and a pile length of 40 m was required.

For detailed design of abutments, BH-R14 of boring data was applied in order to estimate the soil condition in site.

Typical dimensions of abutment are shown in Figure 6.4.9.

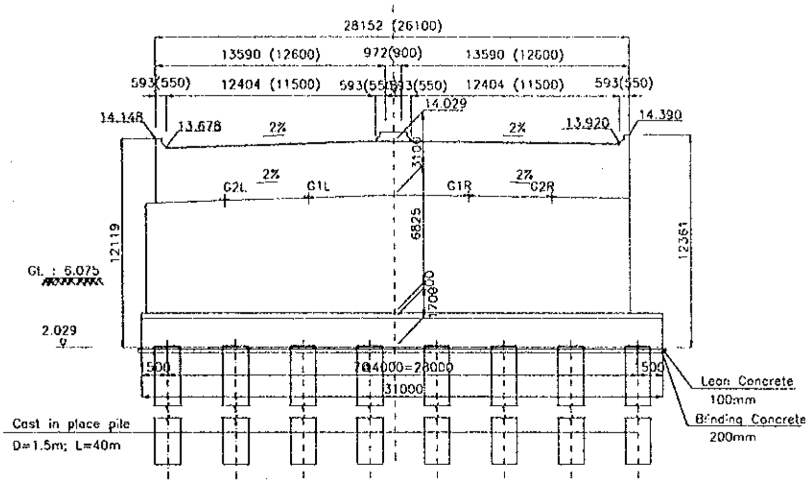


Figure 6.4.9 Typical Dimension of Abutment of the Linh Nam Bridge

6.4.4 Gia Lam Road Bridge

(1) General

In response to future road planning, Gia Lam Road Bridge is to be located at around STA 10+900 in Package 2. The required span length to cross over the proposed road is 33m and simple PC I-girder was adopted as a type of superstructure for this bridge.

Proposed plan of Gia Lam Road Bridge is shown in Figure 6.4.10.

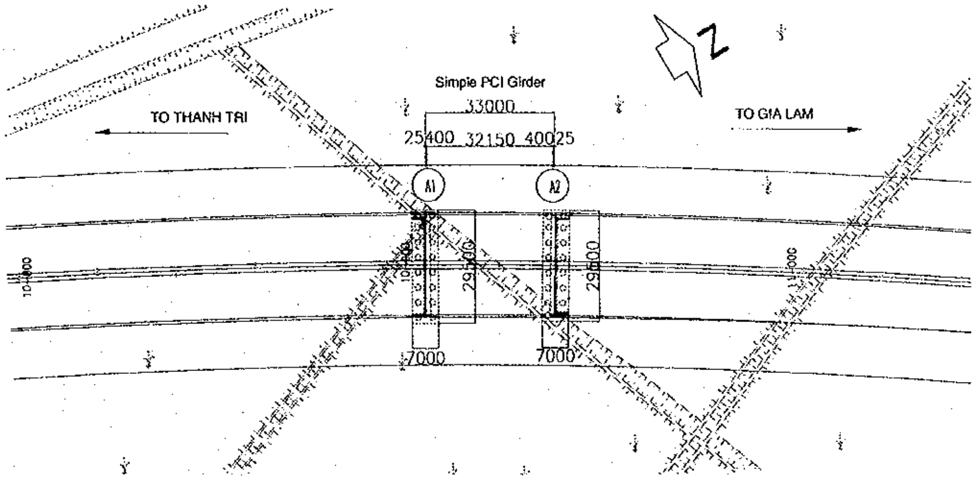


Figure 6.4.10 Proposed Plan of Gia Lam Road Bridge

(2) Superstructure

The effective width of the roadway is 11.5m. This bridge is located within road section with horizontal curve, so that each PC I-girder has a straight shape but width of cantilever section of deck slab varies to fit the road alignment. Detailed design of this type of PC I-girder was studied in Section 6.1.3 (2).

Typical cross section of this superstructure is shown in Figure 6.4.11.

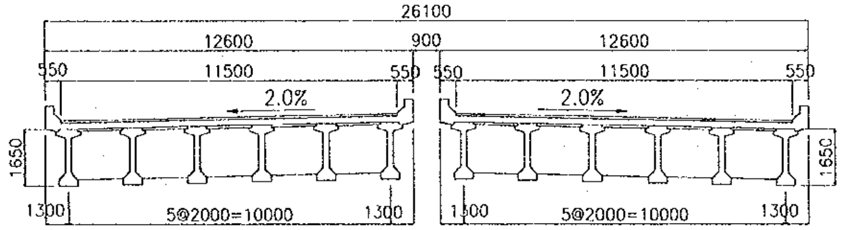


Figure 6.4.11 Typical Cross Section of Superstructure of Gia Lam Road Bridge

(3) Substructure

The Cantilever wall-type abutment was proposed for both A1 and A2 abutments. Boring data which was applied to the detailed design of this bridge is BH-R14 and a pile length needs 40m based on this data in order to ensure the stability of abutments.

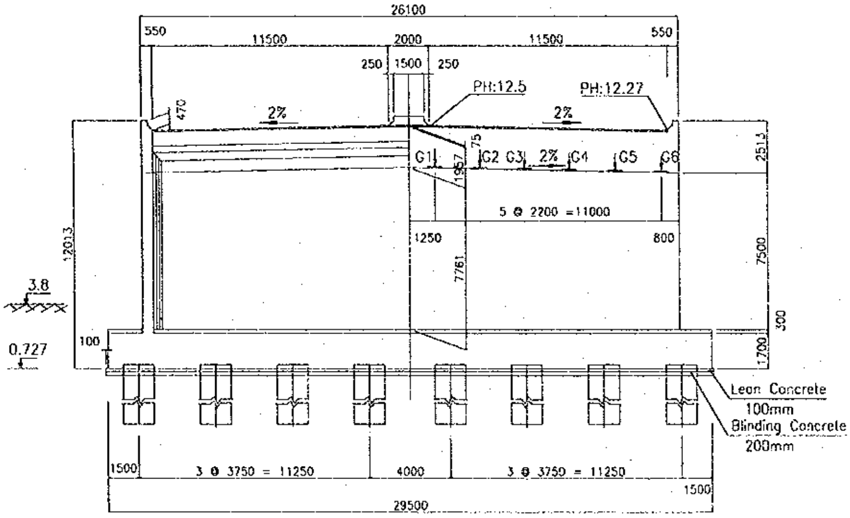


Figure 6.4.12 Typical Dimension of Abutment of Gia Lam Road Bridge

6.4.5 Cau Bay Canal Bridge

(1) General

The Cau Bay Canal Bridge is proposed at the section where throughway crosses over an irrigation canals named the Cau Bay Canal samong rice fields on the Gia Lam side, Package 2. Proposed throughway crosses canals composed of two directions, as shown in Figure 6.4.13. This bridge consists of north- and south-bound bridges. Positions of abutments and piers of north-bound bridge are different with that of south-bound bridge as a result of span arrangement considering less effect on canal streams. The total bridge length of the north-bound bridge is to be 233 m and that of south-bound bridge is to be 249 m. The result of span arrangement is shown in Figure 6.4.13. Two superstructure types, PC I-girder and PC box-girder, are proposed on account of the various span lengths as described in the following section.

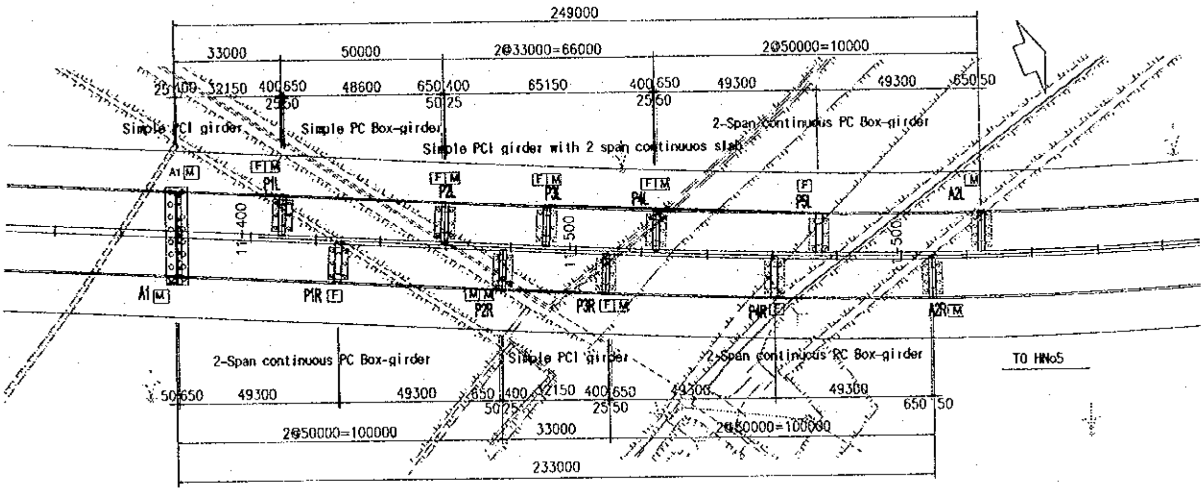


Figure 6.4.13 Proposed Span Arrangement of the Cau Bay Canal Bridge

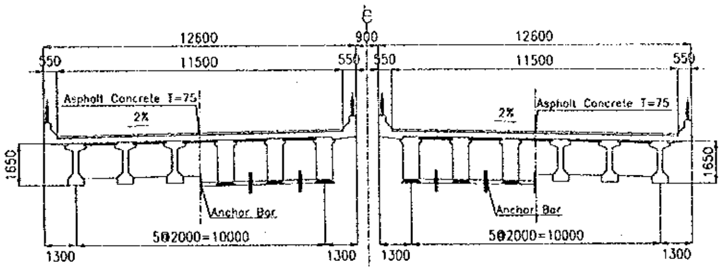
(2) Superstructure

(2A) Span Arrangement

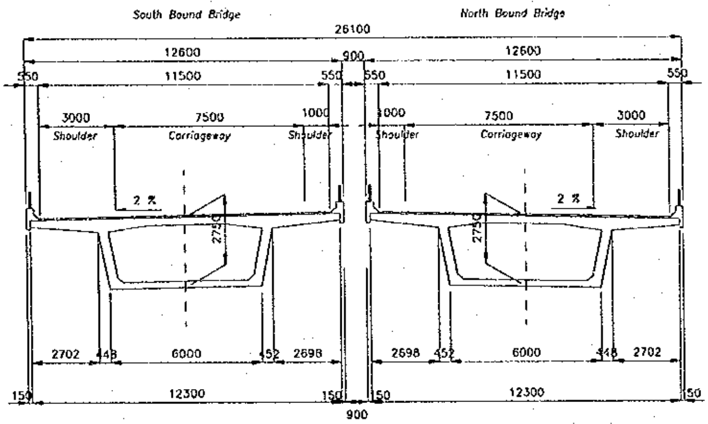
This bridge is constructed over the Cau Bay Canal. Span arrangement has been determined as follows, based on the local land use conditions:

North-bound : 2@50.0 + 33.0 + 2@50.0 = 233.0m
South-bound : 33.0 + 50.0 + 2@33.0 + 2@50.0 = 249.0m

PC box girder bridge and precast PC I-girder bridge have been selected for 50.0m span and 33.0m spans, respectively.



(a) Typical Cross Section of PC I-girder



(b) Typical Cross Section of PC Box-girder

Figure 6.4.14 Typical Cross Sections of the Cau Bay Canal Bridge

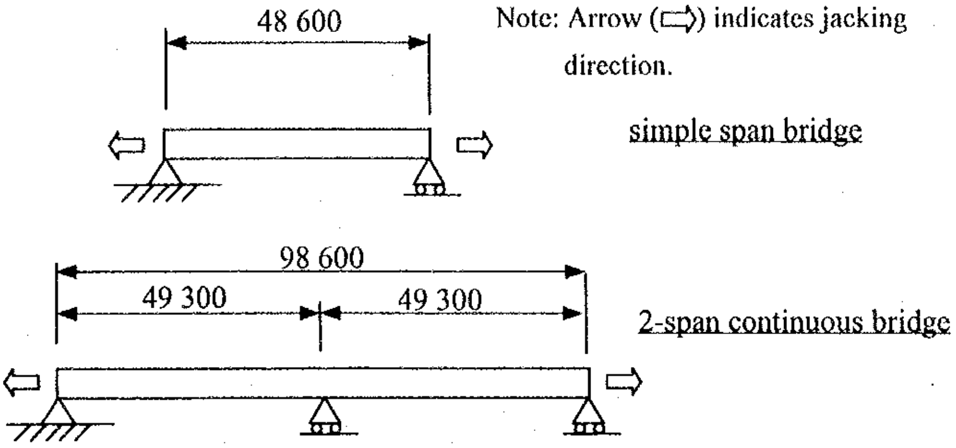
(2B) Box Girder Bridge

1) Structural Dimensions

The typical cross-section is shown in Figure 6.4.14 (b). The girder height of 2.75m is constant throughout the bridge. (Refer to Section 6.2.2 (2) for selection of 2.75m).

2) Structural Model

Conventional pot bearings will be used for the interface with the substructure. The structural models used in the design are shown in Figure 6.4.15.



Note: Arrow (⇨) indicates jacking direction.

Figure 6.4.15 Structural Models for Design

It is assumed that the longitudinal tendons will be jacked throughout their entire lengths from the both ends as shown in Figure 6.4.15.

3) Structural Analysis

(a) Loads

The roadway width is allocated to carriageways and shoulders, as shown in Figure 6.2.x. However, in consideration of future use of the bridge, it is assumed in the design that the entire road width between the curbs is to serve vehicular traffic. The number of traffic lanes is three (3) for roadway width of 11.5m in accordance with AASHTO standard Article 3.6. The road intensity shall be reduced in accordance with Article 3.12 of the standard.

Refer to Section 4.2.2 (2) for other loads.

(b) Deck Slab

Because of the relatively wide deck slab width, the slab is designed as a pre-stressed concrete member.

Similar to the main bridge, the slab is designed to withstand a distributed load of 250kgf/m^2, but not to exceed 1.0tf/m in average in the longitudinal direction. (Refer to Section 6.2.2 (2) 5) for the detail.)

(2C) PC I-girder

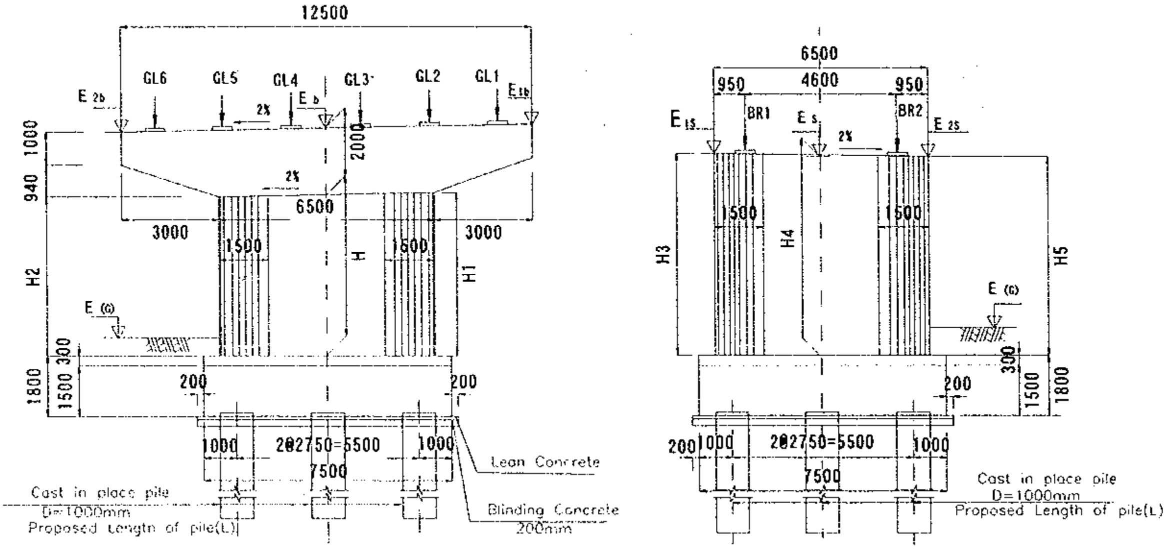
The effective width is 11.5m.

Refer to Section 6.2.3 (2) for details.

(3) Substructure

Unique A1 abutment is constructed for both north- and south-bound bridges. On the other hand, individual A2 abutments are constructed for these bridges. Cantilever wall-type abutment was adopted throughout, and required heights are 9.5 m.

Regarding pier type, two types of piers shown in Figure 6.4.15 are proposed on the premise that the solid wall-type pier which has less effect on the canal streams is more or less appropriate. Solid wall hammerhead pier was designed for piers supporting PC I-girder and solid wall pier was designed for PC box-girder. Top beam was installed for piers supporting PC I-girder to support six I-girders since wider wall leads to higher construction cost.

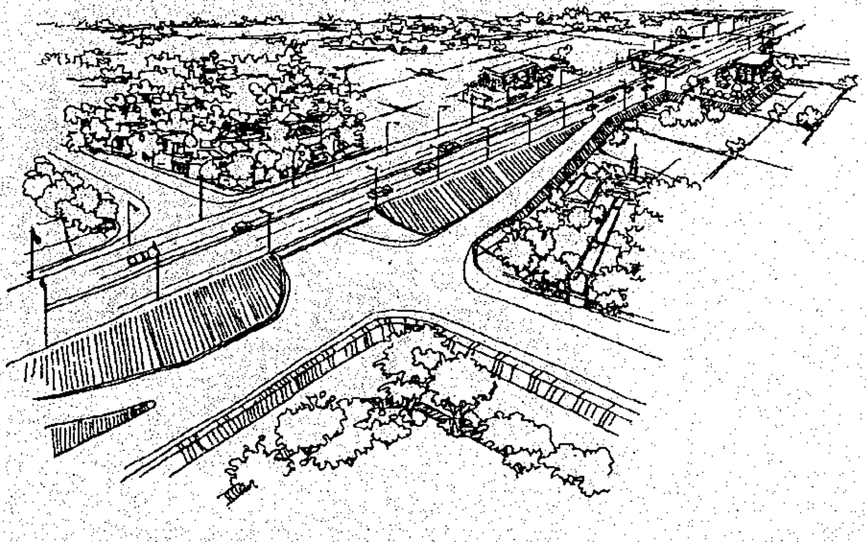


(a) Solid Wall Hammerhead Pier **(b) Solid Wall Pier**

Figure 6.4.15 Typical Dimensions of Substructures of the Cau Bay Canal Bridge

Boring data of BH-R14 was adopted for the design of these substructures and the required pile length is 43m for all substructures.

CHAPTER 7 DETAILED DESIGN OF BOX CULVERT AND RETAINING WALL



CHAPTER 7 DETAILED DESIGN OF BOX CULVERT AND RETAINING WALL

7.1 General

A large-scale structure, namely a bridge as a highway facility, was described in Chapter 6. Small scale structures, namely box culvert and retaining wall, are explained in this chapter.

Box culverts for cross traffic and canals passing under the throughway, frontage roads and interchange ramps have been proposed. Detailed explanations of box culverts for canals are shown in Chapter 8.

7.2 Box Culvert

7.2.1 Proposed Locations of Box Culverts

The total number of proposed box culverts in this project is eighteen (18). Breakdown by function is: four (4) box culverts for canals, five (5) for the pedestrian underpasses and nine (9) for the vehicle underpasses. From the viewpoint of contract segment of the project, four (4) and fourteen (14) box culverts are proposed in Package 2 and Package 3, respectively. Locations for these culverts are shown in Figure 7.2.1, and rough dimensions of these culverts are shown in the table in Figure 7.2.1. Box culverts to be installed for pedestrian underpasses and vehicle underpasses are as follows;

(1) Box Culvert for canal in Package 3

3BX-1:	STA 0+517.000 (STA along frontage road)
3BX-2:	STA 0+510.000 (STA along frontage road)
3BX-7:	STA 3+397.461
3BX-12:	STA 4+890.300

3BX-1, 3BX-2, 3BX-7 and 3BX-12 are proposed for the canals. Their cross sections are shown in Figure 7.2.2.

LOCATION MAP OF PROPOSED BOX CULVERTS

LIST OF BOX CULVERTS

Package	Box Culverts No.	Purpose	Location STA	Reference Road	Crossing Angle (degree)	Inner Dimensions B (m)	Inner Dimensions H (m)	Inner Dimensions L (m)	Elevation of Top of Lower Slab (m)	Max. Overlay (m)
Package 3	3BX- 1	Canal	STA 0 +517.000	Frontage-R	90.000 deg.	4.00	2.50	39.50	GL +2.500 - +2.500	0.00
	3BX- 2	Canal	STA 0 +510.000	Frontage-L	90.000 deg.	4.00	2.50	39.50	GL +2.500 - +2.500	7.12
	3BX- 3	Vehicle	STA 0 +550.080	Frontage-R	90.000 deg.	2@8.75	5.00	17.10	GL +5.500 - +5.400	0.00
	3BX- 4	Vehicle	STA 0 +555.852	Frontage-L	90.000 deg.	2@9.25	5.00	19.80	GL +5.783 - +5.830	1.10
	3BX- 5	Pedestrian	STA 1 +900.000	Throughway	90.000 deg.	4.00	3.00	26.50	GL +5.820 - +5.750	0.00
	3BX- 6	Pedestrian	STA 2 +310.000	Throughway	90.000 deg.	4.00	3.00	29.29	GL +6.119 - +5.782	0.00
	3BX- 7	Canal	STA 2 +397.481	Throughway	77.800 deg.	4.00	2.50	93.00	GL +2.500 - +2.500	6.30
	3BX- 8	Vehicle	STA 3 +439.380	Throughway	48.376 deg.	8.00	4.00	11.50	GL +6.440 - +6.319	0.00
	3BX- 9	Vehicle	STA 3 +965.690	Throughway	47.900 deg.	5.00	4.00	39.03	GL +6.436 - +6.746	0.00
	3BX- 10	Vehicle	STA 4 +503.455	Throughway	74.240 deg.	4.00	3.00	27.52	GL +6.480 - +6.420	0.00
	3BX- 11	Vehicle	STA 4 +820.000	Throughway	90.000 deg.	5.00	4.00	26.50	GL +6.873 - +6.184	0.00
	3BX- 12	Canal	STA 4 +890.300	Throughway	90.000 deg.	2.00	2.00	104.00	GL +2.500 - +2.800	0.50
	3BX- 13	Pedestrian	STA 5 +120.000	Throughway	90.000 deg.	4.00	3.00	26.50	GL +6.888 - +6.728	0.00
	3BX- 14	Vehicle	STA 6 +164.890	Throughway	78.753 deg.	5.00	4.00	48.08	GL +6.271 - +5.780	0.00
Package 2	2BX- 1	Pedestrian	STA 9 +900.000	Throughway	90.000 deg.	4.00	3.00	26.50	GL +5.230 - +4.874	0.00
	2BX- 2	Vehicle	STA 0 +224.300	On Ramp	90.000 deg.	5.00	4.00	11.50	GL +5.836 - +5.408	0.00
	2BX- 3	Vehicle	STA 0 +225.960	Off Ramp	90.000 deg.	5.00	4.00	11.50	GL +5.074 - +4.844	0.00
	2BX- 4	Pedestrian	STA 10 +550.000	Throughway	90.000 deg.	4.00	3.00	16.00	GL +5.028 - +4.763	0.00

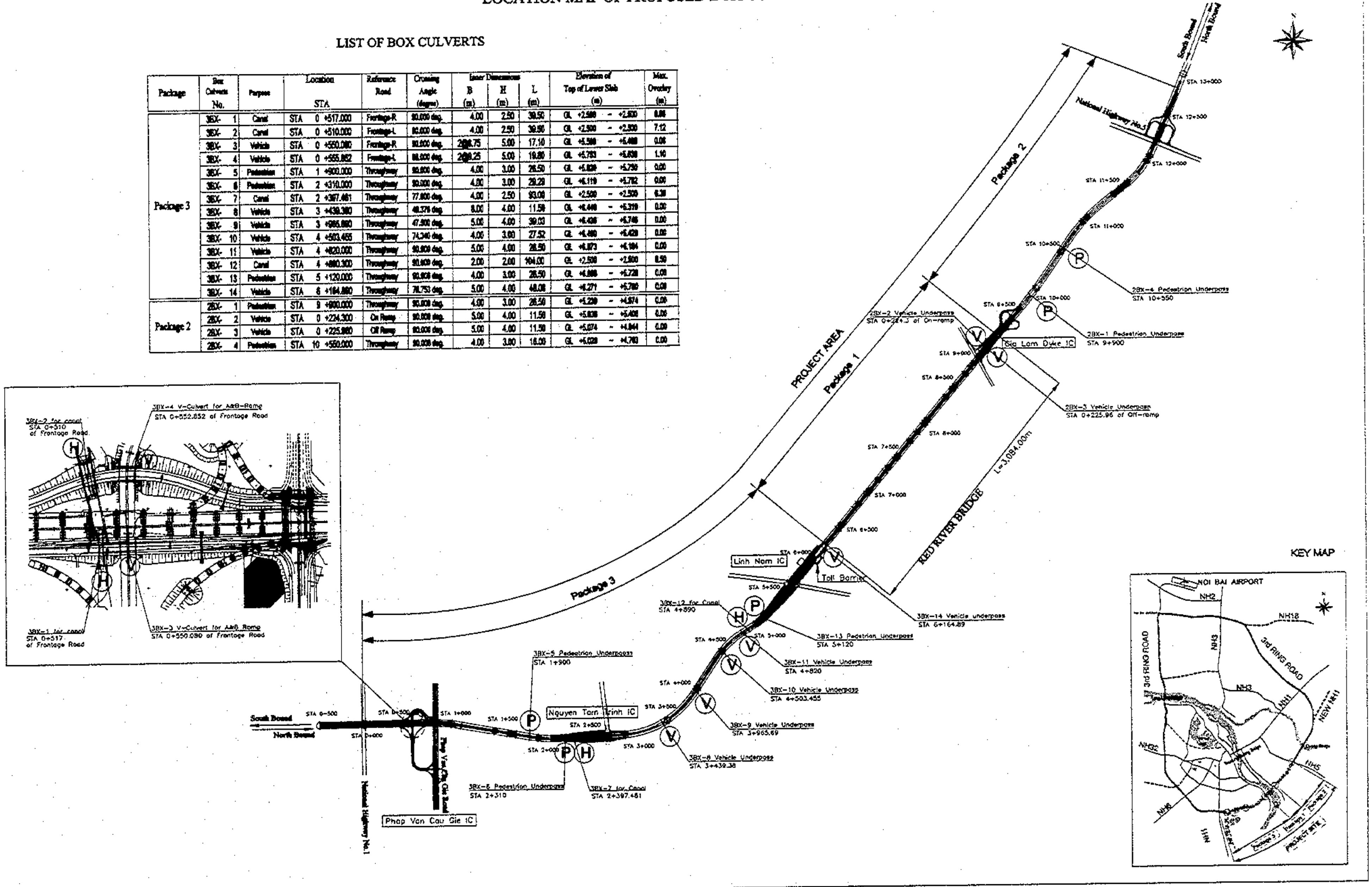


Figure 7.2.1 Location Map of Proposed Box Culverts

(2) Box Culvert for Pedestrian Underpass in Package 3

3BX-5:	STA 0+517.000
3BX-6:	STA 0+510.000
3BX-13:	STA 3+397.461

3BX-5, 3BX-6 and 3BX-13 are provided for the pedestrian underpass across the throughway in order to avoid isolation caused by construction of the throughway. These proposed locations are in residential areas. Vehicle underpasses are not required but passage provision for pedestrians should be ensured for daily activities of residents in these areas. Proposed dimensions of pedestrian underpasses are shown in Figure 7.2.3.

(3) Box Culvert for Vehicle Underpass in Package 3

3BX-8:	STA 3+439.380	3BX-3:	STA 0+550.080
3BX-9:	STA 3+965.690		(STA along frontage road)
3BX-10:	STA 4+503.455	3BX-4:	STA 0+555.852
3BX-11:	STA 4+820.000		(STA along frontage road)
3BX-14:	STA 6+164.890		

Locations of box culvert for the vehicle underpasses are proposed in consideration of the existing crossroads. 3BX-3 and 3BX-4 are located in conjunction with rampways at the Phap Van Cau Gie Interchange and these road sections are across the frontage road. Required inner clearance of these box culverts was studied and their dimensions were ultimately determined as shown in Figure 7.2.5. Underpass 3BX-4 is located at a section of horizontal curve alignment, so that the clearance of 3BX-4 is larger than that of 3BX-3.

(4) Box Culvert for Pedestrian Underpasses in Package 2

2BX-1:	STA 9+900.000
2BX-4:	STA 10+550.000

The above two box culverts are proposed for the pedestrian underpasses in Package 2, Gia Lam Section. Installation of the pedestrian underpasses is based on the same basic policy as Package 3. These two culverts have the same dimension as the above mentioned pedestrian underpass and are shown in Figure 7.2.3.

(5) Box Culvert for Vehicle Underpass in Package 2

2BX-1:	STA	9+900.000 (STA along ramp-A)
2BX-4:	STA	10+550.000 (STA along ramp-C)

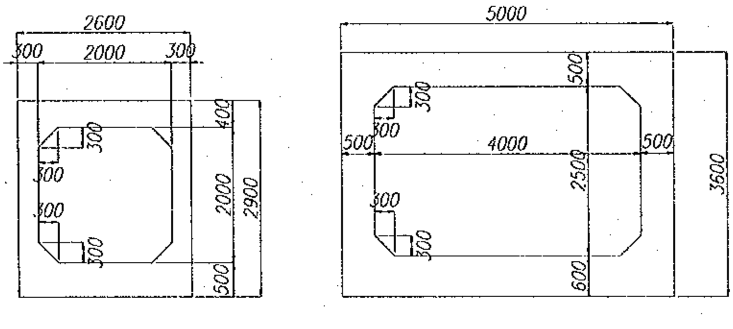
These two box culverts are proposed in order to ensure the clearance of another rampway since two ramps, namely onramps and offramps cross each other due to the proposed horizontal road alignment.

7.2.2 Cross Sections of Box Culvert

As mentioned above, there are three kinds of box culvert in this project according to function. The cross section of each type is shown in this section.

(1) Cross Sections of Box Culvert for Canal

The criteria for inner clearance should be discussed in Chapter 8. Dimensions in Figure 7.2.2 show the result of sufficient structural dimensions considering the required inner section as the canal.



(a) 3Bx-12 **(b) 3BX-1,2 and 7**

Figure 7.2.2 Cross sections of Box Culvert for Canal

(2) Cross Section of Box Culvert for the Pedestrian Underpass

Required inner clearance for the pedestrian underpass is 3.0m wide and 2.5 high, as shown by broken lines in Figure 7.2.3. The height of 2.5m for pedestrians is provided for in the highway design standard. The width of 3.0m is proposed considering the width which is needed for pedestrians in order to pass each other. Dimension of the pedestrian underpass is shown in Figure 7.2.3.

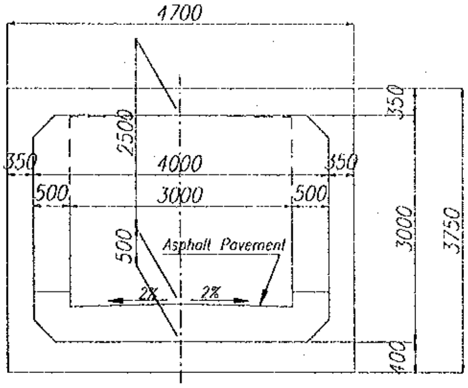
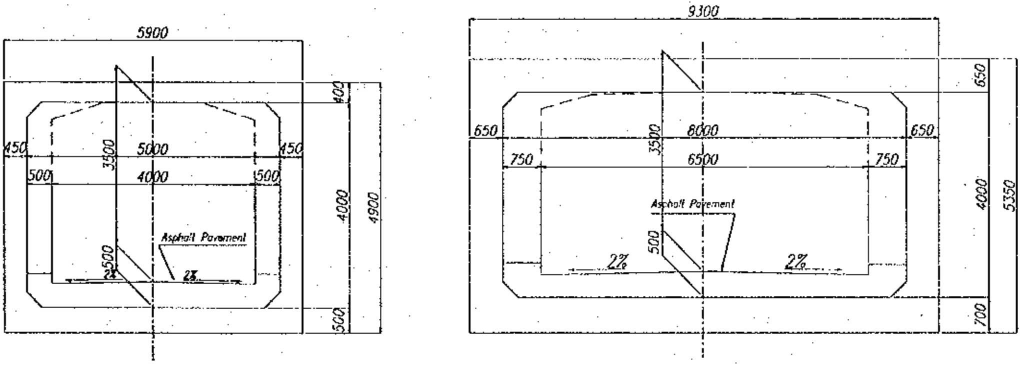


Figure 7.2.3 Cross Section of Box Culvert for Pedestrian Underpass

(3) Cross Sections of Box Culvert for the Vehicle Underpass

There are two types of proposed box culverts for vehicular traffic. One is for local roads and the other is for rampways. The culvert for rampways is to be installed only at the Phap Van Cau Gie Interchange, as mentioned above.

Two types of box culverts for vehicle underpasses are proposed for the section where the project highway will be cross over the existing road. Dimensions of these two types of culverts are shown in Figure 7.2.4. In these cases, required clearance height for vehicle traffic is 3.5 m high, provided for as a clearance of the local road class in the highway design standard. The necessary width for each culvert is determined based on the width of existing road. The type V2 culvert is proposed only for 3BX-# and the type V1 culvert is applied to other culverts for local roads.

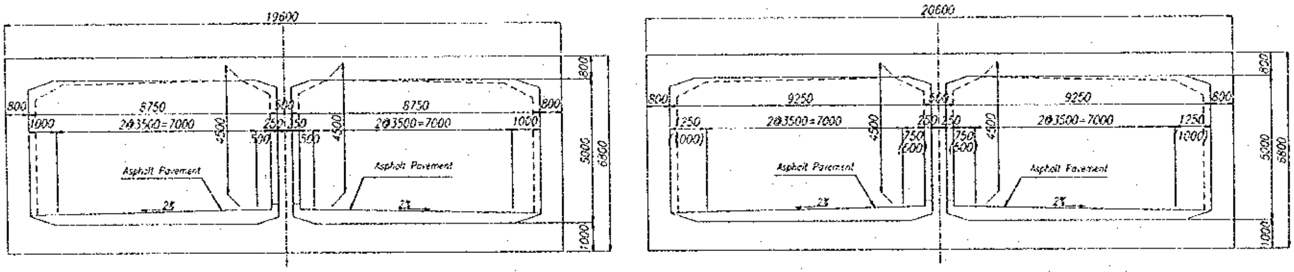


(a) Type V1

(b) Type V2

Figure 7.2.4 Cross Sections of Box Culvert for Vehicle Underpass

Dimensions of box culverts for the rampway are shown in Figure 7.2.5. Provided inner clearance height for the Class I road in highway design standard is 4.5m and these dimensions are proposed so as to satisfy this provision. The width of culvert is determined based on the necessary width for two-way traffic of the rampways. Wider shoulders were required for 3BX-4 due to its location, as mentioned above. Normal inner and outer shoulders are 0.5 m and 1.0 m in width respectively, however, inner and outer shoulders of 3BX-4 are 0.75 and 1.25 m in width respectively. As for the structural feature of these culverts, one-cell structure is not suitable due to their width. Therefore, two-cell structure with diaphragm wall is applied.



(a) 3BX-3

(b) 3BX-4

Figure 7.2.5 Cross-Sections of Box Culvert for Vehicle Underpass of Rampway

7.3 Retaining Walls

7.3.1 Proposed Locations of Retaining Walls

Retaining wall structure is required at one location in this project. Location of retaining wall to be installed is around STA 9+400 in the Gia Lam Interchange area. A retaining wall is required for this road section of throughway since onramps and offramps are proposed near the throughway and a difference of the proposed height between throughway and rampway renders installation of embankment slope unsuitable.

Proposed location of retaining wall is shown in Figure 7.3.1. Cross section STA 9+360 is shown in Figure 7.3.2 as a typical cross section of the area where retaining wall structure is to be applied.

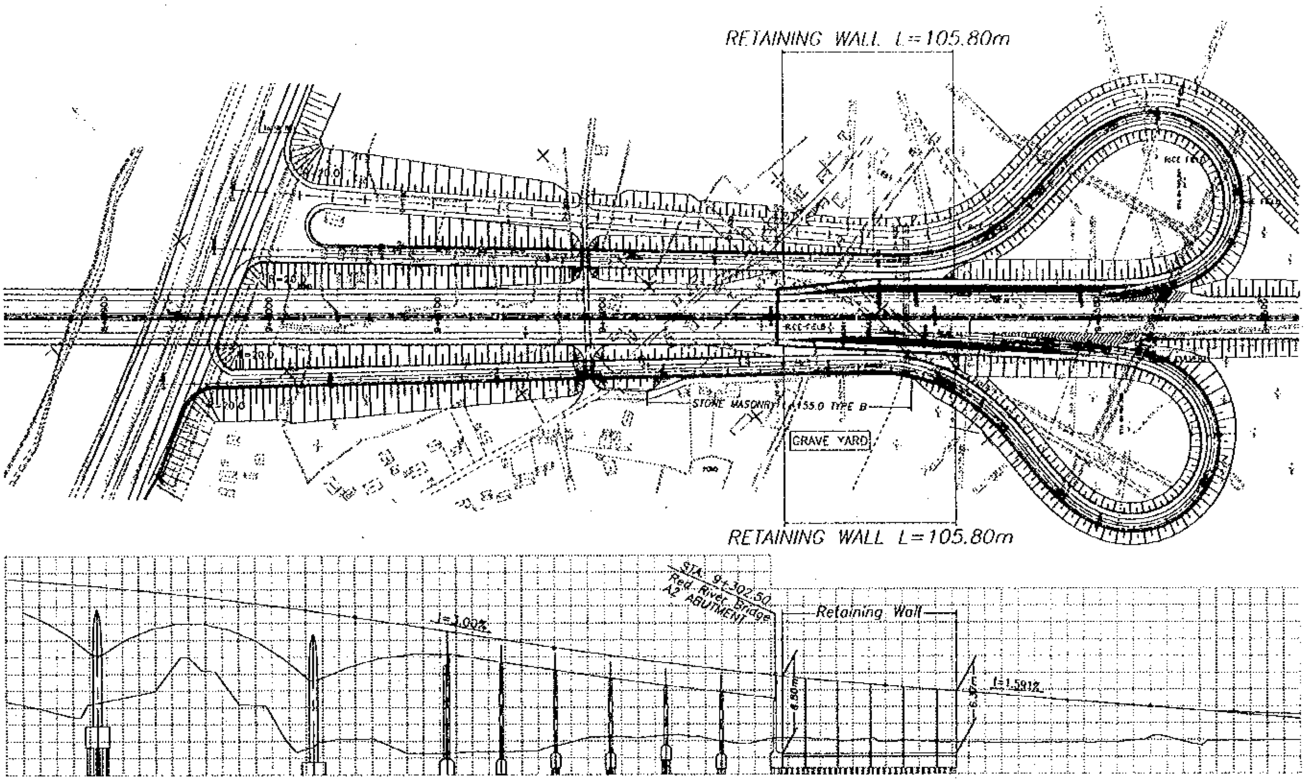


Figure 7.3.1 Proposed Location of Retaining Wall

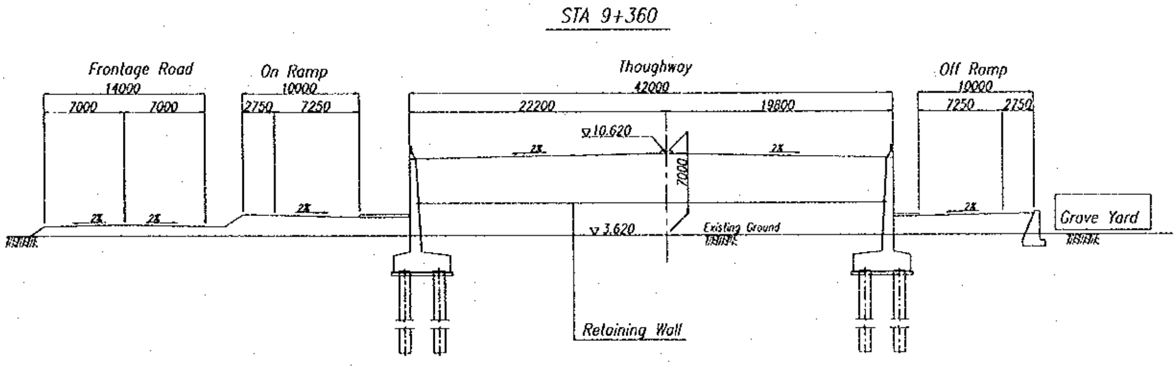


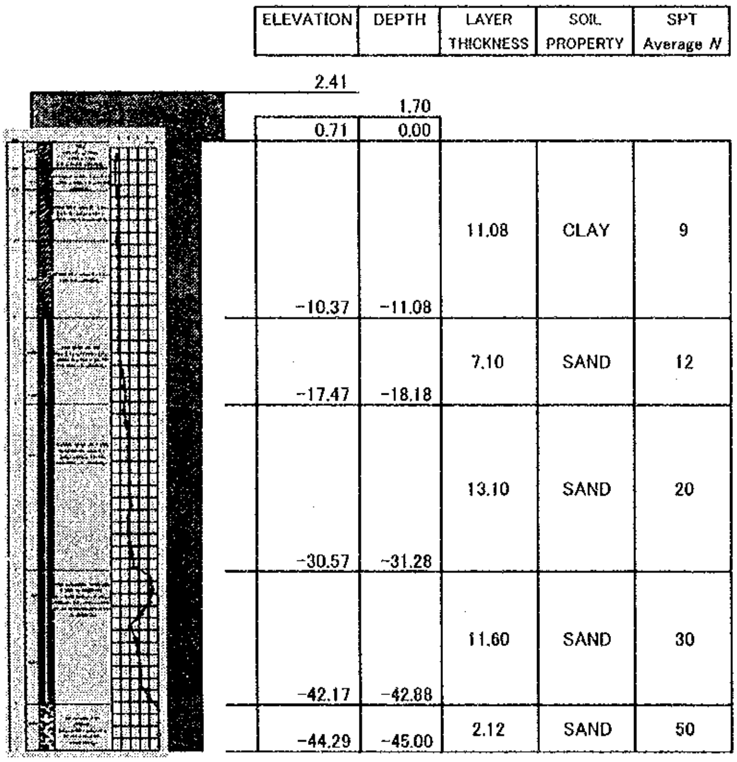
Figure 7.3.2 Typical Cross Section of Part with Retaining Wall

7.3.2 Design Criteria of Retaining Wall

Retaining wall was designed by the following design criteria.

(1) Concrete Class : Class C - 4 (f'c = 290 kgf/cm^2)
(2) Live Load : q = 1.0 tf/m^2
(3) Foundation : Pile foundation
(4) Pile : Cast-in-place bored RC pile, diameter of 1.0 m

(5) Soil condition : Applied boring data is BH-B16.
Estimated properties of soil layer are shown in Figure 7.3.3.



ELEVATION	DEPTH	LAYER THICKNESS	SOIL PROPERTY	SPT Average *N*
2.41	1.70			
0.71	0.00			
-10.37	-11.08	11.08	CLAY	9
-17.47	-18.18	7.10	SAND	12
-30.57	-31.28	13.10	SAND	20
-42.17	-42.88	11.60	SAND	30
-44.29	-45.00	2.12	SAND	50

Figure 7.3.3 Estimated Properties of Soil Layer (BH-B16)

7.3.3 Design Result of Retaining Wall

Dimensions of retaining wall and pile arrangement shown in Figure 7.3.3 were decided based on the design calculation.

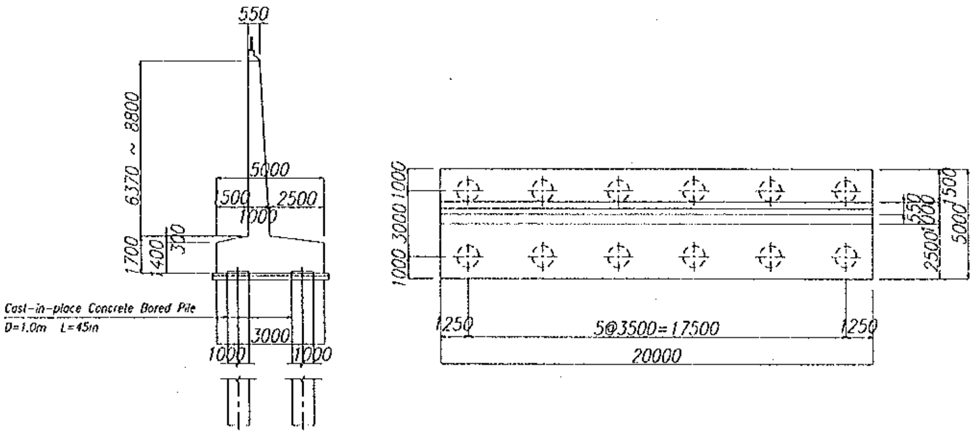
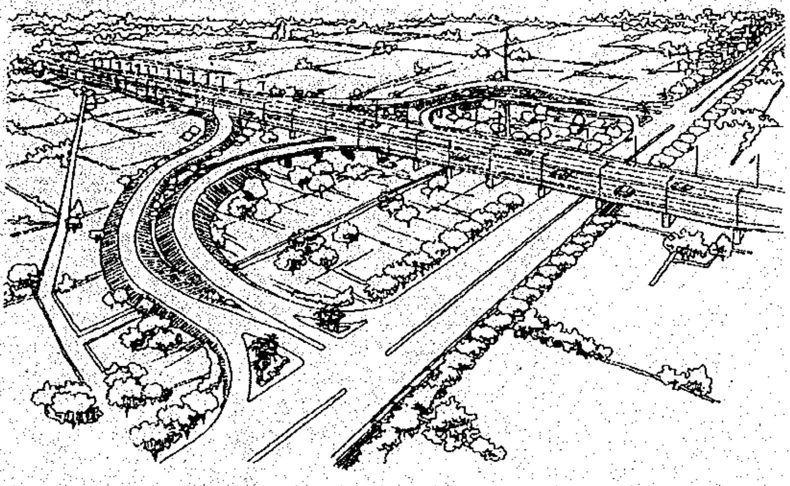


Figure 7.3.4 Dimensions and Pile Arrangement of Retaining Wall

CHAPTER 8 DETAILED DESIGN OF DRAINAGE SYSTEM



CHAPTER 8 DETAILED DESIGN OF DRAINAGE SYSTEM

8.1 Highway Drainage System

Water runoff caused by rainfall on bridge and road surfaces, as well as embankment slopes, not to mention water flow from upstream catchment areas, neighboring residential areas, farmland, ponds, etc., deem necessary an effective drainage system.

Consequently, appropriate drainage facilities such as drainage channels, catch basins, and road crossing to drain out such runoff smoothly downstream are installed in and along the throughway and frontage road for safely and stably retaining the road's subbase, pavement and finally, retaining proper condition of the bridge and road for vehicle and pedestrian traffic without hindrance.

Overall planned drainage facilities and system are shown in Figures 8.1.1 and 8.1.2.

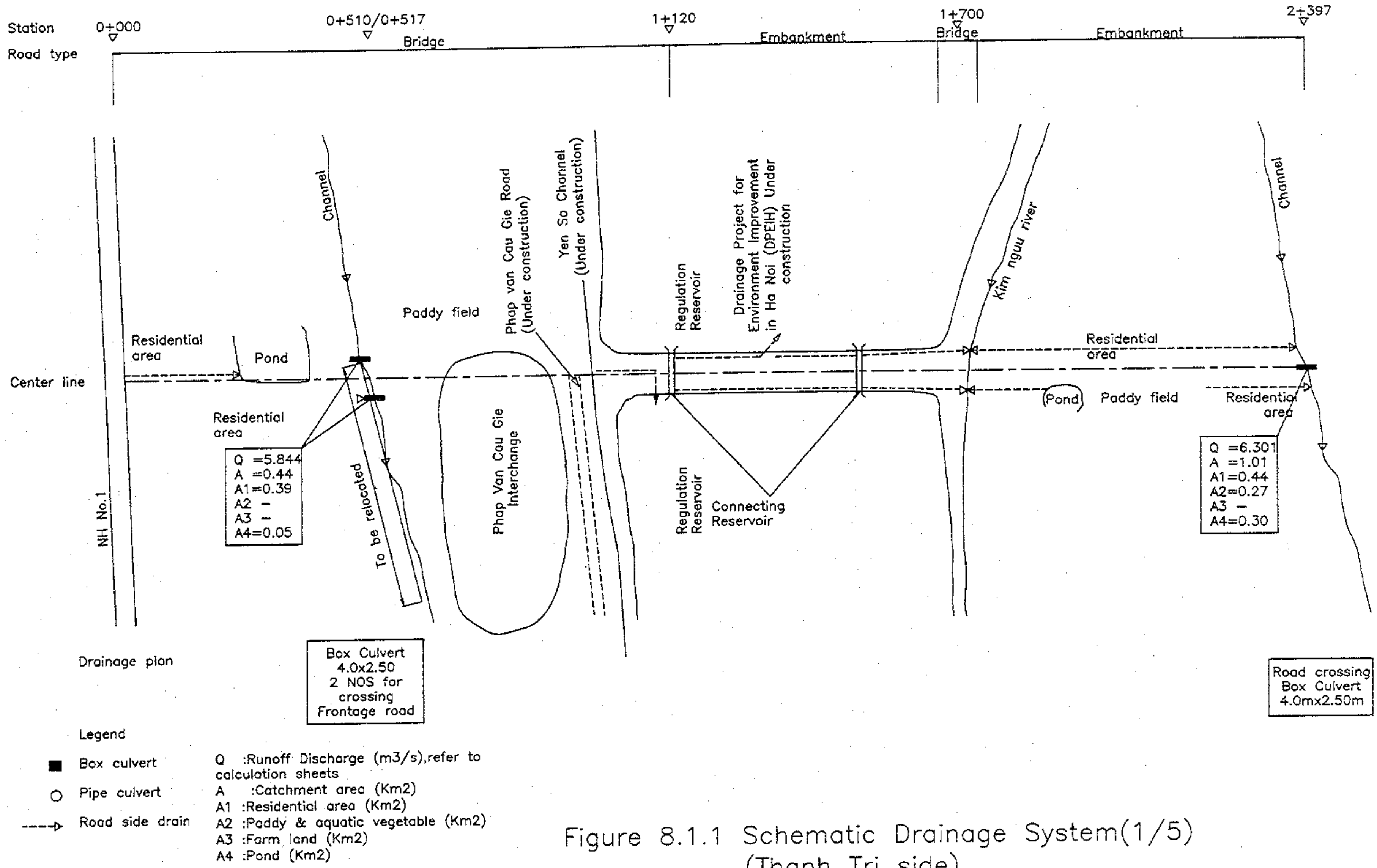


Figure 8.1.1 Schematic Drainage System(1/5)
(Thanh Tri side)

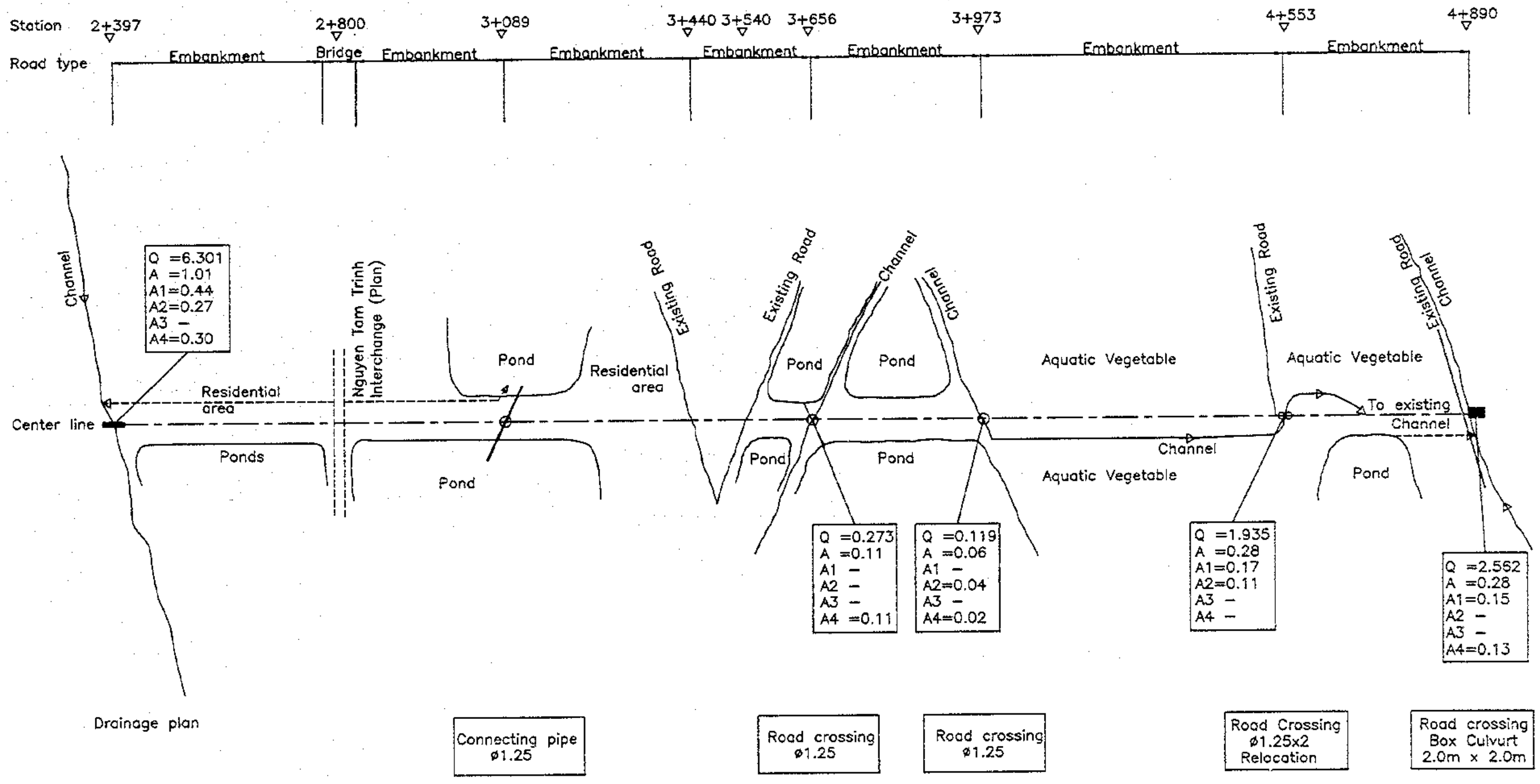


Figure 8.1.1 Schematic Drainage System(2/5)
(Thanh Tri side)

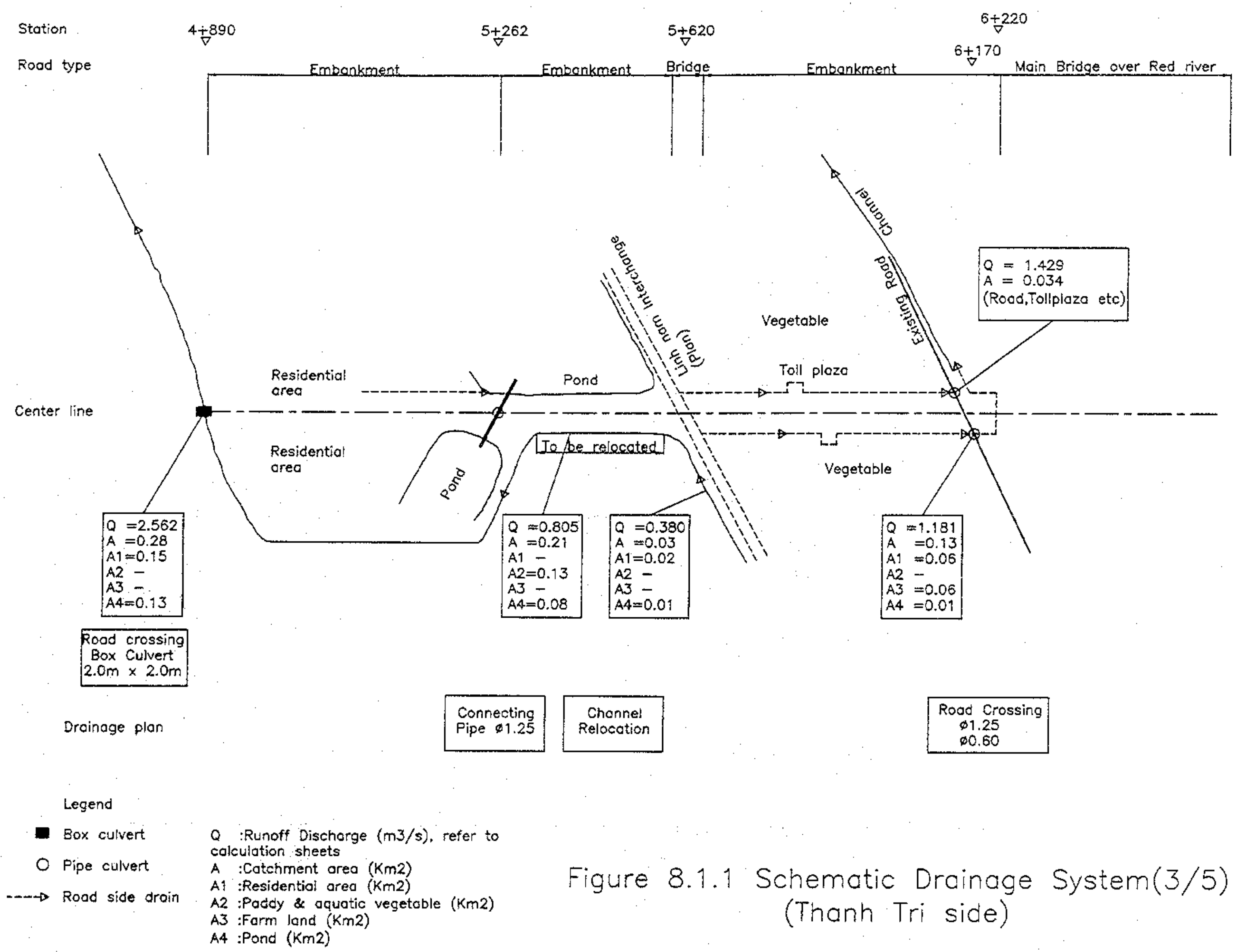


Figure 8.1.1 Schematic Drainage System(3/5)
(Thanh Tri side)

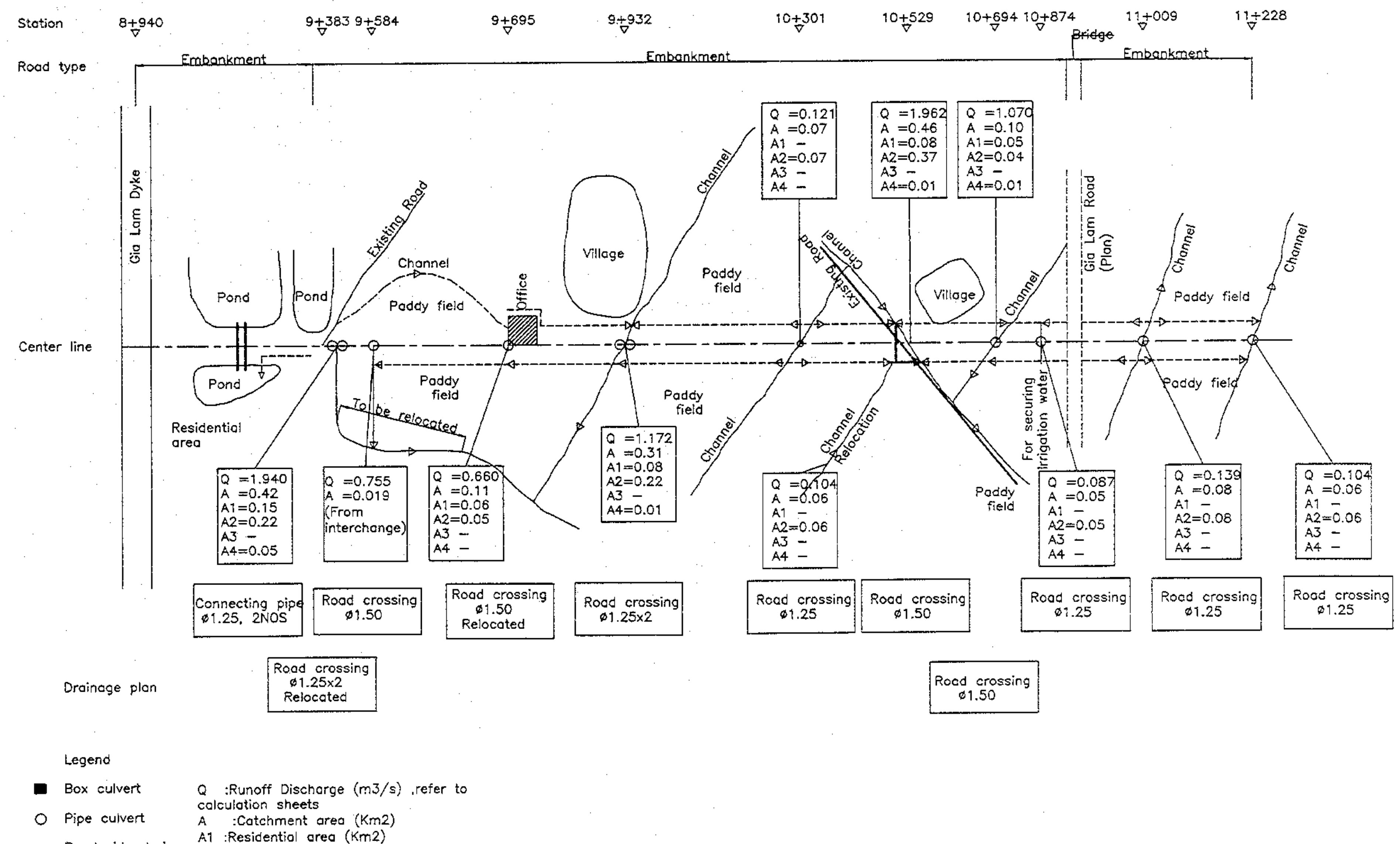
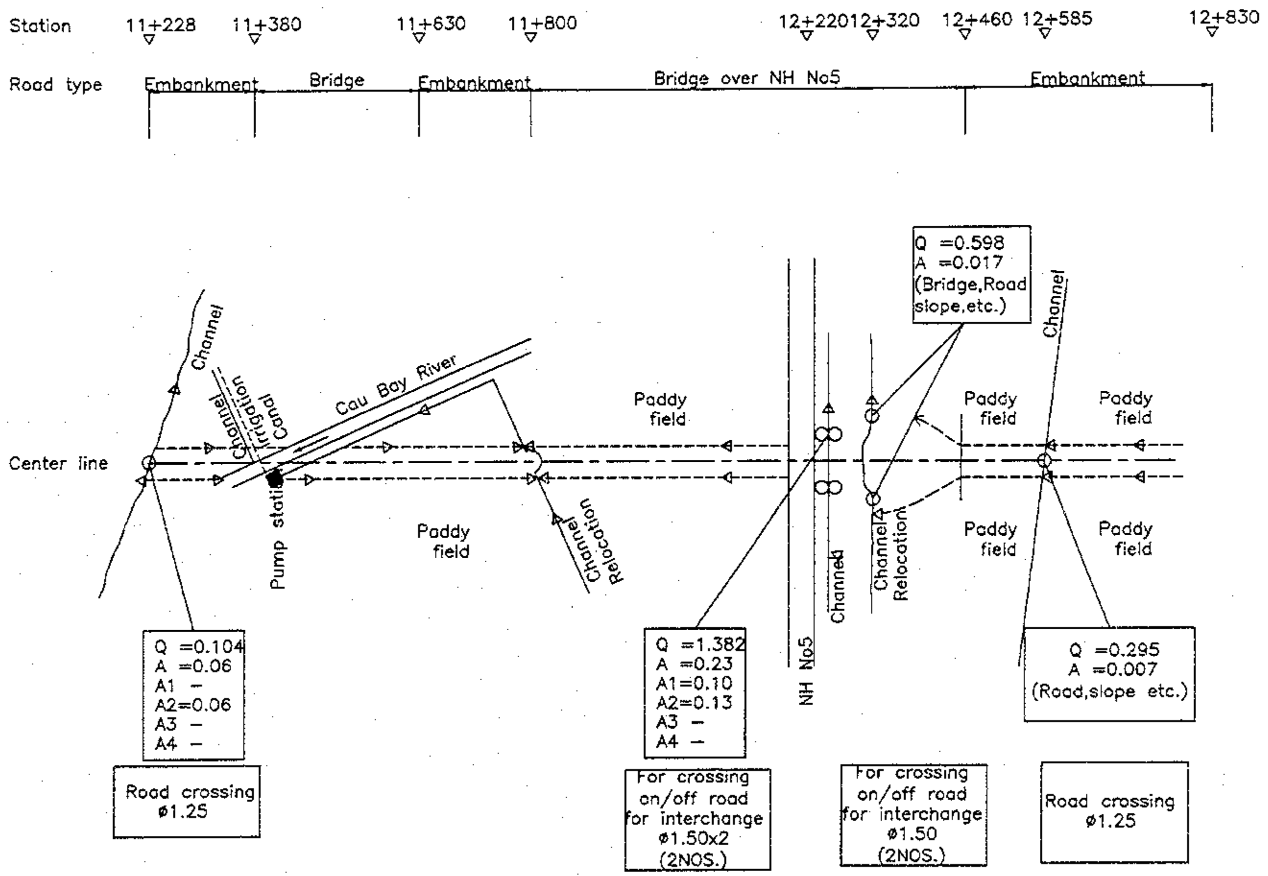


Figure 8.1.1 Schematic Drainage System(4/5)
(Gia Lam side)



Drainage plan

Legend

■ Box culvert

○ Pipe culvert

----▷ Road side drain

Q :Runoff Discharge (m3/s) ,refer to calculation sheets
A :Catchment area (Km2)
A1 :Residential area (Km2)
A2 :Paddy & aquatic vegetable (Km2)
A3 :Farm land (Km2)
A4 :Pond (Km2)

Figure 8.1.1 Schematic Drainage System(5/5)
(Gia Lam side)

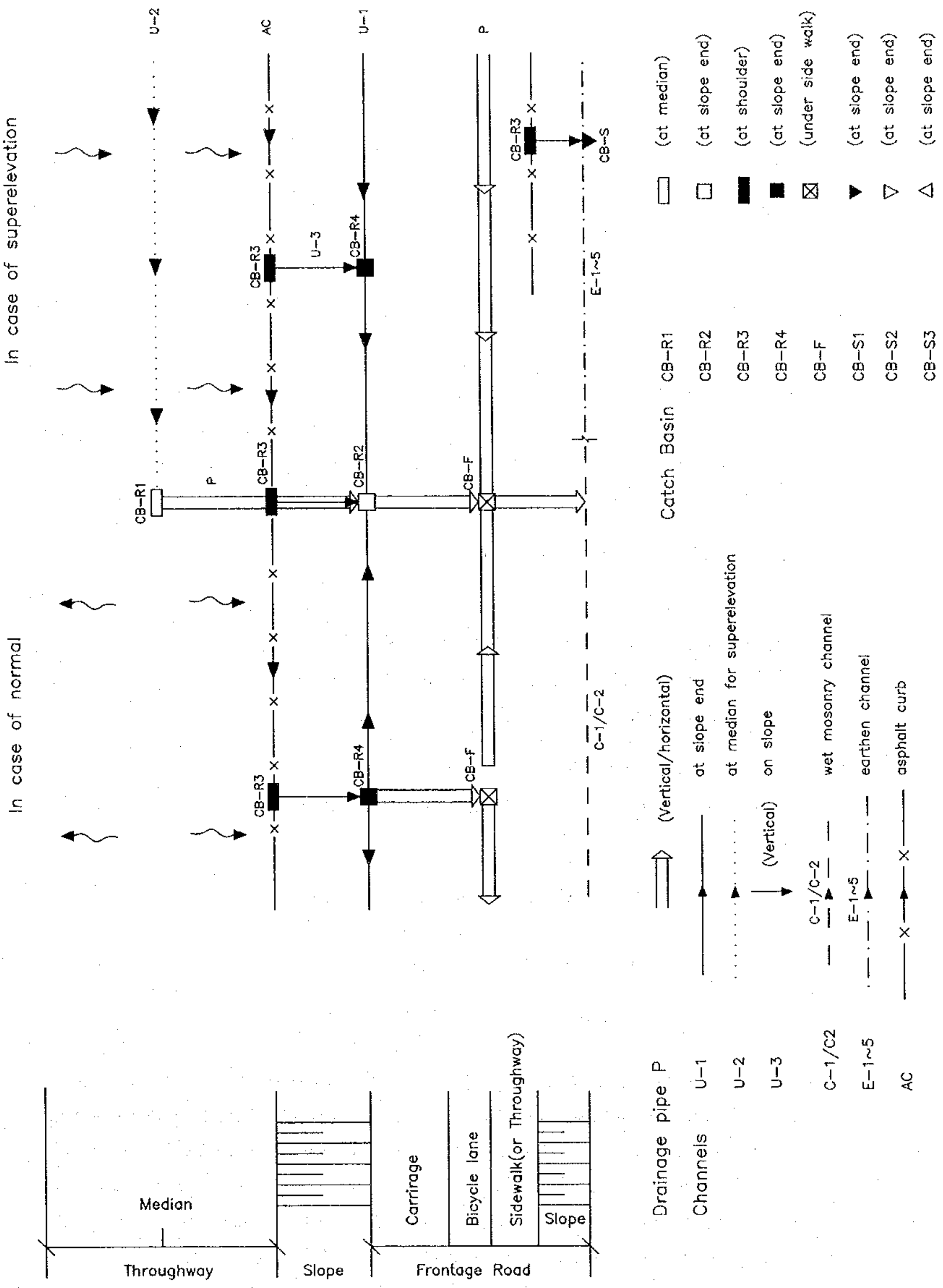


Figure 8.1.2 Schematic Road Drainge

8.2 Rainfall

8.2.1 Rainfall Data

Rainfall has been recorded at Lang, Thanh Tri and Gia Lam meteorological stations, nearby the project site (see Figure 8.2.1). The Lang station is authorized as the member of international meteorological network of observatories, the data observed at the station are reliable, and observing period is longer than other stations. Therefore, the rainfall data observed at the Lang meteorological station were analyzed and applied to drainage facilities designing.

Observation of rainfall on the Thanh Tri side had been executed by the communication post until 1992. On the Gia Lam side, it was recorded from 1960 until 1978 at the Gia Lam Airport, after that recording of rainfall had been carried out at the communication post until 1995.

Collected Rainfall Data (see Appendix)

- Data at Lang Station
  Maximum Single-Day Rainfall (1955 to 1998, 44 years)
  Maximum 10 minutes Rainfall (1957 to 1992, 36 years)
  Maximum 60 minutes Rainfall (- ditto -)

- Data at Thanh Tri Station
  Maximum Single-Day Rainfall (1971 to 1992, 22 years)

- Data at Gia Lam Station
  Maximum Single-Day Rainfall (1960 to 1995, 36 years)

8.2.2 Result of Rainfall Data Analysis

(1) Probability of Rainfall

Probability analysis on rainfall was attempted by utilizing three methods, namely Gumbel, Hazen-Plot and Iwai, and from the results of probability analysis of rainfall, each method had almost the same result. Therefore, the mean value of those results was calculated and applied for the calculation of the runoff discharge for designing road crossing in consideration of the runoff from upstream catchment area. The probability analysis on rainfall data is shown in Table 8.2.1.

- Road Crossing (box/pipe culvert) : 215 mm for one day rainfall (10 year return period) was applied

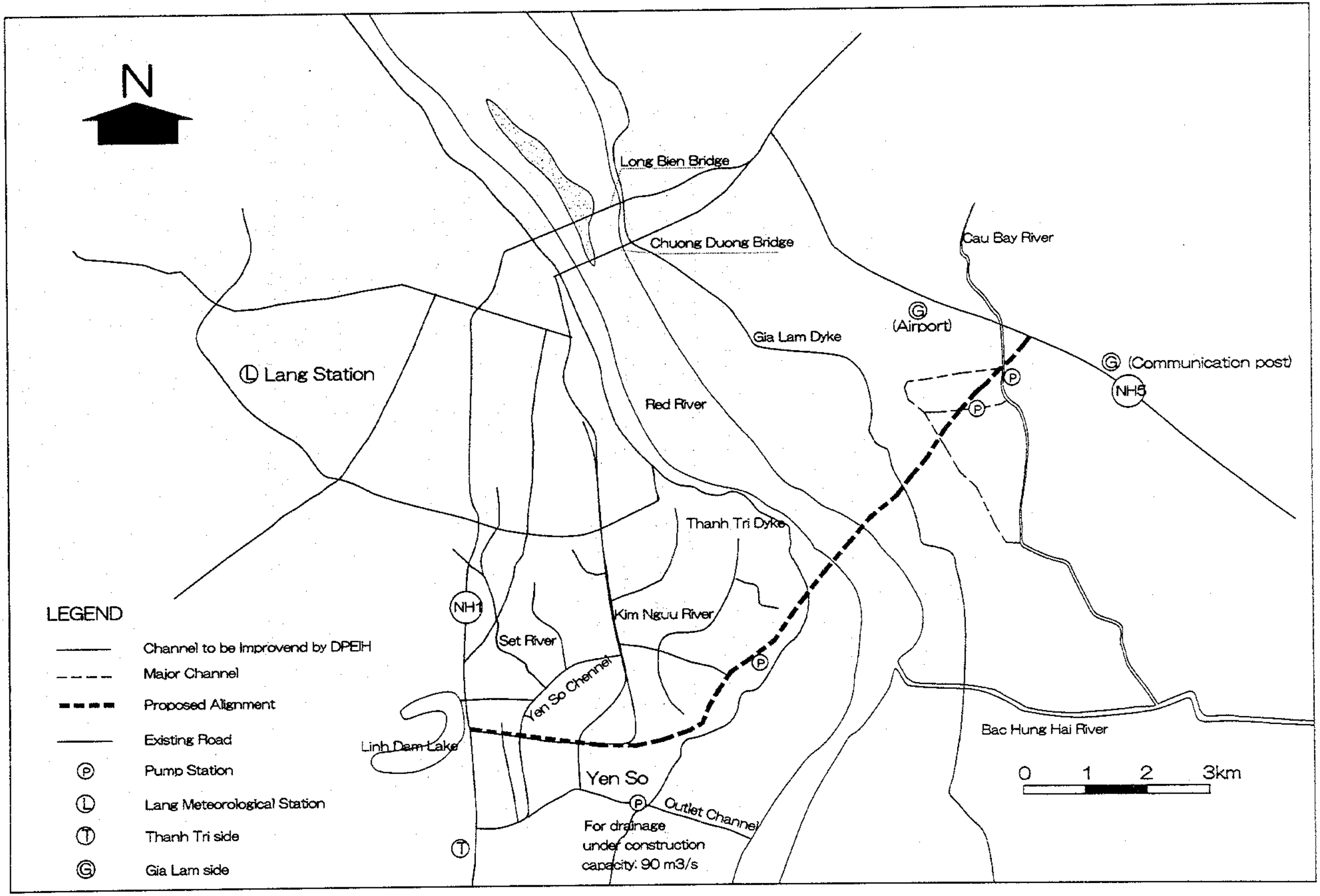


Figure 8.2.1 Condition of Waterways

(2) Rainfall Intensity

The following two (2) formulas for short-time rainfall intensity were developed by Ministry of Construction and the Hanoi Civil Engineering College, respectively. The curves and intensities are shown in Figure 8.2.2.

$$I = 0.36 \bullet \frac{5416\,(1+0.25 \bullet \log p \bullet t^{0.13})}{(t+19)^{0.82}} \qquad \text{(Developed by MOC)}$$

$$I = 0.36 \bullet \frac{5890\,(1+0.65 \bullet \log p)}{(t+20\,p^{0.18})^{0.84}} \qquad \text{(Developed by HCEC)}$$

where I : Rainfall intensity (mm/hr)
p : Return period (year)
t : Time of flood concentration (minutes)

The formula developed by MOC was applied for calculating the runoff discharge originating on the bridge, road and slope of embankment and flowing out rapidly. This is because the calculated rainfall intensities using the formula developed by MOC are moderate and reliable in terms of safety in short-time rainfall in comparison with the formula developed by HCEC.

Besides the result of short time rainfall intensity (10 minutes/60 minutes) probabilities calculated by Gumbel method are also shown in Figures A 8.2.3 and A 8.2.4 (see Appendix). As these probability results are almost as same as that of the formula developed by MOC application of the formula developed by MOC, is adequate.

- 165 mm/h rainfall intensity (3-year return period) in 5 minutes concentration time is applied for calculating the runoff originating on the road and was used for designing drainage facilities to be installed on the road and along the road.

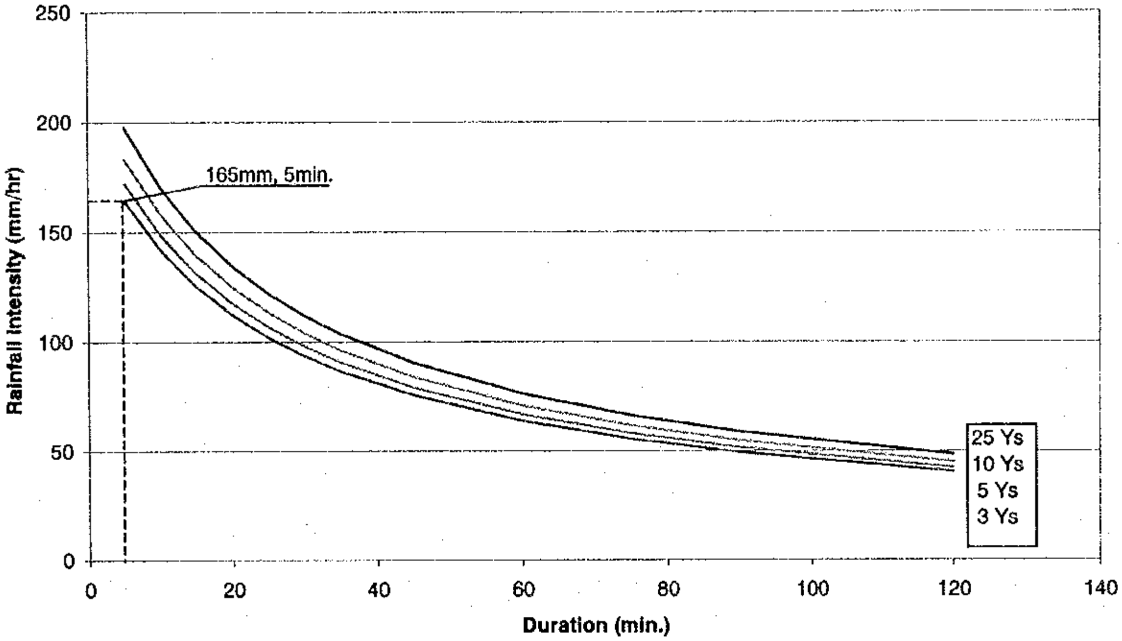


Figure 8.2.2 (1/2) RAINFALL INTENSITY CURVES IN HANOI

Using the formula developed by MOC

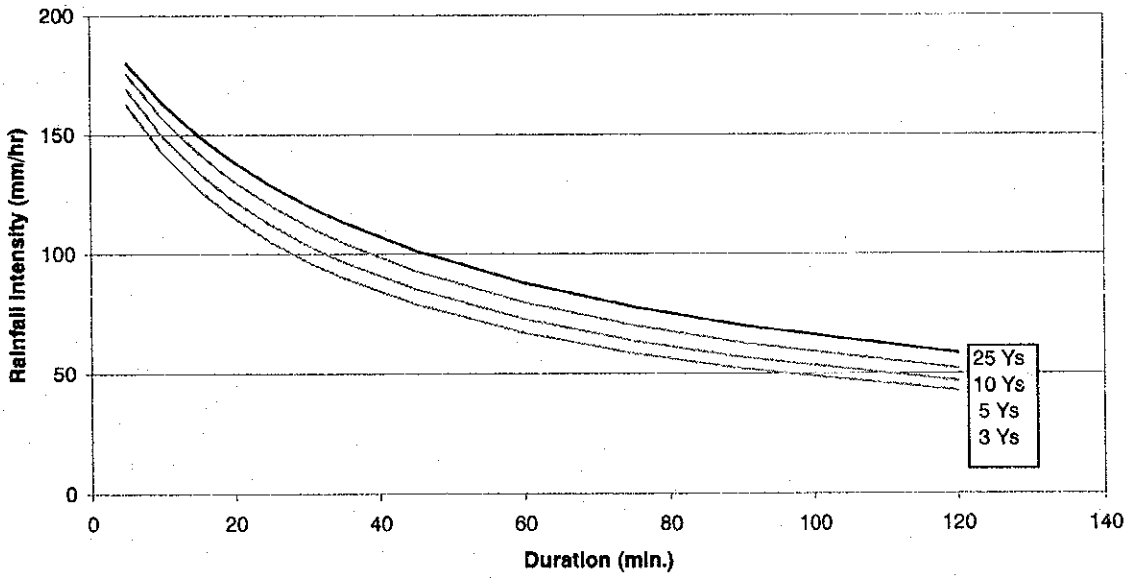


Figure 8.2.2 (2/2) RAINFALL INTENSITY CURVES IN HANOI

Using the formula developed by HCEC

Table 8.2.1 Probability of Rainfall (for one day)

Return Period (Year)	Method			Average (mm)	Remarks
	Gumbel (mm)	Hazen-Plot (mm)	Iwai (mm)		
2	132	124	134	130	
3	158	147	156	154	
4	175	163	170	169	
5	187	176	180	181	
8	212	202	199	204	
10	224	214	208	215	For road crossing
15	244	237	223	235	
20	259	253	234	249	
25	270	265	242	259	
30	279	275	248	267	
40	293	292	258	281	
50	304	304	266	291	
60	313	314	272	300	
80	327	330	282	313	
100	338	343	291	324	
150	358	365	303	342	
200	372	381	313	355	
250	382	394	320	365	
300	391	404	327	374	
400	405	420	335	387	
500	416	432	343	397	

8.3 Physical Condition

8.3.1 Features along Alignment

Drainage area is mainly divided into three parts, namely Thanh Tri side (from No.1 National Highway to right bank dyke of Red River), Gia Lam side (from left bank dyke of Red River to No.5 National Highway) and Red River itself between both dykes (refer to Figure 8.2.1).

(1) Thanh Tri Side

The alignment is planned parallel with existing road (Phap Van Road) from the beginning point (NHW No.1) to dyke road in west-to-east direction after which it turns left then runs into the ponds, farmlands and residential areas along the foot of the dyke road on Thanh Tri side.

Both sides of Phap Van Road or the alignment are inundated through out the year besides residential areas, and such inundated areas with elevation +1.1 m to +3.8 m are utilized as fish ponds and paddy fields. Hanoi is situated on the northern side of the project site, and also on both east and west sides, are situated Thanh Tri Dyke Road and NHW No.1 at the project site.

As for the southern side of the project site, though Kim Nguu River with its flat river bed flows from south to southwest over Phap Van Road as the main drainage channel for the project site at the present, there are also residential areas situated by this river on the southern side. Most of the residential areas are situated above elevations of more than +5.0 m to +5.8 m.

Therefore the proposed alignment is physically to be planned at the depression area with no adequate outlet of drainage on the Thanh Tri side.

(2) Red River Portion

On the right side of the Red River on the alignment, there are barren areas and sand for construction has been collected from the nearby Red River. On the left side of the Red River, certain areas which are not much affected by the river's flow are mainly utilized as farmland for vegetable cultivation and some irrigation facilities, such as pump station and irrigation channels made of brick wet masonry, are found nearby the right of way.

Though certain existing farm roads, as well as irrigation and drainage channels may be slightly affected by the constructing of piers for the main Red River Bridge on the left side of Red River, they can be re-channeled to pass between the piers of the bridge.

(3) Gia Lam Side

The alignment is planned from Gia Lam Dyke road to NHW No.5 toward the northeast direction on the Gia Lam side. On the left side of the alignment is gentle terrain with slope 1/10,000 to 1/14,000 toward southeast, and considerable residential areas with elevation approximate +5.0 m are seen.

On the right side of the alignment, the terrain consists of quite flat paddy fields with elevation +3.5 m to +4.0 m over a wide area. Ponds along both sides of the Gia Lam Dyke Road and NHW No.5, are situated and seem to be linked to each other towards the southeast and the Cau Bay River, which is the main drainage channel at the project site, flows from north to south across NHW No.5.

The runoff originating on the Gia Lam side shall be drained out to the lower areas on the southern side through these waterways and channels installed on the paddy field after being temporarily detained in the paddy fields and the ponds.

8.3.2 Flooding Survey

Since accurate and reliable recorded data regarding flooding conditions on either the Thanh Tri or Gia Lam sides are not available, a hydrological survey consisting of flooding investigation along the alignment and rainfall frequency calculations were conducted.

The result of the hydrological survey conducted by the official agency of Vietnam was reported as follows:

Table 8.3.1 Flooding by Station on Thanh Tri Side

Station Km + m	$H_{84\ survey}$ (m)	$H_{max\ 1\%}$ (m)	$H_{max\ 4\%}$ (m)	$H_{max\ 10\%}$ (m)	Remarks
0 + 120	5.55	5.55	5.40	5.33	
0 + 400	5.50	5.50	5.35	5.28	
0 + 300	5.51	5.51	5.36	5.29	
0 + 520	5.50	5.50	5.35	5.28	
0 + 940	5.45	5.46	5.31	5.24	
1 + 380	5.39	5.39	5.24	5.17	
1 + 700	5.32	5.32	5.17	5.10	Kim Nguu River
2 + 190	5.33	5.34	5.19	5.12	
2 + 600	5.36	5.36	5.21	5.14	
2 + 920	5.36	5.37	5.22	5.15	
3 + 420	5.39	5.39	5.24	5.17	
3 + 640	5.38	5.40	5.25	5.18	
3 + 950	5.41	5.41	5.26	5.19	
4 + 440		5.43	5.28	5.21	
4 + 700	5.42	5.44	5.29	5.22	
5 + 180	5.46	5.46	5.31	5.24	
5 + 460		5.47	5.32	5.25	
5 + 740	5.47	5.48	5.33	5.26	
6 + 120		5.50			$H_{4\%}H_{10\%}$ non flooded
6 + 460		5.51	5.36	5.29	

Note: $H_{84\ survey}$ is the past maximum flooding elevation in 1984.
$H_{max\ 1\%}$ is the estimated flooding elevation 100-year probability.
$H_{max\ 4\%}$ is the estimated flooding elevation 25-year probability.
$H_{max\ 10\%}$ is the estimated flooding elevation 10-year probability.

Table 8.3.2 Flooding by Station on Gia Lam Side

Station Km + m	$H_{84\ survey}$ (m)	$H_{max\ 1\%}$ (m)	$H_{max\ 4\%}$ (m)	$H_{max\ 10\%}$ (m)	Remarks
9 + 010	4.19	4.20	4.05	3.98	
9 + 350	4.18	4.20	4.05		$H_{max10\%}$ non flooded
9 + 600	4.18	4.20	4.05	3.98	
9 + 950	4.18	4.20	4.05	3.98	
10 + 160	4.18	4.20	4.05	3.98	
10 + 500	4.18	4.20	4.05		$H_{max10\%}$ non flooded
11 + 120	4.17	4.20	4.05	3.98	
11 + 560	4.17	4.20	4.05	3.98	
12 + 145	4.17	4.20	4.05	3.98	
12 + 280	4.20	4.20	4.05	3.98	
12 + 525	4.20	4.20	4.05	3.98	
12 + 860	4.21	4.20	4.05	3.98	

Note : $H_{84\ survey}$ is the past maximum flooding elevation in 1984.
$H_{max\ 1\%}$ is the estimated flooding elevation 100-year probability.
$H_{max\ 4\%}$ is the estimated flooding elevation 25-year probability.
$H_{max\ 10\%}$ is the estimated flooding elevation 10-year probability.

8.3.3 Characteristics of Existing Drainage System

(1) Channel Network

Though there are a few channels which are distinct irrigation channels such as the channel connected to the pump station at the site on both Thanh Tri and Gia Lam sides, most channels are utilized as dual-purpose channels for irrigation and drainage and connected to each other (including ponds) in a network.

Furthermore this network of existing channels functions well as a retarding basin to eliminate the peak runoff discharge totally for the protection of inundation for residential areas especially on Thanh Tri side.

Therefore it is indispensable that not only the channels but also ponds affected or interrupted by embanking road of the project should be absolutely connected to any channels or ponds located nearby.

(2) Flow in Channel

Water in the most of existing channels on both Thanh Tri and Gia Lam sides is usually stagnated. Thus, since water does not always flow in a channel, aquatic vegetables are cultivated or aquatic weeds are naturally propagated in the existing channels at present.

This means that the most of existing channels do not have certain longitudinal slope and the water shall not flow unless the discharge in the channel is becomes somewhat greater. Actually, water will start to flow if the water surface gradient in the channel has proper gradient under the adequate physical conditions such as raining or flooding.

(3) Evaluation of Existing Channel System

Some of the existing large scale channels of 8 m to 10 m in width and 1.5 m to 2.0 m in height have proper capacity to be able to drain out the discharge corresponding to the runoff originating in their catchment area.

In general, box or pipe culverts have been installed at the road crossing in channels at present. However, their capacity (opening) to drain out the discharge is rather small in comparison even in the above-mentioned large-scale channels. Therefore, when there is a heavy rainfall, the road crossing facilities are the weak link or neck of the existing channel system for flooding at present.

8.4 Drainage Project for Environment Improvement in Hanoi (DPEIH)

The drainage project (First Stage) for environmental improvement has been implemented to improve the drainage system in Hanoi City.

In the project, rivers and drainage channels, including ponds and lakes, shall be rehabilitated, dredged and widened, and then the runoff originating in Hanoi City and from its upstream catchment shall be precisely planned to convey through the above-mentioned improved facilities to the Yen So Reservoir. Furthermore, certain gates for flooding and pumps for controlling water level at To Lich River and Nhue River shall be installed as well.

In connection, the bottom of the Yen So Reservoir has been dredged to be +0.5 m in elevation to retain the runoff discharge with a capacity of 3,870,000 m^3 for flood control. In particular, the water level must be controlled at the maximum elevation +4.5 m at Yen So Reservoir at flooding (against 10-year return period rainfall) to drain the runoff out to Red River by mechanical drainage system (pump station with capacity 90 m^3/s).

Therefore, flooding and inundation on Thanh Tri side will be noticeably eliminated after project completion. The details of DPEIH are shown in Table 8.4.1 as reference.

8.5 Application to Drainage Facilities Designing

In order to provide appropriate designing of drainage facilities and road facilities economically and conveniently, especially to avoid excessive design, the following applications are introduced.

Table 8.4.1 Drainage Project for Environmental Improvement in Hanoi (DPEIH) Work Items of 1st and 2nd Stage Projects (1/2)

Item	First Stage Project	Second Stage Project
1. Yen So Pumping Station		
(1) Pumping Station	Q = 45 m3/s	Q = 45 m3/s
(2) Inlet Structure	B = 200 m	--
(3) Inlet Channel	L = 1,200 m	--
(4) Ordinary Drainage Channel	L = 1,900 m	--
(5) Outlet Sluiceway	A = 30 m2	A = 30 m2
(6) Outlet Channel	L = 1,600 m	--
2. Yen So Regulating Reservoir		
(1) Regulating Reservoir	A = 203 ha (130ha)	--
(2) Yen So Channel	L = 3,400 m	--
(3) Spoil Bank	A = 40 ha	--
3. Linh Dam and Dinh Cong Lakes		
(1) Linh Dam Channel	L = 1,000 m	--
(2) Linh Dam Lake	--	A = 107 ha
(3) Dinh Cong Channel	--	L = 400 m
(4) Dinh Cong Lake	--	A = 25 ha
4. Floodgates and Control Gates	7 places	--
5. River Improvement		
(1) To Lich and Lower Lu River System	L = 22.1 km (Lower Lu = 3.2 km)	--
(2) Set and Upper Lu River System	L = 7.5 km (Upper L = 3.1 km)	--
(3) Kim Nguu River System	L = 3.4 km	--
6. Drainge Channel Improvement		
(1) To Lich and Lower Lu River Basin	Bridges/Box Culverts (21 places)	Channel works (L=16.4km) and Bridges/Box Culverts (24 places)
(2) Set and Upper Lu River Basin	Bridges/Box Culverts (13 places)	Channel works (L=3.7km) and Bridges/Box Culverts (2 places)
(3) Kim Nguu River Basin	Bridges/Box Culverts (21 places) (21 places)	Channel works (L=10.7km) and Bridges/Box Culverts (1 places) Bridges/Box Culverts (1 places)

Work Items of 1st and 2nd Stage Projects (2/2)

Item	First Stage Project	Second Stage Project
7. Lake Improvement		
(1) Lake Dredging	4 lakes	14 lakes
(2) Lake Conservation	Aeration in 2 lakes as a pilot project	Overall environmental measures for 11 lakes
8. Sewre Rehabilitation and Construction		
(1) West Lake Basin	Rehabilitation	New construction/Rehabilitation
(2) To Lich River Basin	Rehabilitation	New construction
(3) Lower Lu River Basin	--	New construction
(4) Hoang Liet Drainage Basin	--	New construction
(5) Set River Basin	Rehabilitation	New construction
(6) Upper Lu River Basin	Rehabilitation/New constructio	New construction
(7) Kim Nguu River Basin	Rehabilitation/New constructio	New construction
(8) Yen So Drainage Basin	--	New construction
9. Equipment Supply for Cleanup of Drainge Channels and Sewers	Grab bucket excavator, water jet cleaner, etc.	-- --

(1) For Road Crossing Drainage

a. Assessment of Drainage Degree

In accordance with the standard of Vietnam for designing road crossing, 50-year return period rainfall is applied. The 50-year return period is applied for most areas in terms of designing facilities for safety.

However, for an area such as the project site where the inundation or flooding is physically anticipated, it will be slightly uneconomic if the road crossing drainage facilities are designed using the 50-year return period rainfall. Even if the 50-year return period scale facilities was introduced, inundation or flooding would not be avoided physically.

Therefore the 10-year return period rainfall, which is the same as the standard of DPEIH, is applied for calculating the runoff discharge to decide the capacity of the road crossing as mentioned in 8.6.2.

b. Intensity of Drainage

The peak runoff discharge from residential areas, bridge surface, road surface and its embankment is generally calculated using rational formula. As for the runoff discharge originating on agricultural land, in consideration of the specific project site condition and the function of existing channel network, the following drainage intensity for paddy fields and farmland are introduced on the basis of their different environmental cultivation conditions.

- Paddy Fields

Paddy fields can remain relatively unaffected from an inundation lasting one day, so the runoff should be drained out from the paddy field area within 24 hours.

$$Q = \Sigma R * 10^{-3} * f * 10^{6}/86{,}400 \ (m^3/s/km^2)$$
$$= 1.74 \ (m^3/s/km^2)$$

Where : Q = Unit drainage intensity
R = Daily rainfall (mm)
215 mm/day (10 year return period)
f = Runoff coefficient (0.7)

- Farmland (vegetables)

Since vegetables are somewhat weaker against inundation in comparison with the paddy, the runoff should be drained out from the farmland area as soon as possible, and within 4 hours.

$$Q = \Sigma R * 10^{-3} * f * 10^6/3{,}600 * 4\ (m^3/s/km^2)$$
$$= 5.22\ (m^3/s/km^2)$$

Where : Q = Unit drainage intensity
R = Daily rainfall(mm)
215 mm/day(10 year return period)
f = Runoff coefficient (0.35)

(2) For Road Embankment

a. Relevant Elevation to the Project

The formation of the relevant major existing roads, the surveyed elevation of flooding and regulated water level at the Yen So Reservoir (refer to Paragraph 8.4) are readjusted as follows;

Table 8.5.1 Relevant Elevation to the Project

Existing Road	Formation (EL.)	Flooding (EL.)
NHW No.1	+5.5m to +5.7m	+5.55m (Max. at Thanh Tri)
Phap Van - Cau Gie	+6.0m (Min.)	+5.55m (Max. at Thanh Tri)
Nguyen Tam Trinh	+5.3m to +5.5m	+5.55m (Max. at Thanh Tri)
Linh Nam	+5.5m to +5.7m	+5.55m (Max. at Thanh Tri)
NHW No.5	+5.3m to +5.4m	+4.20m (Max. at Gia Lam)

- Regulated water level at the Yen So Reservoir : EL. 4.5 m (Thanh Tri)
- Formations of road are existing height, except Phap Van - Cau Gie (planned)

b. Road Embankment for Flooding

The throughway (toll way), frontage road (carriage, bicycle lane and sidewalk) are planned in the project and the major part of these roads shall be constructed in embankment except for the Red River Portion.

Since it is stipulated in the Vietnam Standard that toll way should be avoidable against a 100-year return period inundation or flooding, the formation of the toll way is planned in consideration of the maximum elevation of flooding surveyed that is corresponding to 100-year return period.

It would thus be better economically and for convenience sake that the other category roads such as of frontage road, bicycle lane, and sidewalk are separately planned in consideration of the smooth transition approach to the above-mentioned major existing roads and the tolerance of the least and short-time inundation or flooding on the road, in case of emergency.

In addition to the above considerations, it is expected that the current situation of inundation or flooding on the Thanh Tri side shall be immensely and noticeably improved by the DPEIH in the near future.

On the basis of the above, these considerations and other specifications of road, and formations by road category are planned as follows;

Table 8.5.2 Finished Formation by Road Category on Thanh Tri Side

Road	Basic Elevation (EL.)	Freeboard (m)	Crossfall/ Super-elevation (m)	Proposed Min. Formation (EL.)
Toll Way	+ 6.0m	0.50m	0.70m	+ 7.20m
Carriage	+ 6.0m	---	---	+ 6.00m
Bicycle Path	+ 6.0m	---	---	+ 6.00m
Sidewalk	+ 6.0m	---	---	+ 6.00m
Arterial Road	+ 6.0m	---	---	+ 6.00m

Note: 1. Basic Elevation is determined in consideration of a flooding to be occur unexpectedly in future and the convenient approach to the existing major road.
2. Arterial Road is the road crossing for vehicle and pedestrian.

Table 8.5.3 Finished Formation by Road Category on Gia Lam Side

Road	Basic Elevation (EL.)	Freeboard (m)	Crossfall/ Super-elevation (m)	Proposed Min. Formation (EL.)
Toll Way	+ 5.5m	0.50m	0.70m	+ 6.70m
Carriage	+ 5.5m	---	---	+ 5.50m
Bicycle lane	+ 5.5m	---	---	+ 5.50m
Sidewalk	+ 5.5m	---	---	+ 5.50m
Arterial Road	+ 5.5m	---	---	+ 5.50m

Note: 1. Basic Elevation is determined in consideration of the convenient approach to the existing major road and physical condition especially residential area elevation.
2. Arterial Road is the road crossing for vehicle and pedestrian.

8.6 Drainage Facilities Designing

As some drainage and irrigation channels, especially at the site of constructing road embankment on the right of way, will be interrupted and affected by the project implementation, such interrupted and affected channels should be amended by some means or others, for example by installing box/pipe culverts for road crossing, etc.

Thus, it is the principal of drainage design that their existing system and network are not changed drastically. Consequently, the runoff from surrounding catchment area, the bridge, the road and their related facilities is to be drained out through those amended channels and drainage facilities to be introduced in and along the road to downstream smoothly.

8.6.1 Design Considerations and Assumptions

The following points are considered for the drainage facilities design.

(1) Since this is a project for construction of a bridge and road connected to it, drastic drainage system improvement must be entrusted by other drainage projects of mechanical drainage such as DPEIH. This is because it is physically very difficult to drain out the peak runoff discharge from certain areas due to flat terrain, low elevation and high ground water level in comparison with terminal direction of drainage that has to be Red River water level.

(2) However, the cross sectional flow area of box/pipe culvert and other drainage facilities to be installed in and along the road must be ensured to drain out the capacity of the peak runoff discharge in consideration of the implementation of the above-mentioned drainage project in the future.

(3) Without the total implementation of the above-mentioned drainage project, flooding may occur temporarily, unless. (This project will provide only partial drainage improvement.)

(4) In case of flooding, interrupted areas on both sides of the road embankment will be equally inundated.

(5) The channels and ponds to be affected or interrupted by embanking road must be connected to channels or ponds nearby.

(6) The runoff to be born at the Red River portion must be disposed to drain into the river directly, so that drainage facilities are not considered in particular except for a catch basin and its accessories to be installed on the bridge.

8.6.2 Drainage Facilities Designing Criteria

Drainage facilities such as channel, box/pipe culvert and so on are designed in accordance with the following procedure.

(1) Drainage Facilities Capacity

To determine the capacity of the drainage facilities, the runoff discharge is calculated by the following standard, in terms of the importance of the highway. As for the rainfall, Paragraph 8.2 is referred to.

Table 8.6.1 Standard of Rainfall Probability by Facilities

Facilities	Rainfall Probability
Bridge, surface of road and embankment slope for general drainage	3-year return period
Road crossing for substantial drainage facilities	10-year return period

(2) Runoff Discharge

As for the determination of capacity of drainage facilities, the following Rational Formula to calculate the peak runoff discharge is applied.

$Qp = 1/3.6\, fp\, \gamma t\, A$ where Qp : Peak Discharge (m^3/s)

A : Catchment Area of (km^2)

γt : Rainfall Intensity during the Flood (mm/hr)

fp : Peak Runoff Coefficient

Table 8.6.2 Conventional Peak Runoff Coefficient

Topography	fp
Residential areas	0.80
Green areas and parks	0.35
Paddy fields under irrigation	0.70
Lakes and ponds	1.00
Utilities (Roads and Squares)	0.90
Other areas (Farmland, etc.)	0.35

(3) Rainfall Intensity

1) Runoff Discharge from Bridge, Road and Its Slope

As for the rainfall intensity to be utilized for calculating the runoff discharge from bridge, road and its slope, the formula developed by Ministry of Construction is applied. (refer to Paragraph 8.2 Rainfall)

2) Runoff through Channel

The following formula is also applied for determining the rainfall intensity for the calculation of the peak discharge of the channel for road crossing in combination with the following concentration time.

$\gamma t = R24/24\ (24/t)^n$ Where γt : Rainfall Intensity during the Flood (mm/hr)

R24: Maximum daily rainfall

t : Flood concentration time

n : Coefficient (2/3)

(4) Concentration Time (t)

Concentration time will fluctuated greatly depending on topographic conditions, size and shape of catchment area, however, concentration time is actually adopted or calculated on the basis of the past experience as follows:

$Tc = t1 + t2$ where Tc : Concentration time

t1 : Time of inflow to channel

t2 : Time of flow in channel

Table 8.6.3 t1 by Type of Area

Type of Area	t1 (in minutes)
Completed paved area	5
Sloped developed area	10 - 15
Flat inhabited area	20 - 30

t2 is generally calculated and applied for determining the rainfall intensity for designing road crossing using Rziha's formula below.

$Tc = L/w$ (hr) Where Tc : Flood concentration time(hr)
$W = 72(H/L)^{0.6}$(Km/hr) w : Propagation velocity of flow(km/hr)
L : Horizontal length of catchment basin (km)
H : Height difference of catchment basin (km)

Finally t1 applies 5 minutes for calculating the runoff discharge for drainage facilities to be installed in and along the road for safety. (refer to Appendix)

(5) Catchment Area

The catchment area and its channel length are measured based on the map having a scale of 1 to 10,000 for calculating the runoff discharge for the road crossing. For the drainage facilities in and along the road, detailed road plan with a scale of 1 to 2000 was utilized for measuring catchment area.

8.6.3 Design of Drainage Facilities

(1) Design Discharge

Design discharge for drainage facilities are to be calculated in accordance with Section 8.6.2.

(2) Design Water Level

On the Thanh Tri side, as some drainage channels shall be basically and ultimately connected to the drainage channel to be improved in the DPEIH Project, design water level is considered as the water level of the drainage channel of the DPEIH

Project. And also design water level on both the Thanh Tri and Gia Lam sides are determined in consideration of the physical conditions, topography, existing channel bed elevation, its cross sectional area, and so on.

(3) Hydraulic Design (Mean Velocity Formula)

Manning's formula (below) is applied to calculate in principal the mean velocity of drainage facilities, channel box/ pipe culvert and other facilities.

$Q = A \cdot V$ where Q : Discharge (m^3/sec)

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

A : Sectional area (m^2)

V : Mean velocity (m/sec)

R : Hydraulic radius (m)

I : Hydraulic gradient

n : Coefficient of roughness

(4) Coefficient of Roughness

Standard values of coefficient of roughness for Manning's formula are shown in the following table, where 0.015 is applied for box and pipe culvert and 0.03 is applied for earthen channel. In case of the brick wet masonry channel which is a typical irrigation channel in Vietnam, 0.016 is applied.

Table 8.6.4 Standard Values of Coefficient of Roughness

Material or conditions of Channel	Coefficient of Roughness
Concrete	0.015
Concrete block	0.016
Concrete sheet pile	0.016
Steel sheet pile	0.025
Earthen Channel	0.03 ~ 0.05

(5) Allowable velocity

Velocity in box culvert or pipe culvert must be less than the allowable maximum velocity 3.0 m, which is derived from preventing material erosion. The allowable minimum velocity 0.45 is to be kept in principal for preventing sedimentation or to control growth of water weeds which pose as obstacles to smooth flow.

8.6.4 Specification of Channel and Culvert

(1) Specification of Channel

Certain channels will be faced with the inevitable situation of not being able to cross the embankment of road on the proposed alignment smoothly and must be relocated. For this reason, the following specifications with hydraulic considerations to secure flow in a channel are applied at the curve portion.

- Maximum intersection angle : 60°
- Minimum radius of curve : 30 m

(2) Specification of Culvert

Culverts to be installed at road crossing are generally divided into box culvert and pipe culvert. On the basis of the calculated runoff discharge, the culvert is provisionally categorized in consideration of the site condition, the type and scale of existing facilities and existing channel width and slope, etc. for the project as follows;

- Box Culvert: Calculated runoff discharge more than 5.0 m^3/s.
- Pipe Culvert: Calculated runoff discharge less than 5.0 m^3/s.

In case of a pipe culvert of more than thirty (30) meters in length, in accordance with the Specification of Vietnam, the diameter of pipe culvert is minimum 1.25m in consideration of maintenance.

(3) Maintenance

Periodical maintenance for the drainage facilities installed in and along the road is vital for maintaining convenient transportation of vehicles and pedestrians without hindrance.

Thus, the drainage facilities are introduced and designed in consideration of maintenance, the depth of embankment from top of the drainage facilities and so on in accordance with the Vietnam Standard. However, the length of the culvert is to be longer than that installed in other normal roads as they are installed in the throughway with frontage road. It is anticipated that certain culverts may not be maintained by hand from hygienic and medical aspect.

Therefore an appropriate maintenance system and organization introducing maintenance equipment for drainage facilities including pipe culvert should be established.

8.7 Arrangement of Drainage Facilities

8.7.1 Drainage Facilities on the Road

In order to retain the smooth-flowing traffic, the following drainage facilities are to be installed on the road, and the following evaluated results are applied for installing those drainage facilities as a standard arrangement (refer to Figure 8.1.2 Schematic Road Drainage).

8.7.2 Drainage Facilities on Throughway

(1) Median Drainage

Drainage facilities for draining out the runoff through the median need to be considered, particlarly at the stretch of super-elevation in road formation.

It is difficult to drain out the runoff at the stretch of super-elevation, as the sectional flow area on the road to be utilized as a drain is not greatly considered. Therefore, the drainage channel and catch basin to be installed in the median are introduced.

Their dimensions and intervals were fixed in consideration of road crossing slope, width of road, road profile gradient, etc. (e.g., road crossing slope is slightly larger in comparison with its standard (2.0 %) at the stretch of super-elevation, the minimum road profile gradient is 0.3 % in general) as follows:

- Median Drainage Channel : 300 mm * 300 mm (This dimension was decided in terms of safety. Refer to Figure A 8.1.1, Table A 8.1.1)
- Median Catch Basin : about 100 m interval installation (refer to Figure A 8.1.1, Table A 8.1.1)

(2) Shoulder Catch Basin for Throughway Drainage

To drain out the runoff originating on the throughway, road shoulder catch basin, which collects the runoff to be introduced along asphalt curb, is to be installed on the throughway's shoulder.

The runoff is drained out to lower area through this shoulder catch basin, channel on the slope and the slope end catch basin for the throughway drainage. (to be explained in the next paragraph)

As the interval of throughway shoulder catch basin varies by road profile gradient and road width, it is evaluated on the basis of each condition of that width of throughway (12.5, 15.0 and 20.0 m). The result of the interval evaluation for the throughway shoulder catch basin is as follows;

- Minimum Interval : about 40.0 m (This is derived from the standard specification of road formation profile gradient (minimum 0.3%), road crossing slope (2.0 %) and road width 12.5 m in principal. Refer to Figure A 8.1.2 and Table A 8.1.2)
- Maximum Interval : about 100 m (in consideration of the drainage capacity of lower drainage facilities and past project drainage system.)

(3) Throughway Slope End Drainage Channel and Catch Basin

The drainage channel and catch basin to collect the runoff originating on the throughway and its slope shall be installed at the toe of throughway slope. This drainage channel shall be rather larger than the channel to be installed in the median as this must receive the runoff from the throughway and its slope.

The evaluation of the drainage channel was conducted in five cases (by various channel dimensions) and thus the channel, 0.5 m in width and 0.5 m in height is applied in consideration of the smooth draining of the runoff.

The maximum interval of catch basin for this drainage channel is about 200 m, based on the standard gradient of profile (minimum 0.3 %) of frontage road, applied deciding the interval of catch basin to be connected to the catch basin of frontage road.

The actual interval of catch basin of this drainage channel shall be regulated by the interval of throughway shoulder catch basin for throughway drainage. (refer to Figure A 8.1.3, Table A 8.1.3)

- Throughway Slope End Channel : 500 mm * 500 mm
- Throughway Slope End Catch Basin Maximum Interval : about 200 m

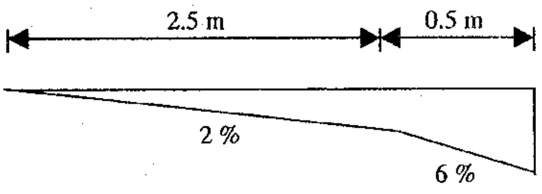
8.7.3 Frontage Road Drainage

(1) Catch Basin under Sidewalk

The runoff born on the frontage road shall be drained out to the lower area through this catch basin and its drainage pipe to be installed under the sidewalk.

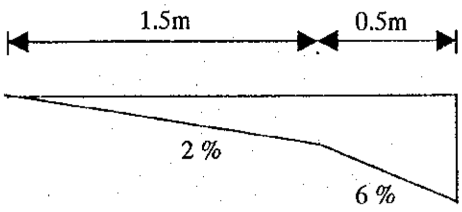
As water runoff on the frontage road is not suitable for the safe passage of vehicles, it is deemed that the drain sectional area be kept on the bicycle lane. The following two assumptions were evaluated and assumption A (case-1) was adopted.

Assumption A : Drain area 3.0 m width corresponding to the total width of bicycle lane (Case-1)



Bicycle Lane

Assumption B : Drain area 2.0 m width corresponding to the 2/3rd width of bicycle lane (Case-2)



Bicycle Lane

The interval of catch basin is about 50.0 m at the minimum standard profile gradient (0.3 %) of the frontage road on the basis of the above assumption, case-1. However in addition to the above assumptions, as the drainage pipe to be installed under the sidewalk shall be evaluated in terms of its maintenance, the interval of catch basin is 20.0m in accordance with the standard of Vietnam. (refer to Figure A 8.1.4, Table A 8.1.4)

- Interval of catch basin : 20.0 m(It is decided based on the Vietnam standard that is 17.0 m catch basin interval for Ø750 pipe. Even in case of gentle profile gradient of pipe, the runoff shall be drained out as explained in the next paragraph.)

(2) Drainage Pipe under Sidewalk

Based on the drainage system, the standard length of frontage road for drainage stretch is about 300.0 m even in longer one, or otherwise to be regulated within about 300.0 m in the drainage system.

Therefore, the runoff originating on the frontage road (carriageway, bicycle lane and sidewalk) is about 0.2m^3/s. Furthermore, considering the runoff from the throughway, mentioned above, the runoff shall be about 0.4 m^3/s, or otherwise to be regulated within about 0.4m^3/s in the drainage system.

The profile gradient of frontage road shall be kept over 0.3 % in principal, keeping the installation gradient (0.3 %) of drainage pipe (Ø750) line, about 0.5 m^3/s discharge could be let. Considering this assumption and other physical conditions at the site, particularly flat terrain, Ø750 drainage pipe must be suitable as it is difficult to secure the appropriate depth and its profile gradient for installing pipe in case of a larger diameter pipe. Therefore Ø750 drainage pipe is applied. (refer to Table A 8.1.5)

8.8 Proposed Plan

In accordance with the aforementioned drainage facilities design, though the road crossing and other drainage facilities are designed and shown in the Detailed Drawings prepared separately, items regarding the road crossing are briefly mentioned in the following Tables 8.8.1 and 8.8.2.

The site recognition such as catchment area delineation and its land use present and future, the existing drainage channels system, etc. observed through careful site investigation, are reflected in this detailed drainage facilities design.

Table 8.8.1 Existing Waterways and Road Crossing Plan(1/3)

Thanh Tri Side

Sta.	Existing Condition	Plan				Description
		Box/Pipe	Lane No.	Length(m)	Discharge(m3/s)	
0 + 510 0 + 517	B=10.0m, H=2.0m with levee(1.5m) both sides, culvert for crossing is only B=2.0m H=1.0m,	4.0m * 2.50m Box Culvert 4.0m * 2.50m Box Culvert	1 1	39.50 39.50	5.844	2 Box culverts for crossing frontage road are planned, In order to secure the proper capacity of drainage, bed elevation of the culvert is planned lower than existing ground elevation, Existing channel course is relocated because the channel is filled for embanking ramp road to interchange. This channel shall be improved by Drainage Project for Environment Improvement in Hanoi(DPEIH) later.
0 + 800 ~ 1 + 700	B=25.0m, H=2.0m with levee(2.0m) one side					Yen So channel, regulating reservoir and other facilities at this stretch shall be improved by DPEIH, Existing channel shall be improved to be Yen So channel at Sta. 0+800,
1 + 700	Kim Nguu river, Bridge L=53.0m, Confluence between Kim Nguu river and Set river exists at just slightly upstream,					For crossing Kim Nguu river, the bridges are planned on the throughway and both frontage roads,
2 + 397	B=10.0m, H=2.0m with levee(1.5m) both sides, culvert for crossing is B=4.5m H=1.5m,	4.0m * 2.50m Box Culvert	1	93.00	6.301	In order to secure the proper capacity of drainage, bed elevation of the culvert is planned lower than existing ground elevation. On the basis of the calculated runoff discharge, cross sectional area of flow for the culvert is planned to be larger than existing one.
3 + 089	Pond	ϕ1.25m	1	74.60	-	Necessary for connecting ponds cut off by embankment, *Vietnam Standard,
3 + 656	Pond	ϕ1.25m	1	74.20	0.273	Necessary for connecting ponds cut off by embankment, *Vietnam Standard,
3 + 973	B=8.0m, H=3.0m, along existing road toward graveyard	ϕ1.25m	1	101.60	0.119	Ultimately the channel is connected to existing channel to be improved by DPEIH, *Vietnam Standard,
4 + 553	B=4.0m, H=1.5m along existing road	ϕ1.25m	2	77.00	1.816 (1.935)	Including the discharge from Sta. 3 + 970, To be relocated in consideration of the existing channel diagram and location of Pagoda,
4 + 890	B=10.0m, H=3.0m, along existing road nearby the warehouse	2.0m * 2.0m Box Culvert	1	104.00	1.756 (2.562)	Including the discharge from Sta. 5 + 300 and 5 + 650, This channel is at the middle of residential area, In consideration of sewerage and consequent hygienic matters, box culvert is planned in terms of periodical maintenance. Ultimately the channel is connected to existing channel to be improved by DPEIH
5 + 262	Pond	ϕ1.25m	1	91.80		Necessary for connecting ponds cut off by road embankment, Vietnam Standard,
5 + 300 ~5 + 650	B=8.0m, H=2.0m with levee(2.0m) both sides				0.425 (0.805)	Since the existing drainage network is changed by road embankment, the channel is temporarily planned to connect to Sta. 5 + 300 directly until Lin Nam road is improved, Relocation channel(earthen) is excavated, Including the discharge from Sta. 5 + 650,
5 + 550	B=3.0m, H=2.0m with levee(1.0m) both sides					Though the pump station is in the right of way, the pump has not been used, Road crossing for connecting to the pump station shall not be required,
5 + 650	B=4.0m, H=3.0m along Mai Dong st. in the residential area				0.380	Until Lin Nam road is improved, the channel is temporarily connected to the abovementioned relocated channel,
6 +170	B=1.0m, H=0.5m both sides along existing road passing by the cement factory	ϕ1.25m ϕ0.60m (for crossing existing road)	1 1		1.138 1.429	The tollplaza is set up around here, Therefore the channel to collect the discharge from the tollplaza is installed surrounding the tollplaza, Road crossings to cross the existing road nearby the tollplaza are also installed,

Table 8.8.1 Existing Waterways and Road Crossing Plan(2/3)

Gia Lam Side

Sta.	Existing Condition	Plan				Description
		Box/Pipe	Lane No.	Length(m)	Discharge(m3/s)	
9 + 383	B=3.0m, H=1.5m along existing road from the residential area	ϕ 1.25m	2	90.75	1.940	This channel is relocated and connected to the existing channel in consideration of the location of the abutment of bridge, grave yard and interchange, The beginning point of the channel is pond and it is consistent with the existing channel network,
9 + 530	B=2.0m, H=0.5m with levee(1.0m) both sides					The runoff from the upstream is collected at this road side drain planned in the Project, since the existing channel passing in the planned interchange are removed,
9 + 584		ϕ 1.50m	1	37.20	0.755	This road crossing is newly planned for draining out the runoff in the interchange,
9 + 695		ϕ 1.50m	1	57.75	0.660	This road crossing is newly planned for draining out the runoff collected at the road side drain from Sta. 9 + 380 to 9 + 700,
9 + 932	B=2.0m, H=0.5m along existing road	ϕ 1.25m	2	65.20	1.172	Cross sectional area of flow for the road crossing is taken the discharge from the village nearby the alignment into consideration, After crossing the road the channel is connected to the existing channel from Sta. 9 + 383,
10 + 170	B=1.0m, H=0.5m with levee(1.0m) both sides					It is judged by the diligent re-survey at the site that this channel does not cross the alignment, Road crossing is not required and the channel is connected to the road crossing at Sta. 9 + 932 through road side drain,
10 + 300	B=1.0m, H=0.7m along existing road	ϕ 1.25m	1	74.60	0.121	*Vietnam Standard,
10 + 490	B=2.5m, H=1.3m along existing road				0.104	The channel is relocated and connected to the next road crossing of which course is revised at Sta.10 + 490, Road crossing is not required,
10 + 490 (10 + 529 previous)	B=5.0m, H=2.2m B=0.7m, H=0.8m(irrigation channel) along existing road	ϕ 1.50m	2	75.75	1.736 (1.962)	Including the discharge from Sta. 10 + 300 and 10 + 490. The channel course is revised according to the relocation of the road crossing for pedestrians. The irrigation channel from the pump station installed at this channel is in the right of way. Relocation of the irrigation channel is planned.
10 + 694	B=5.0m, H=1.2m with levee(1.5m) both sides	ϕ 1.50m	1	81.25	0.983 (1.070)	Including the discharge from Sta. 10 + 874, The runoff from residential area is considered,
10 + 874	B=1.5m, H=0.8m with levee(1.5m) both sides	ϕ 1.25m	1	70.40	0.087	Road crossing is planned for securing irrigation water, *Vietnam Standard
11 + 009	B=2.0m, H=0.5m along existing road	ϕ 1.25m	1	60.00	0.139	*Vietnam Standard,
11 + 228	B=1.5m, H=0.5m along existing road	ϕ 1.25m	1		0.104	*Vietnam Standard,
11 + 460	B=6.0m, H=3.5m B=0.9m, H=0.9m(irrigation channel) along existing road				2.687 (2.931)	Including the discharge from Sta. 11 + 009 and 11 + 228, Bridge is planned to cross these waterways, Therefore road crossing is not required,
11 + 550	B=50.0m, H=3.5m(Cau Bay river) B=0.9m, H=0.9m(head race to pump) B=0.7m, H=0.5m(irrigation channel) along existing road					Bridge is planned to cross Cau Bay river, head race to the pump station and brick wet masonry channel for irrigation, therefore road crossing is not required.

Table 8.8.1 Existing Waterways and Road Crossing Plan(3/3)

Gia Lam Side

Sta.	Existing Condition	Plan				Description
		Box/Pipe	Lane No.	Length(m)	Discharge(m3/s)	
11 + 810	B=5.0m, H=1.5m with levee(1.5m) both sides				0.261	Minor relocation of channel may be required depending on the erection site of pier for the bridge if necessary,
12 + 050	B=5.0m, H=1.5m with levee(1.5m) both sides				0.059	Under the bridge over NH No.5, therefore road crossing is not required,
12 + 220	B=15.0m, H=2.3m with levee(1.5m) right side	ϕ1.50m	2	27.60	1.382	2 Nos. of road crossing for crossing ramp roads to interchange for NH No.5 are planned, To be open channel under the bridge,
		ϕ1.50m	2	25.00		
12 + 320	B=7.0m, H=2.0m with levee(2.0m) both sides	ϕ1.50m	1	36.50	0.598	Cross sectional area of flow for the culvert is taken the discharge from the ramp road and its slope into consideration. Channel relocation may be required in consideration of the site of the pier of bridge if necessary.
		ϕ1.50m	1	29.75		
12 + 580	B=5.0m, H=2.0m with levee(1.5m) both sides	ϕ1.25m	1	63.00	0.492	The discharge was calculated on the basis of the runoff from road and its slope, *Vietnam Standard,

*Vietnam Standard : The minimum diameter of pipe culvert shall be ϕ 1.25m, in case that the length of culvert is more than 30.0m.

Table 8.8.2 Road Crossing Newly Planned at Interchange

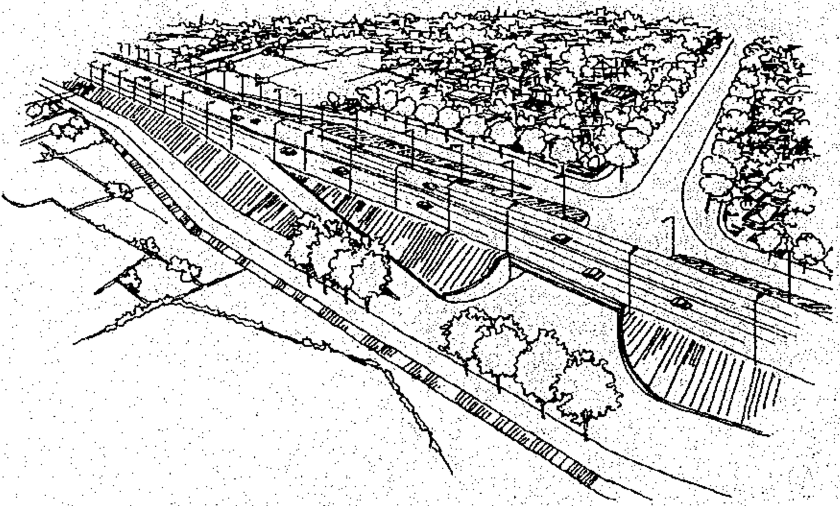
Thanh Tri Side

Sta.	Plan			Description
	Pipe	Lane Nos.	Length(m)	
0 + 680	ϕ 1.25m	1	26.75	To be installed at Sta. 0 + 680 of left side frontage road, To introduce the water to inside interchange for irrigation and
0 + 640	ϕ 1.25m	1	32.95	To be installed at Sta. 0 + 640 of right side frontage road, To introduce the water to inside interchange for irrigation and
0 + 080	ϕ 1.25m	1	32.50	To be installed at Sta. 0 + 080 of ramp road AB to Phap Van Cau Gie interchange, For draining out the runoff in the
0 + 060	ϕ 1.25m	1	32.00	To be installed at Sta. 0 + 060 of ramp road EF to Phap Van Cau Gie interchange, For draining out the runoff in the
0 + 360	ϕ 1.25m	1	27.70	To be installed at Sta. 0 + 360 of ramp road H to Phap Van Cau Gie interchange, For draining out the runoff in the

Gia Lam Side

1 + 150	ϕ 1.24m	1	46.80	To be installed at Sta. 0 + 150 of frontage road at Gia Lam interchange, For connecting pond to be cut off,
0 + 150	ϕ 1.25m	1	18.60	To be installed at Sta. 0 + 150 of ramp road A to Gia Lam interchange, For connecting pond to be cut off,
0 + 620	ϕ 1.25m	1	14.50	To be installed at Sta. 0 + 620 of ramp road A to Gia Lam interchange, For draining out the runoff in the interchange,
0 + 700	ϕ 1.25m	1	16.00	To be installed at Sta. 0 + 700 of ramp road B to Gia Lam interchange, For draining out the runoff in the interchange,

CHAPTER 9 DETAILED DESIGN OF ELECTRICAL FACILITIES



CHAPTER 9 DETAILED DESIGN OF ELECTRICAL FACILITIES

9.1 Road Lighting

The Thanh Tri Bridge Project is comprised of the bridge section and ground-level approach section. Basically, road lights are installed on ground level of the approach road and on the bridge road. Electrical power will be supplied from the respective local power companies. The electrical power company for the Thanh Tri Bridge project is as follows:

Hanoi: Hanoi Power Company

9.1.1 Method of Electrical Power Supply

The design plan of electrical facilities will require the following power supply:

- 3-phase 4-wire systems, 380/220 volts, 50 Hz AC.
- Demand factor input greater than 0.6
- Minimum capacity is planned for 50 kVA receiving point minimum for about two (2) power supply points for bridge section, and for others 31.5 kVA receiving point for ten (10) power supply points for ground level at both sides of the bridge. The location of the power supply points will be planned near the right of way of the project.
- Electrical power shall be supplied to each transformer spaced at less than 1 km apart as medium voltage lines network (according to the meeting with electrical power companies)
- Transformers and distribution boards (* panel) of outdoor type will be installed at each electrical power supply point.
- Transformer and electrical concrete poles will be installed by electrical power companies in accordance with the meeting.

9.1.2. Related documents for Road Lighting System

Criteria on artificial lighting design outside the construction work 20 - TCN - 95 - 83 of the Ministry of Construction - Viet Nam and ASTM

(1) Public Lighting Design Criteria

1) Standard Luminous Intensity for Street Lighting

According to the Vietnamese standards, luminous intensity shall be more than 1 cd/m^2.

Two kinds of round type poles, a standard single arm type and a double arm type, will be used.

Lighting pole height is 8 - 10 meters.

High Mast system will be greater than 15 m for interchange sections.

Spacing of two adjacent poles is less than 35 meters, high pressure sodium (HPS-T) lamp (150-watt) is used.

2) Lighting Control Panel

Distribution boards need to be protected against rain and wind as they are usually externally mounted. Within boards, timers are set to control road lights automatically.

The timing cycle is as follows:

Evening: from 6 PM to 24 PM the entire network is on.
Midnight: from 24 PM to 6 AM half of the network is off.
Daytime: from 6 AM to 6 PM the entire network is off.

The capacity of control box is 3-Phase 4-wire with ground wire, 380/220 volts AC, beside this capacity, the electrical control system will be automatically turned off for safety purposes. Special materials can be used to make the box, which needs to be resistant to environmental effects.

Cables and Conduits

Electrical cables from distribution boards to road lighting poles are underground and/or in conduit by concrete on bridge sections.

Conduit installation will be located in concrete by elevated concrete structures. Manholes will be installed at crossroads or intersection in the town, and connection made to manholes on both sides by the duct bank.

Steel taped armor type cable and X-LPE/PVC (each type as 4 cores) will be used for underground cable.

All cable voltage drops will be planned to maintain less than 5 % of one (1) network.

9.1.3. Operation Cost

Pursuant to Circular No. 367 dated 6/5/1997 stipulating the current prices in Viet Nam, the price for public lighting is VND 450/KWh.

9.1.4. Installation of Road Lighting System

Road lighting is proposed for installation in some sections, as the NH5, NH1 and NH18 Projects were not designed with it in mind. Mainly, road lighting will be furnished at the following sections:

- Throughway at-grade sections; to be located at road center.
- Interchange sections and frontage section; to be located on side walk on one side.
- Bridge sections; to be located on northbound and southbound sides of bridge (or at both ends of bridge)

9.1.5 Design Standard and Detailed Design

Design standards considered 20 TCN - 95 - 83 of Vietnamese standard, ASTM standard. Some parts of lighting criteria are to be applied in accordance with the existing lighting conditions. As a result, the basic conditions and electrical system are set as follows:

(1) Basic Standard

Standard of illumination: > 1 cd/m^2

Standard height of lighting pole: Bridge section: 8 m

Throughway at grade section: 10 m

Calculation formulation of dazzling

Fd = I e Ltb R / U V

In which: Fd = Lamp's Lumens (Lum)

I = Width of roadway (m)

e = Distance pole to pole

Ltb = cd/m^2

R = Coefficient

U = Coefficient

V = Coefficient

(2) Designed Facilities

Designed height of lighting pole (round type steel post) is H = 8 m - 10 m.

Lamp capacity is at least 150 w, located on wide arterial roads, other locations, scheduled lamp capacity is normally 150 w.

Calculation vends of post intervals

Result: High pressure sodium (HPS-T) lamp 150 w (16,500 lumens)

Cd/m^2	Pole height H = 8 m - 10 m
1.0	27.2 lux
1.2	29.8 lux of average level

Designed distance is normally from a maximum of 35 meter intervals, by any method.

9.2 Toll Plaza

9.2.1 Background

The Toll Plaza includes toll gate, toll building and road management unit designed for the project and are included in the scope of these documents.

The facilities of toll plaza are based on the following principles:

- Feasibility study for NH 18 formulated by JICA in March 1996 (F/S).
- Minutes of meeting held between OECF and Vietnamese government (October, 1997)
- Prevailing standards and specifications of Vietnamese government
- Prevailing design criteria of Ministry of Construction - Vietnam

9.2.2 Scope of Design

Toll building and toll gate facility of the project have been completed up to detailed design. (See the road map for tollgate system.) The report only shows scope and specification of typical station and is described below:

To keep the activities of tollgates running smoothly 24 hours, the following facilities need to be constructed:

(1) Grade of constructions:

- Toll plaza, toll building: Grade II
- Subordinate work (sub-building, the guard booth): Grade III and IV

(2) Tollgate consists of:

- Roof area: 462 m^2
- Number of lane islands: 5
- Separated wall: 2
- Number of booths: 5 (4 single type and 1 dual type)

(3) Toll and road management building:

- Floor area: 779 m^2 or more

(4) Garage and generator room: 114 m^2 or more

(5) Water reservoir: net 60 m^3 (gross capacity 78.54 m^3) L 6.8m x W 3.3m x D 3.5m

(6) Deep well: 1

- Suction head: more than 30
- Suction flow: 150 liter/min

(7) Guard booth: 8.5 m^2

(8) Non-motorized parking: 72 m^2

(9) Transformer 50 KVA or 100 KVA: 1

(10) Fence: 187 m

(11) Gate: 2 sets

(12) Yard: 980 m^2

(13) Green Plant:

(14) Water supply, sanitary, and drainage system:

(15) Internal electrical network in toll buildings

9.2.3 Structural Features of Items of Facilities

(1) Toll Canopy

1) Main structures: Foundation, skeleton, ceiling slab made from cast-in-place reinforced concrete (mark 200); and steel structure column, Corrugated-G.I-steel-sheet roof to provide an aesthetic structure and insulation from heat.

2) Area: 288 m^2

3) Number of lanes: three per direction, total of six described below:

+ Six lanes are used for automobiles, trucks and motorbikes; the width of a single lane being 3.2 m.
+ Two lanes are used for non-motorized vehicles, overload and oversize vehicles; the width of a single lane being 4.5 m.

4) Land island:

+ Quantity: 5
+ Dimensions: W = 1.9 m; L = 25m

5) Retaining wall:

+ Quantity: 2
+ Dimensions: W = 0.5; L = 80m x 2 = 160 m

6) Booth:

+ Quantity: 4 single type booths and 1 dual type booth in center
+ Size:
  Single type: W = 1.5 m; L = 2.3 m; H = 2.6 m
  Dual type: W = 1.5 m; L = 4.6 m; H = 2.6 m

(2) Toll and Road Management Building

The station management building is installed with the central control equipment connected to a toll fare facility system at toll plaza. The building with office for staff of tollgate, including office for policemen, is arranged in the same building as the highway management unit.

1) Main Structure:

- Foundation, skeleton, and floor and ceiling slabs made from cast-in-place reinforced concrete (mark 200).
- Outer wall is constructed with solid brick and inner wall, and partitions are constructed with hollow brick. Brick must be of Class A. Compressive strength is over 75 kg/cm^2

- Corrugated G.I. steel sheet roof.
- Floor is tiled with ceramic tile (30 x 30 cm per piece)

2) Finishing

- Interior wall and ceiling are smoothed by mattit and painted with high quality water paint (NIPPON paint)
- Outer wall and ceiling are smoothed by mattit and painted with weatherproofing and high quality paint (NIPPON paint)
- Doors and windows are made from aluminum frame (refer to Item 1.7 of the Specification - Tollgates and toll building - technical specification)

3) Main Dimensions

- Length:	27 m
- Width:	13.8 m
- Height of the first floor:	3.6 m
- Height of the second floor:	3.6 m
- Constructed Area:	432 m^2
- Floor area:	779 m^2
- Working area:	459.8 m^2

In which:

Equipment room	= 40.34 m^2
Admission room	= 19.60 m^2
Police officer's room	= 19.60 m^2
Director' room	= 15.11 m^2
Toilet for the director's room	= 2.52 m^2
Staff room	= 15.11 m^2
Staff room	= 15.11 m^2
Toilet for staff room	= 2.52 m^2
Kitchen	= 19.54 m^2
Lunch room	= 45.55 m^2
Toilet on the first floor	= 24.74 m^2
Corridor on the first floor	= 55.83 m^2
Stairs	= 20.28 m^2
Meeting room	= 40.34 m^2

Computer room	= 19.60 m^2
Control room	= 17.94 m^2
Technical room	= 19.60 m^2
Deputy director room	= 19.54 m^2
Planning department room	= 19.54 m^2
Conference room	= 19.54 m^2
Office	= 19.54 m^2
Director room	= 24.74 m^2
Accounting and cashing room	= 40.34 m^2
Corridor on the second floor	= 44.71 m^2
Toilet on the Second floor	= 24.74 m^2

(3) Garage, Motorbike and Generator

This sub-building is used as a garage and warehouse. In addition, there are some rooms for the laborers that work at night as well as a dinning room.

1) Main Structure:

- Building with bearing brick foundation and wall
- Cast in place reinforce concrete ceiling slab (mark 200)
- Corrugated G.I. steel sheet roofing
- Bearing wall is constructed with solid brick. Partitions are constructed with hollow brick. Brick must be of class A, compressive strength is over 75 kg/cm^2.

2) Finishing:

- Interior walls and partition are smoothed with mattit and painted with high quality water paint (NIPPON paint)
- Exterior wall is smoothed with mattit and painted with high quality weatherproofing water paint (NIPPON paint)
- Concrete floor for storehouse and garage, tiling ceramic tile (30 x 30 cm) for the staff rooms, dining rooms, entry and corridor. Anti-slip ceramic tile for toilets.
- Doors and windows: Doors and windows with aluminum frame are used for the staff rooms, dining rooms and toilet. Folding doors are used for garage and storehouse.

3) Basic Dimension:

- Height of room: 3.6 m^2
- Construction area: 137.28 m^2
- Floor area: 97.8 m^2
- Used area: 97.8 m^2

(4) Water Supply, Sanitary, Drainage Systems

All building utilities installation shall be carried out in accordance with the building codes of Vietnam, applicable ordinances, rule and regulations of the Proceedings of Vietnam Construction Standards, vols. IV, V, VI, and VII.

1) Water Supply System

- Underground or on-ground clean water tank:
  + Capacity: 60 m^3
  + Main structure: Cast-in-place reinforced concrete base and cover, sides of tank constructed with Class A solid brick in combination with reinforced concrete column.

- Deep well: proposed depth is 30 to 40 m
  + Inlet supply water capacity: 1.8 m^3/min
  + Discharge capacity to elevated tank: 0.6 m^3/min
  + Elevated water tank capacity: 5 m^3

2) Sanitary System

- Underground septic tank capacity : 12 m^2

3) Drainage System

- Discharge waste : 3.5 m^3/h

(5) Parking Area for Motorbikes and Bicycles

1) Dimension

-	Length:	8 m
-	Width:	3 m
-	Height:	2.6 m
-	Floor area:	24 m^2

2) Main Structure:

Steel structure, concrete foundation, corrugate G.I. sheet roof

(6) Fence, Gate:

1) Fence: Total length: 196 m
Surrounding fence is constructed with brick.
Front fence is made with the welded square steel.

2) Gate:

- Number of gates: 2
- Steel structure; gate pushed towards one side

(7) Yard and Material Storage

- Area: 980 m^2
- Structure: concrete

(8) Electricity

These works shall consist of furnishing and installing all materials and equipment necessary to complete in place electrical works in the toll building and tollgates.

1) Scope of Works

The scope of works covers the supply, delivery to site, erection, test and commissioning of all materials and equipment in accordance with the electrical installation to the extent described and shown on the installation items, and includes but is not necessarily limited to:

- Low voltage power receiving 50 kVA or 100 kVA from power company.
- Power distribution system
- Lighting and socket outlets
- Fire alarm system (if necessary accordance with regulation or code)
- Lightning protection system
- Emergency generator unit 20 kVA
- Indoor conduit for telephone/computer system
- Air conditioning units

2) Electrical Requirements

i) Voltage Drop shall be total 5 % maximum of one feeder, between the supply point and distribution panel shall be less than 2 %, of any type feeder, and between distribution panel and end of load devices shall be less than 3 % maximum, of any type cable.

ii) Standards and Regulations

The works covered by this contract shall be carried out in accordance with the regulations issued by the local electricity authority and with the applicable standards and codes of any of the followings:

- Proceeding of Vietnam construction standards vol. VI
- Building code of Vietnam vols. I and II.

9.3 Toll Collection System

9.3.1 General

The toll plaza is the facility for collecting of toll fee from road users. Therefore, there is difference of characteristics from main road. Careful consideration should be taken for the design of this facility which must ensure smooth flow of traffic despite the stopping of vehicles. Following are items for attention in designing the toll facility.

- Advance notice must be provided to drivers of the existence of a toll facility ahead so that they will be prepared to stop.
- The number of toll gates should have sufficient capacity to provide for peak hour traffic volume.
- The toll gate facility should be constructed on flat land if possible, to ensure safe and smooth traffic flow.

9.3.2 Toll Collection System

There are three kinds of toll collection systems:

- "The Closed System" : Toll tariff is collected according to the length of actual travel.
- "The Open System" : Toll tariff is collected based on the acceptable average distance for all vehicles.
- "The Flat Rate System" : Toll tariff is collected based on uniform tariff in accordance with the vehicle type.

The flat rate system is designed for the Thanh Tri Bridge due to the limited length of the bridge.

The position of the toll facility will be set on the Highway No.1 side. The main reason is that there is sufficient reclaimed flat land. Reclamation materials may suffice from borrow pits near the beginning point of approach road.

9.3.3 The Number of Lanes for Toll Gate

According to the Vietnamese standards, there are no design standards for the selection of number of lanes for toll facility; only the number of lane for carriageways is set. Therefore, the study team selected the Japan Highway Public Corporation Standard which is commonly employed in Vietnam.

According to the Japan Highway Public Corporation's (JHPC) design standards, the number of toll gate lane will be selected according to the following table.

Number of Lanes	Time of Service (sec)							
	6.0		8.0		10.0		14.0	
	Average Queue							
	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0
1	300	450	230	340	180	270	130	190
2	850	1,040	640	780	510	620	360	440
3	1,420	1,630	1,070	1,230	850	980	610	700
4	2,000	2,230	1,500	1,670	1,200	1,340	860	960
5	2,590	2,830	1,940	2,120	1,550	1,700	1,110	1,210
6	3,180	3,430	2,380	2,570	1,910	2,060	1,360	1,470
7	3,770	4,020	2,830	3,020	2,260	2,410	1,620	1,720
8	4,360	4,630	3,270	3,470	2,620	2,780	1,870	1,980
9	4,960	5,220	3,720	3,920	2,980	3,310	2,130	2,240
10	5,560	5,820	4,170	4,370	3,330	3,490	2,380	2,490
11	6,150	6,420	4,610	4,820	3,690	3,850	2,640	2,750

JHPC's table (above) is for the selection of number of toll gate lanes according to the affected time of service (sec), average queue and hourly traffic volume per direction (vph).

The lane-number selection study for the Bai Chay Bridge toll gate will be carried out according to the selection procedure of JHPC.

Assumed figures are;

Service time: 8.0 seconds (commonly applied for flat rate system)
Average queue: 1.0

Hourly traffic volume/direction: 11,519 PCU ADT (BCB Study Team 1999)
(per year in 2005) ADT per direction = 5,760

Hourly traffic volume/direction: (10 ~ 8 %) x 5,760
= 461 ~ 576 = 519 vph

Hourly traffic volume/direction: 21,512 PCU ADT (BCB Study Team 1999)
(per year in 2010) ADT per direction = 10,756

Hourly traffic volume/direction: (10 ~ 8 %) x 10,756
= 860 ~ 1,076 = 968 vph

The above figures show the necessary number of toll gate lanes. Three lanes for cars and an additional one for motorbikes will be applicable until the year 2010 under the conditions of average queue being 1.0.

9.3.4 Plan of Facilities

Toll facilities commonly consist of toll gate, toll plaza and maintenance facility. There are several toll facilities which have been constructed in Vietnam. Necessary structure for toll facility shall be designed based on these facilities, especially Highway No. 18.

9.3.5 Toll Booth

Type A:

This type of toll booth shall be set on the access road for collecting of tariff and traffic control. The size of this facility is as shown in the next figure. Users of this access road will be limited due to traffic control.

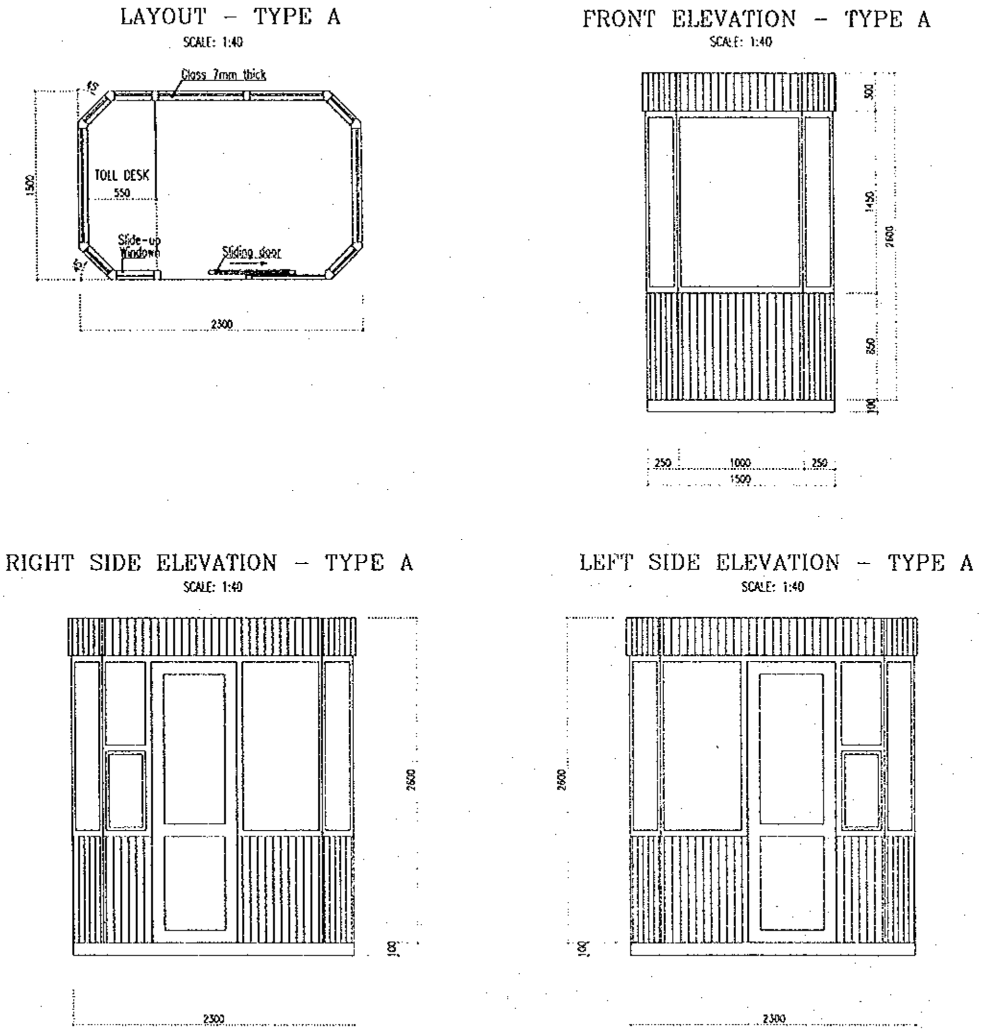


Figure 9.3.1 Toll Booth Type - A

Type B:

The toll booth employed by the Thanh Tri Bridge project of Highway No. 1 to NH No. 5 is to be set in the middle lane of the island. The size of the booth is as shown below.

This booth is to be used for toll collection and control of the vehicles. Necessary equipment will set in the booth.

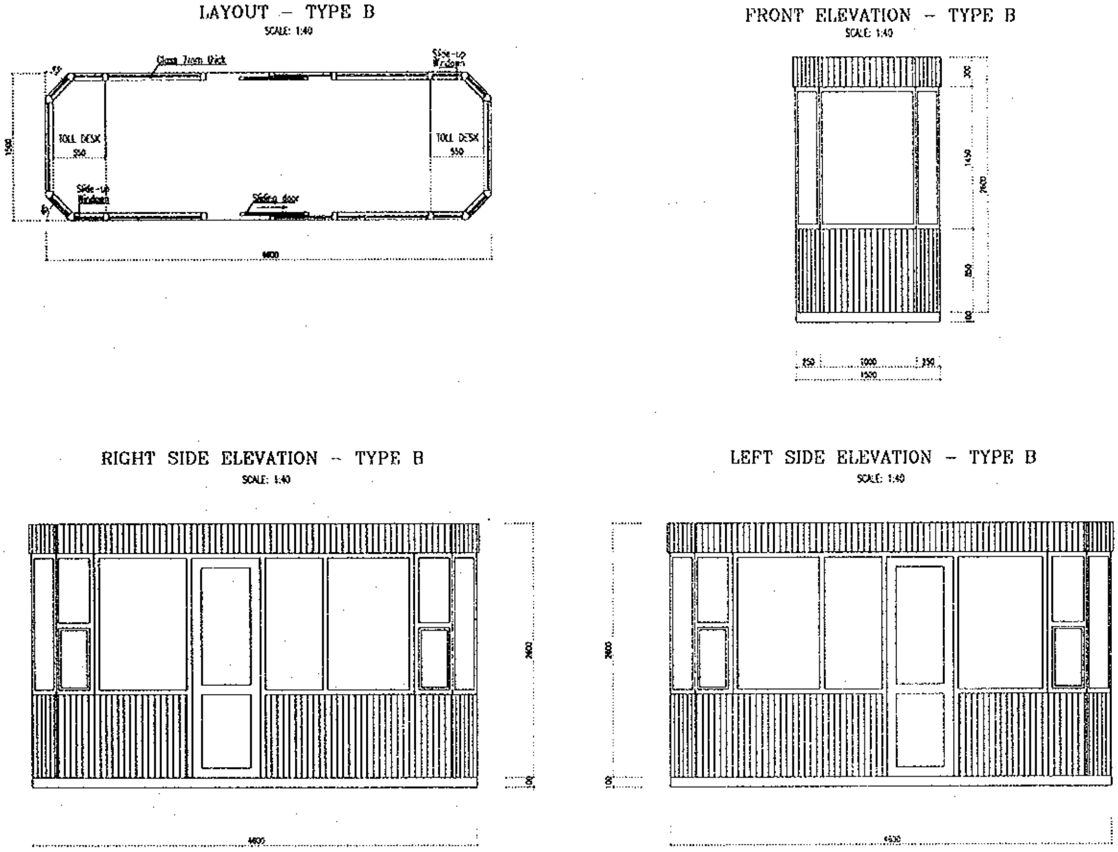


Figure 9.3.2 Toll Booth Type - B

9.3.6 Tariff Collection Facilities

A semi-automatic type of toll collecting system has already been employed at National Highway No.1 Chuong Duong Bridge. Therefore, semi-automatic type of toll collecting system shall be recommended instead of existing manual collection system. Necessary equipment is summarized in Figure 9.3.3.

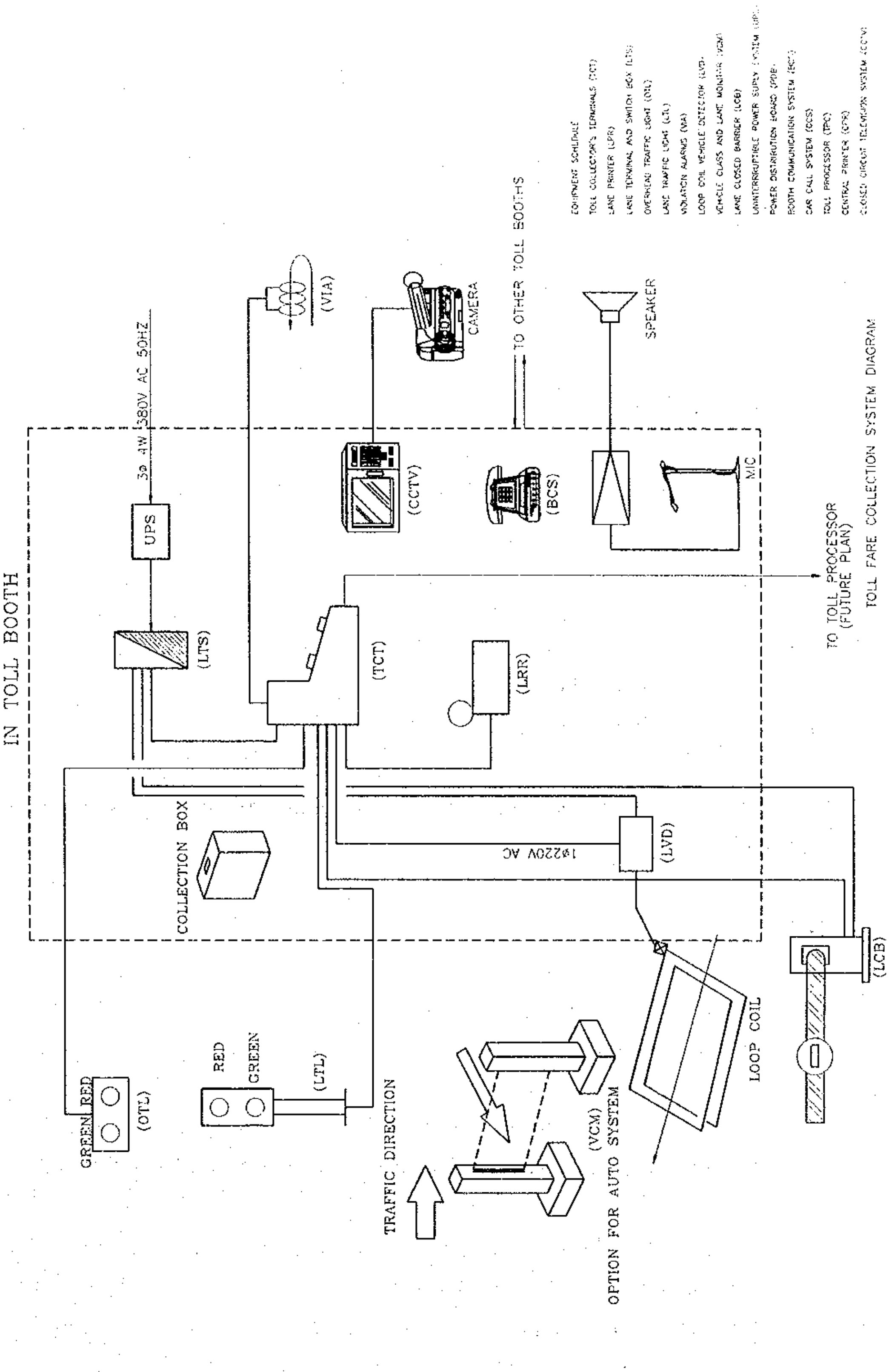


Figure 9.3.3. Toll Collection System Diagram

9.3.7 Toll Gate Configuration

The tollgates will have six lanes + two outer lanes for vehicles over 10 tons and cars, and two lanes for motorbikes and bicycles as explained in previous chapter. Toll booth will be set on the left-hand side (driver's side) of all vehicles and are to be reversible lanes.

- The Thanh Tri Bridge Toll Gate: On throughway six lanes for cars and two lanes for vehicles over 10 tons and bicycles

9.3.8 Vehicle Classification

The vehicles class will be categorized into the following classes based on the financial study results:

Class 1	Motorcycles
Class 2	Cars and mini-buses
Class 3	Buses and trucks
Class 4	Vehicles over 10 tons

However, provision of one more class will be incorporated for a future possible vehicle class.

9.3.9 System Outline

(1) The toll collection system for the Thanh Tri bridge project is a flat rate system in which the toll fare for a vehicle solely depends on the vehicle classification.

(2) Main tollgate will be located at the beginning point before bridge and other toll gate will be set on interchange connection section of NH No.1 side access road.

(3) The patron should stop and pay at the entry and/or exit gate of toll booths. After paying the toll fee, the lane is opened by manual by pushing or automatically and the patron is free to enter or exit to the toll way bridge or arterial.

(4) Method of toll payment systems will be as follows:

1) Cash
2) Pre-paid card
3) Non-revenue
4) Registration tag-type auto toll collection system for future extension.

(5) The toll collector operator should visually assess the class of each vehicle and press the vehicle class key on the toll collector's terminal (TCT). The toll fare will be automatically displayed on the TCT for the toll collector.

(6) The toll collector will inquire the method of payment to the patron and press the method of payment key on the TCT. In case of a cash payment, a receipt will be automatically printed out from the lane printer (LPR).

(7) The vehicles in the toll gate will be detected by the loop coil detector (LVD). The LVD triggers an alarm in the event of a violation in which a vehicle has crossed the LVD before the transaction is properly completed.

(8) At termination of the shift, the end of shift report will be automatically printed out inside of the lane printer in the booth. The report will be taken out from the lane printer only by means of using the supervisor's key.

(9) A daily report of each lane will automatically be printed out from inside the lane printer at the end the each operating day. The report will be taken out from the lane printer only by means of using the supervisor's key.

(10) The toll collector's terminal (TCT) will be planned with the interface with which the data of the end of shift can be automatically transmitted to the central computer system to be equipped in the future.

(11) A station processor and a central printer will be designed in the control center building in the future.

(12) The vehicle class unit by the collector and lane activities will be indicated and warned on the vehicle class and lane monitor to be located inside of the supervision booth in the entry gate or exit gate system in the control room of the control center building.

9.4 Traffic Signals

9.4.1 General

Traffic signals provide for the orderly movement of traffic by alternatively allowing segments of traffic to enter an intersection from intersecting directions. Signals can reduce right-angle collisions.

Since sequence of total signal control is beyond the scope of work, this matter is not discussed in this report.

9.4.2 Location of At-grade Intersection

The location of the at-grade intersections, which are to be planned by this project, are as follows:

- Phap Van Cau Gie
- Nguyen Tam Trinh
- Linh Nam and Thanh Tri
- Gia Lam Dyke
- NH5

9.4.3 Type of Signal and Applicable Places

The recommended places of various types of traffic signals are as follows:

	Type of Traffic Signal	Place of Intersection
1.	Overhead type with tapered pole, for vehicle type - 1	On the left side of traffic on the arterial street at the pedestrian crossing.
2.	On post type, for vehicle type - 2	On an arterial street, on each side of the pedestrian crossing.

9.4.4 Signal Equipment

The selection of the signal equipment is in conformity to the following relative Regulation and Standards of Ministry of Transport in Vietnam:

- 22 TCN 237 - 97

(1) Upper signal for vehicles, Type - 1

The lenses of signal heads are standard red, amber, and green-colored, and are installed on standard pole or overhanging tapered poles. The signal head is installed on the top of a 10 m - 12 m high steel round type pole with arm.

(2) Lower signal for vehicles, Type - 2

The lenses for the lower signal are the same as for the upper signal, but the lower signal is installed at 3.5 m - 5 m in height on steel round-type pole.

9.4.5 Traffic Control Panel. Type - A

The traffic control panel is installed for the control of signals at an individual intersection. The sequence of signal control is determined by authority of Hanoi. Therefore, the handling of the control panel must be carried out with sufficient discussion between Authority of Hanoi and the consultant during design.

(a) Function of Control Panel

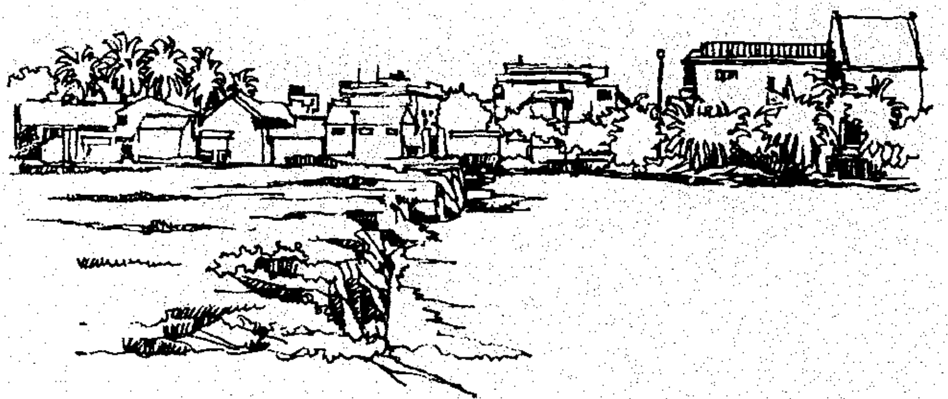
Function of the control panel is as follows:

- The signal control is based on a fixed-time cycles
- The ratio of time for each phase can be adjusted in the control panel
- The function of fixed-time control can be selected by a manual switch
- The control method can be set to automatic or manual control

(b) Installation of Traffic Control Panel

A traffic control panel is provided at each intersection for the control of signals. The traffic control panel is installed at a convenient place so that all signals can be observed from the traffic control panel.

CHAPTER 10 LAND ACQUISITION, COMPENSATION AND RESETTLEMENT IMPLEMENTATION PROGRAM



CHAPTER 10 LAND ACQUISITION, COMPENSATION AND RESETTLEMENT IMPLEMENTATION PROGRAM

10.1 Aspects of the Project-Affected Persons and Assets

10.1.1 Project-Affected Persons

(1) Number of Project-Affected Persons

Around 1,200 households and 6,000 persons are estimated as Project-affected Persons (PAPs). These figures are nearly double from those of the B/D stage. The main reasons for this underestimation are; 1) JICA Study Team counted the number of houses based on a field survey in the B/D stage, and 2) More than one family usually lives together in a house. Therefore, we should re-adjust and re-estimate the figures. The adjusted figures are identified by the basic information on inventory works conducted by the PCs and authorized boards after approval of the right of way (see Table 10.1.1).

Table 10.1.1 Estimated Project-Affected Persons

Locations			Project-Affected Persons	
District	Location	Name of commune	Households	*Persons
Gia Lam	1. Along NH5	Thach Ban/ Co Bi	130	650
	2. Thuong Hoi	Thach Ban	10	50
	3. Near Gia Lam Dyke	Cu Khoi/Dong Du	90	450
	Total Gia Lam		230	1,150
Thanh Tri	4. Along Linh Nam St.	Linh Nam	80	400
	5. Nam Du Ha	Tran Phu	170	850
	6. Yen Duyen	Yen So	140	700
	7. Along Phap Van St.	Yen So	190	950
	8. Along Phap Van St.	Hoang Liet/Thinh Liet	20	100
	9. Along Phap Van St.	Hoang Liet	80	400
	10. Northern corner of NH1	Hoang Liet	290	1,450
	Total Thanh Tri		970	4,850
Total Project			1,200	6,000

Source: JICA Study Team
Note: * 5 persons for one household (family)

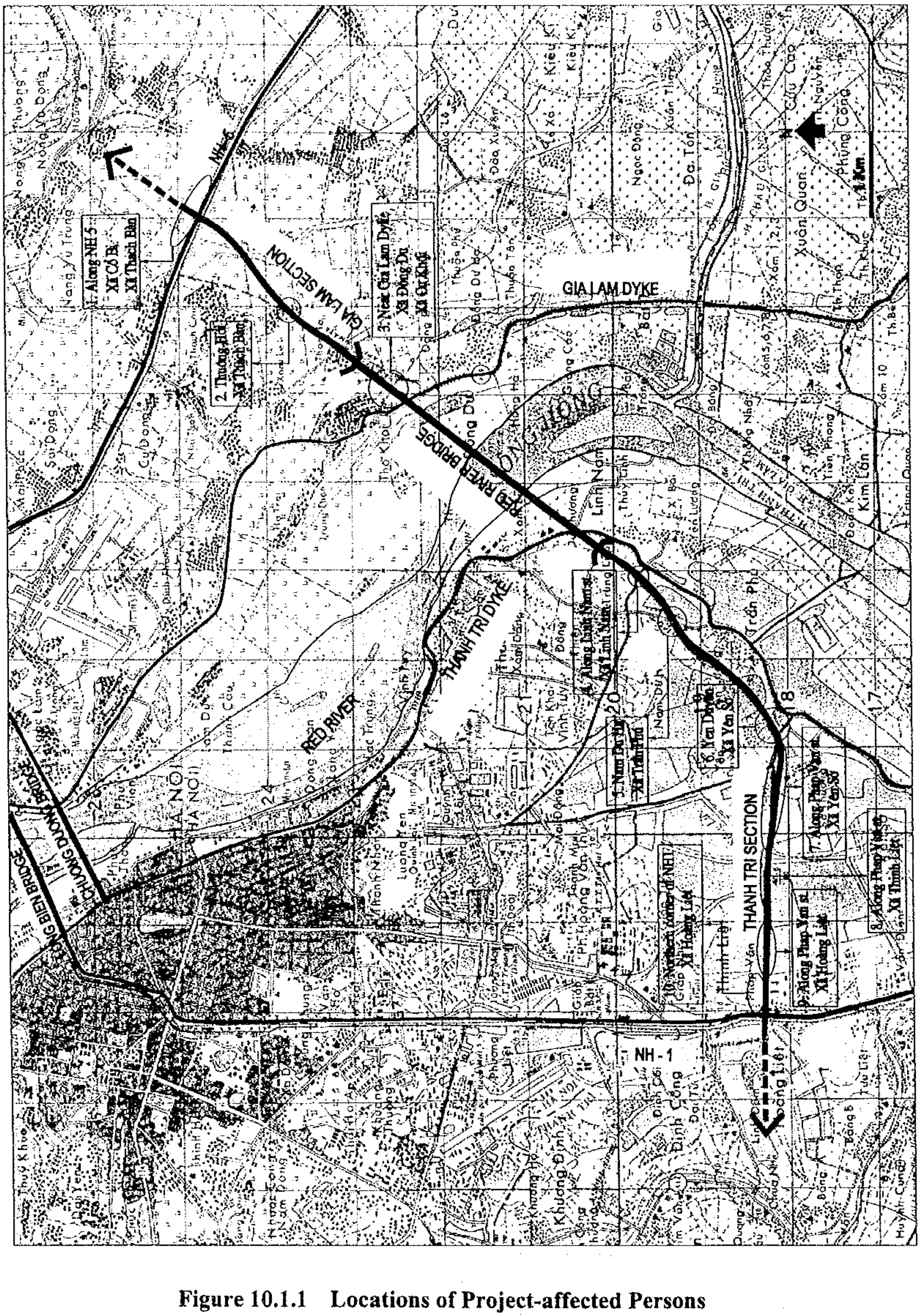


Figure 10.1.1 Locations of Project-affected Persons

(2) Profile of Inhabitants in the Study Area

1) Family Structure

Table 10.1.2 shows that both districts of Thanh Tri and Gia Lam have similar profiles of family structure shown in Table below. Average size of a household is about five persons. The profile of an average family is summarized as follows: a family has two or three persons of labor age (parents and older children), one or two persons of school age (younger children) and one or no elderly person.

Table 10.1.2 Family Structure

(Unit: person)

Average size	Thanh Tri	Gia Lam
Household	4.98	4.72
Persons of labor age	2.66	2.42
Persons of school age	1.90	1.78
Persons of old age	0.68	0.50

Source: Interview survey, 1998

2) Occupation

Each district has a characteristic on occupations of household. "Service and business" dominates in Thanh Tri, and "agriculture" dominates in Gia Lam as the major occupation of households. Besides, one household can hold more than one occupation in both districts, especially in Thanh Tri. Households in Gia Lam have few occupations except "Agriculture". However, "worker and staff" is another major occupation of households in Than Tri, besides "service and business". "Agriculture" accounts for nearly one-fifth of the total households in Thanh Tri (see Table 10.1.3).

Table 10.1.3 Major Occupations

Occupations	Thanh Tri	Gia Lam
Agriculture	24 %	88 %
Worker and staff	42 %	10 %
Small workshop	8 %	0 %
Stockbreeding	0 %	10 %
Service and business	78 %	2 %

Source: Interview survey, 1998

3) Monthly Income Levels

Both districts have a similar monthly income level (see Table 10.1.4). Nearly 80 % of households have an income level less than 2.5 million VND per month. The highest incomes of each household are 3 million VND in Thanh Tri, and 4 million VND in Gia Lam. The lowest ones are 0.1 million VND in Thanh Tri, and 0.2 million VND in Gia Lam. In addition, each average monthly income of household is estimated at 1.3 million VND in Thanh Tri, and 1.2 million VND in Gia Lam.

Table 10.1.4 Monthly Income Levels

Income levels	Thanh Tri	Gia Lam
Over 3.5 million VND	0 %	2 %
3.0 - 3.5 million VND	6 %	2 %
2.5 - 3.0 million VND	6 %	10 %
2.0 - 2.5 million VND	10 %	0 %
1.5 - 2.0 million VND	16 %	6 %
1.0 - 1.5 million VND	8 %	22 %
0.5 - 1.0 million VND	18 %	20 %
Under 0.5 million VND	24 %	28 %
No answer	12 %	10 %

Source: Interview survey, 1998

10.1.2 Lands

(1) Size of Project-Affected Lands

JICA Study Team estimated the size of project-affected areas at around 125.8 hectare (ha), which includes river and riverbed areas (see Table 10.1.5).

In summary, around 18.4 ha of residential area, including gardens, etc., 61 ha of agricultural land, 19 ha of pond and 3.3 ha of land for organizations (almost all state-owned), and public facilities, are affected by the Project.

Table 10.1.5 Project-Affected Lands

Land use	Area (m²)	Gia Lam Sec.	Bridge Sec.	Thanh Tri Sec.
1. Residential Area	184,500	18,600	27,200	138,700
2. Agricultural Area	610,800	249,600	46,600	314,600
3. Pond	191,300	6,300	14,600	170,4
4. Organizations	33,200	3,300	0	29,900
5. Cemeteries	0	0	0	0
6. Public Facilities	6,500	0	0	6,500
7. Others (river, roads and etc.)	231,700	41,700	81,900	108,100
Total	1,258,000	319,500	170,300	768,200

Source: JICA Study Team
Note: "Organizations" indicates office buildings, warehouses, etc.

(2) Aspects of Average Size of Housing Lots

The average size of housing lots is around 230 m² in Thanh Tri, and 500 m² in Gia Lam, however, garden area is included in the housing lots. The average size of housing lots in Gia Lam is somewhat larger than in Thanh Tri, as almost all houses are farmer's houses. Typically, they have a dwelling house, a kitchen house, barns or sheds and garden area on the lot. On the other hand in Thanh Tri, a similar type but rather higher-grade houses can be seen in Yen Duyen Village. Nam Du Ha Village also has a similar type, but smaller lots without garden. Besides, a housing lot is usually enclosed with wall, which is a part of barn or shed on path (see Table 10.1.6).

Table 10.1.6 Size of Housing Sites

Construction year	Thanh Tri	Gia Lam
More than 1,000 m²	0 %	12 %
500 - 1,000 m²	4 %	32 %
200 - 500 m²	52 %	36 %
100 - 200 m²	24 %	20 %
Less than 100 m²	20 %	0 %

Source: Interview survey, 1998

10.1.3 Structures

(1) Number of Project-Afected Structures

House grades are stipulated in details on Circular No. 5-BXD/DT dated 9 February 1993 by the Ministry of Construction. However, it is difficult to identify the grades from the descriptions of the document. Indeed, a work for identification of the grades is difficult without detailed survey or declarations from residents. Therefore, the JICA Study Team assumed the grades of houses roughly in accordance with features of houses as follows:

- Grade I : multi-story building (more than 5 storeys)
- Grade II : multi-story building (2 - 4 storeys)
- Grade III : mortar-finished possibly with flat roof (single storey)
- Grade IV : brick wall with sloped tile roof (single storey)
- Temporary : e.g., galvanized steel sheet-wall or roof, barns and sheds

Table 10.1.7 shows the project-affected structures based on the above categorization.

Table 10.1.7 Project-Affected Structures

Structures	Total	Bridge Sec.	Gia Lam Sec.	Thanh Tri Sec.
1. Grade II	110	0	51	59
2. Grade III	195	8	40	147
3. Grade IV	440	34	31	375
4. Temporary	239	6	21	212
5. * Organizations	59	0	1	58
Total	1,043	48	144	851

Source: JICA Study Team
Note: * "Organizations" include office buildings, warehouses, etc.

(2) Aspects of the House Conditions

These grades are deeply concerned with estimation of compensation costs for houses. According to an interview survey in 1998, houses below grade III are dominant in both districts, more so in Gia Lam. The JICA Study Team ascertained that almost all houses on the alignment in Gia Lam are farmer's houses from the field survey. Somewhat higher-grade houses can be seen on NH5. In Thanh Tri, higher-grade houses are located along the NH1 and Phap Van Street. Lower-grade houses can be seen in Yen Duyen and Nam Du Ha Villages of Tran Phu commune (See Table 10.1.8 and 10.1.9).

Table 10.1.8 Housing Conditions

House classifications	Thanh Tri	Gia Lam
Grade I	12 %	0 %
Grade II	20 %	4 %
Grade III	34 %	44 %
Grade IV	34 %	52 %

Source: Interview survey, 1998

Table 10.1.9 Construction Years

Construction year	Thanh Tri	Gia Lam
After 1990	30 %	26 %
1985 - 1990	18 %	12 %
1980 - 1985	4 %	20 %
1970 - 1980	0 %	24 %
Before 1970	0 %	10 %
No answer	48 %	8 %

Source: Interview survey, 1998

10.2 Policy Framework

10.2.1 Legal Framework

The land acquisition and resettlement policies of the Project are derived from three sources of the Government of Vietnam, Ministry of Transport and Hanoi People's Committee as follows.

(1) Government Decree No. 22/1998/ND-CP: On Losses Compensation When Government Withdraw Land to Use for the Purpose of National Defense, Security, National Benefits and Public Benefits.

(2) Ministry of Transport's Decision No. 592/1999/OD-GTVT, which is pursued to Decree No. 22/1998/ND-CP mentioned above: On Procedures and Progress of Land Clearance for the Transportation Construction Works.

(3) Hanoi People's Committee's Decision No. 20/1998/QD-UB, which is pursued to Decree No. 22/1998/ND-CP mentioned above: On Implementation of Decree

No. 22 within the Hanoi Area. This Decision shows more detailed regulations for some articles of compensation policies in case of Hanoi Metropolitan Area.

The other main related Decrees and Decisions are shown below.

(4) Government Decree No. 87/1994/ND-CP: Prices for Compensation of Different Types of Land.
(5) Hanoi People's Committee's Decision No. 3519/1997/QD-UB, which is pursuant to Decree No. 87/1994/ND-CP mentioned above: On Implementation of Decree No. 87 within the Hanoi Area.
(6) Government Decree No. 60/1994/ND-CP: On Housing Ownership and Land-Use Right.
(7) Government Decree No. 64/1993/ND-CP: On Agricultural Land Allocation for Households, Individuals to Use Long-term Agricultural Production Purpose.

10.2.2 Principles and Objectives

Implementation of land acquisition, compensation and resettlement should be conducted in accordance with Government Decree No. 22, Ministry of Transport's Decision No. 592 and Hanoi People's Committee's Decision No. 20. The policies of land acquisition, compensation and resettlement for the Project follow these regulations. The principles and objectives are summarized as follows.

(1) Land acquisition and resettlement will be minimized to the extent possible.
(2) All families, persons and organizations affected by the Project will be compensated for their lost assets, and supported with subsidies for rehabilitation of their sustenance and relocation.
(3) The compensation and resettlement measures consist of (i) compensation for all lost assets (lands, structures, crops and etc.); (ii) assistance for rehabilitation and relocation with subsidies; (iii) resettlement with suitable infrastructure.
(4) Effective and timely announcement, guidance, survey, planning and consultation for project-affected persons, are conducted by respective PCs and authorities in accordance with each implementation step.
(5) All payments related with compensation and resettlement will be paid to the project-affected persons before the relocation.
(6) Every effort will be made to prepare resettlement sites at the locations as close as possible to former settlements, and the project-affected persons will be resettled within the former community group.

(7) Resettlement sites will be prepared with suitable infrastructures including residential roads, water supply, power supply, drainage and access road.

10.2.3 Project-Affected Persons

Those people designated as "project-affected persons" (PAPs) should include the following persons and organizations. The PAPs and their assets are identified by the basic information on inventory works conducted by PCs and authorized boards.

(1) Persons whose assets are partially or fully affected by the Project: land acquisition for right of way, any other infrastructure construction of resettlement sites, and additional land acquisition, if necessary for the Project. The assets are specified as follows.

- Lands : Residential lands, agricultural lands, aqua-cultural lands (fishponds).
- Structures : Dwelling houses, any other structures (wells, kitchen houses, barns, sheds, walls and etc.), office buildings and warehouses.
- Products : Crops (annual and perennial), trees, fishes and etc.

(2) Persons and organizations whose businesses, sustenance or activities are temporarily and permanently affected by the Project.

10.2.4 Entitlement Policy

The PAPs will be entitled to the following measures according to the regulations. However, the HPC and authorized boards will decide detailed measures in any case through accurate evaluations.

(1) Assets

1) Lands: All types of land acquired should be considered for compensation in cash or land for land, if available. Contractors should compensate the PAPs affected by temporary land acquisition for construction purposes over the construction period.

2) Structures: The loss of residential/commercial structures will be fully compensated at replacement costs without depreciation. If tenants are affected

by land acquisition, they will also be considered for subsidizing of rental fees at the market rate for alternative accommodation.

3) In cases where land and /or structures are only partially affected, the owners may request the acquisition of the entire structure at full replacement costs, if the remaining land or house is not sufficient for living.
4) Crops: The PAPs will be compensated for loss of standing crops and fruit or perennial trees at market price.
5) Others: Graves, trees and other assets should be compensated.

(2) Subsidy

1) Living assistance: Subvention is paid per person to support their sustenance in the term of relocation. If businesses are affected, the PAPs (employees) will be paid compensation in cash for loss of income. Also, organizations would be considered a compensation for lost earnings of businesses.
2) Relocation assistance: The costs for removal including demolition and transportation are also subsidized.
3) Recovering assistance: Farmers, whose agricultural lands will be affected, are supported in following cases; (i) where considerable time is needed to recover one's livelihood, or (ii) they need vocational training due to being forced to change their job for example.
4) Reward policy: Families who move according to schedule, will be rewarded.

(3) Resettlement Sites Preparation

For resettlement, the PAPs would be given options as follows.

1) Cash compensation for land and other assets, and "self-resettlement" to places of their own choice.
2) Cash compensation for dwelling house, other structures and assets, and resettlement at the resettlement site.

(4) Restoration of Communal Infrastructure and Utilities

In cases where communal infrastructure or utilities are affected, the utilities and lost infrastructure will be restored for remaining communities.

10.3 Procedure of Land Acquisition and Resettlement

10.3.1 General Procedure

The outline and procedure of the land acquisition, compensation and resettlement for the Project are summarized as follows. This procedure follows in accordance with the Government Decree No. 22 ND-CP/1998 with HPC Decision No. 20 QD-UB/1998, which is pursued to Decree No. 22.

(1) Decision of land acquisition is promulgated after approval of right of way.

(2) As soon as the decision is promulgated, District's Land Acquisition, Compensation and Resettlement Committees (DLACRCs) are established in Thanh Tri and Gia Lam; however, in case of urgency the committees can be established before the decision is promulgated. DLACRCs will coordinate with People's Committees (PCs) of each level: the city, districts and communes within respective jurisdiction.

(3) PMU would establish an executive division (PED) for land acquisition, compensation and resettlement. The Project Implementation Unit (PIU) would consist of PED and project consultants.

(4) PMU Thang Long and PED will announce and prepare guidelines of compensation and resettlement policies for the project-affected persons through the PCs.

(5) DLACRCs should carry out the land acquisition survey as soon as the Project is approved. At the same time, PIU will carry out socioeconomic survey.

(6) The affected people and communities are informed by their respective PCs on the Project, and prepare legal documents to certify their properties in accordance with guidance from the Commune's People's Committees (CPCs) and District's People's Committees (DPCs)

(7) CPCs and DPCs certify the properties and prepare inventories in accordance with declarations from the PAPs.

(8) CPCs and DPCs submit inventories to DLACRCs, and DLACRCs investigate the inventories.

(9) On the other hand, PCs of each level report to DLACRCs regarding the situation of land reserve area for compensation.

(10) DLACRCs prepare Action Plans for Compensation and Resettlement (APCRs), after defining total size of lands, properties and amount of compensation, which depend on the inventories, the land acquisition survey and socioeconomic survey.

(11) At the same time, the HPC's Appraisal Committee (HPCAC) is established, and HPCAC appraises the APCRs submitted by DLACRCs.

(12) However, DLACRCs should report the action plans for compensation to Ministry of Finance (MOF). MOF co-ordinates with Ministry of Transportation (MOT), and instructs comments for the APCRs to DLACRCs.

(13) After appraisement for APCRs from HPCAC, DLACRCs present APCRs for the affected people through PCs of each level, and discuss together at meetings.

(14) The affected people have the right to complain and request on APCRs. Firstly, they submit complaints to commune authorities. If CPCs can not solve the claims, DPCs are consigned for resolution. Finally, HPC comes to the decision.

(15) PIU, DLACRCs and PCs implement APCRs, compensation payments, resettlement sites preparation, land transfer and relocation. Moreover, they must handle consequent troubles caused by civil works.

(16) PIU and supplementary independent agencies, if needed, carry out monitoring and evaluation of the APCRs.

10.3.2 Important Works

The following two works comprise the core of implementation for land acquisition, compensation and resettlement.

(1) Inventory works

After the Government approves right of way, District's Land Acquisition, Compensation and Resettlement Committees (DLACRCs) and respective PCs immediately undertake the inventory works. They record names of heads of household, number of persons, kinds and sizes of assets (residential lands, agricultural lands, structures, crops and etc.) affected by the Project on legal documents submitted by PAPs. Furthermore, affected organizations should be recorded on the inventory. At the same time, DLACRCs investigate affected communal properties. They also record utilities and the other public facilities to be relocated.

(2) Preparation of Action Plans for Compensation and Resettlement

The DLACRCs investigate the inventories and evaluate lost assets of the PAPs. The DLACRCs prepare Action Plans for Compensation and Resettlement (APCRs) on the evaluation of assets with co-ordination of PMU Thang Long. The APCRs include following items.

1) Inventories of lost assets and affected households with socio-economic profiles of households
2) Compensation measures for each households and organizations on evaluation results
3) Allocation measures for resettlement site
4) Implementation framework, including authorities and organizations, who carry out the tasks

10.4 Roles and Activities of Participants

10.4.1 Institutional Framework

Both District's People's Committees of Than Tri and Gia Lam have the main role for the Land Acquisition, Compensation and resettlement in the Project. The most important task for both committees is to prepare the Action Plans for Compensation and Resettlement. The institutional organization, implementation units and activities are summarized and shown in Figures 10.4.1 and 10.4.2.

(1) Roles of PMU Thang Long

PMU Thang Long fundamentally manages the implementation of land acquisition, compensation and resettlement under MOT. However, establishment of special executive division (PED) consisting of experts for these tasks will be proposed in PMU Thang Long. The PED will announce and prepare guidelines of compensation and resettlement policies for the project-affected persons through the PCs. Furthermore, they support the DLACRCs and review the APCRs.

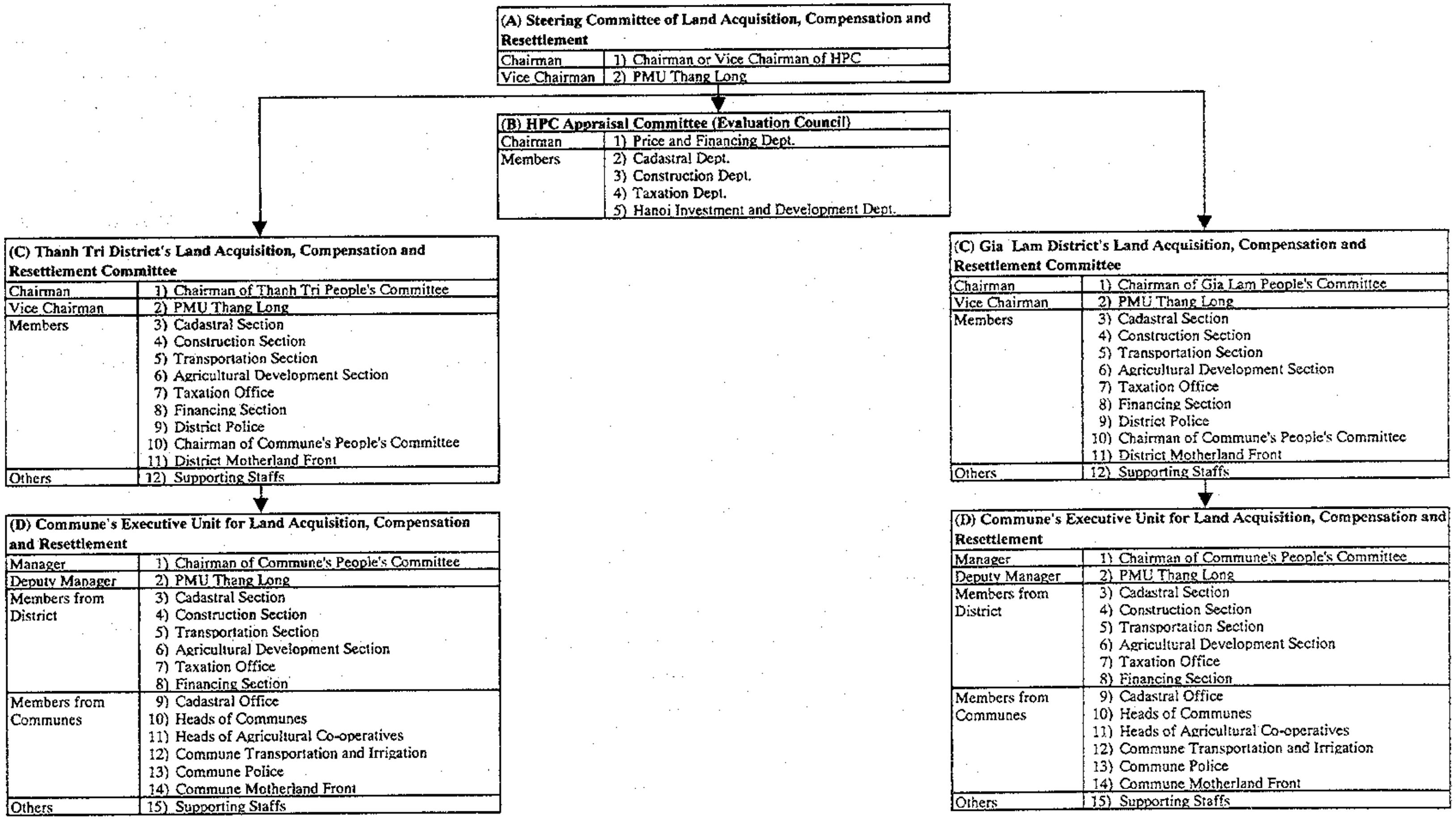
(2) Roles of District's People's Committees

Thanh Tri and Gia Lam Districts establish Land Acquisition, Compensation and Resettlement Committees (DLACRCs). The DLACRCs will coordinate with People's Committees (PCs) of each level: the city, districts and communes within respective jurisdiction. The DLACRCs investigate the inventories submitted by PCs. The DLACRCs prepare Action Plans for Compensation and Resettlement (APCRs), after defining total area of lands, properties and amount of compensation, which depend on the inventories, the land acquisition survey and socioeconomic survey.

(3) Roles of Commune's People's Committees

The Commune's People's Committees will fully inform project-affected persons of the compensation and resettlement policies with guidance. The PCs also ensure frequent participation of PAPs in the preparation of inventories and implementation of the APCRs. Respective PCs certify properties of the PAPs and prepare inventories in accordance with declarations from the PAPs. Afterward PCs submit DLACRCs the inventories, also report regarding the situation of land reserve area for compensation.

Figure 10.4.1 Organization Chart and Members of Respective Committees for Land Acquisition, Compensation and Resettlement



(A) Steering Committee of Land Acquisition, Compensation and Resettlement

Chairman	1) Chairman or Vice Chairman of HPC
Vice Chairman	2) PMU Thang Long

(B) HPC Appraisal Committee (Evaluation Council)

Chairman	1) Price and Financing Dept.
Members	2) Cadastral Dept. 3) Construction Dept. 4) Taxation Dept. 5) Hanoi Investment and Development Dept.

(C) Thanh Tri District's Land Acquisition, Compensation and Resettlement Committee

Chairman	1) Chairman of Thanh Tri People's Committee
Vice Chairman	2) PMU Thang Long
Members	3) Cadastral Section 4) Construction Section 5) Transportation Section 6) Agricultural Development Section 7) Taxation Office 8) Financing Section 9) District Police 10) Chairman of Commune's People's Committee 11) District Motherland Front
Others	12) Supporting Staffs

(D) Commune's Executive Unit for Land Acquisition, Compensation and Resettlement

Manager	1) Chairman of Commune's People's Committee
Deputy Manager	2) PMU Thang Long
Members from District	3) Cadastral Section 4) Construction Section 5) Transportation Section 6) Agricultural Development Section 7) Taxation Office 8) Financing Section
Members from Communes	9) Cadastral Office 10) Heads of Communes 11) Heads of Agricultural Co-operatives 12) Commune Transportation and Irrigation 13) Commune Police 14) Commune Motherland Front
Others	15) Supporting Staffs

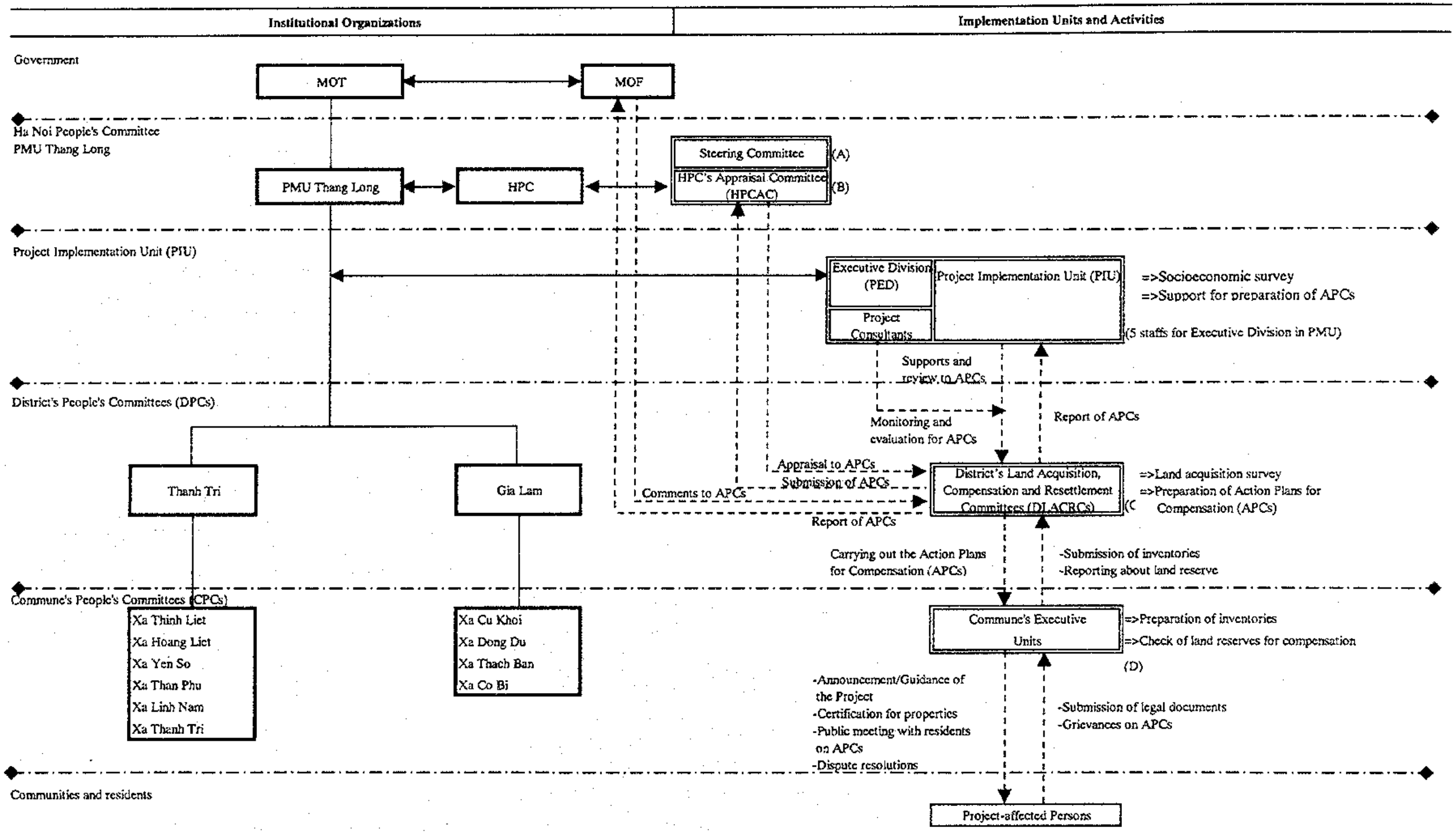
(C) Gia Lam District's Land Acquisition, Compensation and Resettlement Committee

Chairman	1) Chairman of Gia Lam People's Committee
Vice Chairman	2) PMU Thang Long
Members	3) Cadastral Section 4) Construction Section 5) Transportation Section 6) Agricultural Development Section 7) Taxation Office 8) Financing Section 9) District Police 10) Chairman of Commune's People's Committee 11) District Motherland Front
Others	12) Supporting Staffs

(D) Commune's Executive Unit for Land Acquisition, Compensation and Resettlement

Manager	1) Chairman of Commune's People's Committee
Deputy Manager	2) PMU Thang Long
Members from District	3) Cadastral Section 4) Construction Section 5) Transportation Section 6) Agricultural Development Section 7) Taxation Office 8) Financing Section
Members from Communes	9) Cadastral Office 10) Heads of Communes 11) Heads of Agricultural Co-operatives 12) Commune Transportation and Irrigation 13) Commune Police 14) Commune Motherland Front
Others	15) Supporting Staffs

Figure 10.4.2 Organization Chart and Activities



10.4.2 People's Participation

(1) Submitting Legal Documents

The District's and Commune's People's Committees will involve the PAPs through the preparation of inventory. The PAPs should submit legal documents on resident of the city and their assets. Even persons without legal documents can be considered with compensations and subsidies by the relevant People's Committees according to case.

(2) Public Meetings

The District's and Commune's People's Committees will present to PAPs the compensation and resettlement terms, and discuss with the PAPs at public meetings. The PAPs can ask about and make complaints regarding land acquisition and resettlement, including items of the inventory, entitlement of compensation and prices.

(3) Complaint and Grievance Resolutions

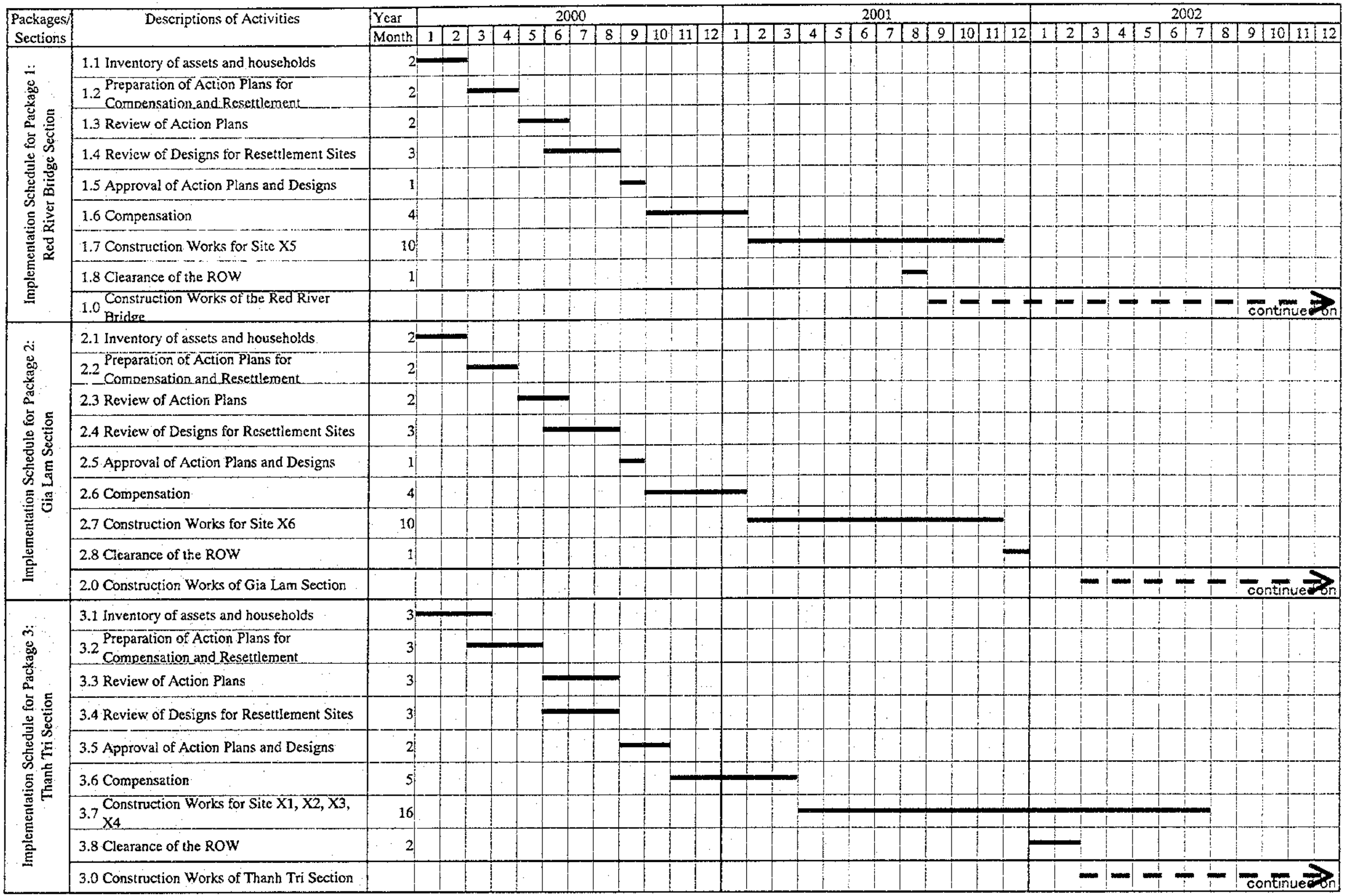
According to the Article 19 (Decision No. 20/1998) based on the Article 38 (Decree No. 22/1998), project-affected persons have the right to complain if the compensation policies do not follow the regulations. First, the complaints will be submitted to the relevant District's People's Committees. The DPCs should resolve these petitions within 15 days. If the person still is not satisfied with the decision, the complaints will be submitted to HPC for final decision.

10.5 Implementation Schedule

10.5.1 Implementation Schedule

In addition to the preparations of inventory and action plans for the PAPs, reviews of action plans and designs of resettlement sites are necessary in procedures of implementation. The review of designs of resettlement sites is important in particular, as complete data on PAPs will be accurately obtained by inventories. The PAPs' intentions for relocation on the resettlement sites also are confirmed in the review works. Furthermore, some additional or supplemental surveys, which include meetings and co-ordinations with related local PCs and HPC, are carried out to approve the designs (See Figure 10.5.1).

Figure 10.5.1 Implementation Schedule of Land Acquisition, Compensation and Resettlement



10.5.2 Supervision and Monitoring

Implementation of land acquisition, compensation and resettlement will be carefully supervised and monitored by PMU Thang Long and Executive Division (PED). They will co-ordinate with respective People's Committees, project consultants, and independent agencies if required.

(1) Internal monitoring

PMU Thang Long and the Executive Division (PED) will supervise the inventory works and preparation of action plans by the District's Land Acquisition, Compensation and Resettlement Committees (DLACRCs). Furthermore, they will monitor progress in the implementation of land acquisition, compensation and resettlement. They also co-ordinate with MOT for instruction in the implementation.

(2) Monitoring by project consultants

During the implementation of the land acquisition, compensation and resettlement, the resettlement specialist of the project consultants will support and monitor the activities of implementation in accordance with respective steps. Main tasks are; (i) review of the designs of resettlement sites, (ii) monitoring of land acquisition and compensation procedure according to the policy framework, (iii) suggestion to complement and amend the procedures in accordance with socioeconomic conditions of affected persons, if necessary.

(3) Independent monitoring

If it is required, PMU will hire an independent agency (research institute, consulting firm and non-government agency, for example), with qualified and experienced experts, to conduct post-evaluation for resettlement activities. The independent agency will assess the adequateness of the procedures, social impacts and sustainment of resettlers in the progress of resettlement activities.

(4) Consultation for the PAPs after resettlement

In the supervision and monitoring, the PMU/PED and respective PCs will conduct consultation or counseling for resettlers in order to solve resultant problems and mitigate troubles in assistance with the project consultants or the monitoring agency.

10.6 Compensation Costs

The latest regulations are followed as guidelines to estimate costs for land acquisition, compensation for property losses and the plan of resettlement sites. However, governments, HPC and authorized boards shall decide detailed policies in all cases, and execute accurate evaluations in accordance with conditions of projects (See Table 10.6.1).

Table 10.6.1 Major Items of Compensation and Unit Costs

Items		Units	Descriptions	Unit costs	Notes	Regulations to be applied	
(A) Compensation	(1) Land	Area	Residential land	**depend on locations** VND/m2	depend on classifications of communes and roads adjoining to areas	No. 3519/QD-UB 12 September, 1997	Article 6,7
			Aquacultural, forestry land	**18,000** VND/m2	average of land class 1 and 2	No. 33/QD-UB(amendment of land prices)10 September, 1998	
			Aquacultural land	13,000 VND/m2	assumed for ponds (land class 3)		
	(2) Houses and buildings	Floor area	Grade I	**1,600,000** VND/m2	Construction prices, although HPC promulgated standard prices to evaluate compensation value for houses No. 3892/QD-UB 10 Oct. 1997, Article 1	No. 22/ND-CP 24 April, 1998	Article 17
			Grade II	**1,300,000** VND/m2			
			Grade III	**1,000,000** VND/m2			
			Grade IV	**800,000** VND/m2			
			Temporary houses or pent-roof houses	**400,000** VND/m2	Several kind of small architectures are also compensated, but it is hardly to confirm.	No. 1120/TBLS 29 October, 1997	
	(3) Crops	Cultivated area	Vegetables	15,000 VND/m2	Unit costs (assumptions) from Compensation for Land Preparation in Yen So Lake Area	No. 22/ND-CP 24 April, 1998	Article 23
			Rice	**10,000** VND/m2			
			Fish	**10,000** VND/m2			
	(4) Tombs	Tomb	Concrete tomb	**1,900,000** VND/tomb	Locations of tombs should be reflected on owner's opinions. (self arrangement)	No. 20/QD-UB 1998	Article 9
			Soil tomb	**1,600,000** VND/tomb			
(B) Subsidy	(5) Living assistance	Person		1,300,000 VND/person	7,200 VND/kg of rice/month X 6 months	No. 22/ND-CP 24 April, 1998	Article 25
	(6) Relocation assistance	Family		3,000,000 VND/family	In case of relocation in a same province		Article 17
	(7) Reward policy	Family		5,000,000 VND/family	In case of relocation up to the plan		Article 26
	(8) Recovering assistance	Cultivated area	training for new career	15,000 VND/m2	60 tons of rice's price/ha, 2,500VND/kg	No. 20/QD-UB 1998	Article 12
(C)Relocation Site Preparation		Area	Grading, Water/Power supply, drainage, road and etc.	**400,000** VND/m2			

10.6.1 Lands and Assets

(1) Compensation for Lands

1) Agricultural and Aquacultural Lands

Landowners forced to lose agricultural land will basically be compensated with land of similar scale and productivity. If the land can not be provided, compensation for land losses is to be paid in cash according to land prices promulgated by the Government. Moreover, in the following cases, landowners are paid in cash for the difference between compensated land and former one: cases in which land area is less or land area price is lower than former property.

Despite basic policy, in which agricultural land losses are compensated with land, compensation amount for agricultural land losses are estimated as indemnity for this project. This is due to the fact that it is not certain where the People's Committee can provide substitute land in light of the current situation. Therefore, our compensation policy for agricultural lands is summarized as follows:

- The costs for compensation are estimated for whole land areas, however, agricultural lands and aquacultural lands (ponds) are fundamentally compensated with equal land.

Latest land prices in Hanoi are shown in Table 10.6.2 as an amendment.

Table 10.6.2 Prices of Agricultural and Aquacultural Land

(Unit: VND/m^2)

Land Category	Annual Crops/ Aquacultural Land	Perennial Plant Land
Class 1	19,000	14,000
Class 2	16,100	11,900
Class 3	13,000	8,500
Class 4	9,800	4,300
Class 5	4,700	1,200
Class 6	1,300	-

Source: Decision No. 33/OD-UB, 10 Sep. 1998

The average price of Classes 1 and 2 is assumed for land prices of rice paddies, vegetable fields and flower farms, and land Class 3 is for aquacultural ponds.

Agricultural land	18,000 VND/m^2
Aquacultural land (ponds)	13,000 VND/m^2

2) Residential Lands

Residential lands are compensated in cash or with land of same purpose and value in land price. Improves living environment is considered in the compensated land. Resettlement sites should be planned for the residential land compensation.

Landowners are also compensated for difference of land size and/or value between former land and compensated one. If part of land is lost, landowners are permitted to use the remaining land. Otherwise, they can request the government to acquire remaining land, or they are encouraged to transfer the land to neighbors.

The policy of residential land compensation would be a "given option"; (i) paid in cash or (ii) compensated with lands on the resettlement sites. However, compensation amount for residential land losses is estimated, as we can not ascertain at present which option is to be selected by the PAPs. Furthermore, we should consider the possibility of urgently required land acquisition or inadequately compensated resettlement lands.

3) Other Lands

In the case of relocation of public facilities, the respective People's Committee that each facility belongs to will prepare substitute lands. The Government also prepares new sites for relocation of Government offices, state-owned companies, etc. The People's Committee also provides substitute lands for relocation of private companies or joint venture companies, case by case. In any case, infrastructures are also prepared with lands.

However, we include compensation costs of land acquisition for public facilities, state or PC-owned companies, etc. into the cost estimation.

Land prices in the Study Area are shown in Table 10.6.3, Figure 10.6.1, Tables 10.6.4 and 10.6.5, and Figure 10.6.2.

Table 10.6.3 Land Prices of Rural Residential Areas

(Unit: VND/m^2)

Districts	Communes	Classifications of Commune	Land Prices	
			with Infla.	without Infla.
Thanh Tri	Hoang Liet	Class 1	38,000	29,000
	Thinh Liet	Suburban	next table	
	Yen So	Class 1	38,000	29,000
	Tran Phu	Class 1	38,000	29,000
	Linh Nam	Class 1	38,000	29,000
Gia Lam	Cu Khoi	Class 2	32,000	24,000
	Dong Du	Class 3	26,000	20,000
	Thach Ban/Co Bi	Class 1	38,000	29,000

Source: Decision No. 3519/OD-UB, 12 Sep. 1997

Figure 10.6.1 Commune Classifications

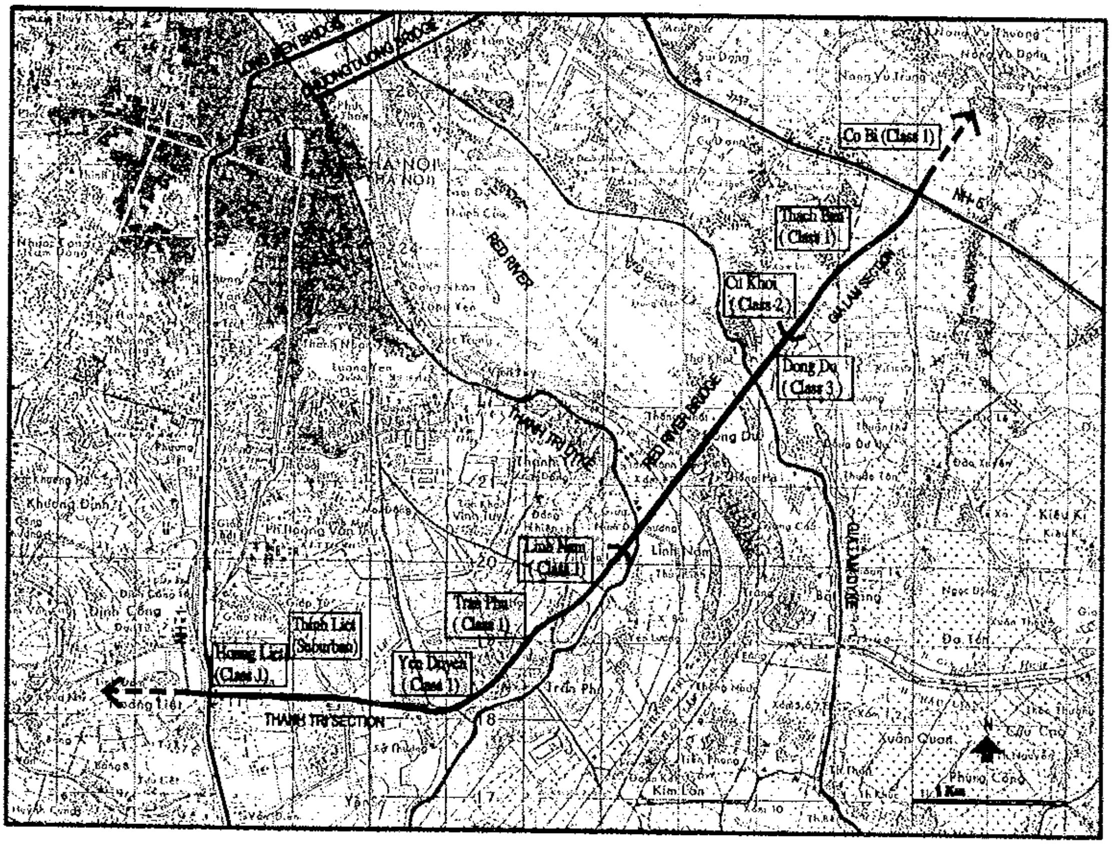


Table 10.6.4 Land Price of Suburban Residential Areas, Traffic Intersections, Main Road, Urban Development Area, Business Center, Tourism Area and Industrial Area

(Unit: VND/m^2)

Area Location	Location 1) Types of Streets 2)		Location 1	Location 2	Location 3	Location 4	Outside of 200m
Suburb Communes, Town, Tourism Area, Urban Dev't Planned Area, Business Center, Industrial Area	Class 1	with infra.	1,500,000	900,000	540,000	320,000	220,000
		without infra.	1,350,000	810,000	485,000	290,000	210,000
	Class 2	with infra.	1,200,000	720,000	430,000	260,000	200,000
		without infra.	1,080,000	650,000	390,000	235,000	190,000
	Class 3	with infra.	960,000	570,000	340,000	200,000	180,000
		without infra.	870,000	520,000	310,000	190,000	170,000
Land of Traffic Intersections, Main Road, Suburban Districts	Class 1	with infra.	880,000	525,000	290,000	140,000	price of rural area
		without infra.	790,000	470,000	260,000	125,000	
	Class 2	with infra.	520,000	310,000	170,000	85,000	
		without infra.	470,000	280,000	155,000	75,000	
	Class 3	with infra.	310,000	190,000	105,000	50,000	
		without infra.	280,000	170,000	90,000	45,000	

Source: Decision No. 3519/OD-UB, 12 Sep. 1997

Note: 1) Land locations are identified as follows

Location 1: 50 m from the right of way
Location 2: 100 m from the end of Location 1 from the right of way
Location 3: 150 m from the end of Location 2 from the right of way
Location 4: 200 m from the end of Location 3 from the right of way

2) Road classifications are shown in table and figure below.

Table 10.6.5 Road Classifications

Districts	Roads		Sections	Classes
Thanh Tri	National Highway	NH1	Section from Hai Ba Trung District to Area adjoining to Van Dien Town	Class 1
	Local Road	Phap Van Street	Section from Crossway of Yen So to Red River Dyke	Class 3
		Dyke road	Red River Dyke (from Thanh Tri to adjoining areas of Ha Tay)	Class 3
		Tam Trinh, Mai Dong	Section Mai Dong - Linh Nam, Tren Phu	Class 2
Gia Lam	National Highway	NH5	Section from Chui Bridge to end of Chau Quy Commune Area	Class 1
	Local Road	Dyke road	Red River Embankment	Class 3

Source: Decision No. 3519/OD-UB, 12 Sep. 1997

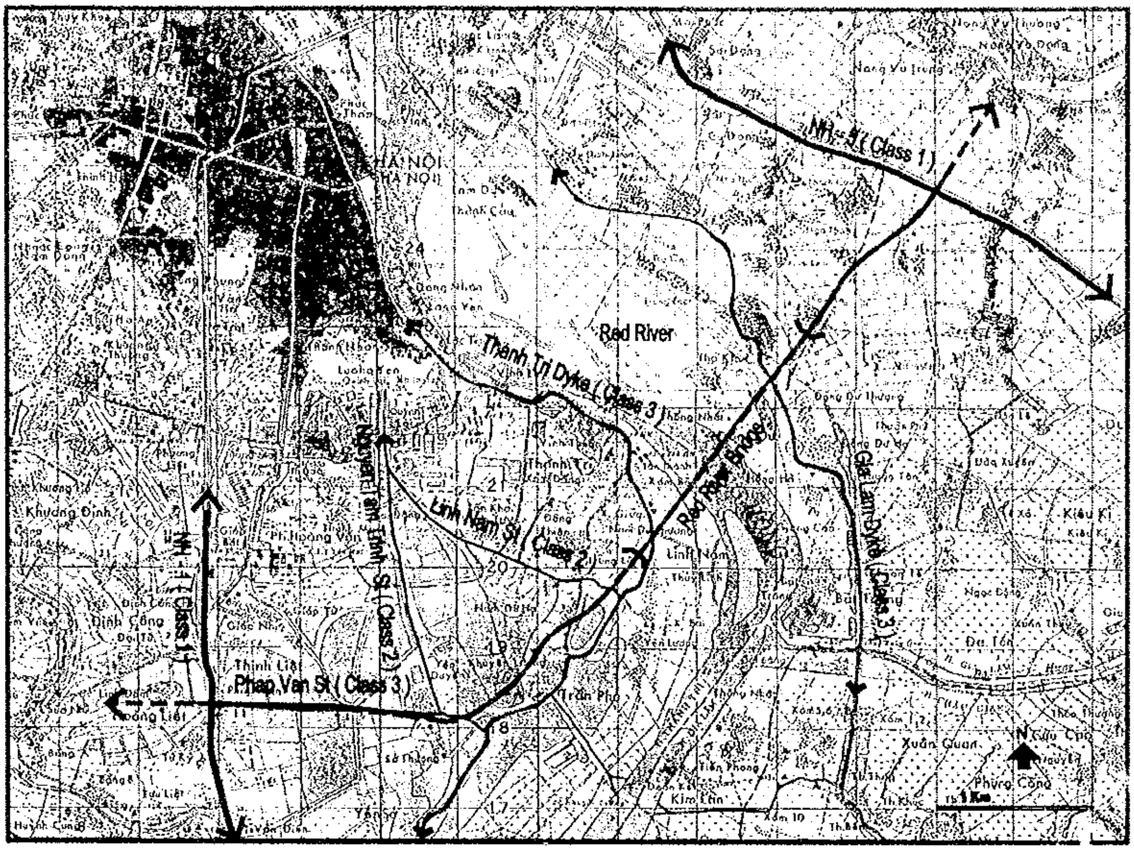


Figure 10.6.2 Road Classifications

(2) Compensation for Property Losses

Compensation policy for dwelling houses is changed. Residences had been planned and provided for affected residents; however, the following critical problems have surfaced:

1) Budget shortage, mainly due to the cost for compensation and resettlement sites with houses.
2) Even if residences were provided after overcoming the budget shortage, some residents prefer to settle in places other than the provided resettlement site. Besides, they sold or rented their houses.

However, the regulation is changed in the Decision No. 22/ND-CP by HPC. Following are main compensation policies for asset's losses according to the latest regulations of HPC.

- Asset losses (houses) are basically compensated with money equivalent to current value (depreciation value), and additional money is subsidized.
- The residents then recover property by themselves on the resettlement sites provided.

1) Farming Products

Compensation for loss of farming products is equivalent to a single year's harvest. This compensation is figured as the average price of the three previous years' harvest according to crop. Fruit trees and rubber plants are compensated by current local prices. Farm produce would be compensated in accordance with land productivity.

The following produce estimates were assumed by an example of compensation for land preparation in Yen So in 1998.

• Rice	10,000 VND/m^2
• Vegetables and flowers	15,000 VND/m^2
• Fishes in ponds	10,000 VND/m^2

2) Houses and Buildings

Evaluation of house value is one of the most complicated matters in the compensation. The HPC's policy to evaluate house value is based on the house grades as mentioned above. Grade I, II and III houses are compensated in accordance with depreciation value, moreover supported with 50 % of the compensation amount decided by the Land Acquisition Committee, however, the amount of compensation should not be less than 60 % of newly construction cost. Grade IV houses or temporary houses are compensated with money equivalent to new construction cost (See Table 10.6.6).

For the project, we estimate houses' compensation cost as unit prices for new housing construction. HPC promulgated a decision on standard prices to evaluate houses for land clearance shown in Table below; however, a 20% to 40% disparity can be seen between the construction prices and evaluation prices. Therefore, we take the construction prices as the affected people prepare their houses on the site. Furthermore, office buildings, warehouses and other structures are also estimated by the same prices (See Table 10.6.7).

Table 10.6.6 Construction Costs for Houses

(Unit: ,000 VND/m^2 of floor area)

Grades	Grade I	Grade II	Grade III	Grade IV	Temporary	Others
Prices	1,600	1,300	1,000	800	400	200

Note: Prices of Grade I, Temporary and Others are estimated.
Source:Local Construction Company, 1999

Table 10.6.7 Standard Prices to Determine Asset's Value

(Unit: ,000 VND/m^2 of floor area)

Grades of House	Grade IV		Grade III	Grade II		Grade I
	110 mm wall without ceiling	220 mm wall without ceiling		2-3 story	3-4 story	
Prices	531	606	794	1,011	1,186	1,300

Source: Decision No. 3892/QD-UB dated 10 October 1997

3) Tombs

Costs for relocation of tombs are fully compensated. The expenditures include preparation, excavation, removal, reconstruction of tombs and etc. If owners arrange by themselves, as the Hanoi People's Committee can not provide it they are additionally compensated with 1,000,000 VND/tomb to prepare the cemetery (See Table 10.6.8).

• Concrete tomb	1,900,000 VND/m^2
• Soil tomb	1,600,000 VND/m^2

Table 10.6.8 Costs for Tombs Relocation

Types of Tombs	Land Prepared
Concrete tomb	900,000 VND/tomb
Soil tomb	600,000 VND/tomb
Non-owner	400,000 VND/tomb

Source: Decision No. 20/QD-UB

4) Other Assets

In addition to houses, other structures (temporary houses, barns, sheds, fences and etc.) and properties (trees, livestock and etc.) are compensated. However, it is difficult to estimate the entire assets without declarations from residents. Therefore, the Study Team estimates compensation cost for structures excluding houses: temporary houses, barns and sheds on maps. The average price of temporary houses and pent-roof houses is assumed as unit cost; however, higher ones are used. These prices are stipulated in Notice No. 1120/TBLS.

- Temporary or pent-roof houses 400,000 VND/m^2

10.6.2 Supporting Policies (Subsidies)

(1) Living Assistance

Subvention is paid per person to support their sustenance within the term of relocation. This amount is calculated at an average price equivalent to 30 kg of rice in the local market for one person per month for six months. If the scale of land acquisition is large or a large family has to move to another province, the subvention amount is equivalent to the same condition but for one year.

The half-year support will be adopted for living assistance policy in this project. The price of rice in the local market in June 1999 was 3,600 VND/kg for middle grade and 7,200 VND/kg for high-grade source according to the Viet Nam Times. The study team takes the higher price to assume a unit cost for living assistance. Therefore, indemnity is calculated at around 1,300,000 VND/person.

This amount is equivalent to the average monthly income for a household in both districts, yet this amount is paid for one person. This means that an average family having five persons is compensated with 6,500,000 VND, which is equivalent to average household income of five months.

- Living assistance policy 1,300,000 VND/person

(2) Relocation Assistance

The costs for removal, including demolition and transportation, are also subsidized. In case of relocation within the same district, the amount is from 1,000,000 to 3,000,000 VND/family, and from 3,000,000 to 5,000,000 VND/family for the case of moving to the other district according to scale of removal. Our policy for resettlement is to relocate residents on resettlement sites as close their former settlements as possible. Thus, we take the former case with higher cost for the relocation assistance.

- Relocation assistance policy 3,000,000 VND/family

(3) Reward Policy

5,000,000 VND per family is paid for relocated privies who relocate according to the plan made by Compensation and Land Acquisition Council. This amount is paid for the case that a family moves more than 16 days earlier than the plan schedule. This is the maximum case for the reward policy.

- Reward policy on the schedule 5,000,000 VND/family

(4) Recovery policy for farmers

Farmers with agricultural lands are supported if it takes time to recover their livelihood, or if they need vocational training due to being forced to change their job, for example. This support money is calculated at current market price equivalent to 60 tons of paddy per hectare.

This recovery policy can be seen in a project acquired for large-scale agricultural lands. The current paddy price is 2,500 VND/kg according to the Viet Nam Times. Thus, we estimated the following recovery policy for farmers.

- Recovery policy for farmers 15,000 VND/ m^2

(5) Salary Assistance

Salaries of all staff and employees are supported in accordance with income levels until the time that companies start and rehabilitate their business or operation after removal. The term of support would be six months on average.

10.6.3 Other Costs

(1) Restoration of Communal Infrastructures

Restoration cost is for communal infrastructure, including relocation of power lines with poles, water supply pipes and underground utilities, reconstruction of drainage and roads, if needed. However, this cost is estimated for 10 % of total compensation costs, as it is very difficult to estimate the cost without information from water supply company, power supply company, and the related PCs.

(2) Administration Costs

Administration costs are estimated by maximum land prices for residential area, agricultural, aquacultural land and unused land stipulated in Decision No. 1146/QD-UB dated 19 March 1998, which is pursuant to Article 18 of No. 20/OB-UB that Hanoi People's Committee promulgated on 30 June 1998. This is a temporary regulation on standard of expenditures for land acquisition confiscated by the Government in the Hanoi area.

(3) Relocation Sites for Organizations

Almost all organizations affected by the Project would be state-owned companies or belong to the PCs. According to the regulations, jurisdictional agencies should take care of their relocations. However, costs for site preparation are considered in the compensation costs. Unit cost of 400,000 VND/m^2, which is in the order of the unit cost for preparation of resettlement site, is applied for estimation.

10.6.4 Cost Estimation

We estimated the compensation costs according to the compensation policies mentioned in the section 10.7. The compensation costs are summarized and shown in Tables 10.6.9, 10.6.10, 10.6.11 and 10.6.12.

Table 10.6.9 Compensation Costs (Bridge Section)

Compensation			Costs (mil.VND)	Notes
	(A)Compensation	1) Lands	2,318	
		2) Houses and	2,362	
		3) Crops	930	
		4) Tombs	0	
		Total	5,610	
	(B)Subsidy	5) Living	650	organizations included
		6) Relocation	450	for supporting transfer
		7) Reward	500	for on scheduled transfer
		8) Recovering	838	for farmers
		Total	2,438	
	(C) Restoration of communal		805	10% of (A) + (B)
(D) Compensation			8,853	(A)+(B)+(C)
(E) Administration costs for			2,012	for compensation
(F) Relocation sites for			0	compensation cost
(G)			1,087	10% of (D)+(E)+(F)
(H) Grand Total			11,951	(D)+(E)+(F)+(G)

Table 10.6.10 Compensation Costs (Gia Lam Section)

Compensation			Costs (mil.VND)	Notes
	(A)Compensation	1) Lands	22,968	
		2) Houses and	24,675	
		3) Crops	3,110	
		4) Tombs	20	
		Total	50,773	
	(B)Subsidy	5) Living	1,238	organizations included
		6) Relocation	627	for supporting transfer
		7) Reward	675	for on scheduled transfer
		8) Recovering	4,450	for farmers
		Total	6,990	
	(C) Restoration of communal		5,776	10% of (A) + (B)
(D) Compensation			63,539	(A)+(B)+(C)
(E) Administration costs for			3,340	for compensation procedure
(F) Relocation sites for			997	compensation cost included
(G) Allowance			6,788	10% of (D)+(E)+(F)
(H) Grand Total			74,664	(D)+(E)+(F)+(G)

Table 10.6.11 Compensation Costs (Thanh Tri Section)

Compensation			Costs (mil.VND)	Notes
	(A) Compensation	1) Lands	176,195	
		2) Houses and	62,141	Office buildings included
		3) Crops	6,601	
		4) Tombs	0	
		Total	244,937	
	(B) Subsidy	5) Living	8,625	organizations included
		6) Relocation	4,035	for supporting transfer
		7) Reward	4,350	for on scheduled transfer
		8) Recovering	5,663	for farmers
		Total	22,673	
	(C) Restoration of communal		26,761	10% of (A) + (B)
(D) Compensation			294,371	(A)+(B)+(C)
(E) Administration costs for			10,821	for compensation
(F) Relocation sites for			22,288	compensation cost included
(G) Allowance			32,748	10% of (D)+(E)+(F)
(H) Grand Total			360,228	(D)+(E)+(F)+(G)

Table 10.6.12 Compensation Costs (Resettlement Sites)

Items			Costs (mil.VND)	Notes
	(A)Compensation	1) Lands	2,160	Agricultural lands or ponds
		3) Crops	1,800	
	(B)Subsidy	8) Recovering assistance	1,800	for farmers
	(C) Restoration of communal infrastructure		576	10% of (A) + (B)
(D) Compensation total			6,336	(A)+(B)+(C)
(E) Administration costs for compensation			600	for compensation procedure
(F) Allowance			694	10% of (D)+(E)
(G) Grand Total			7,630	(D)+(E)+(F)

CHAPTER 11 DETAILED DESIGN OF RESETTLEMENT SITES

CHAPTER 11 DETAILED DESIGN OF RESETTLEMENT SITES

11.1 Locations for the Resettlement Sites

11.1.1 General Conditions

HPC proposed six locations as resettlement sites for the Project, of which four sites are prepared for Thanh Tri and two sites for Gia Lam (See figure 11.1.1). The six sites are for "resettlement for and by present communal groups". Main reasons for site selections are summarized as follows:

1) The sites should be located is as close as possible to former settlements to sustain: (i) present kinship groups, (ii) daily sustenance system such as mutual assistance and aid, (iii) linkage with communal properties or facilities.

2) The resettlement plans need to follow the future land use plan of the Hanoi Master Plan made by the HPC.

3) The sites are selected from reserved lands of the HPC or the related PCs as suitable to both items 1) and 2) mentioned above, as smoother procedure of compensation and resettlement can be expected on the reserved lands of the PCs.

Almost all sites may be acceptable with respects to locations except for sites X1 and X6. Site X6 is located 2 km away and the site X1 is located 1 km in away from the present settlement of PAPs, although the other sites are located within 500 m.

However, the PCs involved with these locations agree to construct the resettlement sites. The HPC also expects that the PAPs will find sites X1 and X6 acceptable, as these sites are located in future urbanized areas according to the Hanoi Master Plan. In particular, X6 is located close to a school and the PC's Thach Ban commune office. This area would become to the center of Thach Ban commune, according to the future plan.

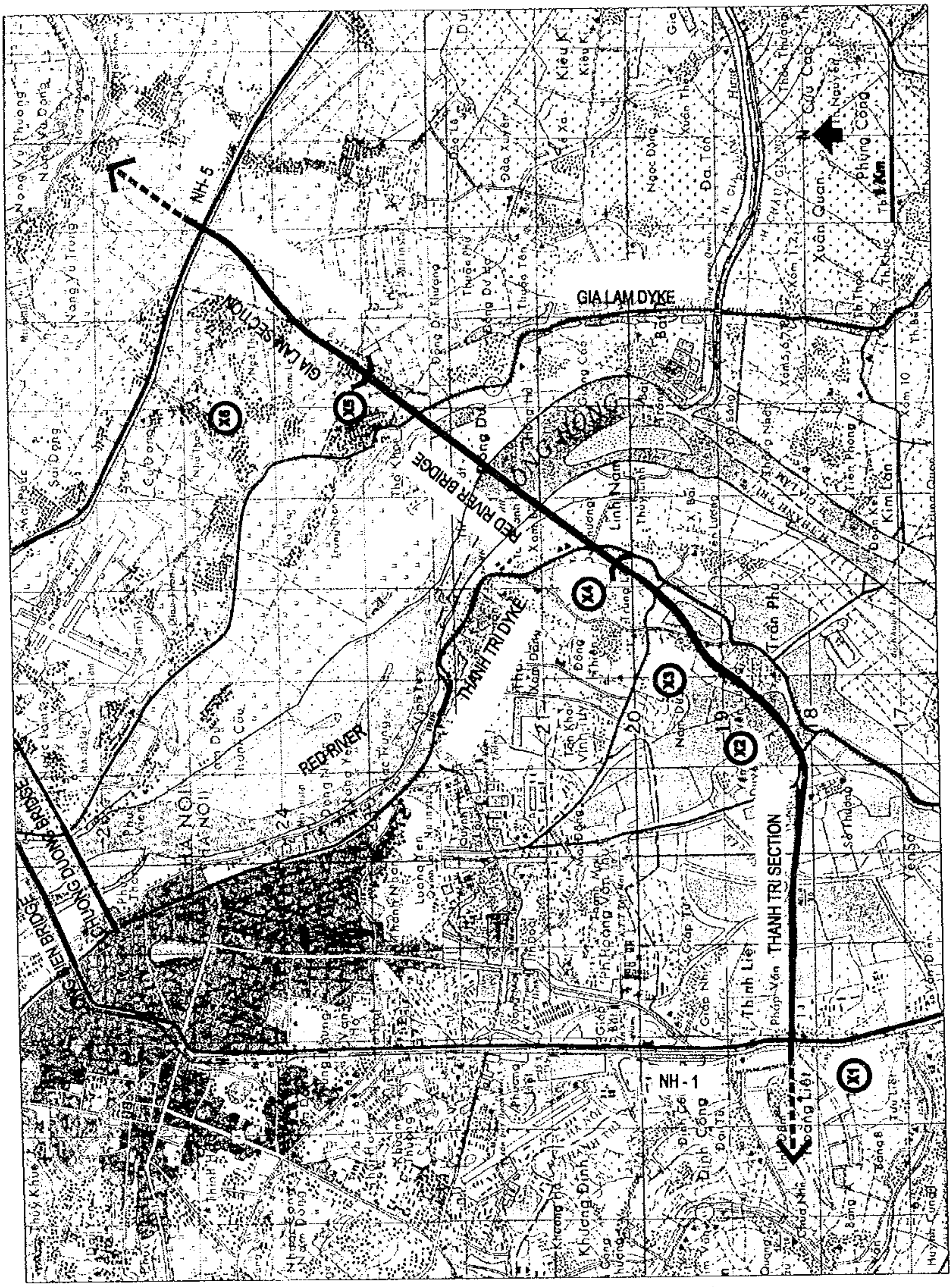


Figure 11.1.1 The proposed six resettlement sites

11.1.2 Present and Future Aspects of the Sites

(1) Site X1: (Hoang Liet commune)

Figure 11.1.2 shows the location of the site X1.

1) General Conditions

(i) Location: This site will be prepared for people who live around the intersection of the NH1 and Phap Van St., and along Phap Van St. in Hoang Liet commune. The site is located near Tu Ky village, around 800 m southwest from the former settlement of project-affected persons.

(ii) Land use: Present land use of the site is paddy fields, and is flat terrain. However, a new cemetery can be seen on or close to the site.

(iii) Access: Narrow paths paved by concrete or tiles run through the Tu Ky village up to the site from the NH1.

(iv) Water supply: The residents of Tu Ky village use wells for water supply, however, city water could be supplied for the site from the main line of the NH1.

(v) Power supply: Power lines are available to supply power for the site.

(vi) Social facilities: The commune has a primary school and junior high school which are located to the north of the site and 1km in distance. The PC's office is also located near the schools. There is a high school adjoining to the site. Furthermore, the commune has a few clinics, pagodas or shrines and communal (assembly) halls.

(vii) Neighborhood community: The aspects of a typical farming village in a suburban area, can be seen in the Tu Ky village which is adjacent to the site. Tile-paved narrow paths with drainage run through the village. The residents usually have a housing lot including a dwelling house, a kitchen house and a shed, which is mainly one floor, consisting brick walls of with tile or concrete roof.

2) Future plans: HPC has a development plan for a residential area, which includes the area between Phap Van St. and Van Dien Town in the Hanoi Master Plan. This area would be developed as a new residential area with collector streets on the site.

3) Advantages and Needs

(i) Advantages

<u>For the residents</u>

- Residents could use the former communal facilities and take advantage of social services.
- The site is located in a proposed urbanizing area, therefore benefit from economic and cultural development is expected.

<u>For construction</u>

- Flat terrain enables to efficient cutting and filling work and lower cost.
- The site has plentiful and rich underground water sources, which can be exploited and used for daily activities of the residents. They could be also served by city water system from the NH1.
- For the other infrastructures, it is easy to connect lines to main lines.

(ii) Needs: The residents could use the former communal facilities, however, present access way passing through the Tu Ky village is narrow. Therefore, a new access way up to the NH1 should be provided for the residents on the site.

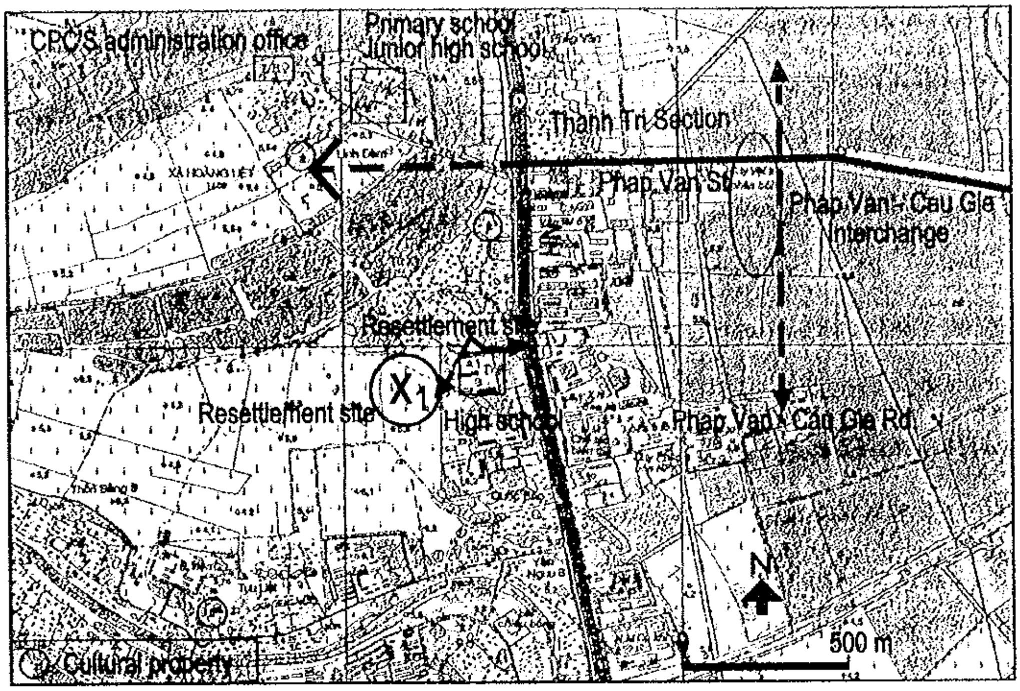


Figure 11.1.2 Site X1: (Hoang Liet commune)

(2) Site X2: (Yen So commune)

Figure 11.1.3 shows the location of the site X2

1) General conditions

(i) Location: This site will be prepared for persons who dwell in the southern Yen Duyen village and along the Phap Van St. in Yen So commune, which is affected by the right of way of SHTRR. The site is located in the Yen Duyen village, and around 800 m north of the present settlement of PAPs.

(ii) Land use: Present land use of the site is pond surrounded by residential area but the eastern side is on a residential street of the village. The pond seems to be used as a washing place, as some steps made of bricks can be seen around the pond.

(iii) Access: This unpaved street runs to the Thanh Tri Dyke 800 m away. Other residential streets which run through the village are paved by tile or concrete, run to Nguyen Tam Trinh St. 500 m away. The street runs in between the Phap Van St. and Hanoi urban area.

(iv) Water supply: The residents of Yen Duyen village use wells for water supply.

(v) Power supply: Power lines are available to supply power for the site.

(vi) Social facilities: The commune has a primary school and junior high school. These schools are located on the south of the site and at 400 m distance, which is adjacent to the CPC's office. Moreover, the commune has a few clinics, pagodas or shrines and communal (assembly) halls.

(vii) Neighborhood community: The aspect of the Yen Duyen village adjoining to the site is similar to the southern Yen Duyen village, which is affected by the SHTRR. Tile-paved narrow paths with drainage run through the village. The residents usually have a housing lot including a dwelling house, a kitchen house and a shed, which are mainly one or two floors, with brick walls and tile or concrete roof.

2) Future plans: HPC has plans to improve the Nguyen Tam Trinh St. connecting to the SHTRR. Vehicles can access to the frontage road and the highway by an interchange. However, the area surrounding the site is reserved for development in the Hanoi Master Plan.

3) Advantages and Needs

(i) Advantages

For the residents

- Less impact to the resettlers for living activities: they could sustain their former daily activities such as access to communal facilities, working places, schools and markets.
- Less difficulty for integration with neighborhood residents.
- The site will have easy access to the improved Nguyen Tam Trinh St., the SHTRR and Thanh Tri Dyke.

For construction

- Flat terrain enables efficient cutting and filling work and lower cost.
- The site has rich underground water sources, which can be exploited and used for the daily activities of the people.
- For other types of infrastructure, conditions are favorable for construction.

(ii) Needs: A residential street runs in front of the site up to the Thanh Tri Dyke; however, it is not paved and is bumpy. Therefore, improvement of the street is required, and this improvement can contribute to local access. On the other hand, the CPC and Yen Duyen village should make efforts to mitigate expected conflict with resettlers from So Thuong neighborhood village.

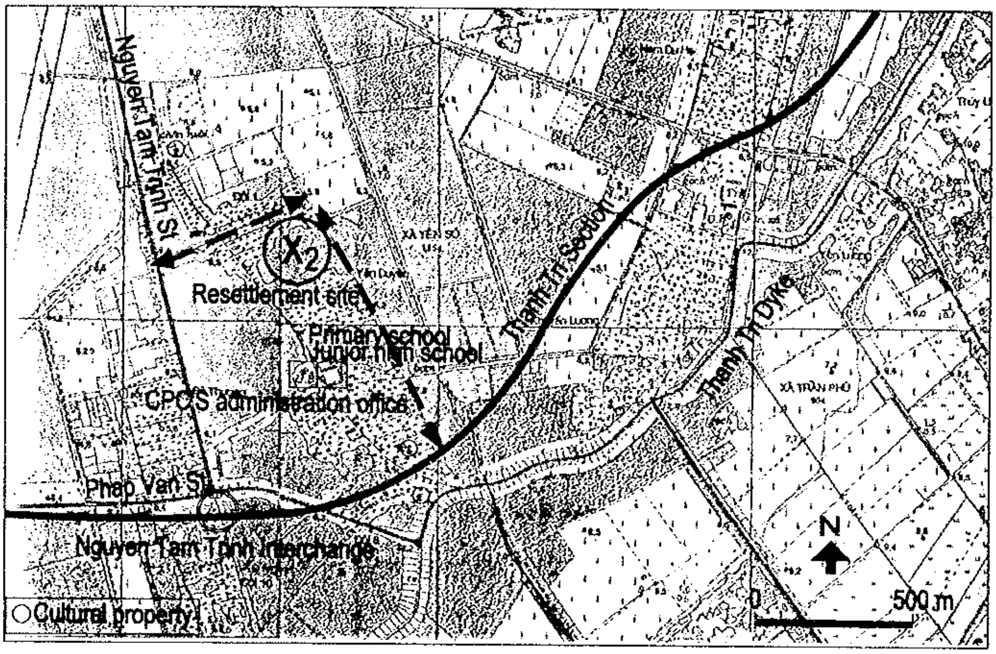


Figure 11.1.3 Site X2: (Yen So commune)

(3) Site X3: (Tran Phu commune)

Figure 11.1.4 shows the location of the site X3.

1) General Conditions

(i) Location: This site will be prepared for persons who live in Nam Du Ha village, which is affected by the SHTRR. The site is located near Nam Du Ha village, around 500 m west from the present settlement of project-affected persons.

(ii) Land use: Present land use of the site is paddy fields, and is flat. A small residential area and a machinery-manufacturing factory are located on the northwestern side of the site.

(iii) Access: A paved (concrete) access way runs to Nam Du Ha village, and to the Thanh Tri Dyke and Linh Nam St., but this is only 3 – 4m in width.

(iv) Water supply: The residents of Nam Du Ha village use wells for water supply.

(v) Power supply: Power lines are available to supply power for the site.

(vi) Social facilities: The commune has a primary school and junior high school. These schools are located on the southeast of the site and at 800 m distance, which is adjacent to the CPC's office. Moreover, the commune has a few clinics, pagodas or shrines and communal (assembly) halls.

(vii) Neighborhood community: The aspects of typical farming village in a suburban area, can be seen in the Nam Du Ha village which is the present community of the resettlers. Tile-paved narrow paths with drainage run through the village. The residents usually have a housing lot including a dwelling house, a kitchen house and a shed, which are mainly one or two floors, with brick walls and tile or concrete roof.

2) Future plans: A pond separates the site from the former settlement, however, the HPC has plans for green area or park around the pond. Also, the HPC has a plan of new inter-community access (minor arterial) roads, which would be around 30m in width, adjoining to the site. These roads will connect to the Linh Nam St., the SHTRR and Nguyen Tam Trinh St. The surrounding area is reserved for developments on the Hanoi Master Plan.

3) Advantages and Needs

(i) Advantages

<u>For the residents</u>

- Less impact to the resettlers for living activities: they could sustain their former daily activities such as access to communal facilities, working places, schools and markets.
- The site will have enhanced accessibility as the site is located near the interseciton of planned inter-community access (minor arterial) roads.

<u>For construction</u>

- Flat terrain enables efficient cutting and filling work and lower cost.
- The site has rich underground water sources, which can be exploited and used for the daily activities of the people.
- For other types of infrastructure, conditions are favorable for construction.

ii) Needs: The residents could use the former communal facilities, however, present access way running to the Nam Du Ha village is narrow. Therefore, improvement of this path will be required, or new access way should be provided for the residents on the site.

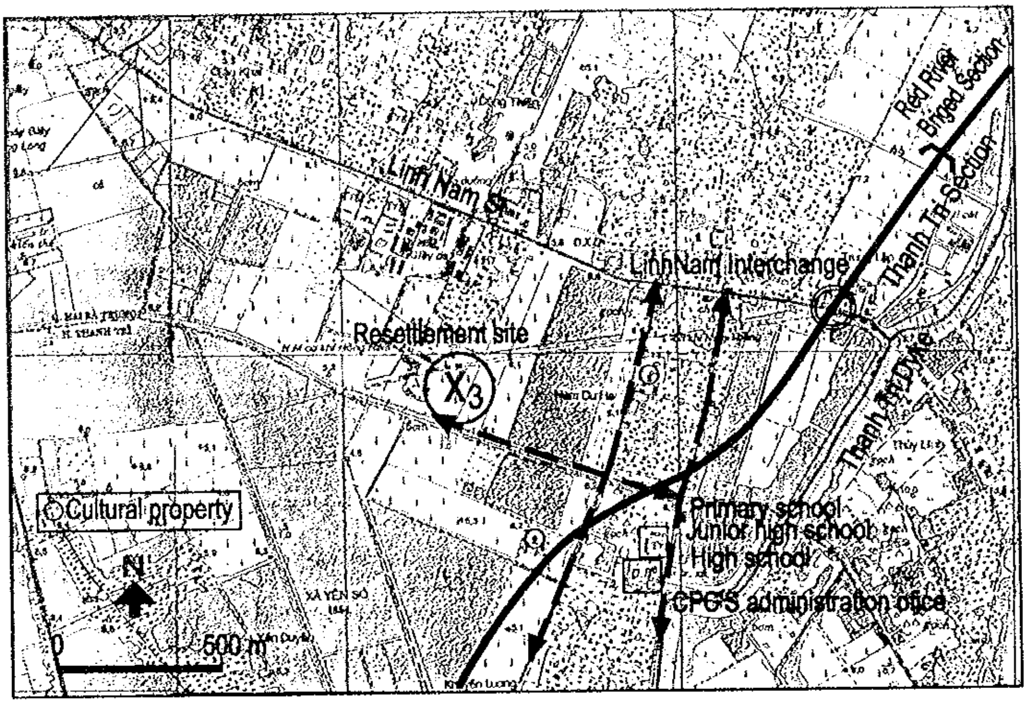


Figure 11.1.4 Site X3: (Tran Phu commune)

(4) Site X4: (Linh Nam commune)

Figure 11.1.5 shows the location of the site X4.

1) General Conditions

(i) Location: This site will be prepared for persons who live along Linh Nam St., and affected by the Linh Nam Interchange to the Red River Bridge. The site is located near Nam Du Thuong village, and around 500 m north away from the present settlement of project-affected persons.

(ii) Land use: Present land use of the site is vegetable fields, and is flat.

(iii) Access: A paved (concrete) access way runs in front of the site between the Nam Du Thuong village and Than Tri Dyke, but this is only 3 - 4 m in width.

(iv) Water supply: The residents of Nam Du Thuong village use wells for water supply.

(v) Power supply: Power lines are available to supply power for the site.

(vi) Social facilities: The commune has a primary school and junior high school, where are located on the southwest of the site and 500m in distance. The CPC's office is located along the Linh Nam St. where is adjacent to the Linh Nam Interchange. Moreover, the commune has a few clinics, pagodas or shrines and communal (assembly) halls.

(vii) Neighborhood community: The aspects of a comparatively urbanized suburban area can be seen in the Nam Du Thuong village adjoining the site. However, some residents have typical farmer housing lots with a dwelling house, a kitchen house, a shed and garden, which are mainly one or two floors, with brick walls and tile or concrete roof. Concrete-paved paths run through the village.

2) Future plans: The HPC has a plan of improvement for residential streets of the village near the site, and the Linh Nam St., which connects the Thanh Tri Dyke and Hanoi urban area, will be also be improved up to 30 m in width. The surrounding area of the site is reserved for development in the Hanoi Master Plan.

3) Advantages and Needs

(i) Advantages

<u>For the residents</u>

- Less impact to the resettlers for daily activities: they could sustain their former living activities such as access to communal facilities, working places, schools and markets.
- Less difficulty for integration with neighborhood residents.
- The site will have easy access to the improved residential street of the village and Thanh Tri Dyke.

For construction

- Flat terrain enables efficient cutting and filling work and lower cost.
- Soil condition is somewhat.
- The site has rich underground water source, which can be exploited and used for the daily activities of the people.
- For other types of infrastructure, conditions are favorable for construction.

(ii) Needs: The residents could use the former communal facilities; however, present access way running to the Nam Du Thuong village and the Thanh Tri Dyke is narrow. Therefore, improvement of this path is required for the residents on the site.

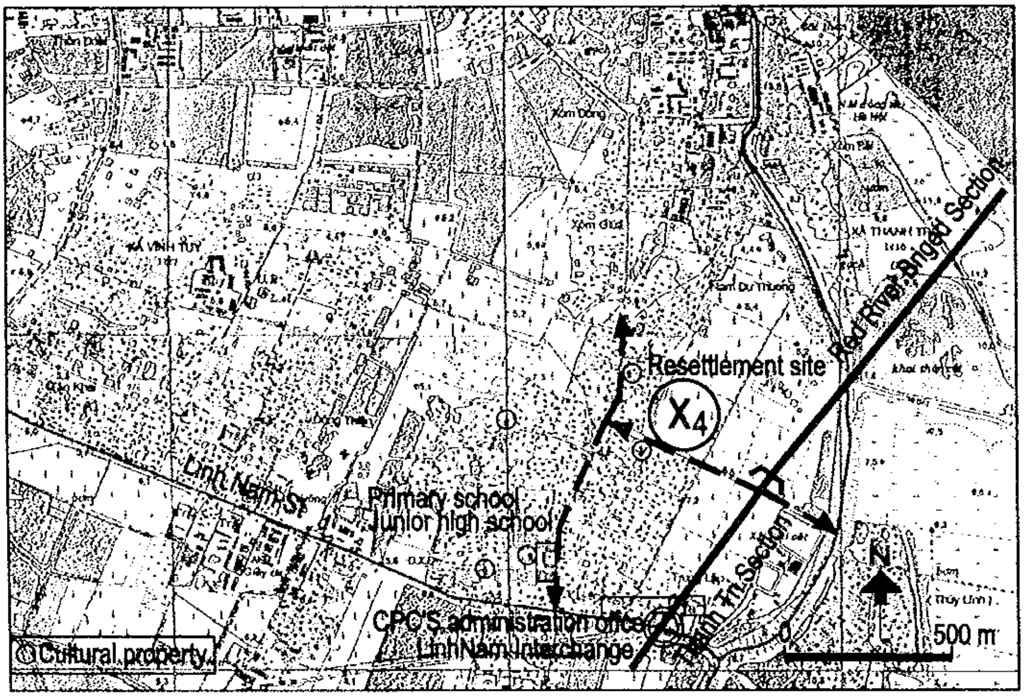


Figure 11.1.5 Site X4: (Linh Nam commune)

(5) Site X5: (Cu Khoi commune)

Figure 11.1.6 shows the location of the site X5.

1) General Conditions

(i) Location: This site will be prepared for persons who live along the Gia Lam Dyke interchange of the Red River Bridge. The site is located adjacent to Tho Khoi village, and around 300 m north of the present settlement of project-affected persons.

(ii) Land use: Present land use of the site is paddy fields, and is flat. A communal cemetery and power transformer poles are located on the site.

(iii) Access: An unpaved narrow path runs up to the residential street of the village, but this is only 3 - 4 m in width. The path connects to an unpaved access way up to the Gia Lam Dyke, and to the residential street paved with concrete or bricks, which runs across the village in direction of southeast to northwest.

(iv) Water supply: The residents of Tho Khoi village use wells for water supply.

(v) Power supply: Power lines are available to supply power for the site.

(vi) Social facilities: The commune has a primary school and a junior high school, which are located to the northwest of the site about 400 m away. The PC's office is also located northwest of the site, nearly the same distance as the schools. Moreover, the commune has a few clinics, pagodas or shrines and communal (assembly) halls.

(vii) Neighborhood community: The aspects of a traditional farming village of the Northern plain of the Red River, can be seen in the Tho Khoi village adjoining to the site. The residents usually have a larger space for housing lot with a dwelling house, a kitchen house, a shed and garden, which are mainly one or two floors, with brick walls and tile or concrete roof.

2) Future plans: The HPC has a development plan of new residential area for the site and surrounding area on the Hanoi Master Plan. Moreover, the site will be constructed at a location close to the Gia Lam Dyke Interchange. The aspect of surrounding areas would be dramatically changed to an urbanized one.

3) Advantages and Needs

(i) Advantages

For the residents

- Less impact to the resettlers for living activities: they could sustain their former living activities such as accesses to communal facilities, working places, schools and markets.
- Less difficulty for integration with neighborhood residents.
- The site is located in a proposed urbanizing area, therefore benefit from economic and cultural development is expected.

For construction

- Flat terrain enables efficient cutting and filling work and lower cost.
- The site has rich underground water source, which can be exploited and used for the living activities of the people.
- For other types of infrastructure, conditions are favorable for construction.

(ii) Needs: The residents could use the former communal facilities, however, present access way up to the village is quite narrow. Therefore, improvement of this path is required, or a new access way up to the SHTRR should be provided for the residents on the site.

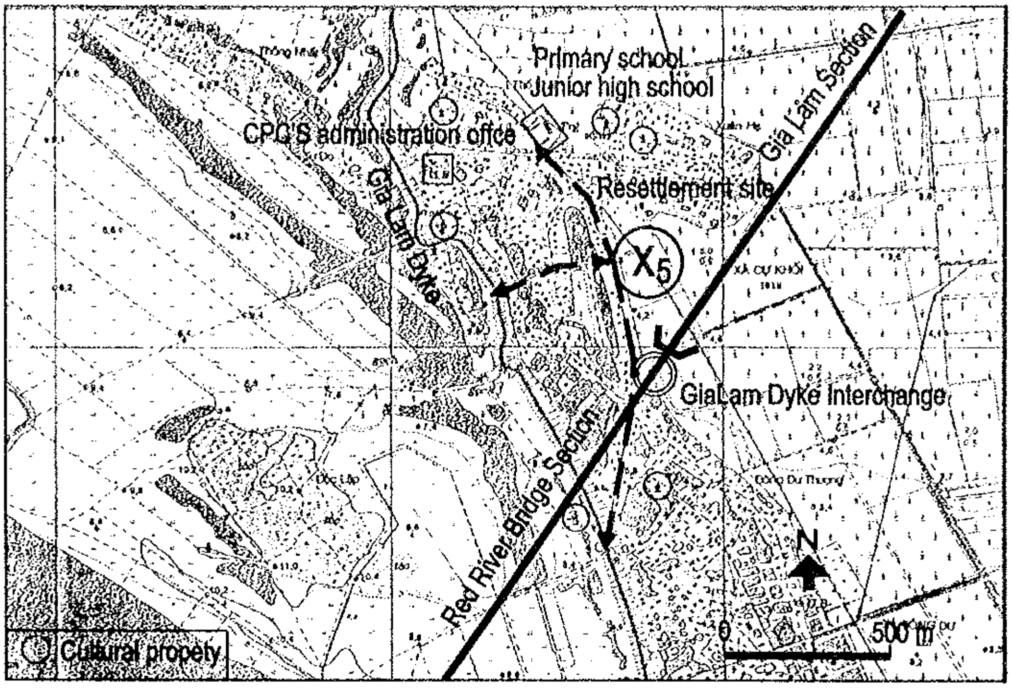


Figure 11.1.6 Site X5: (Cu Khoi commune)

(6) Site X6: (Thach Ban commune)

Figure 11.1.7 shows the location of the site X6.

1) General Conditions

(i) Location: This site will be prepared for persons who dwell on the NH5 affected by the NH5 Interchange, and live on the southern edge of the Thuong Hoi village affected the SHTRR. The site is located adjacent to Xom Duong village, a school and the PC's office, and around 1.5 - 2.0 km west of the present settlement of project-affected persons.

(ii) Land use: Present land use of the site is paddy fields, and is flat.

(iii) Access: A narrow path comes up to the site from an asphalt street, which is 6 m in width and runs between the NH5 and the Gia Lam Dyke.

(iv) Water supply: The residents of Xom Duong village use wells for water supply.

(v) Power supply: Power lines are available to supply power for the site.

(vi) Social facilities: The commune has a primary school located southeast of the site about 500 m away. A junior high school and the PC's office are located adjacent to the site. Moreover, the commune has a few clinics, pagodas or shrines and communal (assembly) halls.

(vii) Neighborhood community: The Xom Duong village has a rather urbanized aspect especially on the street in between the NH5 and the Gia Lam Dyke. However, aspects of a farm village can be seen in the areas behind the street.

2) Future plans: The HPC has a development plan of new residential area on the site and surrounding area in the Hanoi Master Plan.

3) Advantages and Needs

(i) Advantages

For the residents

- They could use the new communal facilities and take advantage of social services, as social facilities are located on where is close to the site.
- The site is located in a proposed urbanizing area, therefore benefit from economic and cultural development is expected. The site would become the center of Thach Ban commune in the future plan.

For construction

- Flat terrain enables efficient cutting and filling work and lower cost.
- The site has plentiful and rich underground water source, which can be exploited and used for the daily activities of the people.

- For other types of infrastructure, conditions are favorable for construction.

(ii) Needs: The present access way is quite narrow, and not favorable for the residents. Therefore, a new access way up to the closest local road should be provided for the residents on the site. On the other hand, the CPC and Xom Duong village should make efforts to mitigate expected conflict with resettlers.

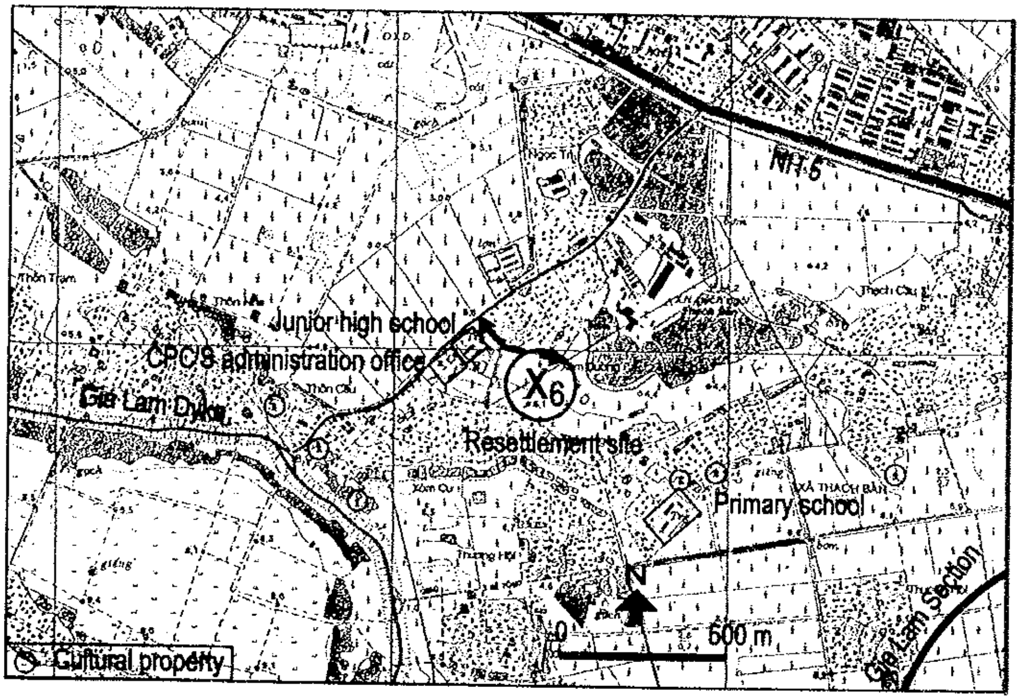


Figure 11.1.7 Site X6: (Thach Ban commune)

11.2 Sizes and Groups of the Resettlement Sites

11.2.1 Estimation of Average Unit Sizes

Accurate sizes of housing lots to be allocated for resettlers in the resettlement sites should be reviewed in accordance with inventories; sizes of residential lands owned by PAPs, which are prepared by respective PCs after approval of the right of way. Therefore, the Study Team estimates the average size for a household as follows:

(1) Examples of Constructed Resettlement Sites

According to the resettlement sites for Lan - Hoa Lac Highway and Phap Van - Cau Gie road, which are already constructed, the average size of housing lot including spaces for residential street, etc., is 100m^2. These sites are located in a suburban area, and the aspects of the locations are similar to the proposed sites for the Project. Thus, the average 100m^2 for a household could be applied to the unit size for the resettlement sites.

(2) Estimation of Average Sizes

The 100 m^2 for a household can be explained as follows.

The Government Decree No. 22/1998/ND-CP stipulates that the minimum sizes to be allocated in resettlement sites are 40m^2 for urban area and 100m^2 for rural area. On the other hand, according to the MOT's Decision No. 592/1999/OD-GTVT, total sizes of resettlement site for households are calculated by the formula below.

Unit size = (Housing lot + 10% of Housing lot) X 1.3 (space for infrastructures)

(i) Urban area = 40m^2 x 1.1 x 1.3 = 57 m^2
(ii) Rural area = 100m^2 x 1.1 x 1.3 = 143 m^2

The average size of (i) and (ii) is around 100m^2 including infrastructure spaces.

11.2.2 Sizes and Groups of the Resettlement Sites

Groups to be resettled on the same site should be from the same community or neighborhoods. These groups are shown in the table below, in accordance with the locations of the resettlement sites mentioned above and present settlements of the PAPs.

The size of each site is also estimated in Table 11.2.1, according to the total number of households to be resettled in the site and unit 100 m^2 for size of allocation.

Table 11.2.1 Size of the Resettlement Sites

District	Location	Name of commune	Sites	Families	Persons	*Size(m^2)
Gia Lam	Along NH5	Thach Ban /Co Bi	X6	130	650	13,000
	Thuong Hoi	Thach Ban				
	Near Gia Lam Dyke	Cu Khoi/Dong Du	X5	100	500	10,000
	Total Gia Lam		2 sites	230	1,150	23,000
Thanh Tri	Along Linh Nam St.	Linh Nam	X4	80	400	8,000
	Nam Du Ha	Tran Phu	X3	170	850	17,000
	Yen Duyen	Yen So	X2	330	1,650	33,000
	Along Phap Van St.	Yen So				
	Along Phap Van St.	Hoang Liet/Thinh Liet	X1	390	1,950	39,000
	Along Phap Van St.	Hoang Liet				
	Northern corner of NH1	Hoang Liet				
	Total Thanh Tri		4 sites	970	4,850	97,000
Total Project			6 sites	1,200	6,000	120,000

Source: JICA Study Team
Notes: * Average 100m^2 for a family including space for infrastructure

11.3 Required Infrastructures

11.3.1 Current Infrastructure Conditions of Residents

According to the interview survey in 1998, current conditions of infrastructures for residents in Thanh Tri District and Gia Lam District are as follows (See Table 11.3.1):

Water supply

- Almost all residents of both districts use subterranean water from wells as drinking water; however, the residents on NH1 and NH5 are served by waterworks.

Power supply

- Charcoal dominates as heat source in Thanh Tri, on the other hand, firewood and straw are major sources in Gia Lam.
- Power lines are provided for almost all residential areas.

Table 11.3.1 Current Infrastructures

Types of infrastructures		Thanh Tri	Gia Lam
Drinking water	City water supply	*18%	0%
	Subterranean water	*86%	100%
	River water	*6%	0%
Power supply	Gas, electric	*18%	0%
	Charcoal	*94%	*24%
	Firewood, straw	*26%	*84%

Source: Interview survey, 1998

* Note: Some households use more than one mode. Therefore, most of the summations are more than 100% in each district.

Additionally, according to our survey, areas along NH1 and NH5 have somewhat higher levels of infrastructures: paved residential streets, drainage, power lines and city water system is provided. Yen Duyen Village and Nam Du Ha Village have somewhat lower infrastructurul conditions and are without city water system. Also, the Gia Lam side has lower infrastructure level except for the area on the NH5.

11.3.2 Required Infrastructures for the Resettlement Sites

Restoration or improvement of the living environment is the main policy for resettlement sites' preparation. Infrastructures and social services should be provided on the resettlement sites of at least the same level of former conditions. A major difference of current conditions of infrastructure among affected residential areas is whether or not drinking water is supplied by city supply system. Therefore, the following infrastructure should be provided on the resettlement sites.

- Drainage
- Power supply
- Water supply
- Residential streets for accesses to residential properties, and local traffic dominate on the streets
- Access roads connecting to local roads, major roads or frontage road

In addition to the current conditions of infrastructures mentioned above, required infrastructures of resettlement sites for persons affected by road construction projects, are specified in the Decision No. 592/1999/OD-GTVT of MOT. The required infrastructure for the resettlement site includes water supply, power supply, drainage, residential streets, access way and etc.

Regarding social services (education (schools), health care and local administrative services, living activities; shopping and commuting, or accesses to communal facilities), almost all resettlers could use former communal facilities, as they will be resettled in the resettlement sites within at 500 m distance from their former settlements. In the case that the resettlers should change their former facilities, they will be relocated on the site which is close to the communal facilities or respective PCs, and neighborhood communities will support the resettlers in all cases.

11.4 Detailed Design of the Resettlement Sites

11.4.1 Design Standards for Resettlement Sites

The design should be followed the local standards and orientations of the Hanoi Master Plan 2020 of the area. It is necessary to meet the local social and economic requirements to resettle the project-affected persons and sustain their living environment in the newly constructed area. In detail, the design standards are proposed as follows:

(1) Architecture

The plan should secure adequate land scale for the households to remove according to the existing targets, which are regulated by the State (Hanoi Chief Architect): 60 m^2/household to 100 m^2/household, 50 % of construction density for entire area of the resettlement sites. The plan also secures the social and economic targets for the general mechanism of urbanized area in Hanoi Master Plan 2020.

(2) Infrastructures

1) Transportation: Target of local road for the households: 2 - 3 m^2/person to ensure smooth traffic.

2) Water supply: City water supply is not available in this area. Therefore, it is necessary to construct one treatment station and one well-pumping station to exploit underground water on site with a treatment system and pump to supply water for the households. The plan should follow national standards on water supply for the households.

   - Clean water: 200 liter/person/day.
   - Water volume supplied for households: 60 m^3/day.

3) Power supply: Currently, the power stations in the sites are operating with full capacity. In order to supply power for the proposed construction sites, it is necessary to apply for granting power source from the existing power lines to construct exclusive transformer stations for resettlement sites. The national standard on supplying power for the households is 3 KW/household.

4) Drainage: It is necessary to construct drainage culverts of a scale calculated for securing smooth drainage for the area and the surrounding residential area, to flow out into the common drainage system. Sewage from houses on the site will be preliminarily treated by septic tanks in order to ensure environmental hygiene conditions, and minimize environmental pollution in the area before discharging into the common drainage system.

11.4.2 Design Policies

The Study Team should follow the local procedure to design the resettlement sites. The procedure includes not only topographic survey but geological survey as well, special coordination with HPC and DPC for the size of resettlement site, demarcation of the site, confirmation of cadastral condition on the site, etc. Furthermore, coordination with local water supply and power supply companies should be required to collect information of infrastructure on surrounding area to connect infrastructure system of the site. On the other hand, six resettlement sites are proposed to match with requirement of the PAPs. This situation makes the procedure of detail designs more complicated.

Therefore, we selected the Site X5 as a model site of resettlement. The main reasons of the selection are: (i) the site preparation of X5 should be required in early construction stage of the Than Tri Bridge Section, as the resettlers of Site X5 are affected by the right of way of the Gia Lam Dyke Interchange, (ii) the number of houses for resettlement would not be greatly changed, (iii) the scale of the site for around 100 households is reasonable. According to a local consultant, conditions of design and civil works for all sites are quite similar, as supported by the descriptions of the six sites in section 11.1.2.

The Study Team follows design policies of Site X5 for other sites. In any case, the detail designs should be reviewed in accordance with inventories of PAPs, which are prepared by respective PCs following approval of the right of way.

(1) Leveling

1) Design Base: Topography maps made at scale of 1/500 by Hanoi surveying company, and the master plan map made at scale of 1/500 by HPC.

2) Design method: Leveling map is based on standard design with slope i>0.04. Leveling elevation is based on the elevation of discharge points into Cau Bay river and proposed station at urban area (Hmax = 5.60 m; Hmin = 5.40 m).

(2) Streets

1) Access way: Two access ways are planned for residents. One street connects to the NH5, which is planned in the Hanoi Master Plan, and the other one connects to the frontage road of the SHTRR. However, the PAPs could temporarily use the existing street passing through Tho Khoi village, otherwise provisional preparation of access way is required, as construction stage of the Gia Lam Section is somewhat later.

2) Residential streets: Paved residential streets with walkway lot the resettlement site for four blocks at 20-30 houses. Each housing lot faces the residential street for greaten accessibility.

(3) Drainage System

The drainage system is designed in order to meet the draining requirements for short-term and long-term period for resettlement site. Draining directions are northeast and southwest. Rain drainage is constructed with reinforced concrete culvert, diameter D = 400 - 600, in combination with manhole and gathering hole. Water drainage system for waste water is constructed in masonry ditch on either side of the pavement to gather contaminated water; in the long-term this ditch system is connected to the general drainage system of the area and for short -term purpose, this system is discharged into the rainy drainage.

(4) Water Supply System

1) Capacity of water supply volume:

- Clean water (household) : 200 liter/person/day
- Contingency water : 20 percent of household water
- Contingency water for fire extinguishing : 5l/s for three hours work

2) Demand of Water:

- Highest water demand per day : Qmax = 150 m^3/day
- Water for fire extinguishing : QFH = 54 m^3/day

3) Water source: Underground water is used as the source to supply water for residents. It is easy to drill wells, aquifer can be reached at a depth of around 30 m. Capacity required of the well is 6 - 8 m^3/h.

4) Water treatment station: Water treatment station is constructed to supply household water. The station consists of a jet rig, a settling tank, filter tank and water tank with capacity W = 160 m^3. 60 m^3 of water is kept for fire extinguishing, and the 100 m^3 more is used for supplying water to the households.

5) Process of water treatment and supply is as follows: (i) water from drilled well is pumped to the jet rig through settling tank and to the filter tank, (ii) then, water flows through a second pumping station and runs through water supply tube to households. In case the pumping machines do not work at the second pumping station, pressurized water still runs into the water supply tube automatically.

6) Structures and size of the station: Main structures of the station are masonry water treatment station and reinforced concrete tanks. The sizes and/or capacities are as follows:

- Treatment station (size) : 3 x 4 = 12m^2
- Water tank (dimension) : 7 x 8 x 3 m
- Pumping station (size) : 3 x 2 = 6 m^2
- Pumping machine for drilling well : Q = 6-8 m^3/h
- Pumping machine for clean water : Q = 6 m^3/h
- Depth from bottom of the tube to the top: 0.5 m
- Tube is provided for 0.3 - 05 m away from house wall.
- All tubes within the residential area are coated with zinc.

7) Fire extinguishing: Water-holding tank always keeps 60 m^3 for fire extinguishing; however, in case of fire, the 100 m^3 tank and all pumping machines temporarily take priority for fire extinguishing.

(5) Power Supply and Lighting System

A 22 KV line is connected from power supply to sub-station, and a twisted low voltage cable is used for transmitting power to household. Single-arm high-voltage lamp is used for lighting. They are connected by HT 0.4 KV cable.

(6) Planting

Each housing block has a planned landscaped area in the center of the block. These green spaces are very important to enhance the living environment for the residents although not on such a large scale. The green space will be valuable, as the area is expecting dramatic change into an urbanized area

(7) Public space

Space for public project is secured on a corner of the site according to a policy of HPC. This space could satisfy demands or request for public facilities from surrounding communities.

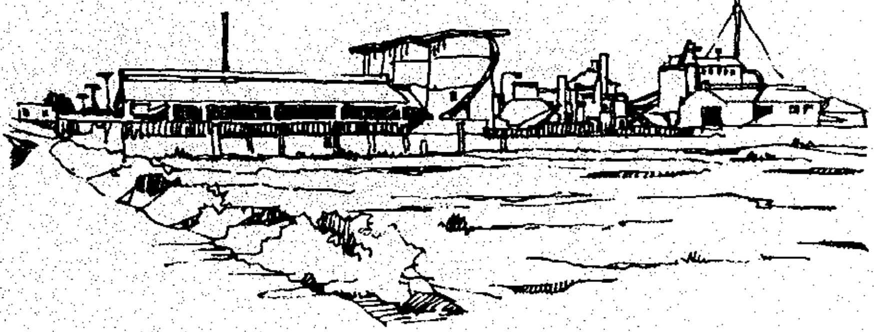
Construction Images

The following pictures provide an image of the resettlement sites. These pictures are from a resettlement site constructed for the Lan-Hoa Lac Highway.

Picture 11.4.2.1: Typical residential streets with walkways in a resettlement site: drain inlets can be seen at the corners, manholes are on the center of streets and utility poles are on the walkway.

Piture 11.4.2.2: Housing lots facing the residential streets in a resettlement site: the resettlement site is lotted for several blocks.

CHAPTER 12 CONSTRUCTION PLANNING



CHAPTER 12 CONSTRUCTION PLANNING

12.1 Red River Bridge

12.1.1 Main Bridge

(1) Superstructure

1) Construction Method

The span arrangement is as follows (Refer to Section 6.2.1 (2)):

80.0 + 4@130.0 + 80.0 = 680.0m

For this span arrangement, the two following construction methods have been employed.

Option I	Cast-in-situ concrete segmental cantilever erection	
Option II	Precast concrete segmental cantilever erection	
	Alternative IIa	construction by erection nose
	Alternative IIb	construction by launching girder

Among the two alternatives of Option II, a launching girder will be more appropriate than an erection nose because lift-up of a segment from the river level is not feasible in the site conditions. However, a launching girder erection will not be feasible either as the size of the girder will be uneconomically large, with for a span more than 100 m. Thus, a large investment cost will be required for the development of a fabrication plant and stock yard and a launching girder.

It has been concluded that Option I is most recommendable judging from the site conditions and economical reasons. Figure 12.1.1 shows the typical construction stage.

Another advantage of this method is that a navigation channel can be maintained during the construction period.

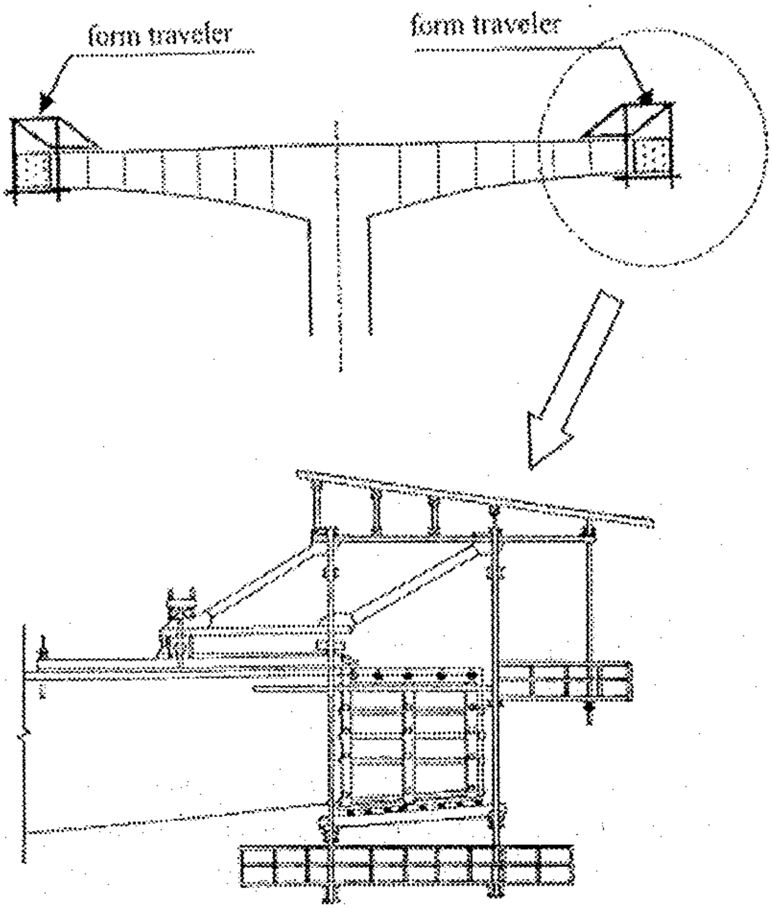


Figure 12.1.1 Typical Construction Stage

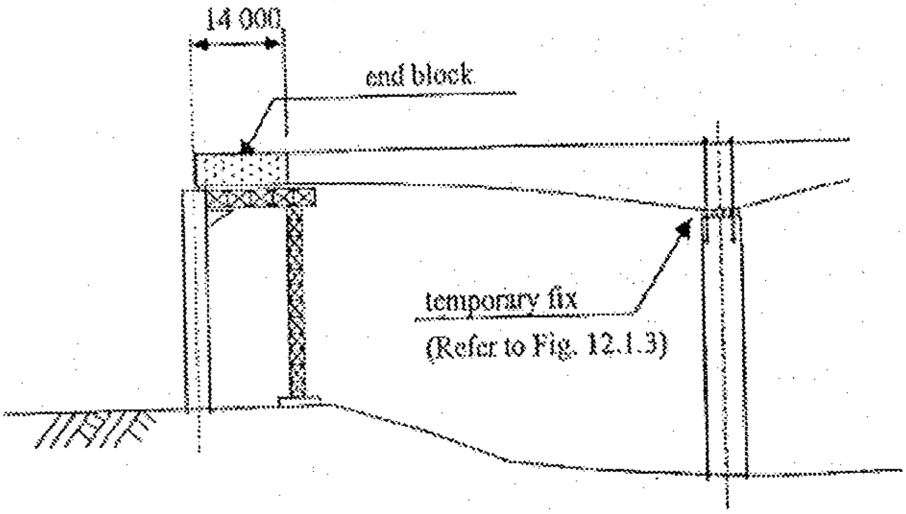


Figure 12.1.2 Construction of End Block in Side Span

2) Construction of End Block

End block of the side span will be constructed on staging. An example of the construction method is illustrated in Fig. 12.1.2.

3) Temporary Fixing of Pier Segment

When completed, the bridge is supported simply at Piers 22 and 26. During the cantilever construction, the girder shall be temporarily fixed to the pier so that it possesses adequate resistance to bending. This temporary fixity is provided by filling the joint between pier and girder with wedges (in metal or concrete) together with vertically placed bars or cables which are then stressed. Thus, during construction a rigid link is formed between girder and pier. When the cantilever girders are linked, the fixity will be freed by removing the temporary pre-stressing and by substituting the wedges with permanent bearings. An example of the temporary fixing is shown in Fig. 12.1.3.

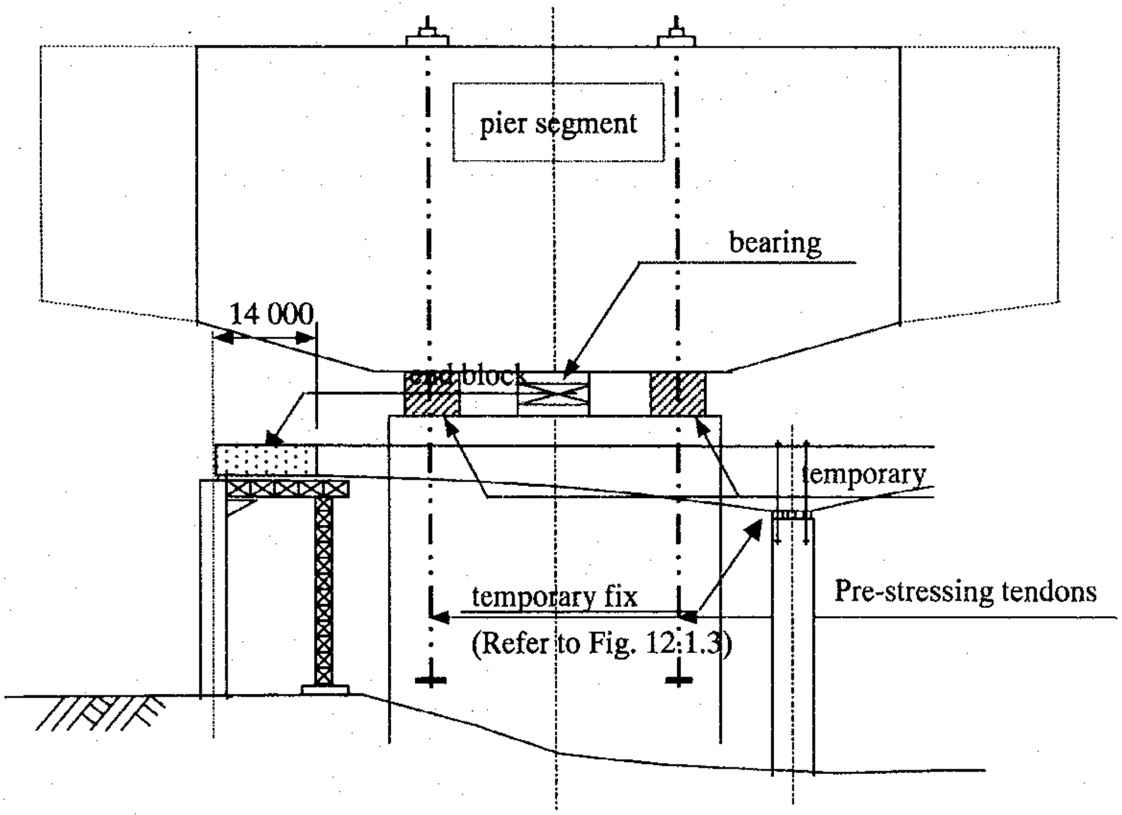


Figure 12.1.3 Example of Temporary Fixing of Pier Segment

4) Construction Schedule

Typical construction schedule for one segment is shown in Table 12.1.1.

Table 12.1.1 Typical Construction Schedule for One Segment

day work item	1	2	3	4	5	6	7	8	9
Form Traveler Installation	═								
Formwork, Rebars, PS tendons	═	═	═	═					
Concrete Casting					═				
Curing					═	═	═	═	
Prestressing								═	═
Preparation for Traveler Transfer									═

Considering the work efficiency rate of 80%, actual cycle work period is assumed to be 10.5 days per segment.

Figure 12.1.4 shows sample construction schedule for main bridge.

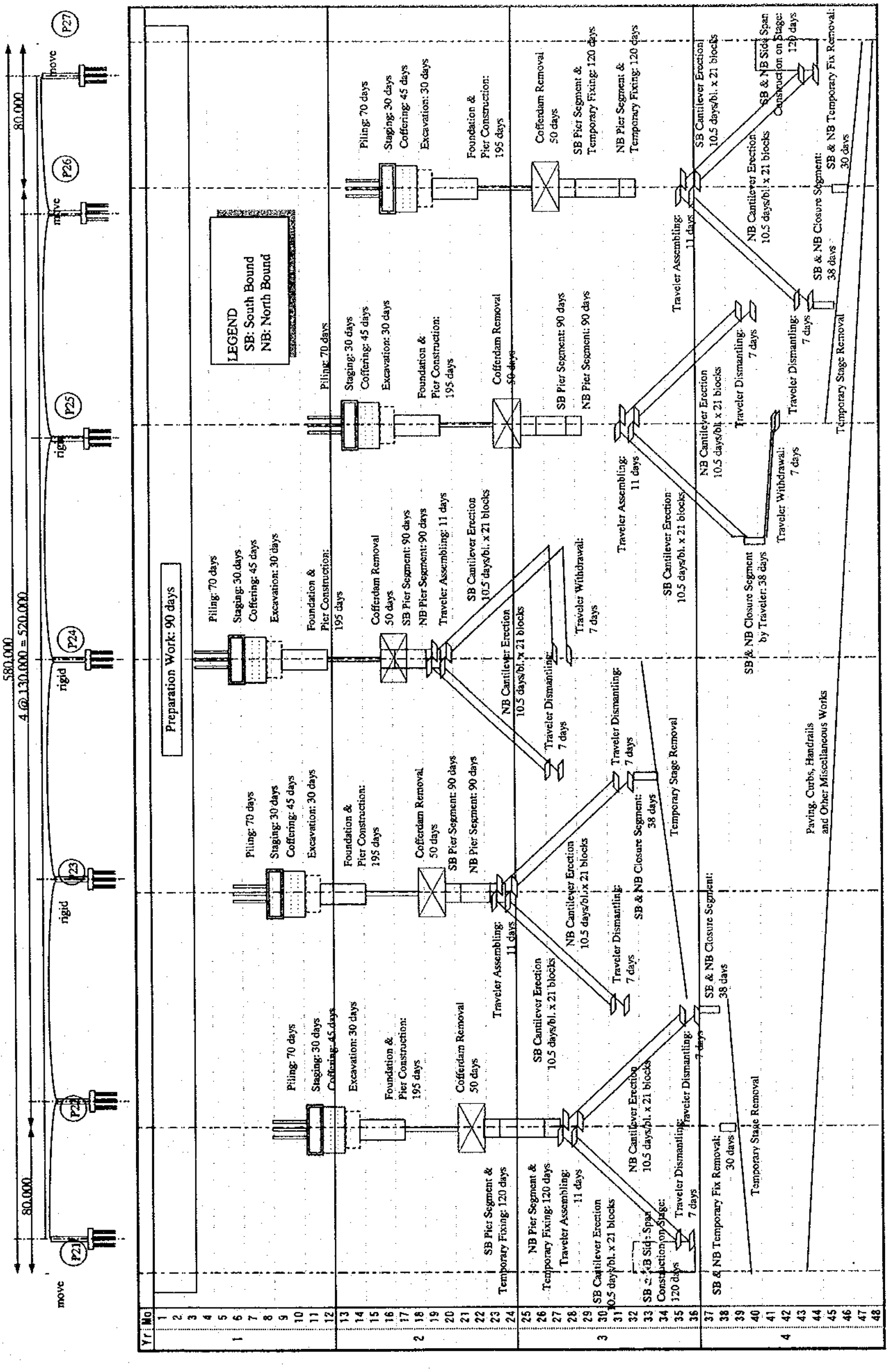


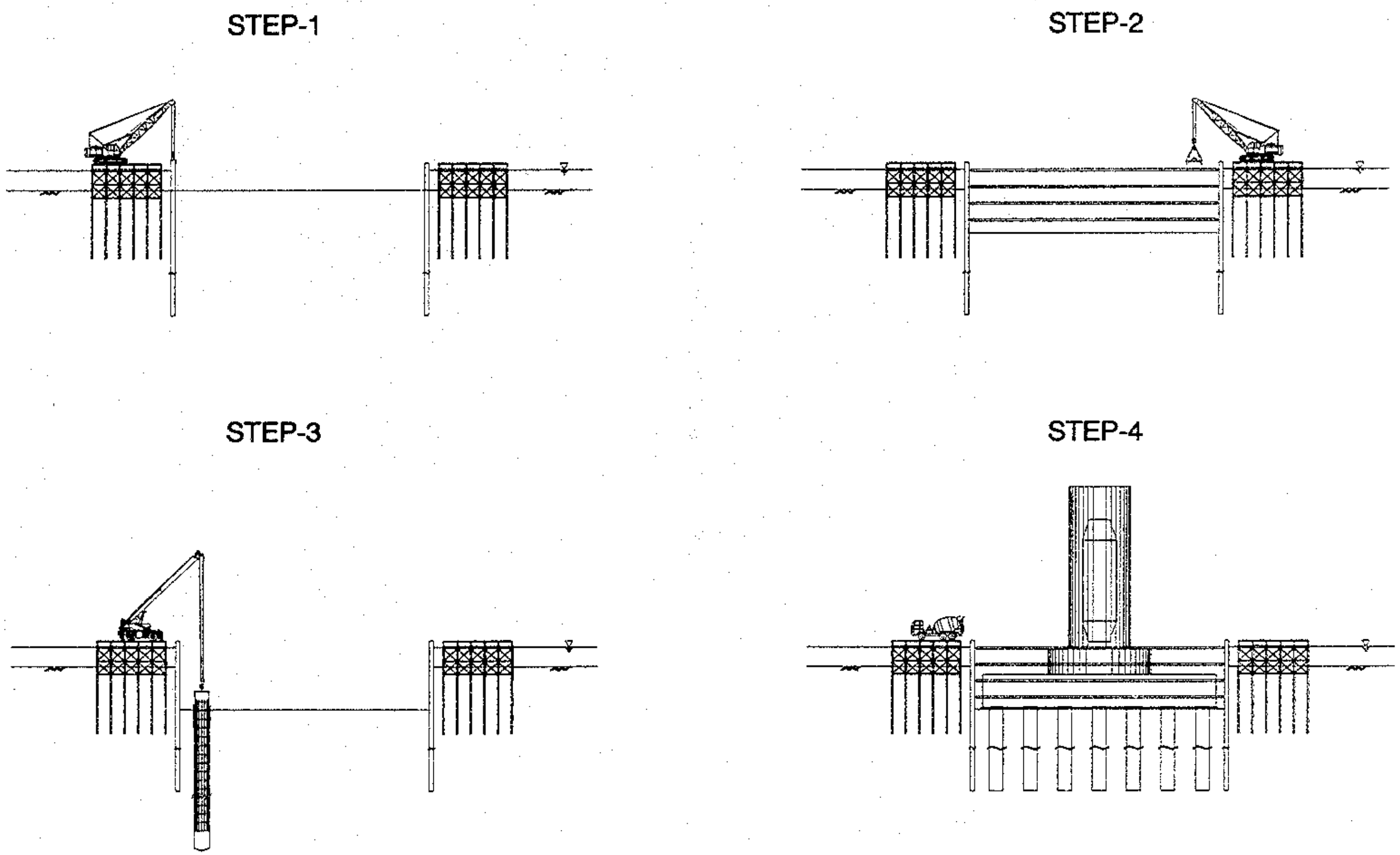
Figure 12.1.4 Sample Construction Schedule for Main Bridge

(2) Substructure/Foundation

The procedure of substructure/foundation for main bridge inside water is shown in Figure 12.1.5

STEP-1 : Construction yard surrounding pier and installation of sheet pile
STEP-2 : Excavation inside of cofferdam and construction of cofferdam
STEP-3 : Construction of cast-in-situ concrete piles
STEP-4 : Construction of substructure

Procedure for construction of cast-in-situ concrete piles is same the reverse circulate pile method mentioned in 12.1.7.


STEP-1

STEP-2

STEP-3

STEP-4

Figure 12.1.5 Procedure of Substructure /Foundation for Main Bridge

12.1.2 Approach Bridge 1

(1) Superstructure

1) Construction Method

The bridge consists of pre-stressed concrete continuous box girders with their span length of 50.0m except one adjustment span of 30.0m. The bridge length and the span arrangement are as follows:

Thanh Tri Side : (30 + 4@50) + (6@50) = 530m (north-bound)
(5@50) + (6@50) = 550m (south-bound)
Gia Lam Side : (6@50) + (6@50) +(5@50) = 850m (both directions)

There are various applicable construction methods as follows:

Option I	Erection by launching girder with cast-in-place concrete
Option II	Span-by-span erection on staging (or falsework/ shoring) with cast-in-place concrete
Option III	Span-by-span erection with precast segments
Option IV	Precast segment cantilever erection with cranes
Option V	Incremental launching

Among the above-listed construction methods, incremental launching (hereinafter called I/L) method would require the greatest girder height. A girder height/span (H/L) ratio of pre-stressed box girder bridge is generally in the range of 1/18 to 1/20. For the I/L, however, the ratio is approximately 1/16 in order to withstand loading conditions during the construction stage. In the feasibility study, the Study Team proposed a girder height of 3.2m, i.e., a H/L ratio of approximately 1/16, considering that the I/L is one possible construction method.

The I/L is preferred generally when the bridge and the site are of the following conditions:

(i) The bridge consists of many spans of which the span length is in the range of 45 to 65m.

(ii) Construction on staging is considered to be uneconomical due to high pier height.

(iii) Construction work under the bridge is limited when the bridge is constructed over operating railway and/or highway in service.

(iv) Construction work is limited as the bridge is constructed in densely populated area.

The approach bridge, however, is not applicable except for Item (i). The I/L will not be necessary for the following reasons:

(i) The bridge is located in the bed of a river and construction on staging is feasible as the pier height is not very high.

(ii) There are no operating railways and/or highways on service at the site.

(iii) The site is not a densely populated area.

Based on the above study, it was concluded that the I/L is not practical for Approach Bridge 1. Further study was conducted on Options I through IV. The results are summarized in Table 12.1.2.

One of the important parameters in determining the construction method is the height of the girder above ground. Alternative 1 of Option II may not be feasible when the clearance between the girder and the ground is great. Table 12.1.3 shows the ground height and the roadway elevation.

Table 12.1.3 Ground Height and Roadway Elevation (Approach Bridge 1)

Pier No.	Ground Height (m)	Roadway Elevation (m)	Clearance approx. (m)	Note
P10R	6.00	24.988	16.0	starting point of Thanh Tri side
P21	8.26	29.384	18.1	ending point of Thanh Tri side
P27	8.25	29.616	18.4	starting point of Gia Lam side
P44	8.40	23.599	12.2	ending point of Gia Lam side

Note for Table 12.1.3

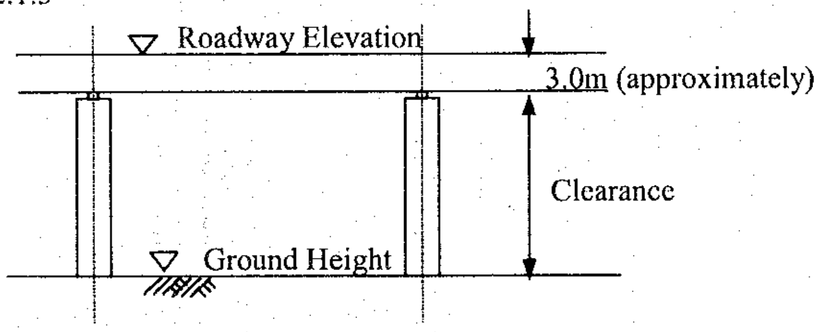
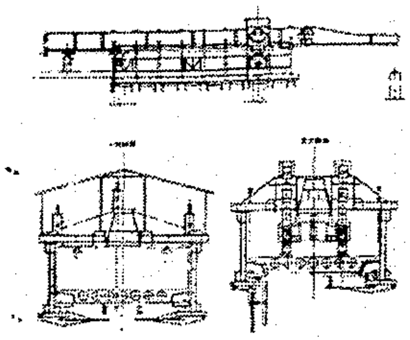
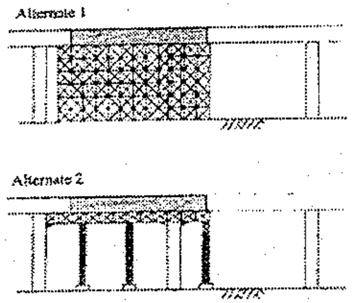
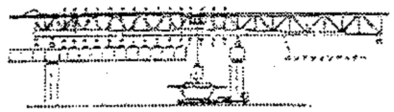
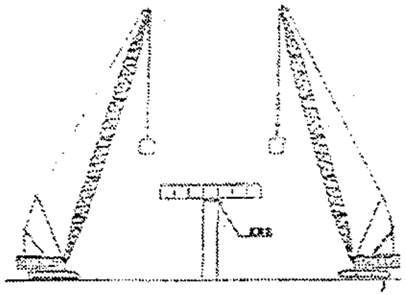


Table 12.1.2 Summary of Comparison Study on Construction Method for Approach Bridge-1

		Option-I Erection by launching girder with cast-in-place concrete	Option-II Erection on staging with cast-in-place concrete	Option-III Span-by-span erection with precast segments	Option-IV Precast segment cantilever erection with cranes
Outline		Note: This image shows an example of hollow slab construction. 			Note: One 450t crane or two 150t cranes are required. 
Constructibility	Advantages	- A launching girder provides a firm stage and workable space.	- No special equipment and/or machinery are needed. - Concurrent works are possible at different location provided that necessary staging is available.	- A long construction length (approximately 2,800m long in total) and uniform girder height make this construction method very feasible. - One span is constructed in approximately 10 days, which is the fastest among the three options. - This method has been applied to many bridges with spans of 40 to 50m.	- A long construction length (approximately 2,800m long in total) and uniform girder height make this construction method very feasible. - Special construction equipment is not required because the segment erection is carried out by movable cranes.
	Disadvantages	- An applicable span for this method is approximately between 20 and 40m. Application to a 50m-span bridge requires special consideration. - Integrated machinery unit is required for a launching girder.	- Cost for staging increases as the bridge located high above the ground. - Measures shall be taken for flooding season.	- Special machinery shall be installed for fabrication of segments. - The use of an erection girder results in an increase of machinery costs. - Land of approximately 50,000m^2 is required for fabrication and stock yard.	- Special machinery shall be installed for fabrication of segments. - Land of approximately 50,000m2 is required for fabrication and stock yard. - A hammer head shall be temporarily fixed during cantilever erection. - Half of a side span shall be constructed on a stage. - Amount of pre-stressing steel is relatively large because of the cantilever erection. - Assembling and disassembling of temporary stage for pre-stressing work is required at every segment erection.
Required construction period		- 36 months when one unit is used. - 23 months when two units are used.	- Flexible depending on available staging	- 10 months for preparation for fabrication yard and precast segments. - 23 months for bridge erection	- 10 months for preparation for fabrication yard and precast segments. - 23 months for bridge erection
Construction cost		1.0 (When one unit of a launching girder is used)	1.1 (When staging for 6 spans are used)	1.0 (When two fabrication units and one erection girder are used)	1.1 (When two fabrication units and one crane are used)
Comments & evaluation		Not feasible for bridges of 50m span length	Traditional method requiring no special experience	Many successful application experience exists & fastest construction	Requires many work steps with a relatively high construction cost
		NOT FEASIBLE	**RECOMMENDABLE**	**RECOMMENDABLE**	**RECOMMENDABLE**

Note: All options can be carried out concurrently with slightly shifted substructure work.

(2) Substructure/Foundation

1) Substructure

The procedure of substructure for Approach Bridge an the road is show in Fig 12.1 6

STEP-1 Installation of sheet piles
STEP-2 Construction of cofferdam and excavation
STEP-3 Construction of Cast-in-situ concrete piles
STEP-4 Construction of substructure

2) Procedure of Cast-in-situ concrete pile (reverse circulate pile Method) is shown in Figure 12.1 2 (2)-B and equipment arrangement is shown in Figure 12.1.8

Procedure of Cast-in-situ concrete pile

① Installation of stand piles
② Excavation
③ Installation of reinforcing bar
④ Installation Tremie pipe
⑤ Concrete
⑥ Backfill

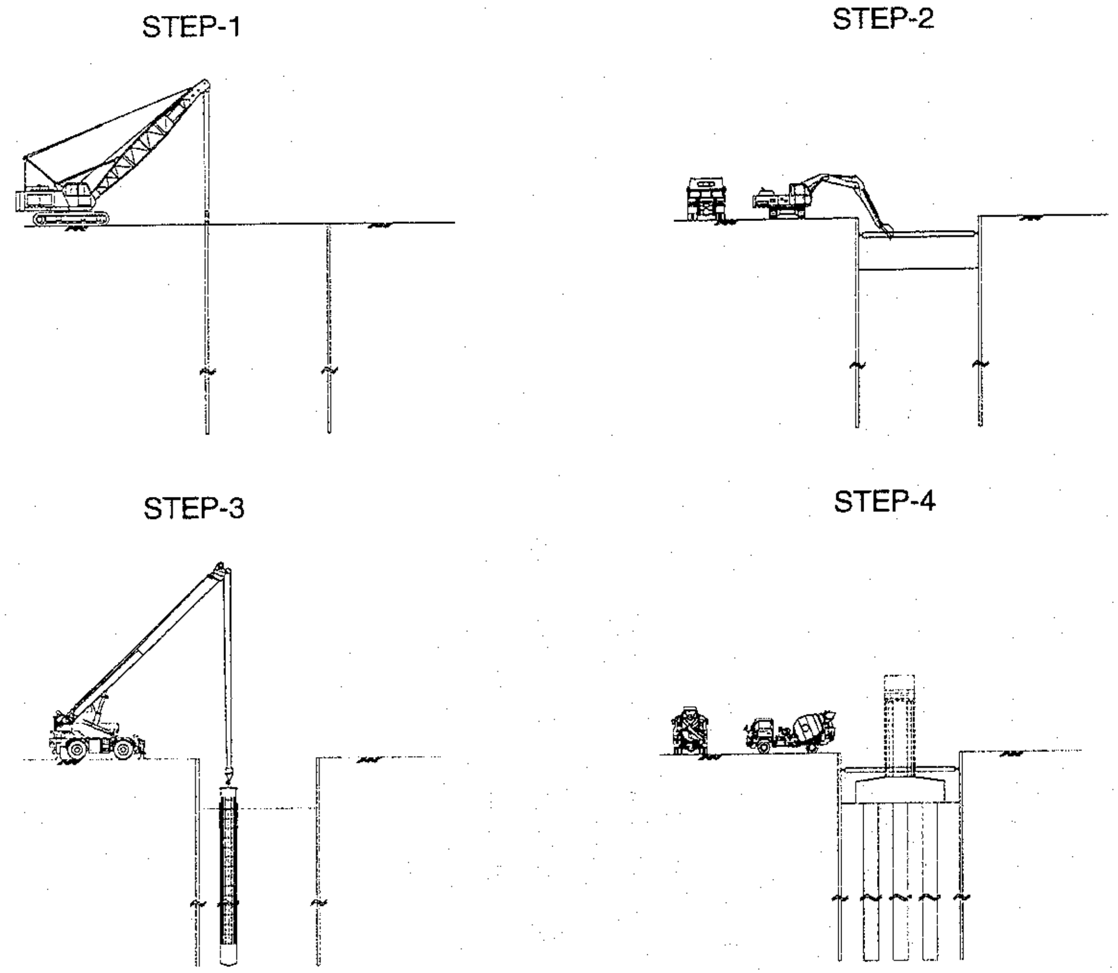


Figure 12.1.6 Procedure of Substructure /Foundation for Approach Bridge

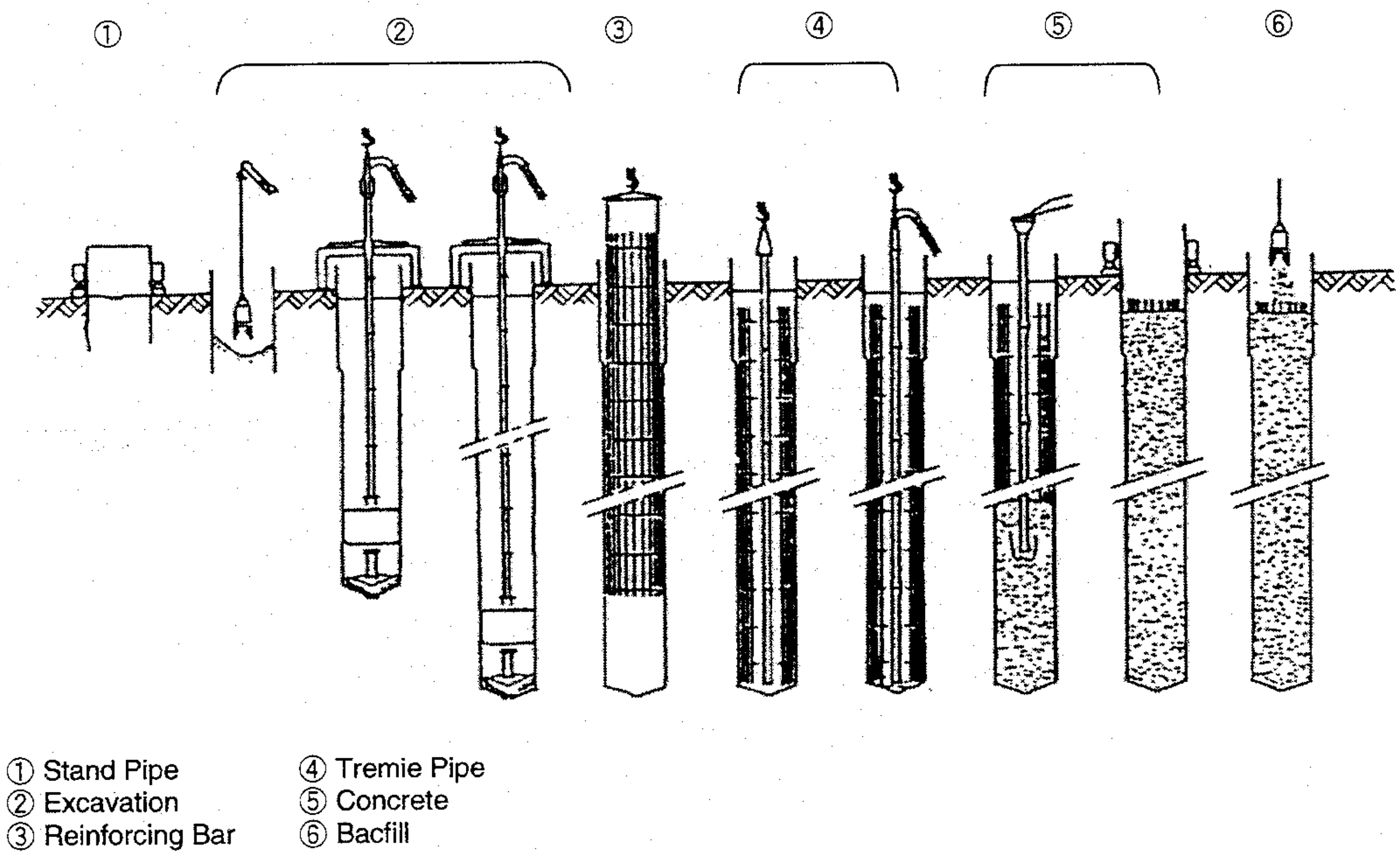


Figure 12.1.7 Procedure of Cast-in-situ Concrete Pile (Reverse Circulation Method)

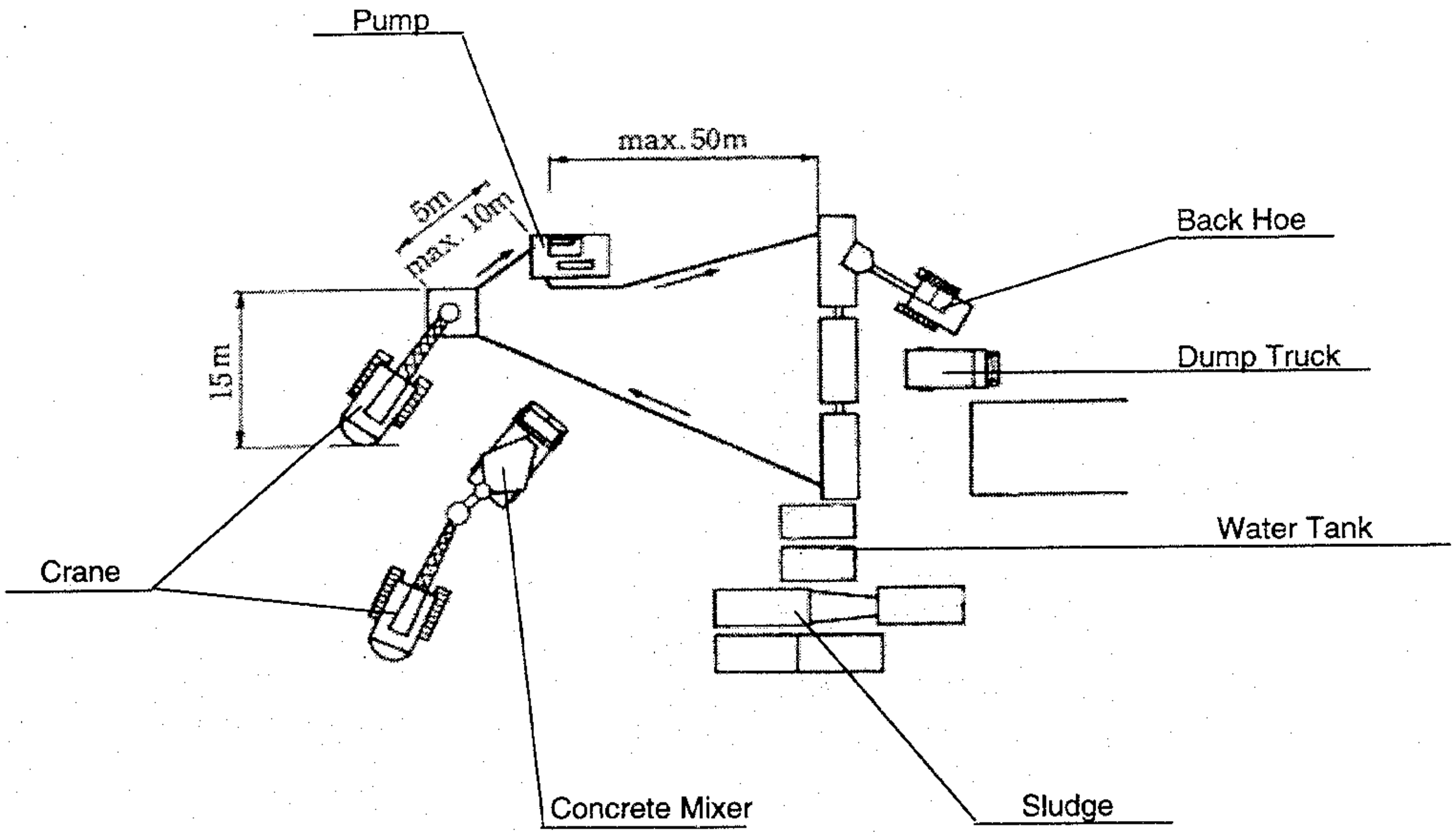


Figure 12.1.8 Equipment Arrange for Reverse Circulation Method

12.1.3 Approach Bridge 2

(1) Superstructure

This bridge will be constructed by precast pre-stressed concrete I-girder (PC I-girder). The span length is 33.0m except for two adjustment spans of 28.0m and 20.0m at the end of Thanh Tri side. The bridge lengths are as follows;

Thanh Tri Side: 226.0m (North Bound), 246.0m (South Bound)
Gia Lam Side: 198.0m (North Bound and South Bound)

When selecting a construction method, clearance under I-girders and the girder weight should be taken into account. For reference, Tables 12.1.4 and 12.1.5 show the elevation data and the girder weight respectively.

Table 12.1.4 Ground Height and Roadway Elevation (Approach Bridge 2)

Pier No.	Ground Height (m)	Roadway Elevation (m)	Clearance approx. (m)	Note
A1	5.6	11.968	4.5	Starting point of Thanh Tri side
P7L	4.9	19.335	12.5	Ending point of Thanh Tri side
P47	2.6	17.035	12.5	Starting point of Gia Lam side
A2	4.3	11.714	5.5	Ending point of Gia Lam side

Note for Table 12.1.4

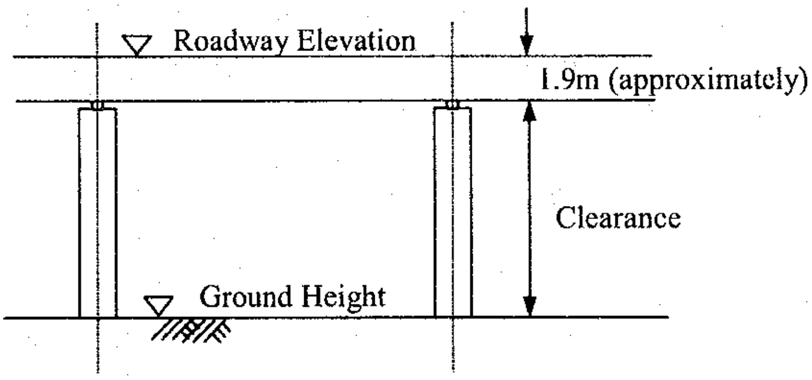


Table 12.1.5 Weight and Numbers of PC I-girders (Approach Bridge 2)

Span Length (m)	Girder Height (m)	Concrete Volume (m^3/each)	Girder Weight (tf/each)	Total No. of Girders (Nos)	Note
20.0	1.65*	15.8	39.5	7	P6 to P7
28.0		21.3	53.3	14	P7aL to P7bL
33.0		24.6	61.5	168	all except above

Note*: The constant height is used for the aesthetic reasons.

Under the above-mentioned conditions, many construction methods are applicable. The followings are examples of the construction methods which can be used for this type of bridge.

Example 1: Erection by Truck Cranes (Refer to Fig. 12.1.9)

Example 2: Erection by Self-driven Portal Frame (Refer to Fig. 12.1.10)

Example 3: Erection by Erection Girder, Option 1 (Refer to Fig. 12.1.11)
A girder is first transported on the ground to the bridge location, then hoisted vertically and shifted transversely to the designed location.

Example 4: Erection by Erection Girder, Option 2 (Refer to Fig. 12.1.12)
A girder is first transported on the completed I-girders to the bridge location, then lowered and shifted transversely to the designed location.

Other than the above-mentioned methods, there are various alternative methods. Final selection will be carried out by the contractor with consideration on, the location of the fabrication yard and available construction equipment, in addition to the above conditions.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

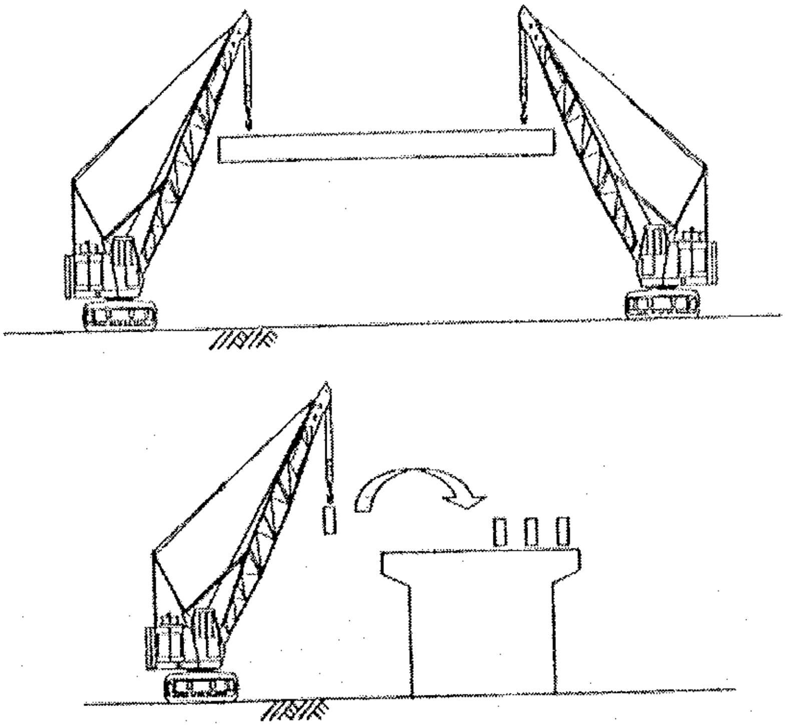


Figure 12.1.9 Erection by Truck Cranes

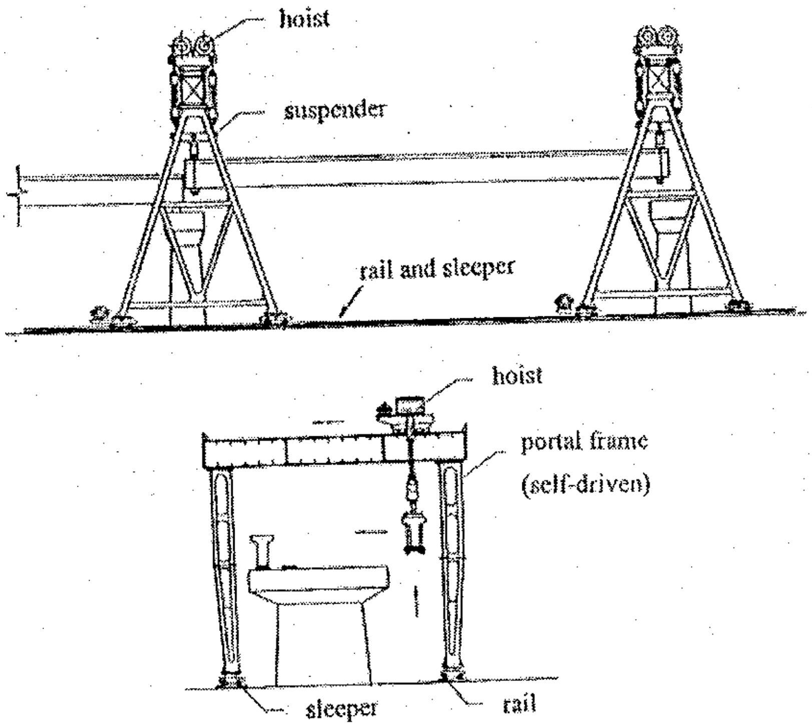


Figure 12.1.10 Erection by Self-driven Portal Frame

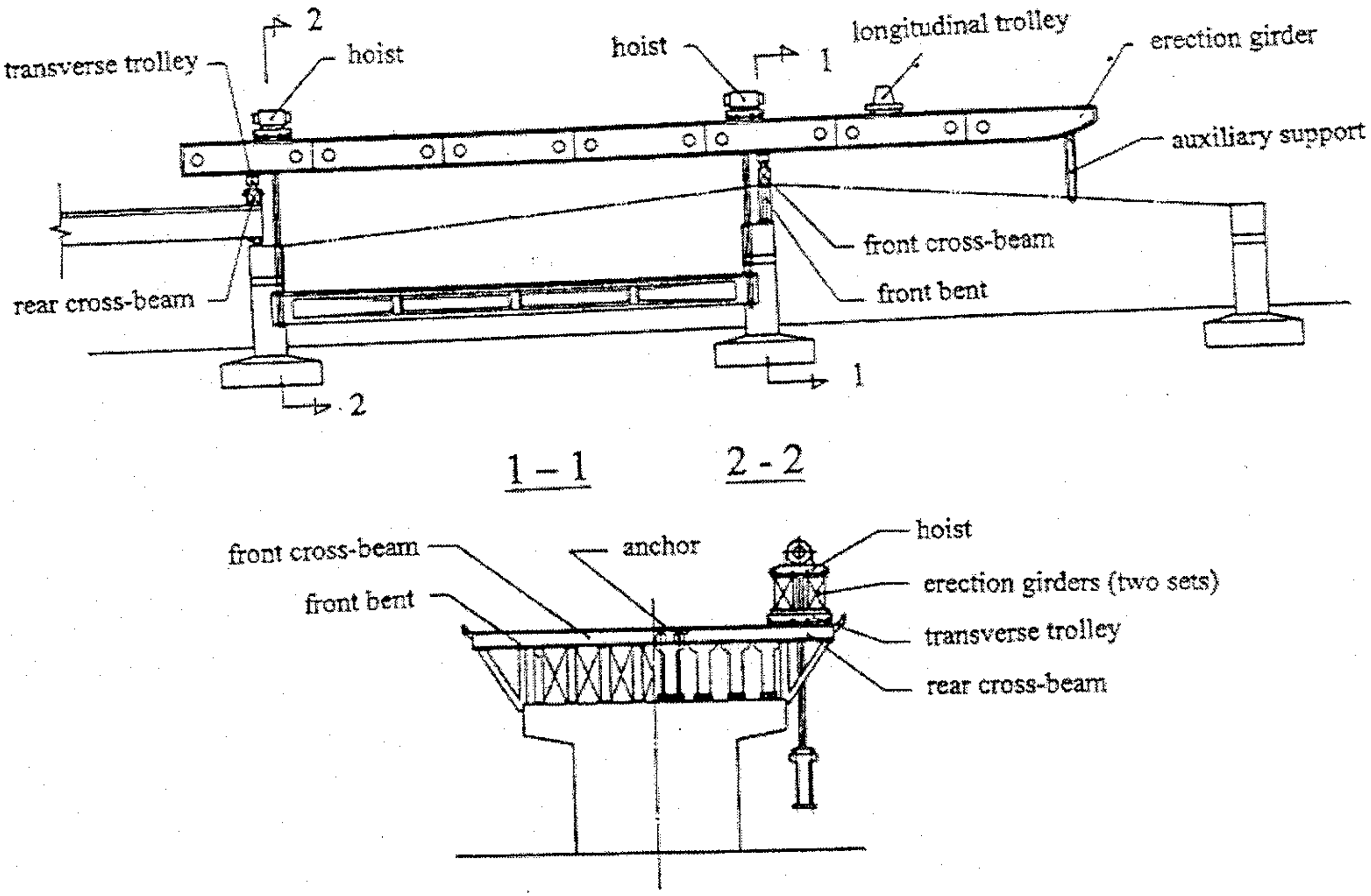


Figure 12.1.11 Erection by Erection Girder, Option 1

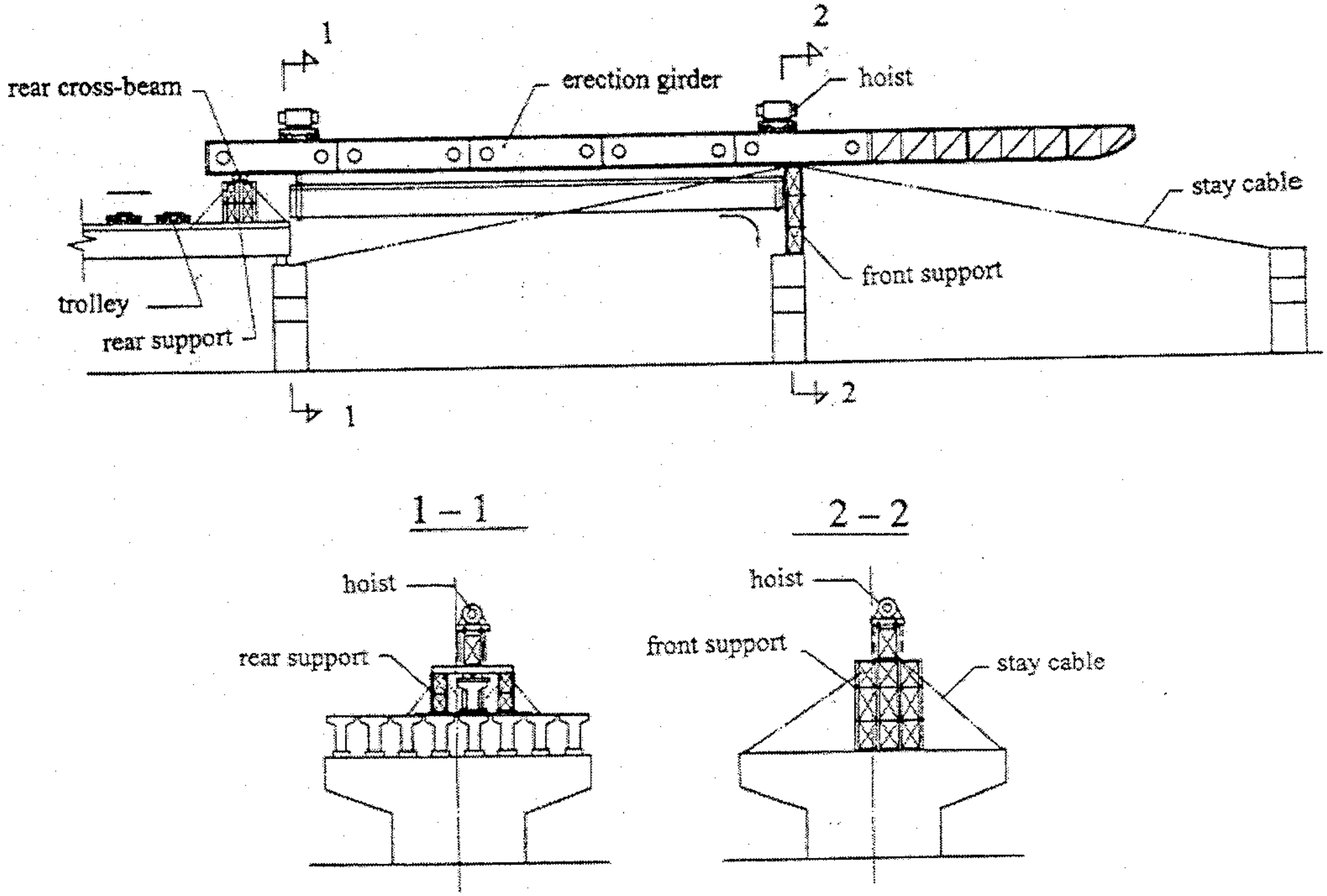


Figure 12.1.12 Erection by Erection Girder, Option 2

12.1.4 Dyke Bridges

(1) Superstructure

This bridge will be constructed by cast-in-place concrete segmental cantilever erection method. The bridge length and the span arrangement for both Thanh Tri side and Gir Lam side are as follows;

Bridge length = 290.0m = 80.0 + 130.0 + 80.0m

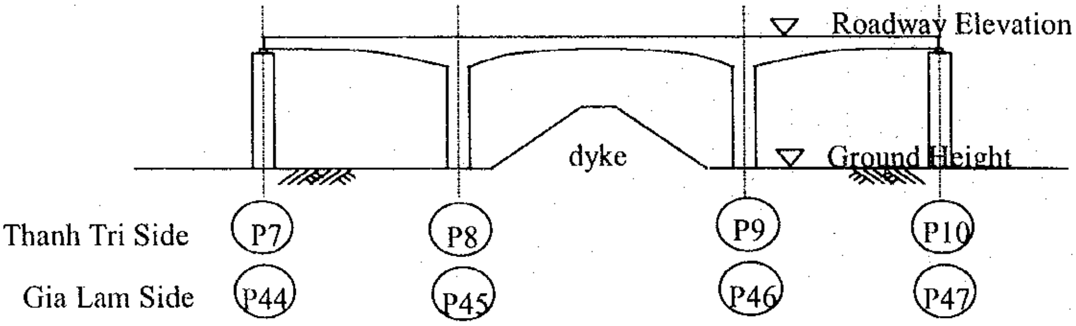
Construction of these bridges will be carried out in a similar way as the main bridge. Refer to Section 12.1.1 (1) for details. Note that temporary fixing of the pier segment is not needed due to the rigid connection.

For reference, Table 12.1.6 shows the approximate ground height and the roadway elevation.

Table 12.1.6 Ground Height and Roadway Elevation (Dyke Bridges)

Location	Pier No.	Ground Height (m)	Roadway Elevation (m)	Note
Thanh Tri Side	P7	5.6	18.735	Indicated data is for the north bound bridge
	P8	7.8	21.016	
	P9	7.0	23.825	
	P10	6.0	24.988	
Gia Lam Side	P44	8.4	23.599	
	P45	8.8	22.404	
	P46	3.3	19.410	
	P47	2.6	17.035	

Note for Table 12.1.6



(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.2 Interchange Bridges

12.2.1 Phap Van Viaduct

(1) Superstructure

This bridge will be constructed by precast pre-stressed concrete I-girder (PC I-girder). The standard span length is 33.0 m mixed with two different spans of 35.0 m and 28.0 m. The total length of the viaduct is 575.0 m for both the north-bound and the south-bound sections.

For reference, Tables 12.2.1 and 12.2.2 show the elevation data and the girder weights respectively.

Table 12.2.1 Ground Height and Roadway Elevation (Phap Van Viaduct)

Pier No.	Ground Height (m)	Roadway Elevation (m)	Clearance approx. (m)	Note
P18	4.0	15.293	9.4	Starting point
P14	4.2	15.635	9.5	Roadway highest point
A1	4.9	11.412	4.6	Ending point (roadway lowest)

Note for Table 12.2.1

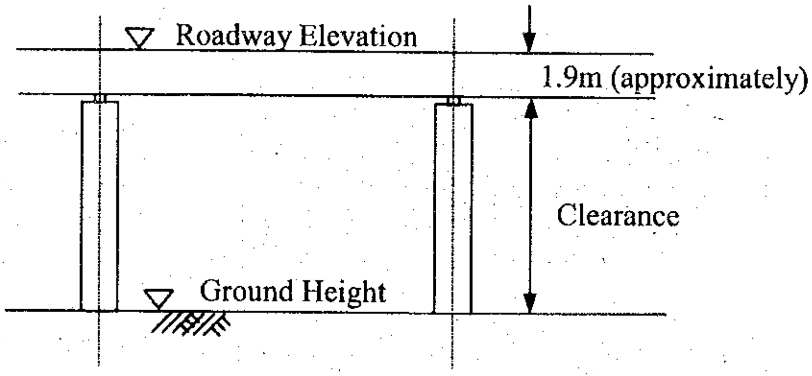


Table 12.2.2 Weight and Numbers of PC I-girders (Phap Van Viaduct)

Span Length (m)	Girder Height (m)	Concrete Volume (m^3/each)	Girder Weight (tf/each)	Total No. of Girders (Nos)	Note
28.0	1.50	20.0	50.0	75	
33.0	1.65	24.6	61.5	199	Standard
35.0	1.75	27.0	67.5	58	

Under the above-mentioned conditions, various construction methods are applicable. Refer to Section 12.1.3 (1) for more details.

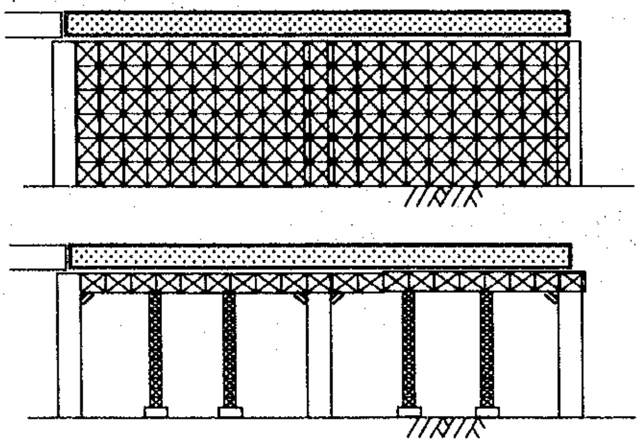
(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.2.2 Phap Van Cau Gie Interchange Ramp Bridge

(1) Superstructure

The ramp bridge will be constructed by cast-in-place reinforced concrete hollow slab. Construction on fixed staging is widely used for this type of bridge. The construction method is very popular and wide variety of structures are possible. Two alternatives are shown in Fig. 12.2.1 as examples:



Alternative 1

on-ground staging

Alternative 2

combination of staging and temporary columns. The columns may be omitted.

Figure 12.2.1 Construction on Fixed Staging (RC hollow slab)

Local conditions, construction safety and economy shall be considered for selection of the construction method.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.2.3 National Highway No.5 Flyover

(1) Superstructure

This bridge will be constructed by precast pre-stressed concrete I-girder (PC I-girder). The standard span length is 33.0 m, mixed with three different spans of 35.0 m, 28.0 m and 20.0 m. The total length of the viaduct is 695.0 m each for the north bound and the south-bound sections.

For reference, Tables 12.2.4 and 12.2.5 show the elevation data and and the girder weights respectively.

Table 12.2.4 Ground Height and Roadway Elevation (NH No.5 Flyover)

Pier No.	Ground Height (m)	Roadway Elevation (m)	Clearance approx. (m)	Note
A1	3.4	11.061	5.8	Starting point (roadway lowest)
P11-P12	3.4	15.299	10.0	Roadway highest point
A2	3.6	12.030	6.5	Ending point

Note for Table 12.2.4

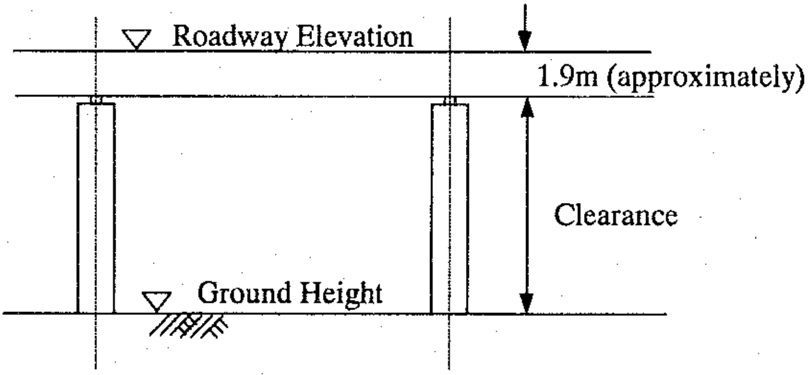


Table 12.2.5 Weight and Numbers of PC I-girders (NH No.1 Flyover)

Span Length (m)	Girder Height (m)	Concrete Volume (m^3/each)	Girder Weight (tf/each)	Total No. of Girders (Nos)	Note
20.0	1.65	15.8	39.5	20	
28.0	1.50	20.0	50.0	79	
33.0	1.65	24.6	61.5	251	standard
35.0	1.75	27.0	67.5	16	

Under the above-mentioned conditions, the construction will be carried out in a similar way to Phap Van Viaduct. Refer to Section 12.1.3 (1) for details.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.2.4 National Highway No.5 Interchange Ramp Bridge

(1) Superstructure

The ramp bridge will be constructed by cast-in-place reinforced concrete hollow slab. The construction will be carried out in similar way to the ramp bridge at Phap Van Cau Gie Interchange. Refer to Section 12.2.2 (1) for the details.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.3 Other Bridges

12.3.1 Kim Nguu River Bridge (ST 1+647)

(1) Superstructure

This bridge will be constructed by precast pre-stressed concrete I-girder (PC I-girder) with a span length of 33.0 m. The weight of each girder is 61.5 tf. Bridge for the frontage road will be constructed next to the throughway bridge. The span arrangement is the same for both bridges but the effective road width is different (as follows):

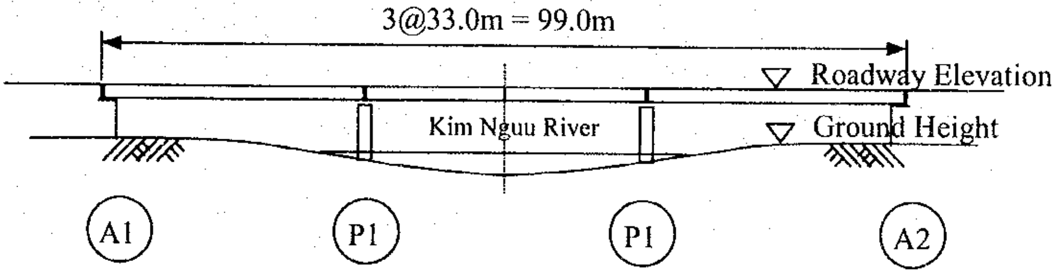
bridge length = 99.0m = 3@33.0m
effective road width: 11.5m (throughway)
14.0m (frontage road)

The bridge spans over Kim Nguu River. The ground height and the roadway elevation are shown in Fig. 12.3.1 for reference.

Table 12.3.1 Ground Height and Roadway Elevation (Kim Gnuu River Bridge)

Pier No.	Ground Height (m)	Roadway Elevation (m)	Note
A1	5.2	9.550	Indicated height and elevation are those at the center of the throughway.
P1	3.2	9.681	
P2	5.4	9.747	
A2	3.6	9.747	

Note for Table 12.3.1



Various construction methods will be feasible due to the relatively low roadway elevation. Refer to Section 12.1.3 (1) for the detail. Local conditions, construction safety and economy shall be considered for selection of the construction method.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.3.2 Nguyen Tam Trinh Bridge (ST 2+775)

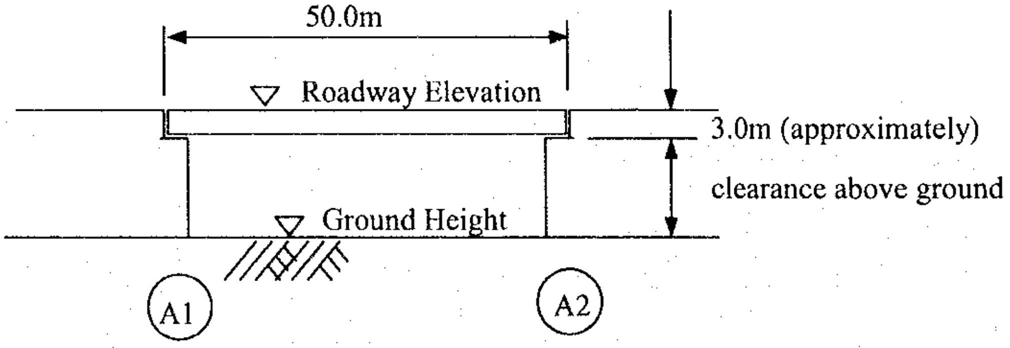
(1) Superstructure

This bridge is a 50m-long simple span bridge of cast-in-place pre-stressed concrete box girder with effective roadway width of 11.5m. For reference, Table 12.3.2 shows the approximate ground height and the roadway elevation.

Table 12.3.2 Ground Height and Roadway Elevation (Gguyen Tam Trinh Bridge)

Pier No.	Ground Height (m)	Roadway Elevation (m)	clearance above ground (m)	Notes
A1	4.7	13.900	6.2	
A2	3.6	13.622	7.0	

Note for Table 12.3.2



The bridge will be constructed on conventional fixed staging on the ground as shown in Fig. 12.3.1. Traffic will be detoured to the side of the abutment for traffic under the bridge during the construction. Alternately, traffic can be maintained by using staging combined with beams and temporary columns as shown in Fig. 12.3.2. The optimum construction method shall be determined considering local conditions, construction safety and economy.

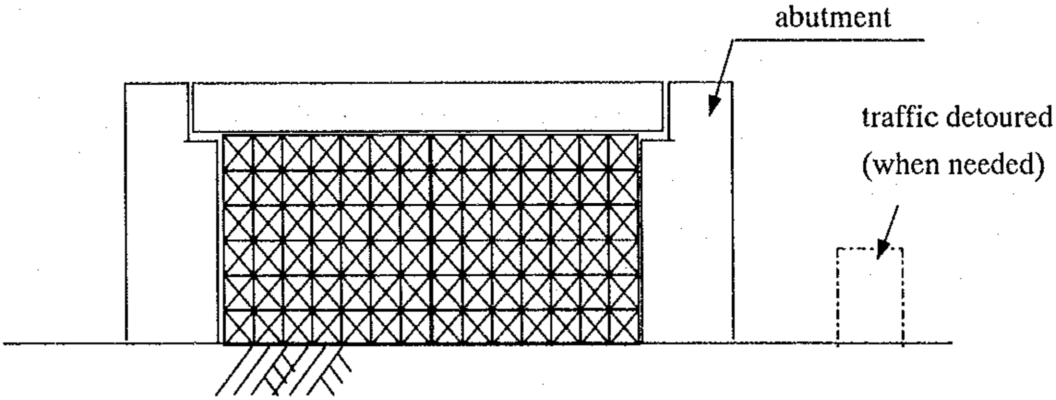


Figure 12.3.1 Construction on Fixed Staging (PC box girder): Option 1

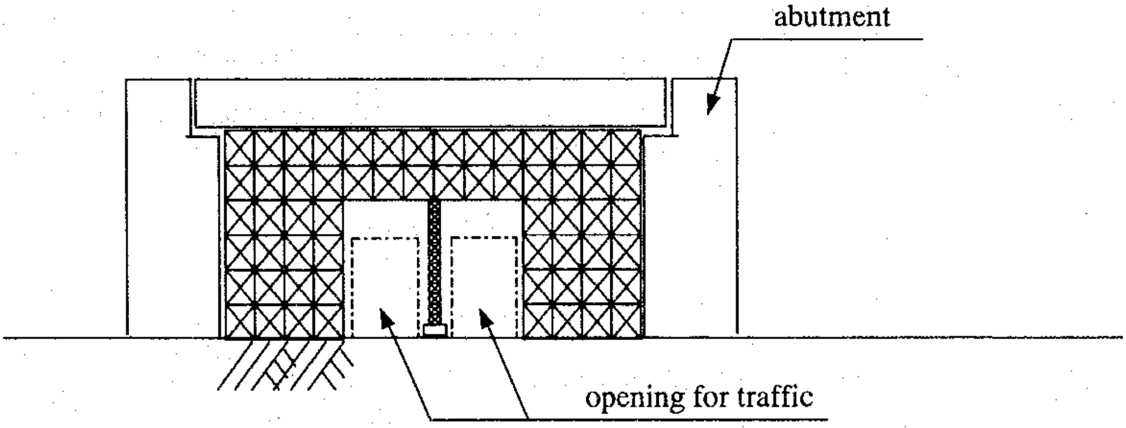


Figure 12.3.2 Construction on Fixed Staging (PC box girder): Option 2

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.3.3 Linh Nam Bridge (ST 5+605)

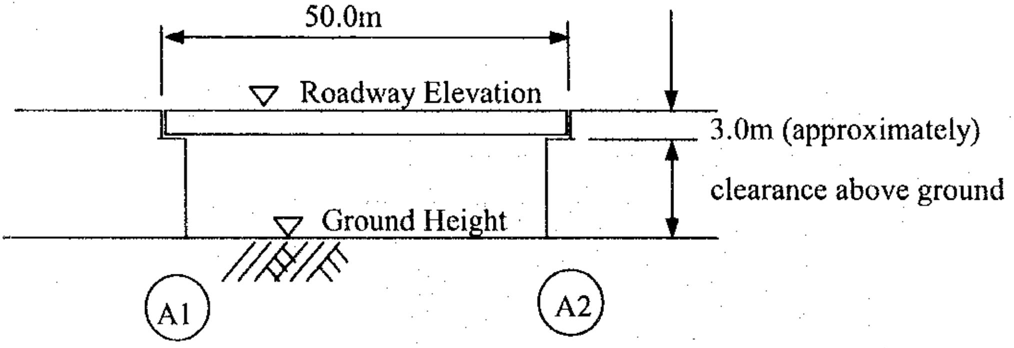
(1) Superstructure

This bridge is a 50 m-long simple span bridge of cast-in-place pre-stressed concrete box girder with effective roadway width of 11.5 m, which is the same as Nguyen Tam Trinh Bridge. The bridge is skewed at 68 degrees due to the crossing conditions with the existing road under the bridge. For reference, Table 12.3.3 shows the approximate ground height and the roadway elevation.

Table 12.3.3 Ground Height and Roadway Elevation (Linh Nam Bridge)

Pier No.	Ground Height (m)	Roadway Elevation (m)	clearance above ground (m)	Note
A1	5.3	13.863	5.6	
A2	6.1	14.029	4.9	

Note for Table 12.3.3



Although the bridge is skewed, construction will be carried out in similar way as Nguyen Tam Trinh Bridge. Refer to Section 12.3.2 (1) for details.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.3.4 Gia Lam Road Bridge (ST 10+903.5)

(1) Superstructure

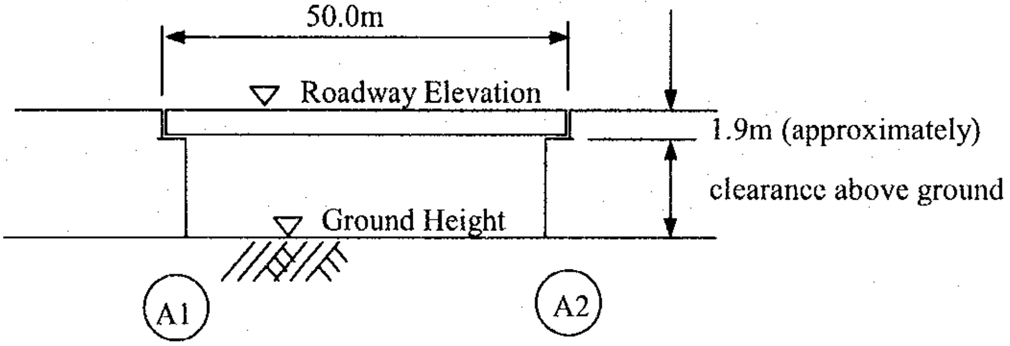
This bridge will be constructed by precast pre-stressed concrete I-girder (PC I-girder) with the span length of 33.0m. The weight of a girder is 61.5tf each.

The bridge spans over planed Gia Lam Road. The ground height and the roadway elevation are shown in Fig. 12.3.4 for reference.

Table 12.3.4 Ground Height and Roadway Elevation (Gia Lam Road Bridge)

Pier No.	Ground Height (m)	Roadway Elevation (m)	clearance above ground (m)	Notes
A1	4.0	12.510	6.6	
A2	4.1	12.510	6.5	

Note for Table 12.1.4



Erection by truck cranes (Refer to Fig. 12.1.9) will be most feasible because;

i) The clearance above ground is relatively small, and

ii) This bridge is constructed at an isolated location from other bridges.

(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

12.3.5 Cau Bay Canal Bridge (ST 11+377.5)

(1) Superstructure

This bridge consists of cast-in-place pre-stressed concrete (PC) box girder bridges and PC I-girder bridges. The effective roadway width is 11.5m throughout the bridge. Table 12.3.5 shows the ground height, the roadway elevation and the span arrangement

The PC box girder can easily be constructed on staging since the clearance above ground is small. (Refer to Figs. 12.3.1 and 12.3.2)
The PC I-girder bridge consists of 33m long I-girders. One girder weighs 61.5tf.

Total number of the girders for Cau Bay Canal Bridge is 24. Erection by truck cranes will be most feasible because:

i) The clearance above ground is small, and
ii) Number of total PC I-girders is only 24.

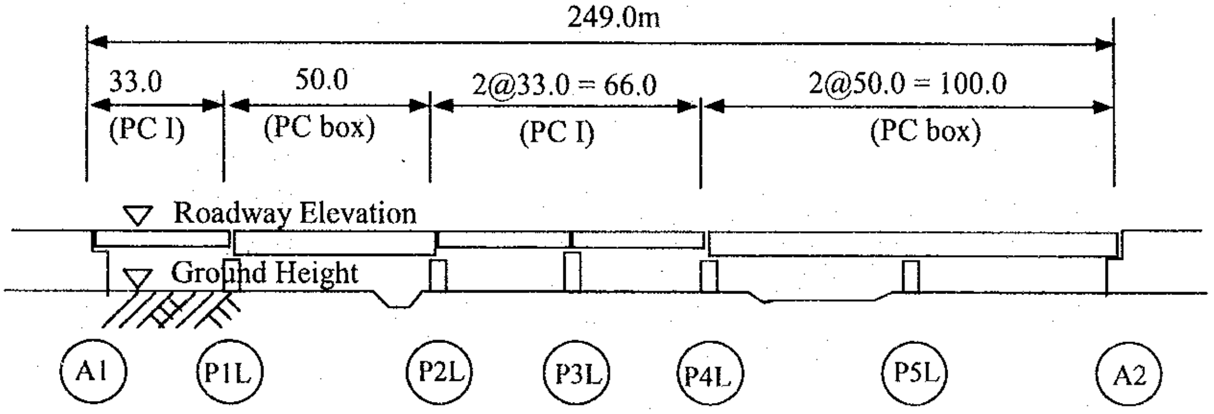
(2) Substructure/ Foundation

Refer to Section 12.1.2 (2).

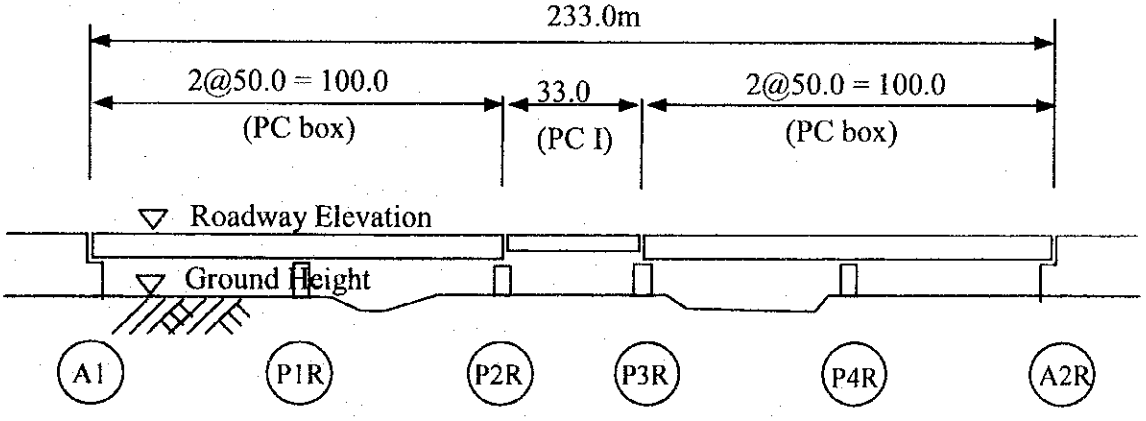
Table 12.3.5 Ground Height and Roadway Elevation (Cau Bay Canal Bridge)

Pier No.	Ground Height (m)	Roadway Elevation (m)	Notes
A1	3.9	9.500	
in-between	4.5 (highest) 2.0 (lowest)	Monotonically ascending	
A2L	3.7	10.600	
A2R	3.7	10.600	

Note to Fig. 12.3.5



South-Bound



North-Bound

12.4 Construction Schedule

Construction Schedule is estimated for Package-1 to Package-4 respectively.

12.4.1 Package-1 Red River Bridge

Package-1 Red River Bridge construction schedule for 7 bridges Each bridge requires the following construction period.
(Fig 12.4.2~12.4.8)
Whole Construction Schedule for Package-1 is show in Fig 12.4.1

Package-1 Construction Schedule.	48 months
Approach Bridge-2 Thanh Tri Side (AP-2(T)).	19 months
Dyke Bridge Thanh tri Side (Dyke(T)).	31 months
Approach Bridge-1 Thanh Tri Side (AP-2(T)).	33 months
Main Bridge.	46 mouths
Approach Bridge-1 Gia Lam Side (AP-1(G)).	36 months
Dyke Bridge Gia Lam Side (Dyke(G)).	31 mouths
Approach Bridge-2 Gia Lam Side (AP-2(G)).	17 months

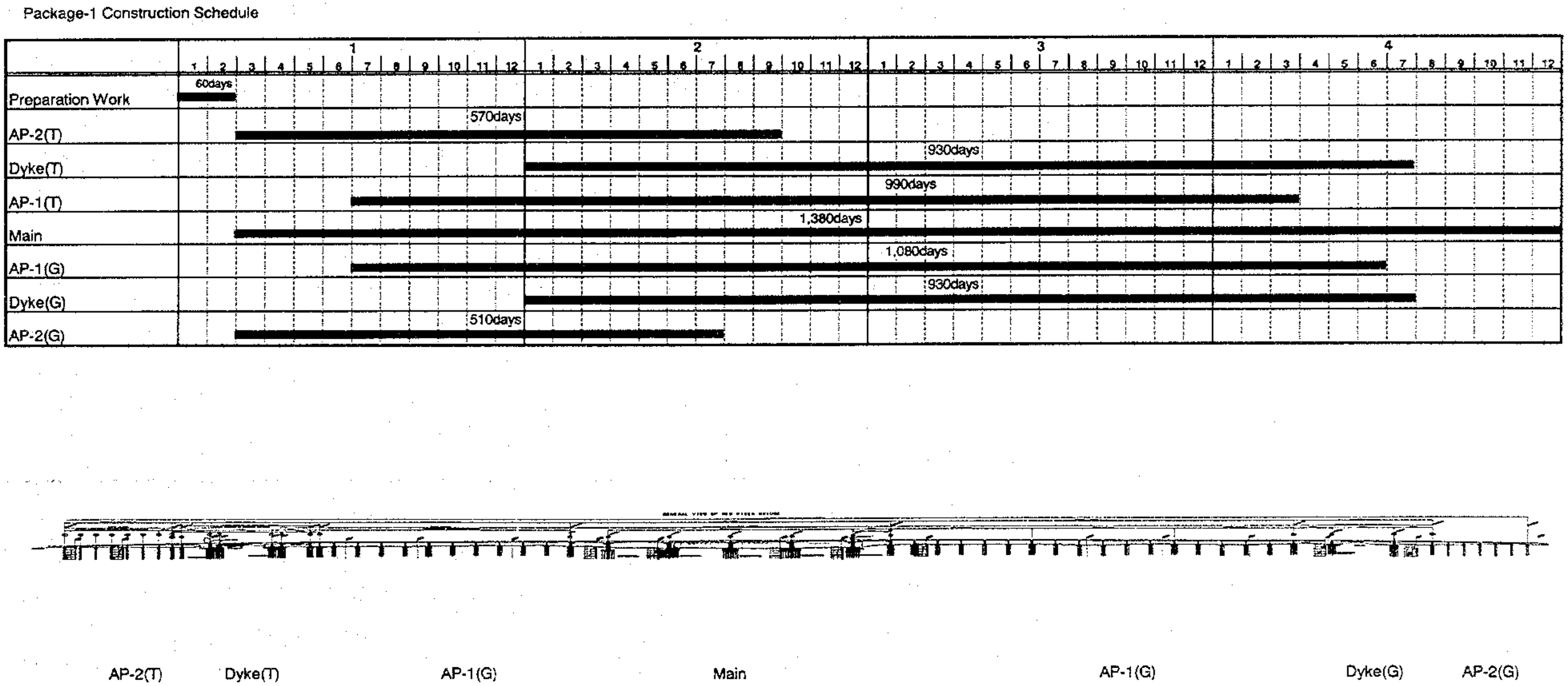


Figure 12.4.1 Package-1 Construction Schedule

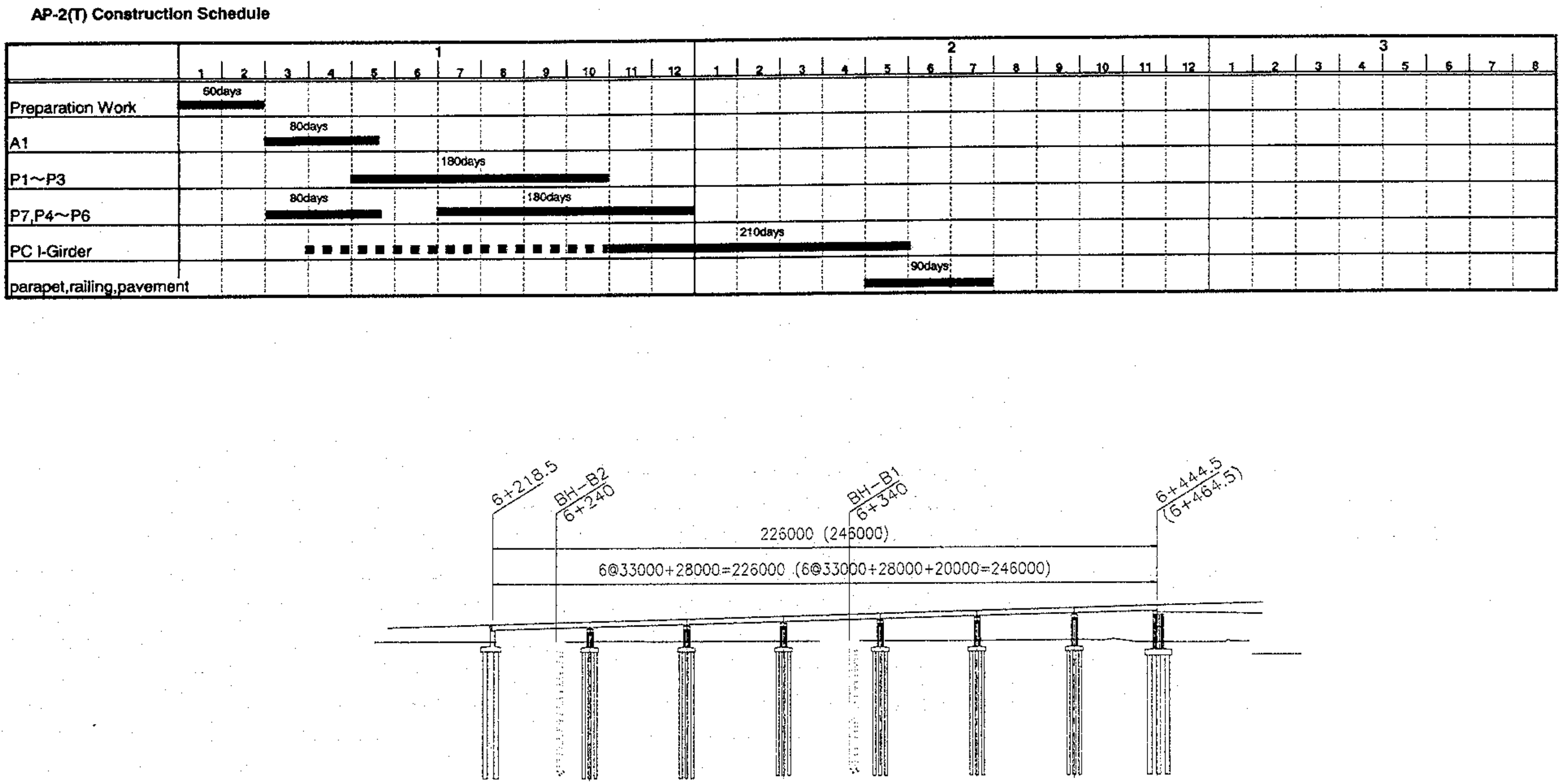
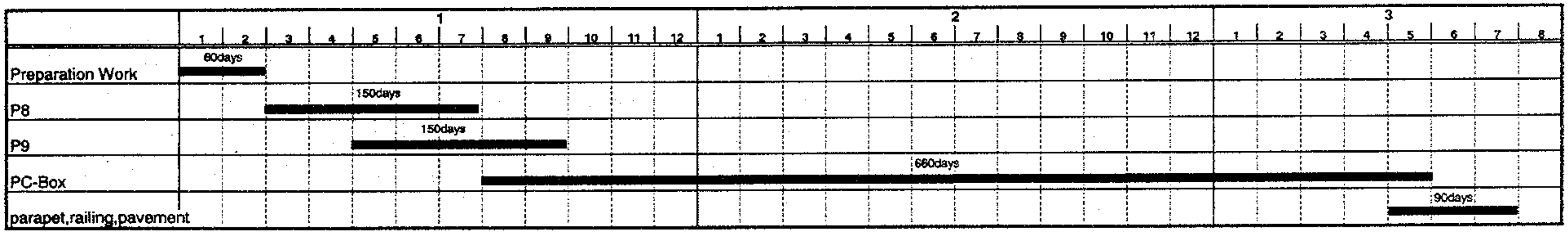


Figure 12.4.2 AP-2(T) Construction Schedule

Dyke(T) Construction Schedule



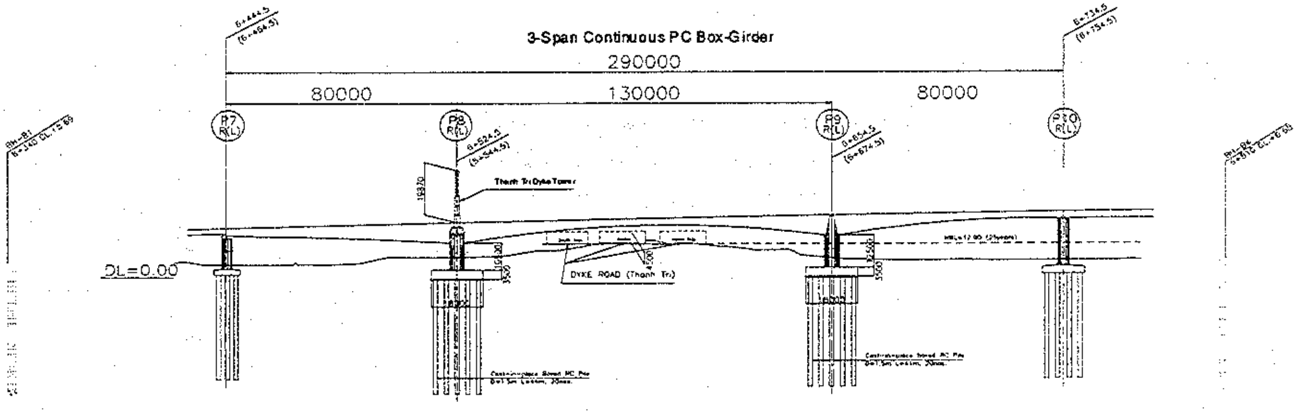


Figure 12.4.3 Dyke(T) Construction Schedule

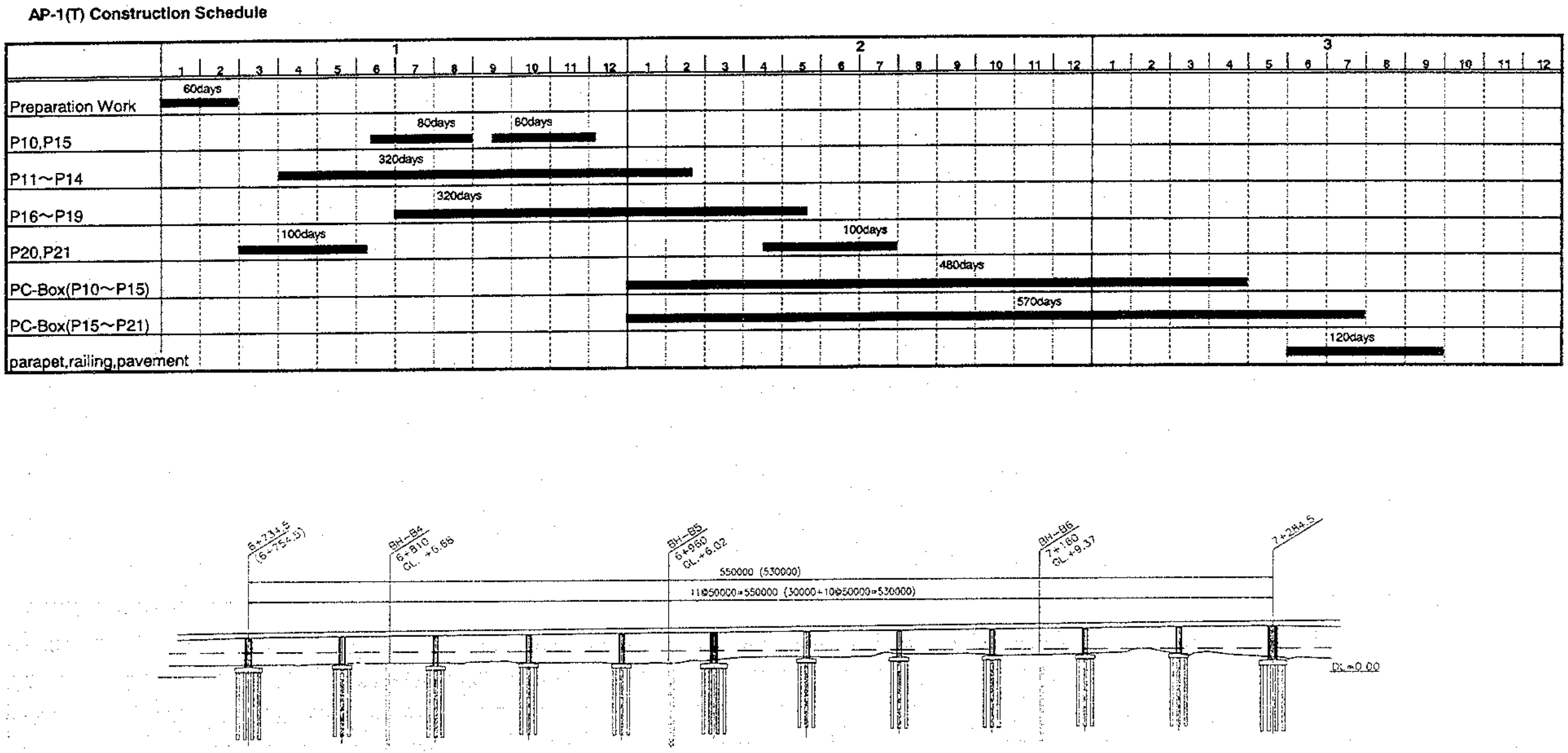
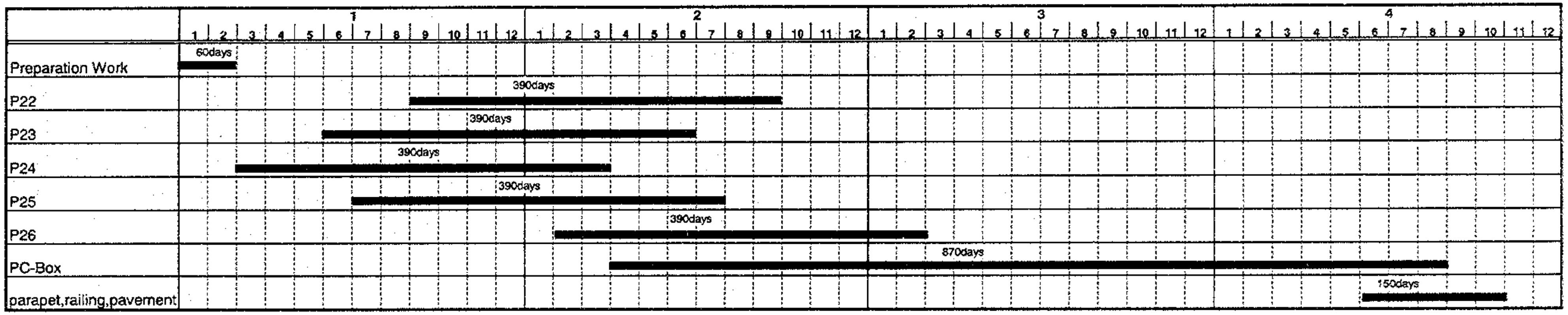


Figure12.4.4 AP-1(T) Construction Schedule

Main Construction Schedule



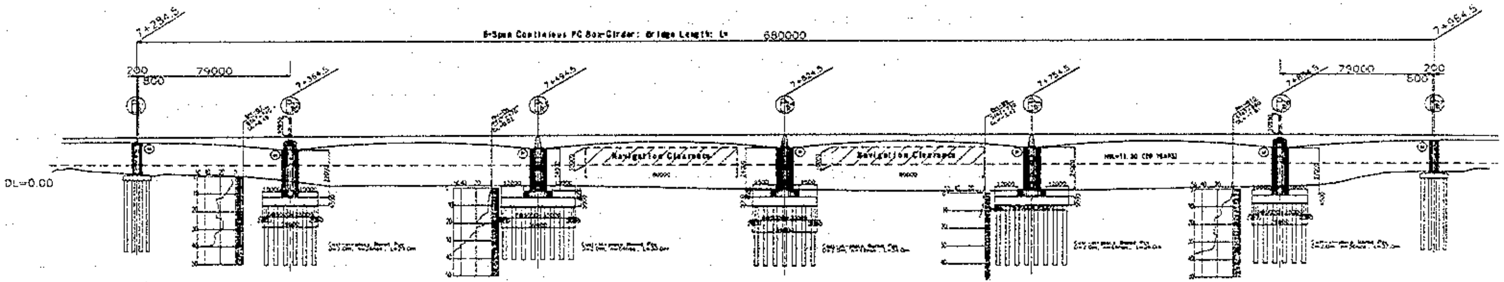
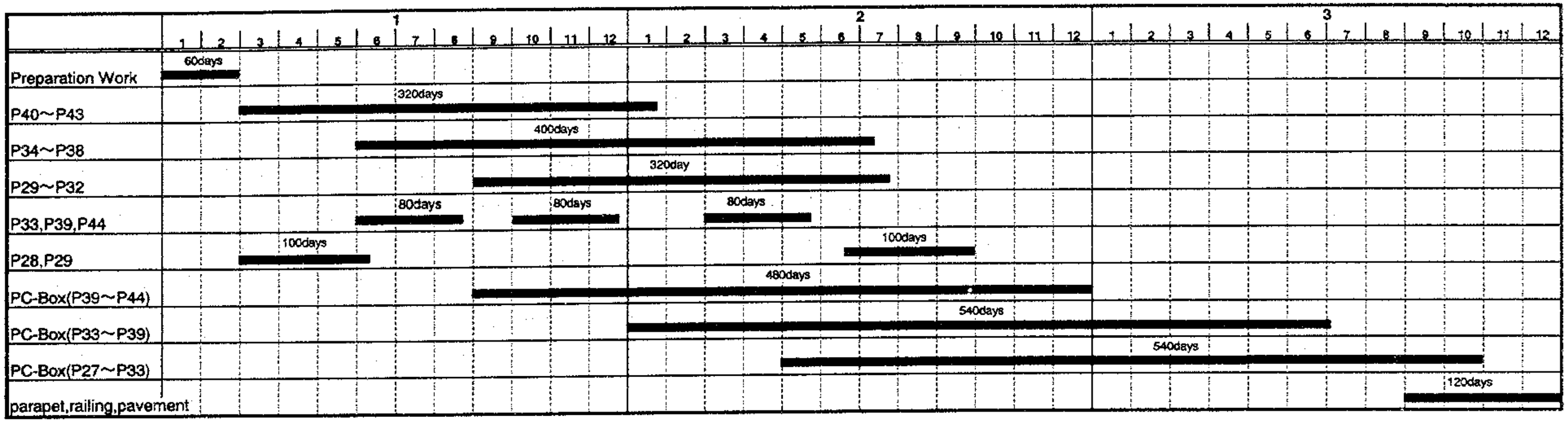


Figure 12.4.5 Main Construction Schedule

AP-1(G) Construction Schedule



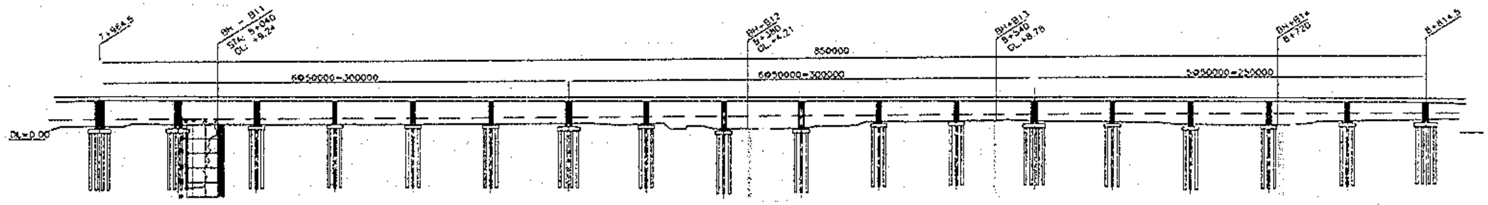
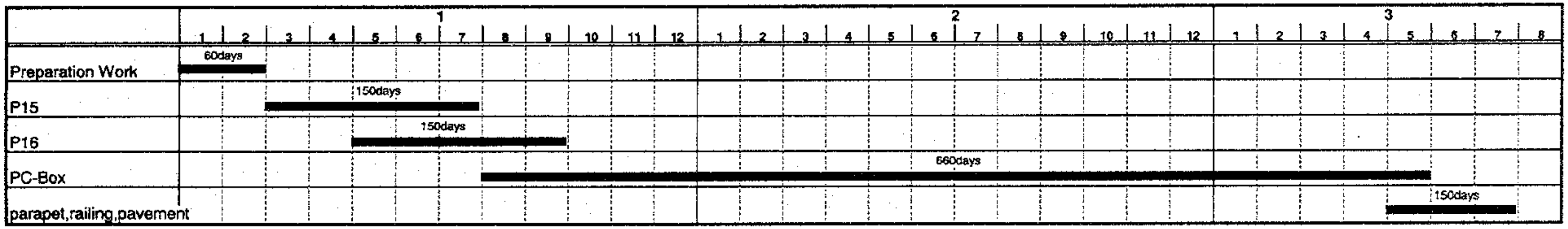


Figure 12.4.6 AP-1(G) Construction Schedule

Dyke(G) Construction Schedule



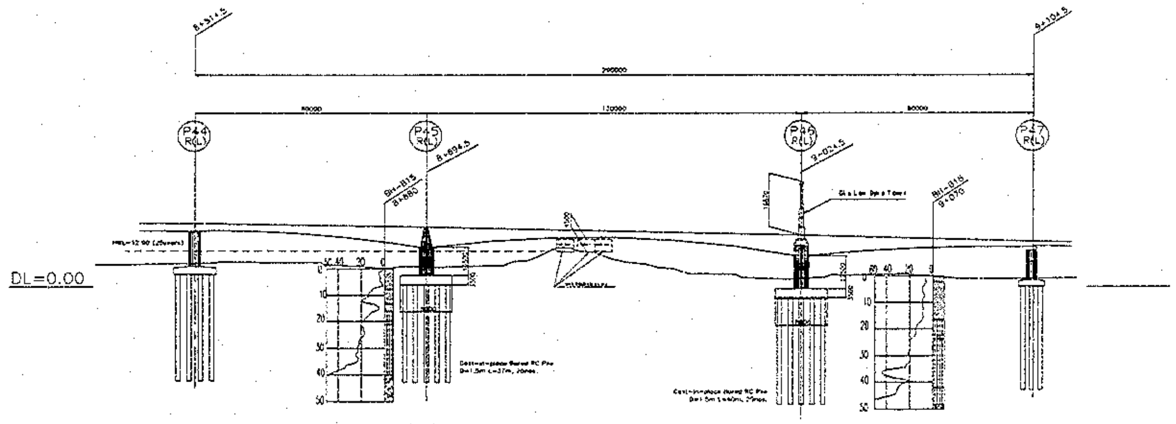


Figure 12.4.7 Dyke(G) Construction Schedule

AP-2(G) Construction Schedule

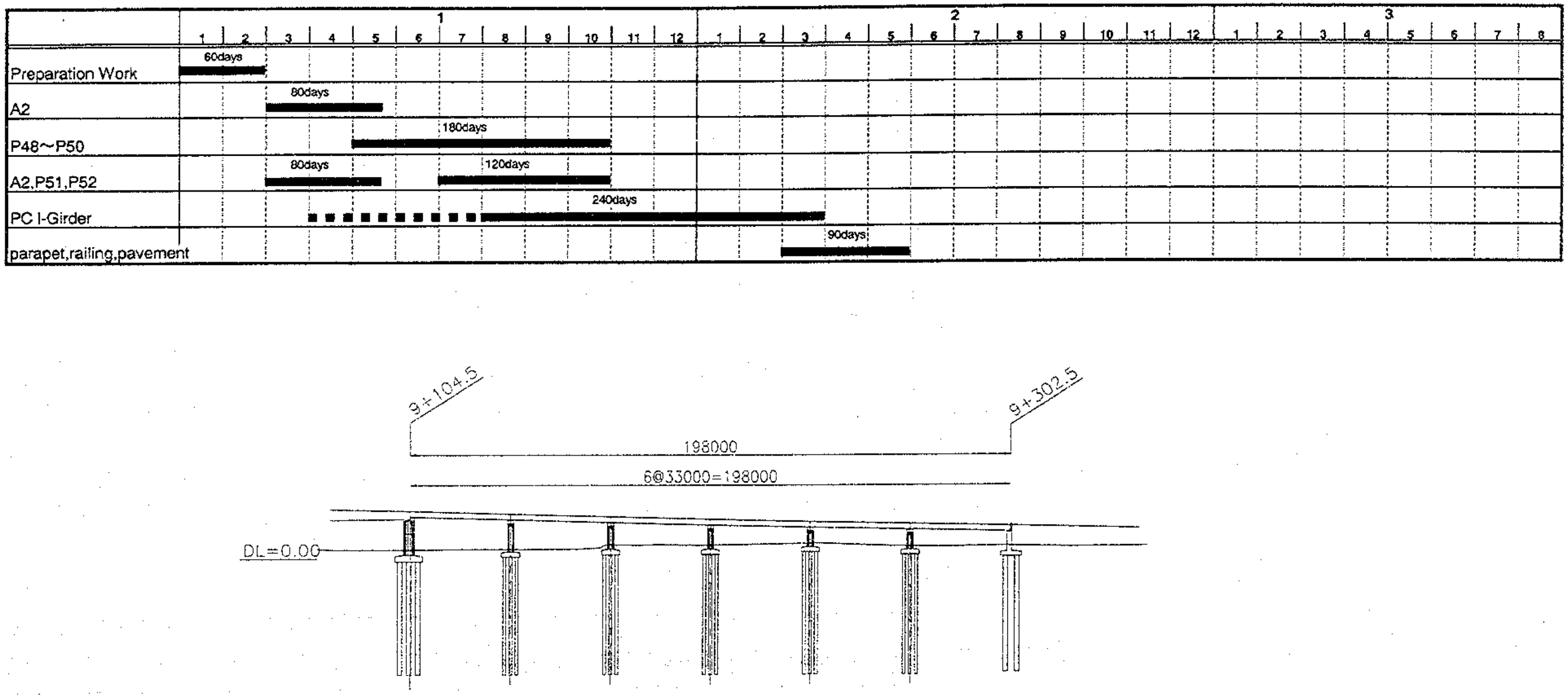


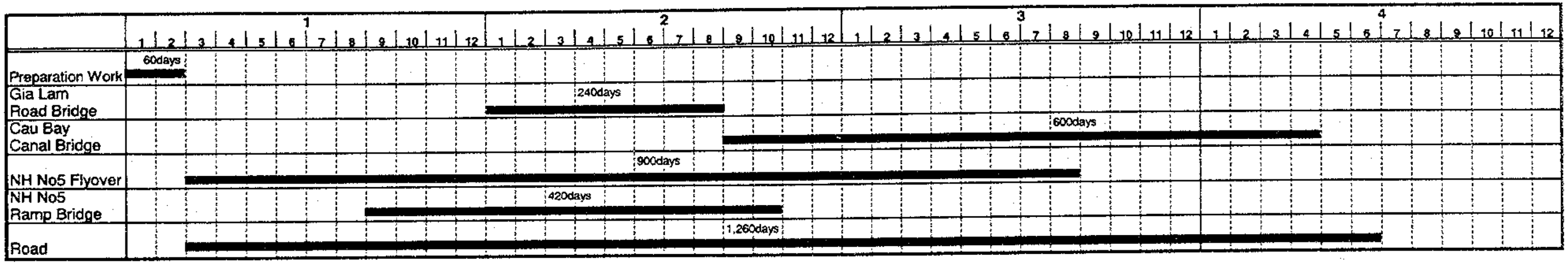
Figure 12.4.8 AP-2(G) Construction Schedule

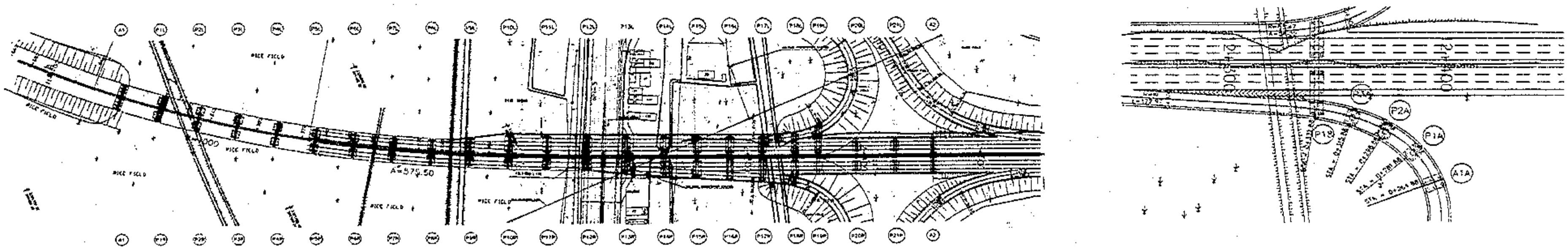
12.4.2 Package-2 Gia Lam Side

Package-2 Consists of Gia Lam Road Bridge, Can Bay Canal Bridge, NH-No5 Flyover Bridge, NH-No5 Ramp Bridge and Road construction respectively.
Whole construction schedule is shown in Fig 12.4.9 and construction schedule for bridges are shown in Fig 12.4.10~Fig 12.4.13

Package-2 Construction Schedule.	42 months
NH-No5 Flyover Construction Schedule.	30 months
NH-No5 Ramp Bridge Construction Schedule.	14 months
Gia Lam Road Bridge Construction Schedule.	8 months
Cau Bay Canal Bridge Construction Schedule.	20 months

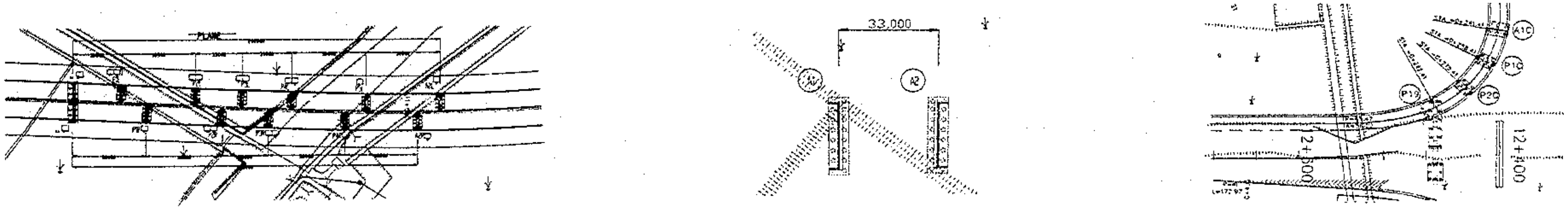
Package - 2 Construction Schedule





NH No5 Flyover

NH No5 A-Ramp Bridge



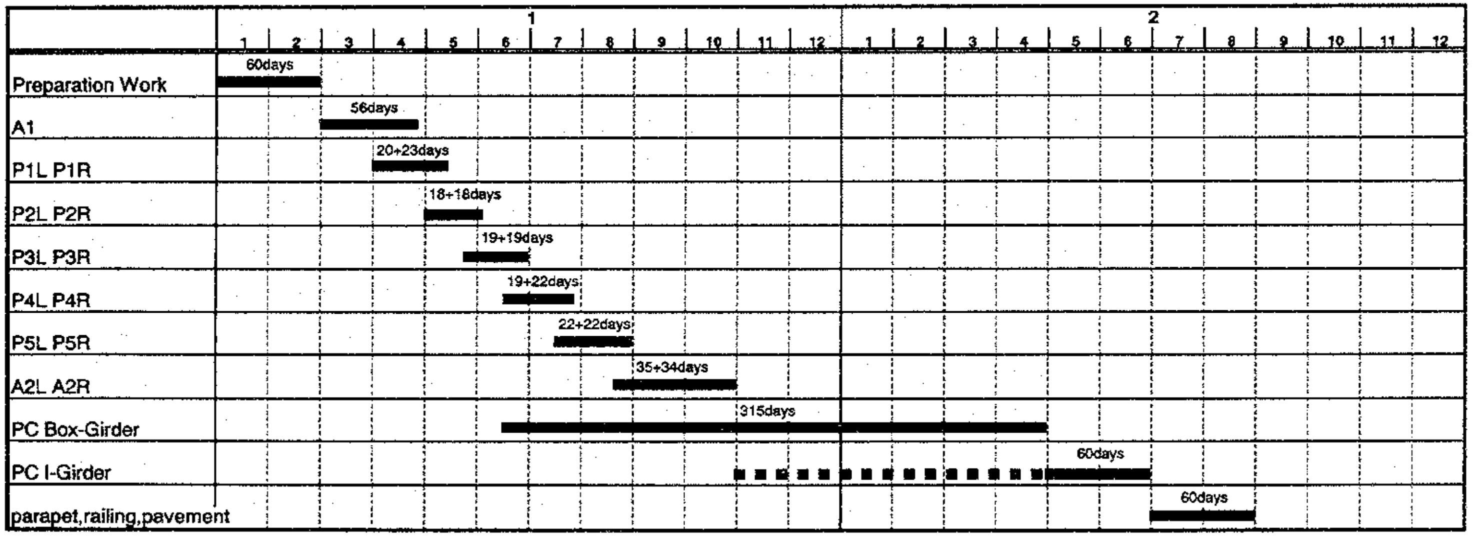
Cau Bay Canal Bridge

Gia Lam Road Bridge

NH No5 C-Ramp Bridge

Figure 12.4.9 Package - 2 Construction Schedule

Cau Bay Canal Bridge Construction Schedule



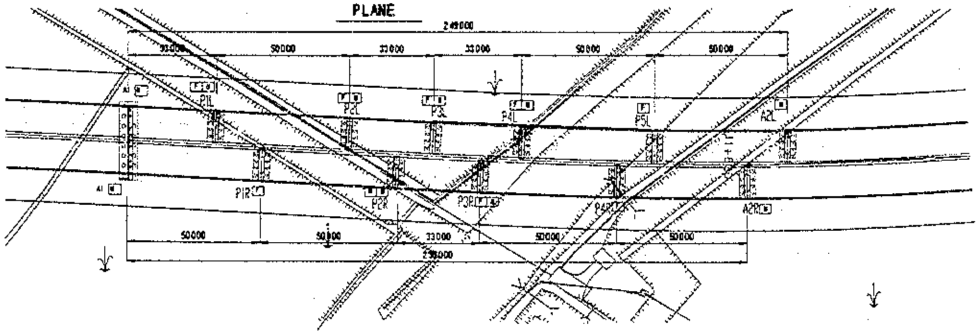


Figure 12.4.10 Cau Bay Canal Bridge Construction Schedule

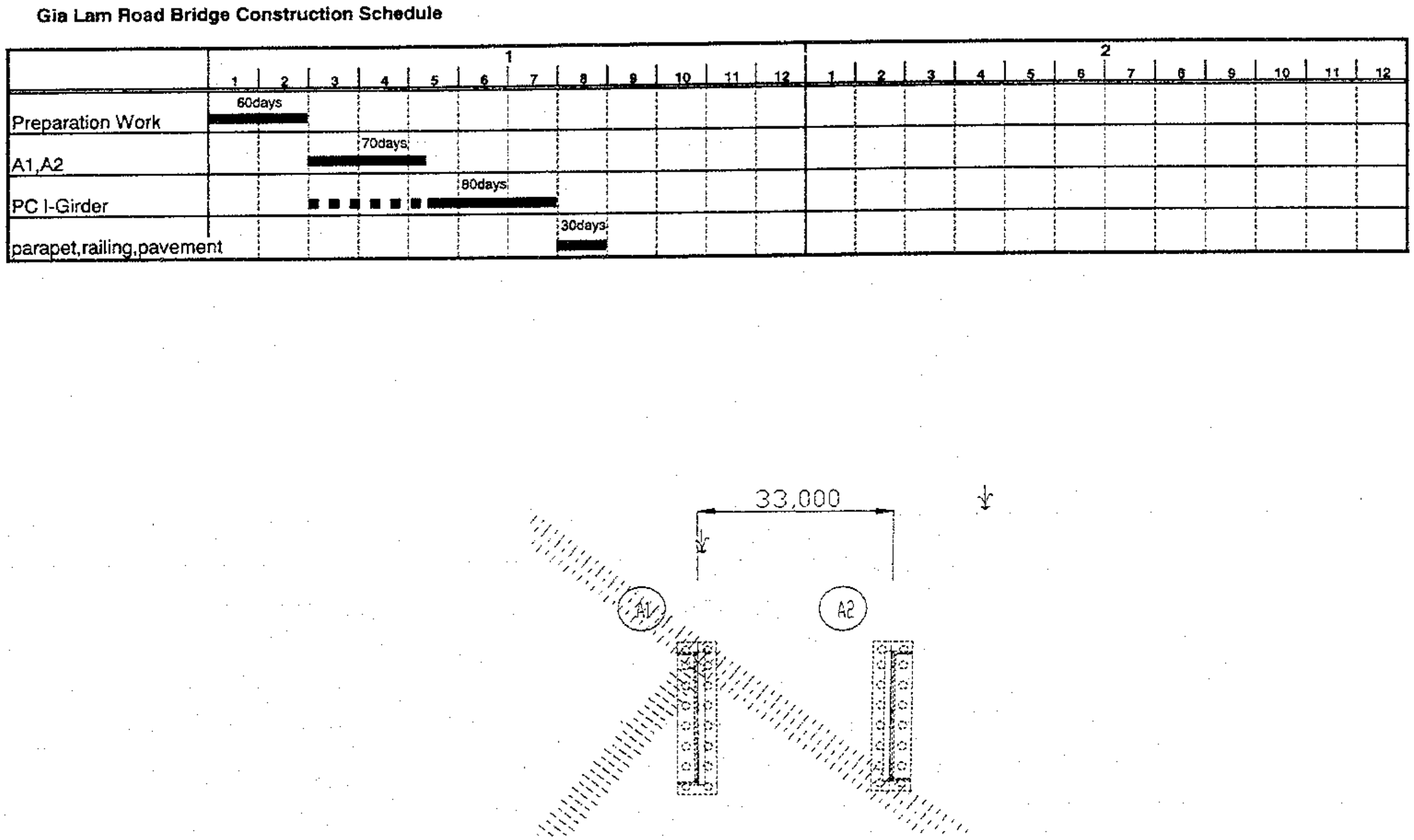
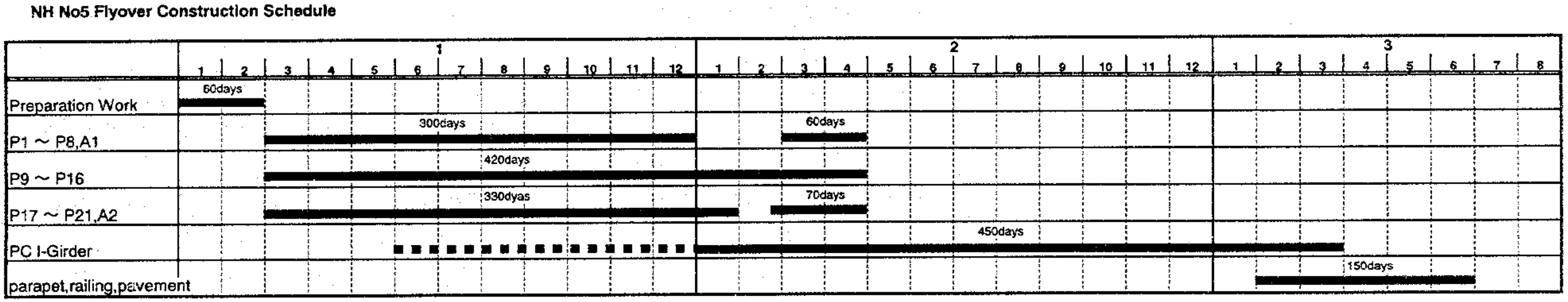


Figure 12.4.11 Gia Lam Road Bridge Construction Schedule



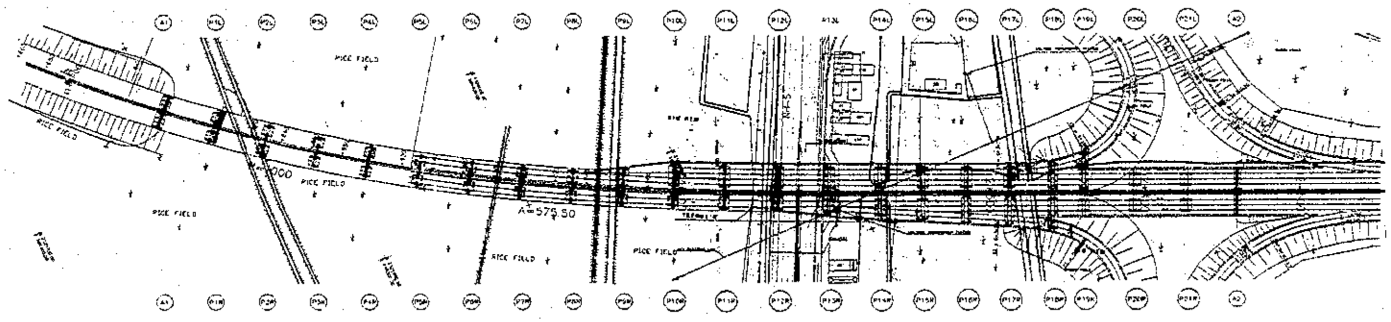
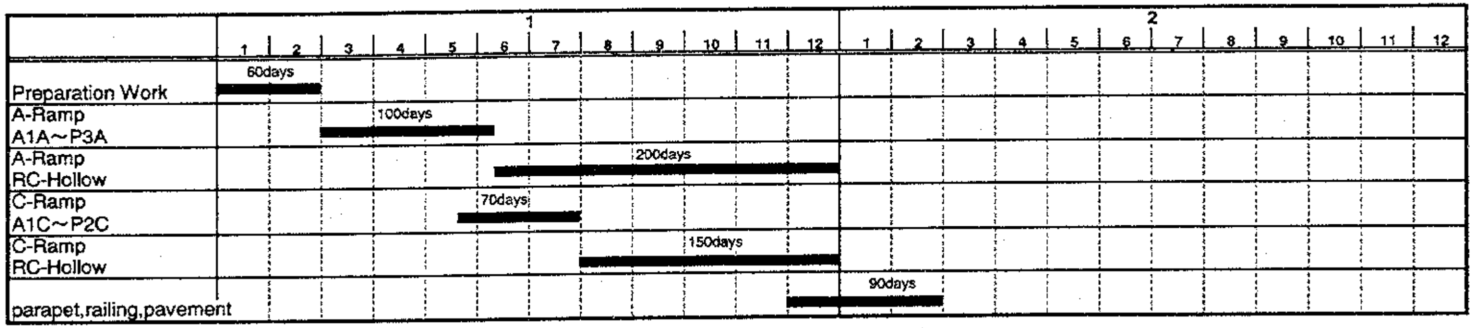


Figure 12.4.12 NH No5 Flyover Construction Schedule

NH No5 Ramp Bridge Construction Schedule



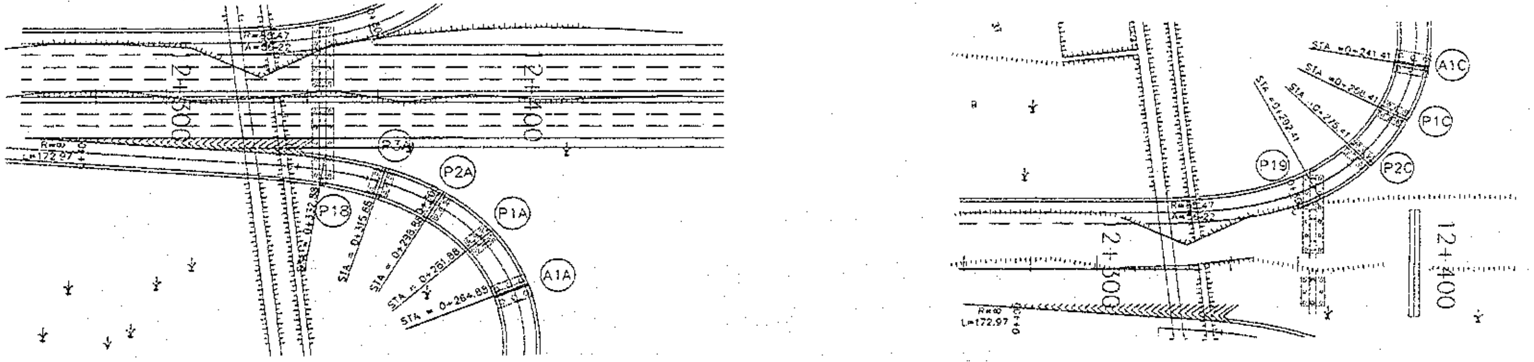


Figure 12.4.13 NH No5 Ramp Bridge Construction Schedule

12.4.3 Package-3 Thanh Tri Side

Package-2 Consists of Phap Van Viaduct, Phap Van Viaduct Ramp Bridge,Kim Nguu River Bridge, Nguyen Tam Trinh Bridge, Linh Nam Bridge and Road Construction respectively.
Whole construction schedule is shown in Fig 12.4.14 and construction schedule for bridges are shown in Fig 12.4.14~Fig 12.4.19

Package-3 Construction Schedule.	42 months
Phap Van Viaduct.	26 months
Phap Van Viaduct Ramp Bridge.	20 months
Kim Nguu River Bridge.	12 months
Nguyen Tam Trinh Bridge.	9 months
Linh Nam Bridge.	9 months

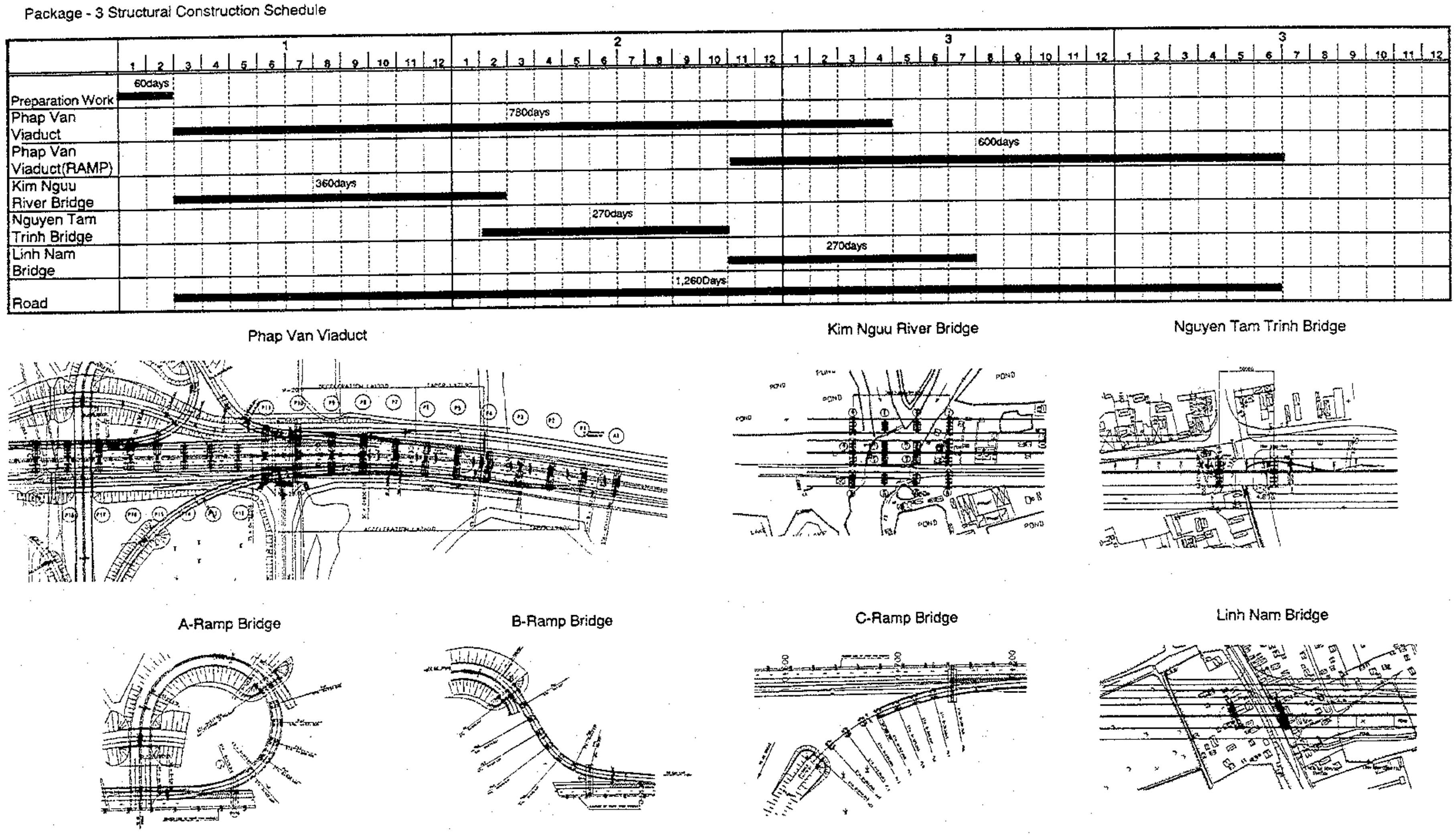
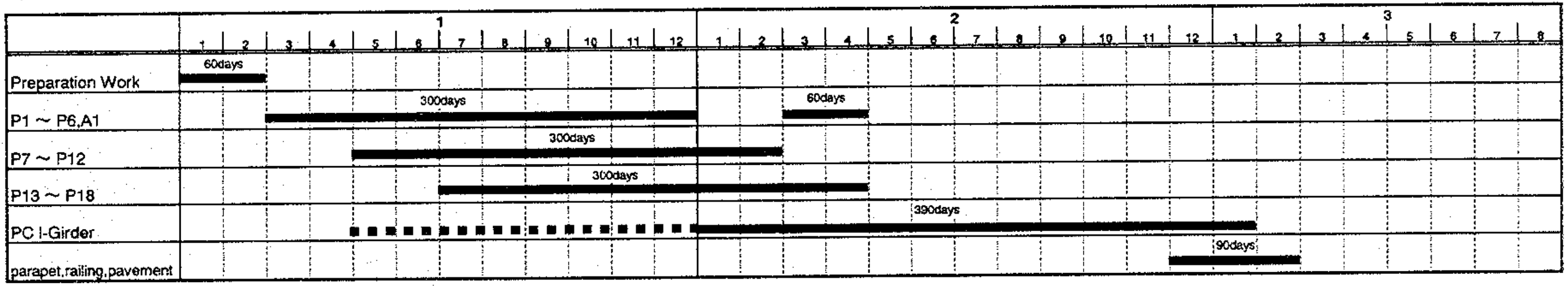


Figure 12.4.14 Package - 3 Structural Construction Schedule

Phap Van Viaduct Construction Schedule



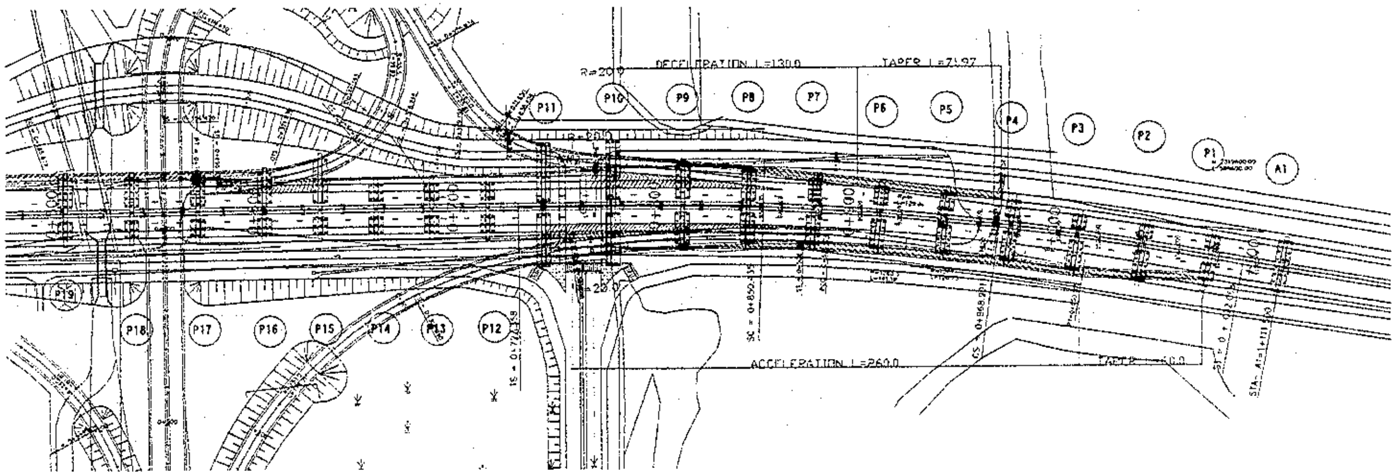
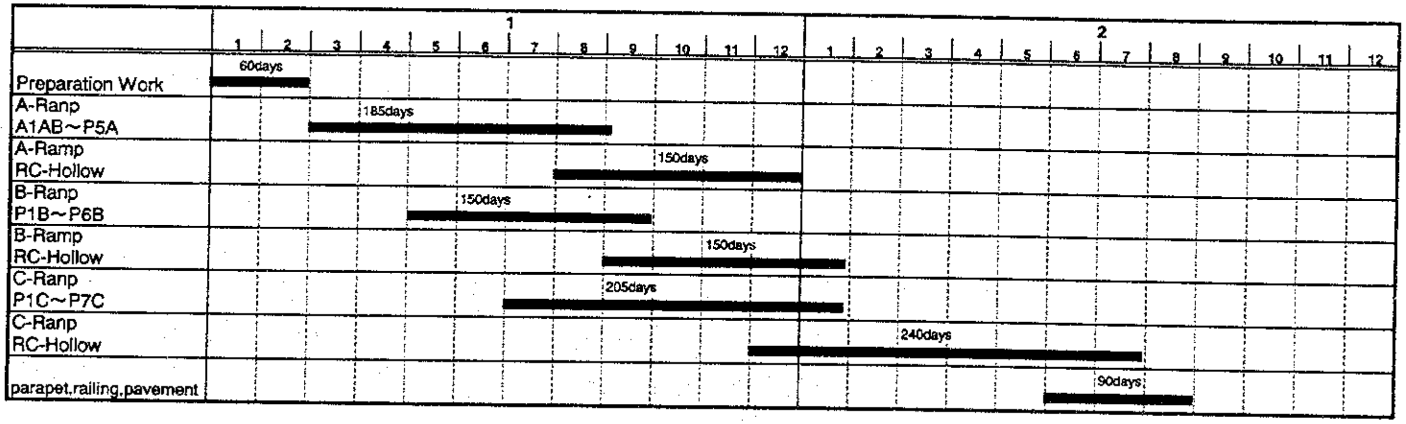


Figure 12.4.15 Phap Van Viaduct Construction Schedule

Phap Van Viaduct Ramp Bridge Construction Schedule



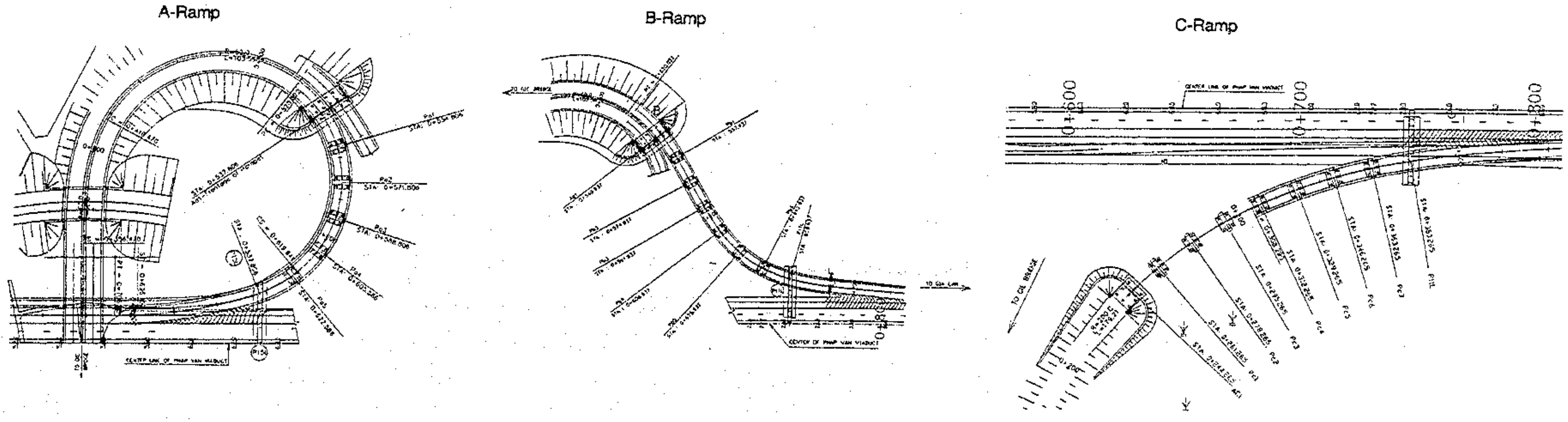


Figure 12.4.16 Phap Van Viaduct Ramp Bridge Construction Schedule

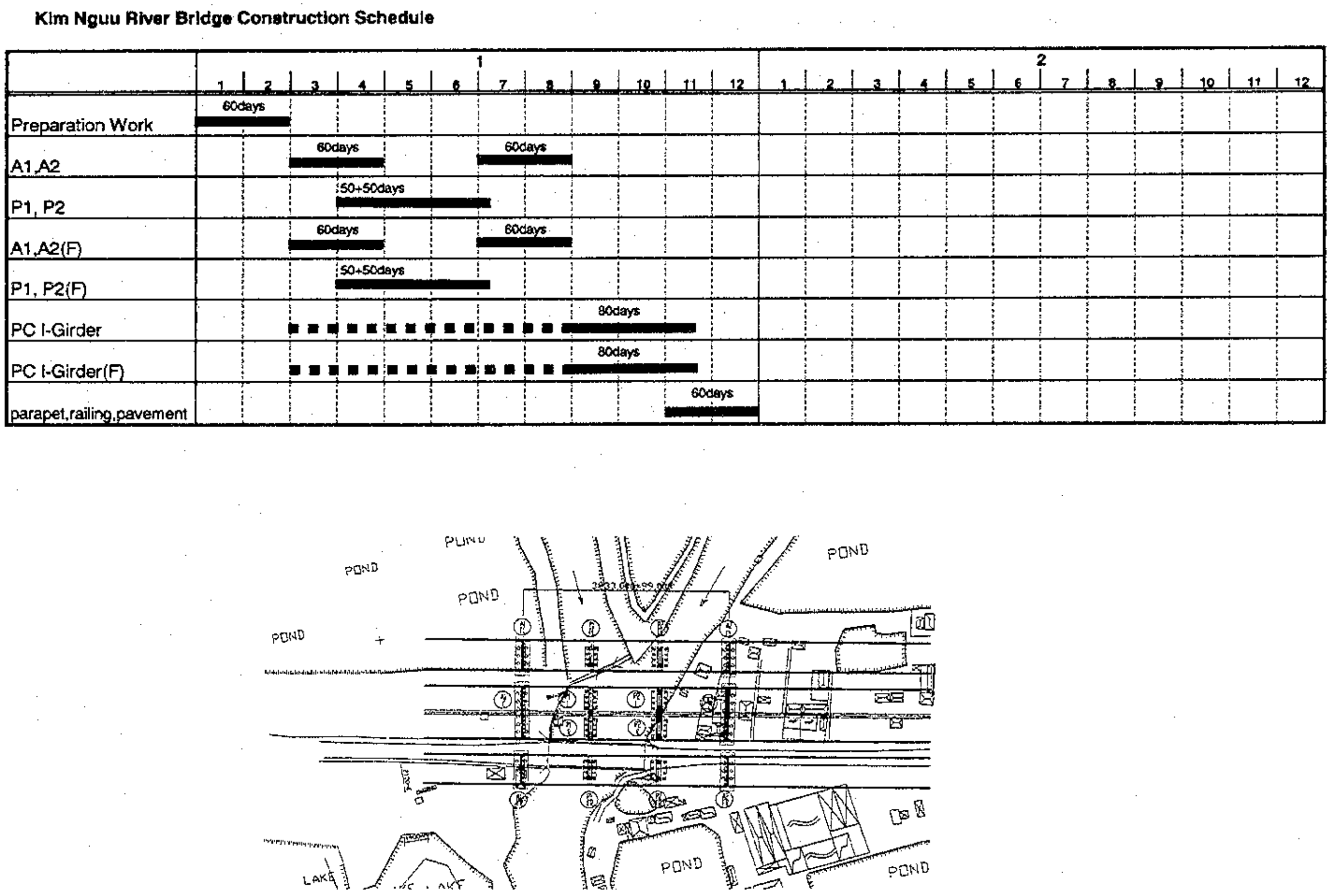
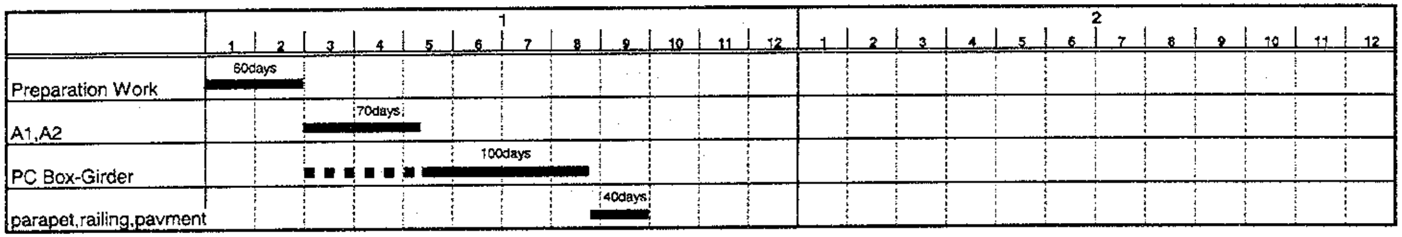


Figure 12.4.17 Kim Nguu River Bridge Construction Schedule

Nguyen Tam Trinh Bridge Construction Schedule



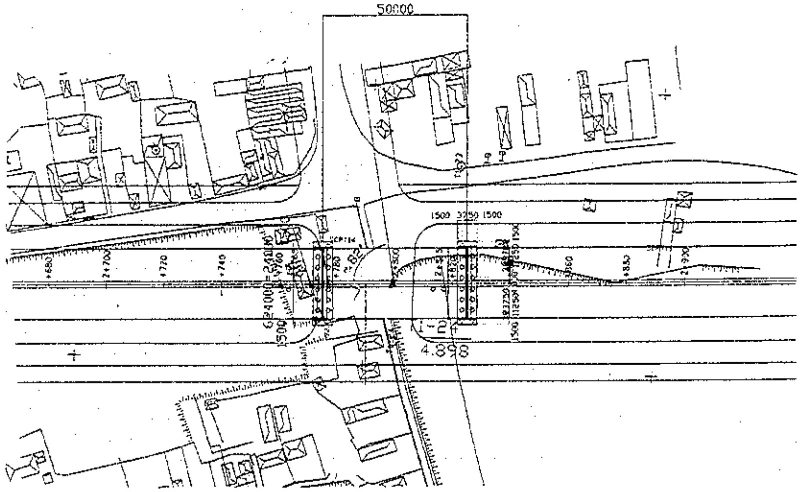
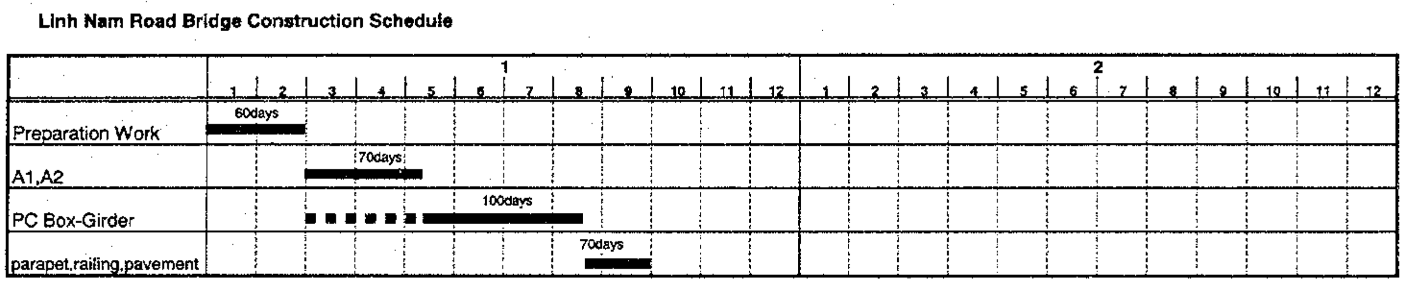


Fig 12.4.18 Nguyen Tam Trinh Bridge Construction Schedule



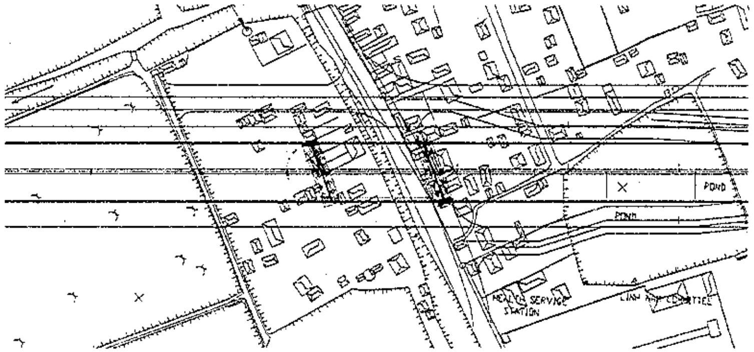


Figure 12.4.19 Linh Nam Road Bridge Construction Schedule

12.4.4 Package-4 Infrastructure in Resettlement Area

Package-4 Consists of 6 areas Entire construction schedule is shown in Fig 12.4.20

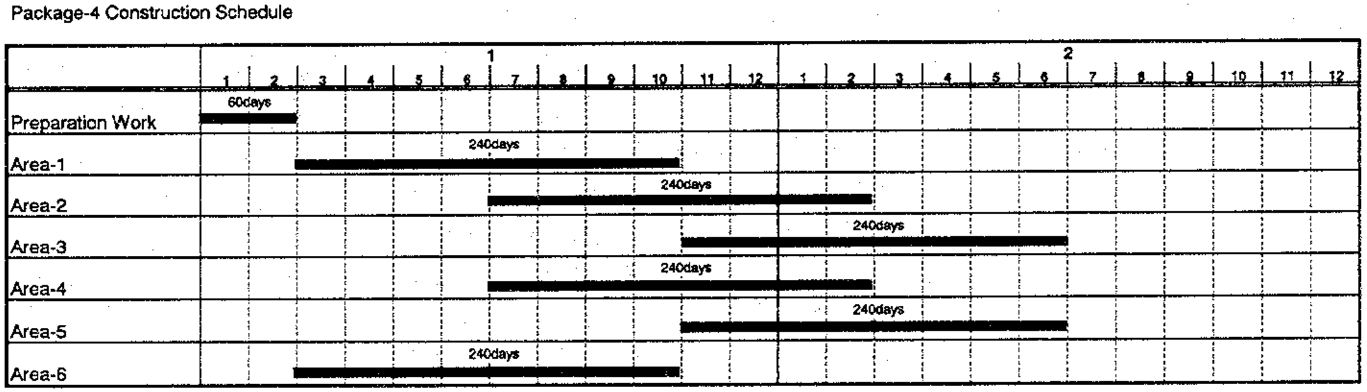

Package-4 Construction Schedule

Figure 12.4.20 Package-4 Construction Schedule

12.5 Soil Stabilization

12.5.1 Construction of Sand Drain

1. General

(1) This specification stipulates the requirements for technical construction, inspection, quality appraisal and approval of construction works using sand drain method.

(2) This specification only applies to works which are constructed on the soft soil embankment with requirement of short time consolidation.

(3) Vertical sand drain is constructed, having vertical column in the soft soil layer. Sand drain is used for draining water from between the lower layer up to the above sand mat layer, draining it out of the embankment. This helps to accelerate the consolidation process and to strengthen the bearing force due to the change of the basic soil property (C) of the soft soil layer and accelerate settlement of the embankment.

(4) The sand mat layer is used for draining water to the above layer and creating plan for running sand drain construction equipment. So the sand mat construction and the driving sand drain work should be constructed all together.

(5) Pre-loading method is a method of increasing pressure on soil in order to accelerate consolidation of soft soil layer (if any).

(6) Besides this specification, supervision consultants and contractors shall comply with the other prevailing stipulations in construction and inspection, quality appraisal and approval to the embankment.

2. Requirements for Construction Material and Equipment

(1) Requirements of Sand Drain

(i) Sand for filling sand mat layer must be of medium-size grain sand fulfilling the following requirements:

- The sand ratio of grain-size more than 0.5 mm should be more than 50 %.
- The sand ratio of grain-size less than 0.5 mm should not exceed 10 %.
- Permeable coefficient of sand must be more than 10^{-4} m/s.
- Organic content should not exceed 5 %.

However, it is possible to use coarse sand mixed with gravel, not including crushed stone.

(2) Requirements of Sand Mat

(i) The characteristics of sand shall be the same as the sand drain materials.

(ii) Geo-textile is used in sand mat structure (if it is mentioned in design complying with the following requirements:

- Tensile strength must not be less than 1.0 kN (ASTM-D4632).
- Elongation: ≤ 60 % (ASTM-D4632).
- Puncture strength (CBR): 1,500 ÷ 5,000 N (BS 9606-4).
- Pore size opening 090 ≤ 0.15 mm (ASTM-D4632).
- Permeable filler: ≥ 1.4 x 10^{-4} m/s (BS 9606-3).

(3) Material for pre-loading:

If it is necessary to apply pre-loading, it is possible to load by different materials such as: soil, sand and stone, etc. However, it is necessary to test in order to define the unit weight of material. It is necessary to use material that is suited to the road construction equipment for loading and unloading works.

(4) Requirements for Equipment

Sand drain equipment must have the following technical specifications:

- Equipment must have enough driven force to drive sand drain casing into the design depth.
- The driven equipment must meet the requirement of stability and be able to properly work under any weather condition.

- The drilling machine must be equipped with twisted drilling rod of 400 mm in diameter interlinked by bolt.
- Water pump must have more than 2.0 m^3/h in capacity.
- Theodolite must be prepared in order to define locations and level in order to define elevations of sand piles.

3. Construction Method

(1) It is necessary to design the working procedure of the driven equipment on the site of the sand mat layer in accordance to the following principles:

- When working, the equipment can not be placed on the head of the constructed sand drain.
- Moving route of the equipment must be shortest.

(2) Before official construction, the contractor must carry out a pilot (sample) construction within the construction scope in which equipment must run 2 to 3 time for driving sand drain.

- Prior to carrying out a pilot construction, the contractor shall submit the test procedure and the construction method for approval in writing to the supervision consultant.
- This pilot (sample) construction must be witnessed by supervision consultant and during the pilot construction be observed and checked.
- Check each construction step and accurate operation of construction of sand drain process (vertical level, position on plan, and the depth).

(3) Preparation plan for filling the sand mat layer

- Site clearance (clear trees, grass and other material)
- Establish the centerline and locate pile for sand mat layer, check the elevation of the bottom of sand mat layer.
- Pave the geo-textile if it is noted in design (joining of geo-textile should be carried out by machine, the two edges of the geo-textile should be placed on each other about 5 to 10 cm). It is necessary to base work on the width of the geo-textile and width of the roadbed to pave crosswise or longitudinally in order to obtain the shortest length of the sewing line.

(4) Construction of the sand mat layer

(i) The sand mat layer should be constructed before construction of sand drain to create conditions for the equipment working in soft soil.

- The upper layer of the sand mat layer should be covered by one sand layer for covering minimum thickness of sand drain (40 cm). Clay should not be directly placed over the head of sand drain.
- Filler layer at slope toe of the sand mat layer must be constructed after construction of sand drain.
- The protection layer of the sand mat layer at the slope of the embankment (if any) should be constructed before unloading period.

(ii) The implementation of sand mat layer shall comply with the regulations and specifications for embankment (30 cm each layer). Compaction density of sand mat shall satisfy two conditions:

- Machines for construction shall move and operate in a stable way.
- Be appropriate to the required density (K) in the embankment structure according to location of sand mat layer.

(5) Technical specifications for the implementation of sand drain

- Locate all the points required to construct sand drain longitudinally and horizontally by normal measuring level strictly according to the design plan; mark the located points. Each machine shift shall be carried out for this work.
- Use machine to construct sand drain into the location according to the steps mapped out in the working procedure mentioned in 9.3 (3). Define the starting mark on central axis in order to calculate the length of sand drain driven into the soil; examine the verticality of the central axis according to plumb-line or pendulum device placed on the rack.
- Install sand drain into the central axis and control the machine putting the end of central axis to the sand drain-placed location.

(6) Implementation of loading and unloading materials

(i) Material of soil, sand filling sand mat layer are used for loading to create the process of compressing shrinkage of the ground under the vertical stress before placing the final loading of the project.

(ii) Loading shall comply with the instructions in the design plan in terms of time, incremental loading of each stage (regularly examine the volume of loading materials in order to secure the accuracy of loading pressure).

If the incremental loading is higher than the final loading, the excess is considered as sub-loading and this is applied only when ideas from supervising consultants are available.

(iii) Regularly observe if water leaks out. There should be measures to facilitate water to run out far from the road-bed area and create, if necessary, water-gathering holes and use pumps to drain water (if the supervising consultants raises such ideas).

(iv) When the loading time is over, the settlement of embankment is equivalent to the design calculated settlement, then unloading is allowed by the supervising consultants. Unloading is conducted for each layer (avoid local unloading as it makes the embankment unstable). When unloading is up to the designed elevation, it is necessary to clean up all the materials inappropriate to the standard of embankment materials.

(v) Put a landmark to observe the settlement and horizontal displacement while the sand mat layer is constructed in accordance with the structure in design plan. It is necessary to observe settlement and horizontal displacement immediately after loading commences by leveling & thedolide with high accuracy. Periodically measure once every two days, and finish at the time of handing over the work. If it is necessary to prolong the time of observation, then the permits from supervision consultants are required.

(vi) If necessary, it is possible to install piezometers of pore-water pressure in order to observe consolidation speed of the embankment soil. Periodically measure pore-water pressure once every two weeks, and finish at the time of handing over the work. If it is necessary to prolong the time of observation, then the permits of Supervision Consultants are required.

4. Check, Quality Appraisal and Approval of the Project

(1) The check before construction includes equipment, material check in accordance with the requirements in SS.09.2.

- The machine for driving sand drain casing shall be operated as a trial first, and re-define the turning angle & range for construction.
- Regarding sand, the test for examining the specifications mentioned in SS.09.2 shall be conducted once for every 500m^3.

(2) During the process of driving sand drain, it necessary to check the following contents each time when driving the plastic board drain:

- Location of driving sand drain casing: the error of this location shall not exceed 15 cm against the designed location
- Verticality of the sand drain: casing check by the verticality of the central axis compared with the plumb-line. The accepted error according to the verticality of the central axis is 5cm/1m.

(3) Quality appraisal and approval of the sand drain shall be conducted after driving it, based on verified minutes of inspection witnessed by the supervising consultants for each sand drain with contents mentioned in (2).

(4) Quality appraisal and approval of the sand drain shall be conducted in accordance with drawings by the Supervising Consultants and Contractor.

12.5.2 Construction of Plastic Board Drain

1. General

(1) This specification stipulates the requirements for technical construction, inspection, quality appraisal and approval for construction works using plastic board drain method.

(2) This specification only applies to the works which are constructed on the soft soil embankment with requirement of short-time consolidation.

(3) Plastic board drain is made of band with Polypropylene core, having serrated section or cuspidate (needle-shaped) section covered by non-woven geo-textile. Plastic board drain is used for draining water from between the low layer up to the above sand mat layer, draining it out of the embankment. This helps to accelerate the consolidation process and to strengthen the bearing force due to the change of the basic soil property (C) of the soft soil layer and accelerate settlement of the embankment.

(4) The sand mat layer is used for draining water to the above layer and creating plan for running plastic board drain construction equipment. So the sand mat construction and the driving plastic board drain work should be constructed together.

(5) Pre-loading method (if any) is a method of increasing pressure on soil in order to accelerate consolidation of soft soil layer.

(6) Besides this specification, supervision consultants and contractors shall comply with the other prevailing stipulations in construction and inspection, quality appraisal and approval to the embankment.

2. Requirements for Construction Material and Equipment

(1) Requirements for plastic board drain

(i) The permeable coefficient of non-woven geo-textile cover must be 3 to 10 times higher than the permeable coefficient of its adjoining soil layer, however, it still prevents the soil of small size grain from passing.

$$K_{cover} \geq 1,4 \text{ x } 10^{-4} \text{ m/s}$$

(ii) The pore diameter of the cover shall not exceed 0.08 mm.

(iii) The cover and the core of the plastic board drain must not be broken while bearing pressure in the process of transport and installation.

(iv) Plastic board drain must have the following physical characteristics:

- Tensile strength (whole width of plastic board drain) must not be less than 1,6kN (ASTM-D4632).
- Elongation (with whole width of plastic board): > 20 % (ASTM-D4632).
- Elongation with the force 0.5kN <10 % (ASTM-D4632).
- Drain probability with pressure 10kN/m^2 and hydraulic gradient I = 0.5 is: (80÷140) x 10^{-6} m^3/sec (ASTM-D4716).
- Drain probability with pressure 300kN/m^2 and hydraulic gradient I = 0.5 is: (60÷80) x 10^{-6} m^3/sec (ASTM-D4716).

(v) Plastic board drain must be properly preserved and avoid prolonged exposure to ultra-violet rays.

(1) Requirements for sand mat material

(i) Sand for filling sand mat layer must be of medium-size grain sand with the following requirements:

- The sand ratio of grain size of more than 0.5 mm should be more than 50 %.
- The sand ratio of grain size of less than 0.5 mm should not exceed 10 %.
- Permeable coefficient of sand must be more than 10^{-4} m/s.
- Organic content should not exceed 5 %.

However, it is possible to use coarse sand mixed with gravel, not including crushed stone.

(ii) Geo-textile is used in sand mat structure (if it is mentioned in design) complying with the following requirements:

- Tensile strength must not be less than 1.0kN (ASTM-D4632).
- Elongation: ≤ 60 % (ASTM-D4632).
- Puncture strength (CBR): 1,500 ÷ 5,000 N (BS 9606-4).
- Pore size opening 090 ≤ 0.15 mm (ASTM-D4632).
- Permeable filler: ≥ 1.4 x 10^{-4} m/s (BS 9606-3).

(2) Material for pre-loading:

If it is necessary to apply pre-loading, it is possible to load by different materials such as: soil, sand and stone, etc. However, it is necessary to test in order to define the unit weight of material. It is necessary to use the material that is suited to the road construction equipment for loading and unloading works.

(3) Requirement for anchor tip

The anchor tips must have a size corresponding to the plastic board drain. The size of the anchor tip is 85 x 140 mm, made of steel, and 0.5 mm in thickness.

(4) Requirements for equipment

Plastic board drain equipment must have the following technical specifications:

- Central axle for installing plastic board drain with the section of 60 mm x 120 mm, with marking line in centimeters along the axle in order to record the driven depth of the plastic board drain and must have a plumb line and pendulum for checking the vertical level.
- Equipment must have enough driving force to drive plastic board into the design depth.
- Maximum driven speed is 65 meters/minute.
- Maximum lifting speed is 105 meters/minute.
- Maximum driving depth: this equipment must be able to drive the plastic board drain into the designed depth.
- The driving equipment must meet the requirements of stability and be able to properly work order any weather condition.

3. Construction Method

(1) It is necessary to design the working procedure of the driven equipment on the site of the sand mat layer in accordance to the following principles:

- When working, the equipment can not be placed on the head of the constructed plastic board drain.
- Moving route of the equipment must be shortest.

(2) Before official construction, the contractor must carry out a pilot (sample) construction within the construction scope in which equipment must run 2 to 3 times for driving plastic board drain.

- Prior to carrying out a pilot construction, the contractor shall submit the test procedure and the construction method for approval in writing to the supervision consultant.
- This pilot (sample) construction must be witnessed by supervision consultant and during the pilot construction be observed and checked.
- Check each construction step and accurate operation of driven plastic board drain process (vertical level, position on plan, and the depth).

(3) Preparation plan for filling the sand mat layer

- Site clearance (clear trees, grass and other material)
- Establish the centerline and locate pile for sand mat layer, check the elevation of the bottom of sand mat layer.
- Pave the geo-textile if it is noted in design (joining of geo-textile should be carried out by machine, the two edges of the geo-textile should be placed on each other about 5 to 10 cm). It is necessary to base work on the width of the geo-textile and width of the roadbed to pave crosswise or longitudinally in order to obtain the shortest length of the sewing line

(4) Construction of the sand mat layer

(i) The sand mat layer should be constructed before driving plastic board drain to create condition for the equipment working in soft soil.

  - The upper layer of the sand mat layer should be covered by one sand layer for covering minimum thickness of plastic board drain (20 cm). Clay should not be directly placed over the head of plastic paper drain.
  - Filler layer at slope toe of the sand mat layer must be constructed after driving plastic board drain and before pre-loading (ie. before water drain from plastic board drain out of the embankment).
  - The protection layer of the sand mat layer at the slope of the embankment (if any) should be constructed before unloading period.

(ii) The implementation of sand mat layer shall comply with the regulations and specifications for embankment (30 cm each layer). Compaction density of sand mat shall satisfy two conditions:

- Machines for construction shall move and operate in a stable way.
- Be appropriate to the required density (K) in the embankment structure according to location of sand mat layer.

(5) Technical specifications for the implementation of plastic board drain

(i)
- Locate all the points required to drive plastic board drain longitudinally and horizontally by normal measuring level strictly according to the design plan; mark the located points. Each machine shift shall be carried out for this work.
- Use machine to drive plastic drain into the location according to the steps mapped out in the working procedure mentioned in SS10.3,(1). Define the starting mark on central axis in order to calculate the length of plastic board drain driven into the soil; examine the verticality of the central axis according to plumb-line or pendulum device placed on the rack.
- Install plastic board drain into the central axis and control the machine putting the end of central axis to the plastic board drain-placed location.
- Make anchor tip closer to the head of plastic board drain with its length folded 30 cm at maximum and pinned by steel pin.
- Drive the central axis, which is already installed with plastic board drain, into the designed depth with speed within the range of 0.15 to 0.6m/second. After driving plastic board drain, pull the central axis up (at this time the anchor tip will keep the plastic board drain in the soil); when the all central axis is pulled up, use scissors to cut the plastic board drain so 20-cm head of plastic board drain remains emerging on the sand mat layer, and restart this process from the beginning for the next plastic board drain-driven location.

(ii) During the construction process, if one roll of plastic board drain is exhausted, it is permissiable to join this plastic board drain to the next roll. When joining, two ends of the plastic board drain shall overlap at least 30 cm and shall be pinned by steel pin.

(iii) In case there is a relatively hard soil layer above the weak soil layer, which makes it impossible for the machine to drive the central axis through, upon discovery countermeasures need to be taken before the implementation of sand mat layer (as proposed in the design plan).

(iv) In case obstructions arise and driving work cannot continue, while plastic board drain is being driven then it is necessary to ask for timely ideas and comments from the supervising consultants to get approval to stop, measure and locate the driving point placing the plastic board drain to the adjoining area within 30 cm.

(v) It is necessary to draw plans and take note in details each time driving the plastic board drain in terms of location, depth, time of construction and bad occurrences arisen during the implementation process.

(vi) After the plastic board drain is driven, it is necessary to clean with rags the plastic board drain and other wastes scattered on the surface; conduct the filling of the next sand layer in order to cover the plastic board drain mentioned in (4), (i).

(6) Implementation of loading and unloading materials

(i) Soil and sand filling materials, and sand mat layers are used for loading to create the process of compressing shrinkage of the ground under the vertical stress before placing the final loading of the project.

(ii) Loading shall comply with the instructions in the design plan in terms of time, incremental loading of each stage (regularly examine the volume of loading materials in order to secure the accuracy of loading pressure).

If the incremental loading is higher than the final loading, the excess is considered as sub-loading and this is applied only when ideas from supervising consultants are available.

(iii) Regularly observe if water leaks out. There should be measures to facilitate water to run out far from the road-bed area and create, if necessary, water-gathering holes and use pumps to drain water (if the supervising consultants raises such ideas).

(iv) When the loading time is over, the settlement of embankment is equivalent to the design calculated settlement, then unloading is allowed by the supervising consultants. Unloading is conducted for each layer (avoid local unloading as it makes the embankment unstable). When unloading is up to the designed elevation, it is necessary to clean up all the materials inappropriate to the standard of embankment materials.

(v) Put a landmark to observe the settlement and horizontal displacement while the sand mat layer is constructed in accordance with the structure in design plan. It is necessary to observe settlement and horizontal displacement immediately after loading commences by leveling & thedolide with high accuracy. Periodically measure once every two days, and finish at the time of handing over the work. If it is necessary to prolong the time of observation, then the permits from supervision consultants are required.

(vi) If necessary, it is possible to install piezometers of pore-water pressure in order to observe consolidation speed of the embankment soil. Periodically measure pore-water pressure once every two weeks, and finish at the time of handing over the work. If it is necessary to prolong the time of observation, then the permits of Supervision Consultants are required.

4. Check, Quality Appraisal and Approval of the Project

(1) The check before construction includes that of equipment and materials in accordance with the requirements in SS10.2.

- The machine for driving plastic board drain shall be operated as a trial first, and re-define the turning angle & range for construction.
- Regarding sand, the test for examining the specifications mentioned in SS.10.2,(2) shall be conducted once for every 500m^3.
- Regarding plastic board drain, the quality check shall be conducted according to the specifications said in SS.10.2, (1),(v), based on the certificate enclosed with each batch of plastic board drain. The average volume for checking is test one sample for every 10,000m^2 or when the batch is changed. In addition, it is necessary to take note the length of

each roll and visually observe whether the core of plastic board drain is broken or not.

- Regarding the project using the geotextile combined with plastic board drain, it is needed to check the specifications of geotextile said in SS10.2,(2),(ii). The average volume for checking is test one sample for every 10,000m^2 or when the batch is changed.
- Check the size of anchor tips, steel pin and the steps of testing steel pins (check once for each machine shift).

(2) During the process of driving plastic board drain, it is necessary to check the following contents each time the plastic board drain is driven:

- Location for driving plastic board drain: the error of this location shall not exceed 15 cm against the designed location (except the case in SS.10.3,(5),(iv).
- Verticality of the plastic board drain: check by the verticality of the central axis compared with the plumb-line. The accepted error according to the verticality of the central axis is 5 cm/1m.
- Length of plastic board drain: check by the length of the central axis driven into the soil according to cm-mark written on the outer surface of the central axis. The accepted error between the length of plastic board drain driven into the soil and the designed depth is 1 %. (except the case mentioned in SS.10.3,(5),(iv).
- Check the residual part of plastic board drain on the surface of sand mat layer to be 20 cm at minimum.

(3) Quality appraisal and approval of the plastic board drain shall be conducted after driving it, based on verified minutes of inspection witnessed by the Supervising Consultants for each plastic board drain with contents said in SS.10.4.(2).

12.6 Pile Loading Test

1. Planning method of pile loading test

The planning method of pile loading test is made based on Vietnamese Standard TCXD 196-1997 as follows:

(1) Application scope

This technical specifications are applied to the examination of quality and bearing capacity of foundation piles.

(2) Static load compaction test

1) Number and location of tested piles

Number of piles tested by static load compaction is often determined by consultants and designers depending on project characteristics, ground soil condition and perfection of equipment for piling work. Normally, the pile number is taken approximately to 1 % of total pile number and location of tested piles is determined by design and consultants at places where ground soil condition is unfavorable or load is strongly concentrated.

2) Test method

Pile test method involves load increment up to two or three times of designed load. Anchor piles or heavy mass placed on a steel girder system locating above the main girder can be used as counterbalance. Jacks for compressing piles are arranged so that combined force is located in center of pile. Two to four displacement-measuring meters for 5 cm itinerary are used to measure at pile tip. Theodolite is used to examine displacement of the meter-attachment system (if any) and displacement of counterbalance system.

3) Test preparation:

Test preparation shall comply with normal pile test procedures.

4) Test standard (According to BS8004: 1986, ASTM and practical experience)

Test standard can be described in detailed as follows:

a) Loading at first step

- Load increment for piles at 25 %, 50 %, 75 % and 100 % of working load and read on settlement-measuring meter at periods of 1, 2, 4, 8, 15, 60, 120, 180 , 240 minutes and once every 2 hours afterwards for each above loading level.
- Load increment up to the next level when settlement after one hour is less than 0.25 mm.
- Loading time for one level shall be not less than one hour.
- At designed load level, loading time shall not be less than six hours and can last up to 24 hours.
- Unloading at 50 %, 25 % and 0 %, measure recovery displacement of pile at the period of 1, 2, 4, 8, 15, 30, 60 minutes. At load level 0 %, observation shall be made until displacement value is constant.

Table 12.6.1 - Test standard

	Load (percentage of designed load)	Loading time
1	25	Up to settlement less than 0.25mm in 1 hour
2	50	Up to settlement less than 0.25mm in 1 hour
3	75	Up to settlement less than 0.25mm in 1 hour
4	100	Up to settlement less than 0.25mm in 1 hour or 24 hours
5	50	Up to recovery less than 0.25mm in 1 hour
6	25	Up to settlement less than 0.25mm in 1 hour
7	0	Up to recovery less than 0.25mm in 1 hour until unchanged
8	25	Up to settlement less than 0.25mm in 1 hour
9	50	ditto
10	75	ditto
11	100	ditto
12	125	ditto
13	150	ditto
14	175	ditto
15	200	Up to settlement less than 0.25mm in 1 hour or in 24 hours
16	175	Up to recovery less than 0.25mm in 1 hour
17	150	Up to recovery less than 0.25mm in 1 hour
18	125	ditto
19	50	ditto
20	125	Up to recovery less than 0.25mm in 1 hour or in 6 hours

b) Loading in second step

- Load increment for piles at 25 %, 50 %, 75 %, 100 %, 125 %, 150 %, 175 %, 200 % of designed load (and can increase up to 225 %, 250 % depending on design) and read on settlement-measuring meter at periods of 1, 2, 4, 8, 15, 30, 60, 90, 120, 180 and 240 minutes and once every 2 hours afterwards for each above loading level.
- Load increment up to the next level when settlement after one hour is less than 0.25 mm.
- Keep loading at 200 % or 250 % within 24 hours or until settlement after one hour is less than 0.25 mm.
- Unloading at 200 %, 150 %, 100 %, 50 % and 0 % of designed load, measure recovery displacement of pile tip after every hour until displacement value is unchanged.

5) Cases in which tested piles should stop being tested

a) Jacks or deformation-measuring meter are broken,
b) Combination between loading system and anchor piles is not secured,
c) Pile tip is cracked or broken,
d) The initial basic readings are not accurate.

6) Cases in which tested piles are considered to be destroyed

a) When piles are destroyed by materials and pile size is not secured,
b) When maximum settlement of pile at load level of 2.0 times of designed load after 24 hours is more than 2 % of pile diameter,
c) When maximum settlement of pile at load level of 2.5 times of designed load after 24 hours is more than 2.5 % of pile diameter,
d) When residual settlement is more than 8mm.

7) The accepted load is adopted to be the minimum value in accordance with the following conditions:

a) Equal to 40 % of the load level at which the settlement increases continuously,

b) Equal to 40 % of the load which results in the settlement of 2 % of the pile's diameter,

c) Equal to 40 % of the limited load, which is determined by tangent method on graph of relation between load and settlement.

8) Report on result of static load pile test

Result of static load pile test will be submitted to the employer and the consultant the following main data:

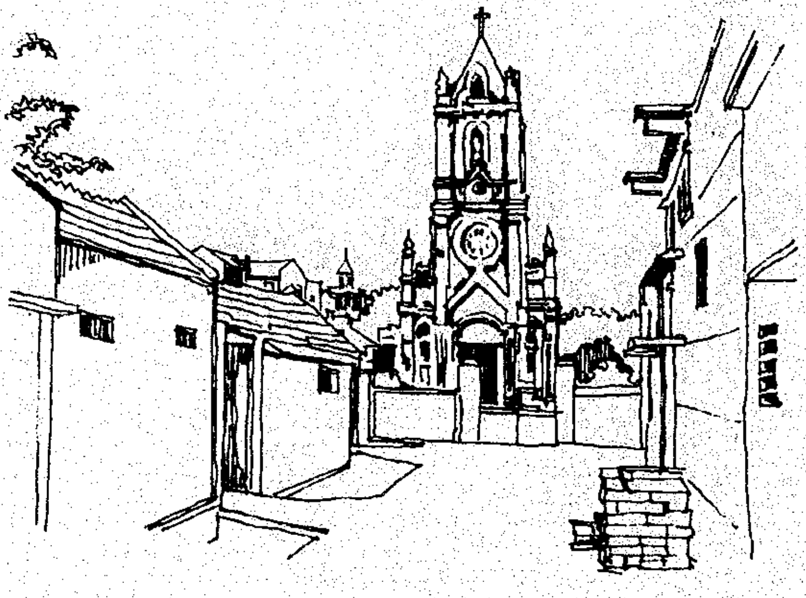
a) Diameter, length of bored piles with the reinforcement arrangement plan,

b) Log-book of result of pile test, readings of force and settlement during the process of loading pile test,

c) Graph of relation between loading time and settlement, and graph of relation between load and settlement,

d) Examination result of the consultant and other matters (if any).

CHAPTER 13 MANAGEMENT AND MAINTENANCE PLAN



CHAPTER 13 MANAGEMENT AND MAINTENANCE PLAN

13.1 General

The study of the management and maintenance for Southern Hanoi Third Ring Road (SHTRR) is broadly divided into four main categories:

i) Present Situation of Highway Maintenance and Management;
ii) Basic Principles of Highway Maintenance;
iii) Maintenance Inspections; and
iv) Management and Maintenance Plan.

13.2 Present Situation of Highway Maintenance and Management

13.2.1 Present Organizations of Ministry of Transport and Road Administration Bureau

Organization chart of the Ministry of Transport (MOT) is shown in Figure 13.1.1. As seen in the figure, MOT has five bureaus of:

- Vietnam Road Administration;
- Vietnam National Railway;
- Vietnam River Administration;
- Vietnam National Maritime; and
- Vietnam Highway Standing Committee.

Road administration exists within the jurisdiction of MOT. Under the Government Decree No. 07, the Road Administration Bureau (VRAB) was formed on 30 January 1993 and commenced operation on 26 May 1993.

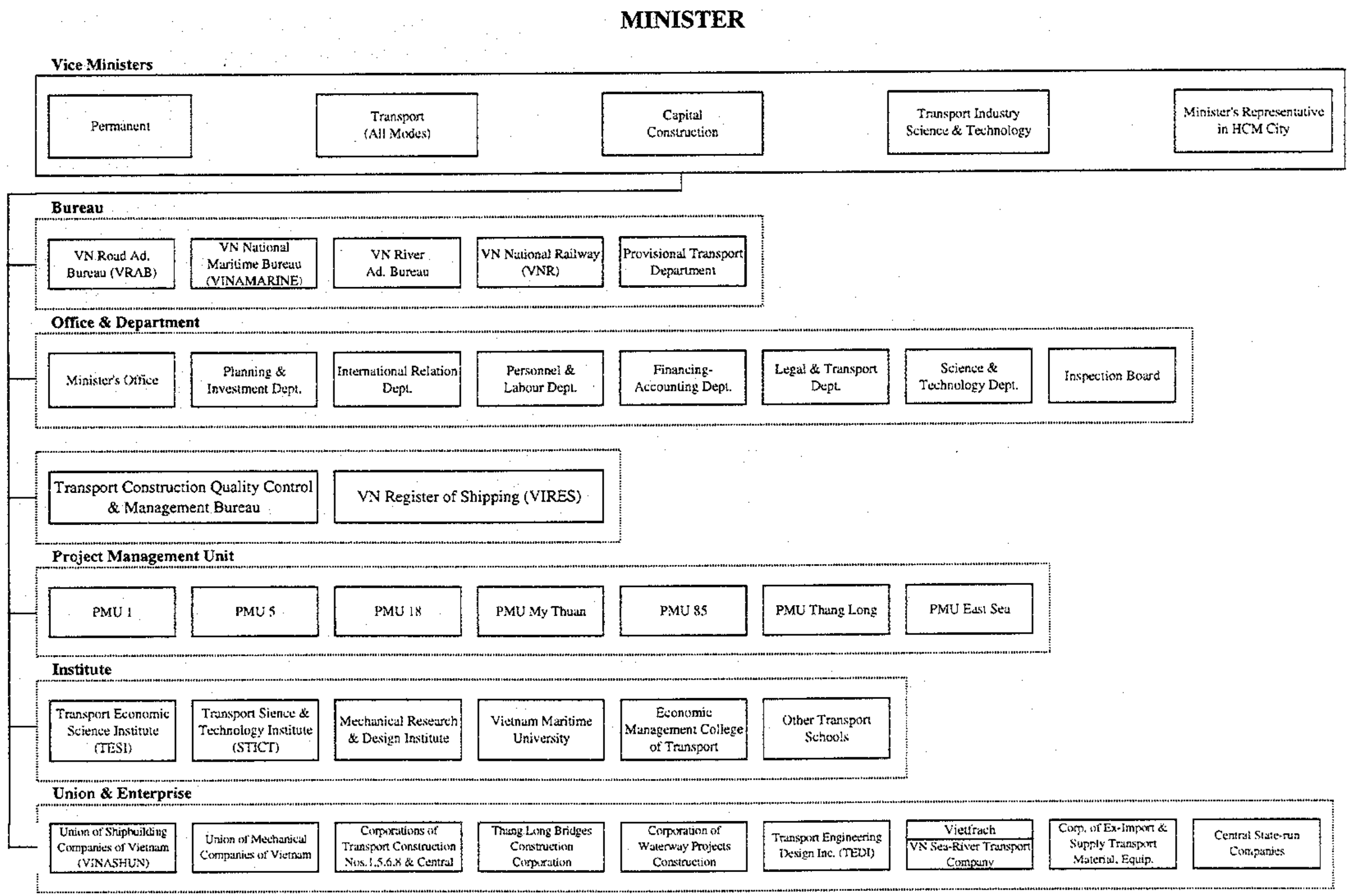
The VRAB has three levels of administrative groups as shown in the following:

- Management;
- Transport Companies; and
- Road Management Units.

The management is divided into 12 sections/offices:

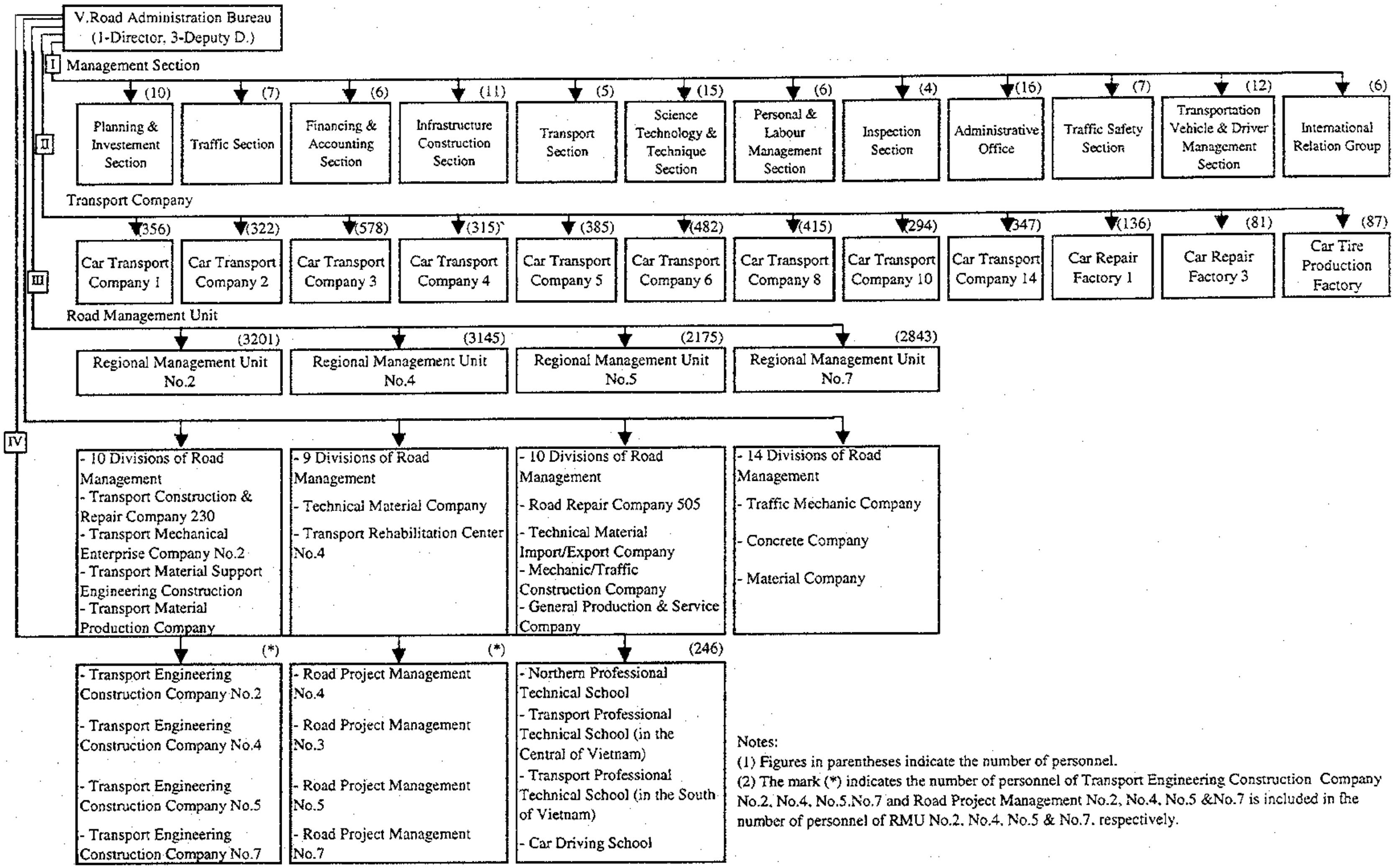
- Planning and Investment Section;
- Traffic Section;
- Financing and Accounting Section;
- Infrastructure Construction Section;
- Transport Section;
- Science, Technology and Technique Section;
- Personnel and Labor Management Section;
- Inspection Section;
- Administrative Office;
- Traffic Safety Section;
- Transportation Vehicles & Driver Management Section; and
- International Relations Group.

The comprehensive organization of the VRAB is shown in Figure 13.2.1 together with the number of employees for each group.



THANH TRI BRIDGE AND SOUTHERN SECTION
OF HANOI THIRD RING ROAD

Figure 13.1.1 Organization Chart of Ministry of Transport



Notes:
(1) Figures in parentheses indicate the number of personnel.
(2) The mark (*) indicates the number of personnel of Transport Engineering Construction Company No.2, No.4, No.5,No.7 and Road Project Management No.2, No.4, No.5 &No.7 is included in the number of personnel of RMU No.2, No.4, No.5 & No.7, respectively.

Figrure 13.2.1 Organization Chart of Vietnam Road Administration Brureau (VRAB)

13.2.2 Presently Possessed Maintenance Equipment

(1) Transport Construction and Repair Company

Transport construction and repair company possesses the following vehicles and equipment for road maintenance and repair (Table 13.2.1).

Table 13.2.1 Vehicles and Equipment Possessed by Transport Construction and Repair Company

Type of Equipment	Number of Unit
Concrete mixing plant	1
Truck, 10 tons	10
Steel wheel roller	1
Tire roller	1
Macadam roller	3
Passenger car	6

(2) RMDs

RMDs suffer from lack of maintenance equipment. In most cases, available equipment consists of only one unit of grader, pick-up truck, and road roller.

13.3 Basic Principles of Highway Maintenance

(1) Purpose

The purpose of maintenance activity is to keep the roadway, surfaces, bridges and other installations (i.e. highway) in as usable and as safe condition as situation permits. Certain basic principles and ideas can help to achieve this purpose.

(2) Minimum Interference with Traffic

In conformance with the idea of keeping surfaces usable, maintenance activities should interfere as little as possible with the normal flow of traffic at the facility.

(3) Importance of Correcting the Basic Cause of Failures

Any maintenance job should involve an investigation to find the cause of the particular damage or deterioration which is to be corrected. That cause must be remedied before the repair is made. To ignore the cause of the damage is to invite prompt reappearance of the damage. This is wasteful, and justifiable only when making temporary repairs to meet immediate minimum needs under urgent conditions.

(4) Categories of Maintenance Work

Categories of highway maintenance can be divided into routine maintenance, periodic maintenance and incidental maintenance.

Routine maintenance is based on routine (daily) inspection of the condition of pavement, cut and fill slopes, drainage, bridges and other structures and facilities to monitor any defects and damages to them. The results of routine inspection should be promptly reported to the maintenance office for follow-up maintenance works as required.

Periodic maintenance is based on detailed inspection to be performed at certain time intervals depending on the type and kind of facilities, including checking and testing the condition of various structures and facilities. Defects and damages must be reported for repairs or remedies. Periodic maintenance also covers such works as maintenance of road marking and painting.

Incidental maintenance is basically the work to be carried out to restore the highway and the related facilities to their normal operating condition after they are damaged by road accident or natural causes.

13.4 Maintenance Inspections

13.4.1 Purpose

The purpose of maintenance inspections is to detect early evidence of defects before actual failure occurs. Frequent inspections and effective follow-up procedures prevent minor defects from becoming serious and causing need for major repair (i.e. preventive maintenance). Special vigilance must be exercised during rainy seasons, and after any heavy storm which has caused flooding.

13.4.2 Bridge Inspections

Regular maintenance inspections during the design life of structures will result in reduced maintenance costs. Initially, maintenance costs will be low but as the structure ages there is a gradual increase in these costs and the rate of increase in costs is non-linear.

The maintenance authority should be vigilant, observant and report on any abnormality in the elements of the bridge. Such practice would identify obvious defects which could bring about higher maintenance costs in the future, failure of parts of the structure, or lead to an accident.

It is good practice at the completion of construction to prepare an Operation and Maintenance Manual for all structures. In practice this may only be a single page for simple structures but as the complexity of the structure increases, so does the size of the manual. The manual should contain details of the component (including material specification), inspection intervals and any design or manufactures requirements.

Generally, bridge inspection is carried out in various types, according to the situation and purpose. There are four types of maintenance inspection for bridge structure.

- Routine Inspection: at daily or weekly intervals
- Periodic Inspection: General - every 1-2 years
  Principal - intervals of approximately 5 years
- Special Inspection: as required

The intervals quoted above are approximate and should be reviewed and developed in the light of experience gained in the operation of the structures.

(1) Routine Inspections

All bridges are included in the routine inspection, which is conducted in conjunction with the routine road inspection. This is for early discovery of any defects and is conducted as a solely visual inspection. Items which would be covered would include condition of the road surfacing, concrete barriers/bridge railings, road lighting, etc. The main objective would be to ensure the continued safe usage of the structure. In addition to the above, less frequent inspection (e.g., quarterly inspection) would include items such as bearings, movement joints and drainage system.

(2) General Inspections

General inspections should be made at intervals not exceeding two years. For major bridges and viaducts these general inspections should be undertaken annually. They would be undertaken by observations from both the ground and deck level. Where necessary the structures should be observed from other available vantage points such as boats in the river, using binoculars and other simple tools or instruments. The inspection should be carried out by a qualified engineer.

(3) Principal Inspections

Principal inspections would involve the close examination of all parts of the structure at intervals not exceeding 5 years. They will require mobilization of suitably qualified personnel, e.g. divers to inspect any scour damage around the piers. However, the scope of inspections will be minimized if the Routine and General Inspection procedures have been carried out correctly.

(4) Special Inspections

These inspections should be carried out in the event of particular events which might include:

(i) Exposure to extreme environmental condition such as typhoons, unusual flooding or earthquake.
(ii) A major incident or accident on or adjacent to the structure.
(iii) Inspection of all common areas following the discovering of defects which are of a potentially repetitive nature.
(iv) Monitoring of the progress of the observed defects which were considered to be at an acceptable level.
(v) The occurrence of settlement of a sudden nature or greater than allowed in the design.
(vi) The experience of abnormal traffic loadings.

When an emergency situation has been detected in the process of routine or general inspection, a special check-up is required to confirm the safety of the bridge or structures in question.

13.4.3 Pavement Inspections

Surface defects can usually be attributed to poor subgrade or base condition, inadequate drainage, or both. An inspection of surface defects should include a careful inspection and investigation of the causes of those surface defects. No surface repair is beneficial unless the cause is first corrected. Another reason for surface defects is the excessive load or use to which a particular area may be subjected.

13.4.4 Drainage Inspections

Inspections of drainage systems should assure that all drainage channels and structures are unobstructed by debris of any sort. Culverts should be checked for structural damage. The reasons for formation of water puddles on, or adjacent to, the surfaced areas should be determined. Drainage inspections should be made during or following every storm/flooding.

13.4.5 Cut and Fill Slopes Inspections

Due to the adverse soil and weather conditions prevailing in the area, the frequent inspection of cut and fill slopes is extremely important. At major high embankment areas, sometimes observation using transit and other surveying equipment and tools will be necessary to identify the potential landslide at an early stage.

13.5 Management and Maintenance Plan

13.5.1 System to Operate Highway Maintenance

(1) General

The following describes i) Overall system of highway maintenance, ii) Maintenance operating system, iii) Data base and management system, keeping in mind the present organization situation mentioned above in Section 13.2.

(2) Overall System of Highway Maintenance

In order to attain proper highway management and maintenance, all systems of highway maintenance must be carried out orderly and in a proper manner, and established organization must be consistent with the requirement of work components and needed capacities. Figure 13.5.1 shows the general flow chart of the recommended overall highway maintenance works.

(3) Maintenance Operating System

Highway Maintenance covers various activities related to inspections, maintenance and repairs, which require quick response and are appropriate to keep the highway open to traffic.

Maintenance agency should be responsible for the following activities of highway maintenance by force account or on contract basis, depending on the work:

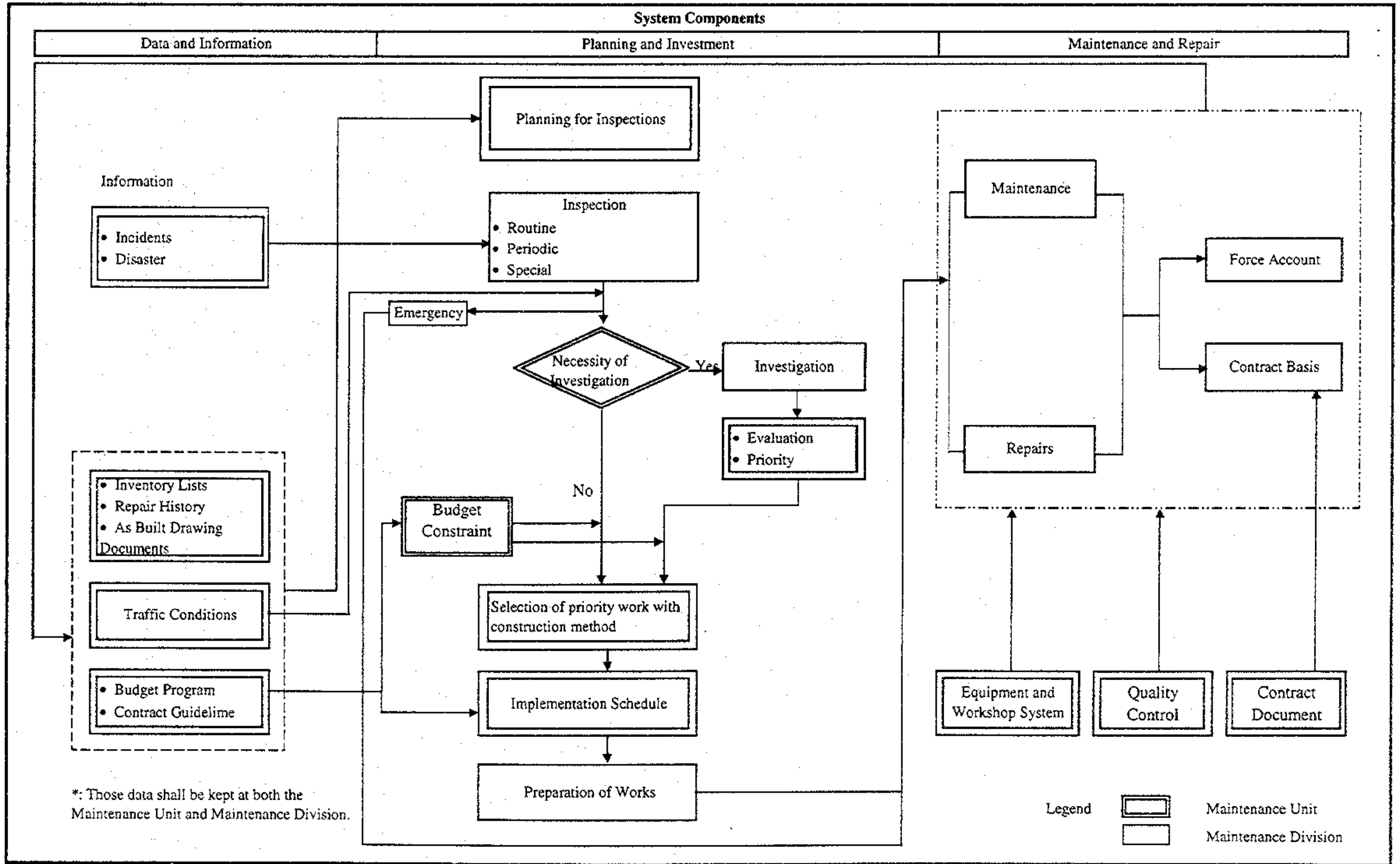
- Inspections by maintenance patrol unit;
- Road surface cleaning;
- Vegetation control;
- Repairs of traffic safety and management facilities;
- Pavement maintenance and repairs;
- Maintenance and repair of bridges;
- Maintenance and repair of other structures;
- Disaster prevention and restoration; and
- Others.

The following matters must be specified to implement the above operations:

- Communications system (instruction, response, duty, decision and coordination) between headquarters of Maintenance Unit and Maintenance Divisions; and
- Extent of activities and responsibility of the Maintenance Unit and Maintenance Division.

The following should be considered to encourage the use of contractors to carry out highway maintenance activities:

- Maintenance activities based on a monthly and annual program;
- Clarification of working criteria of maintenance and repairs;
- Formulation of contracts, supervision and acceptance system for highway maintenance work; and
- Provision of guidance to the contractors as to the significance of highway maintenance.



THANH TRI BRIDGE AND SOUTHERN
SECTION OF HANOI THIRD RING ROAD

Figure 13.5.1 Flow Chart of Highway Maintenance Works

(4) Data Base and Management System

Data base and management systems are indispensable for highway maintenance. One of the most important activities is to collect reliable date; in particular, to collect and keep as-built drawings and documents including design reports and specifications, construction record, and historical repair records. These records must include inspector's observation of a non-routine incident, the related work carried out due to it, and the interference to traffic; particularly in relation to vehicular accidents and the causes of their occurrence. This function is to determine any previous incident that may relate to present condition. Various inventories for road structures, bridges and road furnishings will be developed to maintain the highway properly.

13.5.2 Activities and Tasks of Highway Maintenance

Highway maintenance consists of many types of work for which the scope and scale are involved. It is important to prepare a detailed work plan for each category of work in advance so that the implementation of similar works can be carried out effectively and ambiguous situations avoided. Since inspections, maintenance and repairs are performed on the highway open to public traffic, it is necessary that coordination be effectively handled between Maintenance Unit and Maintenance Division.

It is also necessary that a notice be forwarded to the police office in advance and that public announcement activities are made to highway users and residents along the highway.

The activities and tasks for highway maintenance are shown in Figure 13.5.2. A brief description of each activity of highway maintenance is given in three (3) components: inspection, maintenance, and repairs;

(1) Inspections

Inspections are performed to identify the needs of maintenance and repair works in order that timely maintenance and repairs be made and highways be free from obstructions.

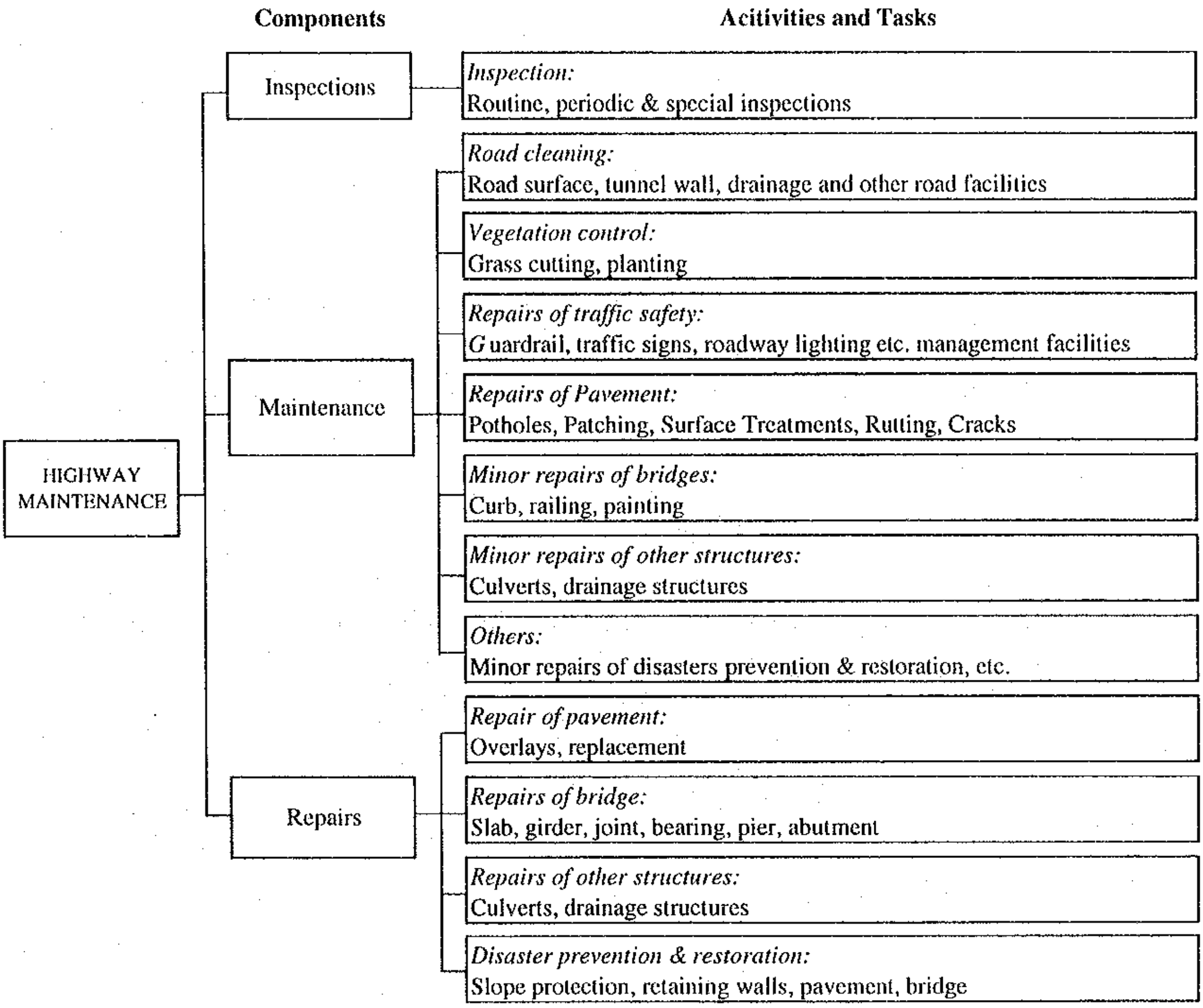


Figure 13.5.2 Activities and Tasks of Highway Maintenance

(2) Maintenance

Maintenance consists of the following activities:

1) Road Cleaning

Road cleaning involves removing dirt and trash from the road and adjacent facilities to eliminate traffic obstructions.

2) Vegetation Control

Vegetation control consists of planting new growth, maintaining established vegetation, and removing old or objectionable vegetation to the end that grass, plants and trees may be well maintained to provide a pleasing ambiance for users.

3) Repairs of Traffic Safety and Management Facilities

Traffic safety and management facilities are directly related to traffic safety and management. The following are the facilities to be maintained and repaired:

- Guardrail and guide post;
- Traffic signs;
- Traffic markings; and
- Roadway lighting.

4) Minor Pavement Repairs

Pavement maintenance consists of pothole repair, crack sealing and patching of small areas of damaged pavement and adjustments of gaps on roadway surface.

5) Minor Repairs of Pavement

Minor repairs to bridges include curbs, barriers, railings, and necessary repainting.

6) Others

Maintenance of buildings, machinery, and electrical equipment as well as communication facilities and small scale repairs for disaster prevention and restoration work are required to operate the highway maintenance activities in a proper manner.

(3) Repairs

1) Repairs of Pavement

Asphalt overlay or replacement will be required when severe cracking and rutting caused by heavy traffic and asphalt deterioration is identified. Overlay and replacement may entail patching and pothole repairs. An evaluation method shall be established to determine the required thickness of overlay, based on a survey and analysis of the existing pavement roughness, cracking ratio and depth of rutting.

2) Repairs of Bridges

Repair of superstructures and substructures is needed for damage caused by heavy traffic, accidents, weathering, scouring, etc.
Replacement and strengthening of bridges, slabs, expansion joints and bearings based on the identification and evaluation of causes and defects are also required for damage caused by heavy traffic, accidents, etc.

3) Repairs of Other Structures

Repair of ditches and other drainage facilities will be needed to protect the road structures.

The repair and restoration of slope failures in cut-and-fill sections are accomplished by execution of slope protection such as construction of retaining walls, concrete cribs, vegetation, etc.

4) Disaster Prevention & Restoration of Damages Caused by Disasters

Slope failures, and pavement and structural damage can be caused by heavy rainfall, earthquake and boat collision (in the case of navigable river). Slope failures are normally related to heavy rainfall, inadequate surface drainage, or water seepage. Work includes both prevention and restoration.

13.5.3 Maintenance Operations

(1) System for Operating Highway Maintenance

The following matters are emphasized to achieve efficient and economic highway maintenance.

A data base and management system are major components for planning any maintenance work, as it is the source of all historical knowledge concerning any road structure or facility. It is also important to collect as-built drawings and documents, including engineering design documents.

Training of inspectors is important to keep the optimum highway maintenance levels. The inspectors should be trained to be responsible for inspections, recording observations and preparing inspection reports in an efficient manner.

(2) Planning of Highway Maintenance

Provided herewith is a breakdown of the planning, implementation methods, inspections, maintenance and repairs.

Highway maintenance programs will be made on annual, monthly and weekly bases, considering job priority, available resources, past work records, road inventories, road structure inventories, traffic volumes, meteorological data, etc.

1) Annual Program

Annual Program will be planned to allocate the scope and scale of monthly work. The following matters will be included based on the annual budget;

- Appropriate monthly activities for inspection, maintenance and repairs will be planned based on the characteristics of the work and traffic conditions. The volume of work shall be allocated carefully so as not to concentrate on a certain period;
- Personnel, equipment and materials will be assigned properly;
- The programming will consider local meteorological conditions;
- Maintenance and repairs of pavement will be undertaken before damage become serious. Cracks, potholes and corrugation should be repaired before the rainy seasons, since these worsen with rainfall; and
- For the drainage system to function properly the cleaning and repairs of drainage facilities shall be conducted at an appropriate time.

2) Monthly Program

A monthly program will be planned to allocate daily maintenance and repairs. Changes to the programs can be made flexibly in case a particular repair work is judged to have a higher priority during the actual implementation of the plan.

A monthly program will be established based on the annual program, as follows:

- Appropriate daily activities for inspection, maintenance and repairs will be assigned throughout the month;
- Appropriate traffic control will be arranged for maintenance and repairs, considering the characteristics of the work, month, date and time-frame; and
- Coordination with other jobs will be made to ensure smooth operation.

3) Weekly Program

A weekly program will be planned to allocate and adjust daily activities for inspections, maintenance and repairs. A weekly program will be made based on the monthly program, considering the following:

- Monthly activities will be broken down into week's and daily activities;
- The amount of the previous week's work accomplishment will be checked and reflected in the following week; and
- The accumulated amount of weekly work accomplishment in a month will be reviewed for updating the weekly program of the following month.

(3) Implementation of Highway Maintenance

1) General

Highway maintenance will be conducted, in careful consideration of traffic regulations, traffic safety and circumstances along the highway.

2) Safety During Maintenance and Repairs

Attention should be paid to the following items during maintenance and repairs:

- Personnel in charge of traffic control will be assigned on-site for the safety of workers and highway users;
- Guide signs and traffic markings will be installed to clearly mark lanes restricted to highway users;
- Lighting facilities will be provided during night maintenance and repairs;
- Equipment, facilities and materials will be neatly located in the work area for efficient and safe work operations; and
- Excavated and excess materials will be disposed of immediately so that the highway surface is always free from obstacles during the work activities.

Personnel in charge of traffic control will be assigned during the maintenance and repairs. They will ensure smooth and safe traffic flow and worker's safety.

(4) Traffic Control Measures

The date, time-frame, construction methods and proposed traffic control measures will be analyzed for the highway maintenance activities based on traffic volumes, number of traffic lanes and detours.

13.6 Recommended Organizations and Maintenance Equipment

13.6.1 Organization of Expressway Management and Maintenance Unit and Operation and Maintenance Division

It is recommended that new Expressway Management and Maintenance Unit as well as Operation and Maintenance Division will be set up in the organization of Vietnam Road Administration Bureau to attain efficient management and maintenance of SHTRR and future Hanoi Third Ring Road.

It is also recommended that the force account activities of the expressway operation and maintenance be kept at minimum level in scope and volume and that the major part of the works should be carried out by contract basis. However, Expressway Maintenance Unit must undertake information collection & dissemination, and maintenance activities requiring a quick response.

(1) Expressway Management and Maintenance Unit

Expressway Management and Maintenance Unit will be responsible for overall management including decision-making related to the activities of operation and maintenance of the expressway, budgetary control, etc., generally having four major departments, technical, administration, operation and finance:

i) Technical Department:

- Construction;
- Planning; and
- Maintenance.

ii) Administration Department

iii) Operation Department:

- Operational Management;
- Procurement; and
- Traffic Control.

iv) Finance Department

(2) Operation and Maintenance Division

Operation and Maintenance Division will be responsible for execution of operation and maintenance of the expressway.

Since the total length of the expressway is only 12 km, the establishment of one office is sufficient. It is recommended that the office be located near the mainline barrier gate.

The organization of the Operation and Maintenance Division will be headed by an Office Manager and generally having two department and five sections:

i) Finance and Administration Department:

- Administration and employment; and
- Finance.

ii) Expressway Operation:

- Supervision of toll collection;
- Maintenance; and
- Traffic services and monitoring.

Normally policemen from the provincial police office will be stationed in this office to serve as traffic police.

(3) Toll Gate Offices

A toll gate office will be provided at the mainline toll barrier to administer toll transactions under control of Operation and Maintenance Division. The expressway will be operated using the flat tariff on-ramp or barrier toll collection system.

13.6.2 Management and Maintenance Equipment

(1) Required Vehicles and Equipment

As recommended in Section 13.6.1, the maintenance works will be performed mostly by contractors under the supervision of the Operation and Maintenance Division. The Division will be equipped with the following limited kinds of equipment for operation and maintenance works under such a system.

- Communication cars, patrol cars and maintenance vehicles for expressway patrol, inspection and supervision of maintenance works being carried out by the contractors;
- Trucks, dump trucks, small crane vehicles, small rollers and tampers, air compressors, breakers, asphalt cutters, etc. for routine maintenance and emergency repair works in case of accidents and disaster;
- Water tankers, grass cutters, etc.; and
- Ambulances.

(2) Workshop and Depots

Workshop and depot will be located near Operation and Maintenance Division (OMD) building. However, they will be of small scale since major maintenance and repair work will be done by contractors under the supervision of OMD.

CHAPTER 14 COST ESTIMATES

CHAPTER 14 COST ESTIMATES

14.1 General

The estimates of the Project costs are based on the results of the detailed design, quantity take-off of each work item, and the studies on construction planning. The Project Cost (PC) consists of the following components:

- Construction Cost (PC1);
- Supervisory Services Cost and Administrative Cost (PC2);
- Land Acquisition and Compensation Cost (PC3); and
- Physical Contingency (Contingency).

The basic premises in estimating cost are as follows:

1) All construction work will be executed by constructor(s) to be selected by international competitive bidding, except for Package 4 below.
2) The unit cost of each cost component was determined based on the economic conditions prevailing in February 2000 (USD $1.0 = VND 14,000 = Yen 110.0).

14.2 Construction Cost

14.2.1 Construction Packages

The construction is divided into the four following packages based on the detailed design.

- Package 1: Red River Bridge
- Package 2: Gia Lam Section of SHTRR
- Package 3: Thanh Tri Section of SHTTR
- Package 4: Infrastructure in the Resettlement Area

14.2.2 Construction Cost (PC1)

Construction cost and estimated contract cost have the same meaning and comprise direct cost and indirect cost. Based on the recent JBIC loan construction practice in Vietnam, this is as shown in Figure 14.1.1.

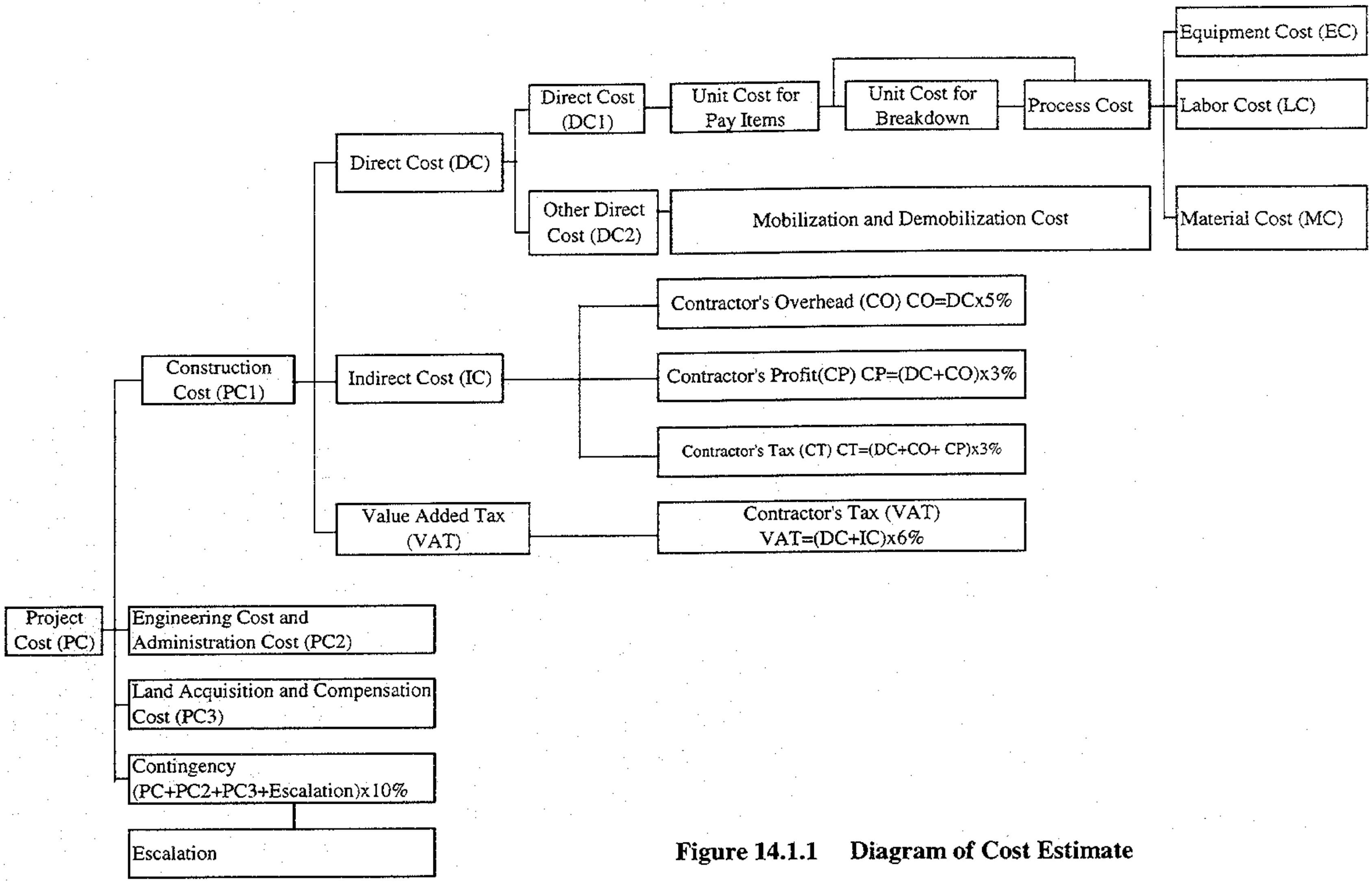


Figure 14.1.1 Diagram of Cost Estimate

(1) Direct Cost (DC)

Base cost (DC1) consists of material, equipment and labor costs. Unit direct cost of each construction work includes other direct cost (DC2) such as mobilization and demobilization cost.

(2) Contractor's Overhead (CO)

Contractor's overhead was estimated as 5% of direct cost:
CO = DC x 5%

(3) Contractor's Profit (CP)

Contractor's profit was estimated as 3% of direct cost and overhead:
CP = (DC + CO) x 3%

(4) Contractor's Tax (CT)

Contractor's tax was estimated as 3% of the total of direct cost, overhead and profit:
CT = (DC + CO + CP) x 3%

(5) Value Added Tax (VAT)

Value-added tax was estimated as 6% of the total of direct cost and indirect cost:
VAT = (DC + IC) x 6%

14.2.3 Foreign Currency Component and Local Currency Component

(1) Foreign Currency Component

- Imported equipment, material and supplies;
- Salaries and wages of foreign personnel; and
- Overhead and profit of foreign firms.

(2) Local Currency Component

- Domestic material and supplies;
- Wages of local personnel; and
- Overhead and profit of local firms.

14.2.4 Unit Cost of Construction Works

The Unit Cost of the direct cost of construction works were studied based on the labor cost, material cost and equipment cost.

(1) Unit Cost of Labor

1) Labor Law

- Decree 25/CP and 26/CP dated 23/5/1993 of the Government concerning the New Wage Policy;
- Decree 197/CP dated 31/12/1994 and 11/LDTBXH-TT dated 3/5/1995 of the Government concerning the Wage for Vietnamese Labor working for Enterprise Financed by Foreign Funding;
- Circular 23/BXD-VKT dated 15/12/1994 of Ministry of Construction issued as a guide to setting up and managing constructional cost which belong to the invested projects;
- Circular 11/LDTBXH-TT dated 3/5/1995 of Ministry of Labor and Veteran and Social Affairs Service to guide the implementation of the Decree 197/CP of the Government;
- Circular 39TC/TCT of Ministry of Finance guide to implement the Decree 05/CP dated 20/1/1995 and Decree 30/CP dated 5/4/1997 of the Government about income tax;
- Decree 385/LDTBXH-QD dated 1/4/1996 of Ministry of Labor and Veteran and Social Affairs Service about Minimum Wage Level for Vietnamese Labor who works for Enterprises, which is financed by Foreign Funding.

2) Determination of Monthly Basic Wage by Grade

L1 = K x Lo

where:

Lo = Minimum Monthly Basic Wage (=US$ 45)
K= Coefficient for Each Grade (Classification)

3) Mobilization Allowance (P1)

P1 = 0.2 x Lo

4) Other Allowances

Allowances other than mobilization allowance are shown in Table 14.2.1.

Table 14.2.1 Allowance to be Added to Basic Wage

Description	Percentage of Basic Wage (%)
Unstable Working Condition (P2)	10
Supplemental salary (Tet holidays, leave and others) (P3)	12
Social Insurance (P4)	5
Health Insurance (P5)	1
Union Dues (P6)	1
Other expenditures paid directly to employees (P7)	4
Total	33

5) Income Tax

Income tax of labor must be determined in accordance with Decree 385/LDTBXH-QD dated 1/4/1996 of Ministry of Labor and Veteran and Social Affairs Services.

6) Average Working Days per Month

i) Number of approved paid holidays and annual leave per year

- Sunday : 52 days
- National Holidays and New Year : 8 days
- Approved paid leave : 15 days
- Miscellaneous leave : 5 days

Total 80 days

ii) Non-working days in construction per year

- Inclement weather (Table 14.2.2) : 17 days
- Study or meeting : 10 days
- Relocation of workers: : 10 days
- Public activities and military training : 4 days
- Illness : 5 days
- Miscellaneous leave : 5 days

Total 51 days

Table 14.2.2 The Average Number Days out of Working due to Inclement Weather

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Hanoi Area	0.1	0.2	0.0	1.6	1.5	2.2	2.6	2.8	3.7	2.2	0.2	0.0	17.1

iii) Average Working Days per Month

$$n = \frac{365 - 80 - 51}{12 \text{ months}} = 19.5 \text{ days} \quad 20 \text{ days}$$

The summary of unit labour cost per day is shown in Table 14.2.3.

(2) Unit Cost of Materials

Materials were classified into two groups, namely local materials which are available in the local market and foreign materials which need to be imported from the overseas market.

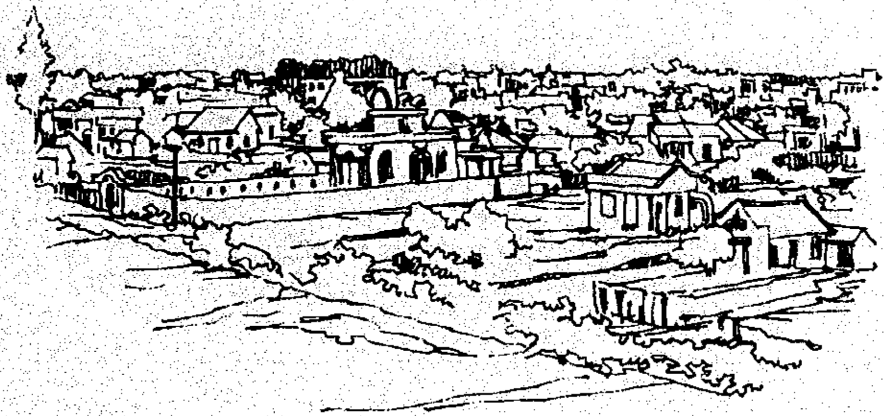
Local material costs were determined based on the market prices in Hanoi and foreign materials costs were determined based on the construction cost data books which are published in Japan. Table 14.2.4 shows summary of unit cost of major materials.

Table 14.2.3 Summary of Unit Labor Cost

Lo = US$ 45 J.Yen 1.0 = 135 VND US$ 1.0 = 14,000VND

Labor	Grade Wage US$		Allowance US$		Total Wage & Allowance		Income Tax		Total Wage (Per Month)		Unit Cost (Per Day)	
	Coefficient K	Wage L1= KxLo	Mobile P1=0.2xLo	Others P2~P7=0.33L1	US$	VND	%	VND	US$	VND	US$	VND
Foreman	3.991	179.60	9.0	59.27	247.86	3,470,059	20	194,012	261.72	3,664,071	13.09	183,300
Common Labor	1.773	79.79	9.0	26.33	115.11	1,611,597	0	-	115.11	1,611,597	5.76	80,600
Unskilled Labor	2.04	91.80	9.0	30.29	131.09	1,835,316	0	-	131.09	1,835,316	6.55	91,700
Skilled Labor	3.73	167.85	9.0	55.39	232.24	3,251,367	20	150,273	242.97	3,401,640	12.15	170,100
Mechanic	2.49	112.05	9.0	36.98	158.03	2,212,371	10	21,237	159.54	2,233,608	7.98	111,700
Electrician	2.49	112.05	9.0	36.98	158.03	2,212,371	10	21,237	159.54	2,233,608	7.98	111,700
Welder	2.49	112.05	9.0	36.98	158.03	2,212,371	10	21,237	159.54	2,233,608	7.98	111,700
Rigger	3.39	152.55	9.0	50.34	211.89	2,966,481	10	96,648	218.79	3,063,129	10.94	153,200
Capenter/Block Worker	2.49	112.05	9.0	36.98	158.03	2,212,371	10	21,237	159.54	2,233,608	7.98	111,700
Steel Worker	2.49	112.05	9.0	36.98	158.03	2,212,371	10	21,237	159.54	2,233,608	7.98	111,700
Concrete Worker	1.935	87.08	9.0	28.73	124.81	1,747,337	0	-	124.81	1,747,337	6.24	87,400
Equipment Operator	2.77	124.65	9.0	41.13	174.78	2,446,983	10	44,698	177.98	2,491,681	8.90	124,600
Truck Driver	2.56	115.20	9.0	38.02	162.22	2,271,024	10	27,102	164.15	2,298,126	8.21	114,900
Office Driver	2.16	97.20	9.0	32.08	138.28	1,935,864	0	-	138.28	1,935,864	6.91	96,700
Ship Officer	3.26	146.70	9.0	48.41	204.11	2,857,554	10	85,755	210.24	2,943,309	10.51	147,100
Sailor	2.38	107.10	9.0	35.34	151.44	2,120,202	10	12,020	152.30	2,132,222	7.62	106,700
Assistant Operator	2.49	112.05	9.0	36.98	158.03	2,212,371	10	21,237	159.54	2,233,608	7.98	111,700
Yardman	1.83	82.35	9.0	27.18	118.53	1,659,357	0	-	118.53	1,659,357	5.93	83,000
Engineer (20 years experience)	5.44	244.80	9.0	80.78	334.58	4,684,176	30	505,253	370.67	5,189,429	18.53	259,400
Engineer (10 years experience)	4.66	209.70	9.0	69.20	287.90	4,030,614	30	309,184	309.99	4,339,798	15.50	217,000
Engineer (5 years experience)	3.48	156.60	9.0	51.68	217.28	3,041,892	20	108,378	225.02	3,150,270	11.25	157,500

CHAPTER 15 PROJECT IMPLEMENTATION PLAN



CHAPTER 15 PROJECT IMPLEMENTATION PLAN

15.1 Execution of the Project

(1) Executing Agency

Projects Management Unit (PMU) Thang Long of Ministry of Transport (MOT) is the Project executing agency and is responsible for the execution of the following tasks:

1) Pre-construction Works

- Engineering Services (Finalization of Detailed Design) and
- Land Acquisition and Resettlement

2) Construction Works and Construction Supervision

The necessary land acquisition and compensation within proposed right-of-way will be undertaken prior to the start of the construction works. The organization chart of the Ministry of Transport is shown in Figure 15.1.1.

(2) Procurement of Contractor(s)

Contractors for packages 1,2, and 3 shall be procured through international competitive bidding and contractor(s) for package 4 shall be procured through domestic competitive bidding. All items to be to be financed by the JBIC shall be procured in accordance with the guidelines for Procurement under JBIC ODA Loans dated October, 1999.

(3) Consulting Services for the Project

The selection of consultant shall be in accordance with *Guidelines for Employment of Consultants under JBIC ODA Loans dated October, 1999.*

(4) Budgetary Appropriation for the Project

Any portion of the Project cost not covered by the JBIC loan are to be financed by the budget of the Government.

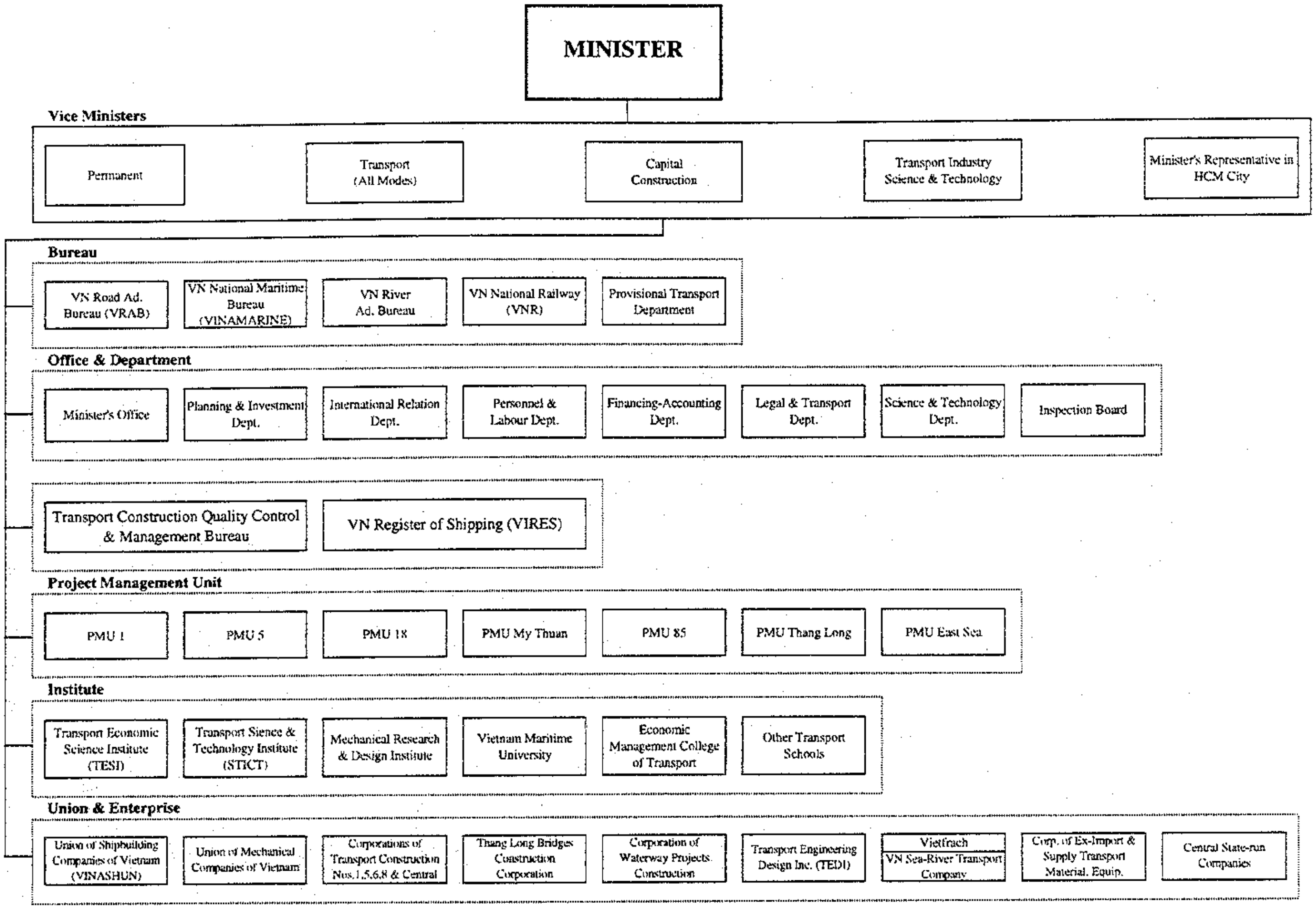


Figure 15.1.1 Organization Chart of Ministry of Transport

15.2 Project Implementation Time Schedule

(1) Construction Package

The entire construction is divided into four packages, they are:

- Package 1: Red River Bridge
- Package 2: Gia Lam Section of SHTRR
- Package 3: Thanh Tri Section of SHTRR
- Package 4: Infrastructure in the Resettlement Area

(2) Project Implementation Time Schedule

Project implementation time schedule was tentatively drawn up as shown in Figures 15.2.1 thru 15.2.4.

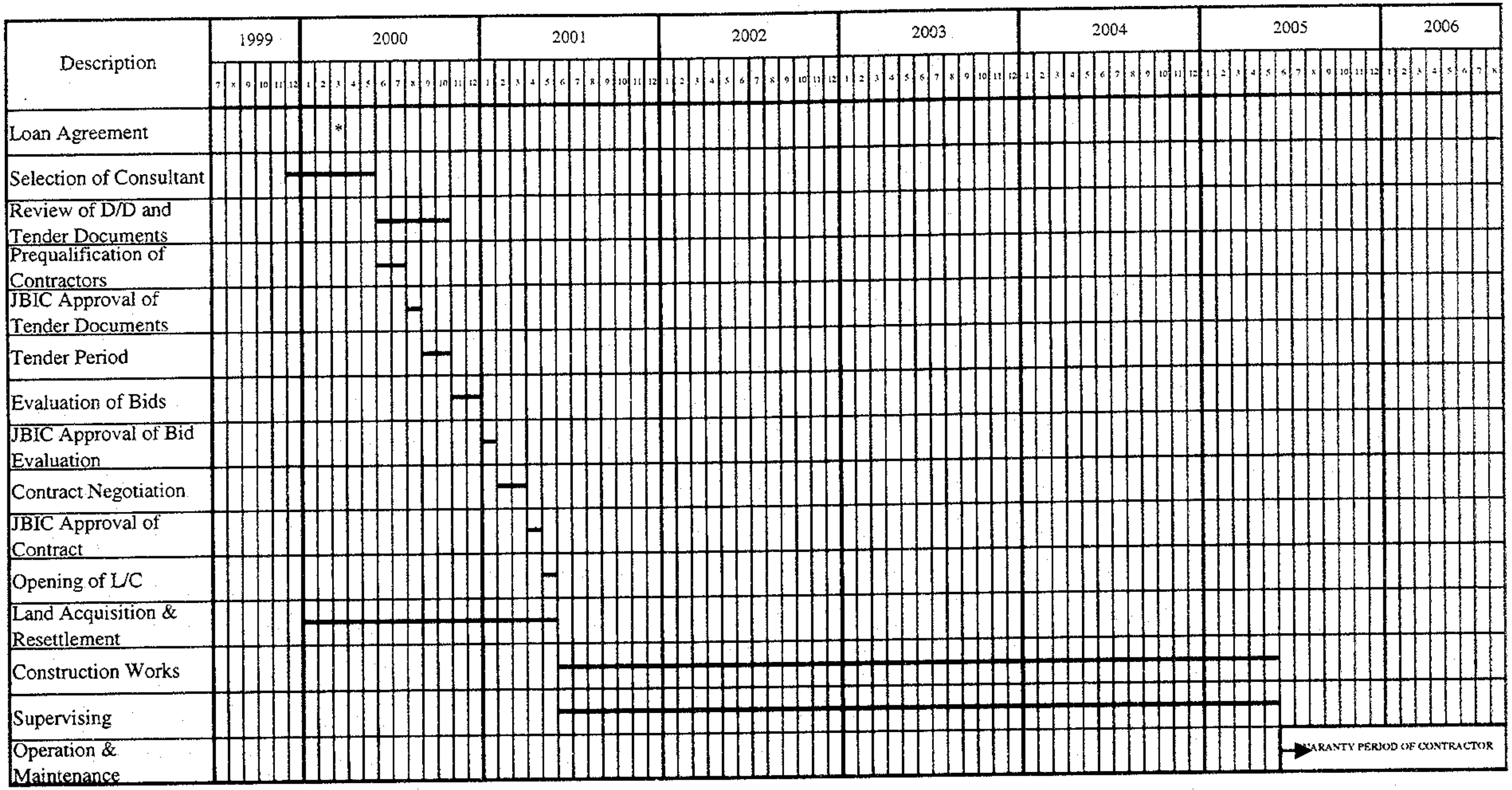


Figure 15.2.1 Implementation Time Schedule for the Red River Bridge Construction Project

Package 1: Red River Bridge

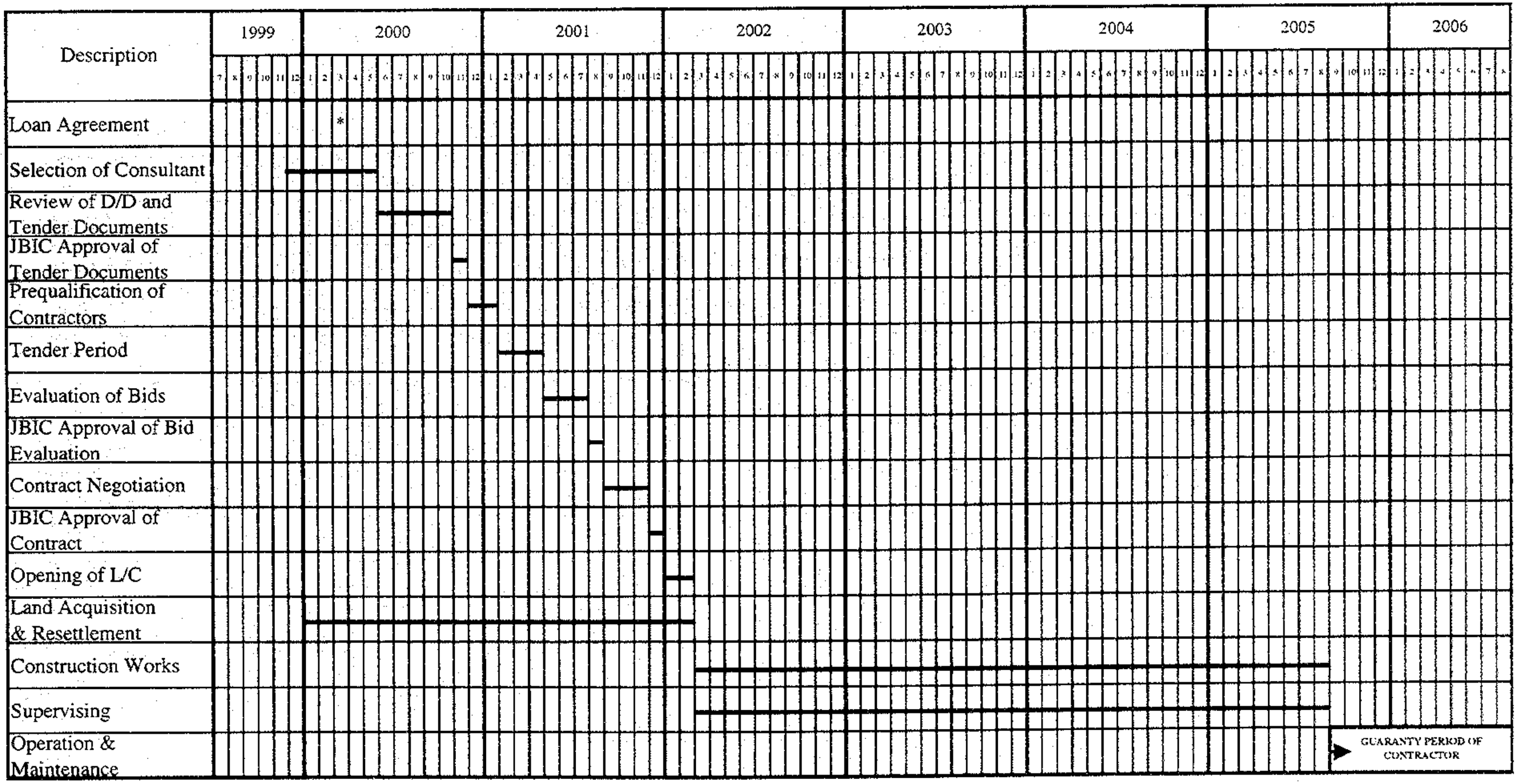


Figure 15.2.2 **Implementation Time Schedule for the Red River Bridge Construction Project**

Package 2: Gia Lam Section of SHTRR

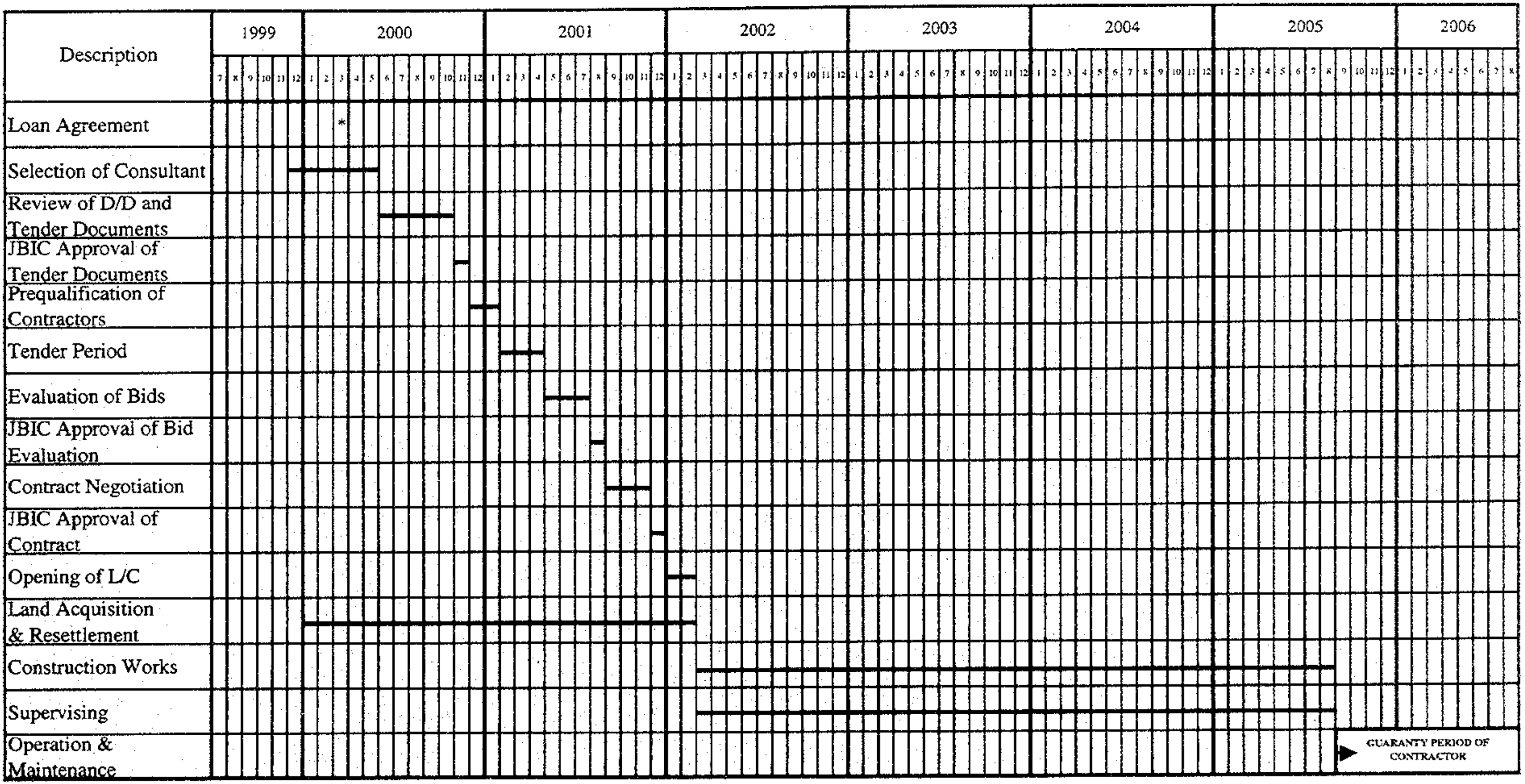


Figure 15.2.3 **Implementation Time Schedule for the Red River Bridge Construction Project**

Package 3: Thanh Tri Section of SHTRR

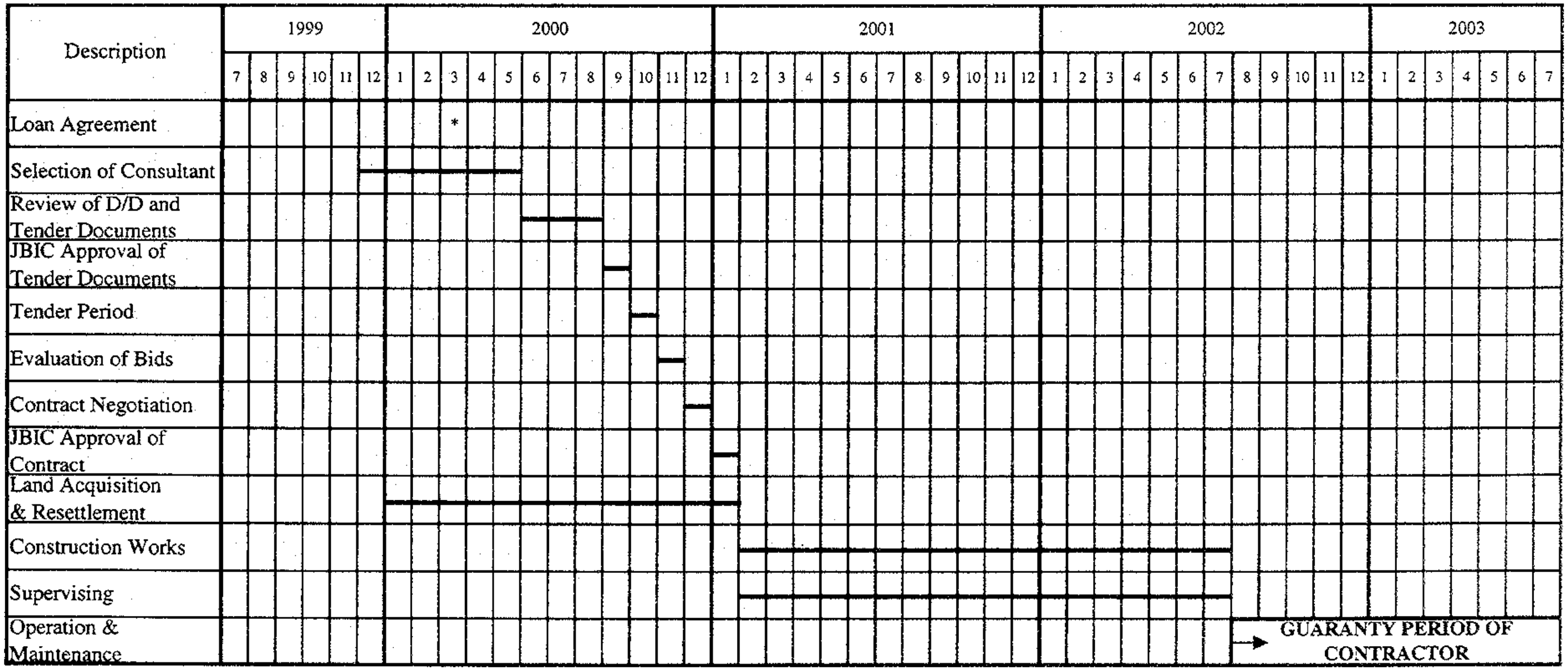
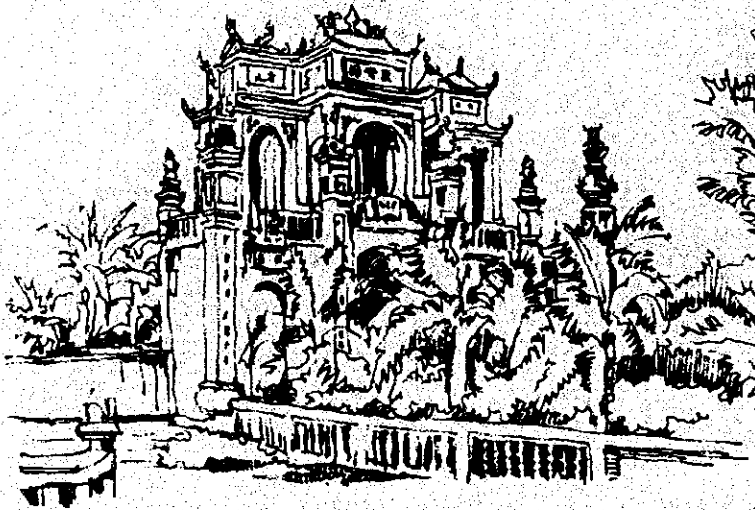


Figure 15.2.4 Implementation Time Schedule for the Red River Bridge Construction Project

Package 4: Infrastructure in the Resettlement Area

CHAPTER 16 TENDER AND CONTRACT DOCUMENTS



CHAPTER 16 TENDER AND CONTRACT DOCUMENTS

16.1 General

In preparing the tender documents for the Project, the prevailing tendering practice of civil works in Vietnam is considered as basic conditions. The documents shown in Table 16.1 are commonly used for tendering. The necessary documents for this Project were decided by negotiation with PMU Thang Long.

Table 16.1 Documents for Tender and Contract

	Instruction to Bidders
Volume I	General Conditions of Contract
Volume II	General Specifications
Volume III	Special Specifications
Volume IV	Bid, including Appendices to Bid, Bid Schedule and Schedule of Rates and Prices
Volume V	Drawings
Volume VI	Addendum (if any)
Volume VII	Detailed Work Schedule, Plant and Contractors Personnel List
	Form of Contract

16.2 Packages

The whole project is separated into four packages, three packages by international competitive tender and one package by local competitive tender.

The Red River Bridge section is named as "Package 1", the Gia Lam section of SHTRR is "Package 2", and the Thanh Tri section of the SHTRR is "Package 3". Package 4 is for the construction of the infrastructure at resettlement areas.

These packages are summarized in the Table 16.2.

Table 16.2 Construction Contract Package

Package No.	Package	Tender Type
1	Red River Bridge	ICB with P/Q
2	Gia Lam Section of SHTRR	ICB with P/Q
3	Thanh Tri Section of SHTRR	ICB with P/Q
4	Infrastructure in Resettlement Areas	LCB

Note: SHTRR denotes Southern Section of Hanoi Third Ring Road.
ICB denotes International Competitive Bid.
P/Q denotes Pre-Qualification.
LCB denotes Local Competitive Bid.

16.3 Instructions to Bidders

Instruction to Bidders is accompanied with guide forms. They are stipulated in one document as the Prime Document. The Prime Document is prepared for each project location specifying the site and Scope of Work. The contents of the Prime Document are:

1. Scope of Work
2. Bidding Time Schedule
3. Bidding Documents
4. Declaration of Intention to Bid
5. Pre-Bid Information
6. Inspection of Bid Documents and Site of the Works
7. Preparation of Bid Schedule and Schedule of Rates and Prices
8. Interpretation of Quantities in Bid Schedule
9. Use of Local Contractor, Sub-contractors, Goods and Services
10. Price Escalation/De-escalation
11. Partnership or Association of Enterprises
12. Signatures
13. Notice to Foreign Contractors
14. Addenda Issued during Bid Period
15. Preparation of Bids
16. Submission of Bids
17. Opening of Bids
18. Evaluation of Bids
19. Validity of Bids

20. Award and Signing of Contract
21. Bid Bond
22. Forfeiture of Bid Bond
23. Performance Bond
24. Advance Payment Bonds
25. Form of Power of Attorney
26. Taxation
27. Method Statements
28. Contractors Superintendence

16.4 General Conditions of Contract

The conditions contained in the document shown below are in accordance with "Conditions of Contract for Works of Civil Engineering Construction" by "Federation Internationale Des Ingenieurs-Conseils" (FIDIC) modified considering local conditions.

(1) Definitions and Interpretations
(2) Engineer
(3) Assignment and Subletting
(4) Contract Documents
(5) General Obligations
(6) Labour
(7) Materials and Workmanship
(8) Commencement Time and Delays
(9) Warranty and Defects
(10) Alterations, Additions and Omissions
(11) Plant, Temporary Works and Materials
(12) Measurement
(13) Certificates and Payments
(14) Remedies and Powers
(15) Special Risks
(16) Frustration and Termination
(17) Settlement of Disputes
(18) Notices
(19) Default of Employer
(20) Changes in Cost
(21) Taxation and Other Duties

16.5 General Specifications

The General Specifications specify the following items:

(1) General
(2) Site Clearing
(3) Demolition
(4) Road Earth Work
(5) Structure Excavation
(6) Drainage
(7) Subgrade
(8) Sub-Base and Base Course
(9) Pavements
(10) Concrete Structures
(11) Structural Steel Work
(12) Miscellaneous
(13) Utilities
(14) Diversion and Protection of Existing Utilities

16.6 Special Specifications

Specifications on design, materials and workmanship, etc. proposed by the Study that are not covered in the General Specifications shall be specified in the Special Specifications. Items to be covered in supplementing the General Specifications shall cover the following items:

(1) Night, Sunday or Official Holiday Work
(2) Taxes and Duties and Other Matters
(3) Price Escalation
(4) Offices, Housing, Vehicles, Computers and Staffing for the Employer, Engineer and their Staff
(5) Temporary Traffic Control
(6) Tolerances for Roadway Construction
(7) Tolerances for Structures
(8) Programs to be Furnished
(9) Construction of Sand Drain
(10) Construction of Plastic Board Drain

16.7 Bid, including Appendices to Bid, Bid Schedule and Schedule of Rates and Prices

A checklist of the documents to be submitted and forms of these documents are provided. They include:

- Table of Contents
- Checklist of Documents to be Submitted
- Total Bid Price and Form of Bid
- Appendix to the Bid
- Preamble to Bid Schedule
  Work Item 1 - General
  Work Item 2 - Site Clearing
  Work Item 3 - Demolition
  Work Item 4 - Road Earthwork
  Work Item 5 - Structure Excavation
  Work Item 6 - Drainage
  Work Item 7 - Subgrade
  Work Item 8 - Sub-base and Base
  Work Item 9 - Pavements
  Work Item 10 - Concrete Structures
  Work Item 12 - Miscellaneous
  Work Item 13 - Utilities
  Work Item 15 - Diversion and Protection of Utilities
  Work Item 16 - Daywork (Force Account)
  Work Item 17 - Provisional Sum
- Preamble to Schedule of Rates and Prices
  A. Wages
  B. Operating Equipment
  C. Material on Site

16.8 Drawings

Drawings of the detailed design for each package are provided separately.

16.9 Addenda and Supplements

As an addendum, "Section 14 Toll Plaza and Control Building", that is planned to be placed in Package 3, is prescribed to the General Specifications.

16.10 Detailed Work Schedule, Plant and Contractors Personnel List

A work schedule, list of construction plant and list of contractor's senior staff shall be submitted together with other tender documents and guide forms for these are provided.

16.11 Form of Contract

A "Form of Contract" is also provided, that is to be used for the contract between the Employer and a successful tenderer.

CHAPTER 17 ENVIRONMENTAL IMPACT STUDY

CHAPTER 17 ENVIRONMENTAL IMPACT STUDY

17.1 Study Objectives and Methods

17.1.1 Objectives of the Study

The Environmental Impact Study consists of an Environmental Study, which was conducted in May and June in 1999, and an Environmental Impact Assessment (EIA), which was carried out in January and February in 2000 for the Detailed Design of the Red River Bridge Construction Project.

The EIA for the Detailed Design of the Red River Bridge Construction Project was implemented based on the sampling data and results of the Environmental Study. The objectives of the EIS are as follows:

- To clarify the present environmental conditions of the Study Area;
- To analyze and forecast possible future environmental impacts caused by the project construction and operation;
- To formulate the environmental management plan for the Project, which includes mitigation measures and the monitoring program; and,
- To formulate the resettlement plan for the Project

With respect to the resettlement plan, which includes the detailed design of resettlement sites, the main contents are described in Chapter 10 and Chapter 11 of this Report.

17.1.2 Study Area and Study Method

The EIS Area consists of the same area as the Project Site of the Detailed Design of the Red River Bridge Construction Project Site, which includes the six proposed resettlement sites. An accurate inventory of the surroundings covers a 100-meter corridor on each side from the proposed centerline of the right of way, and the construction sites of the new facilities such as the proposed intersections. The EIS Area also includes a riparian area of the Red River, which will be located below the proposed Red River Bridge.

Based on the data of air quality, noise, and fish sampling as well as the results of the environmental evaluation of the Environmental Study, the possible significant impacts were identified. The possible future impacts caused by the Project construction and operation phase were forecast and analyzed. After that, based on these analyses, the environmental management plan was formulated. The management plan includes the mitigation measures and their costs, the environmental monitoring plan and its overall cost with their environmental conservation targets.

17.2 Vietnam's Present Environmental Standards and EIA Process

(1) Environmental Standards

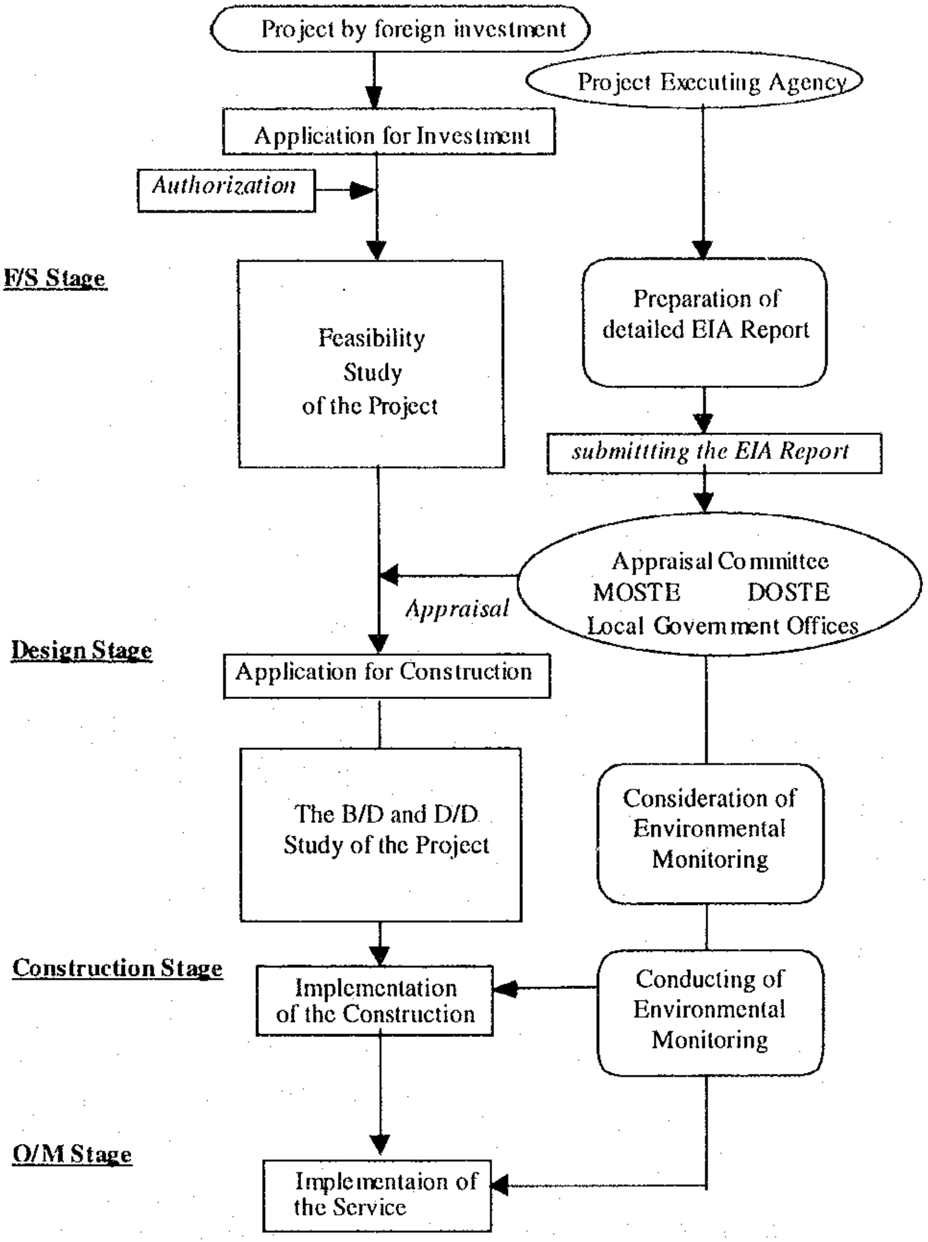
In 1993, the Ministry of Science, Technology and Environment (MOSTE) promulgated Vietnam's provisional Environmental Standards. In 1995, the MOSTE promulgated 70 new standards to replace the equivalent sections in the provisional environmental standards.

In 1998, the MOSTE promulgated a new environmental standard for noise in public and residential areas (TCVN 5949-1998). At present, the main environmental items of the Vietnam's Environmental Standards are air quality, water quality, soil quality, noise/vibration, and the use of wastewater.

(2) Environmental Impact Assessment

The Environmental Impact Assessment (EIA) process and procedure in Vietnam were described in the "Documents of Setting up a Report on Environmental Impact Assessment", which was published in 1995. In 1998, the "Documents" were revised with the relevant present governmental decrees and guidelines. According to these government decrees, all of the development projects, including road development projects, which are supported by foreign funds (excepting 25 specified small-scale projects) must prepare an EIA.

The present environmental consideration flow, including the EIA procedure for foreign investment, is shown in Figure 17.2.1. The flow applies to road development projects of less than 50 km in length within Hanoi. In the case of this Project, the appraisal committee already approved a detailed EIA report at the feasibility study stage in 1998.



note:) DOSTE: Hanoi Department of Science Technology and Environment

Figure 17.2.1 Environmental Consideration Flow for Road Development Project

17.3 Description of the Present Environment of the Study Area

17.3.1 Socio-economic Environment

(1) Population

The total population of Hanoi was 2,672,125 in 1999, thus accounting for 3.5 % of the entire population in Vietnam. The population increase in Hanoi City has accelerated in recent years and a heavy concentration is found in urban areas.

The Study Area is located within the rural area of Hanoi and the population trends in these areas vary by district. In Gia Lam District, the population increase accelerated between 1989 and 1998, while in Thanh Tri District the population was stable from 1995 to 1998. Table 17.3.1 shows recent population trends in these districts.

Table 17.3.1 Recent Population Trends of the Study Area

Unit: thousand persons

District	Population			
	1995	1996	1997	1998
Thanh Tri	205.7	209.8.2	205.5	209.5
Gia Lam	301.1	308.3	313.1	318.0

Source: Hanoi General Statistical Office

(2) Economic Activity

Table 17.3.2 shows the recent labor structure of Thanh Tri district and Gia Lam district. Agriculture such as rice cultivation is still the dominant economic sector in both districts.

Table 17.3.2 Labor Structure of the Study Area

Sector	Thanh Tri district				Gia Lam district			
	Households		Workers		Households		Workers	
Agriculture	29,767	90.7 %	122,046	94.5 %	36,862	83.6 %	149,659	91.1 %
Fishery	477	1.5 %	1,907	1.5 %	63	0.1 %	256	0.2 %
Others	2,581	7.8 %	5,236	4.1 %	7,177	16.3 %	14,354	8.7 %
Total	32,825	100 %	129,189	100 %	44,102	100 %	164,269	100 %

Sources: Thanh Tri District - District survey in July 1997
Gia Lam District - District survey in December 1996

However, according to a recent agricultural household survey in 1997, most of the agricultural households in both districts are dependant on non-agricultural employment for a major portion of their income. In either district, the agricultural income has not exceeded non-agricultural income in recent years.

Many farmers in Thanh Tri district are also engaged in fish breeding in the small low-lying fields, and development of livestock such as pig and cattle. In Gia Lam district, pottery industries, handicrafts, and other small-scale industries contribute as sources of income. In general, the people living in Gia Lam District are of lower income than those who live in Thanh Tri District.

(3) Traffic and Public Facilities

Within Hanoi, there are several kinds of transportation modes such as road, railway, and inland waterway, each mode having a different role and significance. The network of National Highways (NHs) composed of NH1, NH3, NH5, and others contributes significantly to land transportation and major local and regional economic activities. The road network in the Study Area includes NH1, NH5 and local roads, which belong to categories I to III of road classification in Vietnam. In the Study Area, there are also some bus routes, stations, and one seldom-used domestic airport in Gia Lam, and a river port as main traffic facilities.

In both Thanh Tri district and Gia Lam district, every community has a primary and primary-secondary school. Particularly, the Tran Phu School in Thanh Tri district consists of primary, primary-secondary, and secondary-supplement. Most school children go to school on foot and main schools along the proposed right of way are shown in Figure 17.3.1. In terms of health care facilities, each community in Thanh Tri district has a dispensary, while there is only one small dispensary in Gia Lam district.

(4) Communities

Based on the data from the district People's Committees, Thanh Tri district is divided into 24 communes, including one town. Gia Lam district is divided into 36 communes, including four towns. These communes also have their People's Committee as an administrative organ. Each commune can be further divided into smaller units, each consisting of about 40 to 70 households. There is also a women's union and youth community in every commune.

(5) Cultural Property

There are many local cultural properties such as old churches and pagodas in the Study Area. Figure 17.3.1 shows the location of the cultural properties along the proposed right of way. A local cultural monument is also located near the proposed right of way at Linh Nam area. Such Data were collected from the Cultural Information Division in the Hanoi People's committee at Thanh Tri district and Gia Lam district.

(6) Water Rights/Right of Common

The Vietnam Government owns all land in Vietnam and the people has the right to use the land. All matters related to water and land resources are under state regulations. For example, water rights in the Study Area are based on the "Regulations of Protection and Development of Aquatic Products and Resources" which was approved in 1989. Water resources in the Study Area are mainly used for irrigation and small-scale fishery, and other domestic purposes.

However, according to a water-rights interview survey for this Study, which was conducted in June of 1999, the fishermen in the Study Area can collect fish and other aquatic species without any agreement with the local authorities or government management offices. This effectively means that there is no regulation and policy on the water and fishing rights in the Study Area. The present situation of water and fishing rights highlights the following issues:

- The Government does not manage the inland surface water.
- The Government is losing tax benefits from the surface water use activities.
- Conflicts arise among the local fishermen regarding the water and fishing rights.
- It is very difficult to manage aquatic species in terms of species protection.

(7) Public Health Condition

The water supply situation in the Study Area is not adequate. Most of the residents in Thanh Tri district use large brick tanks to store the rainfall water for cooking throughout the year and use well water only for cleaning, washing and others. In Gia Lam district, the residents must use well water for cooking and pond water for cleaning.

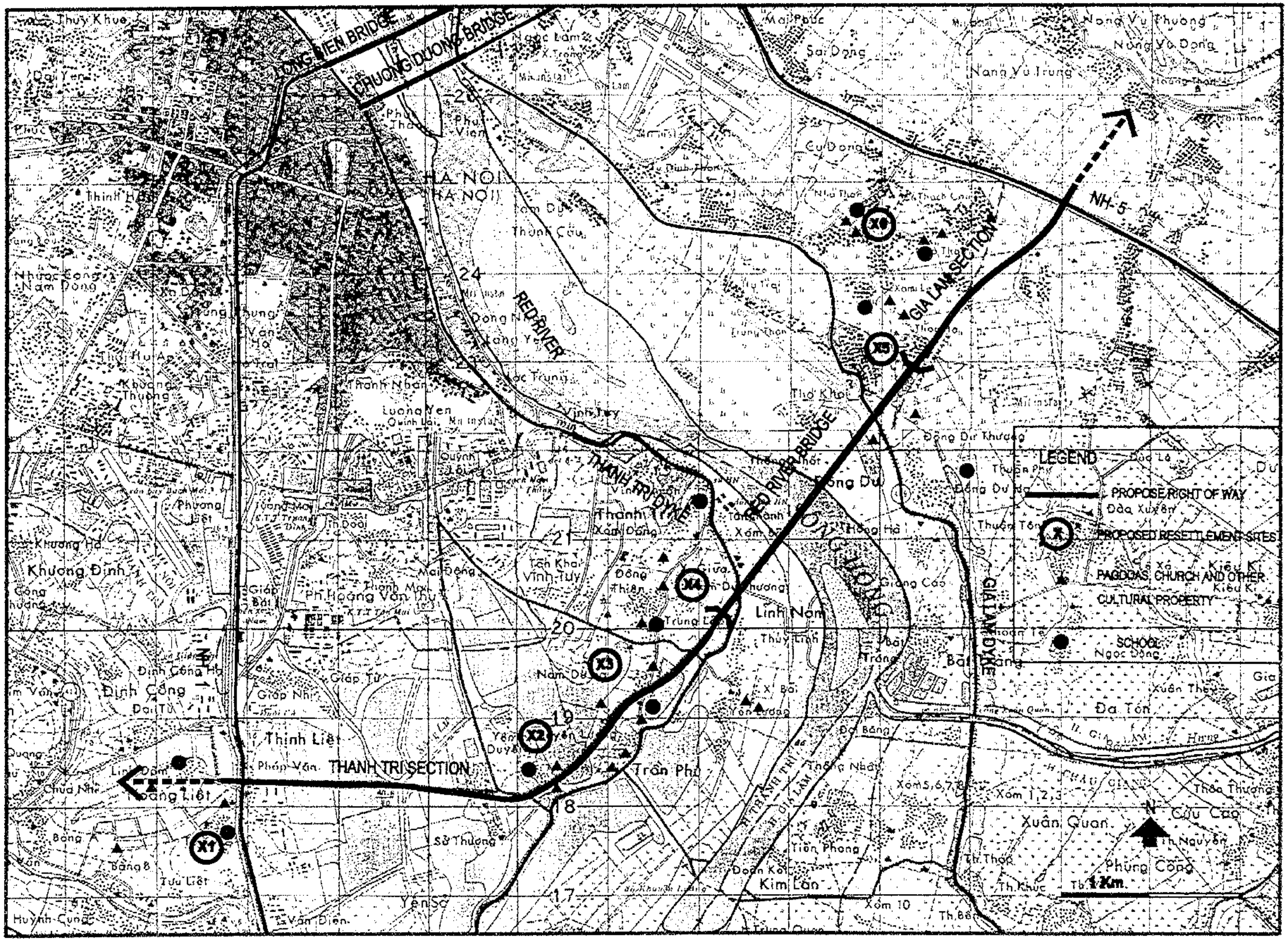


Figure 17.3.1 : Cultural Properties and Schools along the Proposed Right of Way

Nevertheless, each commune has a dispensary with some patient beds and five doctors working there. These facilities are mainly for assisting in birth, giving vaccinations and treating some light illnesses. In a serious case, the patient needs to be taken to a major hospital in Hanoi city area.

(8) Waste

According to the DOSTE in 1994 the total amount of the municipal waste in Hanoi was 599,000 m^3 and industrial waste was around 190,000 m^3. The main composition of the municipal waste is stale fruits and waste from food shops. These organic substances are easily fermented and disintegrated. Waste volume has increased rapidly with the increase of population.

In the Study Area, there are two landfill sites at Tam Hiep in Thanh Tri district and at Bo De in Gia Lam district. However, it is reported that none of them satisfies requirements for technology and environmental hygiene. The uncollected wastes are scattering along the rivers and streams in residential areas and especially found in Yen So on-going Drainage Study Area. This causes a high risk for pollution to the surrounding water and harms of the landscape of the city.

(9) Hazards and Risks

The Red River usually floods following a storm which causes heavy rain in the large catchment area and the high tidal cycle in the East Sea. Inundation is the most common natural hazard in Hanoi and large-scale floods have occurred in 1984, 1986, and 1994. In the Study Area, the 1994 storm caused floods and heavy inundation in most of the Thanh Tri district and a half of Gia Lam district.

With regards to traffic safety, it is well known that bicycles, motorcycles and vehicles are mixed in the same traffic lane and most people do not obey basic traffic rules, and very few motorcyclists wear a safety helmet. One of the most important traffic priorities in Hanoi is to distinguish the traffic lanes according to automobiles, motorcycles, and bicycles, in order to reduce traffic accidents as well as to improve the existing traffic flow.

(10) Land Use

As shown in Table 17.3.3, at present, most of the land in the Study Area is used for agricultural fields (cropland) and fishponds (aquaculture). The category of "Special Land" includes irrigated land, transport land, construction land, cultural/historical land, forested land, etc. The category of "Others" means the lands are unused areas or not specified. Present land use pattern within the proposed right of way is almost the same as in the Study Area as a whole.

Table 17.3.3 Present Land Use of the Study Area

Unit: ha

District	Residential	Crop Land	Aquaculture	Special Land	Others	Total
Thanh Tri	1,188.77	4,515.61	714.48	2,303.54	1,068.60	9,791.00
	12.14 %	46.12 %	7.30 %	23.53 %	10.91 %	100 %
Gia Lam	1,735.50	8,839.78	318.92	3,941.90	2,370.52	17,206.62
	10.09 %	51.37 %	1.86 %	22.90 %	13.78 %	100 %

Source: Thanh Tri District Survey in 1998, Thanh Tri District Office
Gia Lam District Survey in 1995, Gia Lam District Office

17.3.2 Natural Environment

(1) Topographic and Geological Features

The topography of the Study Area is mostly flat with an average elevation of approximately 7 meters. The proposed right of way slopes from the north to the south and crosses over the Red River as well as several depressed areas, including ponds. The entire Study Area lies within Red River Delta. On the eastern side of the river, the soil consists of 15-20 meters of thick clay, underlain by 20-25 meters of thick sand, underlain by fine gravel. On the western side of the river, the upper clay deposits are thicker than the soil on the eastern side, ranging approximately 25-35 meters in thickness.

(2) Soil Condition

In Hanoi, the Red River and its tributaries generate mostly soil that varies from a slightly acidic to neutral. They are rich in mud content and nutrients and are suitable for growing many kinds of trees and crops. In the Study Area, the alluvial sediments and soil are relatively well structured and are not readily erodible.

However, within the proposed right of way this does not apply to a small portion of Thinh Liet area, Thanh Tri Dyke adjacent area, and Cu Khoi adjacent area.

(3) Groundwater

Groundwater-bearing formation in Hanoi consists of loose and alternating quaternary sediments and the Hanoi Water Business Company (HWBC) monitors groundwater in the dry and rainy seasons in each year. In the Study Area, groundwater is one of the main sources for water and the quality generally meets the Vietnamese standards except for iron and ammonia in some areas of the city. For example, groundwater contains high levels of iron, especially in Gia Lam site.

(4) Hydrological Situations

The Red River passes through the center of the Study Area. There are continuous flood tops and these change significantly with rising and shifting water. In the basin of the Red River system there are many lake reservoirs. These are beneficial as they adjust flow volume by reducing the volume of water in the flood season, and increasing it in the dry season. The Study Area has many small reservoirs and a network of small rivers/canals such as Kim Nguu River and Cau Bay River.

(5) Flora and Fauna

There are no protected areas in the Study Area according to the list of the in Vietnam. Flora and fauna in the Study Area is not so diverse. The flora mainly consists of paddies, subsidiary crops, vegetables, and perennial fruit-trees. Existing species such as lotus, water lily and others grow in ponds and marshes. Eucalyptus has been planted densely in the area, particularly along the banks of the Red River.

With respect to fauna, especially fish species in the Study Area, Table 17.3.4 shows the fish species list in the Rid River and Linh Dam Lake according to the Vietnamese Red Book. A fish sampling for this study was conducted at four points along the proposed right of way over four days in June 1999. The sampling points are shown in Figure 17.3.2. Table 17.3.5 summarizes the results of the sampling.
Based on the fish sampling results and the fish species list of the Study Area, the following can be concluded:

- Vulnerable fish species such as *Cranioglanis sinensis* are found in the Study Area, but no endangered species were identified.
- Fish density in the Red River of the Study Area is low, but the fish density of Linh Dam Lake is high.

(6) Meteorology

The location of the Study Area is under the sub-tropical monsoon regime. The climate is humid and hot from May to September. The winter is with little rain and cold from November to March. According to the long-term monitoring meteorological data at Lang station in the Hanoi, the main meteorological features of the study area are as follows:

- Annual average temperature: 23.4 °C
- July maximum average temperature of 1 month: 28.8 °C
- January maximum average temperature of 1 month: 16.6 °C
- Annual average humidity: 83 %
- Annual average rainfall: 1,680 mm
- August maximum monthly average rainfall: 323 mm
- January minimum monthly average rainfall: 18 mm

(7) Landscape

The natural landscape of the Study Area is a richly scenic resource formed by combination of peaceful townscape and agriculture fields such as paddies, fruit trees, and ponds. These places provide recreation and relaxation for the people including some tourists. With respect to cultural landscape, historical properties such as pagodas which are located at Trung Mau village in Gia Lam and at Van Dien in Thanh Tri also provide an inheritance of local and traditional atmosphere.

Table 17.3.4 Fish Species in the Red River and Linh Dam Lake

No.	Name of species	Classification of species (The Vietnamese Red Book)		
		Endangered (E)	Vulnerable (V)	Rare (R)
1	*Cyprinus carpio*			
2	*Carassius auratus*			
3	*Squaliobarbus curriculus*			
4	*Mylopharyngodon piceus*		+	
5	*Ctenopharyngodon idellus*			
6	*Elopichthys bambusa*			
7	*Hypophthalmichthys molitrix*			
8	*Osteochilus melanopleura*			
9	*Semilabeo notabilis*		+	
10	*Cirrhina mobitorella*			
11	*Hemiculter leucisculus*			
12	*Wallagonia attu*			
13	*Claris fuscus*			
14	*Cranioglanis sinensis*		+	
15	*Bagarius*		+	
16	*Mugil cephalus*			
17	*Ophiocephalus maculatus*			
18	*Lates calcarifer*			
19	*Tilapia mossambica*			
20	*Anabas testudineus*			
21	*Mastacembelus armatus*			
22	*Aristichthys nobilis*			
23	*Glossogobius giuris*			
24	*Salmoniformes*			
25	*Clupanodon thrisa*			
26	*Hilsa reevesii*		+	
27	*Anguilla japonica*	+		
28	*Altigena lemassoni*		+	
29	*Labeo tonkinensis*			
30	*Barbus brevifilis*		+	
31	*Megalobrama terminalis*		+	

Source: The Vietnamese Red Book
Biological Department of Hanoi University

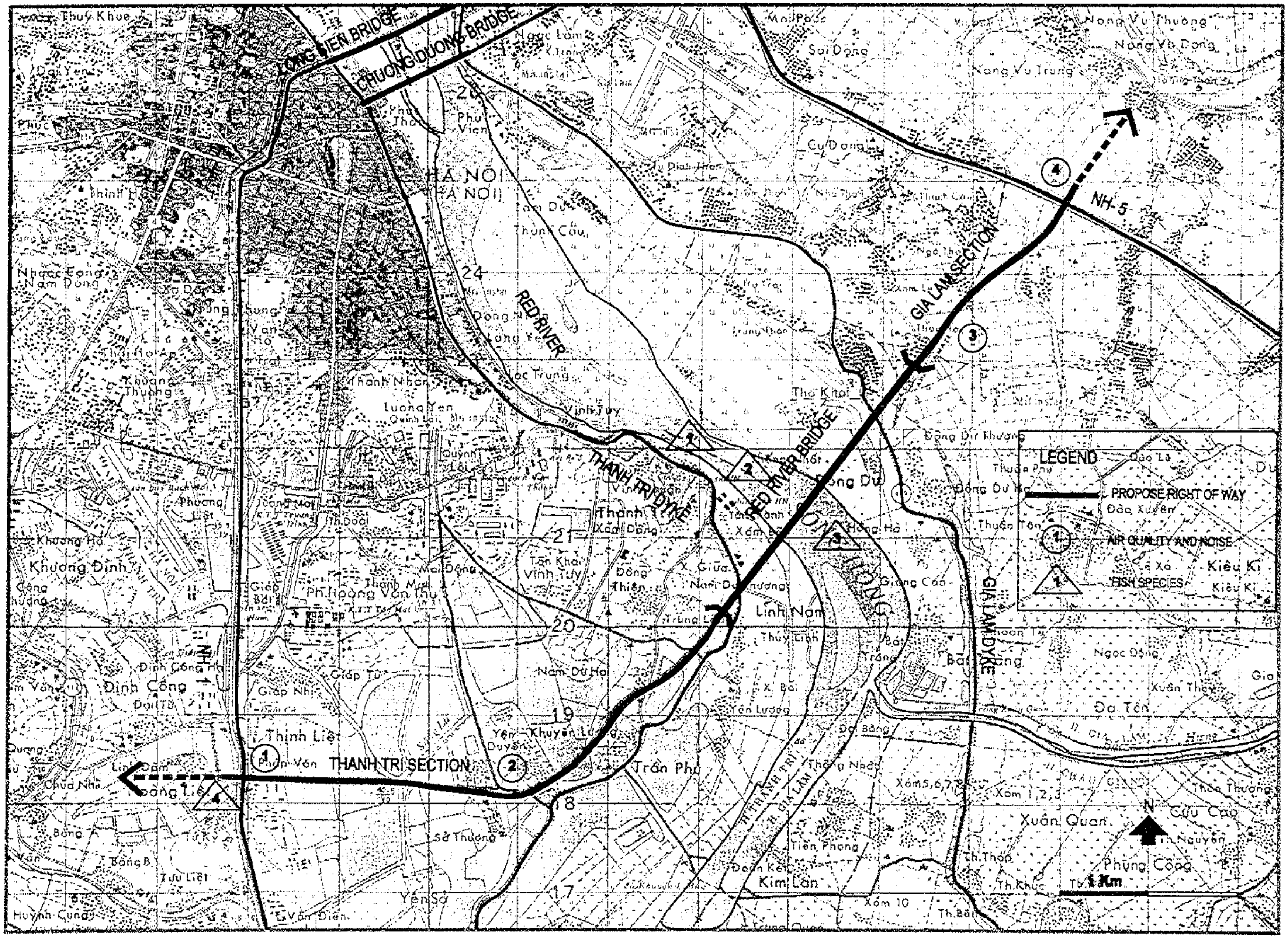


Figure 17.3.2 : Sampling Points of the Environmental Study

Table 17.3.5 Results of Fish Sampling

Sampling Point No.1 (Red River), Sampling date: June 1,1999		
Sampling period	Total fish weight (Kg)	Fish species
Morning	3.2	*Megalobrama terminalis* *Aristichthys nobilis* *Cyprinus carpio* *Cranioglanis sinensis*
Noon	1.8	*Aristichthys nobilis* *Ophiocephalus maculatus* *Cirrhina mobitorella*
Evening	2.5	*Aristichthys nobilis* *Wallagonia attu* *Hemiculter leuciscuius* *Cyprinus carpio* *Cranioglanis sinensis* *Hypophthalmichthys molitrix*
Sampling Point No.2 (Red River), Sampling date: June 2,1999		
Sampling period	Total fish weight (Kg)	*Fish species*
Morning	2.5	*Ctenopharyngodon idellus* *Cranioglanis sinensis* *Cirrhina mobitorella*
Noon	1.2	*Ctenopharyngodon idellus* *Cirrhina mobitorella* *Cyprinus carpio*
Evening	4.5	*Carassius auratus* *Elopichthys bambusa* *Cyprinus carpio* *Cranioglanis sinensis*
Sampling Point No.3 (Red River), Sampling date: June 3,1999		
Sampling period	Total fish weight (Kg)	*Fish species*
Morning	4.1	*Elopichthys bambusa* *Cirrhina mobitorella* *Carassius auratus*
Noon	1.2	*Ctenopharyngodonidellus* *Cirrhina mobitorella* *Cyprinus carpio*
Evening	3.5	*Aristichthys nobilis* *Wallagonia attu* *Hemiculter leuciscuius* *Cyprinus carpio*
Sampling Point No.4 (Linh Dam Lake), Sampling date: June 4,1999		
Sampling period	Total fish weight (Kg)	*Fish species*
Morning	14	*Cirrhina molitorella* *Carassius auratus* *Cyprinus carpio* *Ctenopharyngodon idellus* *Tilapia mossambica* *Ophiocephalus maculatus*
Noon	12	*Ctenopharyngodon idellus* *Cirrhina molitorella* *Tilapia mossambica* *Ophiocephalus maculatus*
Evening	35	*Aristichthys nobilis* *Ctenopharyngodon idellus* *Hemiculter leuciscuius* *Cyprinus carpio* *Tilapia mossambica*

17.3.3 Pollution

(1) Air Quality

Mixed transport and industrial plants are the major causes of air pollution in Hanoi. Vehicles always have to slow down or idle for long times due to the large number of the bicycles or motorcycles in the urban districts. The amount of gases discharged by vehicles is great and the air quality of the urban districts of Hanoi is deteriorating. However, the proposed right of way is located in rural districts, consisting mainly of agricultural lands or rural residential areas, and there is only one factory.

In order to obtain data on the present air quality and background data for the air quality impacts, the air quality sampling was conducted at four sampling points in May and June 1999. Data was collected on the following items:

Air quality sampling items

NOx, SOx, CO, CH, Suspended Particulate Matter (SPM) and Pb

Air quality sampling points

The following sampling points are also shown in Figure 17.3.2:

- Sampling Point No.1 - Adjacent to the proposed intersection between NH1 and the proposed centerline of the right of way (Km 1+000);
- Sampling Point No.2 - Point located along Phap Van Street, near the Kim Nguu Bridge (Km 4+000);
- Sampling Point No.3 - Representative residential site located at approximately 100m from the proposed centerline of the right of way (Km10+500); and
- Sampling Point No.4 - An adjacent to the proposed intersection between NH5 and the proposed centerline of the right of way (Km 13+000).

The results of the sampling are shown in Table 17.3.6, Table 17.3.7, and Table 17.3.8.

Table 17.3.6 Concentration of NOx, SOx, CO, CH at the Sampling Points

No	Date	Sampling Results							unit: mg/m^3
		NOx		SOx		CO		CH	
		24hour average	1 hour Max.	24 hour average	1 hour Max.	24 hour average	1 hour Max.	24 hour average	1 hour Max.
Sampling Point No.1									
1	29-5-1999	0.0477	0.0670	0.0295	0.0467	1.7257	3.1801	3.6990	6.1670
2	30-5-1999 (H)	0.0386	0.0500	0.0024	0.0035	2.1390	2.9987	7.1772	9.1234
3	1-6-1999	0.0524	0.0632	0.0323	0.0425	1.9150	2.8654	4.1055	5.5563
Sampling Point No.2									
1	28-5-1999	0.0632	0.0835	0.0048	0.0085	0.3475	0.9120	5.0924	7.0001
2	30-5-1999 (H)	0.0580	0.0765	0.0050	0.0083	0.3164	0.8296	4.6300	6.3643
3	31-5-1999	0.0696	0.0921	0.0049	0.0089	0.3851	1.0118	5.6520	7.7696
Sampling Point No.3									
1	23-5-1999 (H)	0.0305	0.0430	0.0030	0.0055	0.7238	0.8550	7.2093	9.9123
2	24-5-1999	0.0346	0.0489	0.0039	0.0058	0.8319	0.9827	8.2906	11.398
3	27-5-1999	0.0334	0.0472	0.0037	0.0056	0.8030	0.9485	8.0018	11.002
Sampling Point No.4									
1	23-5-1999 (H)	0.0049	0.0075	0.0024	0.0043	1.2325	2.4923	5.4765	7.6050
2	26-5-1999	0.0057	0.0084	0.0031	0.0050	1.2979	2.6240	5.7653	8.0058
3	28-5-1999	0.0650	0.0925	0.0045	0.0066	0.9134	0.9987	8.6964	16.000
Vietnam's Standard		0.10	0.40	0.30	0.50	5.0	40	-	-

Note: (H) = holiday

Table 17.3.7 Concentration of SPM at the Sampling Points

Date	Sampling Results				unit: mg/m^3
Sampling Point	No.1	No.2	No.3	No.4	Standard
23-5-1999 (H)			0.12	0.74	0.20
24-5-1999			0.18		
26-5-1999				0.69	
27-5-1999			0.13		
28-5-1999		0.58		0.66	
29-5-1999	0.61				
30-5-1999 (H)	0.63	0.61			
31-5-1999		0.51			
1-6-1999	0.56				

Note: (H) = holiday

Table 17.3.8 Concentration of Pb at the Sampling Points

Date	Sampling Results				unit: mg/m^3
Sampling Point	No.1	No.2	No.3	No.4	Standard
23-5-1999 (H)			0.00490	0.00182	0.005
24-5-1999			0.00251		
26-5-1999				0.00171	
27-5-1999			0.00150		
28-5-1999		0.00483		0.00107	
29-5-1999	0.00234				
30-5-1999 (H)	0.00395	0.00562			
31-5-1999		0.00325			
1-6-1999	0.00281				

Note: (H) = holiday

The following can be concluded based on the results of the air quality sampling:

- In comparison with the Vietnamese standards, concentration of NO_x, SO_x, CO, and Pb were lower at all sampling points.
- In comparison with the Vietnamese standards, concentration of SPM exceeds the standard value except the value at residential site in Gia Lam district (sampling point No.3).
- There is no remarkable difference between weekday and holiday in terms of all air quality sampling items at each sampling point except the SO_x value at NH1 (sampling point No.1).

(2) Water Quality

In general, the pollution level of surface water in Hanoi City is not so serious, except for some rivers such as Kim Nguu River and Cau River, which go through dense residential areas and towns. However, these two rivers, which go through the Study Area, are seriously polluted. The pollution of the Red River at the point where the proposed Red River Bridge will be built is not so serious. The following water quality sampling was conducted in March 1998 during the Feasibility Study of this Project.

<u>Water quality sampling items</u>

pH, TS, SS, Turbidity, COD, BOD_5, NO^{3-}, NO^{2-}, SO_4^{2-}, PO_4^{2-}, Cr_4^{3+}, Ni^{2+}, Cu^{2+}, Pb^{2+}, and Oils

On the basis of the sampling results, the water quality in the Study Area was assessed as follows:

In terms of oil and grease, oil was found in samples taken at only two sampling points of the Red River, but the oil concentration does not exceed unacceptable levels (under 0.02 mg/l for all four samples). The low density can be explained by the lowered level of motorized waterway trafic during the dry season, whihch was when the samples were taken.

Toxic heavy metals such as Cr^{3+}, Ni^{2+} (contained in disposal water from electrical plate factories) and Pb^{2+}, Cu^{2+} etc. are found at all sampling points. Their concentrations are far lower than the permitted value in comparison with the environmental standard for disposal water, but they are far higher than the standard value for intake water. The surface water in the Study Area, for example Kim Nguu River is seriously polluted. Such unhealthy water can only be used for irrigation rather than for human intake.

(3) Noise

In Hanoi, especially in urban districts, traffic noise such as automobile horn noise is a significant problem. In the Study Area, it is observed that noise is concentrated near the NH1 and the NH5. Table 17.3.9 shows the Vietnam's Environmental Standard on the noise level in public and residential area (TCVN 5949-1998), which was newly regulated in 1998.

Table 17.3.9 Maximum Permitted Noise Level in Vietnam

Unit: dB (A)

Areas/Category	Hour		
	6.00-18.00	18.00-22.00	22.00-6.00
Quiet areas: hospital, school, library, clinic, etc. (Category 1)	50	45	40
Residential areas: hotel, apartment house and administration office (Category 2)	60	55	50
Residential areas: intermingling areas of business, service and production (Category 3)	75	70	50

In order to obtain present noise level along the right of way and background noise level in a residential site of the Study Area, the following noise level sampling was conducted in May and June 1999.

Noise level indicators

L_{eq} was used as the noise level indicator at the same as the sampling points of air quality sampling of this study (see Figure 17.3.2). The results of the noise sampling levels are summarized in Table 17.3.10.

Table 17.3.10 Results of Noise Level Sampling

Unit: dB (A)

Date	Noise Level [L_{eq}]				
Sampling Point	No.1	No.2	No.3	No.4	Standard
23-5-1999 (H)			58.0	79.6	75 (Category 3)
24-5-1999			58.5		
26-5-1999				79.6	
27-5-1999			59.1		
28-5-1999		83.2		80.2	
29-5-1999	84.9				
30-5-1999 (H)	84.5	83.2			
31-5-1999		83.0			
1-6-1999	84.3				

Note: (H) = holiday

The following can be concluded based on the results of the noise sampling:

- The noise levels at sampling points exceed Vietnamese standards except for the residential site in Gia Lam district (sampling point No.3).
- There is no remarkable difference between weekday and holiday in terms of noise level at each sampling point.

(4) Soil Contamination

Only in recent years, based on recommendations of the Ministry of Health in Vietnam, toxic insecticides for farming such as DDT are gradually being replaced by microbiological insecticides, which cause less soil contamination. In Hanoi, there is little information on soil contamination. The amount of insecticide and herbicide use and their effects should be investigated more carefully, as most of the lands in the Study Area are croplands. However, it is not reported that any serious soil contamination has occurred in the Study Area.

(5) Land Subsidence

It is reported that groundwater exploitation seems to have lowered groundwater level and caused land subsidence in parts of Hanoi, but the relationship between groundwater exploitation and land subsidence has not yet been clarified. Within a few kilometers along Red River and the other rivers, there is a close relationship between groundwater and rivers, but the groundwater level has not been considerably lowered by exploitation in the areas, as the river water seems to recharge the groundwater aquifer.

17.4 Environmental Impact Assessment

17.4.1 Socio-economic Environment

(1) Resettlement

Although the proposed right of way was carefully selected in order to minimize resettlement by the Project implementation, the resettlement will be inevitable along the some portions of the right of way.

According to a field survey by JICA Study Team and inventory works by the People's Committee, which were conducted in 1999, around 1,200 households and 6,000 persons need to be resettled by the project implementation.
In terms of the lands, JICA Study Team estimated the total size of the project-affected areas at around 125.8 hectare. The total size of the areas includes rivers and riverbeds. The project-affected lands consists of the following areas:

• Residential area, including gardens, etc.	(18.5 ha)
• Agricultural area	(61.0 ha)
• Pond	(19.1 ha)
• Office buildings, warehouse, etc.	(3.3 ha)
• Public facilities	(0.7 ha)
• Others (river, riverbeds, etc.)	(23.2 ha)

The detailed resettlement issues by the Project implementation and the resettlement plan are described in Chapter 10 and 11 of this Report.

(2) Economic Activities

After the Red River Bridge is completed and put into operation, the economic activities of the Project site will be strongly developed. Transportation as well as communication will benefit, goods exchange of the two districts with center of Hanoi will increase. Agricultural products of the district such as vegetables, fruits, flowers, etc., will be quickly transported and sold in Hanoi, thus will encourage development of agriculture in this area.

On the other hand, some of the farmers and fishermen in the Study Area will lose production opportunities such as paddy fields and fishponds due to project implementation.

(3) Traffic and Public Facilities

During the project construction phase, it is inevitable that the local residents will be affected by the increase of traffic volume by construction vehicles, waste material transportation and other construction works.

In order to mitigate impacts, it is necessary to make a detour road section for the road users, and to set a reasonable timetable for construction vehicles and waste material transportation aiming at avoiding rush hours in the section with dense traffic of the National Road No.1 and National Road No.5 in the affected area.

(4) Cultural Property

In the Project site, there are many places of historical, cultural importance such as temples, pagodas, and commune houses. At the time of setting up plan, more attention should be paid to avoid these places although impact during construction may be unavoidable. When the route is put into operation, the vibration of vehicles running on the route will affect structures of temples, pagoda and commune houses. The noise will also affect the people who come to visit these cultural properties.

It is predicted that the noise level at area near the right of way will greatly affect tourism if there is not a method for minimizing it. Increasing dust volume and deteriorating air quality at temples and pagodas along the route will reduce attractiveness.

(5) Public Health Condition

Some minor but adverse public health impacts need to be considered. Air pollution is mainly caused by dust. Gases discharging from automobiles and motorcycles may cause respiratory illnesses to people living near the construction site. Solid waste produced during the construction will increase water pollution and may cause digestive diseases of residents living around this area.

17.4.2 Natural Environment

(1) Land and Soil Erosion

The area outside the dyke, where the access road is built, must be protected from loosing its fertility. The excavation and filling work during construction may mix the nutritious cultivated soil on the surface with the poorly nutritious soil below. Consequently, when the construction and land rehabilitation are completed, the land may not be cultivable as most of remaining soil may be clay, sand, or gravel.

The alluvial sediments and soils of the Project site are relatively well structured and are not readily erodible. Also, the road and bridge construction methods are already taking into consideration methods to avoid soil erosion. However, for the long-term sustainability of the proposed bridge and road, it will be necessary to ensure that the bridge approaches and associated roads are built to remain stable.

(2) Water Resources and Hydrological Situations

Although the construction will be carried out taking into account the daily weather conditions, the construction cannot be stopped in the wet and stormy seasons. Therefore the drainage can hardly be prevented from blockage. Waste materials may cause surface and ground water contamination.

After the initial operation of the bridge and road, a hydrological system can lessen impacts. The direction modification may appear at some small stream, which may possibly affect the sewage and drainage systems, or ground water tables in occurrence of heavy long-lasting rain. However, the impact is negligible.

(3) Terrestrial and Aquatic Ecology

Cultivated lands, where vegetables, flowers, and fruit trees are grown may be affected in the construction phase due to waste, especially by oil. Oil leakage or spillage from boats, ships or equipment used for building the bridge may deteriorate water quality and aquatic ecological systems. However, these impacts are not great in the Study Area.

(4) Flora and Fauna

Vegetation cover such as paddy fields, crop plants (e.g., onions, garlics, tomatoes, potatoes, vegetables), and flower gardens in Tho Khoi commune, apple orchards and other fruit trees will be indirectly affected by some pollutants such as dust. However, the impacts are negligible.

In terms of fauna, the environmental impacts caused by the project implementation are not significant.

17.4.3 Pollution

(1) Air Quality

1) Suspended Particulate Matter (SPM)

Based on the results of the air sampling by the Environmental Study, concentration of SPM exceeds the Vietnam's Environmental Standard. During the construction phase, the actual traffic volume is generally increased mainly due to additional vehicles. The batching plant would also generate a considerable volume of dust. After the bridge is completed, the number of vehicles using bridge will be increase. SPM on the road is generated by friction between such surfaces as rubber tires - road, brake shoes - wheel rims and even by emission from engines, etc.

At present, there is no authorized method of forecasted SPM anywhere in the world. However, in general, findings from a study show that the SPM density by the traffic stream has a linear relationship with the number of the traffic vehicles.

In order to forecast SPM density on the Project for the years 2001, 2005, 2010, and 2020, an experimental formula set up by Center for Environmental Protection in Transportation (CEPT) based on the results of studies on several roads in Vietnam was applied. The method would be acceptable as long as proportion of types of vehicles and climate conditions are not different much from existing ones.

Experimental formula determines SPM density is (at 3 m from road pavement 3m, at the end of wind direction, and wind velocity at 1.85 m/second)

$$y = 0.000617993*x + 0.126706$$

where:

y : SPM density, mg/m^3
x : vehicle number per 10 minutes

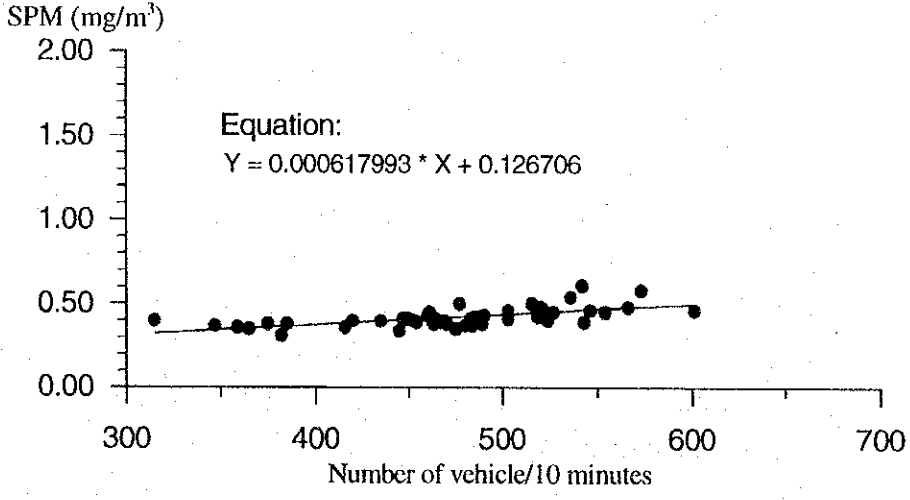


Figure 17.4.1 Relationship between SPM Density and the Number of Vehicles

The results of the forecasted SPM concentration for the years 2001, 2005, 2010 and 2020 are shown in Table 17.4.1.

Table 17.4.1 The Results of SPM Density Forecasted

Unit: mg/m^3

Year / Vietnam's Standard	SPM density	
	Average	Maximum
2001	0.35	0.93
2005	0.52	1.56
2010	0.64	1.99
2020	0.75	2.01
TCVN 5937-1995	0.20	0.30

The results of SPM density show that the SPM densities are 3 to 7 times higher than the present Vietnam's Environmental Standard values. Mitigation measures for these SPM impacts must be considered.

2) Carbon monoxide (CO), Nitrogen Oxides (NO_x), Hydrocarbons (CH)

The concentration of the three poisonous components of exhaust gas - CO, NO_x and CH - is forecasted for the years 2001, 2005, 2010, and 2020. The forecast applies the following formula:

$$C \;=\; 0.8 * E * [\exp[-\frac{(z+h)^2}{2*S_z^2}] \;+\; \exp[-\frac{(z-y)^2}{2*S_z^2}]] / (S_Z * U)$$

where:

C : Concentration of CO, NO, and CH (mg/m^3,
E : Emission source (mg/minutes)
Z : Height of forecasted point
h : The difference in height between road and the surrounding earth surface (m)
U : Wind velocity (m/second)
S_z: Factor of vertical diffusion

S_z is an equation of the distance along wind direction and can be calculated as follows:

$$S_z \;=\; 0.53 * X^{0.73}$$

where: X (m) is the distance from center of the road to the calculated point.

Emission source E depends on the number of vehicle, type of vehicle, type of fuel, and quality of the vehicle as well as wind direction. For calculating, the standards of exhaust gas for all types of vehicle is presented in 175/CP decree on October 18th 1994 guidelines were applied.

The results of the forecasted average concentration of CO, CH, and NO for the year 2001, 2005, 2010 and 2020 are shown in Table 17.4.2 and Table 17.4.3.

Table 17.4.2 Average (24 hour) Concentration of CO, CH, and NO in 2001 and 2005

Unit: mg/m^3

Type of gas	TCVN 5937 1995	Height (m)	Distance (m)			
			10	100	10	100
			Year 2001		Year 2005	
CO	40	2	4.8844	1.1636	8.8278	2.1031
		10	0.0152	0.9471	0.0275	1.7118
CH	-	2	1.0367	0.2470	1.8282	0.4356
		10	0.0032	0.2010	0.0057	0.3545
NO	0.4	2	0.7250	0.1727	1.2981	0.3093
		10	0.0023	0.1406	0.0040	0.2517

Table 17.4.3 Average (24 hour) Concentration of CO, CH, and NO in 2010 and 2020

Unit: mg/m^3

Type of gas	TCVN 5937 1995	Height (m)	Distance (m)			
			10	100	10	100
			Year 2010		Year 2020	
CO	40	2	12.1246	2.8885	18.9233	4.5082
		10	0.0378	2.351	0.0590	3.6693
CH	-	2	2.2056	0.5255	2.1675	0.5164
		10	0.0069	0.4277	0.0068	0.4203
NO	0.4	2	1.7040	0.406	2.3683	0.5642
		10	0.0053	0.3304	0.0074	0.4592

The following can be concluded based on the above-mentioned forecast results:

- All of the concentrations of CO are lower than those regulated by the Vietnam's Air Quality Standard TCVN 5937-1995.
- Most of the concentrations of NO at an elevation of over 10 m do not exceed the Vietnamese Standard TCVN 5937-1995. On the other hand, most of the concentrations of NO at an elevation of 2 m or below exceed Vietnam's Air Quality Standard TCVN 5937-1995.

This may prove that these pollution components will not have considerable influence on roadside residents before 2020. However, pollution components such as NO will have adverse effects on road users such as drivers and their passengers.

(2) Water Quality

Based on the results of water sampling carried out in 1998, water quality in most of the sampling points in the Study Area are not badly deteriorated. However, some small streams such as Kim Nguu River, are seriously polluted.

1) Methods of the analysis and forecast

Methods of the analysis on surface/ground water quality in the Study Area are according to the regulations of "Temporary Guidelines on the Environmental Monitoring Program", which was prepared by National Environmental Agency (NEA) of Ministry of Science, Technology and Environment (MOSTE) and the Vietnam's Water Quality Standard TCVN 5937-1995.

2) Results of the Analysis and Forecast

<u>During the Construction Phase</u>

During the bridge construction, the main water pollutant will be turbidity as the riverbed of the Red River is to be excavated to build pillars for the bridge. It is predicted that in the riverbed turbidity will increase around 3 times. Apart from the bridge construction, turbidity will increase greatly when it rains. Due to the current of river, the turbidity influence only occurs in the lower section of river; there is no turbidity influence in the upper section of the river.

pH: In general, pH of water in this Study Area will decrease; the main reason being that sulfuric acid will be released from excavated soil by rainwater. The process forming sulfuric acid from FeS_2 is very complex and occurs through many reactions. This process can be described by the following chemical reaction:

$$FeS_2 \quad + 15/4\, O_2 \quad + 14/4\, H_2O \quad = 2\, H_2SO_4 \quad + Fe\,(OH)_3$$

pH can be reduced to 0.3 units during the bridge construction; of course, pH is affected by other factors such as household wastewater, oil from vehicles and machines, solutions from making concrete etc.

DO: The expected concentration of Dissolved Oxygen (DO) in water will increase 1.5 times. The reason is that oxygen is dissolved much more as water is always stirred during the underwater construction. On the other hand, creatures in water move away due to the high turbidity and noise, thus oxygen consumption will decrease. BOD increases because of water pollution by waste water from workers, the result being that the oxygen consumption increases, but dissolved oxygen in water is higher than that of oxygen consumption. Therefore, DO still increases.

BOD: Due to the concentration of workers in the bridge constructing area, water organic pollution will be increased by waste and wastewater. The expected Bio-chemical Oxygen Demand (BOD) will increase 1.2 times compared with Vietnam's Environmental Standard.

COD: Chemical Oxygen Demand (COD) is closely related with BOD. During the construction phase, wastes contain many chemicals which damage the environment. The expected COD will be 1.7 times higher than that of normal level. However, this increase is temporary, after completing the bridge construction, COD and BOD will resume to previous levels.

NO_3^-: The concentration of nitrate (NO_3^-) only exists after finishing bio-oxidizing process. During the construction phase, the concentration of oxygen in water increases, and the bio-chemical oxidizing process also increases, therefore the concentration of nitrate decreases. The reduction of nitrate occurs in the constructing area, while the concentration of nitrate increase in the residential area due to wastewater from household and services.

NO_2^-: Nitrite (NO_2^-) is the middle product of the oxidizing process ammonia or deoxidizing nitrate. In the bridge and road construction, if waste management is not efficient, the concentration of nitrite will be much higher. High concentration of nitrite damages health conditions of the settlers.

Heavy metals Cr^{3+}, Ni^{2+}, and $Cu2^+$: During excavation of the construction of the Bridge pillars, heavy metals are diffused from sediment. The result is that the concentration of heavy metals in water will be higher. It depends on the concentration of heavy metals in sediment. The Red River Bridge is situated far from industrial zones, so there are no heavy metals in sediment. Especially, there is no water pollution of Cr^{3+}, Ni^{2+} and Cu^{2+} in the Study Area.

Oil pollution: During the bridge and road construction, oil pollution usually occurs. Due to the high density of vehicles and machines, oil scatter in the construction area is inevitable. Sometimes accidents cause oil scatter. According to existing data, there has been oil pollution in the large construction areas. Especially in the repair stations, lubricant is often spilled. If the construction period is long, both surface waters and underground water will be polluted by oil. It is predicted that oil pollution could be 2-3 times higher that of the Red River Bridge construction area;

Pb: Lead (Pb) pollution mainly depends on the character of transport. Using leaded petrol as fuel is the main cause of the lead pollution. Lead dust condensed from vehicle fume follows rainwater to rivers or lakes. Therefore the concentration of lead in water goes up.

Table 17.4.4 shows results of the forecast water quality during the construction phase in the Project Site.

Table 17.4.4 Results of the Forecasted Water Quality During the Construction Phase

Parameter	Unit	Location		TVCN
		Bridge Site on Red River	Yen So and Linh Dam Lake	
pH		7.5 - 7.7	7.6 - 7.8	5.5 - 9.0
TS	mg/l	180 - 230	350 - 400	-
SS	mg/l	60 - 80	230 - 280	100
Turbidity	-	55 - 70	110 -130	-
DO	mg/l	8 - 9	6 - 8	≥6
COD	mg/l	9 -12	35 - 40	100
BOD	mg/l	8 -10	25 - 30	50
NO_3^-	mg/l	0.4 - 0.5	1.2 - 1.5	10
NO_2^-	mg/l	0.01 - 0.015	0.06 - 0.08	0.01
SO_4^{2-}	mg/l	13 - 15	26 - 28	-
PO_4^{3-}	mg/l	0.12 - 0.15	0.2 - 0.25	6
Cr^{3+}	mg/l	0.003	0.002	1
Ni^{2+}	mg/l	0.003 - 0.004	0.003	1
Cu^{2+}	mg/l	0.02 - 0.025	0.003	1
Oils	mg/l	0.085 - 0.012	0.12 - 0.15	1

During the Operation Phase

After completion of construction, water pollution as described above does not occur. The water environment resumes to that before the Bridge construction. Roads and bridges do not cause water pollution directly; they are indirect reason of water pollution. Leaking accident of fuels or toxic chemicals may cause any environmental damage especially for water. Table 17.4.5 shows results of the forecasted water quality during the operation phase in the Project Site.

Table 17.4.5 Results of the Forecasted Water Quality During the Operation Phase

Parameter	Unit	Location		TVCN
		Bridge Site on Red River	Yen So and Linh Dam Lake	
pH		7.8 - 8.0	7.7 - 7.9	5.5 - 9.0
TS	mg/l	140 - 150	350 - 400	-
SS	mg/l	45 - 60	150 - 180	100
Turbidity	-	40 - 50	80 - 90	-
DO	mg/l	7 - 8	5 - 6	≥6
COD	mg/l	8 - 10	20 - 25	100
BOD	mg/l	6 - 8	15 - 18	50
NO_3^-	mg/l	0.3 - 0.4	0.7 - 0.8	10
NO_2^-	mg/l	0.008 - 0.01	0.15 - 0.18	0.01
SO_4^{2-}	mg/l	9 - 12	15 - 18	-
PO_4^{3-}	mg/l	0.008 - 0.01	0.15 - 0.18	6
Cr^{3+}	mg/l	0.002	0.002	1
Ni^{2+}	mg/l	0.002 - 0.003	0.003	1
Cu^{2+}	mg/l	0.015 - 0.02	0.002	1
Oils	mg/l	0.07 - 0.08	0.09 - 0.12	1

The following can be concluded based on the above-mentioned analysis results.

- Most of the concentrations of the water pollutants will remain within the parameters of Vietnam's Water Quality Standard. Water pollution by the project implementation will be not significant.
- Suspended Solid (SS) and Nitrite (NO_2^-) in Yen So and Linh Dam Lake will be higher than that regulated by Vietnam's Water Quality Standard.

(3) Noise

1) Traffic Noise

Based on the results of the noise sampling by the Environmental Study, noise levels at most of the sampling points in the Study Area are higher than that regulated by the Vietnamese Noise Standard in public and residential area (TCVN 5949-1998)

Forecasting Parameters and Method

The following formula was applied to forecast traffic noise levels:

$$L_A = 10\log(N_C + EN_t) + 20\log V - 10\log\left(d + \frac{w}{3}\right) + 10\frac{\theta}{180} + \Delta_d + \Delta_{vl} + 14$$

where:

L_A : Equivalent noise level at a point per 1 hour (dB (A))
N_c : Number of vehicle for calculated cars per hour (vehicle/hour)
E : Multiplier of the effectiveness of noise generated by car and lorries
N_t : Number of vehicle for calculated lorries per hour (vehicle/hour)
V : Average velocity of the traffic flow (km/h)
d : Distant from the edge of the road to a calculated point (m)
w : Road width (m)
θ : Vision direction from observation point toward the road
Δ_d : Adjustment factor for road pavement.(0-3dB(A))
Δ_{vl} : Adjustment factor for road gradient (0-5dB(A))

Table 17.4.6 shows the above E values.

Table 17.4.6 Values of E

Gradient (%) / Traffic low velocity (Km/h)	≤2	3	4	5	≥6
120	4	5	5	6	6
100	5	5	6	6	7
80	7	9	10	11	12
50	10	13	16	18	20

Note: Noise level in peak hour is calculated by 10-15% of the traffic volume per day.

The following formula could apply to calculate noise level despite distance:

$$L_{dt} = L_A - \Delta L_d = L_A - 10(1-a)\log d_t$$

where:

L_{dt} : Noise intensity at calculated point (dB)
d_t : Distance from the forecasted point to calculated point (m)

Coefficient depends on earth surface as follows:

a = 0.1 for hard surface (concrete or asphalt concrete)
a = 0.0 for the surface
a =-0.1 for grass areas

where:

- Distance from the edge of the road to calculated point d_1 : =7,5 m, d_2=100 m
- Gradient 3 %
- Average velocity of the traffic flow V := 60 km/h
- Road width: W := 22 m
- Vision direction from observation point toward the road θ : = 180^0
- Adjustment factor for the road pavement Δ_d : = 0 dB (A)
- Adjustment factor for the road gradient Δ_{VL} : = 0 dB (A)

Results of the Forecast and Analysis

The results of forecasted noise level for several years is shown in Table 17.4.7 and Table 17.4.8.

Table 17.4.7 Forecast Average Noise Level in a Day

Unit: dB (A)

Category	Year	TCVN 5949-1998	Distance (m)	
			7.5	100
Leq(1h)	2001	75	84.5	75.9
Leq(1h) max.	2001	75	87.0	78.4
Leq(1h)	2005	75	87.1	78.5
Leq(1h) max.	2005	75	89.6	81.0
Leq(1h)	2010	75	88.4	79.9
Leq(1h) max.	2010	75	91.0	82.4
Leq(1h)	2020	75	89.9	81.2
Leq(1h) max.	2020	75	92.5	83.9

Table 17.4.8 Forecast Average Noise Level in Daytime and at Night

Unit: dB (A)

Category	Year	TCVN 5949-1998	Distance (m)	
			7.5	100
Leq(1h) 6 am - 10 pm	2001	75	85.4	76.8
Leq(1h) 10 pm - 6 am	2001	50	82.0	73.4
Leq(1h) 6 am - 10 pm	2005	75	88.0	79.4
Leq(1h) 10 pm - 6 am	2005	50	84.5	75.9
Leq(1h) 6 am - 10 pm	2010	75	89.4	80.8
Leq(1h) 10 pm - 6 am	2010	50	85.6	77.0
Leq(1h) 6 am - 10 pm	2020	75	90.9	82.3
Leq(1h) 10 pm - 6 am	2020	50	86.0	77.4

The following can be concluded based on the above-mentioned forecast results.

- The forecasted noise levels along both sides of the proposed road exceed the Vietnam's Standard on the noise in public and residential areas (TCVN 5949-1998) for daytime and at night as well as for average noise level in a day.
- In the proposed resettlement sites (X1, X2, X3, X4, X5, X6), which are located away from the road approximately 100m, the forecasted noise

levels exceed the values of the TCVN 5949-1998.

- Therefore, it is required to consider mitigation measures for future traffic noise in the Study Area.

2) Construction Noise

The construction noise impact by the Project is temporary. The following construction activities and machinery are associated with possible noise:

- Piling, sheet piling
- Vehicles, other equipments, personnel on construction sites

During the bridge construction, the major noise source will be pile driving. The driving methods normally used for piling and sheet piling are:

- Ramming
- Vibration
- Drilling

Earthwork equipment may also generate high noise levels and will be concentrated where fill is required. Workers and people living near the proposed bridge site and the approach roads would be affected by excessive noise during the construction phase.

(4) Vibration

The following construction activities and machinery are associated with possible vibrations:

- Vehicles on construction sites
- Piling
- Vibratory compaction
- Excavation by heavy equipment

With respect to the bridge vibration during the operation phase, vibration of the bridge deck may cause the following effects:

- Endangering the load-carrying capacity of the bridge

- Impairing the safety of the vehicles
- Impairing the serviceability of adjacent structures

However, these impacts could be mitigated by appropriate construction methods.

(5) Waste

Most of the construction wastes are miscellaneous materials such as rock, sand, gravel. They are not only non-usable but also hamper traffic and harm cultivated soil. The second kind of waste is material - cleaning water and water drained from mixing concrete. They contain toxic substances, which may cause soil contamination and water pollution. However, these waste problems by the Project implementation will be avoidable if construction work is carried out properly.

17.4.4 Environmental Evaluation

Obviously, most of the future environmental impacts in the construction and operation phase are not purely due to Red River Bridge Construction Project. Air pollution or noise and vibration along the Project site will be caused by future industrial and agricultural development around the site or increase of traffic on Ring Road No.3 due to economic growth throughout the country.

On the contrary, the Project will contribute to improvement of air quality and to mitigation of noise and vibration around the Project site, as traffic flow will be smoother.

Based on the above-mentioned analyses and forecasts, the following environmental evaluation during the construction and operation phase could be summarized as shown in Table 17.4.9.

Table 17.4.9 Environmental Evaluation

No.	Environmental Element	Evaluation	Main Impacts and Reasons
Social Environment			
1	Resettlement	▲(C) ▲(O)	About 1,200 households and 6,000 persons need to resettle due to the Project. Also, about 120 ha of agricultural lands will be lost. The resettlers are forced to adapt to new living conditions.
2	Economic Activity	▲ (C) ● & ▲ (O)	Agricultural fields will be lost in some portions near the right of way. However, most of the residents' economic activities will be vitalized by the Project.
3	Traffic/Public Facilities	Δ (C) Δ (O)	The right of way is designed to avoid passing important public facilities such as hospitals, schools, and community centers. However, one community school at Xen So area will be demolished.
4	Community Severance	Δ (C) Δ (O)	As the right of way is designed to pass at only a portion of a densely commune, some community severance in the site may be inevitable.
5	Cultural Property	-	The right of way is kept away from important cultural properties except for one local pagoda in Thanh Tri district.
6	Right of Common	-	There are no specific regulations for the water and fishing rights.
7	Public Health Condition	-	Public health issues will not be affected by the Project.
8	Waste	Δ (C)	Many kinds of construction waste will generate by the Project
9	Hazards (Risk)	-	Risk of hazards will not increase by the Project implementation.
Natural Environment			
10	Topography and Geology	-	As the Project scale is not large, change of topography and geology will not occur due to the Project.
11	Soil erosion	Δ (C)	Topsoil erosion by rainfall after vegetation removal may occur at the project construction phase.
12	Groundwater	-	Groundwater level/quality are in relatively good condition. Change of the distribution of groundwater will not occur due to the Project.
13	Hydrological Situation	-	Change of the river discharge and riverbed condition will not occur due to the bridge construction structures of the Project.
14	Coastal Zone	-	The Study Area does not include any coastal zone.
15	Fauna and Flora	-	There are no endangered/rare species in the Study Area and adverse impacts on the ecosystem by the Project will be light.
16	Meteorology	-	Change of meteorological conditions will not occur.
17	Landscape	Δ (C) ● (O)	Although aesthetic deterioration may occur due to the construction wastes etc., the bridge's design is taking into account harmony with local natural view.
Pollution			
18	Air Pollution	▲ (C) ▲ (O)	As the traffic volume will be increased mainly due to truck vehicles, air pollution especially SPM caused by the Project at the construction phase may occur. Air quality monitoring is needed.
19	Water Pollution	Δ (C)	Increase in water pollution by the Project at the construction phase mainly due to the construction
20	Soil Contamination	-	As the construction methods will consider the countermeasures for soil contamination, the adverse impact will be small.
21	Noise and Vibration	▲ (C) ▲ (O)	As the right of way is designed to pass very close to houses and a pagoda at two small sections in Thanh Tri district, the traffic noise by the Project will be affect the residents near the facilities.
22	Land Subsidence	-	As the construction methods will consider the countermeasures for land subsidence, the impact will be very small.
23	Offensive Odor	-	There are very few factors generating offensive odor by the Project.

Note: 1) Evaluation Categories

●: Potential significant favorable impact is expected. ○: Potential slight favorable impact is expected.

▲: Potential significant adverse impact is expected. Δ: Potential slight adverse impact is expected

2) (C) = Construction Phase, (O) = Operation Phase

17.5 Environmental Management Plan

Based on the analyses and forecasts of possible significant adverse impacts, it is recommended that the following environmental elements should be considered as items for environmental management plan of this Project:

During the Construction Phase

- Resettlement
- Community Severance
- Air pollution
- Water Pollution
- Noise

During the Operation Phase

- Resettlement
- Air Pollution
- Water Pollution
- Noise

In terms of the resettlement and community severance, recommended mitigation measures and their costs as well as action plan was described in Chapter 10 and Chapter 11 of this report. An environmental management plan including mitigation measures and their cost estimates for air pollution, water pollution, and noise are described and recommended in this section.

17.5.1 Environmental Mitigation Measures

(1) Mitigation Measures for Air Pollution

During the Construction Phase

The following measures for air pollution are recommended as effective countermeasures during the construction phase:

- Keep loose construction materials such as sand and filling dirt covered while being transported from quarry area to storage site.

- It is necessary to sprinkle water, especially on the detour road in order to reduce dust which will be generated by increase in traffic by construction vehicles

- Toxic or polluting materials should not be used to start or maintain fires. Burning should be maintained to produce minimal amounts of air pollution.

During the Operation Phase

During the operation phase, air pollution will occur mainly due to dust and smoke by the increase in traffic. The following measures for air pollution are recommended as effective countermeasures:

- Sprinkling water on the road surfaces twice a day at peak hours, especially in the residential areas, schools, pagodas, churches, and other public facilities along both sides of the road.

- Planting trees along both sides of the new roads. The method to plant trees is to be discussed with Hanoi Fresh Tree Company in order to choose types of plants which grow quickly and are suitable for the soil of the Project Site.

- In areas where the farmers cultivate rice, flowers, and vegetables such as tomatoes, and cabbages, the line that borders upon the road should be combined with shrub plantings. Also, a line behind it of taller trees with leaf canopy creates a thick and effective "tree-wall" for dust.

Table 17.5.1 shows the recommended planting for the mitigation of air pollution.

Table 17.5.1 Recommended Planting for the Mitigation

No.	Road Section	Length of Planted Section	Number of Trees	Tree Interval (m)
1	Phap Van-Dike Red River (from KM 1 to KM 7)	6,3 Km (one side)	850	8
2	Dike Gia Lam to Linh Dam (from KM 10 to KM 13)	3.0 Km (both sides)	850	8
Total length of the planted roads		9.3 Km	1,700	

(2) Cost Estimate of Mitigation Measures for Air Pollution

The cost estimate of mitigation measures for air pollution is shown in Table 17.5.2.

Table 17.5.2 Estimated Costs of Mitigation Measures for Air Pollution

	Categories	Cost (US$)
1	Covering of construction material on the construction vehicles	20,000
2	Sprinkling equipment for road	30,000
3	Road sprinkling cars: 2 vehicles	50,000
4	Smoke filter equipment of concrete mixing plants and electric generator with high power	25,000
5	Planting trees on both sides of roads in the first 3 years	80,000
6	Sprinkling systems for trees	25,000
Total Cost		230,000

(3) Mitigation Measure for Water Pollution

<u>During the Construction Phase</u>

The following measures for water pollution are recommended as effective countermeasures during the construction phase :

- Clean and dirty runoff must be kept separate; the dirty runoff area (from truck washing, batching area, materials unloading area) must be isolated by a boundary or mounded barrier;
- Dirty runoff water must be channeled to a settling pit, to collect fine sediment and sediment slurry;
- Water from the settling pits can be recycled, by pumping back to the bathing or washing areas;
- More than one pit will be required so sediment can dry out for removal. Some sediment and slurry can be reused;
- To protect susceptible surface with mulch or fabric, and to plant eroded surfaces as soon as possible to mitigate water degradation by increased sediment;

- To collect and recycle lubricants, and to take measures to avoid accidental spills and mitigate water contamination by oil, grease, fuel and paint in equipment yards and asphalt plants; and,

- To prevent toxic waste from polluting the river by constructing temporary dykes.

During the Operation Phase

When the construction is finished, the concrete batching plants site and construction camp sites must be restored. However, the following measures should be considered:

- To prevent contamination of the Red River from accidental spills, or pollutants deposited on the bridge pavement by vehicles;

- Collecting runoff in gutters and direct it into a rubble and sand drain before discharge via a grassed or vegetated channel. The rubble drain should be able to be closed off to contain a major liquid spillage on the bridge; and

- If this runoff control mechanism is rejected as being too expensive, the design should be modified to minimize the inevitable contamination of the river. In this case, drainage scupper outlets should direct storm-water runoff to areas immediately downstream of the bridge piles, into the zones of maximum water turbulence.

(4) Cost Estimate of Mitigation Measures for Water Pollution

The cost estimate of mitigation measures for water pollution is shown in Table 17.5.3.

Table 17.5.3 Estimated Costs of Mitigation Measures for Water Pollution

	Categories	Cost (US$)
1	Water quality sampling and analyses fee during the construction phase	18,000
2	Equipment to measure pH	110
3	Chemical substances (water treatment)	100
4	Other materials to prevent from water pollution during the construction phase	600
	Total Cost	18,810

(5) Noise Mitigation Measures

During the Construction Phase

Many construction activities may increase ambient noise to a level that exceeds TCVN 5949-1998 standards. The five following activities would be the most possible significant noise sources in this Project:

- Concrete mixing;
- Pile driving for bridges and viaducts;
- Rock blasting and drilling;
- Earth moving; and,
- Generator operation.

In order to mitigate the above noise nuisances, the following measures would be applied:

- Transportation of as much raw material as possible by barge rather than truck;

- Ensuring that unloading of sand and aggregate into storage bins is conducted during daylight hours, and that loading trucks, mixing operations and pumping is carried out during normal working hours, or away from residential areas;

- To utilize low-noise/low-vibration type of construction equipment and work methods; and

- To use heavy equipment for construction only in the daytime period with notice to the residents around the activity sites, with least possible effect on the construction schedule.

During the Operation Phase

To minimize noise levels created by all vehicles during the operation phase, it is necessary to consider the following measures:

Noise monitoring at the baseline monitoring stations will be invaluable in determining the noise level changes due to the operation of the Project. Those geographic locations that exceed TCVN 5949-1998 can be reduce noise levels by:

- Posting of signs that prohibit the use horns;
- Landscape planning and the construction of noise barriers to reduce noise levels in densely populated areas or near schools or clinics.

In addition to the above mitigation measures, the Government of Vietnam promotes policies and programs, which ensure that motorized vehicles meet noise level standards issued by TCVN 5948-1995.

Nevertheless, if the noise level could not be achieved the conservation targets, two noise barriers should be used to reduce the noise levels as one of the most effective physical measures. The following characteristics can be recommended for the noise barriers:

• Minimum Height:	10 inches
• Thickness:	4 inches
• Transmission Loss:	36 dBA
• Material:	Light concrete

The noise barriers should be constructed on the left side of the proposed route for the section from KM 4.000 to KM 6.500 (at Yen So community) and from KM 10.500 to KM 11.500 (at Cu Khoi community), where primary schools and densely populated residential areas are located close to the route.

(6) Cost Estimate of Mitigation Measures for Noise

In terms of noise, the cost of the mitigation measure mainly depends on the more broad environmental policies for transportation sector in Vietnam, except for the cost of the above proposed noise barrier, which could be estimated at approximately US$ 71,500 for this project.

17.5.2 Environmental Monitoring Plan

The objectives of environmental monitoring for environmental management are to evaluate environmental conditions periodically and systematically, and to implement various mitigation measures in order to achieve conservation targets, which are set up to maintain desirable environmental conditions.

(1) Administrative Framework for Environmental Management

The two following organizations are the key agencies and entities in terms of environmental management in Vietnam:

- Ministry of Science, Technology and Environment (MOSTE)
- National Environmental Agency (NEA)

In this Project case, PMU Thang Long has a responsibility for the environmental monitoring as the implementing agency of the Project

In most of countries, including Vietnam, an environmental monitoring has a very important role to maintain the desirable environmental conditions in a certain area as one of the national environmental policies. However, most development projects, including transport development projects, have not been implemented with sufficient environmental monitoring in Vietnam as yet. This is due to the fact that the above three organizations still suffer from the lack of technical staff in order to conduct the environmental monitoring for the development projects.

On the other hand, the Center for Environmental Protection in Transport (CEPT) is one of the candidate organizations that could conduct environmental monitoring for this project, with the following experiences in Vietnam:

- Investigation and preparation of the EIA reports for the industrial facilities, and improvement projects in the transportation field;
- Consulting of the environmental conservation in the transport projects;
- Preparation of the EIA reports in the pre-feasibility and feasibility stages of the infrastructure development projects in transport including the main road, highway, railway, port, habour, and airport;
- Involvement in the national environmental standard and regulation revision in Vietnam, and training program in the environmental protection in transport field; and
- Various data analyses and processing skills on air, water, and noise samples.

Therefore, it is recommended that the CEPT conduct environmental monitoring as the implementing agency.

(2) Conservation Targets

Based on the results of the forecast of possible significant adverse impacts by the Project, the following environmental elements each need a conservation target in order to maintain the desirable environmental conditions in the Study Area.

- Air Quality
- Water Quality
- Noise

Air Quality

Although the results of the air quality forecast in the Study Area are not at a serious pollution level, the concentration of air pollutants will be increased by the Project. Therefore, Vietnam's present air quality standard's SPM, NO_2, SO_2, CO, CH, and Pb values should be set up as the conservation targets for the air quality of this Project.

Water Quality

Although the results of the water quality forecast in the Study Area are not at a serious pollution level, Vietnam's present.water quality standard pH, SS, DO, COD, BOD, P_{total}, Al, and Fe values should be set up as the conservation targets for the water quality of this Project, as there is a possibility of deterioration in the water quality in the Study Area, especially for the Project construction phase.

Noise

Based on the results of the noise forecast in the Study Area, noise problems are at a serious level. But this level will be not caused only by the Project. This situation is caused mainly due to the lack of environmental awareness of traffic noise.

It is difficult to apply the present Vietnam's noise standard value (75 dB (A)) as the conservation target of the Project under present traffic situations and driving manners.

Therefore, 80 dB (A) should be set up as the conservation target for noise during the construction phase of this Project as the first step. Then, 75 dB (A) should be applied as the conservation target during the operation phase of this Project.

(3) Environmental Monitoring

The following are guidelines for planning the environmental monitoring for the Project:

- The monitoring and sampling sites should be chosen based on the availability of the sampling;
- The sampling should be conducted under similar conditions, e.g. weather, in order to properly compare the time series data.

Since the characteristics of possible significant impacts differ between the Project construction phase and operation phase, the environmental monitoring should be divided into the following two phases based on the Project construction schedule:

- Construction phase is from 2001 to 2005
- Operation phase is from 2005 to 2010

During the Construction Phase

1) Air Quality

Table 17.5.4 shows the monitoring items and the monitoring format for the air quality during the construction phase.

Table 17.5.4 Air Quality Monitoring Items during the Construction Phase

	Items		Sampling items					
			SPM	SO_2	NO_2	CH	CO	Pb
1	Location	M_1						
		M_2						
		M_3						
		M_4						
		M_5						
2	Period		1 day/ month for 5 year					

Note: M1: Intersection between NH5 and Third Ring Road
M2: Intersection between NH1 and Third Ring Road
M3: Resettlement site X5
M4: Resettlement site X3
M5: Resettlement site X6
Sampling quantity: 6 samples/ day/ point

2) Water quality

Table 17.5.5 shows the monitoring items and the monitoring format for the water quality during the construction phase.

Table 17.5.5 Water Quality Monitoring Items during the Construction Phase

No	Items		Sampling items							
			pH	SS	COD	BOD	DO	P_{total}	Al	Fe
1	Location	M_1								
		M_2								
		M_3								
2	Period		2 time/ week for 5 year							

Note: M1: At the Yen So lake
M2: At the Linh Dam Lake
M3: At the Red River (at the construction point)

3) Noise

Table 17.5.6 shows the monitoring items and the monitoring format for noise during the construction phase.

Table 17.5.6 Noise Monitoring Items during the Construction Phase

TT	Items		Equivalent Noise Level L_{eq} (dB (A))
1	Location	M_1	
		M_2	
		M_3	
		M_4	
		M_5	
2	Period		1 day/ month for 5 year

Note: M1: Intersection between NH5 and Third Ring Road
M2: Intersection between NH1 and Third Ring Road
M3: Resettlement site X5
M4: Resettlement site X3
M5: Resettlement site X6
Sampling quantity: 24 samples/ day/ point

During the Operation Phase

1) Air Quality

Table 17.5.7 shows the monitoring items and the monitoring format for air quality during the operation phase.

Table 17.5.7 Air Quality Monitoring Items during the Operation Phase

TT	Items		Sampling items					
			SPM	SO_2	NO_2	CH	CO	Pb
1	Location	M_1						
		M_2						
		M_3						
		M_4						
		M_5						
2	Period		1 day/ 6 month for 5 year					

Note: M1: Intersection between NH5 and Third Ring Road
M2: Intersection between NH1 and Third Ring Road
M3: Resettlement site X5
M4: Resettlement site X3
M5: Resettlement site X6
Sampling quantity: 6 samples/ day/ point

2) Water Quality

Table 17.5.8 shows the monitoring items and the monitoring format of water quality during the operation phase.

Table 17.5.8 Water Quality Monitoring Items during the Operation Phase

No	Items		Sampling items							
			pH	SS	COD	BOD	DO	P Total	Al	Fe
1	Location	M_1								
		M_2								
		M_3								
2	Period		2 time/ month for 5 year							

Note: M1: Interchange between Red River and Third Ring Road
M2: Yen So Lake
M3: Linh Dam Lake

3) Noise

Table 17.5.9 shows the monitoring items and the monitoring format for noise during the operation phase.

Table 17.5.9 Noise Monitoring Items during the Operation Phase

	Items		Equivalent Noise Level L_{eq} dB (A)
1	Location	M_1	
		M_2	
		M_3	
		M_4	
		M_5	
2	Period		1 day/ 6 month for 5 year

Note: M1: Intersection between NH5 and Third Ring Road
M2: Intersection between NH1 and Third Ring Road
M3: Resettlement site X5
M4: Resettlement site X3
M5: Resettlement site X6
Period: 24 samples/ day/ point

(2) Environmental Monitoring Cost

The cost of the above-mentioned environmental monitoring during the construction phase could be estimated, which is shown in Table 15.5.10.

Table 17.5.10 Estimated Cost of Environmental Monitoring during the Construction Phase (2001-2005)

No	Study Contents	Unit	Quantity	Unit Price (USD)	Cost (USD)
1	Water quality (3 sites, 2 time/week, for 5 years)				
	1) Analyze Sampling Items				
	pH	Sample	1,440	1	1,440
	SS	-	1,440	2	2,880
	COD	-	1,440	2	2,880
	BOD	-	1,440	3	4,320
	DO	-	1,440	2	2,880
	P Total	-	1,440	2	2,880
	Al	-	1,440	2	2,880
	Fe	-	1,440	2	2,880
	2) Rent car	Day	480	10	4,800
	3) Manpower	Person	960	5	4,800
	Sub Total				32,640
2	Air quality (5 sites, 6 samples/day, 1day/month, for 5 years)				
	1) Analyze Sampling Items				
	SPM	Sample	1,800	4	7,200
	SO_2	-	1,800	4	7,200
	NO_2	-	1,800	4	7,200
	CH	-	1,800	4	7,200
	CO	-	1,800	4	7,200
	Pb	-	1,800	6	10,800
	2) Rent car	Day	60	10	600
	3) Manpower	Person	120	5	600
	Sub Total				48,000
3	Noise (5 sites, 24 samples /day, day/month, for 5 years)				
	1) Analyze Sampling Items				
	Leq	Sample	7,200	1	7,200
	2) Rent car	Day	60	10	600
	3) Manpower	Person	120	5	600
	Sub Total				8,400
	Total (Construction Phase)				89,040

The cost of the above-mentioned environmental monitoring during the operation phase is estimated shown in Table 15.5.11.

Table 17.5.11 Estimated Cost of Environmental Monitoring during the Operation Phase (from 2006)

No.	Item	Unit	Quantity	Unit Price (USD)	Cost (USD)
1	Water quality (3 sites, 2 time/ month, for 5 years) 1) Analysis Sampling Items				
	pH	Sample	360	1	360
	SS	-	360	2	720
	COD	-	360	2	720
	BOD	-	360	3	1,080
	DO	-	360	2	720
	P Total	-	360	2	720
	Al	-	360	2	720
	Fe	-	360	2	720
	2) Rent car	Day	240	10	2,400
	3) Manpower	Person	480	5	2,400
	Sub Total				10,560
2	Air quality (5 sites, 6 samples/day, 1day/month, for 5 years) 1) Analysis Sampling Items				
	SPM	Sample	1,800	4	7,200
	SO_2	-	1,800	4	7,200
	NO_2	-	1,800	4	7,200
	CH	-	1,800	4	7,200
	CO	-	1,800	4	7,200
	Pb	-	1,800	6	10,800
	2) Rent car	Day	60	10	600
	3) Manpower	Person	120	5	600
	Sub Total				48,000
3	Noise (5sites, 24 samples /day, 1day/month, for 5 years) 1) Analysis Sampling Items				
	Leq	Sample	7,200	1	7,200
	2) Rent car	Day	60	10	600
	3) Manpower	Person	120	5	600
	Sub Total				8,400
	Total (Operation Phase)				66,960

The total cost of the environmental monitoring for the Red River Bridge Construction Project will be approximately US$156,000.

CHAPTER 18 LANDSCAPES

CHAPTER 18 AESTHETICS AND LANDSCAPING

18.1 General

Aesthetic design and landscaping of the Than Tri Bridge project are carried out to enhance the symbolism of the bridge as a landmark along the Red River. For drivers the proposed bridge tower would be recognized as their passing points while driving over the bridge, and the tower would become a new landmark of the vicinity and a monument for the 21st century in Hanoi.

Frontage road is to be allocated along with the third link road as an expressway, since the frontage road will function as a collector road serving for community activities. Sidewalk of the frontage road is to be furnished with rows of roadside trees for establishing a provision of greenery and planting of roadside trees would lead to enhancement of the community township landscape and environment.

Plantings are provided at the site of the administration office at the toll plaza and administration office of the road department. Plantings would enhance these facility spaces to be a green rich atmosphere among the solid environment of the expressway.

18.2 Objectives of Landscape

(1) Landscaped Object as a Symbol of the Red River Bridge Project

The Red River Bridge is composed of 3 types of bridge, namely a main bridge, approach bridges and dyke bridges. Total length of the Red River Bridge is to be 1.3 km. Each bridge component has different structure type with different bridge spans. The main bridge has longer span in length and the dyke bridge has shorter span, the approach bridges have the shortest span lengths. Distribution of bridge piers composition formulates a landscape with balanced scenery and rhythmical gradation. The bridge top forms a longer continuous flat, and perception by vehicle drivers would seem to be rather simple and longer while driving through. The bridge tower contributes making a landscape focus and enhances bridge aesthetics and comes to be a significant focal object at the crossing point of the Red River. The bridge tower is composed of two pairs of main tower and sub tower and they will become a distinctive landmark of the Red River Bridge as a whole.

(2) Landscape Establishment by Roadside Tree Planting

The frontage road along the third link road plays a role in development of adjacent township. Planting of roadside trees will provide and enhance environmental conditions of vicinity townships as one infrastructure element.

18.3 The Bridge Tower

(1) Main Bridge Tower

The main bridge tower is placed at the end pier of the dyke bridge and the foundation base of the tower is unified with the bridge sub-structure, and the bridge tower stands on top of the foundation base.

The foundation base is 5 m x 4.5 m to 6.2 m in length, 3.0 m in height and buttress 6.3 m in height. The tower is composed of three portions of square columns with 21.35 m in total height. Bottom column has 2.0 m in each side, middle has 1.5 m and upper column has 1.0 m. And column head with lightening rod is facilitated on the top of the tower. The design of the bridge tower is based on the inherited art-deco style, which Hanoi citizens are fond of.

(2) The sub- bridge tower

The sub-bridge tower is facilitated at both pier ends of the main bridge; foundation base of the tower is unified with the bridge sub-structure same as the main bridge tower. The foundation base has a dimension of 7 m x 3.5 m to 5.8 m in length, 2.5 m in height and buttress has 6.65 m in height. The tower is composed of three square columns with 13.1 m in total height. Bottom, middle and upper columns have the same dimensions on each side as the main tower, also same as for column head with lightening rod. Figure 18.1 shows elevations of the main and sub-bridge tower.

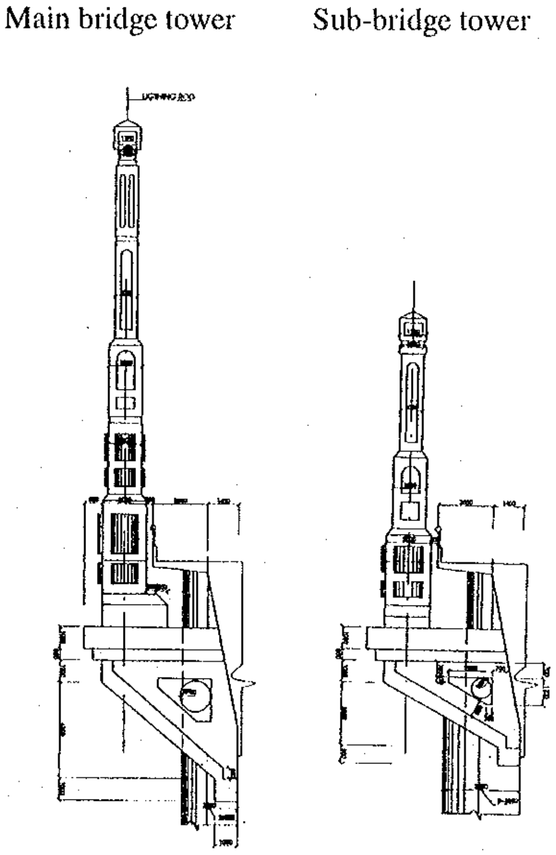


Figure 18.3.1 Elevation of the Main and Sub Bridge Tower

18.4 Planting

(1) Planting at the Frontage Road

Roadside trees are to be planted along the frontage road in order to enhance and improve the vicinity township environment as well as landscape. For selection of tree species, they should have balanced form with good crown either round or umbrella type in shape, as they grow for providing enough shadow in hot season, also having attractive flowers in season. They should also be hardy enough to grow with low maintenance. Planting interval of the road side trees shall be 8 m on average, planting box with curb stone shall be minimum 1.8 m square for trees to grow safely. Species for roadside tree are recommended as follows.

Queen crape-myrtle (Lagerstroemia regimae, Lagerstroemia speciosa):
The tree grows 10 m in height and crown grows 7 m in width. Plenty of purple pinkish flowers bloomed over a long period during hot season in Hanoi. Good

foliage and shadow provision may be expected, and it is half-deciduous in winter. This tree species shall be planted along the frontage road of Than Tri side.

Golden shower (Cassia fistula):
The tree grows 10 m in height and crown grows 5 m in width. Plenty of golden yellow flowers bloom over a long period during the hot season. Good foliage and shadow provision may be expected, as it is evergreen. This tree species shall be planted along the frontage road of Gia Lam side.

(2) Plantings at the Administrative Office Site of Toll Plaza and the Administrative Office Site of the Road Department

Plantings in the facility-building site may enrich the vicinity environment by provision of form of trees, color of leaves and flowers. In some space shade tree species would be required. Species for these areas are recommended as follows.

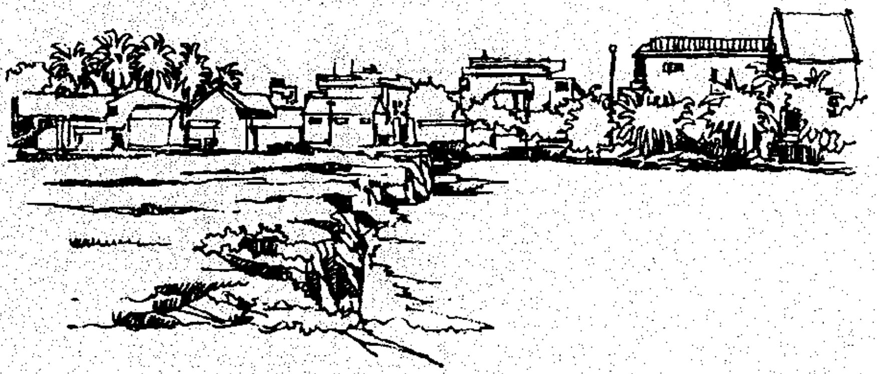
Mahogany (Swietnia mahagoni):
This species grow tall, has dense foliage and has magnificent tree form. Great shade provision than other trees.

Flamboyant (Delonix regia):
This tree grows tall and crown spreads horizontally with elegant shape; red flowers give full blossom in hot season as a landscape focal point. It is deciduous in winter.

Bauhinia (Bauhinia variegata):
Bauhinia is a shrub and grows 3 to 4 m in height, it blooms pinkish orchid-like flower over long period from hot to cool season.

Hibiscus (Hibiscus rosa sinensis):
One of the most popular flowering shrubs in Vietnam, the flower has many colors and varieties.

CHAPTER 19 ECONOMIC AND FINANCIAL ANALYSIS



CHAPTER 19 ECONOMIC AND FINANCIAL ANALYSIS

19.1 Economic Analysis

19.1.1 Project Cost

(1) Total Financial Cost

Project cost estimated by market price, hereafter referred to as financial cost, is shown as follows:

1)	Construction work	4,288,440 million dong
2)	Review of detailed design and construction supervision	322,782 million dong
3)	Land acquisition	477,196 million dong
	Total	5,088,417 million do

Financial cost is estimated under the following conditions.

1) Physical contingency is assumed at 10 % of the construction works and consultant services, and is assumed at 5 % of land acquisition.
2) Price contingency (price escalation) is not included is this estimation.

(2) Difference between F/S and D/D

The cost is estimated at 11 % higher in detailed engineering year 2000 over the time of feasibility study in 1998. The rate of increase by main items is as follows. It is explained in detail in Appendix Table 19.1.1 "Basic Data for the Estimation of Project Cost (Market Price)".

1)	Highway and interchange	+ 34%
2)	Bridge	- 9%
3)	Consultant services	- 20%
4)	Land acquisition	+ 268%

19.1.2 Economic Cost for Economic Evaluation

(1) Total Economic Cost

Market price is converted to economic cost to express real value of resources used in the project and to compare economic benefits for project justification. Table 19.1.1 shows the conversion result from market price to economic price.

Economic cost of capital investment is 4,546,659 million dong, which is about 11 % lower than market price.

Table 19.1.1 Conversion to Economic Cost from Financial Cost

Unit: Million Dong

Items	Investment Costs in Market Price	Foreign Portion	Local Portion					Overall Conversion Factor	Investment Costs in Economic Prices
			Tradable Goods	Non-tradable Goods	Skilled Labor	Unskilled Labor	Transfer (Tax)		
Conversion Factor		1.00	1.00	0.98	0.98	0.55	0.00		
Hwy & Interchange	1,863,790	60.0%	10.0%	7.0%	3.0%	15.0%	5.0%	88.0%	1,639,949
Thanh Tri Bridge	2,424,650	60.0%	10.0%	7.0%	3.0%	15.0%	5.0%	88.0%	2,133,450
Engin.Supervision	322,782	79.0%			16.0%		5.0%	94.7%	305,610
Land Acquisition	477,195			100.0%				98.0%	467,651
Total	5,088,417							89.4%	4,546,659
Routine Maint.	30,531	0%	2%	3%	0%	90%	5%	54.3%	16,587
Periodic Repair	5,088	0%	2%	3%	0%	90%	5%	54.1%	2,752

Note: Routine maintenance cost is estimated at 0.6% and periodic maintenance cost at 0.1%of total investment cost.

For overall conversion factor, 89.4 % is used to adjust many distorted factors. Details are shown in Appendix table 19.1.2 "Standard Conversion Factor to Economic Price for Local Product" and Appendix Table 19.1.3 "Shadow Price for Unskilled Labor". Concern allocation of foreign and local portions, refer to Appendix Table 19.1.1.

(2) Investment Cost by Year

Construction period is assumed at six years, which is the shortest period possible through efficient implementation. Table 19.1.2 shows cost allocation of six years of the construction period for both financial cost and economic cost. For details of investment cost per year, refer to Appendix 19.1.1.

Table 19.1.2 Comparison of Investment Cost Between F/S and D/D

Unit Million Dong

Year	Feasibility Study in 1998			Detailed Design Study in 2000		
	Financial	Component	Economic	Financial	Component	Economic
1999	132,517	3%	110,251			
2000	361,319	8%	322,520	323,100	6%	288,700
2001	1,054,047	23%	940,837	447,074	9%	399,475
2002	1,740,617	38%	1,553,665	1,059,687	21%	946,863
2003	1,307,079	28%	1,166,691	1,396,312	27%	1,247,648
2004				1,386,585	27%	1,238,957
2005				475,659	9%	425,016
Total	4,595,579	100%	4,093,964	5,088,417	100%	4,546,659
Increase Rate				11%		11%

19.1.3 Traffic Demand and Vehicle Kilometer

(1) Traffic Demand

The traffic volume in the feasibility study is used for benefit calculation here. Table 19.1.3 shows forecasted daily traffic volume on the project expressway in the target year. Traffic is expected to use the entire 12.3 km section, and partial section of 4.8km, on the expressway.

Table 19.1.3 Traffic Volume on Project Road in the Target Year

Unit: Vehicle/day

Year	Passenger Car	Bus	Truck	Motorcycle	Total
2010	8,619	6,044	14,375	116,253	145,291
2020	40,337	8,223	21,171	59,709	129,440
Increase Rate	16.7%	3.1%	3.9%	-6.4%	

(2) Traffic Characteristics

Following is the summary of the characteristics of traffic.

1) Highest increase rate is 16.7 % of passenger cars during the period between 2010 and 2020.
2) Motorcycle use decreases at the rate of 6.4 % every year.
3) 120,480 vehicles per day (83 %) are estimated as through-traffic using entire in 2010.

4) 121,560 vehicles per day (94 %) is estimated as through traffic using the entire in 2020.
5) Traffic will reach capacity by the year 2020, and is assumed not to increase afterwards.

(3) Vehicle Km (Without Project)

Vehicle km without project is estimated for traffic using only city roads as in the following formula. Average travelling distance of all types of vehicles is obtained as 21.45 km on city roads.

Vehicle km without project = Traffic volume on expressway x vehicle km on city road.

(4) Vehicle Km (With Project)

Vehicle km with project is estimated for traffic using expressway and city roads as in the following formula. Average travelling distance of all types of vehicles is obtained as 15.40 km on city roads.

Vehicle km with project = Traffic volume on expressway x vehicle km on expressway x vehicle km on city road

Table 19.1.4 shows the result of vehicle km with and without project. Details are in Appendix Table 19.1.4 "Vehicle km With and Without Project".

Table 19.1.4 Vehicle Km Without and With Expressway

Unit:Vehicle km/day

Year	Passenger Cars	Buses	Trucks	Motorcycles	Total
Without Expressway					
2010	199,536	153,714	383,375	2,380,574	3,117,199
2020	988,654	219,685	594,730	1,343,802	3,146,870
With Expressway					
2010	142,869	109,824	273,902	1,710,599	2,237,194
2020	705,751	156,591	423,918	960,171	2,246,430

19.1.4 Passenger Time Cost Saving Benefit

(1) Traveling Speed

Time cost saving can be obtained from the difference between traveling speed on expressway with project and travelling speed on city road without project. Travelling speed in the feasibility study is used with minor alterations:

1) With project: average travel speed on expressway by motorcycle is changed from 50 km/h in F/S to 45 km/h at this time.
2) Without project: average travel speed on city road is decreased to 12 km/h here, from 15 km/h used in F/S due to traffic congestion.

(2) Revision of Time Cost

Passenger time value is a function of the wage rate, trip purpose and time utilization. Time value is obtained by the following procedures, same as in F/S:

1) Income per worker by income level
2) Working time value by vehicle user
3) Travel time value of passenger by vehicle type

Basic data of population, labor and GRDP are updated as follows and explained in details in Appendix Table19.1.5 "Estimation of Population and Number of Workers in the Study Area" and in Appendix 19.1.6 "Estimation of GRDP in the Study Area".

1) Population of study area: Increased from 10,079,000 in 1996 to 10,914,000 in 2000
2) Labor force of study area: Increased from 4,489,000 in 1996 to 5,817,000 in 2000
3) GRDP of study area: Increased from 27,332 billion Dong in 1966 to 3,4,145 billion Dong in 2000(1994 constant price)

(3) Passenger Time Value

The same data are used as in F/S for income structure, trip purpose, time productivity, and number of passenger on vehicle used. Details are in Appendix Table 19.1.7 "Estimation of Passenger Time Value by Types of Vehicles User".

Thus following value unit is used for estimation of passenger benefit.

1) Time value per minute ....Passenger car .... 164.67 dong /minute
2) Time value per minute ....Bus ....426.41 dong /minute
3) Time value per minute ....Motorcycle .... 43.13 dong /minute

(4) Estimation of Time Cost Saving Benefit

Table 19.1.5 shows the time saving benefit of passenger by type of vehicle.

Table 19.1.5 Passenger Time Cost Saving Without and With Project

Unit: billion Dong/Year

	Without Expressway					With Expressway					Benefit
Year	P. Car	Bus	Truck	M.cycle	Total	P. Car	Bus	Truck	M.cycle	Total	
2006	15	53		100	168	6	22		54	82	86
2007	19	58		104	181	7	24		56	87	94
2008	23	63		109	195	9	26		57	92	103
2009	28	69		114	212	11	28		59	98	113
2010	35	76		119	230	13	31		61	105	125
2011	42	80		114	236	15	32		58	106	130
2012	51	85		109	244	18	34		55	108	136
2013	61	89		104	255	22	36		53	110	144
2014	74	94		100	268	26	38		50	114	154
2015	89	99		96	284	31	40		48	119	165
2016	107	105		92	303	37	42		46	125	178
2017	129	111		88	327	44	44		44	132	195
2018	155	117		84	356	52	46		43	141	214
2019	186	123		80	390	63	49		41	153	237
2020	238	137		85	459	80	53		44	176	283
2021	245	140		87	472	81	54		44	179	293
2022	253	143		89	485	83	55		44	182	303
2023	261	147		91	499	85	55		45	185	313
2024	270	150		93	513	87	56		45	189	324
2025	278	154		95	527	89	57		46	192	335
2026	287	157		97	542	91	58		46	195	346
2027	296	161		100	557	93	59		47	199	358
2028	296	165		102	563	93	60		47	200	363
2029	296	169		104	569	93	61		47	202	367
2030	296	173		107	576	93	62		48	203	372

19.1.5 Vehicle Operation Cost Saving Benefit

(1) Fuel Cost and Labor Cost

A sharp drop in fuel price in 1997 caused retail price to fall far below the regulated maximum price 4,200 dong per liter of gasoline and 3,500 dong per liter of diesel fuel. The special surcharge in fuel was increased in Feb.1998 from 15 % to 30 % on gasoline, and from 18 % to 23 % on diesel fuel.

As a result, economic cost of fuel is revised as shown in Table 19.1.6, though financial cost remains the same as in F/S. Economic cost of diesel is shown in Appendix 19.1.8 "Financial and Economic Cost of Diesel".

1)	Economic cost of gasoline	decrease from 3,150 dong/liter to 2,675 dong/liter
2)	Economic cost of diesel	decrease from 2,450 dong/liter to 2,405 dong/liter

Table 19.1.6 Financial and Economic Cost of Gasoline

Unit: Dong/Litter, Year 1999

Item	% of Charges	Economic Cost	Financial Cost	
			Tax/duty	Cumulative
a) Border price		1,460		1,460
b) Transport margin	15%	219		1,679
c) Import tax	60%		876	2,555
Luxury tax	35%		511	3,066
Special surcharge	30%		438	3,504
d) Transportation fee		500		4,004
e) Wholesale price				4,004
f) Retail commission	3%	120		120
g) Retail price				4,124
h) Maximum retail price				4,200
I) Extra commission		376		4,500
Economic & Financial		**2,675**	1,825	**4,500**
Cost Component %		**59%**	**41%**	**100%**

Source: Transport Development Strategy Institute (TEDI), Ministry of Finance
JICA Study Team

Maintenance labor cost, overhead cost and crew cost are increased by 8 %. The unit vehicle operating cost is estimated in the same calculation procedure as in F/S. Revised VOC is shown in Appendix Table 19.9 "Input Data for Unit Vehicle Operating Cost Calculation by Base Speed".

(2) Running Speed and VOC

The relationship between running speed and running cost by vehicle types is expressed in the following formulas where Y is running cost, and X is running speed. Table 19.1.7 shows the comparison of VOC between F/S and D/D for the case of travelling speed of 25 k/h and 70 km/h as examples.

1) Passenger Car
2) Bus $Y=0.4488488X^2-56.1100182x+3724.45192$
3) Truck $Y=0.7037682x^2-91.8380220x+5031.98241$
4) Motorcycle $Y=0.0775585x^2-7.0382924x+431.71109$

Table 19.1.7 Comparison of VOC Between F/S in 1998 and D/D in 2000

Case of 25 km/h and 70 km/h Unit:Dong

Vehicle	Cost Item	25 km/h		70 km/h	
		F/S	D/D	F/S	D/D
Passenger Car	Running	2,753	2,643	1,536	1,475
	Fixed	395	395	395	395
	Total	3,148	3,039	1,931	1,870
Bus	Running	2,766	2,602	2,122	1,996
	Fixed	419	905	419	905
	Total	3,185	3,507	2,541	2,901
Truck	Running	3,152	3,176	2,021	2,052
	Fixed	998	998	998	998
	Total	4,150	4,174	3,019	3,050
Motorcycle	Running	316	304	331	319
	Fixed	41	41	41	41
	Total	357	345	372	360

(3) Vehicle Operating Cost Saving Benefit:

Table 19.1.8 shows calculated result of vehicle operating cost saving benefit for project life. Vehicle operating cost saving from higher design standards and shortening traveling distance by project is estimated simultaneously.

Table 19.1.8 Vehicle Operating Cost Saving Benefit Without and With Project

Unit: Million Dong

	Without Expressway(day)					With Expressway(day)					Benefit
Year	P. Car	Bus	Truck	M.cycle	Total	P. Car	Bus	Truck	M.cycle	Total	(Year)
2006	305	429	1,271	792	2,797	159	265	735	514	1,673	410,125
2007	368	461	1,375	812	3,017	191	284	793	525	1,793	446,806
2008	445	496	1,488	832	3,261	229	304	855	536	1,925	487,816
2009	537	533	1,610	853	3,534	275	326	922	548	2,071	533,809
2010	648	573	1,742	874	3,838	330	350	995	560	2,234	585,555
2011	764	594	1,822	822	4,002	386	361	1,037	524	2,309	617,857
2012	900	615	1,906	773	4,193	453	373	1,081	491	2,399	655,089
2013	1,059	637	1,993	726	4,416	531	386	1,127	460	2,504	697,953
2014	1,247	660	2,084	683	4,674	622	398	1,175	431	2,626	747,275
2015	1,468	683	2,179	642	4,972	728	412	1,225	404	2,769	804,023
2016	1,727	708	2,277	603	5,315	853	425	1,277	378	2,934	869,332
2017	2,032	733	2,380	567	5,712	999	439	1,331	354	3,124	944,536
2018	2,389	759	2,488	533	6,168	1,170	454	1,387	332	3,343	1,031,196
2019	2,809	786	2,600	500	6,695	1,370	469	1,446	311	3,596	1,131,144
2020	3,496	854	2,861	517	7,728	1,701	508	1,588	319	4,117	1,318,027
2021	3,521	858	2,876	519	7,773	1,707	509	1,592	320	4,128	1,330,361
2022	3,545	861	2,890	521	7,817	1,713	510	1,596	320	4,139	1,342,442
2023	3,569	864	2,904	523	7,860	1,718	511	1,600	320	4,150	1,354,275
2024	3,592	867	2,918	525	7,902	1,724	512	1,604	321	4,160	1,365,861
2025	3,615	870	2,931	528	7,944	1,729	513	1,608	321	4,170	1,377,202
2026	3,637	873	2,945	530	7,984	1,734	513	1,611	322	4,180	1,388,303
2027	3,658	876	2,958	532	8,024	1,739	514	1,615	322	4,190	1,399,165
2028	3,658	879	2,971	534	8,041	1,739	515	1,619	322	4,195	1,403,916
2029	3,658	882	2,983	536	8,059	1,739	516	1,622	323	4,200	1,408,586
2030	3,658	884	2,996	537	8,076	1,739	516	1,626	323	4,204	1,413,174

19.1.6 Economic Cost Benefit Analysis

(1) B/C Ratio and NPV

Table 19.1.9 shows comparison of economic cost with benefit discounted at 12 % of opportunity cost of capital. As shown in the results below, total discounted benefit is greater than total discounted cost, which proves that the investment amounting to 5,088,417 million dong of Thanh Tri project is economically feasible.

- Benefit Cost Ratio discounted at 12 %	1.18
- Net Present Value discounted at 12 %	594,854 million dong

(2) Economic Internal Rate of Return

Table 19.1.10 shows the result of the calculation of economic internal rate of return. Total present value of cost and benefit become equal when discounted at 13.49 %, which means economic internal rate of return (EIRR) is 13.49 %.

Table 19.1.9 Cost Benefit Analysis for Investment Justification of Thanh Tri Project

Net Present Value: 594,854 Million Dong (Total Benefit Discounted by 12%- Total Cost Discounted by 12%)
Benefit Cost Ratio: 1.18 (Total Benefit Discounted by 12% / Total Cost Discounted by 12%)

Unit:Million Dong

No.	year	Economic Cost			Economic Benefits			Present Worth		
		Capital	Routine Operation	Total	Vehicle Ope.Cost	Passenger Time Cost	Total	Discount Factor	Cost	Benefit
1	2000	288,700		288,700				1.000	288,700	
2	2001	399,475		399,475				0.893	356,674	
3	2002	946,863		946,863				0.797	754,833	
4	2003	1,247,648		1,247,648				0.712	888,051	
5	2004	1,238,957		1,238,957				0.636	787,379	
6	2005	425,016		425,016				0.567	241,166	
7	2006		16,587	16,587	410,125	86,029	496,154	0.507	8,403	251,367
8	2007		16,587	16,587	446,806	94,072	540,878	0.452	7,503	244,666
9	2008		16,587	16,587	487,816	103,077	590,893	0.404	6,699	238,652
10	2009	2,752	16,587	19,339	533,809	113,203	647,012	0.361	6,974	233,319
11	2010		16,587	16,587	585,555	124,645	710,200	0.322	5,341	228,665
12	2011		16,587	16,587	617,857	129,987	747,844	0.287	4,768	214,987
13	2012		16,587	16,587	655,089	136,454	791,543	0.257	4,257	203,169
14	2013		16,587	16,587	697,953	144,257	842,210	0.229	3,801	193,013
15	2014	2,752	16,587	19,339	747,275	153,648	900,923	0.205	3,957	184,347
16	2015		16,587	16,587	804,023	164,930	968,953	0.183	3,030	177,024
17	2016		16,587	16,587	869,332	178,469	1,047,801	0.163	2,706	170,919
18	2017		16,587	16,587	944,536	194,703	1,139,238	0.146	2,416	165,924
19	2018		16,587	16,587	1,031,196	214,161	1,245,356	0.130	2,157	161,946
20	2019	2,752	16,587	19,339	1,131,144	237,479	1,368,623	0.116	2,245	158,906
21	2020		16,587	16,587	1,318,027	282,973	1,601,000	0.104	1,720	165,970
22	2021		16,587	16,587	1,330,361	292,799	1,623,159	0.093	1,535	150,239
23	2022		16,587	16,587	1,342,442	302,905	1,645,347	0.083	1,371	135,976
24	2023		16,587	16,587	1,354,275	313,300	1,667,575	0.074	1,224	123,047
25	2024	2,752	16,587	19,339	1,365,861	323,992	1,689,852	0.066	1,274	111,331
26	2025		16,587	16,587	1,377,202	334,990	1,712,192	0.059	976	100,717
27	2026		16,587	16,587	1,388,303	346,303	1,734,605	0.053	871	91,103
28	2027		16,587	16,587	1,399,165	357,940	1,757,104	0.047	778	82,397
29	2028		16,587	16,587	1,403,916	362,622	1,766,538	0.042	694	73,964
30	2029	2,752	16,587	19,339	1,408,586	367,415	1,776,001	0.037	723	66,393
31	2030		16,587	16,587	1,413,174	372,321	1,785,495	0.033	554	59,596
		4,560,419	414,675	4,975,094	25,063,827	5,732,672	30,796,499	**12.00%**	**3,392,782**	**3,987,636**

Table 19.1.10 Cost Benefit Analysis for Investment Justification of Thanh Tri Project

Internal Economic Rate of Return: 13.49% (Total discounted cost = Total discounted Benefit)

Unit:Million Dong

No.	year	Economic Cost			Economic Benefits				Present Worth	
		Capital	Routine Operation	Total	Vehicle Ope. Cost	Passenger Time Cost	Total	Discount Factor	Cost	Benefit
1	2000	288,700		288,700				1.000	288,700	
2	2001	399,475		399,475				0.881	351,996	
3	2002	946,863		946,863				0.776	735,165	
4	2003	1,247,648		1,247,648				0.684	853,569	
5	2004	1,238,957		1,238,957				0.603	746,880	
6	2005	425,016		425,016				0.531	225,761	
7	2006		16,587	16,587	410,125	86,029	496,154	0.468	7,764	232,225
8	2007		16,587	16,587	446,806	94,072	540,878	0.412	6,841	223,070
9	2008		16,587	16,587	487,816	103,077	590,893	0.363	6,028	214,733
10	2009	2,752	16,587	19,339	533,809	113,203	647,012	0.320	6,193	207,182
11	2010		16,587	16,587	585,555	124,645	710,200	0.282	4,680	200,386
12	2011		16,587	16,587	617,857	129,987	747,844	0.249	4,124	185,929
13	2012		16,587	16,587	655,089	136,454	791,543	0.219	3,634	173,404
14	2013		16,587	16,587	697,953	144,257	842,210	0.193	3,202	162,575
15	2014	2,752	16,587	19,339	747,275	153,648	900,923	0.170	3,289	153,239
16	2015		16,587	16,587	804,023	164,930	968,953	0.150	2,486	145,223
17	2016		16,587	16,587	869,332	178,469	1,047,801	0.132	2,191	138,375
18	2017		16,587	16,587	944,536	194,703	1,139,238	0.116	1,930	132,569
19	2018		16,587	16,587	1,031,196	214,161	1,245,356	0.103	1,701	127,694
20	2019	2,752	16,587	19,339	1,131,144	237,479	1,368,623	0.090	1,747	123,655
21	2020		16,587	16,587	1,318,027	282,973	1,601,000	0.080	1,321	127,458
22	2021		16,587	16,587	1,330,361	292,799	1,623,159	0.070	1,164	113,864
23	2022		16,587	16,587	1,342,442	302,905	1,645,347	0.062	1,025	101,702
24	2023		16,587	16,587	1,354,275	313,300	1,667,575	0.054	903	90,825
25	2024	2,752	16,587	19,339	1,365,861	323,992	1,689,852	0.048	928	81,100
26	2025		16,587	16,587	1,377,202	334,990	1,712,192	0.042	701	72,405
27	2026		16,587	16,587	1,388,303	346,303	1,734,605	0.037	618	64,635
28	2027		16,587	16,587	1,399,165	357,940	1,757,104	0.033	545	57,692
29	2028		16,587	16,587	1,403,916	362,622	1,766,538	0.029	480	51,108
30	2029	2,752	16,587	19,339	1,408,586	367,415	1,776,001	0.025	493	45,275
31	2030		16,587	16,587	1,413,174	372,321	1,785,495	0.022	373	40,107
		4,560,419	414,675	4,975,094	25,063,827	5,732,672	30,796,499	**13.49%**	3,266,430	3,266,430

Therefore project is judged feasible and proves economically feasible from the national point of view, showing EIRR of 13.49 %, higher than 12 % of the opportunity cost of capital in Vietnam.

(3) Sensitivity

Table 19.1.11 shows possible change of EIRR by the degree of influence of future uncertainty at cost increase and benefit decrease of the project in the case of base case.

Table 19.1.11 Sensitivity Analysis of Economic Indicator

Unit: EIRR

		Benefit Decrease			
		0%	-10%	-15%	-20%
Cost Increase	0%	13%	13%	12%	11%
	10%	13%	12%	11%	11%
	15%	12%	11%	11%	10%
	20%	12%	11%	10%	10%

Followings are the results of the sensitivity analysis.

1) Project is feasible even if the cost increases around 15 %.
2) Project is not feasible if the cost increases 20 %.
3) Project is feasible even if the benefit decreases around 15 %.
4) Project is not feasible if the benefit decreases 20 %.
5) Project is feasible if benefit decreases 10 % and cost increases 10 %.

(4) Comparison of EIRR with F/S and D/D

EIRR, 13.49 % in D/D is slightly higher than EIRR in F/S, 13.14 %. Following are the summary of main factors which have negative and positive influences.

Negative factors:

1) Increased project cost of 11 % at D/D study for market price: from 4,586 billion dong to 5,088 billion dong.
2) Increased project cost of 11 % at D/D study for Economic Piece: from 4,094 billion dong to 4,547 billion dong.
3) Changed travel speed of motorcycle on expressway by the result of testing: from 50 km/h to 45 km/h.

Positive factors:

1) Extending the term of construction period by at D/D study.......from 5 years to 6 years.
2) Delay of commencement of construction work by judgment of D/D...from 1999 to 2000.
3) Changing the minimum limit of traveling speed on city road by applying experience in other cases......... from 15 km/h to 12 km/h.
4) Increasing passenger time cost due to increase of gross domestic product and of income per capita in study area.
5) Decrease of economic price of fuel price due to increase of fuel tax levied.

(5) Comparison with the Same benefit of F/S and Cost of D/D

Appendix Table 19.1.10 shows the result of EIRR calculation compared with cost in D/D study with using the same amount of benefit of F/S. Thus 12.10 % is obtained, still proving feasible economically.

19.1.7 Conclusion

Results of the sensitivity analysis proves the project is economically feasible from the national viewpoint, as EIRR is found to be more than the opportunity cost of capital in spite of many uncertain conditions. These uncertain conditions are, namely:

1) Cost increase;
2) Benefit decrease due to toll system and to toll level;
3) Possible improvement of running conditions on road;

There are many other benefits, which will increase benefits of the project and contribute to an increase in EIRR, such as:

1) Benefit, especially vehicle operating cost saving and time cost saving, for non-project users (remaining traffic on city road) with higher travelling speed resulting from high amount of diversion to project road.
2) Benefits from increase of land productivity, especially utilization near the interchange area.
3) Enhancement of urban development of land reform and industrial activities.

4) Strengthening function as the capital city by connecting NH No.4 and NH No.1.
5) Decrease of social cost such as traffic accidents, noise, and vibration.

Unmeasurable benefits are not included here for EIRR calculation. Therefore, actual EIRR will be more than 12 %. Therefore this project is feasible on national level and needs to be implemented as soon as possible.

19.2 Financial Analysis

19.2.1 Users' Benefit, Level of Toll and Toll Revenue

(1) Toll Charge System

The toll barrier is located on the main expressway near Thanh Tri Bridge. Toll will be collected neither at gates or off gates. Therefore, the 4.8 km section of project road between interchange of National Highway No.1 and Thanh Tri dike will not collect toll. 83 % of the traffic through the toll barrier will collect tolls in 2010 and 94 % in 2020.

(2) Basis of Users' Benefit Compared with Toll Level

Vehicle operating cost savings and passenger's time cost savings "with" and "without" project are estimated as user', benefit. Data used for the users' benefit calculation such as travel speed, travelling distance, time cost in the case of "with" and "without" project is also used in economic analysis

(3) Toll Charge and Surplus

Table 19.2.1 shows the relation between users' benefit and the level of toll, which is the same level of Thang Long Bridge including 15 km of TL-Noi Bai section.

(Shown in more in detail in Appendix Table 19.2.1 Toll Rate of Thang Long and TL-NB Huighway in 2000, and Appendix Table 19.2.2 Users' Benefit, Toll Level and Toll Benefit Ratio from 2000 to 2030)

Table 19.2.1 Users Benefit, Toll Level and Toll-Benefit Ratio

1) Total Users Benefit(Dong/One Trip)

Year	P. Car	Bus	Truck	M.cycle
2000	39,378	52,447	49,473	4,214
2006	45,105	57,935	53,323	4,738
2010	48,847	61,774	55,739	5,110
2020	58,022	72,131	61,210	6,128
2030	64,471	83,878	65,862	7,288

2) Toll Charge(Dong/One Trip)

Year	P. Car	Bus	Truck	M.cycle
2000	12,000	21,480	22,840	1,000
2006	12,000	21,480	22,840	1,000
2010	12,000	21,480	22,840	1,000
2020	12,000	21,480	22,840	1,000
2030	12,000	21,480	22,840	1,000

3) Toll Benefit Ratio

Year	P. Car	Bus	Truck	M.cycle
2000	**30%**	**41%**	**46%**	**24%**
2006	27%	37%	43%	21%
2010	25%	35%	41%	20%
2020	21%	30%	37%	16%
2030	19%	26%	35%	14%

(4) Establishing of Toll Fee

Table 19.2.2 shows the level of toll fee by vehicles in target year. Level of toll is shown in two cases since the present toll is too low to be profitable.

1) The same toll-benefit ratio.......... 35 % as toll and 65 % as users' surplus,
2) 20% increase of the ratio .... 42 % charge on toll and 58 % as users' surplus.

Table 19.2.2 Setting Up Toll Level by Vehicle Type for Project Life

Dong / one trip

Toll applied the same toll /revenue ratio in year 2000					
	P. Car	Bus	Truck	M.cycle	Average
T/B Ratio	**30%**	**41%**	**46%**	**24%**	**35%**
2000	12,000	21,480	22,840	1,000	
2006	13,745	23,728	24,618	1,124	
2010	14,885	25,300	25,733	1,213	
2020	17,681	29,542	28,259	1,454	
2030	19,647	34,353	30,407	1,729	
Toll applied 20% Increase					
	P. Car	Bus	Truck	M.cycle	Average
T/B Ratio	**37%**	**49%**	**55%**	**28%**	**42%**
2000	14,400	25,776	27,408	1,200	
2006	16,494	28,473	29,541	1,349	
2010	17,862	30,360	30,880	1,455	
2020	21,218	35,450	33,910	1,745	
2030	23,576	41,223	36,488	2,075	

(5) Estimation of Toll Revenue

Table 19.2.3 shows the amount of toll revenue for target years. More in detail is shown in Appendix Table 19.2.3 “Toll and Toll Revenue Applying the Same Toll-Benefit Ratio of Year 2000 During Project Life”, and in 19.2.4 “Toll and Toll Revenue Applying 20 % Increase to Toll-Benefit Ratio”.

Table 19.2.3 Toll Revenue by Vehicle Type and Target Year

Unit:Million Dong/Year

Toll revenue applying the same toll /revenue ratio of year 2000 during project life					
Year	P. Car	Bus	Truck	M.cycle	Total
2006	18,402	36,469	88,548	35,765	179,185
2010	40,638	50,975	123,607	41,750	256,969
2020	243,564	86,262	213,507	29,254	572,587
2030	270,636	100,310	229,735	34,792	635,474
Toll Revenue applied 20% Increase					
Year	P. Car	Bus	Truck	M.cycle	Total
2006	22,083	43,763	106,258	42,918	215,022
2010	48,765	61,170	148,328	50,099	308,363
2020	292,277	103,515	256,208	35,105	687,105
2030	324,764	120,373	275,682	41,751	762,569

19.2.2 Simple Cost and Revenue Analysis

(1) Base Cost for Financial Analysis

Financial Internal Rate of Return (FIRR) is calculated simply to identify fundamental financial merit. Financial sources such as soft loan, bank loan interest equity, etc. are not considered in these calculations. Table 19.2.2 shows the cost stream used for the calculation as base cost case.

Table 19.2.4 Project Cost for Financial Analysis as Base Case

Unit: Million Dong

Year	Foreign	Local	Total	
2000	69,795	253,305	323,100	6%
2001	138,906	308,168	447,074	9%
2002	648,123	411,563	1,059,687	21%
2003	846,584	549,728	1,396,312	27%
2004	838,045	548,540	1,386,585	27%
2005	302,008	173,651	475,659	9%
Total	2,843,461	2,244,955	5,088,417	100%
%F.C &L.C	56%	44%	100%	

(2) Result of Simple Calculation of FIRR

EIRR shows the discount rate in which total discount present value of cost equals to the total discounted present value of toll revenue. As Table 19.2.5 shows FIRR is 4.18% which is relatively low.

Table 19.2.5 Cost Revenue Analysis for Investment Justification of Thanh Tri Project

Base CaseUnit: Million Dong

No.	Year	Toll Revenue	Capital	Routine Maint.Cost	Operating Cost	Total Cost	Discount Factor	Net Present Worth
1	2000		323,100			323,100	1.000	(323,100)
2	2001		447,074			447,074	0.960	(429,150)
3	2002		1,059,687			1,059,687	0.921	(976,423)
4	2003		1,396,312			1,396,312	0.884	(1,235,017)
5	2004		1,386,585			1,386,585	0.849	(1,177,246)
6	2005		475,659			475,659	0.815	(387,656)
7	2006	179,185		30,531	365	30,896	0.782	116,009
8	2007	195,579		30,531	369	30,899	0.751	123,666
9	2008	213,823		30,531	372	30,903	0.721	131,857
10	2009	234,183		30,531	376	30,907	0.692	140,656
11	2010	256,969	5,088	30,531	380	35,999	0.664	146,769
12	2011	271,350		30,531	384	30,914	0.638	153,296
13	2012	287,639		30,531	387	30,918	0.612	157,117
14	2013	306,109		30,531	391	30,922	0.587	161,667
15	2014	327,087		30,531	395	30,926	0.564	167,013
16	2015	350,953	5,088	30,531	399	36,018	0.541	170,480
17	2016	378,159		30,531	403	30,934	0.520	180,424
18	2017	409,234		30,531	407	30,938	0.499	188,688
19	2018	444,805		30,531	411	30,942	0.479	198,152
20	2019	485,606		30,531	415	30,946	0.460	208,959
21	2020	572,587	5,088	30,531	420	36,038	0.441	236,708
22	2021	580,016		30,531	424	30,954	0.423	232,517
23	2022	587,446		30,531	428	30,958	0.407	226,214
24	2023	594,880		30,531	432	30,963	0.390	220,044
25	2024	602,322		30,531	437	30,967	0.375	214,008
26	2025	609,776	5,088	30,531	441	36,060	0.360	206,277
27	2026	617,244		30,531	445	30,976	0.345	202,339
28	2027	624,732		30,531	450	30,980	0.331	196,707
29	2028	628,310		30,531	454	30,985	0.318	189,957
30	2029	631,891		30,531	459	30,989	0.305	183,433
31	2030	635,474	5,088	30,531	463	36,082	0.293	175,637
		11,025,359	5,113,859	763,263	10,309	5,887,430	**4.18%**	0

(3) Sensitivity Analysis

Following is the result of sensitivity analysis:

1) FIRR for the Base Case .... 4.18 %
2) 20 % increase of toll fee .... 5.48 %
3) Including interest (1.8 %) during construction .... 4.14 %
4) Decrease of routine maintenance cost from 0.6 % to 0.15 %........ 4.50 %
5) No charge for motorcycles.. 3.56 %
6) No charge for motorcycles, with increase of
   20 % of toll charge on other vehicles .... 4.18 %

(4) Tentative Conclusion

As analyzed above, FIRR is lower than 6 %, ranging from 3.6 % to 5.5 %. It should be higher than at least 8 % if operated by a private company, which includes 2 % of dividend and 3 % of profit. Therefore, the project is not feasible to be implemented by the private sector. Net cash flow analysis in the following chapter is necessary for more funds in good conditions.

19.2.3 FIRR and Net Cash Flow Analysis

(1) Debt Structure

Following cases are assumed related to fund structures:

Case 1	Soft loan	56%(covering 100% of foreign portion)
	Government financing	44% (covering 100% of local portion)
Case 2	Soft loan	56%(covering 100% of foreign portion)
	Bank loan	44% (covering 100% of local portion)
Case 3	Soft loan	80%
	Government financing	20% (covering local portion)
Case 4	Soft loan	80%
	Bank loan	20% (covering local portion)
Case 5	Equity	30%
	Soft loan	70%
Case 6	Equity	30%
	Soft loan	56% (=70%x80%), (covering 100% of local portion)
	Bank loan	14% (=70%x20%)

(2) Debt Condition by Sources

The following alternatives were assumed in financing structures:

1) Soft loan Rate of interest 1.8%
Repayment period .... 30 years including 10 years grace period
2) Government financing
Rate of interest 0%
Repayment............................ 15 years
3) Bank loan Rate of interest 10%
Repayment period .... 15 years
4) Equity Private concessionaire, other private domestic companies

(3) Estimation of Capital Investment Cost by Fund Resources

Table 19.2.6 shows the capital cost by debt structure of 6 cases. (Shown in detail in Appendix 19.2.5 "Capital Investment Cost by Fund Resources")

Table 19.2.6 Summary of Capital Investment Cost by Fund Recourse

(at Constant Price in Year 2000) Unit: Billion Dong

Year	Base Case	1) Implementation by Government				2) Implementation by Private Sector	
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
		56%:Soft Loan 44%: G.Finance	56%:Soft Loan 44%:BankLoan	80%:Soft Loan 20%:G.Finance	80%:Soft Loan 20%:Bank Loan	70%:Soft Loan 30%:Equity	56%Soft,14%Bank 30%:Equity
2000	323	326	341	328	334	327	330
2001	447	456	498	460	479	458	469
2002	1,060	1,092	1,247	1,106	1,176	1,100	1,140
2003	1,396	1,454	1,740	1,479	1,609	1,469	1,543
2004	1,387	1,459	1,832	1,490	1,659	1,477	1,576
2005	476	515	677	528	601	523	566
Total	5,088	5,303	6,334	5,391	5,859	5,354	5,624
Order		6	1	4	2	5	3

Note (1) Working Capital 9,269Million Dong is included in local fund in Year 2005
(2) Working capital requirements are estimated at 30% of Annual O and M requirements

The cost is shown in constant price for the year 2000 and does not include price contingency. Working capital requirement is estimated at 30%, 9,269 million dong for annual operation and management in local portion in 2005.

(4) Result of Net Cash Flow Analysis

Table 19.2.7 shows the cash flow analysis of case 2, which is an example of a negative case and Table 19.2.8 shows the net cash flow of the case 5 which is an example of a positive case. Case 1, Case 3, Case 4 and Case 5 are shown in Appendix Table 19.2.6, 19.2.7, 19.2.8, and 19.2.9.

Column of loan as a part of repayment in the tables are the total of the principal and interest of each year. 25 % tax is levied to the amount minus operation cost and interest from toll revenue.

Table 19.1.9 shows the result of all cases of cash flow analysis. Three cases are negative and three cases are positive.

Negative case:

1) Case 1: Project cannot meet long term debt service for 8 years from 2010 to 2017 due to shortage of revenue, which cannot cover the repayment of principle and interest (Appendix Table 19.2.6).
2) Case 2: As Table 19.2.7 shows, the project cannot meet long term debt service in the first 17 years.
3) Case 4: Project cannot meet long term debt service in first 13 years (Appendix Table 19.2.8).

Table 19.2.9 Result of Appraisal of Cash Flow Analysis

Case	Soft Loan	Bank Loan	G.Finance	Equity	Appraisal	
					IFRR	Cash Flow Balance
Case 1	56%		44%		3.92%	X Negative
Case 2	56%	44%			2.82%	X Negative
Case 3	80%		20%		3.82%	D Acceptable in principle
Case 4	80%	20%			3.30%	X Negative
Case 5	70%			30%	3.86%	O Acceptable
Case 6	56%	14%		30%	3.55%	O Acceptable with Difficulty

Table 19.2.7 Total Cashflow and Debt Service Analysis After Long-term Financing

Case-2 (56% of Soft Loan and 44% of Bank Loan)

Unit: Billion Dong

No.	Year	Net Cash Flow Before Financing					Financing Cash Flow									Net Cash Flow after LT.Fina	Corporate Tax Payments	Net Cash Flow aft. LT-Financing&Tax
		Inflow	Outflow			Composite Flow	Inflow					Outflow			Net Financing Stream			
		Revenues	Investment Cost	O.&M. Cost	Total Outflow		Equity	Fund Recourses		Tot.Fin. Inflow	Comulative Inflow	Repayment		Total Debt Service				
								Soft Loan	G.Finance			Soft Loan	G.Finance					
1	2000		341		341	-341	0	184	157	341	341				341			
2	2001		498		498	-498	0	259	239	498	838				498			
3	2002		1,247		1,247	-1,247	0	625	622	1,247	2,085				1,247			
4	2003		1,740		1,740	-1,740	0	838	902	1,740	3,825				1,740			
5	2004		1,832		1,832	-1,832	0	847	985	1,832	5,657				1,832			
6	2005		677		677	-677		296	381	677	**6,334**				677			
7	2006	179		31	31	148						106	351	458	-458	-309	0	**-309**
8	2007	196		31	31	165						106	364	470	-470	-306	0	**-306**
9	2008	214		31	31	183						106	398	504	-504	-321	0	**-321**
10	2009	234		31	31	203						106	445	551	-551	-348	0	**-348**
11	2010	257	5	31	36	221						106	491	597	-597	-376	0	**-376**
12	2011	271		31	31	240						115	493	609	-609	-368	0	**-368**
13	2012	288		31	31	257						136	471	607	-607	-350	0	**-350**
14	2013	306		31	31	275						163	449	612	-612	-337	0	**-337**
15	2014	327		31	31	296						190	426	616	-616	-320		**-320**
16	2015	351	5	31	36	315						199	404	602	-602	-287	8	**-296**
17	2016	378		31	31	347						299	381	680	-680	-333	22	**-355**
18	2017	409		31	31	378						295	359	654	-654	-275	37	**-312**
19	2018	445		31	31	414						291	336	628	-628	-214	52	**-266**
20	2019	486		31	31	455						288	314	602	-602	-147	69	**-216**
21	2020	573	5	31	36	537						284	291	576	-576	-39	96	**-135**
22	2021	580		31	31	549						281	255	535	-535	14	105	**-91**
23	2022	587		31	31	557						277	219	497	-497	60	112	**-53**
24	2023	595		31	31	564						274	163	437	-437	127	119	8
25	2024	602		31	31	571						270	94	364	-364	208	124	84
26	2025	610	5	31	36	574						267	25	292	-292	282	126	156
27	2026	617		31	31	586						263	0	263	-263	323	130	193
28	2027	625		31	31	594						260	0	260	-260	334	133	201
29	2028	628		31	31	597						256	0	256	-256	341	135	207
30	2029	632		31	31	601						252	0	252	-252	349	136	212
31	2030	635	5	31	36	599						249	0	249	-249	351	137	214
Total		11,025	6,360	772	7,132	3,893	0	3,048	3,286	6,334		5,441	6,729	12,170	-5,835	-1,942	1,538	-3,480

Table 19.2.8 Total Cashflow and Debt Service Analysis After Long-term Financing

Case-5 (70% of Soft Loan and 30% of Equitye)

Unit: Billion Dong

No.	Year	Net Cash Flow Before Financing					Financing Cash Flow									Net Cash Flow after LT.Fina	Corporate Tax Payments	Net Cash Flow aft. LT-Financing&Tax
		Inflow	Outflow			Composite Flow	Inflow					Outflow			Net Financing Stream			
		Revenues	Investment Cost	O.&M. Cost	Total Outflow		Equity	Fund Recourses		Tot.Fin. Inflow	Comulative Inflow	Repayment		Total Debt Service				
								Soft Loan	G.Finance			Soft Loan	G.Finance					
1	2000		327		327	-327	97	230	0	327	327				327			
2	2001		458		458	-458	134	324	0	458	786				458			
3	2002		1,100		1,100	-1,100	318	783	0	1,100	1,886				1,100			
4	2003		1,469		1,469	-1,469	419	1,050	0	1,469	3,355				1,469			
5	2004		1,477		1,477	-1,477	416	1,061	0	1,477	4,832				1,477			
6	2005		523		523	-523	152	371	0	523	**5,354**				523			
7	2006	179		31	31	148						69	0	69	-69	80	20	60
8	2007	196		31	31	165						69	0	69	-69	96	24	72
9	2008	214		31	31	183						69	0	69	-69	114	29	86
10	2009	234		31	31	203						69	0	69	-69	135	34	101
11	2010	257	5	31	36	221						69	0	69	-69	152	38	114
12	2011	271		31	31	240						76	0	76	-76	164	43	121
13	2012	288		31	31	257						87	0	87	-87	170	47	123
14	2013	306		31	31	275						113	0	113	-113	162	52	111
15	2014	327		31	31	296						147	0	147	-147	149	57	92
16	2015	351	5	31	36	315						181	0	181	-181	134	62	72
17	2016	378		31	31	347						191	0	191	-191	156	71	85
18	2017	409		31	31	378						189	0	189	-189	189	79	110
19	2018	445		31	31	414						187	0	187	-187	227	89	139
20	2019	486		31	31	455						184	0	184	-184	270	99	171
21	2020	573	5	31	36	537						182	0	182	-182	355	120	234
22	2021	580		31	31	549						180	0	180	-180	369	124	245
23	2022	587		31	31	557						177	0	177	-177	379	127	252
24	2023	595		31	31	564						175	0	175	-175	389	129	260
25	2024	602		31	31	571						173	0	173	-173	399	131	267
26	2025	610	5	31	36	574						171	0	171	-171	403	133	271
27	2026	617		31	31	586						168	0	168	-168	418	136	282
28	2027	625		31	31	594						166	0	166	-166	428	139	289
29	2028	628		31	31	597						164	0	164	-164	434	140	293
30	2029	632		31	31	601						161	0	161	-161	440	142	298
31	2030	635	5	31	36	599						159	0	159	-159	440	142	298
Total		11,025	5,380	772	6,152	4,873	1,536	3,819	0	5,354		3,576	0	3,576	1,778	6,651	868	4,445

(5) Sensitivity Analysis

As shown in Table 19.2.10, project cost of Case 2 and Case 4 cannot meet long term debt service even if the level of toll fee is increased 20%. Therefore, this alternative must be rejected.

In the case of Case 1 and Case 3, project cost meet long-term debt service with very limited amount by 20 % increase of toll fee. Therefore, Case 5 and Case 6 are most safely balanced.

Table 19.2.10 Result of Appraisal of Cash Flow Analysis (20% Increase Toll)

Case	Soft Loan	Bank Loan	G.Finance	Equity	Appraisal		
					FIRR	Cash Flow Balance	
Case 1	56%		44%		5.21%	O	Positive
Case 2	56%	44%			4.06%	X	Negative
Case 3	80%		20%		5.10%	O	Positive
Case 4	80%	20%			4.56%	X	Negative
Case 5	70%			30%	5.15%	O	Acceptable
Case 6	56%	14%		30%	4.83%	O	Acceptable

(6) Conclusion

1) Implementation of the project by 100 % private sector is judged to be financially unfeasible since FIRR is less than 6 %.

2) For implementation by government, it is necessary to fund with combinations of two types of loan; 80 % soft loan with 1.8 % interest, and the rate with no interest. The Government should prepare the fund since FIRR turned out to be more than 12 % which justifies the implementation from the viewpoint of the national economy (Case 3).

3) Private concessionaire needs to participate in the project if the government cannot prepare the 20 % of project cost of non interest. In this case, the government needs to prepare soft loan to 70 % of the project cost with government certificate.

4) Implementation by private concessionaire is not easy with 30 % of equity of the project cost since FIRR is very low. The Government needs to consider giving some considerations such as tax exemption or increase of toll fee.

CHAPTER 20 CONCLUSION AND RECOMMENDATIONS

CHAPTER 20 CONCLUSION AND RECOMMENDATIONS

20.1 Necessity of the Project

The Project for the construction of the Thanh Tri Bridge and Southern Section of Hanoi Third Ring Road (SHTRR), is of great importance for the development of the Hanoi capital region and is expected to play the following important roles:

- To improve and strengthen the road network in Hanoi capital region to cope with the future increase in vehicle traffic demand and rapid development in the region;
- To provide a by-pass road of National Highway No.1, since the existing roads in Hanoi central business district are seriously congested, especially in National Highway No.1 corridor; and
- To encourage development of Hanoi to the west and north of the red River by an increase in the traffic handling capacity of bridges crossing the river.

20.2 Conclusion on Technical Aspects

(1) Selection of Type of Highway for Throughway in the Phap Van Area

On the section between Phap Van –Cau Gie Interchange and National Highway No.5 in the Phap Van area, both the at-grade type and the viaduct type were studied from the standpoint of road geometric structure, embankment stability, construction cost, landscaping and environment and land / house compensation. From the result of the study, the viaduct was superior to the at-grade type and selected as the recommended option.

(2) Selection of Single Trumpet Type for Phap Van – Cau Gie Interchange

The interchange between STA 0+000 and STA 0+800 is to manage the traffic flow between the Phap Van - Cau Gie road and SHTRR and also between the NH1 and the SHTRR. Two types of interchange (clover leaf type and single trumpet type) were studied from the point of view of the construction cost, land acquisition and compensation expense, trafficability and accessibility. From the study result, single trumpet type is superior to the clover leaf type and selected as the recommended interchange type.

(3) Selection of Red River Bridge Type

Red River Bridge consists of the Main Bridge and Approach Bridge. The Approach Bridge is subdivided into Approach Bridge 1, Dyke Bridge and Approach Bridge 2.

After the review of F/S and comparison study regarding the bridge types from technical and economical view points, the following bridge types were selected for the Red River Bridge.

Main Bridge:	Superstructure:	Continuous PC Box Girder Bridge (Cantilever Erection Method) 80 m + 4 @ 130 m + 80 m = 680 m
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 2.0m

Approach Bridge

Approach Bridge 1:	Superstructure:	Continuous PC Box Girder Bridge 50m span base
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 1.5
Dyke Bridge:	Superstructure:	Continuous PC Box Girder Bridge (Cantilever Erection Method) 80 m + 130 m + 80 m = 290 m
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 1.5m
Approach Bridge 2:	Superstructure:	Simple PC I-Girder Bridge 33m span base
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 1.0m

(4) Major Design Features

1) A design speed of 100 km/h is applied to the throughway and 60 km/h to the frontage roads.

2) The lane width is 3.75m for the throughway and 3.50m for the frontage roads.

3) Number of lanes of throughway in each construction package is shown in the following table.

Package No.	Section	Number of Lane
1	Thanh Tri Bridge	6
2	Thanh Tri	4
3	Gia Lam	4

4) The width of the throughway in the interchange section was decided taking account of the future stage II throughway (6 lanes). This will avoid the difficulty of the additional work after the road is open to traffic.

5) Five interchanges: Phap Van - Cau Gie (Single Trumpet); Nguyen Tam Trinh (Half Diamond); Linh Nam (Full Diamond); Gia Lam Dyke (Half Diamond); and NH5 (Half Clover Leaf) were designed.

6) From the standpoint of efficient collection of toll fee, geological condition of the site and road alignment, a barrier type toll gate included in Package 3 was proposed at a location between the Linh Nam Interchange and the Thanh Tri Dyke road

7) Flexible pavement was designed with a view to lower initial investment cost, better adaptability in embankment section and more comfortable riding condition than rigid pavement.

8) Bridge Design Loads

   - 125% of the standard AASHTO HS20-44 truck or lane loads was used in the design. H30 and XB80 live loads specified in VNBDC are also considered

   - The collision forces to be considered in the design were calculated in accordance with AASHTO LRFD specification based on the maximum ship and the maximum barge weights.

   - Seismic acceleration coefficient of 0.17 was adopted considering the natural conditions in the study area and recommendation by the Institute of Geophysics of Vietnam National Center for Natural Science and Technology.

20.3 Recommendations

(1) Implementation of the Project

The results of the Study indicate that the Project is technically sound (no serious technical difficulties are anticipated for the construction) and also economically feasible. Taking into account the direct and enormous indirect benefits towards regional development other than the quantified savings in travel costs, the Project should be implemented at the earliest opportunity.

(2) Land Acquisition and Resettlement

Delay of implementation would entail increasingly difficult land acquisition and resettlement due to the rapid development of the region, especially in Thanh Tri area. Arrangement of land acquisition and resettlement should commence immediately

(3) Project Implementation Schedule

Proposed implementation schedule is to emphasize simultaneous commencement of services in all four packages, subject to due consideration on inevitable lead-time for land acquisition and resettlement, to optimize investment schedule.

(4) Construction Scheme for the Future Widening

A stage construction scheme such as widening from four lanes to six lanes in the future will entail immense technical difficulties when applied to Thanh Tri Bridge, Pahp Van – Cau Gie Interchange and National Highway No.5 Interchange. Thus it is recommended to provide a six-lane width in the initial stage to avoid this problem, even though only four lanes will be required initially.

(5) Environmental Evaluation

Based on the results of Environmental Study and the EIA, the environmental measures shall be provided during the construction and operation phases.

(6) Maintenance and Operation after the completion of construction

In order to maintain the smooth traffic conditions and safeguard the investment, the maintenance and operation shall be adequately planned and provided for.

JICA