No.

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF COMMUNICATION, TRANSPORT, POST AND CONSTRUCTION
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC
DEPARTMENT OF HIGHWAYS
THE KINGDOM OF THAILAND

THE DETAILED DESIGN OF THE SECOND MEKONG INTERNATIONAL BRIDGE CONSTRUCTION PROJECT IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC AND THE KINGDOM OF THAILAND

FINAL REPORT

MAIN REPORT

JUNE 2000

ORIENTAL CONSULTANTS COMPANY LIMITED
NIPPON KOEI CO., LTD.

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PREFACE

In response to the request from the Government of the Lao People's Democratic Republic and the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Detailed Design of the Second Mekong International Bridge Construction and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Lao People's Democratic Republic and the Kingdom of Thailand a study team headed by Mr. HIROTANI Akihiko, Oriental Consultants Co., Ltd., three times between March 1999 to June 2000.

The team held discussions with the officials concerned of the Government of the Lao People's Democratic Republic and the Government of the Kingdom of Thailand, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations among our there countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Lao People's Democratic Republic and the Government of the Kingdom of Thailand for their close cooperation extended to the team.

June, 2000

Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Kimio Fujita,
President
Japan International Cooperation Agency (JICA)
Tokyo, Japan

We are pleased to submit to you the Final Report on the Study for the Detailed Design of the Second Mekong International Bridge Construction Project which will be implemented in the Lao People's Democratic Republic and the Kingdom of Thailand.

This Study was conducted by Oriental Consultants Company Limited in association with Nippon Koei Company Limited under a contract with JICA, during the period of March 1999 and June 2000. In conducting the Study, we have completed the Basic Design and the Detailed Design of the Project.

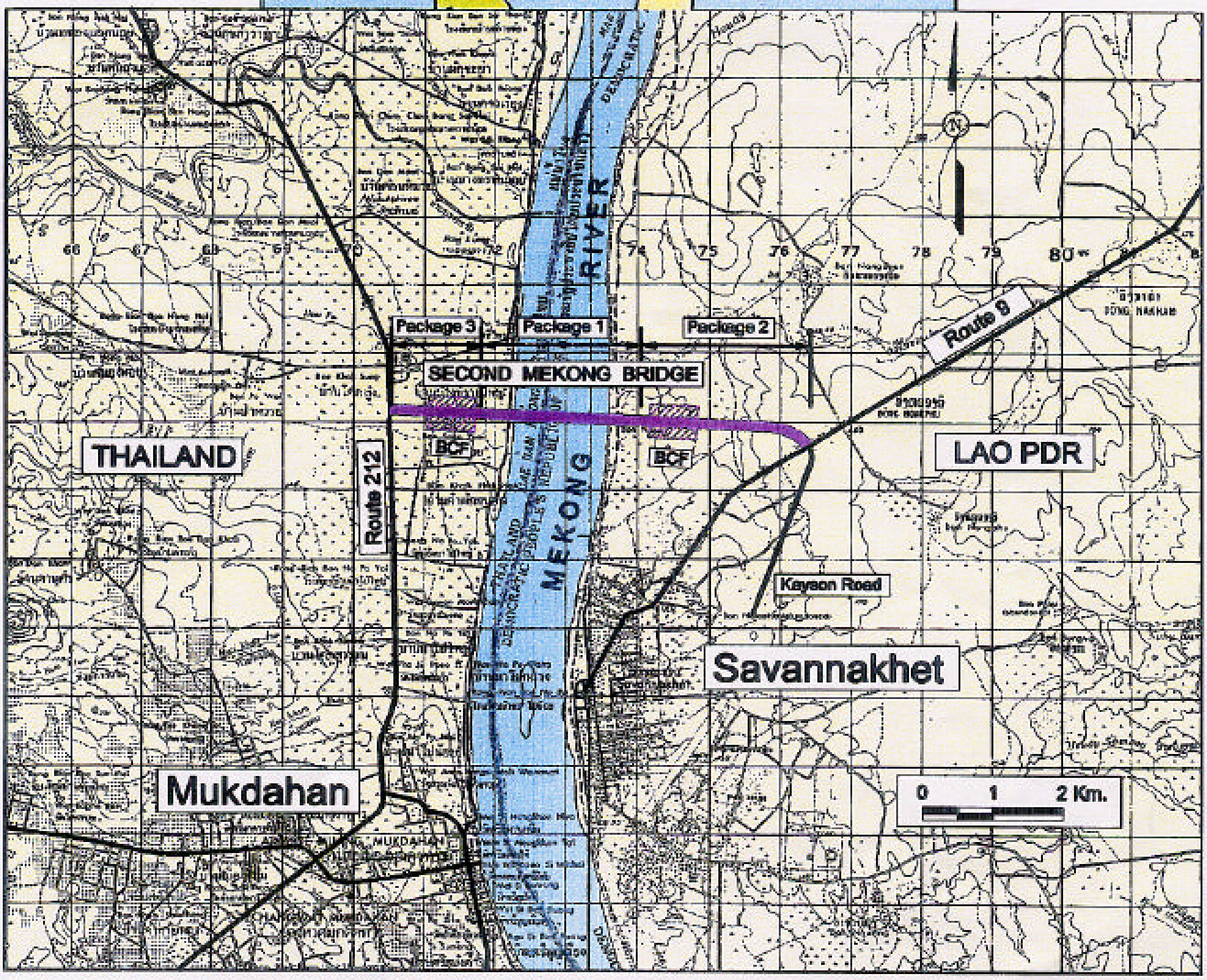
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA. We would also like to express our gratitude to the officials concerned of the Study, the relevant authorities of the Lao PDR and Thailand, and the Embassies of Japan in both of those countries for their cooperation and assistance throughout our Study.

Finally, we hope that this report will contribute to further promotion of the Project.

Very truly yours,
June 2000

Akihiko HIROTANI
Team Leader,
Study Team
The Detailed Design of the Second Mekong International Bridge Construction Project

LOCATION MAP



BRIDGE LOCATION MAP

EAST - WEST TRANSPORT CORRIDOR : MEKONG RIVER CROSSING CONSTRUCTION PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) STUDY TEAM

ORIENTAL CONSULTANTS COMPANY LIMITED in association with NIPPON KOEI COMPANY LIMITED

View of the Main Bridge from the Lao PDR side

View of the Main Bridge from the Thailand side

PROJECT SUMMARY

Project objectives	The Study has been conducted based on the request by both governments of the Lao PDR and Thailand for the detailed design of the Second Mekong International Bridge that is scheduled to link Savannakhet in the southern region of the Lao PDR and Mukdahan in the north-eastern region of Thailand. The study commended with reviews of the SAPROF study of the JBIC, the Basic Design stage during which time various local conditions were surveyed, collected and analized, alternatives were studied and facilities were preliminary designed. Further to the Basic Design, works continued from the detailed designs of the Bridge, roads, Border Control Facilities and others, assessment of environmental impact, constructions, planning, estimation of Project cost, planning on management and maintenance, preparation of draft bidding documents, and transfer of technology during the study duration to counterpart personnel in the both countries.
Study methodology	Contents and procedures of the Study are : *1) Preparatory work in Japan* ① Collection and analysis of related documents and information. ② Reviews on the Study fundamentals, policies, methodology, processes, procedures etc. ③ Preparation of the inception report. *2) First Work on Site* ① Discussion and workshops to present the inception report. ② Investigation on existing situations and collection and analysis of data. ③ Investigation of natural conditions e.g. surveying, soil and material properties, hydrologic and hydraulic properties, earthquake and meteorological properties. ④Basic design i.e. determination on design conditions and design criteria, review on the optimum alternative, examination of initial environmental aspects, design on fundamentals, review on construction plan, estimation of project cost. ⑤ Preparation of the Basic Design Report *3) First Work in Japan* (discussions on the Basic Design Report) *4) Second Work on Site* ① Presentation of the Basic Design Report. ② Detailed design of facilities e.g. Main Bridge, approach viaducts, connecting and approach roads, traffic changeover, revetment, Border Control Facilities. ③ Environmental impact assessment. ④ Construction planning. ⑤ Management and maintenance planning. ⑥ Project cost estimation. ⑦ Draft Bidding documents. ⑧ Project implementation planning. ⑨ Evaluation and recommendations. ⑩draft final report preparation and presentation to the relevant authorities of the both countries. *5) Scheduled forthcoming work: Second work in Japan* (preparation of the Final Report)
Project outlines	The Project is planned in three packages (a total length of 6,166m) as follows: *1)Package 1* (International part: L=2,702m) Thailand side: Traffic changeover L=395m, Approach road L=79.4m, Approach viaduct L=5@50m=250m Main Bridge : PC sail type continuous box girder bridge L= 60+4@80+2@110+5@80+2@110+4@80+60=1600m The Lao PDR side: Approach road L=178m, Approach viaduct L=4@50m=200m *2)Package 2* (the Lao PDR side: L=2,514m) Border Control Facility L=650m, Connecting road L=1864m Intersection: National road route 9 (and Kaysone road) and Provincial road route A3. *3)Package 3* (Thailand side: L=951m) Border Control Facility L=436m, Connecting road L=520m, Intersection: National Highway route 212.
Project evaluation	This Project is an extremely impacted crossing facility of the Mekong River to formulate the Indochina East West Corridor in the Greater Mekong Sub-region that includes China, the Lao PDR, Myanmar, Thailand and Vietnam. Construction of the Project will largely contribute to development of the Mekong sub-region since it will contribute to enhancing exchanges of commodities, transportation local economy and culture.
Conclusion and recommendations	The Study objectives are fulfilled with economical appropriate and design achievements. Since the Financial ODA Pledge has been made among the Government of the Lao PDR, the Royal Thai Government and the Government of Japan, the Project construction is expected to be implemented as early as possible.

OUTLINES OF THE STUDY

The Detailed Design of the Second Mekong International Bridge Construction Project in the Lao PDR and Thailand (hereinafter referred to as the "Project" the "Study").
Study Term : March 1999 – June 2000
Counterpart Agencies : The Ministry of Communication, Transport, Post and Construction of the Lao PDR (hereinafter referred to as the "MCTPC") and the Department of Highways of Thailand (hereinafter referred to as the "DOH")

1. Background

The Indochina East West Corridor that links Myanmar in the west and Vietnam in the east and passes through the Lao PDR and Thailand is one of the high priority project for a development of the Greater Mekong Sub-region. The Project will facilitate a crossing of the Mekong River within the Corridor.

The Japan Bank for International Cooperation (hereinafter referred to as the "JBIC"), the official agency responsible for extending financial assistance program of the Government of Japan (hereinafter referred to as the "GOJ"), has pledged loans to the Government of the Lao PDR (hereinafter referred to as the "GOL") and the Royal Thai Government (hereinafter referred to as the "RTG"), in December 1998 to assist in implementation of The Project.

The location of the Project has been selected in the Special Assistance for Project Formation (SAPROF) study of the JBIC in 1998 at a site approximately 5 km north of Savannakhet in the Lao PDR and approximately 7.5km north of Mukdahan in Thailand.

In response to the request of the GOL and the RTG, the GOJ decided to conduct the Detailed Design Study of The Second Mekong International Bridge Construction Project.

The Japan International Cooperation Agency (hereinafter referred to as the "JICA"), the official agency responsible for implementation of technical cooperation programs of the GOJ, has undertaken the Study in close cooperation with both the MCTPC and the DOH.

2. Objectives

Objectives of the Study are as follows:

- Conducting the necessary engineering and environment surveys to get the basic data for the design. The Detailed Design for the Bridge, connecting road and border control facilities, the Environmental Impact Assessment, the Construction Plan, the Maintenance Plan, the cost estimation and Draft Tender Documents.
- To persue technology transfer to the GOL and the RTG counterpart personnel during the course of the Study.

3. Study area

The Study area of the Project is located approximately 5km north of Savannakhet and approximately 7.5km north of Mukdahan.

4. Outlines of Basic Design Report

The Basic Design Report was submitted to the MCTPC and theDOH in August 1999. The Report contains the following items:

- Project Appreciation
- Natural Conditons
- Social Conditions
- Bridge and Road
- Border Control Facities
- Relocation / Resettlement Plan

- Environment
- Preliminary Cost Estimate
- Public Relation and Technology Transfer

5. The Detailed Design

(1) Road

Fundamental parameters for the detailed design such as location, classification, lane geometry assignment, crossings with local roads and relation with the Border Control Facilities (hereinafter referred to as "BCF") were studied, discussed among parties concerned and were determined during the Basic Design stage then the Detailed Design of roads has been completed.

(2) Main Bridge

The type of the Main Bridge had been studied among several alternatives by taking into consideration climate (rain or dry), topography, geology, material supply, local construction industry and other relevant matters. The Bridge is, consequently, established as a PC sail type continuous box girder bridge.

The Detailed Design of the Main Bridge was conducted with regard to the following contents:

Bridge type	: PC sail type continuous box girder bridge
Bridge and Span length	: 60+4@80+2@110+5@80+2@110+4@80+60 = 1,600m
Layout of bridge deck	: 2×4.25m (carriageway) + 2×1.5m (sidewalk) + 0.5m (median)
Erection method	: Precast segment balanced cantilever erection method
Pier type	: RC wall type pier
Foundation type	: ϕ2.0m cast-in-place RC multi-pile foundation

(3) Viaduct and Ancillary Works

The type of the Bridge was determined by taking into consideration structural balancing with the Main Bridge, topography and geology.

The Detailed Design of the Approch Viaduct was conducted with regard to the following contents:

Bridge type	: PC continuous box girder bridge
Bridge length and span	: the Lao PDR side 50.0m@4=200.0m
	Thailand side 50.0m@5=250.0m
Layout of bridge deck	: 2×4.25m(carriageway)+2×1.5m(sidewalk)+ 0.5m(median)=12m
Erection method	: Temporary staging and cast-in-place concrete method
Pier type	: RC wall type pier
Abutment type	: RC reverse T-type abutment
Foundation type	: ϕ1.0m cast-in-place RC multi-pile foundation

The type of the Bridge accessary had been studied among several alternative by taking into consideration durability, maintenance and cost.

Bridge Bearing	: Elastometric laminated bearing
Expansion Joints	: Steel finger joint
Guardrail	: Steel type

(4) Border Control Facilities

Integrated type BCF (combined cargoes + passengers) was selected. Buildings were designed in conformity with respective local laws, codes, standards and other applicable international codes.

6. Construction Planning

The entire Project is divided into three (3) contract packages whose construction schedules are described below.

Package 1:Main Bridge, approach viaducts (the Lao PDR and Thailand sides), approach roads (the Lao PDR and Thailand sides) and traffic changeover (Thailand side)..36 months

Package 2:Border Control Facility and connecting road in the Lao PDR side.............24 months

Package 3:Border Control Facility and connecting road in Thailand side..................24 months

7. Management and Maintenance

Management and maintenance aspects of the Bridge are described.

8. Environmental Study

On the stage of the Basic Design Report of the Project, the initial environmental examination (IEE) has been carried out. Based on the findings of the IEE, the environmental impact assessment (EIA) has been conducted. Environmental impacts from the Project were verified as insignificant.

9. Cost Estimation

The Project cost estimation has been made for the following components:

- Package 1 : Further divided into the Package 1A (the Lao PDR Portion) and Package 1B (the Thailand Portion).
- Package 2
- Package 3
- Engineering Services

10. Draft Bidding Documents

The following draft documents have been prepared based on the 'Guidelines for Procurement under JBIC ODA Loan' for package 1, package 2 and package 3:

1. Prequalification documents
2. Volume 1: Invitation for Bids
   Section 1. Instruction to Bidders
   Section 2. Part 1 – General Conditions
   Section 3. Part 2 – Conditions of Particular Applications
   Volume 2: Section 4. Technical Specifications
   Volume 3: Section 5. Forms of Bid, Appendix, Bid Security and List of Eligible Countries of JBIC ODA Loans
   Section 6. Bill of Quantities
   Section 7. Form of Agreement
   Section 8. Form of Security
   Section 9. Schedule of Supplementary Information
   Volume 4: Section10. Drawings

11. Implementation Program

The Implementation program of the Project is presented. Seasonal conditions are take into account for commencement of the foundation work in December when the Mekong River water level will be low. The total Project duration from the loan agreement conclusion date to the Bridge opening date is estimated at five years and one month.

12. Evaluation and Recommendations

In accordance with the Study, the design objectives are fulfilled in appropriate and economical design achievements. Since the Finance Assistance Pledge has been made among the Government of the Lao PDR, the Royal Thai Government and the Government of Japan, the Project construction is expected to be implemented as early as possible.

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ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
ARI	Average Recurrence Interval
BCF	Border Control Facility
BMC	Bridge Management Committee
CBSB	Cross Border Shuttle Bus
COWI Study	Original ADB study for the East West Corridor development in 1991, the Southern Thai-Lao Mekong Bridge Project
DCTPC	Department of Communication, Transport, Post and Construction (province or district of the Lao PDR)
DG	Diesel Generator
DOH	Department of Highways (of Thailand)
EIA	Environmental Impact Assessment
EIED	Environmental Impact Evaluation Division (of Thailand)
EIS	Environmental Impact Statement
FWL	Flood Water Level
GDP	Gross Domestic Product
GOJ	Government of Japan
GOL	Government of the Lao PDR
GPP	Gross Provincial Product
GPS	Global Positioning System
HWL	High Water Level
ICZ	International Construction Zone
IDA	International Development Association (World Bank)
IEE	Initial Environmental Examination
JBIC	Japan Bank for International Cooperation (Successor of the OECF)
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standard
JRA	Japan Road Association
JRA-SHB	Specifications for Highway Bridge of Japan road Association
LWL	Low Water Level

MCTPC	Ministry of Communication, Transport, Post and Construction (of the Lao PDR)
MOSTE	Ministry of Science, Technology and Environment (of Thailand)
MOTC	Minister of Transport and Communications (of Thailand)
NR	National Road
OECF	Overseas Economic Cooperation Fund (Predecessor or of the JBIC)
PC	Prestressed Concrete
PCC	Project Coordinating Committee
PR	Provincial Road
RC	Reinforced Concrete
ROW	Right of Way
RTG	Royal Thai Government
SAPROF	Special Assistance for Project Formation
SIDA	Swedish International Development Agency
STENO	Science, Technology and Environment Organization
the Study, the Project	Detailed Design of The Second Mekong International Bridge Construction Project
TIS	Thai Industrial Standard
UPS	Uninterrupted Power Supply
VNC	Valuation and Negotiation Committee

CHAPTER 1
Study Contents

CHAPTER 1 : STUDY CONTENTS

1.1 INTRODUCTION

In response to a request by the Government of The Lao PDR (hereinafter referred to as the "GOL") and the Royal Thai Government (hereinafter referred to as the "RTG"), the Government of Japan (hereinafter referred to as the "GOJ") decided to conduct the Detailed Design (hereinafter referred to as "the Study") of The Second Mekong International Bridge Construction Project (hereinafter referred to as "the Project") in accordance with relevant laws and regulations in force in Japan. The study location is shown in the Figure 1.1.1.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for implementation of the technical co-operation programs of the GOJ, has undertaken the Study in close co-operation with the authorities concerned of the GOL and the RTG, and dispatched a Study Team

The Japan Bank for International Cooperation (hereinafter referred to as "JBIC"), the official agency responsible for extending the financial assistance program of the GOJ, has pledged loans to the GOL and the RTG in December 1998 to assist in implementation of the Project.

This Final Report covers the results and conclusions of all the work of the Study, including the Detailed Design of the Second Mekong International Bridge, connecting roads, Border Control Facilities, Construction Planning, Environmental Study, Cost Estimate and Draft Tender Documents.

1.2 BACKGROUND

The central area in the Indochinese Peninsula, such as the northern part of Thailand, the southern and the central part of the Lao PDR and the central part of Vietnam, is an area in which development was lacking in the past. An economic co-operation council has been formed in 1992 with participation of the Lao PDR, Vietnam, Cambodia, Myanmar, Thailand and China. The purpose of the council is to develop the Greater Mekong Sub-region through mutual economic co-operation. Since then, efforts have been made to identify and formulate priority development projects and programs. One of the identified priority projects is to develop the Indochina East West Corridor linking Myanmar in the west and Vietnam in the east and passing through the Lao PDR and Thailand (See Figure 1.2.1).

Prior to the fully-fledged development of the Corridor, the Second Mekong International Bridge was initially proposed in the first study for the East West Corridor development in 1991. This study titled the Southern Thai-Lao Mekong Bridge Project (hereinafter referred to as "the COWI Study") was financed by the Asian Development Bank (hereinafter referred to as the "ADB") to examine the link between the Lao PDR and Thailand after request of local authorities. The site at about 4 km north of Savannakhet and Mukdahan was recommended as the most appropriate bridge location.

Figure 1.1.1 Study Location Map

The East West Corridor Study (hereinafter referred to as "the Maunsell Study") was carried out under the ADB's regional technical assistance. This study seems not directly have come from the previous COWI Study, but rather was a part of several transport improvement programs identified by the ADB in 1994 as priority projects in the Greater Mekong Sub-regional Transport Study, covering China, the Lao PDR, Myanmar, Thailand and Vietnam. In the course of the Maunsell Study, the priority project was fixed as the national road Route 9 in the Lao PDR while a bridge site 10 km north of Savannakhet and Mukdahan was recommended.

Under the circumstances, the GOL requested the GOJ to provide the Yen Loan assistance for construction of the Bridge in June 1997, and the RTG also requested the GOJ to provide the Yen Loan assistance for the construction of the Bridge for the Thailand part. The JBIC (OECF) of Japan decided to carry out its facilitation program named the Special Assistance for Project Formation (SAPROF) Study. The SAPROF Study selected a new location for the bridge crossing at approximately 5 km north of Savannakhet and Mukdahan.

Following the result of the SAPROF Study, the GOJ decided to request the JICA Preparatory Study Team to prepare the Scope of Works for the Detailed Design of the Second Mekong International Bridge Construction Project in December 1998. The Detailed Design Team of JICA (hereinafter referred to as "the Study Team") was dispatched to carry out the Detailed Design for the Project in March 1999.

Figure 1.2.1
Location Map of the Indochina East West Corridor

1.3 OBJECTIVES

The objectives of the Study are the following design items for the Second Mekong International Bridge Construction Project on demands of both the GOL and the RTG.

- To examine alternative plans for the route and the bridge structure with review to the SAPROF Study of the JBIC (OECF) at the Basic Design stage. To conduct necessary engineering and environmental surveys to get basic data for the design; the Detailed Design for the Bridge, connecting roads and border facilities; the environmental impact assessment; the construction plan; the maintenance plan; the cost estimation and Draft Tender Documents.

- To pursue technology transfer to the GOL and the RTG counterpart personnel during the course of the Study.

1.4 STUDY AREA

The study area of the Project is located at approximately 5.0 km north of Savannakhet in the Lao PDR and at approximately 7.5 km north of Mukdahan in Thailand, as proposed by the SAPROF Study for the bridge location and the connecting roads of both sides. The connecting roads of the Second Mekong International Bridge will connect the national road Route 9 in the Lao PDR and the national highway Route No. 212 in Thailand. Figure 1.4.1 shows the location of the present study and the other ADB study.

The connecting road on the Thailand side is approximately 1.7 km long from the intersection of the national highway Route No. 212 to the riverbank of the Mekong River, while the connecting road on the Lao PDR side is approximately 3.0 km long from the intersection of the national road Route 9 to the riverbank.

The Mekong River has an approximate width of 1,450m at this point, and its riverbed elevation is approximately 15m lower than the riverbank level.

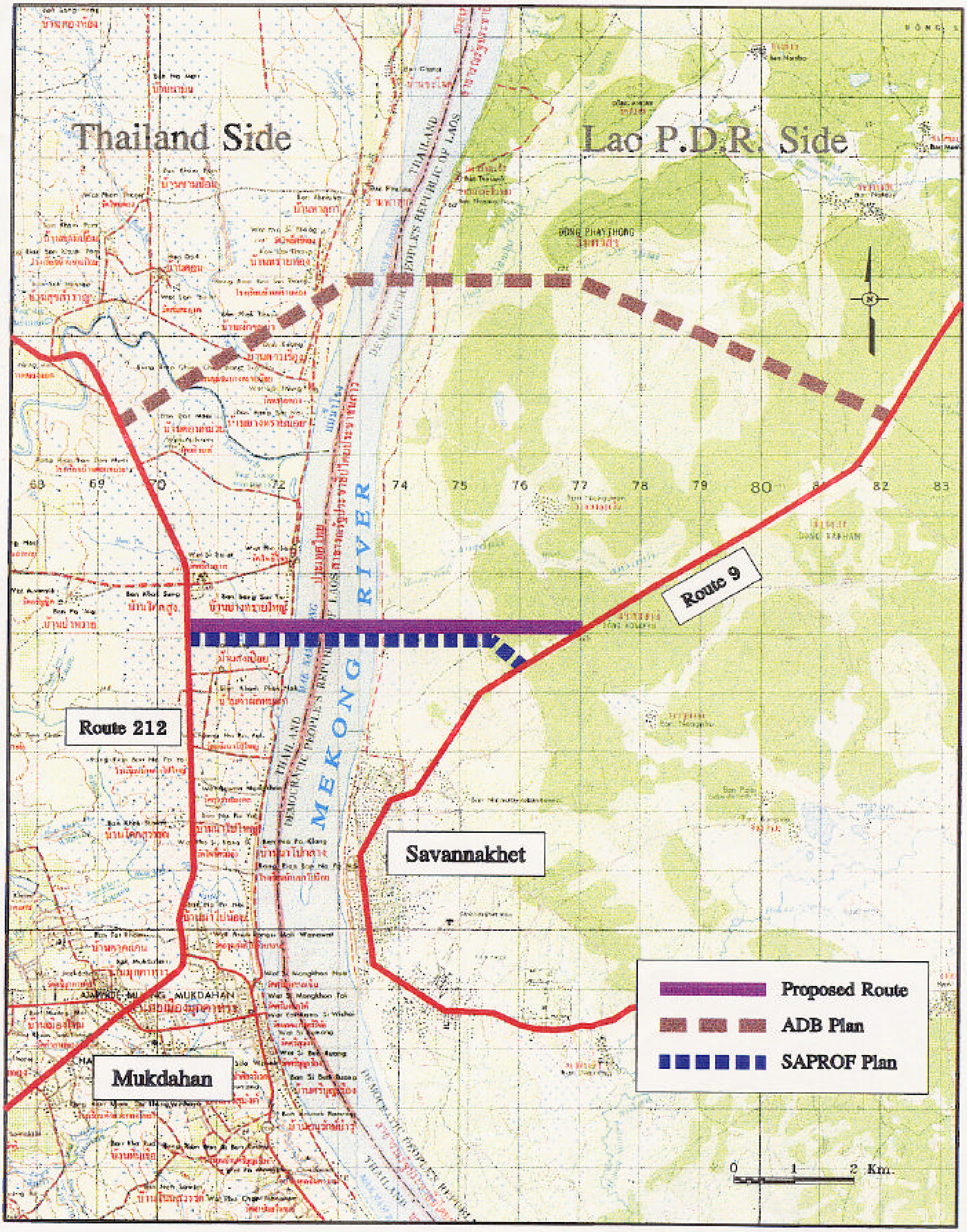


Figure 1.4.1 Study Location Map

1.5 SCOPE

The Study was executed in accordance with the Scope of Works in the Inception Report of this Study agreed on 9 April 1999 by the GOL, the RTG and the JICA Study Team.

For the purpose of this Study, the following items were covered.

(1) Preliminary Study
- Review of the Studies conducted by the ADB and the JBIC, current transport plans and programs, and other related information including the result of the JBIC's appraisal.

(2) Natural Condition Survey
- Topographic Survey
- Hydrologic and Hydraulic Investigation
- Soil/Material and Geo-technical Investigation

(3) Basic Design
- Determination of Design Criteria and Standards
- Examination of the structural type of Bridge, connecting road and Border Control Facilities
- Examination of the horizontal and vertical alignment of the Bridge and connecting roads
- Examination of the construction plan and method for the Bridge and facilities
- Execution of the Initial Environmental Examination (IEE)
- Estimation of the Project cost of each package

(4) Detailed Design
- Bridge including the superstructure, substructure and foundation
- Connecting roads including the intersections to existing roads
- Traffic changeover facility
- Border Control Facilities
- Revetment and protection of riverbed and riverbanks

(5) Environmental Impact Assessment (EIA)
- Study of the pollution and noise/vibration issues
- Establishment of the environmental protection programs
- Implementation plan of the environmental protection plan and method

(6) Construction Plan
- Method of construction
- Material and machinery schedule
- Temporary facilities, equipment and works

(7) Management / Maintenance Plan
- Maintenance plan for the Bridge, roads and border facilities
- Management and maintenance plan, sharing of the two countries

(8) Estimation of Cost for the Project

- Cost of each package based on the Detailed Design and the construction plan
- Material cost, Labor cost, machinery cost, fare, and insurance fee
- Site management cost and general management cost
- Overall construction cost
- Cost for management and administration expenses
- Compensation cost
- Classification of foreign currency and local currency
- Taxes

(9) Draft Tender Documents

The draft tender documents for the construction packages hereunder including the Pre-qualification Procedures were prepared.

Package I : Bridge Section including approach viaducts and approach roads of both the Lao PDR and the Thailand sides (International Competitive Bidding)

Package II : Connecting Road, Border Control Facility and associated facilities on the Lao PDR side (International Competitive Bidding or National Tender)

Package III : Connecting Road, Border Control Facility and associated facilities on the Thailand side (International Competitive Bidding or National Tender)

1.6 STUDY SCHEDULE

The Study for the Detailed Design of the Second Mekong International Bridge Construction Project was commenced in March 1999 in accordance with the Scope of the Study. The Study schedule is shown in Figure 1.6.1 Study Flow.

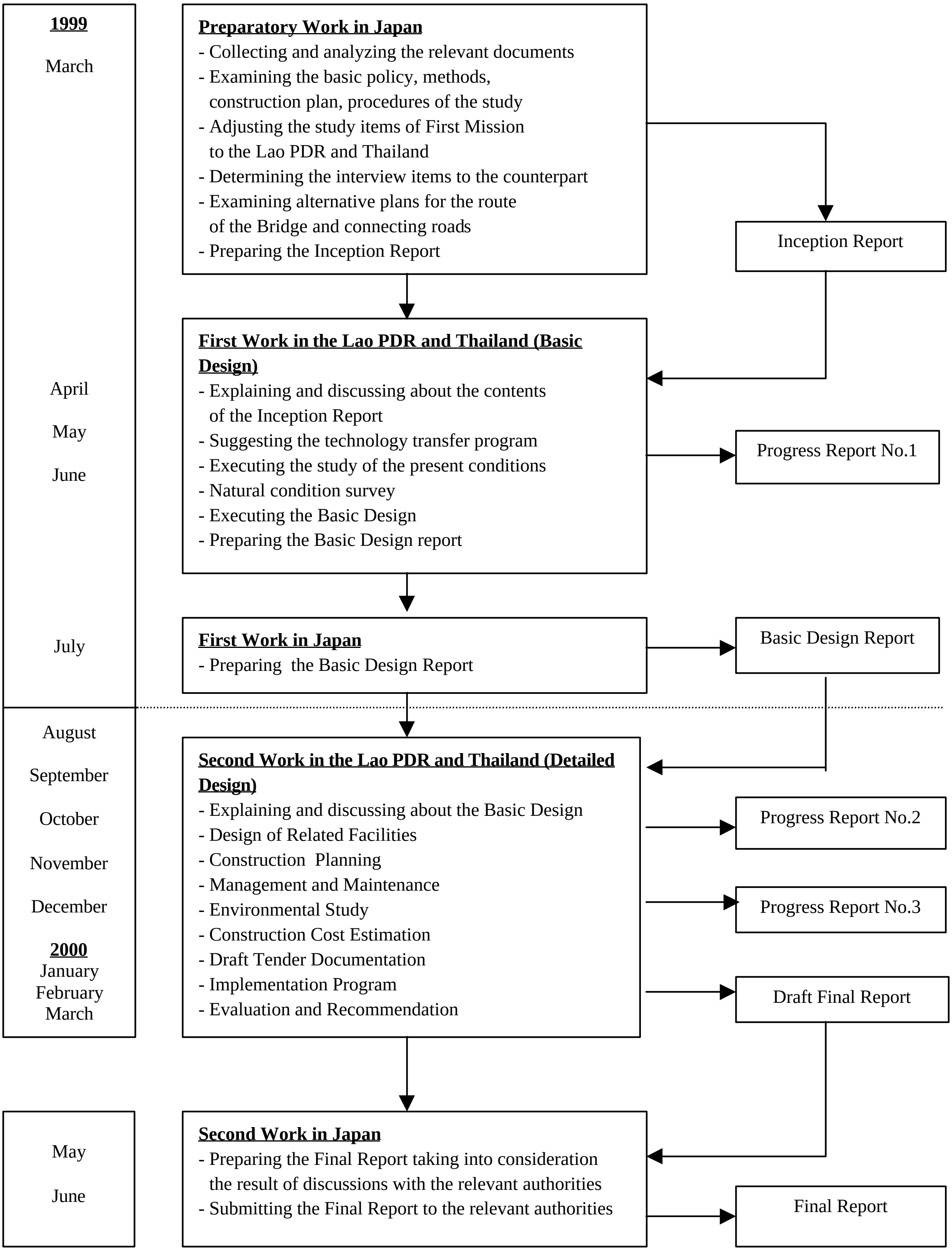


Figure 1.6.1 Study Flow

1.7 STUDY STRUCTURE

The Ministry of Communication, Transport, Post and Construction of the GOL (hereinafter referred to as the “MCTPC”) and the Department of Highways of the RTG (hereinafter referred to as the “DOH”) act as counterpart agencies co-operating with related organizations of each country, the JICA Study Team and also act as coordinating bodies in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study, and for applying guidance provided by the JICA.

The two committees involve with political matters of the Study and will solve the problems. The committees are described as follows;

(1) Bridge Management Committee (BMC)

The BMC includes representatives of the MCTPC and the DOH

(2) Project Coordinating Committee (PCC)

The PCC consists of personnel of higher status than BMC. The PCC adjusts political matters concerning the Study and solves the problems which are not to be solved by the BMC.

Relationship among these institutions is shown in Figure 1.7.1. The counterparts and member lists of each committee are shown in Table1.7.1, 1.7.2 and 1.7.3.

In this Study, BMC functions as the discussion and the decision-making agency related to critical items or troubles fundamental to survey or design. Detailed conditions of survey or design were discussed with relevant counterparts. BMC meetings were held in parallel to progress of the Study to discuss on survey or design details or results based on reports of each stage submitted by the Study Team as well as on implementation conditions on later stages. Items of decision were written as minutes of meetings. In this Study stage, all troubles related to survey and design were decided by BMC. Therefore, PCC was not required to take actual actions at practical levels.

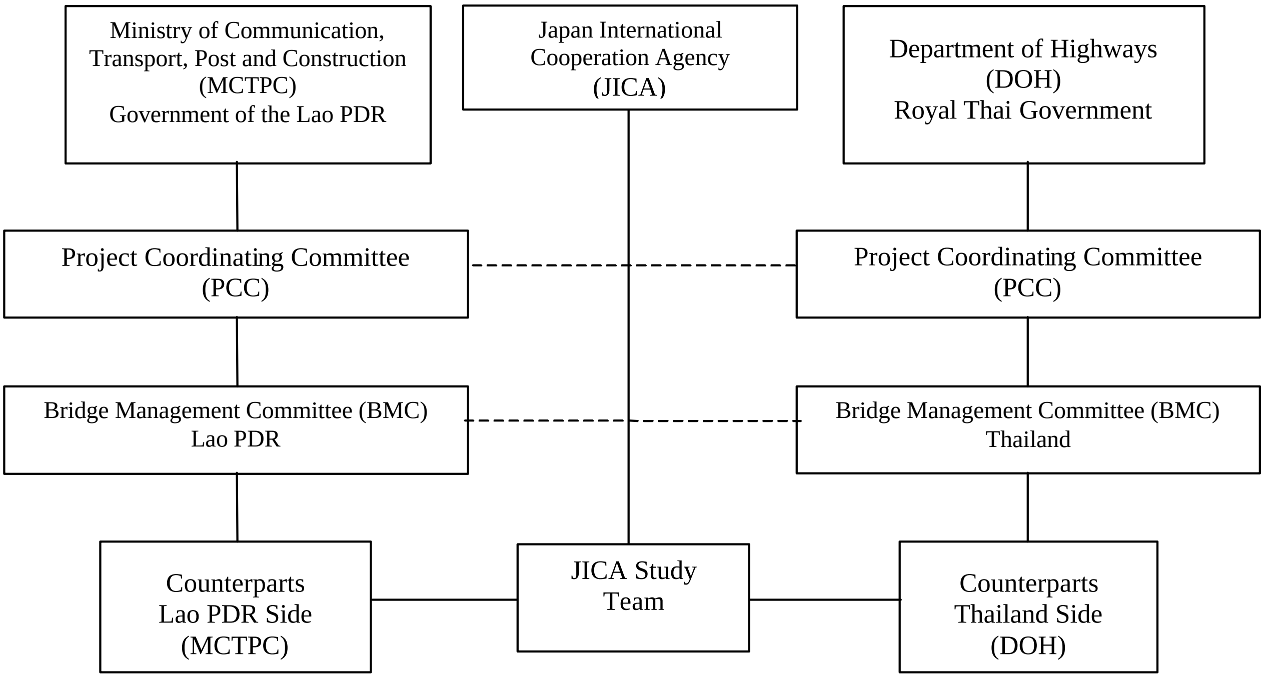


Figure 1.7 Study Structure

Table 1.7.1 Member List of Counterpart

Lao PDR	Thailand
Mr. Khamphone Phannouvong Road & Bridge Engineer & Assistant to Project Manager	Mr. Wanchai Parkluck Expert Engineer for Highway Design Bureau of Location and Design, DOH : Leader for Electric and Lighting
Mr. Khamseo Moulaphasith Office Administrator	Mr. Veera Ruangsooksriwong Expert Engineer for Highway Design Bureau of Location and Design, DOH : Road Section
Mr. Chanthy Vilayvong Road Engineer	Mr. Sombat Charoenpat Senior Engineer for Structure Design Bureau of Location and Design, DOH : Structure Section
Ms. Khamphet Rattanavong Project Financialist	Mrs. Phimchai Yuthabandol Chief of Environmental Group Bureau of Planning, DOH : Environment Section

Table 1.7.2 Member List of Bridge Management Committee

Lao PDR
Mr. Phetsamone Viraphanth National Project Manager, MCTPC
Mr. Inthalongsinh Sithimorada Director of DCTPC, Savannakhet Province
Mr. Phongsavanh Phommavong Custom Officer of Financial Department, Savannakhet Province
Mr. Bounma Senphasouk Immigration Officer, Savannakhet Province
Mr. Oulay Phaduangdeth Chief Technical Division of Communication Department, MCTPC
Mr. Khamphone Phannouvong Road & Bridge Engineer & Assistant to Project Manager, MCTPC

Thailand
Mr. Solos Temiyabutra Director, 1st Bureau of Highway Construction DOH
Mr. Kumphol Uruyos Expert Design Engineer, Bureau of Location and Design DOH
Mr. Sunant Gliengpradit Civil Engineer, Bureau of Planning DOH
Representative of the Customs Department
Representative of Office of Police Immigration
Representative of Mukdahan Province Governor
Mukdahan Field Highway District, DOH

Table 1.7.3 Member List of Project Coordinating Committee

Lao PDR
Mr. Somad Pholsena Director of Communication Department, MCTPC
Mr. Soukhaseum Bhodhisane Vice Governor, Savannakhet Province
Mr. Thoummy Phounthongsy Department of Immigration, Ministry of Interior
Mr. Viravong Viaravong Chief of Law Division, Protocol & Law Department, Ministry of Foreign Affairs
Mr. Ouly Si Amnouy Deputy Director of Custom Department, Ministry of Finance
Mr. Phetsamone Viraphanth National Project Manager, MCTPC

Thailand
Mr. Srisook Chandrangsu Director General DOH
Representative of Ministry of Transport and Communications
Representative of Ministry of Foreign Affairs
Representative of Ministry of Interior
Representative of the Customs Department
Representative of Office of Police Immigration
Representative of the Fiscal Policy Office
Representative of Mukdahan Province Governor
Mr. Solos Temiyabutra Director, 1st Bureau of Highway Construction DOH
Mr. Kumphol Uruyos Expert Design Engineer Bureau of Location and Design, DOH

1.8 REPORTING

The Study Team has submitted the following reports to the MCTPC and the DOH at each stage of progress in the Study work:

- Inception Report April 1999
- Progress Report No.1 June 1999
- Basic Design Report August 1999
- Progress Report No.2 October 1999
- Progress Report No.3 December 1999
- Draft Final Report March 2000
- Final Report June 2000

CHAPTER 2
Detailed Design of Road

CHAPTER 2 : DETAILED DESIGN OF ROAD

2.1 GENERAL

There have been many studies on the route of the Indochina East West Corridor and discussions have been held on how to cross the Mekong River. This Study has started from the point where the concerned parties, such as the MCTPC of the Lao PDR, the DOH of Thailand, and the JICA and the OECF of Japan, have agreed to set the location of the Second Mekong International Bridge between Savannakhet in the Lao PDR and Mukdahan in Thailand.

The above concerned parties did not exactly settle on the crossing location. The JICA Study Team started the Study by inspecting the expected crossing location at the site, interviewing with concerned parties, taking into account of various controlling matters and set the area for topographic survey, geo-technical investigations, hydrological survey and Initial Environmental Examination.

Various analysis have been conducted. They included alternative studies on the Bridge, connecting road routes and structures, Border Control Facilities and other matters of influence to the Project.

With the general view of the natural and social conditions of the construction site, the results of the study for the bridge location, the proposed route, the vertical alignment, and the Detailed Design of the Roads are described as follows.

2.2 DESIGN CONDITIONS

The Second Mekong International Bridge crosses the Mekong River and it includes connecting roads and approach roads.

Connecting roads will connect the national road Route 9 in the Lao PDR and the national highway Route No.212 in Thailand. Moreover, it will contain an at-grade intersection with the Provincial Road A3 in the Lao PDR. Therefore, geometry of the carriageway has been applied on the basis of standards of the connecting roads in the both countries.

The connecting roads were designed with a 2 traffic lane in the Lao PDR side and 4 traffic lane with the 11m width central median in the Thailand side. Approach roads were designed with 2 traffic lane with central median both in the Lao PDR and Thailand.

The traffic changeover is necessary as vehicles travel on the right-hand side of the road in the Lao PDR and on the left - hand side in Thailand. The traffic changeover becomes a separated one lane roadway and its geometry conforms basically with geometry of the carriageway.

2.2.1 Design Criteria

(a) Connecting Roads, Approach Roads and Bridge

The design standards for the carriageway of connecting roads, approach roads and the Bridge are shown in Table 2.2.1.
The design speed of the carriageway was provided on the basis of the Asian Highway Class II - Level Terrain classification at 80km/h. The geometry of the carriageway was provided to contain the standard of connecting roads in both countries.

Table 2.2.1
The Design Standards of The Project

Standard Items	Second Mekong Bridge
Class*	Asian Highway Class II-L
Design Speed	80km/h
Minimum Horizontal Curve Radius	400m
Minimum Horizontal Curve Radius (without Transition Curve) (without Superelevation)	 900m 3,500m
Minimum Vertical Curve Radius (Crest) (Sag)	 5,000m 2,000m
Maximum Gradient	4.0%
Maximum Superelevation	10.0%
Carriageway Width	3.5m x 2 lane = 7.0m
Shoulder Width (Traffic Side)	2.5m
Verge Width	0.5m x 2 (both sides)
Formation Width	13.0m
Crossfall	2.0%
Right of Way	60m (the Lao PDR) 60m (Thailand)

* L = Level Terrain

(b) The Traffic Changeover

The design standard for the traffic changeover is shown in Table 2.2.2.

The design speed of the traffic changeover was provided at 50km/h, on the basis of Grade B that is prescribed in the Road Structure Ordinance of Japan.

Table 2.2.2
The Design Standards for the Traffic Changeover

Standard Items	Second Mekong Bridge
Class*	Japanese Grade-B
Design Speed	50km/h
Number of Lanes	1
Minimum Horizontal Curve Radius	90m
Minimum Horizontal Curve Radius (without Transition Curve) (without Superelevation)	 220m 1,300m
Minimum Horizontal Curve Length	90m
Minimum Vertical Curve Radius (Crest) (Sag)	 5,000m 2,000m
Maximum Gradient	4.0%
Maximum Superelevation	10.0%
Lane Width	3.5m
Shoulder Width (Traffic Side)	2.5m
Shoulder Width (Center Side)	1.0m
Verge Width	0.5m x 2 (both sides)
Formation Width	8.0m
Crossfall	2.0%

2.2.2 Typical Cross Section

Typical cross-sections of the connecting roads, approach roads and traffic changeover were decided in accordance with the design criteria above.

2.2.2.1 Connecting Road

(a) Connecting Road in the Lao PDR Side

The typical cross-section of the connecting road in the Lao PDR side is shown in Figure 2.2.1.

The traffic lane width was applied at 3.5m and a road shoulder width was applied at 2.5m. A verge width of 0.5m was established on both sides of the carriageway on the basis of the Road Structure Ordinance of Japan.

The length of the connecting road in the Lao PDR side is approximately 1,850 m. by located between the BCF and the intersection of the national road route No.9.

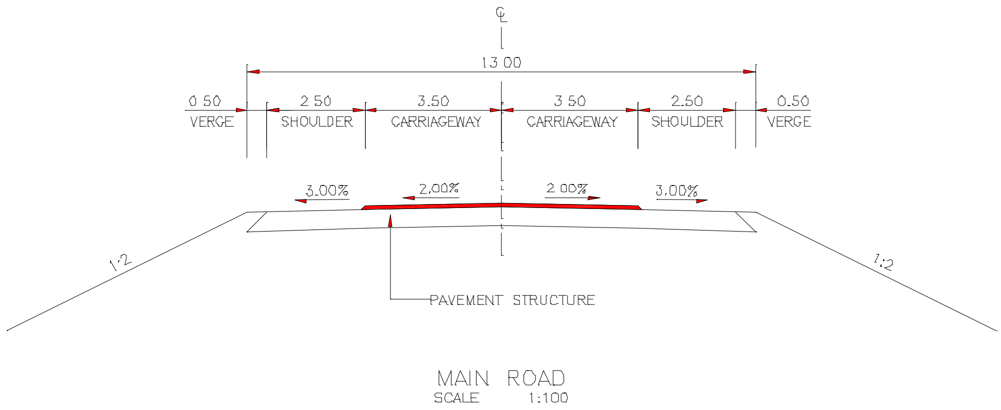


Figure 2.2.1
The Typical Cross-section of the Connecting Road in The Lao PDR Side

(b) Connecting Road in The Thailand Side

The typical cross-section of the connecting road in the Thailand side is shown in Figure 2.2.2.

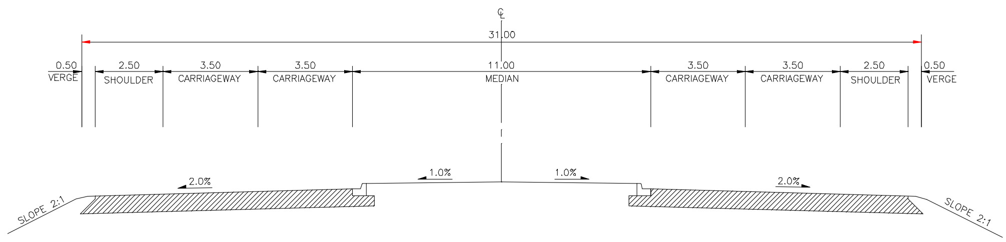


Figure 2.2.2
The Typical Cross-section of the Connecting Road in the Thailand Side

Length of the connecting road in the Thailand side is approximately 540m long, located between the BCF and the intersection of the national highway Route No.212.

The central median width of 11m has been decided in consideration of widening the carriageway because a new national highway is expected to be built west of this intersection as a part of the future Indochina East West Corridor.

2.2.2.2 Approach Road

The typical cross-section of approach roads located between the BCF and the approach viaducts both in the Lao PDR and the Thailand sides is shown in Figure 2.2.3.

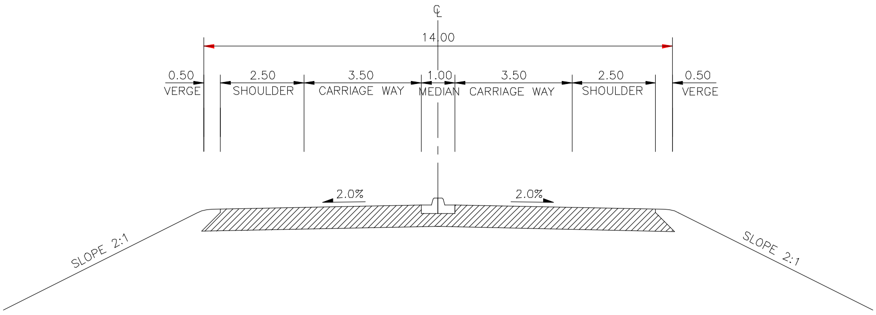


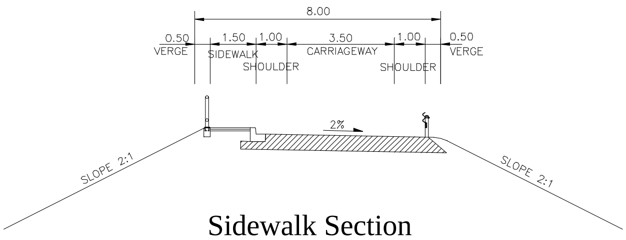
Figure 2.2.3
The Typical Cross-section of the Approach Road

The traffic lane width was applied at 3.5m and the road shoulder width is applied at 2.5m on the basis of the design criteria. A central median width of 1m was established between the up and down lanes similar to the bridge section because the approach roads connect to the Bridge directly.

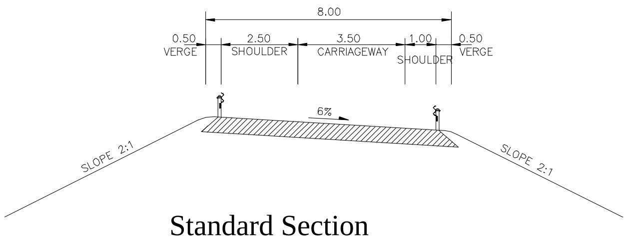
2.2.2.3 Traffic Changeover

The approach road is separated into the up and down lanes with a 1 lane carriageway in the traffic changeover. The shoulder with 1m width is established on the inner side of the two separated roads.

The typical cross-section for the traffic changeover is shown in Figure 2.2.4.



Sidewalk Section



Standard Section

Figure 2.2.4
The Typical Cross-section at the Traffic Changeover

2.3 ROAD ALIGNMENT

The Study Team decided on the bridge alignment at right - angles to the Mekong River while taking into consideration other conditions such as the social and environmental situations.

2.3.1 Horizontal Alignment

2.3.1.1 Control Points

The Study Team decided on the plan of the Bridge and connecting roads by considering the public facilities around the site and situation of land use of the Mekong River in both the Lao PDR and Thailand. Table 2.3.1 shows the items of control points.

Table 2.3.1
Control Points of the Connecting Roads

		Control Points	Outline
Bridge		The Mekong River	River width : 1.5km. Secured the navigation clearance (60m width, 10m×2 from the HWL in the middle of the River, and 60m width, 5.5m from the HWL near the riverbanks of the River.)
Connecting Roads	The Lao PDR Side	Existing Road No.1	A north-south road along the Mekong River
		Existing Road No.2	A gravel road connecting the national road Route 9 at the Rehabilitation Facility
		Bailey Bridge	15m length bridge located at about 100m upstream from the construction site of the SAPROF study.
		Irrigation Canal	Located at about 300m downstream from the construction site of the SAPROF study. Pumping up water from the Mekong River, and using as irrigation water supply
		Water Intake and Purification Plant	Located at about 1.2km downstream from the construction site of the SAPROF study
		Thaoudom Village	A village where about 400 people (30 households) live
		Leisure Center	Cottages, ponds, and a zoo in a 16ha area
		Rehabilitation Facility	Korean assisted facility
	Thailand Side	Existing Road	A north-south paved road along the Mekong River
		Ban Khoh Song Village	A village where about 3,000 people live

(a) Lao PDR Side

There are many control points around the given location of the Bridge such as the Ban Nake village, approximately 500m south; the Huai Nunadeun Canal, approximately 100m north; the high voltage river crossing line, approximately 1 km north; the irrigation canal, approximately 400m south; the water intake facility for Savannakhet, approximately 1.2 km south and other similar points.

Along the route of the connecting roads, there were several control points such as the irrigation canal, the electricity transmission line coming from the Thailand side, the fishpond area, the leisure center, local roads and other similar points. Along the north side of the national road Route 9, various facilities occupy the space. However, at K.M. 6 and nearer toward the city, there is a more dense coverage of buildings.

On the other side of the national road Route 9, there is Kaysone Road, factories, and several other facilities to be taken into consideration when planning the intersection with the connecting road.

(b) Thailand Side

There are not many control points on the Thailand side and villages such as Ban Khan Phak Nok, approximately 1 km south; Ban Bang Sai Yai, approximately 200m north; and Ban Khok Sung, approximately 500m north and at about station KM171+150 of the national highway Route No. 212 would need some considerations. There are also Huai Po River, canal and other similar control points identified.

2.3.1.2 Horizontal Alignment Design

(a) Positioning of the Bridge

The Mekong River has been observed on stability of the riverbank, current, control points on the riverbanks, control points immediately behind the riverbanks and further areas concerned.

The Mekong River is running not exactly north to south but tilts slightly northeast – southwest. The angle of the Bridge was inspected and it was determined at 5.5 degrees from the true east - west direction as shown in Figure 2.3.1.

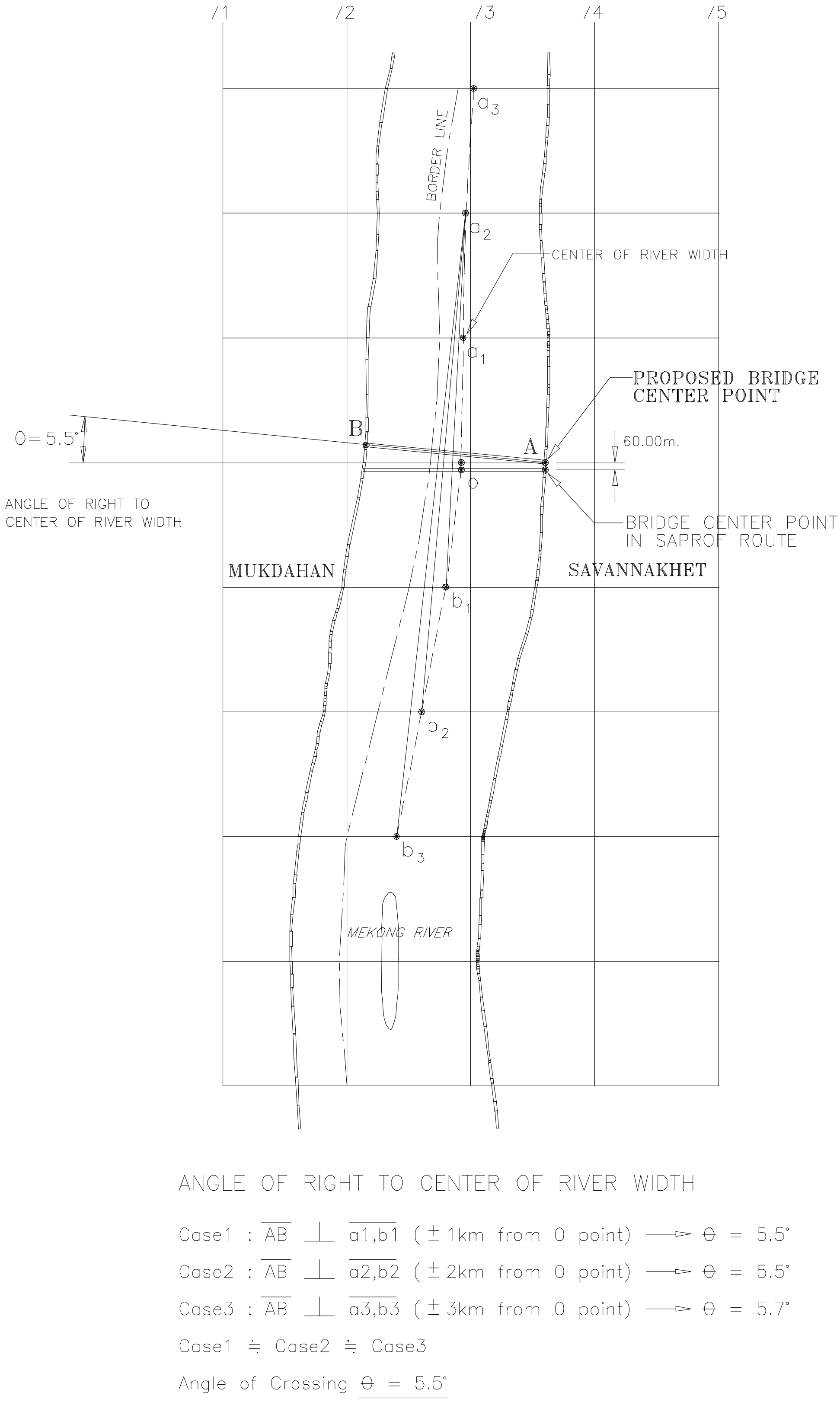


Figure 2.3.1
Crossing Point of the Bridge

(b) The Lao PDR Side

The centerline of the Bridge was extended straight to the Lao PDR side. There were several alternatives made on the alignment of the connecting road.

The final route was selected as the most favorable route after comprehensive comparisons of total lengths, topography, compensation cost, environmental items, accessibility to Kaysone Road and others.

(c) Thailand Side

There are not many control points on the Thailand side, thus the alignment of the road continues straight from the Bridge, while crossing paddy fields, a small river and a concrete lined canal.

(d) Location of Border Control Facilities

(1) The Lao PDR Side

The site for the Border Control Facilities (BCF) was found to be the most favorable on a small hill approximately 600m from the riverbank. This location has advantages such as development prospects along the connecting road from the Route 9 and a higher elevation than the surrounding area so as to avoid any flooding.

(2) Thailand Side

A small hill, at an approximate elevation of about the same as that of the riverbank, was found to be a favorable site for the BCF. This location has some advantages such as to be high enough to avoid flooding, smaller land price than the paddy fields, nearer to the river and easy access from the main road. A short connecting road coming from the national highway Route No.212 that is perpendicular to it also secures the access to the BCF area.

(3) Horizontal Alignment of the Bridge and Connecting Roads

The horizontal alignment of the Second Mekong International Bridge and the connecting roads are determined as shown in Figure 2.3.2.

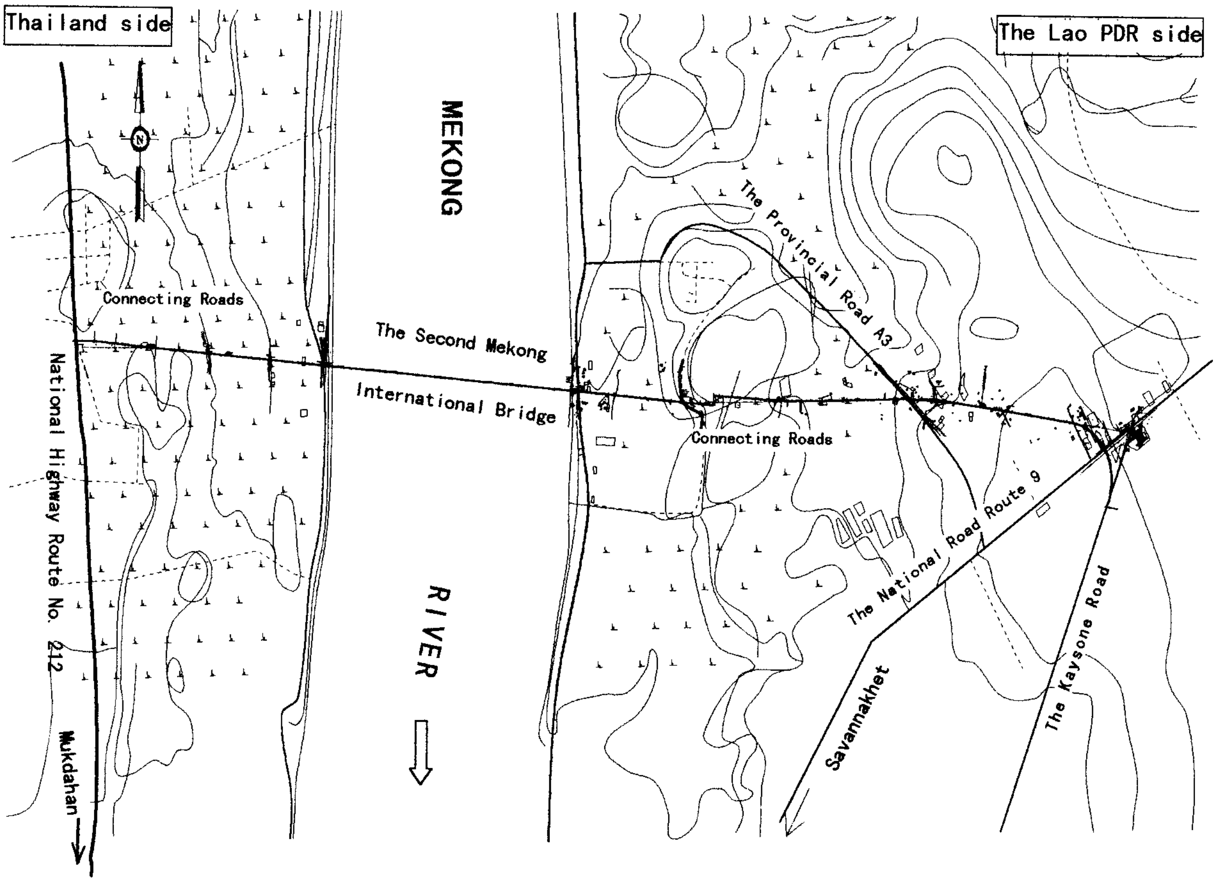


Figure 2.3.2
Horizontal Alignment of the Bridge and Connecting Roads

2.3.2 Vertical Alignment

2.3.2.1 Control Points

The vertical alignment of the connecting roads was controlled under the following features and conditions.

(a) Navigation Clearance

- A navigation clearance of 10.0m height by 60.0m width from the High Water Level (HWL) at the middle of the river and 5.5m height by 60.0m width from the HWL near the river banks shall be applied.

- The HWL of 1 in 25 years average recurrence interval (ARI) flood water level is applied for small bridges in Thailand. However, the Second Mekong International Bridge is important as an international highway and the HWL of 1 in 100 years ARI flood water level has been applied on the Pakse Bridge. Therefore, the HWL of 1 in 100 years ARI flood water level was also applied to the Second Mekong International Bridge.

- A HWL of 139.6m, the level of a 1 in 100 years ARI flood water level was adopted as the result of the River Hydrology Study

(b) Vehicle Clearance

- A vehicle clearance of 5.5m height over the existing road width is applied over roads along the riverbanks on both the Lao PDR and Thailand sides.

- At the top of the formation of roads along the riverbank, an elevation of 140.0m and width of 9.0m was applied in the Lao PDR side, and an elevation of 140.0m and width of 5.5m in the Thailand side as the result of topographic survey.

(c) Ground Elevation at Intersections

- Elevation of formation at the crossing point with existing roads are for at-grade crossings except for roads along the riverbank.

- Roads along the riverbank were planned as grade separated from main Bridge by embankments or connecting viaduct structures.

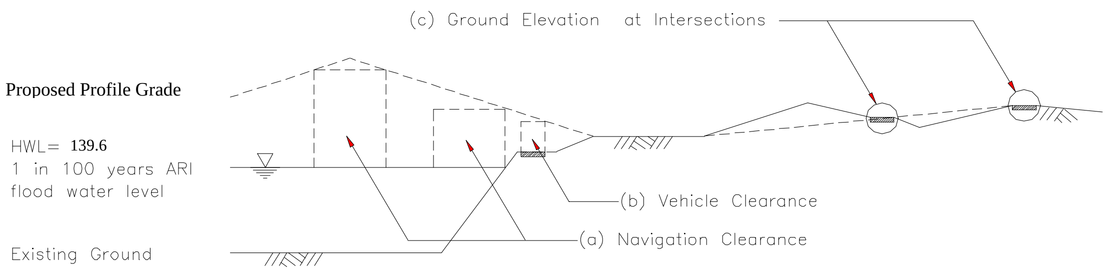


Figure 2.3.3
Control Points for the Vertical Alignment

(d) Elevation of the Pavement Structure

- The road design in Thailand is usually influenced by the bottom elevation of the pavement structure and is secured at 0.3m above the 1 in 25 years ARI flood water level.

- HWL of 138.5m, the level of a 1 in 25 years ARI flood water level is adopted as the result of the River hydrology study.

- According to these requirements, the bottom elevation of the pavement structure is established as greater or equal to 138.8m.

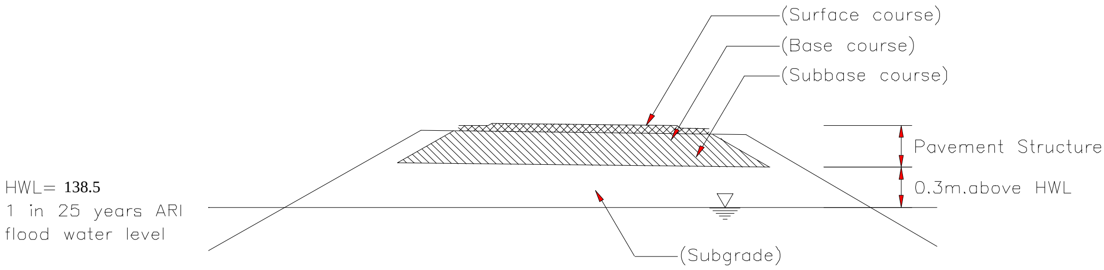


Figure 2.3.4
Necessary Elevation of the Pavement Structure above HWL

2.3.2.2 Vertical Alignment of the Bridge and Connecting Roads

The vertical alignment of the Second Mekong International Bridge and connecting roads were determined as shown in Figure 2.3.5.

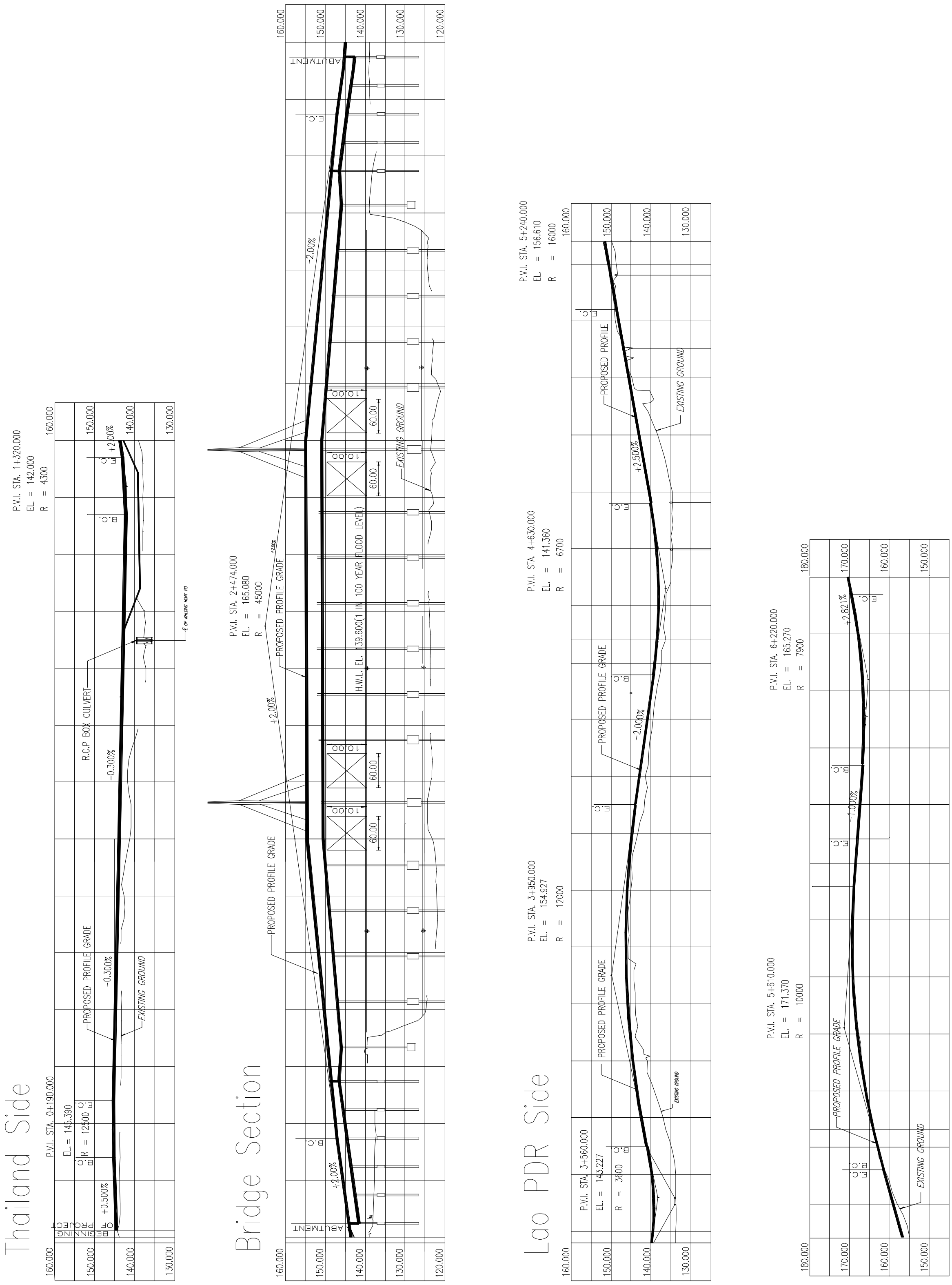


Figure 2.3.5
Vertical Alignment of the Bridge and Connecting Roads

2.4 EARTHWORK

The design standard of cuttings and embankments has been provided on the basis of the standard of connecting roads in both countries as well as the Japanese standards.

(a) Cuttings

The soil conditions of cutting area are sandy soil on hard rock and the maximum height of cutting is approximately 5m. The design standard of cutting has been decided as shown in Table 2.4.1.

Table 2.4.1
The Design Standard of Cutting Slope

Soil Conditions of the Ground	Height of Cutting	Gradient of Slope	Position of Berm	Width of Berm
Hard Rock	-	1:0.5	Every 5m	1 - 5m
Soft Rock	-	1:1.0		
Sandy Soil	5m or less	1:1.0		
	5 - 10m	1:1.0		

(b) Embankments

The provision of the standard embankment slope and the berm in the road design standards of the relevant countries and projects are shown in Table 2.4.2.

Table 2.4.2
The Provision of Embankment Slope

Embankment Materials	Height of Embankment	Gradient of Slope	Position of Berm	Width of Berm
Sandy Soil	3m or less	1:3.0	-	-
	3m – 6m	1:2.0	-	-
	6m or more	1:2.0	Every 6m	2m

(c) Standard for Earthworks

The standard cross - section for earthworks is shown in Figure 2.4.1.

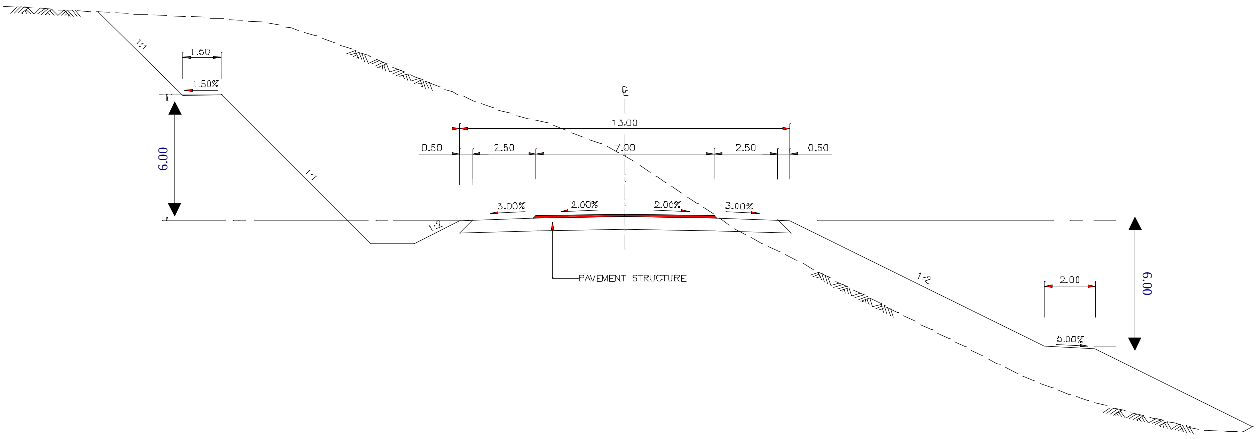


Figure 2.4.1
Proposed Standard Cross-section at Earthworks

2.5 PAVEMENT

2.5.1 Type of Pavement

The type of pavement structures on connecting roads and Border Control Facilities (BCF) were adopted as shown in Table 2.5.1 and in Figure 2.5.1.

Table 2.5.1
Type of Pavement

Object	Type of Pavement Structure
Connecting Road, Approach Road	Asphalt concrete pavement
Improved Existing Road	Asphalt concrete pavement
Traffic Changeover BCF	Cement Concrete pavement
Maintenance Road	Asphalt concrete pavement
Footpath	Concrete block pavement

Reinforced concrete pavement was adopted for the traffic changeover and the BCF because the traffic passing through these sections may often stop and/or apply braking forces to the pavement.

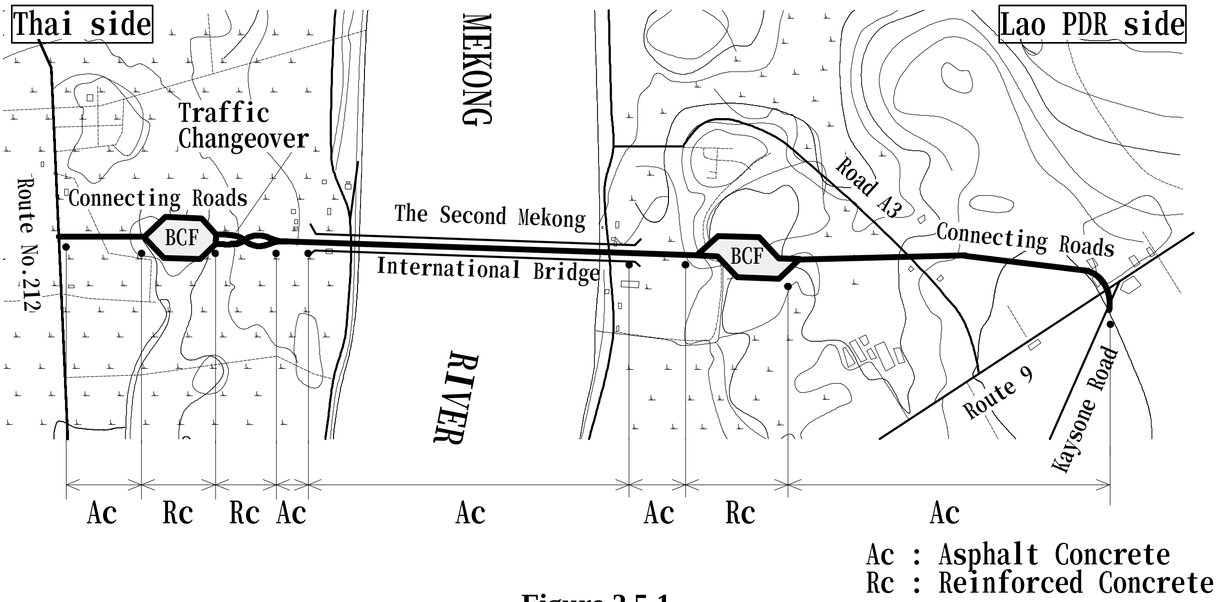


Figure 2.5.1
Types of Pavement Structures

2.5.2 Pavement Design

Manual for Asphalt Pavement/Manual for Cement Concrete Pavement (JRA) is adopted for the pavement design

(a) Design CBR for Pavement Design

The subgrade CBR value of 6% is adopted as the design CBR in consideration of result of material testing.

(b) Design Traffic Volume Classification

The annual average of daily traffic (AADT) of heavy vehicles in the year 2003 to the year 2009 is estimated at 285 per day. Therefore, a class B in the standard of JRA is used for design traffic volume classification.

(c) Typical Composition for Pavement Structure

Typical compositions of asphalt concrete pavement and cement concrete pavement are shown in Table 2.5.2 and 2.5.3.

Table 2.5.2
Typical Composition of Asphalt Concrete Pavement Structure

Composition	Materials	Thickness	Remarks
Wearing Course	Asphalt Concrete	5 cm	Hot Asphalt Mix
Binder Course	Asphalt Concrete	5 cm	Hot Asphalt Mix
Base Course	Crushed Rock	20 cm	Lab CBR > 80%
Sub-base Course	Soil Aggregate	25 cm	Lab CBR > 25%
Sub grade		100 cm	Lab CBR > 6%

Table 2.5.3
Typical Composition of Cement Concrete Pavement Structure

Composition	Materials	Thickness	Remarks
Concrete	Cement Concrete	25 cm	
Base Course	Sand cushion	10 cm	
	Crushed Rock	15 cm	Lab CBR > 80%
Sub grade		100 cm	Lab CBR > 6%

2.5.3 Asphalt Pavement

(a) Connecting Road and Approach Road

The composition of the asphalt pavement for the connection road and approach road is shown in Figure 2.5.2.

(Unit : cm.)

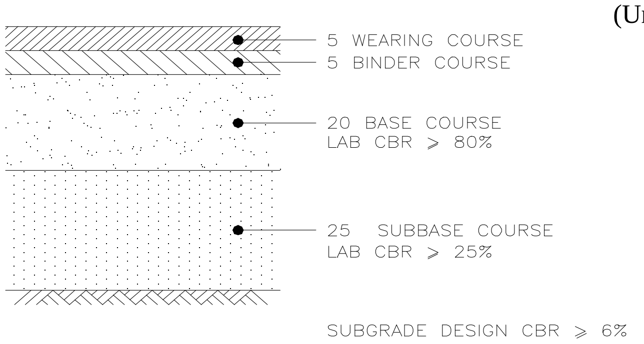


Figure 2.5.2
Composition of Asphalt Pavement for the Connecting Road and the Approach Road

(b) Maintenance Road

The composition of the asphalt pavement for the maintenance road is shown in Figure 2.5.3.

(Unit : cm.)

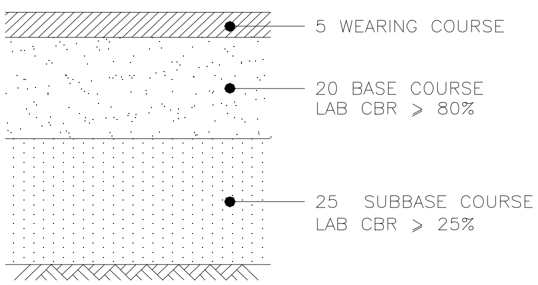


Figure 2.5.3
Composition of Asphalt Pavement for the Maintenance Road

2.5.4 Concrete Pavement

(a) Traffic Changeover

The composition of the cement concrete pavement for the traffic changeover is shown in Figure 2.5.4.

(Unit : cm.)

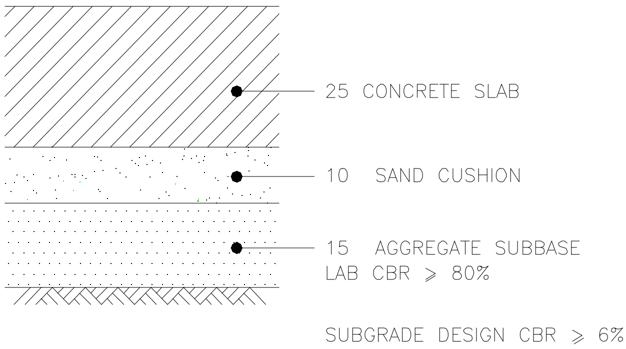
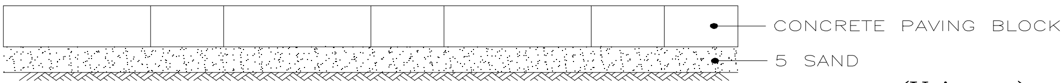


Figure 2.5.4
The Composition of the Cement Concrete Pavement of the Traffic Changeover

2.5.5 Concrete Block Pavement

The concrete block pavement was adopted for the footpath as shown in Figure 2.5.5.



(Unit : cm.)

Figure 2.5.5
The Concrete Block Pavement for the Footpath

2.6 DRAINAGE

2.6.1 Design Condition

(a) Rainfall Intensity

Rainfall intensity of 120mm/hour is adopted for the design of the drainage. This was based on a duration of rainfall of 15minutes and a return period of 5 years.

(b) Design formula

The outflow for the design of the drainage structure size was calculated using the National formula. The capacity of drainage was calculated using the Manning formula.

2.6.2 Drainage System

The drainage system was decided as shown in Figure 2.6.1 after the site investigation of the existing drainage system, topographic conditions and discussions with the MCTPC and the DOH.

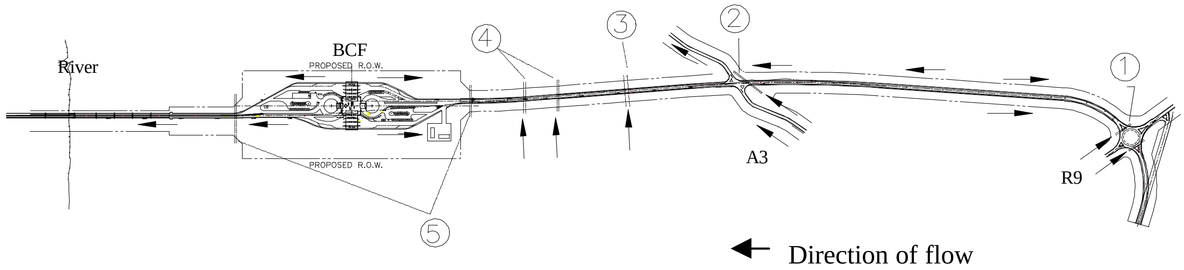


Figure 2.6.1
Drainage System in the Lao PDR side

① Pipe culverts for drainage at the intersection of the national road Route 9
② Pipe culvert for A3 road drainage.
③ Box culvert for the upstream drainage.
④ Pipe culverts for the upstream drainage and irrigation
⑤ Pipe culverts for BCF boundary drainage

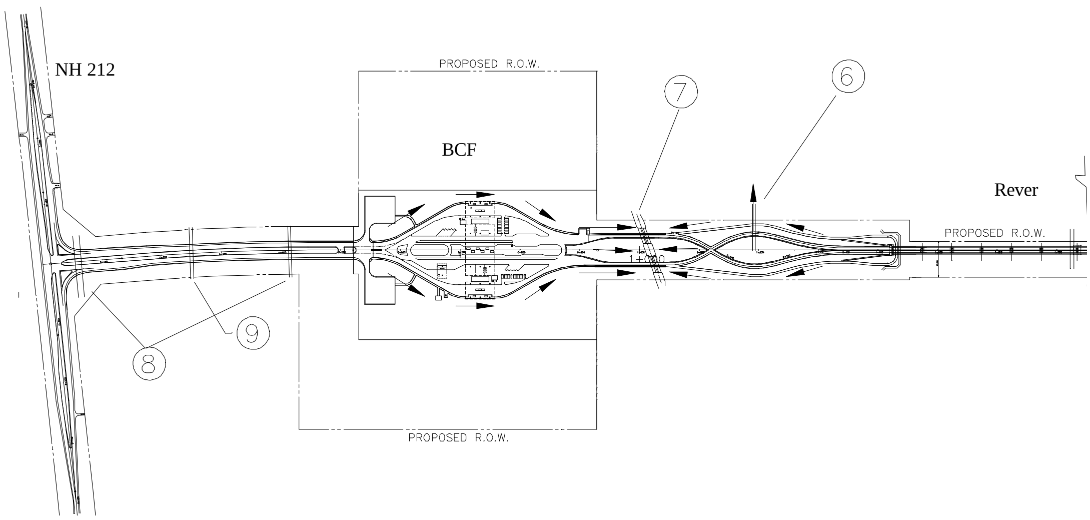


Figure 2.6.2
Drainage System in the Thailand side

Direction of flow

⑥ Pipe culvert for drainage of traffic changeover
⑦ Box culvert for the Po river – 3 cells box, 3.6m x 3.6m
⑧ Pipe culverts for the upstream drainage and irrigation
⑨ Pipe culverts for an irrigation canal

2.6.3 Drainage Structure

The drainage structures as shown in Table 2.6.1. and Table 2.6.2 were used as the result of the drainage design.

Table 2.6.1
Drainage Structure in the Lao PDR Side

Location	A km^2	R 1/year	r mm/h	C	Qi m^3/s	Drainage structure		Qo m^3/s
						Section m	incline %	
Sta. 3+740	1.0	10	60	0.5	8.3	Box 2.5x2.5	0.2	9.5
BCF (West side)	0.105	5	120	0.8	2.8	U 1.3x1.0	0.3	3.0
BCF(East-South Side)	0.091	5	120	0.8	2.4	ϕ 1.2	0.6	3.0
BCF(East Side)	0150	5	120	0.8	4.0	U 1.3x1.2	2.0	5.0

Note. A: Drainage Area, R: Return Period, r: Design rainfall intensity, C: Runoff coefficient, Qi: Inflow, Qo: Outflow

Table 2.6.2
Drainage Structure in the Thailand Side

Location	A Km^2	R 1/year	r mm/h	C	Qi m^3/s	Drainage structure		Qo m^3/s
						Section m	incline %	
Po river	8.20	50	80	0.5	90	Box 3@3.6x3.6	0.2	97
BCF (North side)	0.120	5	120	0.8	3.2	U 1.2x1.2	1.0	4.1
BCF(South Side)	0.150	5	120	0.8	4.0	U 1.2x1.2	1.0	4.1
Traffic Changeover	0.012	5	120	0.8	0.33	U 0.6x0.6	0.3	1.2

Note. A: Drainage Area, R: Return Period, r: Design rainfall intensity, C: Runoff coefficient, Qi: Inflow, Qo: Outflow

2.7 CULVERTS

Box culverts and pipe culverts were designed in accordance with the standards of the MCTPC and the DOH.

2.7.1 Culvert Type

Box culverts and pipe culverts are used for the drainage structure, irrigation line and river crossing structure as shown in Table 2.7.1.

Table 2.7.1
Culvert Type

Type	Dimension B * H (m) D (m)	Purpose	Standard
Box Culvert	3 Box type (3.6 * 3.6) * 3	Crossing over the small river in Thailand side	DOH
	2.0 * 2.0	Crossing over the small river in the Lao PDR side	MCTPC
Pipe culvert	0.80, 0.50	Drainage structure under road	MCTPC DOH
	0.80	Connection of irrigation water distribution	

2.8 SLOPE PROTECTION

Soddings were adopted on slope protection for embankment structure due to wind and rain storms

The verge with 0.5 m width is adopted next to the shoulder for the typical cross section of connecting roads and approach roads. The surface of the verge and slope is covered by a 100mm thick layer of topsoil planted with native ground cover.

2.9 INTERSECTION

Connecting roads connect the national road Route 9 in the Lao PDR and the national highway Route No.212 in Thailand. Moreover, it will contain an at-grade intersection with the Provincial Road A3 in the Lao PDR. Connecting roads also cross roads along the riverbank grade separated. Therefore, the following three intersections have been designed. Locations of these intersections are shown in Figure 2.9.1.

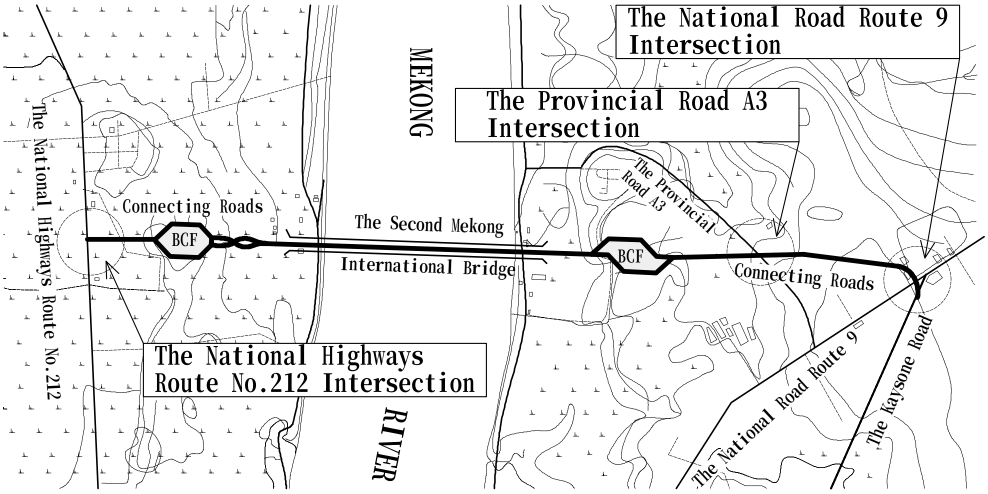


Figure 2.9.1
Location of Intersections

2.9.1 Design Criteria of Intersection

(a) Regular Intersections

The design standards of the intersections which correspond to the design speed of 80km/h of the carriageway in the Lao PDR and Thailand are shown in Table 2.9.1.

The criteria of intersections are adopted on the basis of the standards in each country as the Road Design Manual is applied in the Lao PDR side and the Standard Drawings for Highway Construction are applied in the Thailand side.

(b) Roundabout Intersections

In the city areas of the Lao PDR, roundabout intersections are adopted and they supply an accent to the cityscapes. The DCTPC requested to establish a monument on the national road Route 9 intersection which is located at the entrance of Savannakhet city.

A roundabout intersection is adopted on the national road Route 9 and the Kaysone Road.

The roundabout intersection was designed according to the British standard, Design Manual for Roads and Bridges vol.6, as follow ;

- TD16 / 93 : Geometric Design of Roundabouts
- TA42 / 95 : Geometric Design of Major / Minor Priority Junctions

Table 2.9.1
Design Criteria of Intersections

		The Lao PDR Standard	Thailand Standard
Standard		Road Design Manual (1996)	Standard Drawings (1994)
Crossing Angle		70 ~ 110 degrees	-
Taper Length	Formula	-	V· Δ W/3.6S [***]
	Value	40m	Max. 50m
Turn-left (right) Lane Length (storage section)	Formula	N·9.75 [*] (more than 300 pcu/h)	-
	Value	20m (0-150 pcu/h) [**] 40m (151-300 pcu/h) [**]	Min. 30m
Deceleration Lane Angle	to Stop	-	120m [****]
	to 20km/h	-	112m [****]
	to 30km/h	-	104m [****]
	to 40km/h	30m	94m [****]
	to 50km/h	40m	82m [****]
	to 60km/h	60m	64m [****]
Acceleration Lane Length	from Stop	-	V· Δ W/3.6S [***]
	from 20km/h	-	
	from 30km/h	-	
	from 40km/h	-	
Remark * N : turning traffic volume per 2 minutes (pcu) ** : turning traffic volume		*** V : design speed for carriageway Δ W : added lane width S : rate of lateral movement **** including taper length	

2.9.2 The National Road Route 9 Intersection in the Lao PDR

The national road Route 9 intersection is an irregular four-leg intersection. It connects the national road Route 9 and the Kaysone Road.

2.9.2.1 Road Cross Section

The existing national road Route 9 and the Kaysone Road have already been improved as two-lane roadways. Therefore, the design of the intersection shall be in accordance with the existing geometry.

The existing cross - sections of the national road Route 9 and the Kaysone Road are shown in Figure 2.9.2 and Figure 2.9.3.

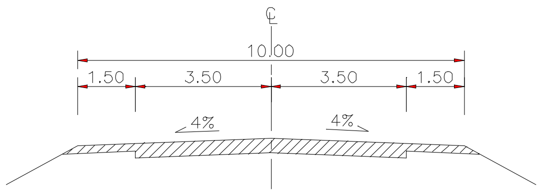


Figure 2.9.2
Cross-section of the National Road Route 9

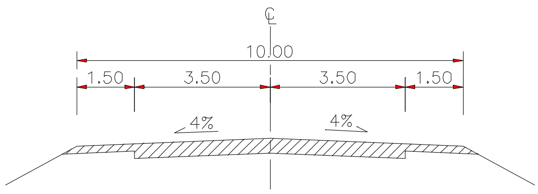


Figure 2.9.3
Cross-section of the Kaysone Road

2.9.2.2 Type of Intersection

The plan of the national road Route 9 intersection is shown in Figure 2.9.4.

To secure visibility distance when a monument is established on the center island, the diameter of the inside island shall not be less than 40m. According to calculations, the traffic capacity of the roundabout was estimated to be approximately 700 pcu/h, and it is greater than the estimated peak hour traffic volume of 450 pcu/h.

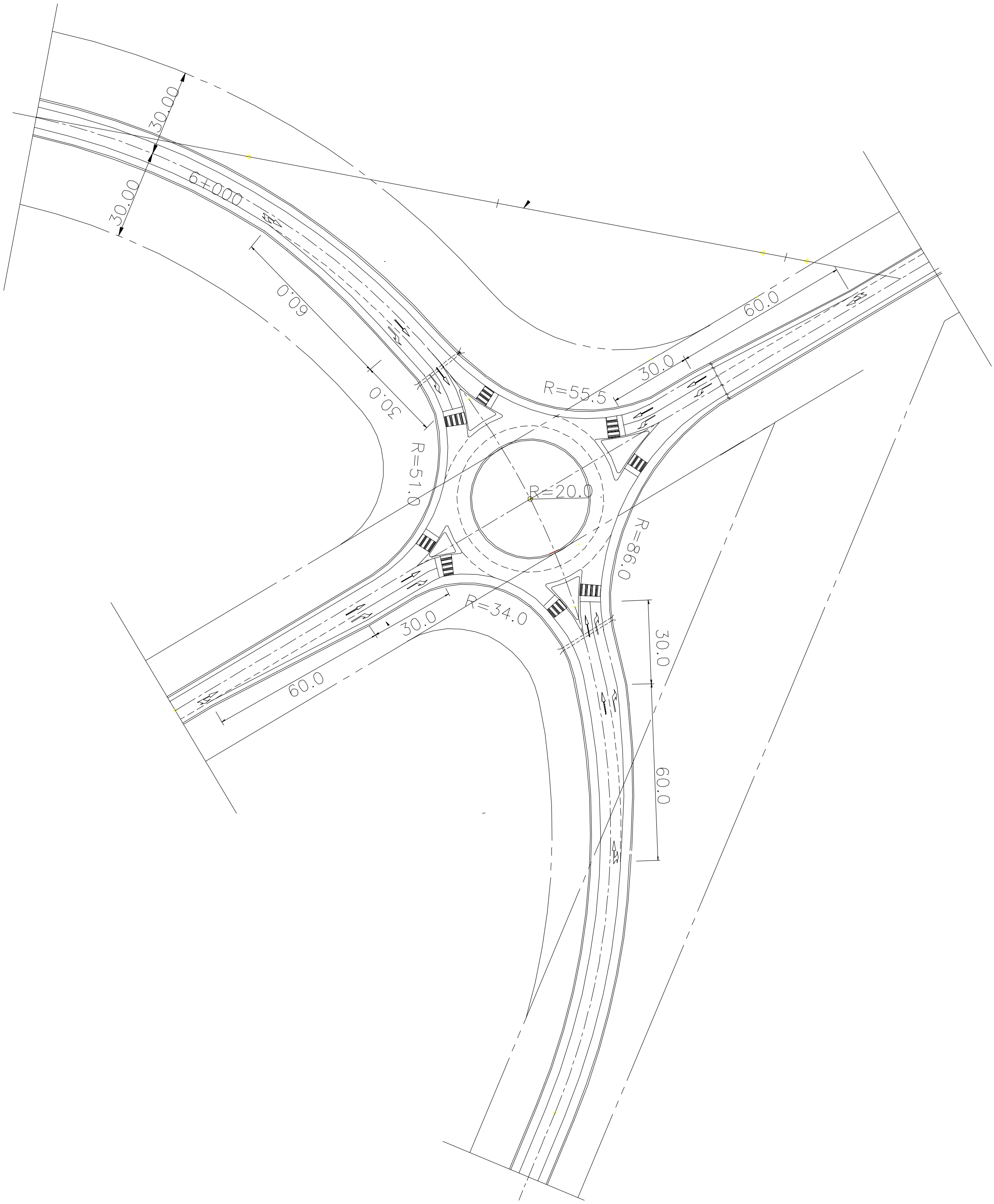


Figure 2.9.4
The National Road Route 9 Intersection (Roundabout)

2.9.3 The Provincial Road A3 Intersection in the Lao PDR

2.9.3.1 Road Cross Section

The cross-section of the existing Provincial Road A3 is a single-lane rural road. However, it was considered favorable that the intersection shall be planned since the Provincial Road A3 will be improved to a two-lane roadway in the future.

The expected cross-section of the Provincial Road A3 is shown in Figure 2.9.5.

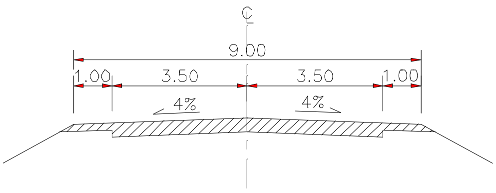


Figure 2.9.5
The Cross-section of the Provincial Road A3

2.9.3.2 Type of Intersection

The crossing angle of connecting roads and the Provincial Road A3 is approximately 42 degrees. However, the crossing angle is stipulated as more than 60 degrees in the AASHTO standard or in the Road Structure Ordinance of Japan.

The horizontal alignment of the Provincial Road A3 was changed to be more than 60 degrees near the crossing point.

The plan of the Provincial Road A3 intersection is shown in Figure 2.9.6.

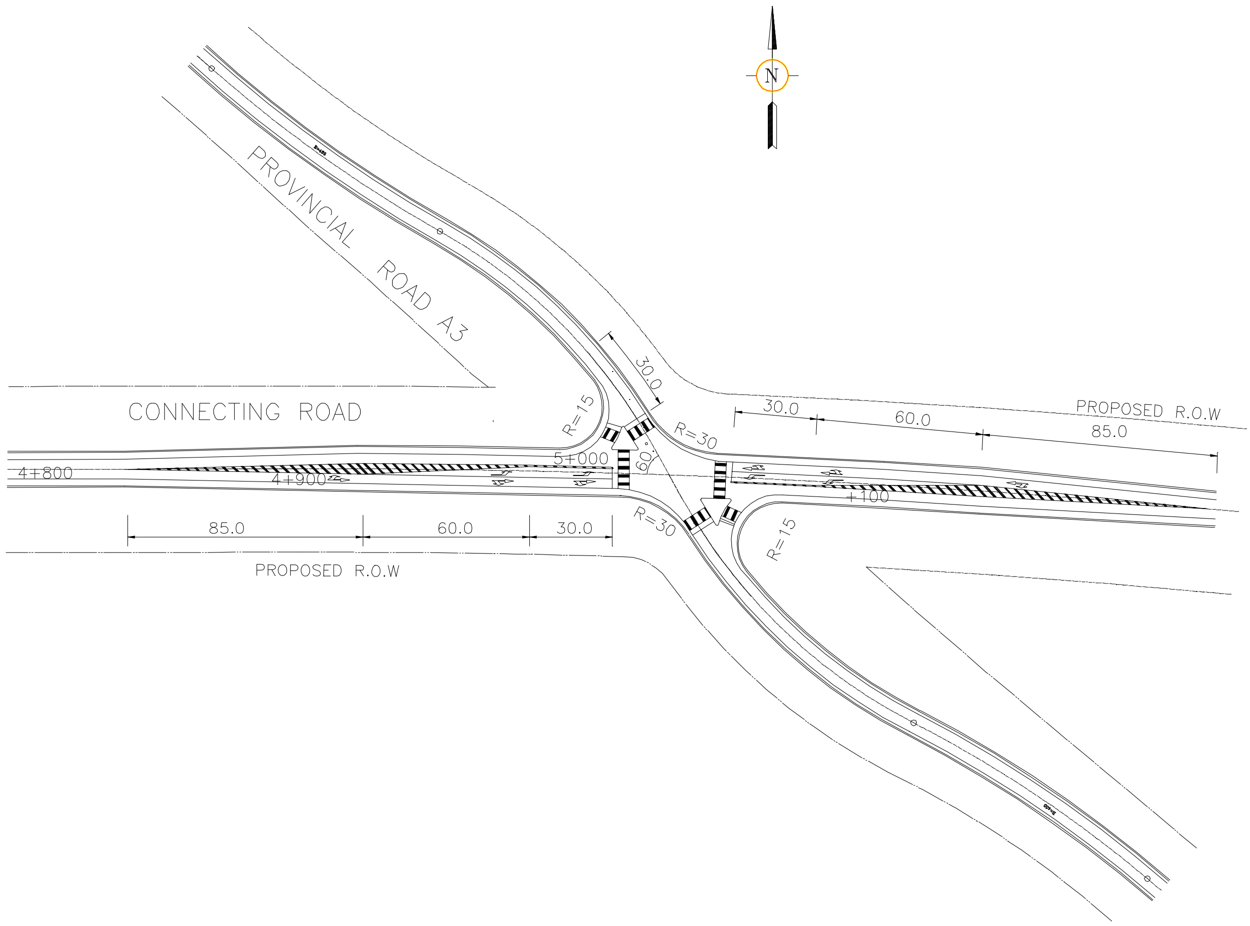


Figure 2.9.6
The Provincial Road A3 Intersection

2.9.4 The National Highway Route No.212 Intersection in Thailand

2.9.4.1 Road Cross Section

The national highway Route No.212 intersection is a regular three-leg intersection. The cross-section of the existing national highway Route No.212 is a two-lane roadway. However, the Route No.212 with length of 35km between Mukdahan and Nikhon Kham Soi will soon be modified into a four-lane roadway. The modification will be carried out as part of the rural road network improvement plans and will be conducted by the DOH. The execution of the work is expected in the year 2000.

The designed cross-section of the national highway Route No.212 is shown in Figure 2.9.7.

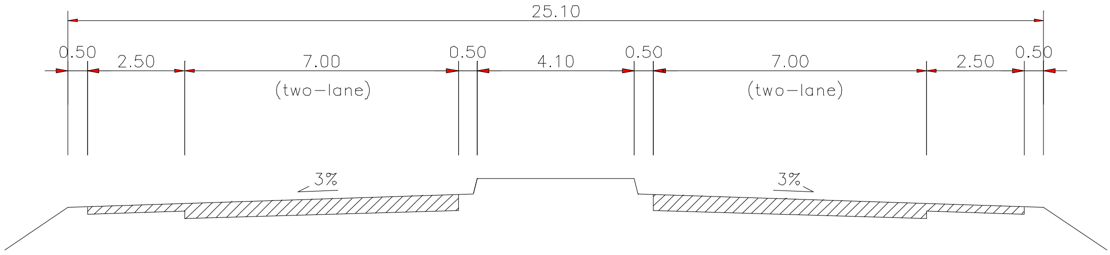


Figure 2.9.7
The Cross-section of the National Highway Route No.212

2.9.4.2 Type of Intersection

The crossing angle of connecting roads and the national highway Route No.212 is approximately 89 degrees.

Therefore, this intersection was designed according to the standard design of three - leg intersection on the basis of the Standard Drawings in Thailand. This plan is shown in Figure 2.9.8.

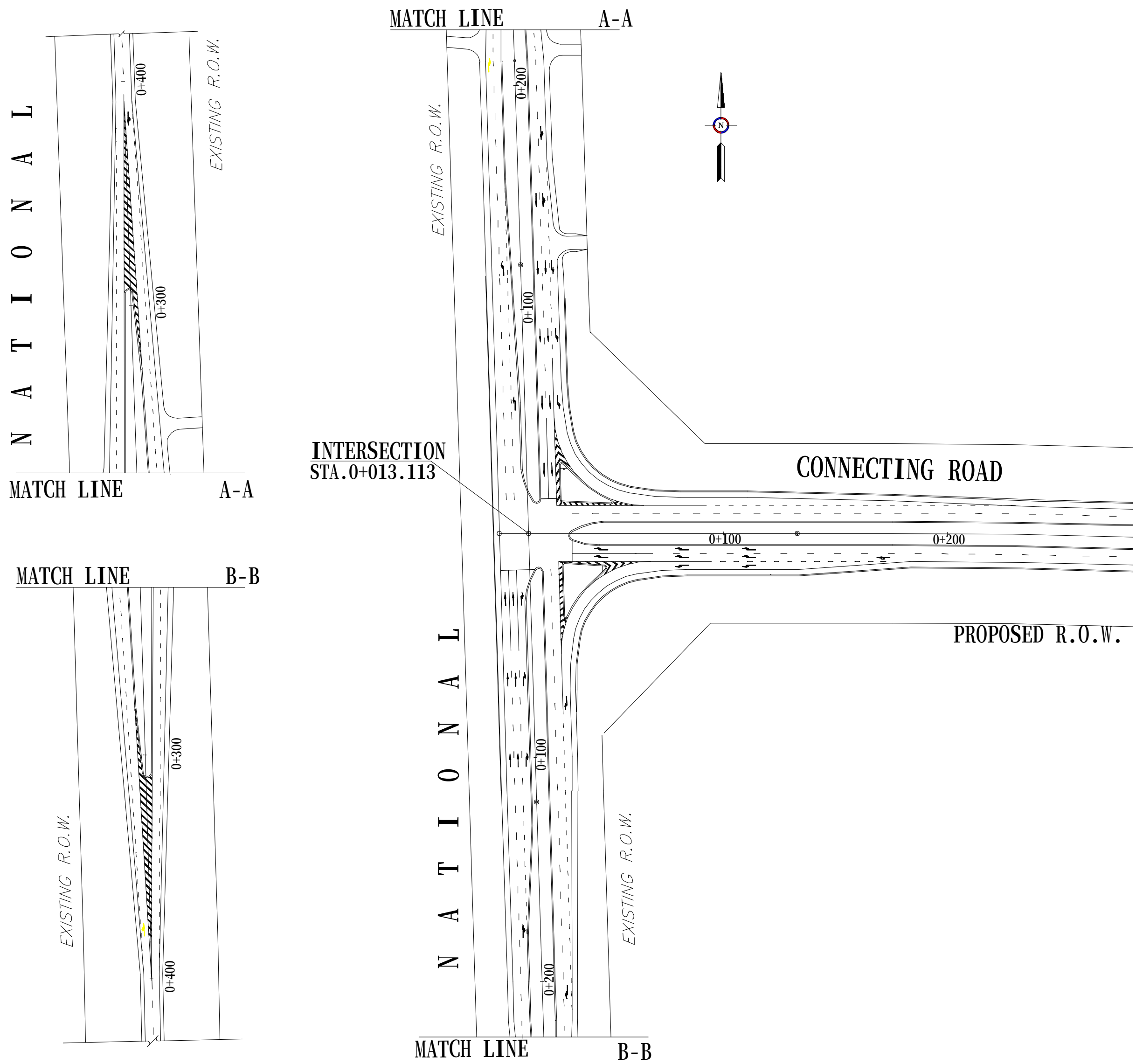


Figure 2.9.8
The National Highway Route No.212 Intersection (Three-leg Intersection)

2.10 TRAFFIC CHANGEOVER

2.10.1 Location

The traffic changeover is planned on the Thailand side of the Mekong River.

The traffic changeover is located in an approach road with a length of approximately 500m between the BCF and the approach viaduct in the Thailand side as shown in Figure 2.10.1.

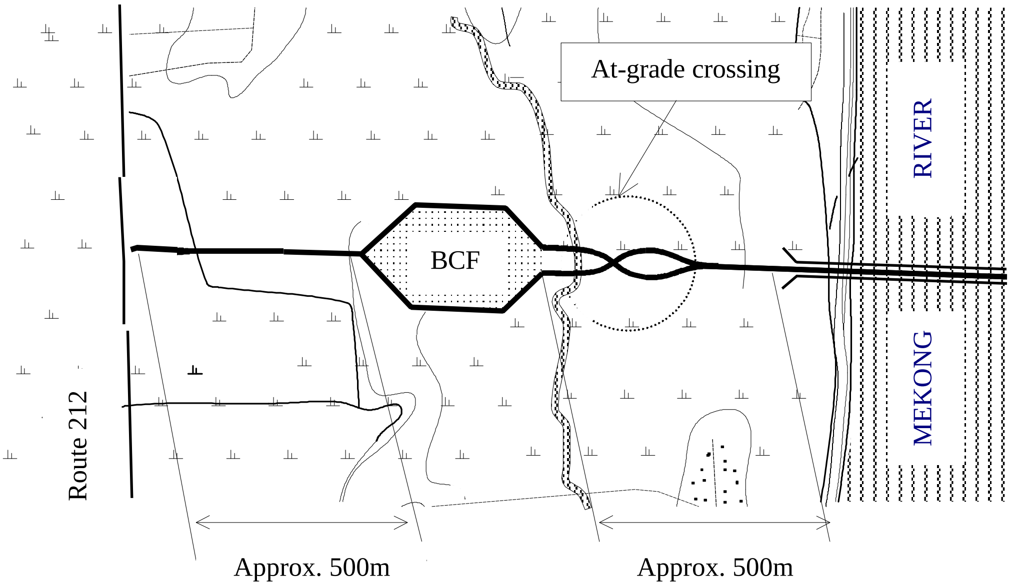


Figure 2.10.1
Location of the Traffic Changeover

2.10.2 Type of Traffic Changeover

An at-grade crossing with a control by traffic signal was adopted on the traffic changeover. The plan of the traffic changeover is shown in Figure 2.10.2.

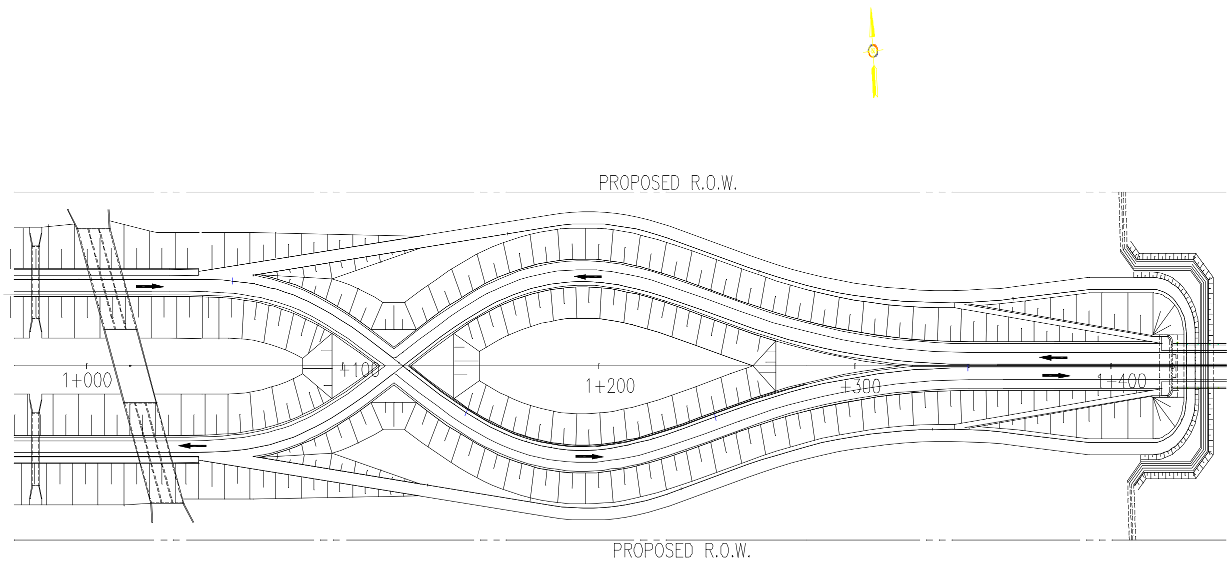


Figure 2.10.2
The Traffic Changeover

2.11 TRAFFIC SAFETY FACILITY

2.11.1 Traffic Sign Board

Traffic sign boards were designed in accordance with the regulations of traffic control of both the Lao PDR and Thailand. Warning signs, signs to control speed and information sign are provided at appropriate places for the traffic safety and control.

2.11.2 Traffic Signal

Traffic signals are provided at the at-grade intersection in the traffic changeover on the Thailand side to avoid traffic accidents .

2.11.3 Guardrail and Fence

Guardrail is required on the outside of the horizontal curve with small radius and high embankment section. The W-beam steel type guardrail is provided along the approach road in a section of the traffic changeover

Fence for pedestrian is provided on high enbankment sections with steep side slopes. A fence is provided on the outside of the sidewalk and pedestrain walk in the traffic changeover section and approach road sections on both the Lao PDR and Thailand sides.

2.11.4 Emergency Telephone

Emergency telephones are provided on the Main Bridge for communucation with users and traffic control officers of both the Lao PDR side and the Thailand side in case of emergency.

2.12 ANCILLARY WORKS

2.12.1 Traffic Lane Marking

The traffic lane marking is provided on the carriageway along the entire length of connecting roads, approach roads, Bridge, the BCF and the traffic changeover in accordance with regulations of traffic control of both the Lao PDR and Thailand.

2.12.2 Road Lighting

The roadway lighting was designed in accordance with the DOH standard.

The spacings between lighting poles were selected as in Table 2.12.1

Table 2.12.1
Lighting pole Spacing

Location		Position	Lighting Pole Spacing (m)
The Lao PDR Side	Connecting Road	One Side	30
	Approach Road	One Side	30
Main Bridge and Approach Viaducts		One Side	35
Thailand Side	Approach Road	One Side	40
	Traffic Changeover	Both Sides	40
	Connectiong Road	Both Sides	40
	Intersection, Route 212	Both Sides	40

CHAPTER 3

Detailed Design of Main Bridge

CHAPTER 3 : DETAILED DESIGN OF MAIN BRIDGE

3.1 GENERAL

Main bridge type and material were studied taking into account natural condition, cultural background, social situation environment, economy and other determine factors. The present type was selected among several alternatives as most suitable and was accepted by the people concerned. This chapter explains the design condition, design method and design result of the Main Bridge. The general drawing of the Main Bridge is shown in Figure 3.1.1.

3.1.1 Design General

(1) Design Standard

1) JRA-SHB; Japan Road Association (JRA): Specifications for Highway Bridges (SHB), I Common Specifications, III Concrete Bridges, IV Substructures, 1998. The design live load is based on the DOH standards of Thailand rather than that of the JRA-SHB design live load.
2) JIS (Japanese Industrial Standard); The material prescribed by JIS is used.
3) Japan PC Technology Association; Design execution criteria for external cable structure/precast segment construction method, March, 1996.

(2) Bridge Superstructure and Construction Method

- The girder height is constant for the entire Bridge length except at end spans.
- A standard span to girder height ratio is about 1/20 by past experiences for this type of bridges and the girder height is set at 4.0 m.
- Construction method of the main girder is by a precast segmental method.
- Erection method of the main girder is by a cantilever method.
- Inner and external PC cables are used for the PC cable system of the main girder to reduce weight of the main girder and to improve the erection speed.
- The inner cable is for the erection loads while the external cable is for the loads after erection.
- Joining shear keys of the segments are multiple wave type. Epoxy resin adhesion is also used.

(3) Bridge Substructure and Construction Method

- Pier is a wall type RC structure, while pile foundations are cast-in-place piles of 2.0m diameter. The pile foundation will be constructed during the dry season.
- Since sand and gravel of the riverbed can be shifting by the river current during rain season, piles are to be socketed 5.0m. into the base rock.

(4) Structural Safety

Safety of the superstructure and substructure conforms with the design method of JRA-SHB.

3.1.2 Design Flow Chart

The procedure of the design works is shown in Figure. 3.1.2.

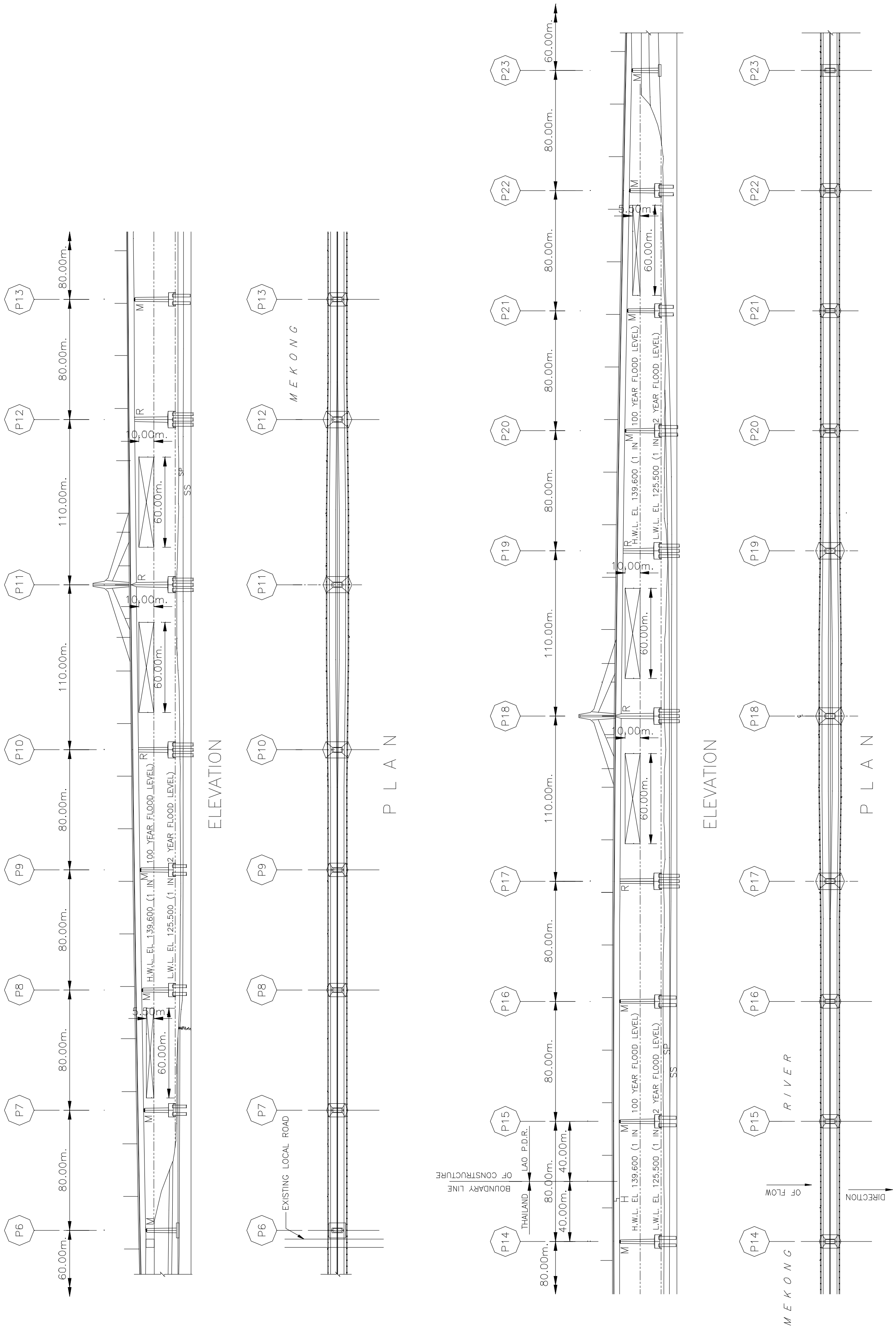


Figure 3.1.1(1/2) General View of Main Bridge

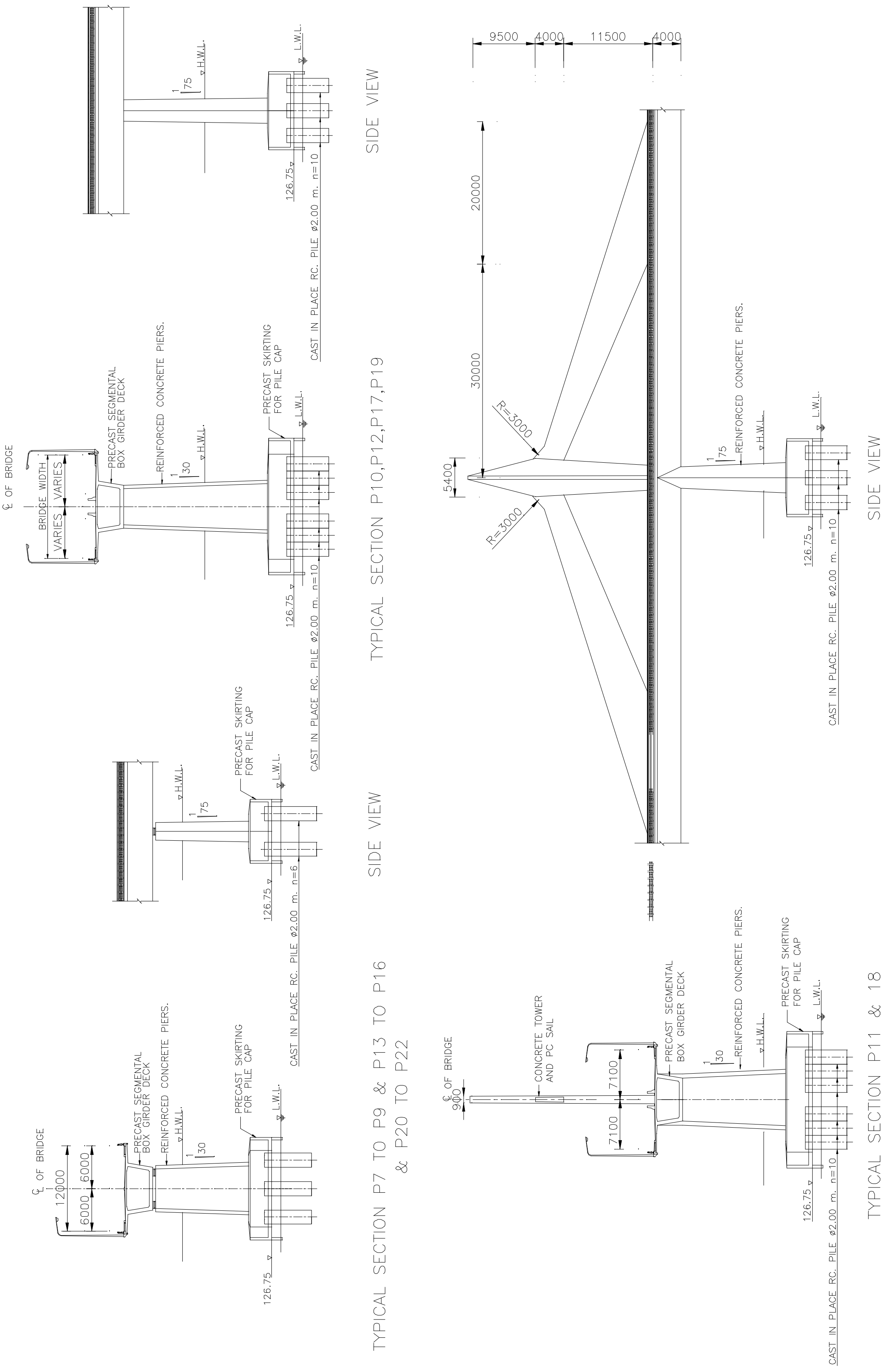


Figure 3.1.1(2/2) General View of Main Bridge

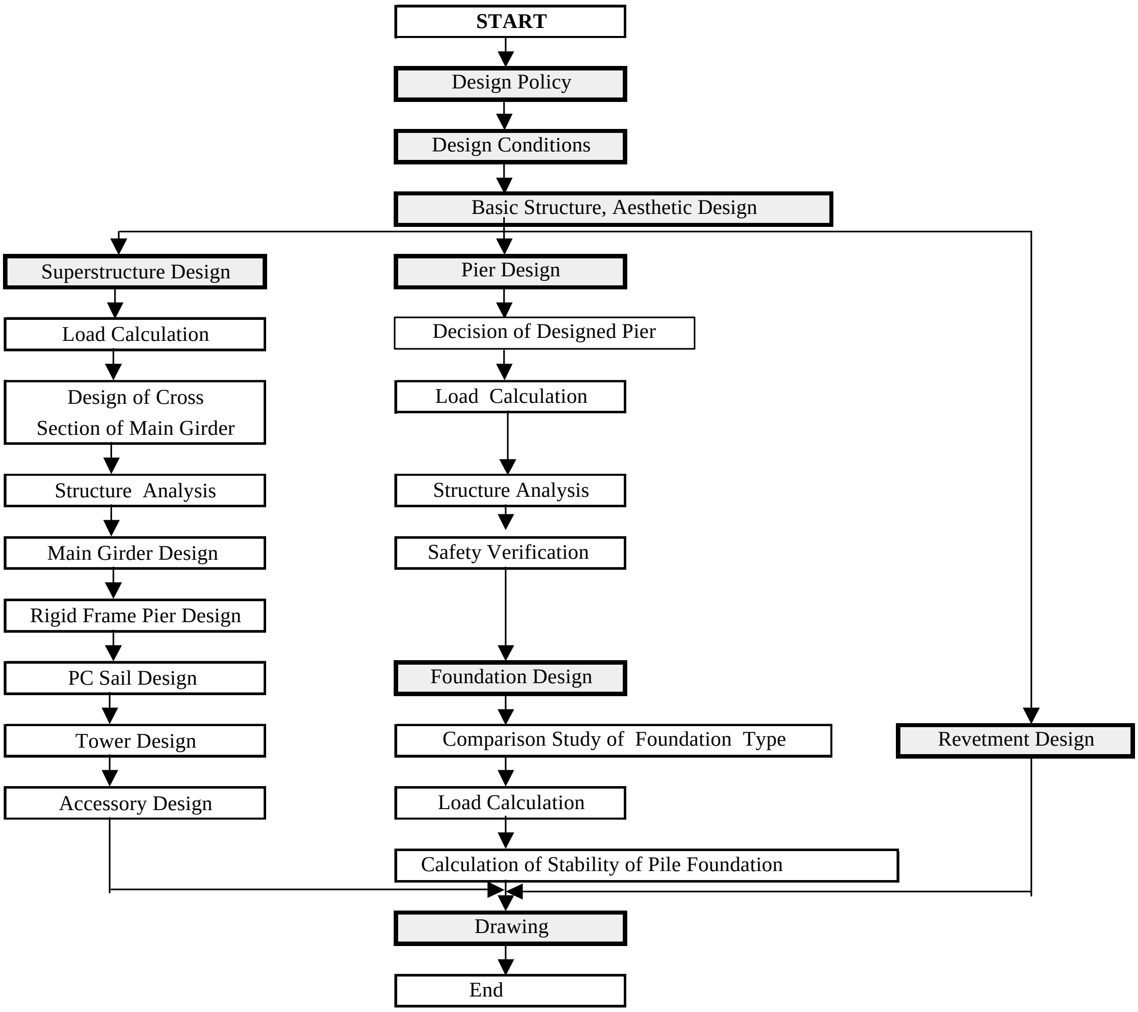


Figure 3.1.2 Design Flow Chart of Approach Bridge

3.1.3 Method of Structural Analysis

1) The basis of the structural analysis is a two (2) dimensional structure beam model analysis that is regarded as an elastic body.
   The superstructure is analyzed by the CONST structure analysis program which takes into consideration the influence of concrete creeps and prestressing.
2) The structural analysis of the Main Bridge is made on the basis that the pier system has lower end flexibility fixation, and influence of rotation of the pile foundation is considered.
3) The general structural analysis evaluates the girder and pier treatment as a beam member.
4) The spring constant of the pile foundation is evaluated by considering the safety side of the design purpose and considering the riverbed foundation shifted by the flood. Stability calculation of the pile foundation is conducted.

3.1.4 Design Loads

(1) Basic Load

Table 3.1.1 Basic Load

Basic Load	
Principal Load (P)	(1) Dead load (D) (2) Live load (L) (3) Impact (I) (4) Prestressing force (PS) (5) Effect of creep of concrete (CR) (6) Effect of shrinkage of concrete (SH) (7) Earth pressure (E) (8) Hydraulic pressure(HP)
Subsidiary Load (S)	(9) Thermal force (T)
	(10) Earthquake force (EQ)
Particular Load (PA)	(11) Temporary load and force during erection (ER) (12) Collision force (CO)

(2) Loading Combinations

1) Superstructure

Table 3.1.2 Loading Combination of Service Load

Loading Combinations		Allowable Stress Increase Rate
Construction Stage	(1) D+ER	1.25
Service Stage	(1) D+PS (after prestressing) (2) D+PS (after prestressing)+L+I (3) D+PS (effective)+CR+SH (4) (3)+L+I (5) (3)+L+I+T (6) (3)+HP (7) (3)+HP+CO (8) (3)+EQ	1.00 1.00 1.00 1.00 1.15 1.20 1.50 1.50

Table 3.1.3 Loading Combination of Ultimate Load

Loading Combinations	
Construction Stage	(1) 1.3 x (D+CR)
Service Stage	(1) 1.3 x (D+CR) + 2.5 x (L+I) (2) 1.0 x (D+CR) + 2.5 x (L+I) (3) 1.7 x (D+CR+L+I)

2) Substructure

Table 3.1.4 Loading Combination of Service Load

Loading Combinations		Allowable Stress Increase Rate
Construction Stage	(1) D+ER	1.25
Service Stage	(1) D	1.00
	(2) D+ (E)+HP	1.00
	(3) (2)+L+I	1.00
	(4) (2)+L+I+T	1.15
	(5) (2)+HP	1.20
	(6) (2)+CO	1.50
	(7) (2)+EQ	1.50

3.1.5 Design Conditions

3.1.5.1 Structural Source

(1)	Bridge type	:	PC (Prestressed concrete) sail type continuous box girder bridge.
(2)	Bridge length	:	1600m
(3)	Span		60+4@80+2@110+5@80+2@110+4@80+60m
(4)	Layout of bridge deck	:	1.5m+4.25m+0.5m+4.25m+1.5m=12.0m(Standard section) 1.5m+4.25m+2.7m+4.25m+1.5m=14.2m (PC sail section) (1.5 m = Footpath, 4.25 m = Carriageway)
(5)	Erection method	:	Precast Segment balanced Cantilever method
(6)	Alignment	:	Horizontal Alignment R= ∞
		:	Vertical Alignment 2.0%
		:	Crossfall of the road 2.0%
			Crossfall of the side walk 1.5%
(7)	Pier type	:	RC wall-type pier
(8)	Foundation type	:	ϕ 2.0m Cast-in-place RC pile foundations (except for P6,P23)
		:	Spread foundation (P6, 23)
(9)	Bearing Strata	:	Mudstone or sandstone
(10)	Bearing support	:	Elastomeric laminated bearing
(11)	Expansion joints	:	Steel finger joint type
(12)	Drainage	:	Steel type drain box
(13)	Guardrail	:	Steel type
(14)	Lighting pole	:	Steel type

3.1.5.2 Loads

(1)	Live load	:	Main Girder	DOH standard (AASHTO HS20-44×1.30)
		:	Deck slab	B-live load by JRA-SHB
		:	Side walk	AASHTO
(2)	Unit weights			
	Reinforced Concrete	:	24.5 kN/m³	
	Concrete	:	23 kN/m³	
	Prestressed Concrete	:	24.5 kN/m³	

Asphalt pavement : 22.5 kN/m^3
Steel : 77.5 kN/m^3

(3) Bridge deck surfacing

Asphalt pavement	t = 50mm
Guardrail	w = 500N/m each side
Electronic cable including future service load	500N/m on each side

(4) Range of Temperature

Coefficients of thermal expansion	10×10^{-6}/°C
Calculation of statically indeterminate structure	T = ±15°C
Temperature difference of bridge deck	ΔT= 5°C
Calculation of the amount of movement at movable bearings	T = 10~40°C

(5) Seismic horizontal load
6.0% of dead load equivalent static horizontal load in any direction

(6) Drying shrinkage and creep of concrete : Based on JRA-SHB

(7) Earth pressure : Coulomb earth pressure

3.1.5.3 Materials

(1) Material Properties

1) Concrete

Compressive strengths of concrete by structure items are as follows.

Prestressed concrete structure	: σ ck = 40N/mm^2
Rigid connection pier	: σ ck = 27N/mm^2
Movable pier, footing and abutment	: σ ck = 24N/mm^2
Cast-in-place RC pile	: σ ck = 30N/mm^2

The specified strength is the compressive strength of concrete cylinders at an age of 28 days.

2) Steel

Reinforcing bar (JIS G3112)

SD345, Yield strength : σ sy ≥350N/mm^2

SD390 is used in the drawings since it is equivalent to SD345 in the Lao PDR and Thailand.

Strand cable for prestressing steel (JIS G3109)

Main girder inner cable	:12S15.2 (SWPR7BL)
Main girder external cable, PC Sail	:19S15.2 (SWPR7BL)
Deck slab, dapped hinge	:4S15.2 (SWPR7BL)
Temporary PC bar (JIS G 3109)	:ϕ32 (SBPR930/1180)

(2) Allowable Stress

1) Characteristic Value of Materials

a) Concrete

Table 3.1.5
Characteristic Value of Concrete

Item	PC box girder PC sail, tower	Rigid Pier	Movable Pier Pile cap	Cast-in-place concrete pile
Specified compressive strength of Concrete, σck (N/mm^2)	40	27	24	30
Prestressing time, σci (N/mm^2)	30	-	-	-
Young's modulus, Ec (N/mm^2)	$3.1 x 10^4$	2.65×10^4	2.5×10^4	2.8×10^4
Shear modulus, Gc (N/mm^2)	1.5×10^4	1.15×10^4	1.1×10^4	1.2×10^4
Coefficient of linear expansion, α (1/deg)	$10 x 10^{-6}$	$10 x 10^{-6}$	$10 x 10^{-6}$	$10 x 10^{-6}$
Concrete shrinkage, εs	$15 x 10^{-5}$	-	-	-

b) Reinforcing bar

Table 3.1.6
Characteristic Value of Reinforcing Bar (JIS G 3112)

Item	SD 345
Yield strength, σ sy (N/mm^2)	350
Young's modulus, Es (kN/mm^2)	210

c) Prestressing steel strand, bar

Table 3.1.7
Characteristic Value of Prestressing Steel Strand (JIS G 3109)

Item	Main Girder, PC sail Deck slab, Dapped hinge SWPR 7BL, 15.2mm	Temporary PC bar ƒ32, SBPR930/1180
Tensile strength, σ pu	≥ 222 (kN)	≥ 930 (N/mm^2)
Yield strength, σ py	≥ 261 (kN)	≥ 1180 (N/mm^2)
Young's modulus, Ep	200 (kN/mm^2)	200 (kN/mm^2)
Relaxation rate : (Low Relaxation PC Steel)	≤ 2.5 (%)	≤ 4.0 (%)
Cross section area, Ap	138.7 (mm^2)	804.2 (mm^2)

2) Allowable Stress

a) Prestressed Concrete

Table 3.1.8
Allowable Stress of Prestressed Concrete

Item		s ck=40 (N/mm²) [kg/cm²]
Allowable flexure extreme compressive fiber stress	After prestressing : rectangular box section Design load state : rectangular box section	19 [190] 18 [180] 15 [150] 14 [140]
Allowable flexure extreme tensile fiber stress	After prestressing design load state deck slab other case	1.5 [15] 0 [0] 0 [0] 1.5 [15]
Allowable mean shear stress		0.55 [5.5]
Allowable diagonal tensile stress	Consideration of shear force only	*(1.9)[19]
Upper limit of shear stress	Consideration of shear force only	5.3 [53]

Comment : 1.*(1.9) - Based on Japan PC Technology Association
2. Because the design results of 3.2 and 3.3 clauses are expressed with the kg-units, the value of the kg/cm² -unit is shown in [ ].

b) Reinforced Concrete

Table 3.1.9
Allowable Stress of Reinforced Concrete

Item	s ck=27 (N/mm²)[kg/cm²]	s ck=24 (N/mm²)[kg/cm²]
Extreme Flexural compressive fiber stress	9.0 [90]	8.0 [80]
Axial compressive stress	7.5 [75]	6.5 [65]
Allowable mean shear stress	0.42 [4.2]	0.39 [3.9]
Upper limit of mean shear stress	3.6 [36]	3.2 [32]

Comment : Value in [ ] is kg/cm² -unit.

c) Reinforcing bar

Table 3.1.10
Allowable Stress of Reinforing Bar (JIS G 3112)

Allowable tensile stress	SD345 (N/mm²)[kg/cm²]
For loading combinations excluding collision force or earthquake force (1) for ordinary members (2) for deck slab (3) for member in water or below ground-water level (4) Bare value of allowable stress for loading combinations including earthquake force	 180 [1800] 140 [1400] 160 [1600] 200 [2000]
Compressive Stress	200 [2000]

Comment : Value in [ ] is kg/cm² -unit.

d) PC steel, bar

Table 3.1.11
Allowable Stress of PC Steel and Bar (JIS G 3109)

Allowable Tensile Stress	**Main Girder,PC sail Deck slab, Dapped hinge SWPR 7BL, 15.2mm (N/mm^2)[kg/mm^2]**	**Tempory PC bar ｆ32, SBPR930/1180 (N/mm^2)[kg/mm^2]**
When prestressing force is initially given	1440 [144]	837 [85.5]
Immediately after the prestressing	1295 [133]	790 [80.7]
Others	1110 [114]	697 [71.2]

Comment : Value in [ ] is kg/mm^2 -unit.

3.2 SUPERSTRUCTURE

3.2.1 Design of Girder Transverse Cross Section

3.2.1.1 Cross Section of Box Girder

(1) General

The main girder cross section is composed of a deck slab with cantilevered parts, two webs and a lower slab. The cross section of box part is a reverse trapezoid type by slanting of the web section, and has a constant configulation for the entire bridge. The width of slab is constant also but widens only at the PC Sail section.

The bridge slab in the transverse direction is a PC structure for high durability. Tensile stress is not allowed at the design loading.

Design of the bridge slab in the axis direction is the same as a RC structure. Tensile stress of reinforcing bar is less than 140N/mm^2 at the design loading.

The transverse cross sectional force is analyzed as a box rigid frame structure that is supported at the web lower corners.

Webs and the lower slab are considered as a RC structure while the deck slab is considered as a full prestressed concrete structure.

(2) Calculation Procedures

1) Calculation of Load and Cross Section Force

The following load were considered.

- Dead load
- Bridge surface load: Pavement, curb, handrail
- Live load: B-load
- Prestressing force: After prestressing, effective prestress
- Secondary prestress force: After prestressing, effective prestress
- Temperature difference: deck slab temperature+5°C

2) Calculation of Prestressing Force

Transverse PC cable at standard cross section is arranged at 62.5cm intervals by using 4S15.2 (SWPR7BL). Transverse PC cable of widen cross section is arranged at 50cm intervals by using 4S15.2 (SWPR7BL). Prestress σ pi of PC cable is 1295 N/mm^2. The PC cable is tensioned from one side but alternating the side due to an anchorage wedge "draw in" effect.

3) Calculation of Deck Slab, Web and Lower Slab

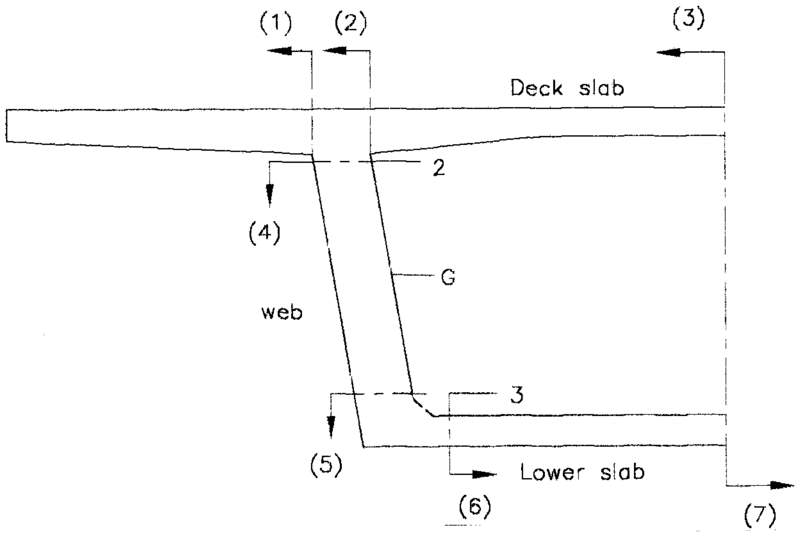


Figure 3.2.1 Position of Stress Checking

(3) Stress Checking Results of the Member

The stress checking result at the following sections are shown in Table3.2.1~3.2.3.

The design condition and drawing are expressed with SI-Unit (N), because this bridge is an international bridge while the result of design calculation are expressed with kg/ton-unit, to the actual state of the Lao PDR and Thailand.

Since the design result has to be evaluated against the allowable stress, the results are expressed in both of N and kg.-unit.

- Case-1: Standard cross section at span center of 80m span section (refer to Table 3.2.1)
- Case-2: Standard cross section at support of 80m span section (refer to Table 3.2.2)
- Case-3: Wider cross section of 110m span section (refer to Table 3.2.3)

Table 3.2.1(1/3) Cross Section at Span Center of 80m Span Section: Bridge Transverse Composite Stress of Deck Slab (kg/cm²)

Design Section		(1)		(2)		(3)	
Bridge Transverse		Upper	Lower	Upper	Lower	Upper	Lower
1. Prestressing stress after prestressing		46.8	-3.6	44.6	-2.1	-11.9	65.6
2. Secondary stress after prestressing		0.0	0.0	2.0	-2.0	3.0	-3.0
3. Reduction stress of prestressing		-5.7	0.4	-5.4	0.2	1.6	-9.1
4. Reduction stress of secondary force		0.0	0.0	-0.2	0.2	-0.4	0.4
5. Dead-load		-7.6	7.6	-9.1	9.1	7.4	-7.4
6. Deck surface load		-6.2	6.2	-3.5	3.5	0.9	-0.9
7. T-load	Max.	0.0	0.0	3.8	-3.8	40.0	-40.0
	Min.	-16.3	16.3	-24.3	24.3	0.0	0.0
8. Sidewalk load	Max.	0.0	0.0	2.5	-2.5	0.0	0.0
	Min.	-3.8	3.8	-3.5	3.5	-1.5	1.5
9. Temperature difference		0.0	0.0	-0.5	0.5	-0.8	0.8
10. After prestressing		39.1	4.0	37.4	5.1	-1.4	55.1
11. Dead load state		27.2	10.7	28.2	9.1	0.8	45.5
12. Design load state	Max.	27.2	10.7	32.0	5.4	40.9	5.4
	Min.	11.0	26.9	3.9	33.4	0.8	45.5
13. Design load state + Sidewalk load	Max.	27.2	10.7	34.5	2.9	40.9	5.4
	Min.	7.1	30.8	0.4	36.9	-0.7	47.0
14. Design load state + Temperature difference	Max.	27.2	10.7	31.5	5.9	40.1	6.2
	Min.	11.0	26.9	3.4	33.9	0.1	46.2
15. Design load state + Sidewalk load + Temperature difference	Max.	27.2	10.7	34.0	3.4	40.1	6.2
	Min.	7.1	30.8	-0.1	37.4	-1.5	47.8

Comment : (1), (2), (3) are design sections in Figure 3.2.1.

Table 3.2.1(2/3)
Bridge Axis Bending Stress of Deck Slab

Design Section		Cantilever Part Of Deck Slab	Middle Part of Deck Slab
Member thickness	(m)	0.406	0.385
Bending moment	(tm)	2.275	6.595
Reinforcement	(cm²/m)	9.018	29.102
Concrete stress	(kg/cm²)	39.4	93.9
Rebar stress	(kg/cm²)	1362.5	1464.4

Table 3.2.1(3/3)
Bridge Transverse Composite Stress of Web and Lower Slab

Design Section		(4)	(5)	(6)	(7)
Reinforcement	(cm^2/m)	23.459	5.535	10.374	5.137
Dead load state					
Concrete stress	(kg/cm^2)	2.0	12.2	16.5	19.6
Rebar stress	(kg/cm^2)	53.0	756.7	532.4	949.9
Live load state					
Concrete stress	(kg/cm^2)	66.3	27.3	54.7	20.9
Rebar stress	(kg/cm^2)	1787.9	1701.1	1761.7	1009.8
Temperature difference state					
Concrete stress	(kg/cm^2)	67.1	27.8	55.9	19.4
Rebar stress	(kg/cm^2)	1810.8	1729.1	1797.9	938.8

Comment : (4), (5), (6), (7) are design sections in Figure 3.2.1.

Table 3.2.2(1/3) Cross Section at Support of 80m Span Section
Bridge Transverse Composite Stress of Deck Slab (kg/cm^2)

Design Section		(1)		(2)		(3)	
		Upper	Lower	Upper	Lower	Upper	Lower
1. Prestressing stress after prestressing		46.3	-3.6	43.1	-1.3	-11.8	65.0
2. Secondary stress after prestressing		0.0	0.0	3.3	-3.3	5.2	-5.2
3. Reduction stress of prestressing		-5.6	0.4	-5.2	0.2	1.6	-8.9
4. Reduction stress of secondary force		0.0	0.0	-0.4	0.4	-0.6	0.6
5. Dead-load		-7.6	7.6	-8.4	8.4	5.8	-5.8
6. Deck surface load		-6.2	6.2	-2.7	2.7	1.4	-1.4
7. T-load	Max.	0.0	0.0	1.6	-1.6	0.0	0.0
	Min.	-13.0	13.0	-16.6	16.6	-0.6	0.6
8. Sidewalk load	Max.	0.0	0.0	1.6	-1.6	0.0	0.0
	Min.	-3.8	3.8	-2.0	2.0	-0.6	0.6
9. Temperature difference		0.0	0.0	-0.7	0.7	-1.0	1.0
10. After prestressing		38.7	4.1	38.0	3.8	-0.8	54.1
11. Dead load state		26.9	10.7	29.6	7.1	1.6	44.4
12. Design load state	Max.	26.9	10.7	31.2	5.6	25.5	20.4
	Min.	13.9	23.7	13.0	23.7	1.6	44.4
13. Design load state + Sidewalk load	Max.	26.9	10.7	32.8	3.9	25.5	20.4
	Min.	10.0	27.5	11.0	25.8	1.0	45.0
14. Design load state + Temperature difference	Max.	26.9	10.7	30.5	6.2	24.5	21.5
	Min.	13.9	23.7	12.3	24.4	0.5	45.4
15. Design load state + Sidewalk load + Temperature difference	Max.	26.9	10.7	32.2	4.6	24.5	21.5
	Min.	10.0	27.5	10.3	26.4	-0.1	46.0

Table 3.2.2(2/3)
Bridge Axis Bending Stress of Deck Slab

Design Section		Cantilever Part of Deck		Middle Part of Deck Slab
		Left	Right	
Member thickness	(m)	0.406	0.406	0.385
Bending moment	(tm)	1.820	1.820	4.796
Reinforcement	(cm^2/m)	7.214	7.214	21.161
Concrete stress	(kg/cm^2)	34.3	34.3	74.8
Reinforcement bar stress	(kg/cm^2)	1349.1	1349.1	1434.9

Table 3.2.2(3/3)
Bridge Transverse Composite Stress of Web and Lower Slab

Design Section		(4)	(5)	(6)	(7)
Reinforcement	(cm^2/m)	12.111	5.290	31.101	32.228
Dead load state					
Concrete stress	(kg/cm^2)	4.0	8.5	37.9	105.2
Rebar stress	(kg/cm^2)	207.5	690.0	369.4	999.4
Live load state					
Concrete stress	(kg/cm^2)	33.1	21.1	184.1	112.4
Rebar stress	(kg/cm^2)	1703.2	1712.7	1794.4	1067.9
Temperature difference state					
Concrete stress	(kg/cm^2)	33.7	22.8	203.6	93.1
Rebar stress	(kg/cm^2)	1734.8	1853.7	1984.1	884.3

Table 3.2.3(1/3) Widen Cross Section of 110m Span Section
Bridge Transverse Composite Stress of Deck Slab (kg/cm^2)

Design		(1)		(2)		(3)	
		Upper	Lower	Upper	Lower	Upper	Lower
1. Prestressing stress after prestressing		67.1	-9.6	67.2	-9.6	21.9	65.6
2. Secondary stress after prestressing		0.0	0.0	-3.1	3.1	-7.0	7.0
3. Reduction stress of prestressing		-8.8	1.3	-9.1	1.3	-3.3	-9.8
4. Reduction stress of secondary force		0.0	0.0	0.4	-0.4	1.0	-1.0
5. Dead-load		-14.8	14.8	-10.0	10.0	3.4	3.4
6. Deck surface load		-10.9	10.9	-5.3	5.3	-0.2	0.2
7. T-load	Max.	0.0	0.0	5.9	-5.9	21.9	-21.9
	Min.	-24.8	24.8	-18.8	18.8	-4.9	4.9
8. Sidewalk load	Max.	0.0	0.0	3.4	-3.4	0.0	0.0
	Min.	-6.2	6.2	-4.5	4.5	-2.5	2.5
9. Temperature difference		0.0	0.0	-0.3	0.3	-0.7	0.7
10. After prestressing		52.4	5.2	54.1	3.5	18.3	69.2
11. Dead load state		32.6	17.3	40.1	9.8	15.8	58.7
12. Design load state	Max.	32.6	17.3	45.9	3.9	37.7	36.8
	Min.	7.8	42.2	21.3	28.5	10.9	63.5
Design load state + Sidewalk load	Max.	32.6	17.3	49.3	0.5	37.7	36.8
	Min.	1.6	48.3	16.8	33.0	8.5	66.0
Design load state + Temperature difference	Max.	32.6	17.3	45.6	4.2	37.0	37.5
	Min.	7.8	42.2	21.0	28.8	10.3	64.2
Design load state + Sidewalk load + Temperature difference	Max.	32.6	17.3	49.0	0.8	37.0	37.5
	Min.	1.6	48.3	16.5	33.3	7.8	66.7

Table 3.2.3(2/3)
Bridge Axis Bending Stress of Deck Slab

Design Section		Cantilever Part of Deck Slab	Middle Part of Deck Slab
Member thickness	(m)	0.318	0.300
Bending moment	(tm)	3.925	2.189
Reinforcement	(cm^2/m)	27.171	17.871
Concrete stress	(kg/cm^2)	124.8	103.2
Rebar stress	(kg/cm^2)	1502.9	1476.9

Table 3.2.3(3/3)
Composite Stress of Web and Lower Slab

Design Section		(4)	(5)	(6)	(7)
Reinforcement	(cm^2/m)	16.759	6.471	18.366	10.008
Dead load state					
Concrete stress	(kg/cm^2)	12.7	11.1	26.8	1.084
Rebar stress	(kg/cm^2)	419.1	633.9	437.5	41.4
Live load state					
Concrete stress	(kg/cm^2)	53.2	30.0	109.5	57.4
Rebar stress	(kg/cm^2)	1758.0	1709.6	1785.1	1377.3
Temperature difference state					
Concrete stress	(kg/cm^2)	52.7	30.4	111.6	54.8
Rebar stress	(kg/cm^2)	1741.0	1734.7	1819.4	1316.5

3.2.2 Design of Main Girder

3.2.2.1 General

Some features from the bridge design are explained here.

(1) Support conditions of the bridge axis direction

The supporting condition of the main bridge was determined taking into consideration an appropriateness of structure, good vehicle comfort, easy maintenance and cost effectiveness, as well as some basic policy such as;

- The main girder must be connected as entirely as possible.
- The girder proper and piers at central part of the Main Bridge must be rigidly connected as much as possible.

The support conditions are shown in Figure 3.2.2. The spring force of vertical, horizontal and rotation was considered at the lower end of piers P10, P11, P12, P17, P18 and P19, to consider influences of deformation of pile foundations.

(2) Saddle structure of main tower

Stay cables at two main towers are arranged as going through the tower rather than anchoring at the tower, because the stay cables have to be concentated at the tower head to reduce the face area of PC Sail. Special measures are taken against a huge concentated stress induced along the radius of the cable saddle.

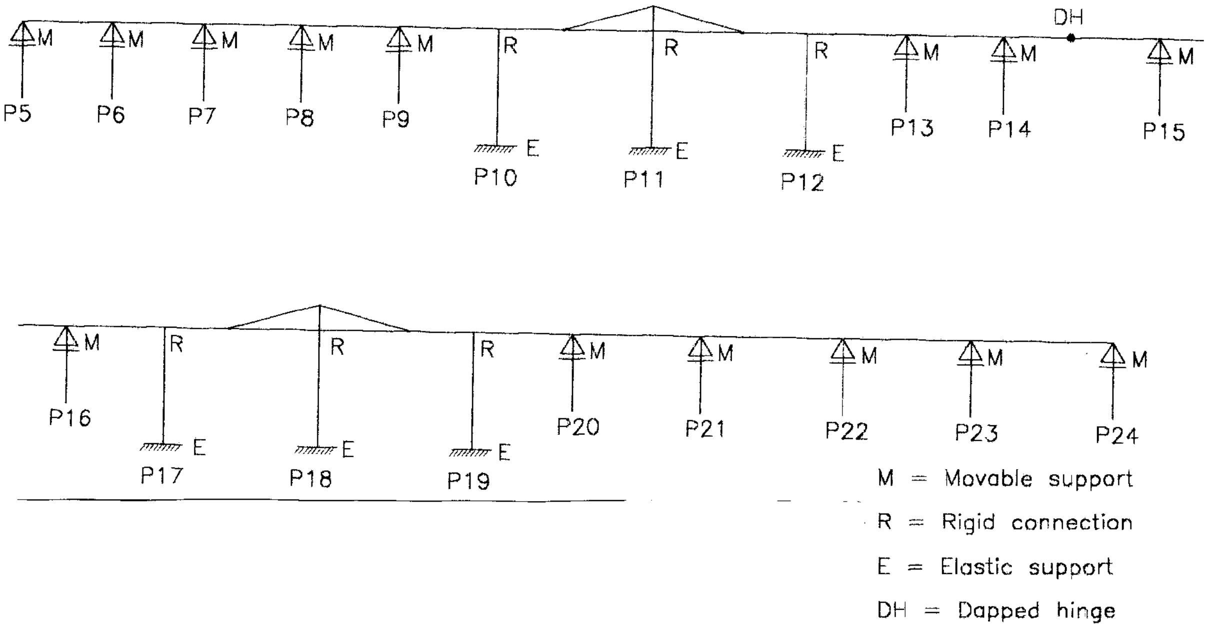


Figure 3.2.2 Support Conditions

(3) PC Sail and Tower

- Design of Bridge Axis direction
  The section stress is analyzed by the two dementional frame model, together with other girder members.
- Design of transverse direction
  Bending moment by the wind load is calculated.
- The design policy for the wind load is as follows:
  a) V=40 m/s (basic wind velocity of JRA-SHB) :
     Limit of rebar tensile stress, $\sigma s \leq 180 \times 1.2 = 216 N/mm^2$
  b) V=48 m/s (estimated wind velocity in 50 year probability):
     Check of ultimate bending strength.
- Measurement against bending crack occurring at PC Sail.

It is expected that cracks by stress from temperature changes and drying shrinking way occur because the member is thin and has a wide face area. The measures against the cracks are as follows:

1) Prestress is introduced after concreting.
2) The reinforcing bar arrangement with small pritch.
3) Surface coating for high durability.

- Prestressing of the PC sail is divided into two stages.

The primary prestress (30% of total prestress) is applied before concreting of PC Sail but after the segment is joined for stress improvement of a main girder.

The secondary prestress (70% of total prestress) is applied after concreting of the PC Sail, to introduce prestress to the PC sail.

- The PC Sail is designed as a Prestressed Reinforced Concrete Structure, allowing tensile stress at design loading, to reduce quantity of prestressing steel.

(4) Division, Joint of the precast segment

- The length of segment was determined not to exceed the maximum segment weight of 1372 kN (140 Tonne).
- Closure pour at the span center and pier head of rigid connection pier P10~12, P17~19 is made of cast-in-place concrete.
- Epoxy resin is applied at the segment joint. The segment is compressed together by PC steel bars.
- Stress at joint of precast segments is examined by the following equation.

1) For girder ; $\sigma_o+1.7\,\sigma_{L,g}$

2) For deck slab ; $\sigma_o+1.7\sigma_{L,s}+0.5\sigma_{L,g}$

where, σ_o ; Flexural tensile stress of concrete due to the principal load excluding the live load and impact load

$\sigma_{L,s}$; Flexural tensile stress of concrete at the main girder due to the live load (L-loading) and the impact load

$\sigma_{L,g}$; Flexural tensile stress of concrete at the deck slab due to the live load (T-loading) and the impact load

Allowable flexural tensile stress for this examination is 2.5 N/mm^2 (25kg/cm^2) under the specified compressive strength of 40N/mm^2.

(5) PC cable system

The PC cable of the main girder axis direction uses inner cables and external cables. Inner cables under the cantilever erection are arranged mainly into the deck slab. External PC cables are arranged from anchorages at deviators inside the box girder after cantilever erection.
Prestress σ_{pi} of PC cable is 1295 N/mm^2.

3.2.2.2 Calculation procedures

The main girder was analyzed as a two (2)-dimensional frame model with elastic support of pier at lower end (refer to Figure 3.2.2). Temporary supports of the PC-Sail spans and dapped hinged span were modeled as a simple supported column.

1) Effective cross section of Main Girder
   All members of cross section are considered against bending moment, shearing force and axial force.

2) Calculation of load and Main Girder cross section force
   Design loads in Table 3.1.2 and table 3.1.3 were considered.

3) Calculation of prestressing force
   Prestressing steel was inner cable 12S15.2 and external cable 19S15.2.

4) Calculation of cross sectional force and stress of girder
   Calculation of force and checking of stress were carried out by using the structural analysis program CONST.

5) The increase in stress of external PC cables in calculation of the ultimate bending moment of the main girder was assumed at 105 N/mm^2 (10.5kg/mm^2).

3.2.2.3 Result of safety check of main girder

Bending stress, shearing stress and safety factor at the ultimate failure of the Main Girder are shown in Table 3.2.4 and Table 3.2.5.

3.2.2.4 Result of Safety Check at the Dapped Hinge

The design of dapped hinge was carried out considering it as a RC structure.
Bending stress, shearing stress and the safety factor at the ultimate failure are shown in Table 3.2.4. To raise safety against diagonal cracking, oblique PC cables 4S15.2 were arranged at interior angle portion of web.

3.2.2.5 Result of Safety Check at the PC Sail and Tower

Safety results of the PC sail and tower at times of erection and service are shown in Table 3.2.7.

3.2.2.6 Amount of Movement at Movable Bearing and Expansion Joint

The amount of movement of the movable bearing and the expansion joint are shown in Table 3.2.8.

3.2.2.7 Result of Safety Check of Main girder during Erection

The bending stress of main girder during cantilever erection is as follows:

1) Girder bending stress at maximum cantilever length at Pier No.8.
   - upper edge; σ_{co} = 30.8 kg/cm^2 > 0 kg/cm^2
   - lower edge; σ_{cu} = 88.5 kg/cm^2 < 175 kg/cm^2

2) Girder and Tower bending stress at 110m PC Sail span section.

   a) Girder bending stress at maximum cantilever length at Pier No.11.
      - upper edge; σ_{co} = 30.8 kg/cm^2 > 0 kg/cm^2
      - lower edge; σ_{cu} = 88.5 kg/cm^2 < 175 kg/cm^2

   b) Girder bending stress at First Prestressing for PC Sail.
      - upper edge; σ_{co} = 38.3 kg/cm^2 > 0 kg/cm^2
      - lower edge; σ_{cu} = 105.0 kg/cm^2 < 175 kg/cm^2

   c) Girder bending stress at Second Prestressing for PC Sail.
      - upper edge; σ_{co} = 42.0 kg/cm^2 > 0 kg/cm^2
      - lower edge; σ_{cu} = 105.5 kg/cm^2 < 175 kg/cm^2

   d) Tower bending stress at Second Prestressing for PC Sail.
      - upper edge; σ_{co} = 41.3 kg/cm^2 < 187.5 kg/cm^2
      - lower edge; σ_{cu} = 28.1 kg/cm^2 > 0 kg/cm^2

Table 3.2.4(1/2)
Bending Stress and Safety Ratio at Ultimate Bending Failure

Design Section		Concrete Bending Stress (kg/cm^2)						Ultimate Bending Moment (tm)		
		Dead Load State		D+L(+)		D+L(-)				
		Upper	Lower	Upper	Lower	Upper	Lower	Bending Moment M	Resisting Moment Mu	Safety Ratio Mu/M
P05	Max	17.4	32.9	17.4	32.9	17.4	32.9	2190	3670	1.7
	Min	36.9	54.0	52.5	27.2	32.1	62.2	9029	9265	1.0
P06	Max	101.9	109.6	104.3	106.4	89.0	126.9	-33319	-47697	1.4
	Min	22.3	53.1	37.0	28.0	16.6	62.9	9937	11033	1.1
P07	Max	98.5	113.2	102.2	108.2	84.3	132.2	-33357	-47667	1.4
	Min	20.1	56.7	35.2	31.0	14.0	67.2	9848	11032	1.1
P08	Max	97.7	114.4	101.6	109.1	83.2	133.8	-33960	-47678	1.4
	Min	23.0	52.1	38.0	26.4	16.9	62.5	10311	11032	1.1
P09	Max	103.6	107.2	107.6	101.8	89.2	126.4	-32389	-47682	1.5
	Min	12.4	69.0	26.4	45.1	6.6	78.9	8148	11031	1.4
P10	Max	77.3	92.5	83.9	84.5	58.8	114.8	-43060	-56285	1.3
	Min	66.3	33.9	79.8	11.4	60.3	42.9	20411	24027	1.2
P11	Max	6.1	141.8	11.5	136.5	4.9	153.3	-60301	-60588	1.0
	Min	67.7	34.0	81.3	11.4	61.5	43.6	20563	24178	1.2
P12	Max	82.0	86.9	88.8	78.7	63.0	109.4	-40797	-56294	1.4
	Min	18.2	59.8	33.3	34.1	11.7	71.1	9602	11033	1.1
P13	Max	107.9	92.0	116.1	89.5	92.3	121.4	-32394	-47633	1.5
	Min	14.7	66.9	33.1	35.3	2.3	88.1	9982	10650	1.1
P14	Max	56.9	128.10	61.5	122.8	34.4	153.9	-46046	-57543	1.2
	Min	21.0	42.6	26.3	33.3	19.0	46.1	5235	6937	1.3
P15	Max	100.5	106.0	106.3	99.4	83.4	125.5	-38414	-57924	1.5
	Min	19.7	56.6	35.4	29.7	12.4	69.2	9967	11032	1.1
P16	Max	116.8	91.5	121.6	85.0	102.1	111.2	-30531	-47639	1.6
	Min	16.2	62.6	30.5	38.1	10.2	72.8	8849	11033	1.2
P17	Max	79.3	92.2	85.8	84.4	60.9	114.2	-43544	-56318	1.3
	Min	65.3	33.6	78.2	12.0	58.4	44.6	20844	24043	1.2

Table 3.2.4(2/2)
Bending Stress and Safety Ratio at Ultimate Bending Failure

Design Section		Concrete Bending Stress (kg/cm^2)						Ultimate Bending Moment (tm)		
		Dead Load State		D+L(+)		D+L(-)				
		Upper	Lower	Upper	Lower	Upper	Lower	Bending Moment M	Resisting Moment Mu	Safety Ratio Mu/M
P18	Max	10.6	135.7	14.6	132.8	1.7	149.7	-54954	-59719	1.1
	Min	70.2	30.2	83.8	7.7	64.1	39.5	20880	24202	1.2
P19	Max	84.5	86.6	91.0	78.7	66.2	108.6	-41214	-56283	1.4
	Min	15.7	62.8	26.9	66.1	13.8	49.5	8984	11031	1.2
P20	Max	106.4	106.4	110.3	101.1	92.1	125.5	-32833	-47655	1.5
	Min	22.6	52.9	37.7	27.1	16.6	63.2	10222	11031	1.1
P21	Max	101.8	113.0	105.7	107.8	87.5	132.3	-33669	-47683	1.4
	Min	20.3	56.7	35.4	30.9	14.2	67.1	9932	11031	1.1
P22	Max	102.9	111.7	106.6	106.8	88.9	130.6	-33297	-47680	1.4
	Min	21.4	54.7	36.2	29.5	15.7	64.4	9890	11031	1.1
P23	Max	104.6	109.4	106.9	106.4	91.8	126.5	-33234	-47713	1.4
	Min	35.9	58.9	51.6	32.0	31.2	67.0	8926	9264	1.0
P24	Max	17.6	31.8	17.6	31.8	17.6	31.8	4470	6469	1.4

Table 3.2.5(1/2)
Shear Stress and Safety Ratio at Ultimate Shear Failure

Design Section		Diagonal Tensile Stress						Mean Shear Stress
		s max (kg/cm^2)			s min (kg/cm^2)			Ultimate Load State
pier	**web (mm)**	**2-2**	**G-G**	**3-3**	**2-2**	**G-G**	**3-3**	**(kg/cm^2)**
P5	600	-9.3	-9.9	-8.4	-4.4	-4.5	-3.5	39.0
	400	-5.8	-6.5	-4.5	-9.5	-10.2	-7.0	50.2
P6	600	-7.4	-8.3	-4.7	-7.7	-8.6	-4.9	44.0
	400	-7.8	-8.8	-5.8	-8.5	-9.4	-5.6	48.8
P7	600	-7.9	-8.6	-4.7	-8.0	-8.7	-4.8	44.1
	400	-8.2	-9.0	-5.5	-8.5	-9.3	-5.5	49.0
P8	600	-8.2	-8.8	-4.8	-8.0	-8.7	-4.7	44.7
	400	-8.4	-9.2	-5.7	-8.1	-9.0	-5.8	49.5
P9	600	-6.8	-7.8	-4.5	-7.1	-8.2	-4.8	43.8
	400	-7.5	-8.3	-4.7	-5.2	-5.4	-2.9	46.1
	600	-4.6	-4.7	-2.0	-9.1	-8.8	-3.1	36.5
P10	800	-6.2	-7.7	-5.2	-5.6	-5.6	-4.5	39.5
	600	-11.1	-11.9	-5.3	-6.7	-7.2	-3.1	46.4
	400	-6.2	-7.2	-4.9	-9.2	-9.6	-4.1	45.0
	600	-5.3	-6.3	-4.5	-7.2	-8.5	-6.0	49.7
P11	800	-15.7	-12.8	-11.7	-15.2	-12.8	-11.7	50.2
	600	-6.6	-7.0	-4.0	-4.5	-4.9	-3.0	45.5
	400	-9.3	-9.7	-4.0	-5.8	-6.8	-4.9	45.8
	600	-6.3	-7.0	-3.3	-11.0	-11.9	-5.5	45.3
P12	800	-5.2	-5.5	-4.6	-5.8	-7.6	-5.4	43.6
	600	-8.1	-8.4	-3.4	-3.7	-4.1	-2.1	36.1
	400	-4.8	-5.4	-3.5	-7.6	-8.5	-5.4	47.2
P13	600	-6.9	-7.9	-4.7	-6.7	-7.9	-4.7	43.2
	400	-7.1	-8.0	-5.1	-9.0	-8.5	-2.9	47.2
	600	-5.6	-6.3	-2.9	-10.1	-10.7	-4.5	45.3
P14	800	-10.6	-9.5	-5.5	-6.9	-7.1	-4.5	44.8
	600	-13.2	-13.4	-6.0	-8.1	-8.2	-3.6	40.7
	400	-16.2	-11.7	-2.9	-11.0	-8.5	-3.2	45.1

Comment : 2-2, G-G, 3-3 are positions of stress checking (refer to Figure 3.2.1)

Table 3.2.5(2/2)
Shear Stress and Safety Ratio at Ultimate Shear Failure

Design Section		Diagonal Tensile Stress						Mean Shear Stress
		s max (kg/cm²)			s min (kg/cm²)			Ultimate Load State
Pier	**Web (mm)**	**2-2**	**G-G**	**3-3**	**2-2**	**G-G**	**3-3**	**(kg/cm²)**
P15	600	-8.1	-9.4	-6.9	-7.0	-8.1	-5.9	45.6
	400	-8.9	-9.6	-4.1	-6.9	-8.2	-4.5	46.8
P16	600	-4.8	-6.2	-4.0	-5.4	-6.7	-4.2	41.6
	400	-6.2	-7.4	-4.1	-5.2	-5.3	-2.7	40.4
	600	-3.9	-4.1	-1.6	-8.0	-7.7	-2.7	37.6
P17	800	-8.7	-10.6	-7.3	-7.8	-7.7	-4.9	40.6
	600	-9.1	-9.8	-4.2	-5.5	-5.9	-2.5	46.8
	400	-5.8	-6.7	-3.5	-8.6	-9.4	-4.3	43.7
	600	-4.3	-4.7	-3.1	-6.7	-7.4	-4.4	49.5
P18	800	-15.2	-12.7	-11.6	-13.9	-12.4	-11.5	50.6
	600	-6.6	-7.0	-4.0	-4.8	-5.2	-3.1	47.3
	400	-8.9	-9.5	-4.2	-5.4	-6.6	-4.0	45.0
	600	-4.9	-5.4	-2.4	-8.6	-9.4	-4.3	46.5
P19	800	-6.6	-7.3	-4.9	-7.9	-10.2	-7.4	46.2
	600	-6.3	-6.5	-2.6	-2.7	-3.2	-1.4	35.1
	400	-4.7	-5.5	-2.7	-7.9	-8.8	-4.1	42.7
P20	600	-6.6	-7.5	-4.2	-6.7	-7.6	-4.2	42.6
	400	-7.5	-8.6	-4.2	-8.6	-9.5	-4.4	44.3
P21	600	-6.6	-7.5	-4.2	-6.7	-7.6	-4.2	43.3
	400	-8.2	-9.1	-4.3	-8.4	-9.3	-4.3	44.1
P22	600	-6.5	-7.4	-4.2	-6.5	-7.4	-4.2	43.0
	400	-8.1	-9.1	-4.3	-8.2	-9.2	-4.4	43.9
P23	600	-6.3	-7.4	-4.2	-6.1	-7.1	-4.1	42.7
	400	-9.3	-10.0	-5.2	-5.6	-6.2	-3.2	47.3
P24	600	-3.5	-3.8	-3.1	-8.3	-9.3	-8.3	35.7

Comment : 2-2, G-G, 3-3 are positions of stress checking (refer to Figure 3.2.1)

Table 3.2.6 Safety Check of Dapped Hinge

		P12~Hinge	Hinge~P13
1.Design Reaction			
Dead load	R_D**(t)**	446	446
Live load	R_{L+I}**(t)**	120	120
Service state	R_{D+L+I}**(t)**	566	566
Ultimate	R**(t)**	962	962
2.Service State			
Concrete bending tensile stress	σ ct(kg/cm^2)	49	42
(All the sections effective; σ ct=M/W)			
Rebar tensile stress of RC	σ_s(kg/cm^2)	1361	1161
Concrete compresion of RC	σ_c(kg/cm^2)	61	53
Mean shearing stress	τ_m(kg/cm^2)	15.0	12.3
3.Ultimate State			
Bending moment	M(tm)	962	962
Resisting moment	Mu(tm)	1400	1636
Safety ratio	Mu/M	1.46	1.70
Mean shearing stress	τ_m(kg/cm^2)	50.9	43.3

Table 3.2.7 Safety Check of PC Sail and Tower

Member	PC Sail				Tower	
	P10~11				P11	
	Main girder side		Tower side			
	Bridge axis	Transverse	Bridge axis	Transverse	Bridge axis	Transverse
Load state	D+L+i	wind	D+L+i	wind	D+L+i	wind
σ c (kg/cm^2)	18	44	71	90	65	140
σ s (kg/cm^2)	214	566	1200	1010	442	940

Table 3.2.8 Movement of Movable Bearing and Expansion Joint

PIER NO.	Thermal ΔLt(mm)	Shrinkage ΔLs(mm)	Creep ΔLc(mm)	Max(mm)	Min(mm)
P5	± 72	79	155	306	162
P6	± 64	68	134	266	138
P7	± 52	55	108	215	111
P8	± 40	42	83	165	85
P9	± 28	29	60	117	61
P13	± 29	-27	-48	-104	-46
P14	± 40	-41	-75	-156	-76
Hinge	± 45/ ± 48	-46/ 52	-82/ 104	-173/ 204	-83/ 108
P15	± 41	43	90	174	92
P16	± 27	30	64	121	67
P20	± 28	-26	-47	-101	-45
P21	± 40	-40	-73	-153	-73
P22	± 52	-53	-98	-203	-99
P23	± 64	-66	-121	-251	-123
P24	± 72	-75	-134	-281	-137

3.3 PIER AND FOUNDATION

3.3.1 General

Extreme scour to riverbed level has been assumed in the design for the main bridge foundations. Observations have indicated that the channel scour characteristics in the riverbed are increasing. A possible reason for this is the changing riverbed regime downstream of the bridge site due to (a) river dredging (for the passage of local ships), and (b) river quarrying (for sands and gravel for civil and building construction).

In the Basic Design Report, calculations have estimated the scour depth at 4.7 m. This scour depth is physically and considerably less in many places along the bridge crossing site due to the high level of bedrock and the small sedimentary (sand and gravel) overlay.

The design of the piled foundation has, therefore, been based on full scour to bedrock and in the detailed design the piles have been socketed at least 5m into the bedrock for both stability and bearing capacity conditions. The AASHTO 1992 specifications clause 4.6.5.3.3.1 recommends for socketed piles a minimum socket length of 2ϕ into striking strata and the design here has, therefore, been based on the following criteria:

i)	Weathered or fractured rock	=	1 m	(estimated)
ii)	Socket length 2 x ϕ 2.0 m	=	4 m	(minimum)
	Total minimum socket length	=	5 m	

3.3.2 Change of Pile Type and Diameter

During the basic design, ϕ1.5m cast-in-place concrete composite piles were proposed because of their so called economic and engineering advantages. However, a comparative evaluation between ϕ1.5m cast-in-place composite piles and ϕ 2.0m cast-in-place reinforced concrete piles has been carried out during the detailed design stage. This evaluation has shown that for the dominant main bridge pile type group, the cost for piling and pile cap construction is about the same (within ± 5%), but construction time for ϕ2.0 pile will be less since its number is less. This is critical since considering that the pile caps have to be constructed above the low water level during the dry season. Any savings in piling construction time can, therefore, be enjoyed as advantage in the pile cap and pier construction during the low water season.

Table 3.3.1 shows the evaluation comparison between the ϕ1.50m and ϕ 2.0m pile types.

Table 3.3.1
Comparison of Pile Type

Comparison of ø1.50m Cast-in-place Composite Piles (Basic Design) or ø2.0m Cast-in-place Reinforced Concrete Piles	**Rating Of Pile Type**	
	ø 1.50	**ø 2.0**
1. Cost of one composite ø1.50m pile is approximately 20% cheaper than one ϕ2.0m pile.	A	B
2. Number of ø1.50m piles is reduced from 8 to 6 by using ø2.0m piles in the majority of the river piers.	B	A
3. Cost of 8 of ø1.50m piles is greater than 6 of ø2.0m piles by approximately 7%.	B	A
4. Cost of ø1.50m piled footing is less than a ø2.0m piled footing by approximately 10%.	A	B
5. Total cost of foundations almost the same (piles plus pile cap within ± 5%).	A	A
6. Drilling time in rock for ø1.50m piles and ø2.0m piles is almost the same; for ø2.0 piles a larger drilling machine is used instead.	A	A
7. As there are less number of ø2.0m piles than those of ϕ1.50m piles; construction will be quicker.	B	A
Overall Rating	B	A
Conclusion : Costs are almost the same but construction is quicker for ø2.0m piled foundation. This is critical during dry season.		
Recommendation : Change from ø1.50m piles to ø2.0m piles to speed up construction at site especially during the dry season.		

Notes : A : More cost effective or time effective.
B : Less cost effective or time effective.

3.3.3 Pile Cap Soffit Level and Skirt Level

From the hydrological data in the basic design report the 2 year return period for the low water level was calculated at EL 125.50. However, further determination of a suitable soffit level for the main bridge pile cap soffits was required to allow pile cap construction during January, February, March and April of each low water season.

The detailed design study, consequently, used the IWAI probability analysis for the maximum and minimum monthly water levels. The 10 year return period for the monthly maximum water level being exceeded was used as the basis to set the pile cap soffit level with approximately 300mm clearance in February, March and April of each low water season. The pile cap soffit level was fixed at EL 126.75.

A level of EL 125.25 representing a level less than the 5 year return period for the monthly minimum water level was set for the pile cap precast skirt bottom level. This means that for a short period (1 week) each 4 or 5 years the piles supporting pile cap and pier will be visible underneath the skirt in March and or April.

Figure 3.3.1 shows the monthly maximum and monthly minimum water levels at Mukdahan adjusted to the bridge longitudinal centerline.

Subsequently to keep all pile cap top elevations at a similar level of EL 130.25 the soffit elevation for Piers P7, P8, P9, P13, P14, P15, P16, P20, P21 and P22 has been raised to EL 127.25 while the soffit for the rigid pier pilecaps (P10, P11, P12 and P17, P18, P19) remains the same at EL 126.75. All skirt bottom levels remain the same at EL 125.25.

3.3.4 Pile and Pile Cap Construction Methodology

For the construction of the piles it is assumed that the Contractor will use a temporary H-beam jetty for the installation and operation of piling machines. Piling will be carried out using either a temporary and permanent steel casing method or just a permanent casing method. This methodology is covered in more detail under Chapter 6.

3.3.5 Substructure Design Conditions

a) Topographic and Geological Condition

The geological survey was carried out at each boring location (6 locations in the Mekong River and 2 locations on each side of the riverbank on both the Lao PDR and the Thailand sides). After the boring survey was completed, various kinds of laboratory tests were carried out to get the geotechnical design parameters that were needed for the design.

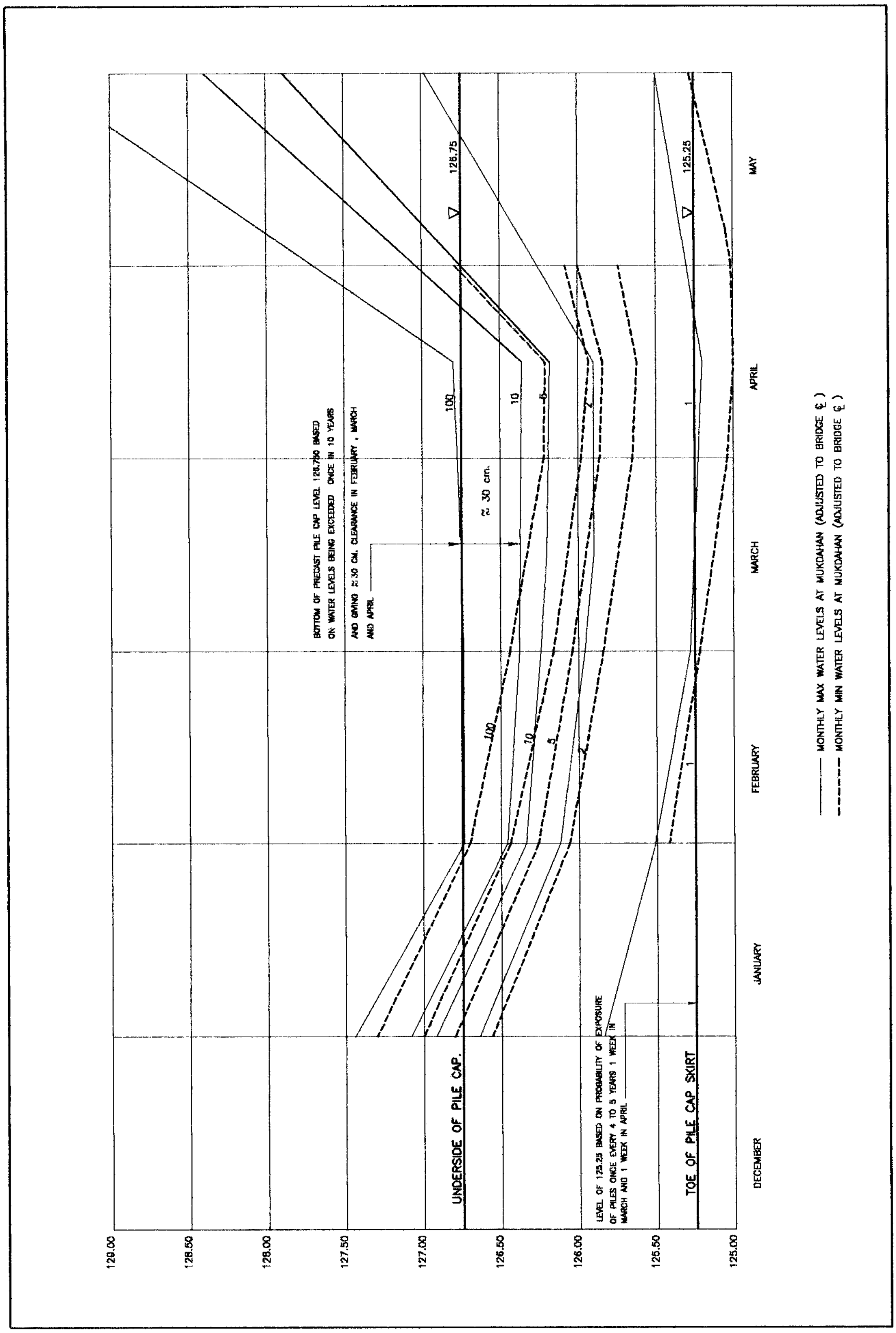


Figure 3.3.1 Monthly Maximum and Minimum Water Levels at Bridge Site

b) Foundation Support

The foundation support criteria adopted for the bridge is a rock layer with an SPT N value ≥50.

Foundation Support - Mudstone (N-Value ≥ 50)
- Sandstone (N-Value ≥ 50)

c) Material Properties for Design

The material properties for the design of each foundation that is located in the river is shown in Table 3.3.2.

Table 3.3.2
Soil Properties

	g(t/m^3)	c(t/m^2)	f(°)	Eo(t/m^2)	Remarks
Sand	-------	-------	-------	-------	Not considered
Gravel	-------	-------	-------	-------	Not considered
Mudstone or Standstone	2.45	15	35	44,000	At normal time : α = 2.5 At earthquake time : α = 5.0

Remarks : The value of the ground coefficient α is 2.5 under normal time and 5.0 under earthquake time.

The soil values for design as listed above are based on the geotechnical survey result. The adopted values are set up on the basis of an average SPT N - value from each boring log result of the Mekong River (i.e. : a total of 6 boreholes in the river).

d) Water Level Condition

i) The design water levels have been based on the following parameters.
HWL = EL 139.6m (100 years ARI flood)
LWL = EL 125.5m (2 years ARI minimum water level)

ii) The dynamic water pressure is calculated on the basic of the JRA-SHB.

$$\mathbf{P = K*V^2*A}$$

where P = Dynamic water force (Ton)
K= Coefficient determined by shape of the pier
V= Maximum current velocity (2.6m /sec)
A= Vertical projected area of bridge pier (m^2)

iii) The ship impact force is a 300 ton vessel impacting at a velocity of 5m/sec in the downstream direction and the equivalent static force is 3400 KN acting in any direction.

e) Design Reaction of Superstructure

The Design Reaction of Superstructure is shown in Table 3.3.3. Horizontal load is based on JRA-SHB standards. Since horizontal seismic factor, kh=0.06, is less than the friction factor of the support, fs=0.10, selection of horizontal loads on the bridge axis direction of the rigid piers and the movable piers are made as follows:

1) Rigid piers must resist all horizontal loads of the superstructure.
2) Movable piers must resist all loads from temperature (fs*Rd) and seismic load (kh*Rd) generated by each pier reaction.

Table 3.3.3
Pier and Foundation – Design Load by Superstructure

		P6	P14	P17	P18	P20	P23
Bearing Condition		Move	Move	Rigid	Rigid	Move	Move
Vertical Load	Dead Load (ton)	2,100	2,700	Shown below	Shown below	2,300	2,100
	Live Load (ton)	310	350			330	310
Horizontal Load (Axis)	Temperature Load (ton)	210	270			230	210
	Earthquake Load (ton)	126	162			138	126
Horizontal Load (Transverse)	Earthquake Load (ton)	126	162			138	126

Comment: The acting position of the design load is the upper end of the pier.

Pile Cap Design of P17 and P18

Substructure No..		P17			P18		
Section Force		N(ton)	H(ton)	M(ton*m)	N(ton)	H(ton)	M(ton*m)
Bridge Axis	D+L	5,400	530	8,880	9,100	360	5,250
	D+L+T	5,200	580	10,230	9,000	360	5,250
	D+E	5,200	830	14,480	8,800	1,010	14,430
Bridge Transverse	D+L	5,400	0	0	9,100	0	0
	D+L+T	5,200	0	0	9,000	0	0
	D+E	5,200	320	6,540	8,800	530	15,250

Remarks : D+L : Dead Load + Live Load
D+L+T : Dead Load + Live Load + Temperature
D+E : Dead Load + Earthquake Load
Comment: The acting position of the design load is the surface of the pile cap.

3.3.6 Substructure Arrangement

The main bridge consists of 1600m of PC Sail type continuous box girder bridge with spans as follows:

Table 3.3.4
Span Arrangement of Main Bridge

Section	Span (m)	Length (m)
P5-P6	1 span @ 60m	60m
P6-P10	4 span @ 80m	320m
P10-P12	2 span @ 110m	220m
P12-P17	5 span @ 80m	400m
P17-P19	2 span @ 110m	220m
P19-P23	4 span @ 80m	320m
P23-P24	1 span @ 60m	60m
Total Length		**1,600m**

Design calculations of pile foundations are divided into 5 groups as shown in Table 3.3.5 since similarity in reaction forces of superstructure and support conditions are taken into consideration. Next, design was conducted using the 5 typical models.

Table 3.3.5
Main Bridge Pier and Foundation Design Grouping

Groups	Contents	Design Model	Remark
A	P6, P23	P6 and P23	Movable Pier (Spread Footing)
B	P13, P14, P15, P16	P14	Movable Pier (Center)
C	P10, P12, P17, P18	P17	Rigid Pier
D	P11, P18	P18	Rigid Pier (Tower Pier)
E	P7, P8, P9, P20, P21, P22	P20	Movable Pier (Side)

The substructure arrangement is outlined below:

(a) Pier 6 and 23 - A reinforced concrete wall type pier supported on a 10m x11m spread footing keyed into the rock surface of 0.5m. The superstructure is free to move in the bridge axis direction at these piers.

(b) Pier 7, 8, 9, 20, 21 and 22 - A reinforced concrete wall type pier with pile cap supported by 6 of ϕ 2.0m reinforced concrete steel cased piles. The superstructure is free to move in the bridge axis direction at these piers.

(c) Pier 10, 12, 17 and 19 - A reinforced concrete wall type pier with pile cap supported by 10 of ϕ 2.0m reinforced concrete steel cased piles. The superstructure is rigidly fixed to the top of these piers.

(d) Pier 11 and 18 - A reinforced concrete wall type pier with pile cap supported by 10 of ϕ 2.0m reinforced concrete steel cased piles. The superstructure is rigidly fixed to the top of these piers. The edges of the piers extend to the underside of the superstructure top slab. These piers carry the full tower load of the PC sail.

(e) Pier 13, 14, 15 and 16 - A reinforced concrete wall type pier with pile cap supported by 6 of ϕ 2.0m reinforced concrete steel cased piles. The superstructure is free to move at the top of these piers in the bridge axis direction.

3.3.7 Piles and Foundations

a) P6 and P23 (Footing)

In the Basic Design Report both these piers were designed on the basis of being supported by 400 x 400mm precast piles. During the early stages of the detailed design, however, worries about the possibility of riverbank scour forced a re-evaluation of the design and comparisons of different foundation styles were carried out.

Essentially 4 types of foundation were compared against one another for (1) aesthetics, (2) construction method and probable construction problems and (3) construction cost. A spread foundation was evaluated as the most suitable foundation type based essentially on aesthetics after erosion as well as construction cost factors.

Comparisons were made on cofferdam costs of sheet piling versus a concrete pile cofferdam method. Although construction problems are also expected, sheet piling had a very substantial cost advantage ratio.

Finally for confirmation, a detailed cost comparison was made between a cast-in-place piled foundation and a spread foundation. The spread foundation confirmed its cost advantage by 25% even with substantial cofferdam costs.

In conclusion, a spread footing keyed into the existing rock surface constructed within a steel sheet piled cofferdam has been selected as the best foundation option. However, at construction time other suitable excavation methods may be considered by the Engineer.

Since these footings are constructed on riverbanks, they are designed to be stable at the complete washing away state of the surrounding ground. Design has been discussed in the three stages i.e. (1) after completion, (2) if the ground in front of the pier is washed out, and (3) if the rear side ground is washed away. These footings are most seriously affected in stage (2) and member dimensions as well as reinforcements are accordingly determined under this stage of loading.

b) Piers P13, P14, P15 and P16 (Piles)

These 4 river piers with superstructure movement allowed at the top of the piers are supported on 6 of ϕ 2.0m reinforced concrete steel cased pile, socketed 5m into the rock layer.

Reinforcement consists of 42 of D40 bars at 130mm centers (each bar is installed with 2 alternating bars as shown in the drawings). The minimum pile casing thickness is 9mm and the casing extends 1000mm into the pile cap above soffit level.

c) Piers P10, P12, P17 and P19 (Piles)

These 4 piers with rigid connection to the superstructure are supported on 10 of ϕ 2.0m reinforced concrete steel cased piles socketed 5m into the rock layer.

Pile reinforcement consists of 63 of D40 bars at 130mm centers (each bar is installed with 2 alternating bars as shown in the drawings). The minimum pile casing thickness is 9mm and the casing extends 1000mm into the pile cap.

d) Piers P11 and P18 (Piles)

The two piers with rigid connections to the superstructure support the PC sail tower loads. Support is on 10 of ϕ 2.0m reinforced concrete steel cased piles socketed 5m into the rock layer.

Pile reinforcement is similar to that for Piers P10, P12, P17 and P19.

e) Piers P7, P8, P9, P20, P21 and P22 (Piles)

These 6 piers have superstructure movement allowed at the top of the pier. They are supported by 6 of ϕ 2.0m reinforced concrete steel encased piles socketed 5m into the rock layer.

Pile reinforcement consists of 42 of D40 bars at 130mm centers. Once again the steel casing extends 1000mm into the concrete pile cap above soffit level.

3.3.8 Piles Caps

a) Piers P7, P8, P9, P13, P14, P15, P16, P20, P21 and P22

The overall dimensions of these pile caps are 9.000m x 14.336m with each pile cap supported on 6 of ϕ 2.0m piles. The thickness of the pile cap is 3.0m.
The top level of the pile cap is EL 130.25 which allows for a soffit level of EL 127.25. This level gives sufficient clearance above the water surface for construction during the dry season.

It is assummed that precast concrete formwork placed on steel channels or H- beams welded to the steel casing will be used for the soffit formwork of the pile caps. Pile cap concrete will be cast in two layers.

i) The first layer of 500mm containing 3 layers of bottom reinforcing.

ii) The second layer of 2500mm containing steel from the precast skirting slabs and a top layer of reinforcement.

Precast skirting slabs of 5000 x 1000 x 300 will be used as the side formwork for the second concrete pour.

Reinforcement of D32 @ 125 centers will be placed in 3 layers due to the pile casing protruding 1000mm into the pile cap. Starter bars for pier steel will be cast into the second concrete pour.

The ends of pile caps are beveled at 22° at each end to allow for a better hydraulic water flow.

b) Piers P10, P12, P17, P19, P11 and P18

The overall dimension of these pile caps are 11.000m x 19.144m with each pile cap supported on 10 of ϕ 2.0m piles. The thickness of each pile cap is 3.50m. The top level of the pile cap is again EL 130.25 with a soffit level of EL 126.75. Other constructional details for these pile caps are similar to those described in 3.3.8 (a). However, the amount of bottom reinforcement is considerably larger. Once again the ends of the pile caps allow a better hydraulic water flow.

3.3.9 Piers

All piers are standard wall type piers with small tapers on both the longitudinal and transverse axes. The edges of the piers are beveled at 22° to keep the same geometry with the pile cap ends.

Piers are expected to be constructed in no more than 3.0 meter lifts using barged concrete and concrete pumping.

Where piers allow for superstructure movement, plinths for bearing will be located at the pier top surface. In addition, extra reinforcement will be provided in the top 1 m of the pier to prevent bursting effects from high bearing loads.

Steel size varies from D40 bars at 125mm centers (in 3 layers) for the rigid piers P10-P12 and P17-P19 to D20 bars at 125mm centers for piers P7-P9 and P20-P22.

For the rigid piers fixed to the superstructure, continuity steel is installed from the pier into the superstructure.

3.3.10 Calculation Result

Table 3.3.6
Summary of Calculation – Substructure – A Group-1

Calculation Result

Group	Group name		A Group-1					
	Contents		P6, P23					
	Design Model		**P6**					
Structure Components			Column		Footing		----	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		----	
Steel Materials			SD345		SD345		----	
Location of Components (Axis*transverse*Height)			3.0m*7.8m*20.1m		10.0m*11.0m*2.5m		----	
Direction			Axis	Transverse	Axis	Transverse	----	----
Critical Loading Time			Temperature	Normal	Temperature	----	----	----
Section Force	M	ton *m	4326	3264	3026	----	----	----
	N	ton	3350	3350	----	----	----	----
	S	ton	210	340	1639	----	----	----
Stress	σ c	kg/cm^2	76≤92	26.9≤80	40.9≤92	----	----	----
	σ s	kg/cm^2	1550≤1840	0≤1600	1680≤1840	----	----	----
	τ m	kg/cm^2	0.99≤4.48	1.56≤3.9	5.85≤8.97	----	----	----
Main Steel Bar			D19@125	D19@125	D35@125	----		
Shear Force	Sh	ton	----	----	----	----	----	----
Shear Stress	τ m	kg/cm^2	----	----	----	----	----	----
Stirrup Necessary			----	----	----	----	----	----
Stirrup Area (cm ^{2})			----	----	----	----	----	----
Stirrup			----	----	----	----	----	----
Remarks								

Result of Stability

State of Ground		Case-1		Case-2		Case-3	
		Design Value	Allowable Value	Design Value	Allowable Value	Design Value	Allowable Value
Critical Loading Time	---	Earthquake		Earthquake		Earthquake	
Reversing	m	1.12	3.33	1.43	3.33	1.15	3.33
Sliding	---	7.3	1.2	4.4	1.2	8.5	1.2
Ground Reaction	ton/m^2	68.3	90.0	62.9	90.0	48.7	90.0
Ground bearing Capacity	ton	54143	4795	30108	3728	54345	3172

Case-1: Balanced Earth Pressure Condition (Present Condition)
Case-2: Unbalanced Earth Pressure Condition (Partially Eroded)
Case-3: No. Earth Pressure Condition (Fully Eroded)

Table 3.3.7
Summary of Calculation – Substructure – A Group-2

Calculation Result

Group	Group name		A Group-2					
	Contents		P6, P23					
	Design Model		**P23**					
Structure Components			Column		Footing		----	
Concrete Materials			σck=240 kg/cm^2		σck=240 kg/cm^2		----	
Steel Materials			SD345		SD345		----	
Locations of components (Axis*transverse*Height)			2.9m*7.6m*15.9m		8.0m*11.0m*2.5m		----	
Direction			Axis	Transverse	Axis	Transverse	----	----
Critical Loading Time			Temperature	Normal	Temperature	----	----	----
Section Force	M	ton *m	3444	3264	2078	----	----	----
	N	ton	3114	3114	----	----	----	----
	S	ton	210	340	1529	----	----	----
Stress	σc	kg/cm^2	$67.0 \leq 92$	$29.4 \leq 80$	$32.8 \leq 92$	----	----	----
	σs	kg/cm^2	$1036 \leq 1840$	$0 \leq 1600$	$1692 \leq 1840$	----	----	----
	τm	kg/cm^2	$1.11 \leq 4.48$	$1.74 \leq 3.9$	$5.92 \leq 8.97$	----	----	----
Main Steel Bar			D19@125	D19@125	D29@125	----		
Shear Force	Sh	ton	----	----	----	----	----	----
Shear Stress	τm	kg/cm^2	----	----	----	----	----	----
Stirrup Necessary			----	----	----	----	----	----
Stirrup Area (cm^2)			----	----	----	----	----	----
Stirrup			----	----	----	----	----	----
Minimum Rebar Area (cm^2)			313.8	----	316.7	----	----	----

Result of Stability

State of Ground		Case-1		Case-2		Case-3	
		Design Value	Allowable Value	Design Value	Allowable Value	Design Value	Allowable Value
Critical Loading Time	---	Earthquake		Earthquake		Earthquake	
Reversing	m	0.95	2.67	1.24	2.67	0.97	2.67
Sliding	---	7.87	1.2	4.42	1.2	8.77	1.2
Ground Reaction	ton/m^2	71.1	90.0	64.6	90.0	59.8	90.0
Ground bearing Capacity	ton	26658	4674	20884	3443	26475	3354

Case-1: Balanced Earth Pressure Condition (Present Condition)
Case-2: Unbalanced Earth Pressure Condition (Partially Eroded)
Case-3: No. Earth Pressure Condition (Fully Eroded)

Table 3.3.8
Summary of Calculation – Substructure – B Group

Calculation Result

Group	Group name		B Group					
	Contents		P13, P14, P15, P16					
	Design Model		**P14**					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Location of Components (Axis*transverse*Height)			3.1m*7.9m*21.5		9.0m*12.0m*3.0m		ϕ2.0m,l=13.0m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Temperature	Normal	Temperature	----	Temperature	Normal
Section Force	M	ton*m	5805	3306	2953	----	6620	4280
	N	ton	4032	4032	----	----	4910	4370
	S	ton	270	348	----	----	270	355
Stress	σ c	kg/cm^2	89.2≤92	29.7≤80	29.4≤92	----	88.6≤92	79.5≤80
	σ s	kg/cm^2	1698≤1840	0≤1600	1528≤1840	----	1315≤1840	1158≤1600
	τ m	kg/cm^2	1.27≤5.85	1.59≤3.90	0.42≤4.48	----	4.87≥4.48	4.51≥3.90
Main Steel Bar			D29@125	D296@125	D32@125	----	D38@125*1.0	
Shear Force	Sh	ton	----	----	----	----	59.2	
Shear Stress	τ m	kg/cm^2	----	----	----	----	4.87	
Stirrup Necessary			----	----	----	----	Necessary	
Stirrup Area (cm^2)			----	----	----	----	0.93	
Stirrup			----	----	----	----	D19	
Minimum Rebar Area (cm^2)			406.3	----	351.6	----	125.7	----

Result of Stability

Direction	Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time		Temperature	Normal
PN max	ton	1181	1031
PN min	ton	455	424
Ra	ton	1211	1211
Pa	ton	-166	-166
δ x	cm	1.45	0.96
δ xa	cm	2.00	2.00

Table 3.3.9
Summary of Calculation – Substructure – C Group

Calculation Result

Group	Group name		C Group					
	Contents		P10, P12, P17, P18					
	Design Model		**P17**					
Structure Components			----		Pile Cap		Pile	
Concrete Materials			----		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			----		SD345		SD345	
Location of Components (Axis*transverse*Height)			----		9.0m*12.0m*3.0m		ϕ2.0m,l=13.0m	
Direction			----	----	Axis	Transverse	Axis	Transverse
Critical Loading Time			----	----	Normal	----	Earthquake	Earthquake
Section Force	M	ton *m	----	----	6354	----	15100	6600
	N	ton	----	----	----	----	5200	5200
	S	ton	----	----	----	----	930	320
Stress	σ c	kg/cm^2	----	----	31.4≤92	----	119.8≤120	48.8≤120
	σ s	kg/cm^2	----	----	1426≤1600	----	2681≤3000	660≤3000
	τ m	kg/cm^2	----	----	0.42≤4.48	----	8.64≥5.85	3.25≤5.85
Main Steel Bar			----	----	D32@125	----	D38@125*1.5	
Shear Force	Sh	ton	----	----	----	----	93.0	
Shear Stress	τ m	kg/cm^2	----	----	----	----	8.64	
Stirrup Necessary			----	----	----	----	Necessary	
Stirrup Area (cm^2)			----	----	----	----	3.16	
Stirrup			----	----	----	----	D19	
Minimum Rebar Area (cm^2)			----	----	548.4	----	125.7	----

Result of Stability

Direction	Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time		Earthquake	Earthquake
PN max	ton	1096	756
PN min	ton	-56.8	283
Ra	ton	1829	1829
Pa	ton	-267	-276
δ x	cm	1.98	0.61
δ xa	cm	2.00	2.00

Table 3.3.10
Summary of Calculation – Substructure – D Group

Calculation Result

Group	Group name		D Group					
	Contents		P11, P18					
	Design Model		**P18**					
Structure Components			----		Pile Cap		Pile	
Concrete Materials			----		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			----		SD345		SD345	
Location of Components (Axis*transverse*Height)			----		11.0m*16.0m*3.5m		ϕ2.0m,l=13.2m	
Direction			----	----	Axis	Transverse	Axis	Transverse
Critical Loading Time			----	----	Normal	----	Earthquake	Earthquake
Section Force	M	ton *m	----	----	8200	----	14500	15300
	N	ton	----	----	----	----	8800	8800
	S	ton	----	----	----	----	1010	528
Stress	σ c	kg/cm^2	----	----	37.7≤80	----	117.3≤120	73.2≤120
	σ s	kg/cm^2	----	----	1540≤1600	----	1978≤3000	1006≤3000
	τ m	kg/cm^2	----	----	0.45≤3.90	----	8.24≥5.85	4.46≤5.85
Main Steel Bar			----	----	D35@125*1.5	----	D38@125*1.5	
Shear Force	Sh	ton	----	----	----	----	101.0	
Shear Stress	τ m	kg/cm^2	----	----	----	----	8.24	
Stirrup Necessary			----	----	----	----	Necessary	
Stirrup Area (cm^2)			----	----	----	----	3.68	
Stirrup			----	----	----	----	D19	
Minimum Rebar Area (cm^2)			----	----	548.4	----	125.7	----

Result of Stability

Direction	Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time		Earthquake	Earthquake
PN max	ton	1423	1371
PN min	ton	336	388
Ra	ton	1834	1834
Pa	ton	-271	-271
δ x	cm	1.80	0.96
δ xa	cm	2.00	2.00

Table 3.3.11
Summary of Calculation – Substructure – E Group

Calculation Result

Group	Group name		E Group					
	Contents		P7, P8, P9, P20, P21, P22					
	Design Model		**P20**					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Location of Components (Axis*transverse*Height)			3.0m*7.7m*18.7m		9.0m*12.0m*3.0m		ϕ2.0m,l=13.0m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Temperature	Normal	Temperature	----	Temperature	Normal
Section Force	M	ton *m	4301	3304	2606	----	5000	4210
	N	ton	3455	3455	----	----	4340	4010
	S	ton	230	347	----	----	230	245
Stress	σ c	kg/cm^2	81.9≤92	29.6≤80	28.1≤92	----	71.0≤92	77.6≤80
	σ s	kg/cm^2	1620≤1840	0≤1600	1642≤1840	----	1160≤1840	1312≤1600
	τ m	kg/cm^2	1.15≤4.48	1.69≤3.90	0.39≤4.48	----	3.86≤4.48	4.45≥3.90
Main Steel Bar			D19@125	D19@125	D29@125	----	D38@125*1.0	
Shear Force	Sh	ton	----	----	----	----	58.4	
Shear Stress	τ m	kg/cm^2	----	----	----	----	4.45	
Stirrup Necessary			----	----	----	----	Necessary	
Stirrup Area (cm^2)			----	----	----	----	0.87	
Stirrup			----	----	----	----	D19	
Minimum Rebar Area (cm^2)			348.1	----	351.6	----	125.7	----

Result of Stability

Direction	Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time		Temperature	Normal
PN max	ton	1003	937
PN min	ton	442	332
Ra	ton	1211	1211
Pa	ton	-166	-166
δ x	cm	1.14	0.95
δ xa	cm	2.00	2.00

3.4 RIVERBANK PROTECTION

3.4.1 Riverbank Erosion

The Mekong River is basically straight for 3 or 4 km both upstream and downstream of the bridge centerline. There are, however, minor riverbank intrusions into the river which are liable to scouring during flood times.

From the Mekong River survey map of 1960 (Scale 1/20,000) very little change in the river alignment has been observed over the past 40 years. It is considered that a meandering phenomenon in this section of the river is not likely to occur in the future. However, riverbank erosion at localized areas has occurred.

3.4.2 Necessity for Protection of Riverbank

a) As previously stated, the ground of the riverbank consists of sand, silt and clay. The characteristic of the clay is solid during the dry season but, soft and rather viscous during the wet season. The clay surface is, therefore, easy to become eroded and washed away during flooding.

   The loose to medium sand lies on a lower flatter riverbank area and is also liable to erosion due to its lack of cohesion. However, topography of the riverbank in the area of sand layers helps prevent this erosion to a major extent.

b) The slope of the riverbank is basically divided into two parts. The lower part has a slope of 1:3 to 1:4 and consists of loose soil and sand which is covered by plants and vegetation and helps protect the erosion.

   The upper part of the riverbank is steep and more unstable as it can be easily scoured by fluctuation of water level, river craft wave surges and storm water runoff.

   The upper riverbank will gradually slide down to the lower part. This type of erosion will repeat over and over again especially during flooding periods.

   The enclosed sketch below shows erosion mechanism.

c) According to interviewing with local inhabitants (both in the Lao PDR and Thailand) at the Basic Design stage, it was confirmed that at least 10m of the riverbank has been eroded during the past 50 years.

d) It is quite evident from observations along the riverside that where there are temples and important places to protect from possible erosion, revetment has been constructed.

e) For the pier in the riverbank (P23 of the Lao PDR Side and P6 of Thailand Side), revetment is also necessary for scour and erosion protection.

f) The existing riverbank soil will be loosened from pier construction (excavation, piling etc.). Therefore, it is easier for the riverbank to be eroded.

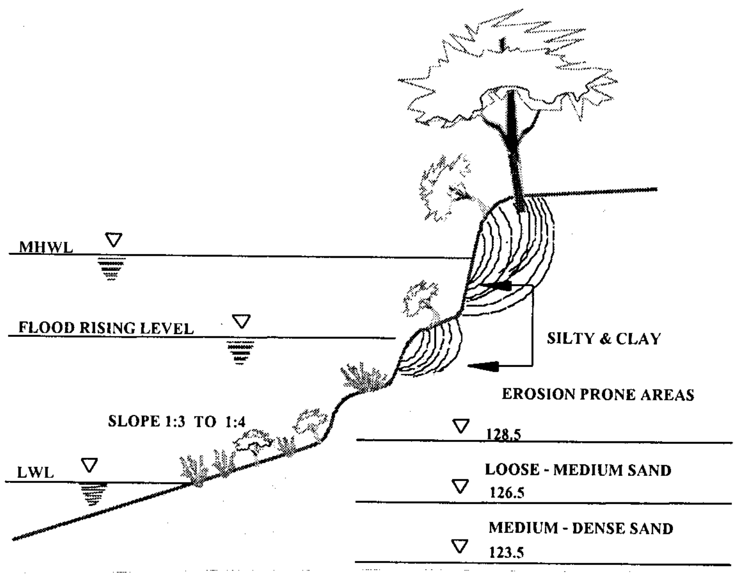


Figure 3.4.1
Riverbank Profile – Thailand Side

g) For the pier in the river closest to the riverbank, there will be scour around the pier piles. This scour depth will affect the foot of the riverbank under the water. The flow direction at this pier may also affect erosion of the riverbank.

h) The parameters presented in the table in Section 3.4.3 and used in the design of the revetment clearly indicate low cohesion and low angles of internal friction in the undrained condition for the clay deposits. This indicates the probability of erosion as comparatively high and that revetment is necessary.

3.4.3 Design of Protection

a) A typical cross-section of the revetment is shown in Figure 3.4.2. A 3.0m wide berm is designed at the middle of LWL and HWL for stability and for ease of construction and maintenance works. Below the berm to LWL of EL 126.75, a revetment slope of 1:2.5 is used. Below the LWL, the natural slope of the riverbank is used up to the end of the revetment mattress.

If scour does occur, the gabion mattress would be able to protect the natural bank slope to an assumed scour depth at the rock bed. Above the berm to HWL, a revetment slope of 1:2.0 is used.

It is expected that the gabion mattress at the lower section of the riverbank will be placed under water using a floating crane launching system.

b) Riverbank stability calculation is not very essential, but it is used for reconfirmation only of the design. The riverbank stability was analyzed by using the soil design parameters below and the computer program of FORUM 8 in Japan.

Table 3.4.1
The Soil Design Parameters

Depth (m)		Material	g t/m^3	Cu (t/m^2)		Angle of internal friction f	
Thai-land	The Lao PDR			UD	D	UD	D
0~10	0~6	Stiff to hard clay	2.0	T - 8 L - 10	0.5 0.5	0°	32°
10~12	6~11	Median stiff sandy clay	2.0	5	0.5	0°	32°
12~14		Loose to medium dense sand	1.8	0		30°	
14~15		Medium to dense sand	1.9	0		33°	

Comment: UD = Undrained, D = Drained

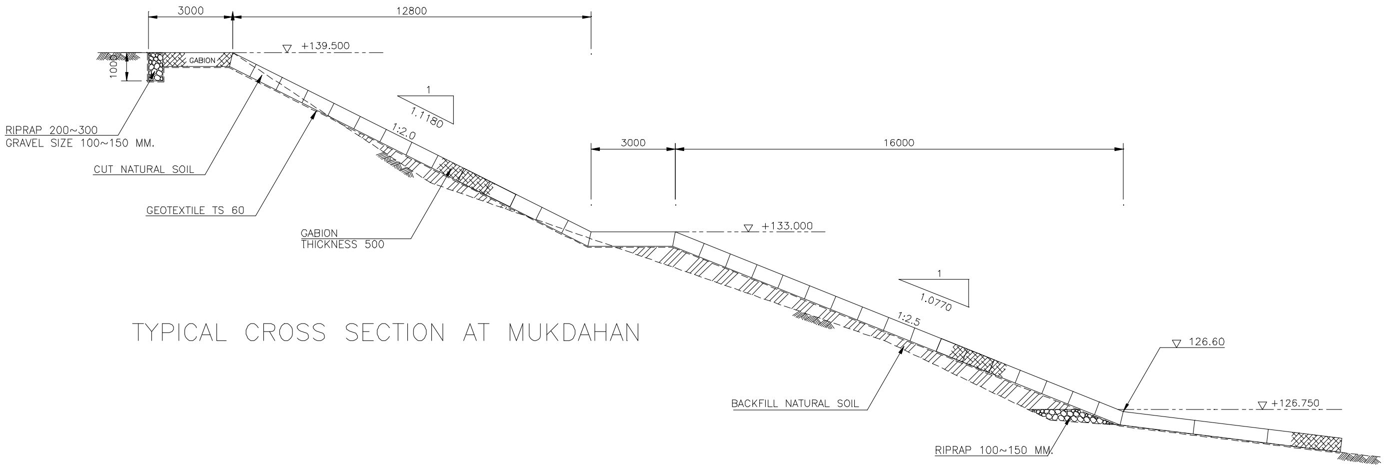


Figure 3.4.2 Typical Section for Revetment

The bank slopes have a minimum factor of safety as follows.

Table 3.4.2
Minimum Factor of Safety

	Water Level	Savannakhet	Mukdahan	Note
Existing slope	LWL (126.75m)	1.25	1.35	Surcharge = $1t/m^2$
	HWL (139.00m)	1.48	1.78	Surcharge = 0
Proposed slope	LWL (126.75m)	1.90	1.79	Surcharge = $1t/m^2$
	HWL (139.00m)	1.98	1.81	Surcharge = 0

The existing bank slopes have a minimum factor of safety of 1.25 at Savannakhet and 1.35 at Mukdahan. The proposed slopes have a minimum factor of safety of 1.90 at Savannakhet and 1.79 at Mukdahan. Both banks are consequently safe.

c) Geotextile type for Filter

Type of Geotextile used is Polyfelt TS60 or equivalent.

d) Extent of Protection

The riverbank protection is provided for at a distance of 50m upstream and 50m downstream of the bridge centerline. The total length is 100m and the end edges will be covered with riprap. The length of the protection is the minimum length prescribed by the Japanese River Regulations.

3.4.4 Incidentals

a) Water Flow Velocity

The flow velocity measurement at the bridge location on the Mekong River was carried out on 1st and 2nd of September 1999.
The water levels of those days were EL133.4m ~ EL133.6m which is around 3m lower than the average HWL of the same period.
The three measurements at traversal location i.e. (a) the centerline of the Bridge, (b) upstream 100m of the Bridge, (c) downstream 100m of the Bridge centerline, were conducted in 10 positions each.
Shown below is the maximum velocity, the second maximum velocity and the minimum velocity of each line and the location.

Table 3.4.3
Maximum, Minimum Velocity and Locations

Line	Max. Velocity		Second M.V.		Min. Velocity		Note
	Location	Velocity	Location	Velocity	Location	Velocity	
U-Line	L1	1.94	L2	1.88	L10	1.45	Max. Measured Depth = 0.2H
C-Line	C3	1.9	C6	1.9	C7	1.58	-ditto-
D-Line	R2	2.07	R5	1.86	R10	1.49	-ditto-

Note : Location L1 is 40m from the riverbank of the Mukdahan side and continuous L2, L3 are at 150m spacing. L10 is the last survey location.
L10 is located 45m from the Savannakhet side of the riverbank.

From the above table the highest velocity occurs at the right bank side (Mukdahan) and the lowest velocity at the left bank side (Savannakhet). On the Savannakhet side, the Mekong River has a shallow depth in that area while flow velocity is almost uniform.
The maximum measured velocity is 2.07m/sec. at location R2 in this time but the maximum velocity is recorded as 2.53m/s in September 1998 at the Savannakhet station. This phenomenon should be considered since an increase in velocity will come with a larger inundation in the future as the flood. In contrast, the measured velocity in this year is below average.

b) Protection of Bridge Pier

The scour depth is estimated at 4m ~ 12m from several equations, but the actual scour depth is limited when the river bedrock level is high. It is considered in the design of the bridge piers that as the estimated scour regime of the existing river is only 5m, it is unnecessary to provide protection to the bridge piers.

c) Recommendation

It is difficult to predict long term problems and a careful maintenance plan and measurement cycle needed to be formulated. Therefore, the following is recommended for the Project.

1. Regular measurement (every 2 or 3 years) on the changes in riverbed and riverbank topographies and appropriate analysis.
2. Annual checking of revetment after each rainy season.
3. Proper maintenance of the revetment structures, piers etc.

CHAPTER 4

Detailed Design of Viaduct and Ancillary Works

CHAPTER 4 : DETAILED DESIGN OF VIADUCT AND ANCILLARY WORKS

4.1 GENERAL

This chapter shows the following items.

1) The design conditions, design method and design result of the approach viaduct on the Lao PDR and Thailand sides.
2) The Bridge design results of the ancillary works of the Main Bridge and approach viaducts.

General drawing of Approach Viaduct are shown in Figure 4.1.1

4.1.1 Design General

(1) Applicable design standards
Design standards are same as those of the Main Bridge
(2) Bridge superstructure and construction method
- The Bridge type is a PC continuous box girder bridge.
- The bridge girder height has been constructed at 2.5m, being 1/20 of the viaduct span of 50m. The cross section of girder and pier shape is similar to that of the Main Bridge.
- Fixed support are made in both the Lao PDR and Thailand viaduct sections.
- Construction method of the viaduct is the cast-in-place concrete method.
- The Bridge superstructure will be built on temporary staging.
- Pre-stressing will be via inner cables.

(3) Bridge substructure and construction method
- The pier is the wall type RC structure, while the pile foundation are cast-in-place piles of 1.0m diameter.
- The piled foundation has to be socketed, 1.0m., into the base rock.

4.1.2 Design Flow Chart

The procedure of the design are shown in Figure. 4.1.2.

4.1.3 Method of Structural Analysis

Because the superstructure is a continuous girder, the analysis model is a continuous beam with support. Also, the superstructure (which is a PC member) uses the structure analysis program CONST that is able to consider the influence of concrete creep and prestressing.

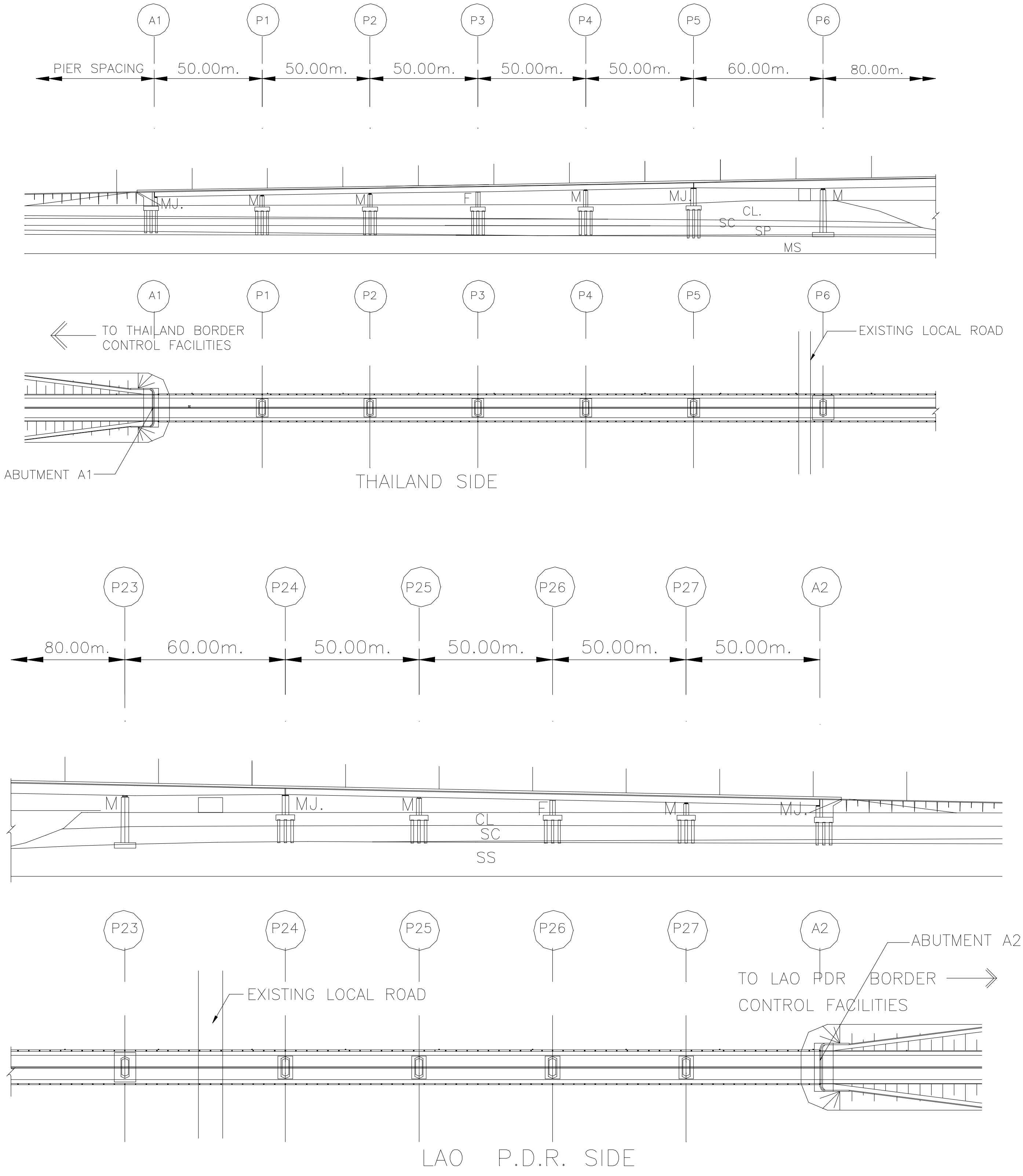


Figure 4.1.1(1/2) General View of Approach Viaduct

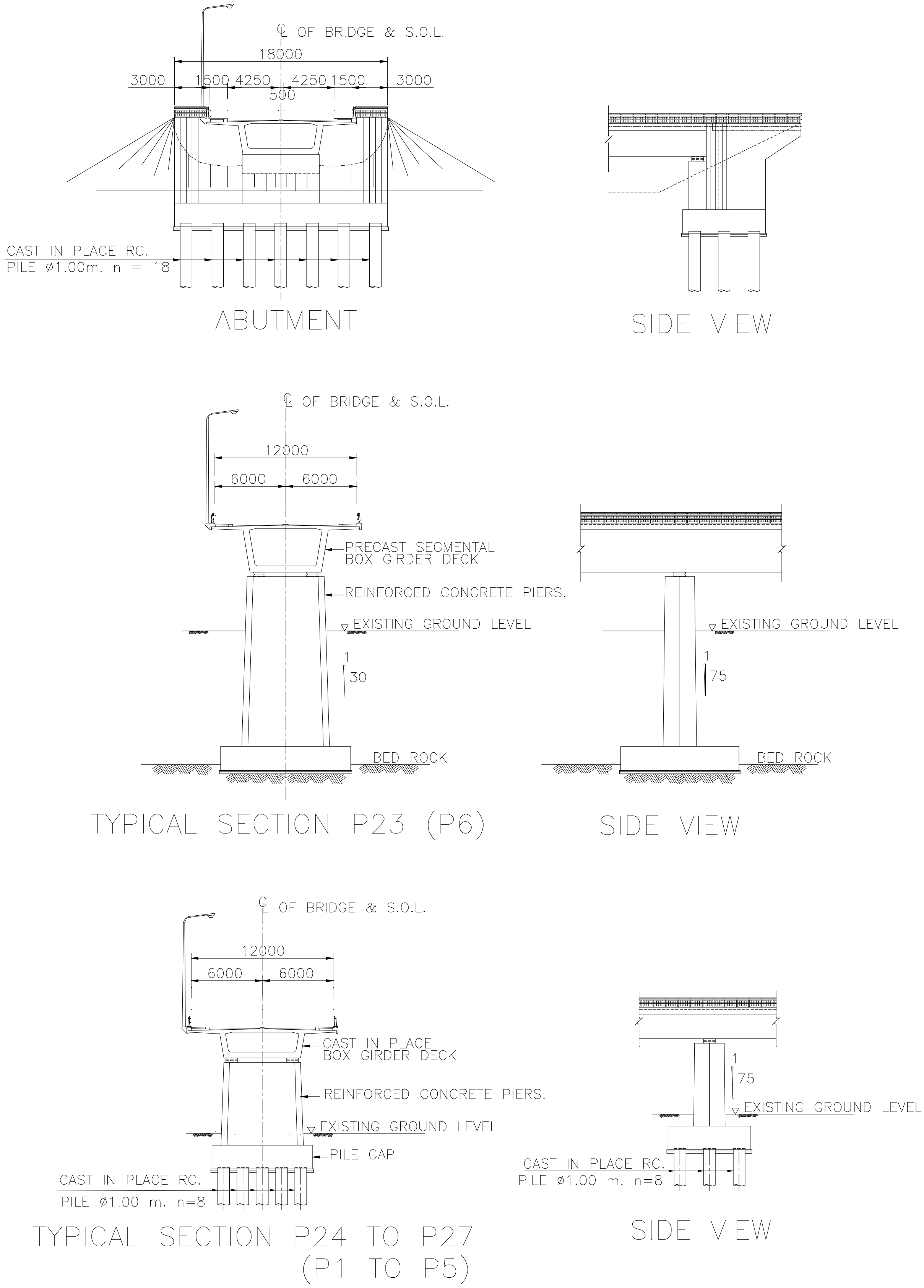


Figure 4.1.1(2/2) General View of Approach Viaduct

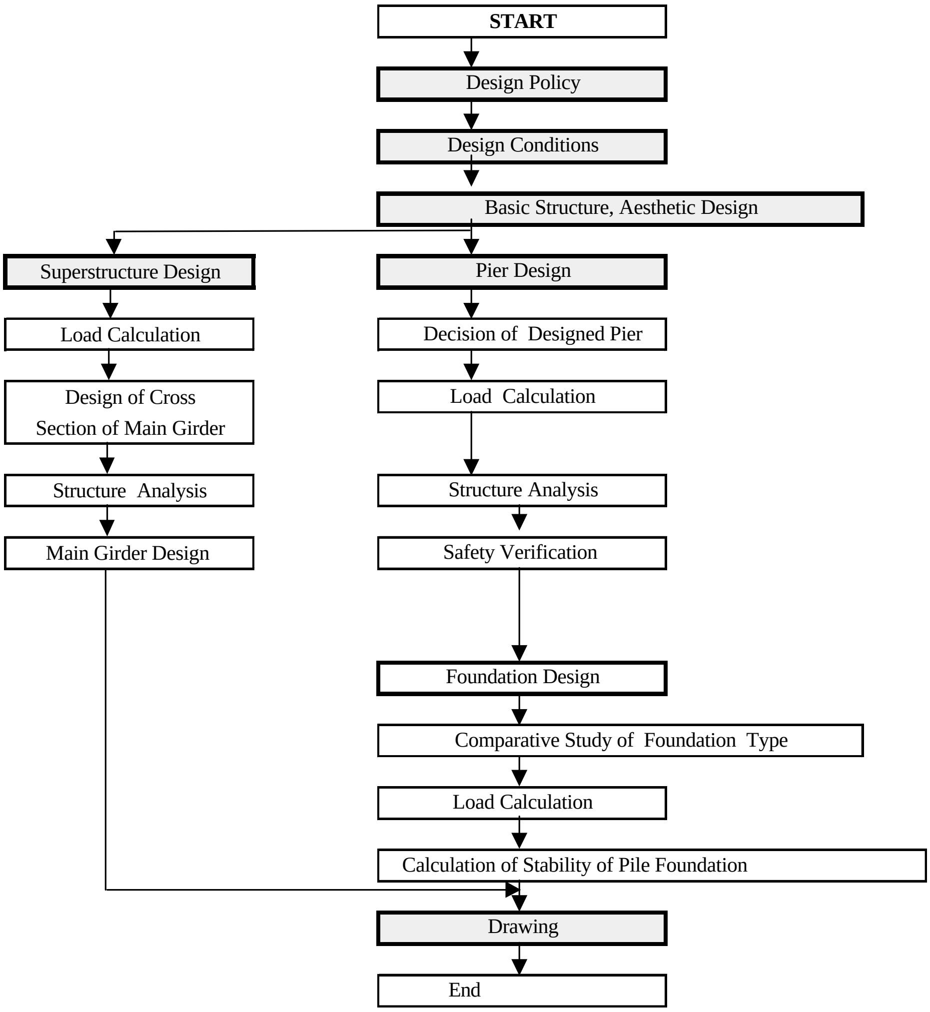


Figure 4.1.2 Design Flow Chart of Approach Viaduct

4.1.4 Design Loads

(1) Basic Load

The basic load is shown in Table 4.1.1.

Table 4.1.1 Basic Load

Basic Load	
Principal Load (P)	(1) Dead load (D) (2) Live load (L) (3) Impact (I) (4) Prestressing force (PS) (5) Effect of creep of concrete (CR) (6) Effect of shrinkage of concrete (SH) (7) Earth pressure (E)
Subsidiary Load (S)	(8) Thermal force (T)
	(9) Earthquake force (EQ)
Particular Load (PA)	(10) Temporary load and force during erection (ER)

(2) Loading Combinations

1) Superstructure

- Loading combination of service load and ultimate load is shown in Table 4.1.2, Table 4.1.3.

Table 4.1.2
Loading Combination of Service Load

Loading Combinations		**Allowable Stress Increse Rate**
Construction Stage	(1) D+ER	1.25
Service Stage	(1) D+PS (after prestressing)	1.00
	(2) D+PS (after prestressing)+L+I	1.00
	(3) D+PS (effective)+CR+SH	1.00
	(4) (3)+L+I	1.00
	(5) (3)+L+I+T	1.15
	(6) (3)+EQ	1.50

Table 4.1.3
Loading Combination of Ultimate Load

Loading Combinations	
Construction Stage	(1) 1.3 x (D+CR)
Service Stage	(1) 1.3 x (D+CR) + 2.5 x (L+I)
	(2) 1.0 x (D+CR) + 2.5 x (L+I)
	(3) 1.7 x (D+CR+L+I)

2) Substructure

Loading combination of service load is shown in Table 4.1.4.

Table 4.1.4
Loading Combination of Service Load

Loading Combinations		**Allowable Stress Increse Rate**
Construction Stage	(1) D+ER	1.25
Service Stage	(1) D	1.00
	(2) D+ (E)*	1.00
	(3) (2)+L	1.00
	(4) (2)+L+T	1.15
	(5) (2)+EQ	1.50

*Comment: consider at the abutment

4.1.5 Design Conditions

Approach viaduct design conditions are shown below.

4.1.5.1 Structural Source

(1) Bridge type	:	the Lao PDR Side - 4 span PC continuous box girder bridge
	:	Thailand Side - 5 span PC continuous box girder bridge
(2) Bridge length,Span	:	the Lao Side 50.0m@4=200.0 m
	:	Thailand Side 50.0m@5=250.0m
(3) Layout of Bridge deck	:	1.5m+4.25m+0.5m+4.25m+1.5m=12.0m
		(15m = Footpath, 4.25m = carriageway)
(4) Erection method	:	Temporary staging and cast-in-place concrete method
(5) Alignment	:	Horizontal Alignment R= ∞
	:	Vertical Alignment 2.0%
	:	Crossfall of the road 2.0%
		Crossfall of the side walk 1.5%
(6) Abutment type	:	RC reverse T-type abutment
(7) Pier type	:	RC wall-type pier
(8) Foundation type	:	ϕ1.0m cast-in-place RC pile foundations
(9) Bearing strata	:	Mudstone or Sandstone
(10) Bearing support	:	Elastomeric laminated bearing
(11) Expansion joints	:	Steel finger joint type
(12) Drainage	:	Steel type drain box
(13) Guardrail	:	Steel type
(14) Lighting pole	:	Steel type

4.1.5.2 Loads

(1) Live load	:	Main Girder DOH standard
		(AASHTO HS20-44×1.30)
	:	Deck slab B-live load by JRA-SHB
	:	Side walk AASHTO
(2) Unit weights		
Reinforced Concrete	:	24.5 kN/m^3
Concrete	:	23 kN/m^3
Prestressed Concrete	:	24.5 kN/m^3
Asphalt pavement	:	22.5 kN/m^3
Steel	:	77 kN/m^3
(3) Bridge deck surfacing		
Asphalt pavement	:	t = 50mm
Guardrail	:	w = 500N/m each side

Electronic cable including future service load = 500N/m each side
(including future service)

(4) Live load

Main Girder DOH standard (AASHTO HS20-44×1.30)

Deck slab B-live load by JRA-SHB standard

Foot path AASHTO

(5) Range of Temperature

Coefficients of thermal expansion 10×10^{-6}/°C

Calculation of statically indeterminate structure T = ±15°C

Temperature difference of Bridge deck ΔT = 5°C

Calculation of the amount of movement at movable bearings

T = 10~40°C

(6) Seismic horizontal load

6.0% of dead load equivalent static horizontal load in any directions

(7) Drying shrinkage and creep of concrete Creep coefficient, ϕ = 2.60

Drying shrinkage, $\varepsilon_s = 20.0\text{x}10^{-5}$

(8) Earth pressure Coulomb earth pressure

4.1.5.3 Materials

(1) Material Properties

1) Concrete

Compressive strengths of concrete by structure items are as follows.

Prestressed concrete structure: σ ck = 40N/mm^2

Pier, footing and abutment : σ ck = 24N/mm^2

Cast-in-place RC pile : σ ck = 30N/mm^2

The specified strength is the compressive strength of concrete cylinders at an age of 28 days.

2) Steel

Reinforcing bar (JIS G3112) :

- SD345, Yield strength σ sy ≥350N/mm^2
- SD390 is used in the drawing since it is equivalent to SD345 in the Lao PDR and Thailand.

Strand cable for prestressing steel (JIS G3109) :

- Main girder 12S15.2(SWPR7BL)
- Deck Slab 4S15.2(SWPR7BL)

(2) Allowable Stresses

Respective material allowable stresses are in the tables below.

Table 4.1.5
Characteristic Value of Concrete

Item	PC box girder	Pier, Abutment	Cast-in-place RC pile
Specified compressive strength of concrete σck (N/mm^2)	40	24	30
At prestressing σci (N/mm^2)	30	-	-
Young's modulus Ec (N/mm^2)	3.1×10^4	2.65×10^4	2.8×10^4
Shear modulus Gc (N/mm^2)	1.5×10^4	1.15×10^4	1.2×10^4
Coefficient of linear expansion α (1/deg)	10x10^{-6}	10x10^{-6}	10x10^{-6}
Concrete shrinkage εs	15x10^{-5}	-	-

Table 4.1.6
Characteristic Value of Reinforcing Bar (JIS G3112)

Item	SD 345
Yield strength σ sy (N/mm^2)	350
Young's modulus Es (N/mm^2)	210

Table 4.1.7
Characteristic Value of Prestressing Steel Strand (JIS G 3109)

Item	Main Girder Deck Slab SWPR 7BL, 15.2mm
Tensile strength σ pu (kN) Yield strength σ py (kN) Young's modulus Ep (kN/mm^2) Relaxation rate (%) : Low relaxation PC Steel	≥ 222 ≥ 261 200 ≤ 2.5
Cross section area Ap (mm^2)	138.7

Table 4.1.8
Allowable Stress of Prestressed Concrete

Item		s ck=40 (N/mm^2)[kg/cm^2]
Allowable flexural extreme compressive fiber stress	After prestressing rectangular box section	19 [190]
	Design load state rectangular box section	15 [150]
Allowable flexural extreme Tensile fiber stress	After prestressing	1.5 [15]
	Design load state	0 [0]
	Deck slab	0 [0]
	Other members	1.5 [15]
Allowable shear stress		0.55 (5.5)
Allowable diagonal tensile stress	Consideration of shear force only	*(1.9) [19]
Upper limit of mean shear stress	Consideration of shear force only	5.3 [53]

Comment :*(1.9) - depends on Japan PC Technical Association; JSCE : Railway structural design specifications.
Because the design result of 4.2 and 4.3 clauses is expressed with the kg-unit, the value in the kg/cm^2 unit is shown in [ ].

Table 4.1.9
Allowable Stress of Reinforced Concrete

Item	s ck=24 (N/mm^2) [kg/cm^2]
Extreme flexural compressive fiber stress	8.0 [80]
Axial compressive stress	6.5 [65]
Allowable mean shear stress	0.39 [3.9]
Upper limit of mean shear stress	3.2 [32]

Comment :Value in [ ] is in kg/cm^2 unit.

Table 4.1.10
Allowable Stress of Reinforing Bar (JIS G 3112)

Allowable tensile stress	SD345 (N/mm^2) [kg/cm^2]
For loading combinations excluding collision force or earthquake force	
(1) For ordinary members	180 [1800]
(2) For deck slab	140 [1400]
(3) For member in water or below ground-water level	160 [1600]
(4) Basic value of allowable stress for loading combinations including earthquake force	200 [2000]
Compressive Stress	200 [2000]

Comment :Value in [ ] is in kg/cm^2 unit.

Table 4.1.11
Allowable Stress of PC Steel (JIS G 3109)

Item	Main Girder, Deck Slab SWPR 7BL 15.2mm (N/mm^2) [kg/cm^2]
When prestressing force is initially given	1440 [144]
Immediately after prestressing	1295 [133]
Others	1110 [114]

Comment : Value in [ ] is in kg/cm^2-unit.

4.2 APPROACH VIADUCT IN THE LAO PDR

4.2.1 General

The design results of the superstructure, piers and pile foundation on the Lao PDR side are shown. Design calculations depend on the JRA-SHB specifications.

4.2.2 Superstructure

4.2.2.1 Design of Girder Transverse Cross Section

A main girder cross section is composed of a deck slab with cantilevered parts, two webs and a lower slab. Transverse cross sectional force was analyzed as a box rigid frame structure that was supported at the web lower corners.

The web and lower slab member were considered as RC structure when the deck slab is fully prestressed.

(1) Calculation of Load and Cross Sectional Force

The following loads were considered.
- Dead load
- Bridge surface load : Pavement, Curb, Guardrail
- Live load : B-Load
- Prestressing force : After prestressing, Effective prestress
- Secondary prestress force : After prestressing, Effective prestress
- Temperature difference : Deck slab temperature + 5°C

(2) Calculation of Prestressing Force

Transverse prestressing cable is arranged at 62.5cm intervals by using 4S15.2 (SWPR7BL). Prestress σpi of PC cable is 1,295 N/mm^2. The PC cable is tensioned from one side, but alternating the side due to an anchorage wedge "draw in" effect.

(3) Calculation of Deck Slab, Web and Lower Slab

The design section has a standard web thickness of 40cm. Position of stress checking is shown in Figure 3.2.1. The result of the stress check is shown in Table 4.2.1~4.2.3.

The design condition and drawings are expressed with SI-unit (N), because this Bridge is an international bridge while the results of design calculations are expressed with kg/ton-unit to conform with the actual state of the Lao PDR and Thailand.

Since the design result has to be evaluated against the allowable stress the results are expressed in both N-unit and kg-unit.

Table 4.2.1

Bridge Transverse Composite Stress of Deck Slab (Kg/cm^2)

Design		(1)		(2)		(3)	
		Upper	Lower	Upper	Lower	Upper	Lower
1. Prestressing stress after prestressing		45.7	-3.5	43.6	-2.0	-11.4	63.1
2. Secondary stress after prestressing		0.0	0.0	2.7	-2.7	4.1	-4.1
3. Reduction stress of prestressing		-5.2	0.4	-5.0	0.2	1.5	-8.2
4. Reduction stress of secondary force		0.0	0.0	-0.3	0.3	-0.5	0.5
5. Dead-load		-7.6	7.6	-9.5	9.5	6.8	-6.8
6. Deck surface load		-6.2	6.2	-3.2	3.2	1.4	-1.4
7. T-load	Max.	0.0	16.3	-26.0	26.0	0.0	0.0
	Min.	-16.3	0.0	2.1	-2.1	0.0	0.0
8. Sidewalk load	Max.	0.0	0.0	2.1	-2.1	0.0	0.0
	Min.	-3.8	3.8	-2.1	2.7	-0.9	0.9
9. Temperature difference		0.0	0.0	-0.9	0.9	-1.4	1.4
10. After prestressing		38.1	4.1	36.7	4.8	-0.5	52.2
11. Dead load state		26.7	10.7	28.2	8.6	1.9	43.1
12. Design load state	Max.	26.7	10.7	30.4	6.4	41.6	3.4
	Min.	10.4	27.0	2.2	34.6	1.9	43.1
13. Design load state + Sidewalk load	Max.	26.7	10.7	32.5	4.3	41.6	3.4
	Min.	6.6	30.8	-0.6	37.4	1.0	44.0
14. Design load state + Temperature difference	Max.	26.7	10.7	29.5	7.3	40.2	4.8
	Min.	10.4	27.0	1.3	35.6	0.5	44.5
Design load state + Sidewalk load + Temperature difference	Max.	26.7	10.7	31.6	5.2	40.2	4.8
	Min.	6.6	30.8	-1.5	38.3	-0.4	45.4

Comment : (1), (2), (3) are stress check points of Figure 3.2.1.

Table 4.2.2
Bridge Axis Bending Stress of Deck Slab

Design Section		Cantilever Part	Middle Part of Fixed Slab
Member thickness	(m)	0.406	0.385
Bending moment	(tm)	2.275	6.539
Reinforcement	(cm^2/m)	5.075	15.471
Concrete stress	(kg/cm^2)	19.6	40.0
Rebar stress	(kg/cm^2)	1305.1	1364.0

Table 4.2.3
Bridge Transverse Composite Stress of Web and Lower Slab

Design Section		(4)	(5)	(6)	(7)
Reinforcement	(cm^2/m)	23.628	5.390	8.128	5.931
Dead load state					
Concrete stress	(kg/cm^2)	3.6	14.8	22.8	21.4
Rebar stress	(kg/cm^2)	96.3	934.8	848.8	955.2
Live load state					
Concrete stress	(kg/cm^2)	66.6	21.2	46.9	22.1
Rebar stress	(kg/cm^2)	1788.6	1335.7	1742.0	985.5
Temperature difference state					
Concrete stress	(kg/cm^2)	68.0	21.6	48.7	20.0
Rebar stress	(kg/cm^2)	1827.7	1363.7	1811.0	892.1

Comment : (4), (5), (6), (7) are design sections of Figure 3.2.1.

4.2.2.2 Design of Main Girder

The main girder was analyzed as a continuous beam with one fixed point support.

(1) Effective cross section of main girder
All members of cross section are considered against bending moment, shearing force and axial force.
(2) Calculation of load and main girder cross section force
The design load that is shown in Table 4.1.2 and 4.1.3 was considered.
(3) Calculation of prestressing force
Prestressing steel was arranged by using 12S15.2 (SWPR7BL).
(4) Calculation of cross-sectional force and stress of girder.
Calculation of cross-sectional force and checking of stress were carried out by using the structural analysis program CONST.

Bending stress, shearing stress and safety factor of ultimate failure are shown in Table 4.2.4 and 4.2.5.

Table 4.2.4
Bending Stress Safety Factor at Ultimate Bending Failure

Design Section		Bending Stress (kg/cm²)						Ultimate Bending Moment (tm)		
		Dead load state		D+L(+)		D+L(-)				
		Upper	Lower	Upper	Lower	Upper	Lower	Bending Moment M	Resisting Moment Mu	Safety Factor Mu/M
P24	**1**	7.3	20.3	7.3	20.3	7.3	20.3	-	-	-
	10	56.6	29.3	72.8	0.9	52.4	36.8	10012	12472	1.2
P25	**19**	16.0	52.2	18.2	49.4	1.9	70.4	-9667	-11388	1.2
	28	41.7	32.6	55.1	9.3	35.7	43.0	7028	11151	1.6
P26	**37**	25.3	32.6	29.4	27.4	12.4	49.3	-7219	-10134	1.4
	47	45.9	26.7	59.9	2.3	40.8	35.7	8585	11151	1.3
P27	**56**	14.8	54.0	17.0	51.2	0.6	72.3	-10021	-11390	1.1
	65	57.0	28.2	73.2	-0.1	52.7	35.6	9994	12478	1.2
A2	**74**	7.4	19.9	7.4	19.9	7.4	19.9	-	-	-

Table 4.2.5
Shear Stress and Safety Factor at Ultimate Shear Failure

Design Section	Diagonal Tensile Stress						Mean Shear Stress	
	s max (kg/cm²)			s min (kg/cm²)			Design load state	Ultimate load state
	2-2	G-G	3-3	2-2	G-G	3-3	(kg/cm²)	(kg/cm²)
3	-9.9	-11.0	-9.6	-6.2	-6.7	-5.6	15.5	33.5
17	-12.0	-12.2	-9.4	-18.5	-17.0	-12.0	27.3	45.8
21	-16.7	-15.1	-10.5	-10.1	-10.1	-7.6	25.5	41.9
35	-8.4	-10.0	-9.3	-14.7	-15.2	-12.2	24.5	38.8
58	-14.5	-15.1	-12.1	-8.3	-9.9	-9.2	24.4	38.1
72	-10.4	-10.2	-7.5	-17.1	-15.3	-10.4	25.7	42.6
58	-18.8	-17.2	-12.0	-12.3	-12.3	-9.3	27.7	46.2
72	-6.2	-6.8	-5.9	-9.9	-11.1	-9.9	15.6	34.4

Comment : 2-2, G-G, 3-3 are position of stress checking of Figure 3.2.1

4.2.3 Pier Foundation and Abutment (the Lao PDR)

4.2.3.1 General

(1) Substructure Arrangement

The approach viaduct on the Lao PDR side consists of 4 spans @ 50 m of PC continuous box girder bridge supported by the following substructure arrangements.

a) Pier 24 - A reinforced concrete wall type pier with a pile cap supported by 8 of ϕ1.0 m bored piles. The superstructure is free to move in the bridge axis direction at this pier.

b) Pier 25 - A reinforced concrete wall type pier with pile cap supported by 8 of ϕ1.0 m bored piles. The superstructure is free to move in the bridge axis direction at this pier.

c) Pier 26 - A reinforced concrete wall type pier with a pile cap supported by 9 of ϕ1.0 m bored piles. The superstructure is fixed at the top of this pier, but superstructure rotation is able to take place at this pier.

d) Pier 27 - Same conditions as Pier 25

e) Abutment A2 - A reinforced concrete reverse T-type abutment supported by 18 of ϕ1.0 m bored piles. The superstructure is free to move in the bridge axis direction at this abutment.

(2) Design Grouping

Design calculations of pile foundations are divided into 4 groups as shown in Table 4.2.6 since similarity in reaction forces of superstructure and support conditions are taken into consideration. Next, design was conducted using the 4 typical models.

Table 4.2.6
Design Grouping of Pier and Abutment

Groups	Contents	Design Model	Remark
A	A1, **A2**	A2	Abutment
B	P1, P2, P4, **P25,** P27	P25	Movable Pier
C	P3, **P26**	P26	Fixed Pier
D	P5, **P24**	P24	Transition Pier (Main and Approach Bridge)

(3) Design Load

The design reaction of superstructure is shown in Table 4.2.7. Horizontal load is based on JRA-SHB standards. Since horizontal seismic factor, kh=0.06, is less than the friction factor of the support, fs=0.10, selection of horizontal loads on the bridge axis direction of the fixed pier and the movable piers are made as follows :

Table 4.2.7
Design Load by Superstructure

Substructure No		A2	P27	P26	P25	P24	Total Weight
Bearing Condition		Move	Move	Fix	Move	Move	
Vertical Load	Dead Load (ton)	560	1,290	1,200	1,300	1,090	4,900
	Live Load (ton)	130	250	250	250	200	
Horizontal Load (Axis)	Temperature Load (ton)	56	129	0	130	109	
	Earthquake Load (ton)	34	77	366	78	65	
Horizontal Load (Transverse)	Earthquake Load (ton)	34	77	72	78	65	

Comment : The acting position of the design load is the pier upper end.

(4) Foundations P24, P25, P26, P27

The 4 land based boreholes carried out during the Basic Design phase of the Project (BM1 and BM2 on the Mukdahan side and BS1 and BS2 on the Savannakhet side) show layers of silty clay and silty sand up to base rock level and the SPT readings in BM1 and BS1 in these layers are considerable at only 5 to 6 meters below the ground surface.

A review of the Basic Design with 0.4 m x 0.4 m prestressed precast piles indicated for both the approach viaduct piers and abutments shows that these piles may not be able to be driven through such stiff stratum. The study team has then further reviewed at the start of the Detailed Design phase with higher quality ϕ 0.60 prestressed spun concrete piles to JIS standards and has carried out the design of the piled foundations based on ϕ1.0m cast-in-place piles socketed 1 meter into the bedrock.

In the Contract documents, options of ϕ1.0 m bored cast-in-place piles and ϕ0.60 prestressed precast spun piles will be made available. The Contractors will be instructed to carry out further borehole tests to confirm on pile option it considers the most appropriate based on the borehole results.

(5) Footings (Pile Caps) P24, P25, P26, P27

Footings are of standard rectangular shape of 7m x 8.5 m x 2 meter thick with the footing top located at 1 m below the existing ground surface. Pile concrete is extended into the footing base at a minimum of 100 mm.

(6) Abutment A2

The abutment A2 is of the reverse T-type supported on ϕ1.0 m bored piles. The abutment has wing walls for the support of road embankment. Allowance is also made for a bridge approach slab to key into the back wall of the abutment. A front plinth of the abutment supports the superstructure on two proprietry bearings to take longitudinal movement. Tables are enclosed below showing the full design philosophy and the strength of materials to be used in the construction.

(7) Piers P24, P25, P26, P27

All piers are standard wall type piers with small tapers both on the longitudinal and transversal axes. The edges of the piers are beveled at 22° to keep the same shape and geometry as the river based piers.

4.2.3.2 Result of Stress Calculation of Pier, Pile and Pile Cap

Result of stress calculation of pier, pile and pile cap are shown in Table 4.2.8.1 and Table 4.2.8.2.

Table 4.2.8.1
Member Stress Result of Abutment A2

Group		Group name	A Group						
		Contents	A1, A2						
		Design Model	A2						
Structure Components			Parapet	Column	Pile Cap		Pile	Wings	
Concrete Materials			σ ck=240 kg/cm²	σ ck=240 kg/cm²	σ ck=240 kg/cm²		σ ck=240 kg/cm²	σ ck=240 kg/cm²	
Rebar Materials			SD345	SD345	SD345		SD345	SD345	
Locations of Parts (Axis*transverse*Height)			1.0m*18.0m*2.9m	2.5(1.0)m*6.5(18.0)m*4.1m	7.0m*18.0m*2.0m		ϕ1.0m,l=12.5m, 18nos	***	
Design Section			Back Side	Back Side	Front Underside	Back Upside	***	A Point	B point
Critical Loading Time			Normal	Normal	Normal	Normal	Normal	Normal	Normal
Section force	M	ton *m	14.9	52.2	0.63	78.2	1590	13.7	19.7
	N	ton	----	55.8	----	----	3040	----	----
	S	ton	----	18.7	2.5		431	6.84	11.4
Stress	σ c	kg/cm²	19≤80	60.0≤80	0.25≤80	23.4≤80	75.1≤80	57≤80	69≤80
	σ s	kg/cm²	1120≤1800	1786≤1800	22≤1600	1422≤1600	775≤1600	1677≤1800	1413≤1800
	τ m	kg/cm²	0.98≤3.9	2.07≤3.9	0.13≤5.34	2.31≤5.34	3.56≤3.9	1.71≤3.9	2.843≤3.9
Main Rebar			D16@125	D19@125	D16@125	D22@125	D25@125	D19@125	D25@125

Table 4.2.8.2
Stability Calculation Result of Abutment A2

Direction		Unit	Bridge Axis Direction
Critical Loading Time			Normal
Axial force of pile	PN max	ton	217.5
Axial force of pile	PN min	ton	106.4
Allowable axial compression	Ra	ton	344.4
Allowable axial tension	Pa	ton	-57.5
Horizontal displacement	δ x	cm	0.79
Allowable horizontal displacement	δ xa	cm	1.50

4.2.3.3 Result of Stability Calculation of Pile Foundation

Result of Stability Calculation of Pile Foundation are shown in Table 4.2.9.1~Table 4.2.11.2

Table 4.2.9.1
Member Stress Result of P25

Group								
Group	Group name		B Group					
	Contents		P1, P2, P4, P25, P27					
	Design Model		P25					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Locations of Parts (Axis*transverse*Height)			2.2m*7.6m*8.5		7.0m*8.5m*2.0m		ϕ 1.0m,l=12.5m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Temperature	Earthquake	Temperature	----	Temperature	Earthquake
Section Force	M	ton *m	1105	940	1476	----	1370	1160
	N	ton	1853	1610	----	----	2240	1990
	S	ton	130	100	----	----	130	120
Stress	σ c	kg/cm^2	33.4≤92	15.2≤120	42.5≤92	----	73≤92	61≤120
	σ s	kg/cm^2	148≤2070	15.2≤3000	1700≤1840	----	0≤1840	0≤3000
	τ m	kg/cm^2	0.89≤3.90	0.63≤5.85	6.98≤8.97	----	2.5≤4.48	2.4≤5.85
Main Steel Bar			D16@125	D16@125	D32@125	----	D22@300	
Shear Force	Sh	ton	----	----	----	----	----	----
Shear Stress	τ m	kg/cm^2	----	----	----	----	----	----
Stirrup Necessary			----	----	----	----	----	----
Stirrup Area (cm^2)			----	----	----	----	----	----
Stirrup			----	----	----	----	----	----
Remarks								

Table 4.2.9.2
Stability Calculation Result of P25

Direction		Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time		-	Temperature	Earthquake
Axial force of pile	PN max	ton	351.7	320.4
Axial force of pile	PN min	ton	178.3	159.6
Allowable axial compression	Ra	ton	449.4	676.3
Allowable axial tension	Pa	ton	113.1	-210.9
Horizontal displacement	δ x	cm	0.60	0.37
Allowable horizontal displacement	δ xa	cm	1.50	1.50

Table 4.2.10.1
Member Stress Result of P26

Group								
Group	Group name		C Group					
	Contents		P3, P26					
	Design Model		P26					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Locations of Parts (Axis*transverse*Height)			2.2m*7.5m*7.8m		7.0m*8.5m*2.0m		ϕ 1.0m,l=12.0m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Earthquake	Earthquake	Earthquake	----	Earthquake	Earthquake
Section force	M	ton *m	2920	805	1780	----	3720	1020
	N	ton	1480	1480	----	----	1860	1860
	S	ton	385	90	----	----	410	115
Stress	σ c	kg/cm^2	81≤120	14≤120	55≤120	----	99≤120	42≤120
	σ s	kg/cm^2	2282≤3000	0≤3000	2510≤3000	----	2470≤3000	0≤3000
	τ m	kg/cm^2	2.67≤5.85	0.59≤5.85	8.48≤11.7	----	6.78≤5.85	1.90≤5.85
Main Steel Bar			D32@125	D32@125	D29@125	----	D32@125	
Shear force	Sh	ton	----	----	----	----	45.6	----
Shear Stress	τ m	kg/cm^2	----	----	----	----	6.78	----
Stirrup Necessary			----	----	----	----	Necessary	----
Stirrup Area (cm^2)			----	----	----	----	5.50	----
Stirrup			----	----	----	----	D19	----
Remarks								

Table 4.2.10.2
Stability Calculation Result of P26

Direction		Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time			Earthquake	Earthquake
Axial force of pile	PN max	ton	463.5	264.9
Axial force of pile	PN min	ton	-50.2	148.4
Allowable axial compression	Ra	ton	653.5	653.5
Allowable axial tension	Pa	ton	-194.0	-194.0
Horizontal displacement	δ x	cm	1.32	0.31
Allowable horizontal displacement	δ xa	cm	1.50	1.50

Table 4.2.11.1
Member Stress Result of P24

Group	Group name		D Group					
	Contents		P5, P24					
	Design Model		P24					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Locations of Parts (Axis*transverse*Height)			3.2m*7.6m*8.9m		7.0m*8.5m*2.0m		ϕ 1.0m,l=13.5m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Temperature	Earthquake	Temperature	----	Temperature	Earthquake
Section Force	M	ton *m	980	860	880	----	1200	1080
	N	ton	1750	1550	----	----	2120	1920
	S	ton	110	92	----	----	110	115
Stress	σ c	kg/cm^2	16≤92	10.5≤120	30≤92	----	65≤92	58≤120
	σ s	kg/cm^2	0≤2070	0≤3000	1560≤1840	----	0≤1840	0≤3000
	τ m	kg/cm^2	0.53≤4.48	0.43≤5.85	0.33≤8.97	----	2.05≤4.48	2.14≤5.85
Main Steel Bar			D16@125	D16@125	D25@125	----	D22@300	
Shear Force	Sh	ton	----	----	----	----	----	----
Shear Stress	τ m	kg/cm^2	----	----	----	----	----	----
Stirrup Necessary			----	----	----	----	----	----
Stirrup Area (cm^2)			----	----	----	----	----	----
Stirrup			----	----	----	----	----	----
Remarks								

Table 4.2.11.2
Stability Calculation Result of P24

Direction		Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time			Temperature	Earthquake
Axial force of pile	PN max	ton	351.7	320.4
Axial force of pile	PN min	ton	178.3	160.0
Allowable axial compression	Ra	ton	444.4	676.3
Allowable axial tension	Pa	ton	-113.1	-210.9
Horizontal displacement	δ x	cm	0.60	0.37
Allowable horizontal displacement	δ xa	cm	1.50	1.50

4.3 APPROACH VIADUCT IN THAILAND

4.3.1 General

The design result of the superstructure, piers and piled foundation on the Thailand side are shown. Design calculations are based on JRA-SHB standards.

4.3.2 Superstructure

4.3.2.1 Design of Girder Transverse Cross Section

A main girder cross section is composed of a deck slab with cantilevered parts, a web and a lower slab. Transverse cross sectional force was analyzed as a box rigid frame structure that was supported at the web lower corners.

Web and lower slab member were considered as RC structure when the deck slab is full prestressed.

(1) Calculation of Load and Cross Section Force

The following loads were considered.

- Dead load
- Bridge surface load : Pavement, Curb, Guardrail
- Live load : B-Load
- Prestressing force : After prestressing, Effective prestress
- Secondary prestress force : After prestressing, Effective prestress
- Temperature difference : Deck slab temperature + 5°C

(2) Calculation of Prestressing Force

Transverse prestressing cable is arranged at 62.5cm intervals by using 4S15.2 (SWPR 7BL). Prestress σpi of PC cable is 1,295 N/mm^2. The PC cable is tensioned from one side but alternating the side due to the anchorage wedge “drawing in” effect.

(3) Calculation of Deck Slab, Web and Lower Slab

The design section has a standard web thickness of 40cm. Position of stress checking is shown in Figure 3.2.1. The result of stress check is shown in Table 4.3.1~4.3.3.

Table 4.3.1
Bridge Transverse Composite Stress of Deck Slab (Kg/cm^2)

Design		(1)		(2)		(3)	
		Upper	Lower	Upper	Lower	Upper	Lower
45. Prestressing stress after prestressing		45.7	-3.5	43.6	-2.0	-11.4	63.1
45. Secondary stress after prestressing		0.0	0.0	2.7	-2.7	4.1	-4.1
45. Reduction stress of prestressing		-5.2	0.4	-5.0	0.2	1.5	-8.2
45. Reduction stress of secondary force		0.0	0.0	-0.3	0.3	-0.5	0.5
45. Dead-load		-7.6	7.6	-9.5	9.5	6.8	-6.8
6. Deck surface load		-6.2	6.2	-3.2	3.2	1.4	-1.4
7. T-load	Max.	0.0	16.3	-26.0	26.0	0.0	0.0
	Min.	-16.3	0.0	2.1	-2.1	0.0	0.0
8. Sidewalk load	Max.	0.0	0.0	2.1	-2.1	0.0	0.0
	Min.	-3.8	3.8	-2.1	2.7	-0.9	0.9
9. Temperature difference		0.0	0.0	-0.9	0.9	-1.4	1.4
10. After prestressing		38.1	4.1	36.7	4.8	-0.5	52.2
11. Dead load state		26.7	10.7	28.2	8.6	1.9	43.1
12. Design load state	Max.	26.7	10.7	30.4	6.4	41.6	3.4
	Min.	10.4	27.0	2.2	34.6	1.9	43.1
13. Design load state + Sidewalk load	Max.	26.7	10.7	32.5	4.3	41.6	3.4
	Min.	6.6	30.8	-0.6	37.4	1.0	44.0
14. Design load state + Temperature difference	Max.	26.7	10.7	29.5	7.3	40.2	4.8
	Min.	10.4	27.0	1.3	35.6	0.5	44.5
15. Design load state + Sidewalk load + Temperature difference	Max.	26.7	10.7	31.6	5.2	40.2	4.8
	Min.	6.6	30.8	-1.5	38.3	-0.4	45.4

Comment : (1), (2), (3) are stress check points of Figure 3.2.1.

Table 4.3.2
Bridge Axis Bending Stress of Deck Slab

Design Section		Cantilever Part	Middle Part of Fixed Slab
Member thickness	(m)	0.406	0.385
Bending moment	(ton/m)	2.275	6.539
Reinforcement	(cm^2/m)	5.075	15.471
Concrete stress	(kg/cm^2)	19.6	40.0
Reinforcement bar stress	(kg/cm^2)	1305.1	1364.0

Table 4.3.3
Bridge Transverse Composite Stress of Web and Lower Slab

Design Section		(4)	(5)	(6)	(7)
Reinforcement	(cm^2/m)	23.628	5.390	8.128	5.931
Dead load state					
Concrete stress	(kg/cm^2)	3.6	14.8	22.8	21.4
Rebar stress	(kg/cm^2)	96.3	934.8	848.8	955.2
Live load state					
Concrete stress	(kg/cm^2)	66.6	21.2	46.9	22.1
Rebar stress	(kg/cm^2)	1788.6	1335.7	1742.0	985.5
Temperature difference state					
Concrete stress	(kg/cm^2)	68.0	21.6	48.7	20.0
Rebar stress	(kg/cm^2)	1827.7	1363.7	1811.0	892.1

Comment : (4), (5), (6), (7) are design sections of Figure 3.2.1.

4.3.2.2 Design of Main Girder

The main girder was analyzed as a continuous beam with one fixed point support.

(1) Effective cross section of main girder
All members of cross section are considered against bending moment shearing force and axial force.

(2) Calculation of load and main girder cross sectional force
The design load in Table 4.1.2 and 4.1.3 was considered.

(3) Calculation of prestressing force
Prestressing cable was arranged by using 12S15.2 (SWPR7BL).

(4) Calculation of cross-sectional force and stress of girder
Calculation of cross-sectional force and checking of stress were carried out by using the structural analysis program CONST.

Bending stress, shearing stress and safety factor of ultimate failure are shown in Table 4.3.4 and 4.3.5.

Table 4.3.4
Bridge Axis Bending Stress and Safety Factor at Ultimate Bending Failure

Design		Bending Stress (kg/cm²)						Ultimate Bending Moment (tm)		
		Dead load state		D+L(+)		D+L(-)				
		Upper	Lower	Upper	Lower	Upper	Lower	Bending Moment M	Resisting Moment Mu	Safety Factor Mu/M
A1	**1**	7.3	20.3	7.3	20.3	7.3	20.3	-	-	-
	10	56.6	29.3	72.8	0.9	52.4	36.8	10012	12472	1.2
P2	**19**	16.0	52.2	18.2	49.4	1.9	70.4	-9667	-11388	1.2
	28	41.7	32.6	55.1	9.3	35.7	43.0	7028	11151	1.6
P3	**37**	25.3	32.6	29.4	27.4	12.4	49.3	-7219	-10134	1.4
	47	45.9	26.7	59.9	2.3	40.8	35.7	8585	11151	1.3
P4	**56**	24.7	33.6	28.8	28.3	11.7	50.3	-6631	-10192	1.5
	65	40.6	24.7	54.0	1.4	34.6	35.3	7164	11155	1.6
P5	**75**	14.8	54.0	17.0	51.2	0.6	72.3	-10021	-11390	1.1
		57.0	28.2	73.2	-0.1	52.7	35.6	9994	12478	1.2
P6	**93**	7.4	19.9	7.4	19.9	7.4	19.9	-	-	-

Table 4.3.5
Bridge Axis Shear Stress and Safety Factor at Ultimate Shear Failure

Design Section	Diagonal Tensile Stress						Mean shear stress	
	s_I max (kg/cm²)			s_I min (kg/cm²)			Design load state	Ultimate load state
	2-2	G-G	3-3	2-2	G-G	3-3	(kg/cm²)	(kg/cm²)
3	-9.9	-11.0	-9.6	-6.2	-6.7	-5.6	15.5	33.5
17	-12.0	-12.2	-9.4	-18.5	-17.0	-12.0	27.3	45.8
21	-16.7	-15.1	-10.5	-10.1	-10.1	-7.6	25.5	41.9
35	-8.4	-10.0	-9.3	-14.7	-15.2	-12.2	24.5	38.8
39	-15.1	-15.7	-12.6	-8.8	-10.5	-9.8	24.4	38.1
54	-8.8	-10.5	-9.8	-15.1	-15.8	-12.7	25.5	42.0
58	-14.5	-15.1	-12.1	-8.3	-9.9	-9.2	24.4	38.1
73	-10.4	-10.2	-7.5	-17.1	-15.3	-10.4	25.7	42.6
77	-18.8	-17.2	-12.0	-12.3	-12.3	-9.3	27.7	46.2
91	-6.2	-6.8	-5.9	-9.9	-11.1	-9.9	15.6	34.4

Comment : 2-2, G-G, 3-3 are position of stress checking of Figure 3.2.1

4.3.3 Pier Foundation and Abutment (Thailand)

4.3.3.1 General

(1) Substructure arrangement

The approach viaduct on the Thailand Side consists of 5 spans @ 50 m = 250 m of PC continuous box girder bridge supported by a substructure arrangements as outlined below.

a) Abutment A1 - A reinforced concrete reverse T-type abutment supported by 18 of ϕ 1.0 m bored piles. The superstructure is free to move in the bridge axis direction at this abutment.

b) Pier P1 - A reinforced concrete wall type pier with pile cap supported by 8 of ϕ 1.0 m bored piles. The superstructure is free to move in the bridge axis direction at this abutment.

c) Pier P2 - Same conditions as pier P1.

d) Pier P3 - A reinforced concrete wall type pier with a pile cap supported by 9 of ϕ 1.0 m bored piles. The superstructure is fixed at the top of this pier but superstructure rotation is able to take place at this pier.

e) Pier P4 - Same conditions as piers P1 and P2.

f) Pier P5 - A reinforced concrete wall type pier with a pile cap supported by 8 of ϕ 1.0 m bored piles. The superstructure is free to move in the bridge axis direction at this pier.

(2) Design Grouping

Table 4.3.6
Design Grouping of Pier and Abutment

Groups	Contents	Design Model	Remark
A	**A1,** A2	A1	Abutment
B	P1, P2, **P4,** P25, P27	P4	Movable Pier
C	**P3,** P26	P3	Fixed Pier
D	**P5,** P24	P5	Transition Pier (Main and Approach Bridge)

(3) Design Load

Table 4.3.7
Design Load by Superstructure

Substructure No		A1	P1	P2	P3	P4	P5	Total Weight
Bearing Condition		Move	Move	Move	Fix	Move	Move	
Vertical Load	Dead Load (ton)	560	1,290	1,200	1,200	1,300	1,090	6,100
	Live Load (ton)	130	250	250	250	250	200	
Horizontal Load (Axis)	Temperature Load (ton)	56	129	120	0	130	109	
	Earthquake Load (ton)	34	77	72	366	78	65	
Horizontal Load (Transverse)	Earthquake Load (ton)	34	77	72	72	78	65	

Comment : The acting position of the design load is the pier upper end.

The setting method of horizontal load is the same as section 4.2.3.1(1).

(4) Foundations P1, P2, P3, P4, P5

The 4 land based boreholes carried out during the Basic Design phase of the Project (BM1 and BM2 on the Mukdahan side and BS1 and BS2 on the Savannakhet side) show layers of silty clay and silty sand up to base rock level and the SPT readings in BM1 and BS1 in these layers are considerable at only 5 to 6 meters below the ground surface.

A review of the Basic Design with 0.4 m x 0.4 m prestressed precast piles indicated for both the approach viaduct piers and abutments shows that these piles may not be able to be driven through such stiff stratum. The Study Team has then further reviewed at the start of the detailed design phase with higher quality ϕ 0.60 prestressed spun concrete piles to JIS standards and has carried out the design of the piled foundations based on ϕ 1.0 m cast-in-place piles socketed 1 meter into the bedrock.

In the Contract documents, the options of ϕ 1.0 m bored cast-in-place piles and ϕ 0.60 prestressed precast spun piles will be made available. The Contractors will be instructed to carry out further borehole tests to confirm on pile option it considers the most appropriate based on the borehole results.

(5) Footings (Pile Caps) P1, P2, P3, P4, P5

Footings are of standard rectangular shape of 7m x 8.5 m x 2 meter thick with the footing top located 1 m below the existing ground surface. Pile concrete is extended into the footing base at a minimum of 100 mm.

(6) Abutment A1

The abutment A1 is of the reverse T-type supported on ϕ 1.0 m bored piles. The abutments have wing walls for the supports of road embankment. Allowance is also made for a bridge approach slab to key into the back wall of the abutment. A front plinth of the abutment supports the superstructure on two proprietry bearings to take longitudinal movement. Tables are enclosed below showing the full design philosophy and the strength of materials to be used in the construction.

(7) Piers P1, P2, P3, P4, P5

All piers are standard wall type piers with small tapers both on the longitudinal and transversal axes. the edges of the piers are beveled at 22° to keep the same shape and geometry as the river based Piers.

4.3.3.2 Result of Stress Calculation of Pier, Pile, Pile Cap

Results of stress calculation of pier, pile and pile cap are shown in Table 4.3.8.1 and Table 4.3.8.2.

Table 4.3.8.1
Member Stress Result of Abutment A1

Group	Group name		A Group						
	Contents		A1, A2						
	Design Model		A1						
Structure Components			Parapet	Column	Pile Cap		Pile	Wings	
Concrete Materials			σ ck=240 kg/cm^2	σ ck=240 kg/cm^2	σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	σ ck=240 kg/cm^2	
Steel Materials			SD345	SD345	SD345		SD345	SD345	
Locations of Parts (Axis*transverse*Height)			1.0m*18.0m* 2.9m	2.5(1.0)m*6.5 (18.0)m*4.1m	7.0m*18.0m*2.0m		ϕ1.0m,l=12.5m, 18nos	***	
Design Section			Back Side	Back Side	Front Underside	Back Upside	***	A Point	B point
Critical Loading Time			Normal	Normal	Normal	Normal	Normal	Normal	Normal
Section Force	M	ton *m	14.9	52.2	0.63	78.2	1590	13.7	19.7
	N	ton	----	55.8	----	----	3040	----	----
	S	ton	----	18.7	2.5		431	6.84	11.4
Stress	σ c	kg/cm^2	19≤80	60.0≤80	0.25≤80	23.4≤80	75.1≤80	57≤80	69≤80
	σ s	kg/cm^2	1120≤1800	1786≤1800	22≤1800	1422≤1800	775≤1600	1677≤1800	1413≤1800
	τ m	kg/cm^2	0.98≤3.9	2.07≤3.9	0.13≤5.34	2.31≤5.34	3.56≤3.9	1.71≤3.9	2.843≤3.9
Main Rebar			D16@125	D19@125	D16@125	D22@125	D25@125	D19@125	D25@125

Table 4.3.8.2
Stability Calculation Result of Abutment A1

Direction		Unit	Bridge Axis Direction
Critical Loading Time			Normal
Axial force of pile	PN max	ton	217.5
Axial force of pile	PN min	ton	106.4
Allowable axial compression	Ra	ton	344.4
Allowable axial tension	Pa	ton	-57.5
Horizontal displacement	δ x	cm	0.79
Allowable horizontal displacement	δ xa	cm	1.50

4.3.3.3 Result of Stability Calculation of Pile Foundation

Results of stability calculation of pile foundation are shown in Table 4.3.9.1~4.3.11.2

Table 4.3.9.1
Member Stress Result of P4

Group	Group name		B Group					
	Contents		P1, P2, P4, P25, P27					
	Design Model		P4					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm²		σ ck=240 kg/cm²		σ ck=240 kg/cm²	
Steel Materials			SD345		SD345		SD345	
Locations of Parts (Axis*transverse*Height)			2.2m*7.6m*8.5		7.0m*8.5m*2.0m		ϕ 1.0m,l=12.5m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Temperature	Earthquake	Temperature	----	Temperature	Earthquake
Section Force	M	ton *m	1105	940	1476	----	1370	1160
	N	ton	1853	1610	----	----	2240	1990
	S	ton	130	100	----	----	130	120
Stress	σ c	kg/cm²	33.4≤92	15.2≤120	42.5≤92	----	73≤92	61≤120
	σ s	kg/cm²	148≤2070	15.2≤3000	1700≤1840	----	0≤1840	0≤3000
	τ m	kg/cm²	0.89≤3.90	0.63≤5.85	6.98≤8.97	----	2.5≤4.48	2.4≤5.85
Main Steel Bar			D16@125	D16@125	D32@125	----	D22@300	
Shear Force	Sh	ton	----	----	----	----	----	----
Shear Stress	τ m	kg/cm²	----	----	----	----	----	----
Stirrup Necessary			----	----	----	----	----	----
Stirrup Area (cm²)			----	----	----	----	----	----
Stirrup			----	----	----	----	----	----
Minimum Rebar Area (cm²)			186.8	----	199.1	----	31.4	----

Table 4.3.9.2
Stability Calculation Result of P4

Direction		Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time			Temperature	Earthquake
Axial force of pile	PN max	ton	351.7	320.4
Axial force of pile	PN min	ton	178.3	159.6
Allowable axial compression	Ra	ton	449.4	676.3
Allowable axial tension	Pa	ton	113.1	-210.9
Horizontal displacement	δ x	cm	0.60	0.37
Allowable horizontal displacement	δ xa	cm	1.50	1.50

Table 4.3.10.1
Member Stress Result of P3

Group	Group name		C Group					
	Contents		P3, P26					
	Design Model		P3					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ_{ck}=240 kg/cm^2		σ_{ck}=240 kg/cm^2		σ_{ck}=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Locations of Parts (Axis*transverse*Height)			2.2m*7.5m*7.8m		7.0m*8.5m*2.0m		ϕ 1.0m, l=12.0m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Earthquake	Earthquake	Earthquake	----	Earthquake	Earthquake
Section Force	M	ton *m	2920	805	1780	----	3720	1020
	N	ton	1480	1480	----	----	1860	1860
	S	ton	385	90	----	----	410	115
Stress	σ_c	kg/cm^2	81≤120	14≤120	55≤120	----	99≤120	42≤120
	σ_s	kg/cm^2	2282≤3000	0≤3000	2510≤3000	----	2470≤3000	0≤3000
	τ_m	kg/cm^2	2.67≤5.85	0.59≤5.85	8.48≤11.7	----	6.78≥5.85	1.90≤5.85
Main Steel Bar			D32@125	D32@125	D29@125	----	D32@125	
Shear Force	Sh	ton	----	----	----	----	45.6	----
Shear Stress	τ_m	kg/cm^2	----	----	----	----	6.78	----
Stirrup Necessary			----	----	----	----	Necessary	----
Stirrup Area (cm^2)			----	----	----	----	5.50	----
Stirrup			----	----	----	----	D19	----
Minimum Rebar Area (cm^2)			174.0	----	199.1	----	31.4	----

Table 4.3.10.2 Stability Calculation Result of P3

Direction		Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time			Earthquake	Earthquake
Axial force of pile	PN max	ton	463.5	264.9
Axial force of pile	PN min	ton	-50.2	148.4
Allowable axial compression	Ra	ton	653.5	653.5
Allowable axial tension	Pa	ton	-194.0	-194.0
Horizontal displacement	δx	cm	1.32	0.31
Allowable horizontal displacement	δxa	cm	1.50	1.50

Table 4.3.11.1
Member Stress Result of P5

Group	Group name		D Group					
	Contents		P5, P24					
	Design Model		P5					
Structure Components			Column		Pile Cap		Pile	
Concrete Materials			σ ck=240 kg/cm^2		σ ck=240 kg/cm^2		σ ck=240 kg/cm^2	
Steel Materials			SD345		SD345		SD345	
Locations of Parts (Axis*transverse*Height)			3.2m*7.6m*8.9m		7.0m*8.5m*2.0m		ϕ 1.0m,l=13.5m	
Direction			Axis	Transverse	Axis	Transverse	Axis	Transverse
Critical Loading Time			Temperature	Earthquake	Temperature	----	Temperature	Earthquake
Section Force	M	ton *m	980	860	880	----	1200	1080
	N	ton	1750	1550	----	----	2120	1920
	S	ton	110	92	----	----	110	115
Stress	σ c	kg/cm^2	16≤92	10.5≤120	30≤92	----	65≤92	58≤120
	σs	kg/cm^2	0≤2070	0≤3000	1560≤1840	----	0≤1840	0≤3000
	τ m	kg/cm^2	0.53≤4.48	0.43≤5.85	0.33≤8.97	----	2.05≤4.48	2.14≤5.85
Main Steel Bar			D16@125	D16@125	D25@125	----	D22@300	
Shear Force	Sh	ton	----	----	----	----	----	----
Shear Stress	τ m	kg/cm^2	----	----	----	----	----	----
Stirrup Necessary			----	----	----	----	----	----
Stirrup Area (cm ^{2})			----	----	----	----	----	----
Stirrup			----	----	----	----	----	----
Minimum Rebar Area (cm^2)			176.2	----	199.1	----	31.4	----

Table 4.3.11.2
Stability Calculation Result of P5

Direction		Unit	Bridge Axis Direction	Bridge Transverse Direction
Critical Loading Time			Temperature	Earthquake
Axial force of pile	PN max	ton	351.7	320.4
Axial force of pile	PN min	ton	178.3	160.0
Allowable axial compression	Ra	ton	444.4	676.3
Allowable axial tension	Pa	ton	-113.1	-210.9
Horizontal displacement	δ x	cm	0.60	0.37
Allowable horizontal displacement	δ xa	cm	1.50	1.50

4.4 ANCILLARY WORKS

4.4.1 Bridge Bearing

As the concern for the bearing durability and maintenance are high, the "Elastomeric Laminated Bearing" type has been selected.

The allowable bearing capacity for elastomeric bearings is shown in table 4.4.1 under JRA-SHB standard. It is adopted in calculation of the horizontal forces at movable bearing.

Table 4.4.1
Allowable Capacity for Elastomeric Bearing

Item		Check Formula	Allowable Values	Remark
Compressive Stress	Maximum	$\sigma_{max.} \leq \sigma_{max.a}$	$\sigma_{max.a}$= 8N/mm^2	Effective bearing area considered.
	Minimum	$\sigma_{min.} \geq \sigma_{min.a}$	$\sigma_{min.}$= 1.5N/mm^2	
	Stress Fluctuation	$\Delta\sigma \leq \Delta\sigma_a$	$\Delta\sigma_a$= 5N/mm^2	
Shearing Strain	Normal Earthquake	$\gamma_s \leq \gamma_a$ $\gamma_{se} \leq \gamma_{ae}$	$\gamma_{a = 70\%}$ $\gamma_{ae = 150\%}$	
Buckling		a,b ≥ 5 x Σ_{te} and a,b ≥ 10cm		
Rotation		$\Sigma\alpha_e$ x a/2 < δ		
Local Shearing Strain		$\gamma = \gamma_c + \gamma_s + \gamma_r$ $\gamma \leq \gamma_{ta}$	$\gamma_{ta} = \frac{\gamma_u}{1.5}$	To be checked at normal conditions
Stress on Reinforcing Steel		$\sigma_s \leq \sigma_{sa}$		
Spring Constants (Compressive and Shearing to conform to design)				JIS K 6835

Where : $\Delta\sigma$ = $\Delta\sigma_{max.} - \Delta\sigma_{min}$
a = Longitudinal effective length of bearing shoe,
b = Transverse effective width of bearing shoe,
Σ_{te} = Total thickness of the elastomeric rubber,
$\Sigma\alpha_e$ = Overall rotation (radians) of the total rubber thickness,
δ = Compressive stain under vertical load of bearing effective area,
γ_c = Local shearing strain under vertical load,
γ_s = Local shearing strain due to shearing deformation,
γ_r = Local shearing strain due to rotation,
γ_u = Shearing strain at rupture

The moveable bearings were designed to accommodate movement of superstructure caused by temperature change, deflection, creep and shrinkage of concrete and elastic deformations of the members due to the prestressing forces.

The range of temperature change to calculate movement of bearings from thermal expansion and values of the creep and the shrinkage are shown in Table 4.4.2

Table 4.4.2
Range of Temperature Change, Creep Coefficient and Shrinkage

Range of temperature	10 ºC – 40 ºC
Creep coefficient	φ = 2.0
Shrinkage	Equivalent to 20 ºC descent

In calculation of the horizontal force at the movable bearing, a coefficient of friction of 0.10 using a PIFE (Polytetrafluoroethylene) sliding type bearing is applied.

In lateral direction, no movement is permitted and, therefore, anchor bars are installed on every pier and abutment.

Main Bridge and Approach Viaduct bearings are divided into 8 types based on vertical load and longitudinal movements.

The design vertical loads and the longitudinal movements are shown in Table 4.4.3.

Table 4.4.3 Design Vertical Loads and Longitudinal Movements for Bearing

Bridge		**Approach Viaduct**				**Main Bridge**							
Type		**1**	**2**	**3**		**4**	**5**		**6**			**7**	**8**
Bearing Locations		P3, P26	A1, P5, P24, A2	P2, P4, P25, P27	P1	P5, P24	P13, P16	P6, P23	P9, P20	P8, P15, P21	P7, P22	P14	D.H.
		Fix	Move	Move	Move	Move	Move	Move	Move	Move	Move	Move	Move
Design Vertical Load Per Bearing (KN)	Dead Load	6,100	2,800	6,600		2,700	11,000		11,900			13,700	2,300
	Maximum	7,300	3,400	7,800		3,400	12,500		13,400			15,500	2,800
	Minimum	5,900	2,700	6,500		2,600	10,800		11,700			13,500	1,900
Design Longitudinal Movement (mm)	Shrinkage and Creep	-	50	20	35	235	95	205	90	135	165	120	285
	Thermal Expansion and Contraction	--	25	10	15	70	30	65	30	40	55	40	95
	Maximum Movement	-	75	30	50	305	125	270	120	175	220	160	380

4.4.2 Bridge Expansion joint

As durability and maintenance issues are significant, a "Finger type Joint " has been selected. Total movement length at expansion – joint locations is shown in Table 4.4.4

Table 4.4.4
Expansion of A1, P5, Hinge, P24 and A2

	A1	P5	hinge P14- P15	P24	A2
Shrinkage + Creep (mm)	51	271	93	246	32
Temperature (mm)	23	87	284	87	15
Total (mm)	74	358	377	333	47

4.4.3 Guardrail

Guardrail is made of three parallel steel pipes with a space of 2 meters between the vertical steel posts and at a height of 1.1 meter. It will be fixed along the curb of the Bridge. This railing has been designed to perform dual roles as a vehicle guard and pedestrian guard.

4.4.4 Bridge Drainage

The drainage area is located between the roadway and sidewalk. The inlets are at intervals of less than 12 meter and are able to absorb the design rainfall intensity of 120mm/h.

4.4.5 Bridge Utilities

4.4.5.1 Bridge Street Lighting

Bridge Street lights are 250W high pressure sodium lights installed on galvanized steel columns with 2.5m long curved outreaching arms. The mounting height of the lights is 10m. Lights are at 35m spacing to suit the Bridge structure. The average illumination on the road is 24 lux. This is higher than the standard required by DOH which is 21.5 lux.

4.4.5.2 Bridge Light-Up

Bridge Light-Up Towers and PC sails are lighted up by 1000W lights for night view. Four tower lights are installed on 3m high galvanized steel columns to the sidewalk of the curb. Eight PC sail lights are installed on galvanized steel brackets to the PC sail.

4.4.5.3 Pier Lighting

A total of 32 Pier lights will be installed to illuminate the upstream and downstream faces of the main river piers. Pier lights will be 250W high pressure sodium installed on hinged brackets to allow the light to be raised to sidewalk level for maintenance.

4.4.5.4 Navigation Lighting

The navigation clearance envelope under the PC sail span will be defined by navigation lights consisting of green lights on each side to mark the channel limits and one red lights on center to mark channel limits in PC sail span.

4.4.5.5 Cable Installation

Cables within the sidewalk void will be installed in 100mm PVC conduit supported on brackets to allow for drainage of rain water underneath cables.

Cables within the Bridge girder will be fixed directly to the concrete structure.

At the two positions, cables will be diverted into the internal girder space via cast-in ducts.

4.4.5.6 Telephone

Emergency telephones will be installed in weatherproofed enclosures mounted on steel brackets attached to the sidewalk of the curb.

Telephone cables will be installed within the sidewalk void in 25mm PVC conduit supported on brackets to allow for drainage of rain water underneath cables.

4.4.5.7 Provision for the Future Cable Duct

The Bridge has been designed to accommodate at least one future Cable duct up to 100 mm diameter.

CHAPTER 5
Detailed Design of Border Control Facilities

CHAPTER 5:DETAILED DESIGN OF BORDER CONTROL FACILITIES

5.1 GENERAL

The Second Mekong International Bridge Construction Project entails not only the construction of a major bridge over the Mekong River between the Lao PDR and Thailand but also the construction of Border Control Facilities (BCF) in the both countries to control the cross border movement of people and vehicles and the transportation of goods. These facilities are essential and it is imperative that lessons be learned from the previous Border Control Facilities arrangements at the Friendship Bridge between Nong Khai and Vientiane so that the problems previously encountered do not reoccur here.

The main issues involved with the BCF is the flow of cross border passengers and vehicles and the efficient and harmonious transportation of goods. As an integral part of the harmonious cross border transportation of goods, the Lao PDR, Thailand and Vietnamese Governments in November 1999 signed a cross-border transportation agreement in Vientiane. This agreement is based on the **ASEAN Framework of Agreement on the Facilitation of Goods in Transit** signed in Hanoi – Vietnam in December 1998 by the ASEAN Ministers. It is hoped that this agreement will set the trend in bilateral and trilateral cross border trade in the Indochina Region.

The detailed design of the cross border movement of passengers, vehicles and the transportation of goods together with the layout, operation and utilities required for the BCF is discussed in the following sections of this Report.

5.2 NATURAL AND SOCIAL CONDITIONS

5.2.1 The Lao PDR BCF

The location of the Lao PDR Border Control Facilities (BCF) is set up between 470 and 1,070m from the Mekong riverbank. The BCF are contained in an area of approximately 600 x 250m = 150,000m^2 or 15 hectares (Refer to Figure 5.2.1).

The existing land topography in the BCF area varies between 141 and 155m above MSL and the land slopes generally upwards in the north direction. On the other hand, from the geotechnical surveys the dense sandy rock is located only 3m in average below the existing ground surface. Considering these conditions as well as the adjacent levels of connecting and approach roads, the pavement at the cross center of the BCF has been set up at 151.5m above MSL so that both rock excavation and filling could be minimized.

There is an abandoned irrigation canal running through the site in a north-south direction, for which no modification will be made, while an existing 22kV transmission line is also running through the site and this will be required to be re-routed before starting the construction work of the BCF.

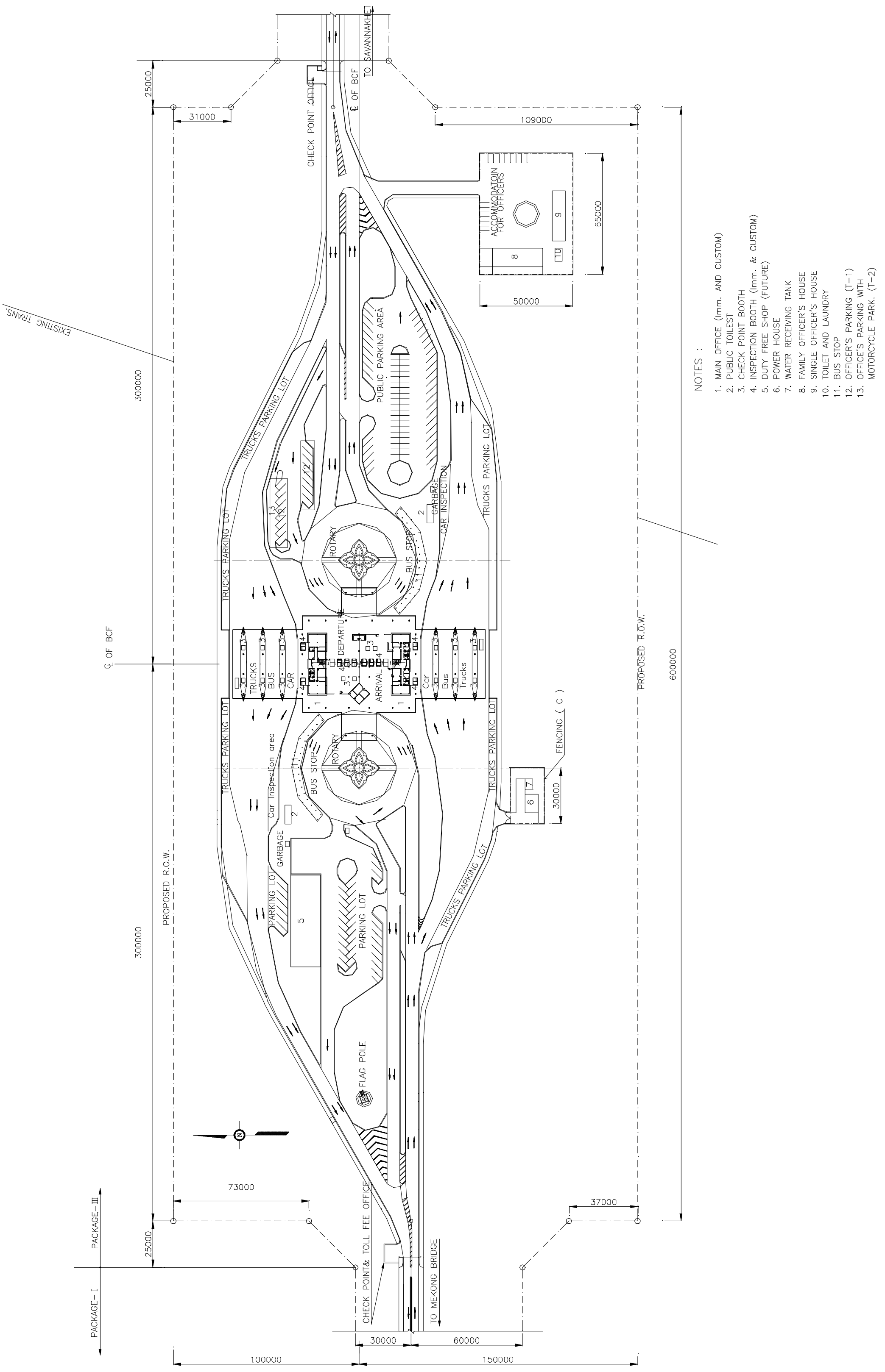


Figure 5.2.1 General Layout of the Lao PDR BCF

The land consists of secondary forest and scrub areas and there is little or no crop cultivation within the BCF area. Only 2 dwellings on the north-west edge of the BCF area are affected together with one or two small huts and consequently no relocation of people will be required. The social effects are, therefore, minimal and it is anticipated that the BCF construction will have little effects on the surrounding village people. The relocation and land acquisition issues is handled of the Chapter 8 of this Report.

5.2.2 The Thailand BCF

The location of the Thailand Border Control Facilities (BCF) is set up between 800 and 1,200m from the Mekong riverbank and from 500 to 900m from the national highway Route No.212 in consideration of the adjacent road levels of connecting road and traffic changeover as well as the reason of minimizing the disturbances to the private property in the area. The BCF are contained in an area of approximately (400~500m) x 600m = 270,000m^2 or 27 hectares (Refer to Figure 5.2.2)

The existing land topography in the BCF area varies between 137.5 to 142.5m above MSL. The pavement of the BCF is set up at 144m above MSL so that only fill is involved. The BCF land consists essentially of a hill or ridge at level MSL 141 – 142.5 running through the Border Control Facility in the north south direction.

The land consists of paddy fields in the east and the west and an uncultivated area on the hill or ridge area. Only two very minor temporary houses in the BCF are affected together with one or two agricultural huts and consequently no relocation of people will be required. Therefore, the social effects are minimal and the BCF construction will have little effects on the surrounding village people as these populated areas are far enough from the construction site.

5.3 CROSS BORDER TRAFFIC SYSTEMS

5.3.1 Mode of Cross Border Transport

For designing on the layout of the BCFs, the following three modes of cross border transport systems in terms of the flow of passengers and goods had been discussed in depth with appropriate authorities. The transfer type of transport has been finally taken up as the cross border traffic systems. Three modes of transport are shown in Figure 5.3.1.

- Transfer Type of Transport : Passengers transfer to another mode of transport at the border (i.e. shuttle bus)

- Through Type of Transport : Passengers go through the border by the same mode of transport (i.e. motor car, tourist bus etc.)

- Separated Type of Transport : Passengers and goods movement are completely separated from other modes (i.e. cargo truck, small goods vehicles)

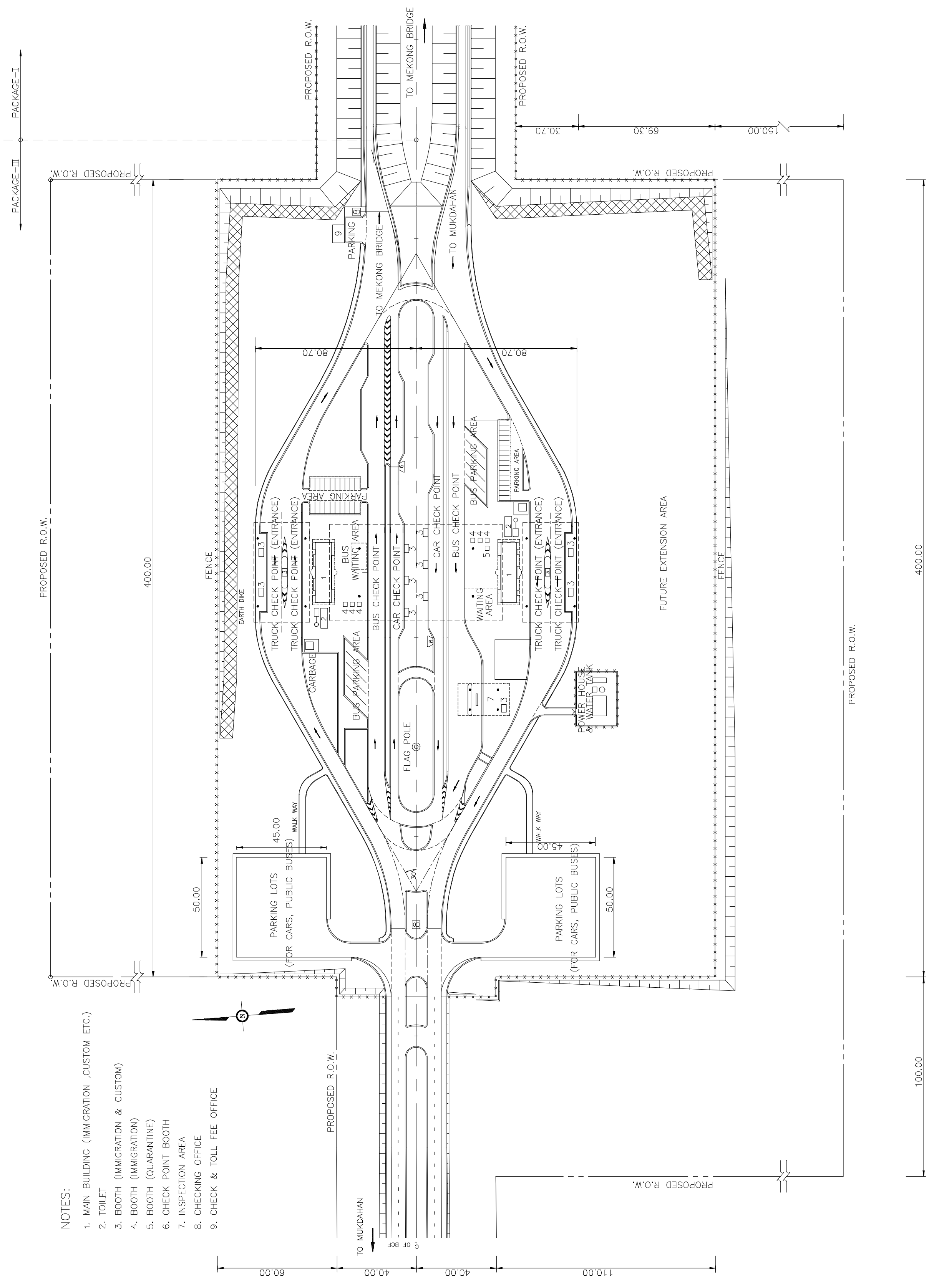


Figure 5.2.2 General Layout of the Thailand BCF

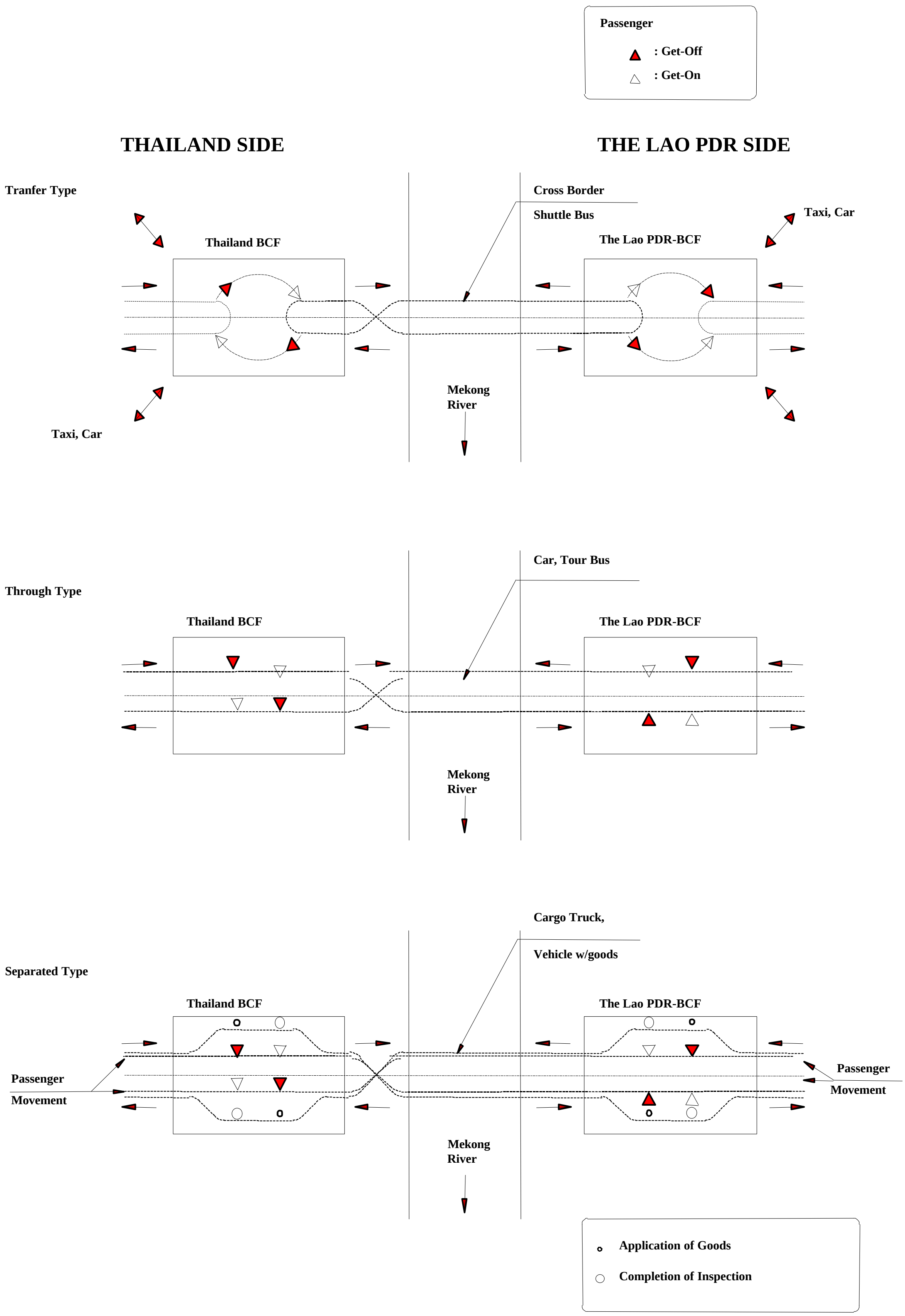


Figure 5.3.1
Mode of Transport

5.3.2 Flow of Passengers

Under the transfer type of transport system, the passengers who use both BCFs from the Lao PDR and Thailand are classified in the right side columns of Table 5.3.1 and 5.3.2 and will be picked up at the points mentioned in the left side columns of the Tables.

Figure 5.3.2 shows flow of passengers who use the cross border shuttle bus and the means of arriving at and departing from each Border Control Facility (BCF).

As mentioned in the previous section 4.1, the Lao PDR, Thailand and Vietnamese Governments have signed on the cross – border transport agreement on 26 November 1999.

By combining separate border controls, the agreement boasts not only easy flow of people, vehicle and goods through jointly and speedy inspection but also huge trilateral trade in the transport corridor area, so that the cross-border goods are expected to increase enormously.

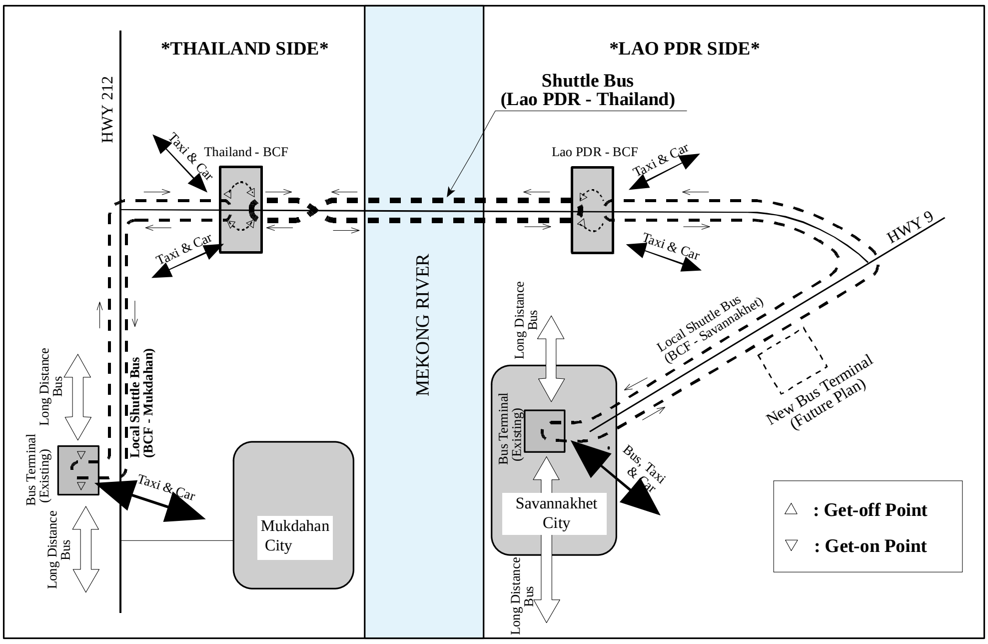
For the purpose of handling those increasing goods smoothly, the Project is proposed to set up the construction site for the new Bonded Warehouse in an area of approximately 250 x 500 = 125,000 m^2 or 12.5 Hectares located beside the Lao PDR – BCF alongside of the approach road from the national road Route 9.

Table 5.3.1
Passenger Pick Up Points for the Lao PDR

THE LAO PDR	
Pick up Point	**Passenger Classification by Mode**
Savannakhet Bus Terminal by Local Shuttle Bus (LSB)	- All long distance bus passengers - Taxi/tuk tuk users from local, outlying or long distance origin - Third party car user passengers
The Lao PDR – BCF by cross border shuttle bus (CBSB)	- Local Shuttle Bus (LSB) - Taxi/tuk tuk users from local, outlying or long distance origin - Third party car user passengers - Passengers by own car (park at the BCF)

Table 5.3.2
Passenger Pick Up Points for Thailand

THAILAND	
Pick up Point	**Passenger Classification by Mode**
Mukdahan Bus Terminal by Local Shuttle Bus (LSB)	- All long distance bus passengers - Taxi/tuk tuk users from local, outlying or long distance origin - Third party car user passengers
Thailand – BCF by cross border shuttle bus (CBSB)	- Local Shuttle Bus (LSB) - Taxi/tuk tuk users from local, outlying or long distance origin - Third party car user passengers - Passengers by own car (park at the BCF)



PASSENGER FLOW - CROSS BORDER SHUTTLE BUS (CBSB)

Figure 5.3.2
Passenger Flow – Cross Border Shuttle Bus (CBSB)

5.3.3 Flow of Cross Border Goods

Cross border goods can be classified into the following two categories.

(a) Goods imported or exported into either the Lao PDR or Thailand.

(b) Goods in transit.

5.3.3.1 Goods Imported or Exported into either the Lao PDR or Thailand

All goods imported or exported will be subjected to the following procedures.

- The person who imports the goods prepares the master list of imported goods and obtains permission from the government to import (a special agent is normally employed for this work).
- The cargo truck (which should have advance permission to cross the border) comes to the export side BCF and gets the documents checked by the customs office. The driver and truck pass through the departure immigration process.
- The cargo truck comes to the import side BCF and gets the first customs check of the documents and the goods in the truck. The driver passes the arrival immigration process and pays an entry fee for the truck if necessary.
- The cargo truck then moves to the bonded warehouse outside the BCF. All goods are unloaded at the bonded warehouse and the truck returns back to the export country in an empty condition.
- Customs check the goods in details at the bonded warehouse.
- The goods are loaded onto a cargo truck at the bonded warehouse and are sent to their final destination.

5.3.3.2 Goods in Transit

All goods in transit will follow the procedures below.

- The person who imports the goods prepares the master list and obtains permission from the government to import (a special agent is normally employed for this work).
- The cargo truck (which should have advance permission to cross the border) comes to the export side BCF and gets the documents checked by the customs office. The driver passes through the departure immigration process.
- The cargo truck comes to the transit country BCF and gets the first customs check of the documents and goods in the truck. The driver passes through the arrival immigration process and pays an entry fee for the truck if necessary.
- The cargo truck moves through the transit country to its BCF next to the import country. There is no transshipment of goods. Customs check the documents and the driver passes the transit country departure immigration process.
- The cargo truck comes to the import country BCF and gets a simple customs check of the documents and goods in the truck. The driver passes the arrival immigration process and pays an entry fee for the truck if necessary.
- The cargo truck moves to a bonded warehouse outside the BCF in the import country. All goods are unloaded into the bonded warehouse. The truck returns back through the transit country to the original export country in an empty condition.
- The customs check the goods in details at the bonded warehouse.
- The goods are loaded onto a cargo truck at the bonded warehouse and sent to their final destination.

The flow of cross border goods is shown in Figure 5.3.3.

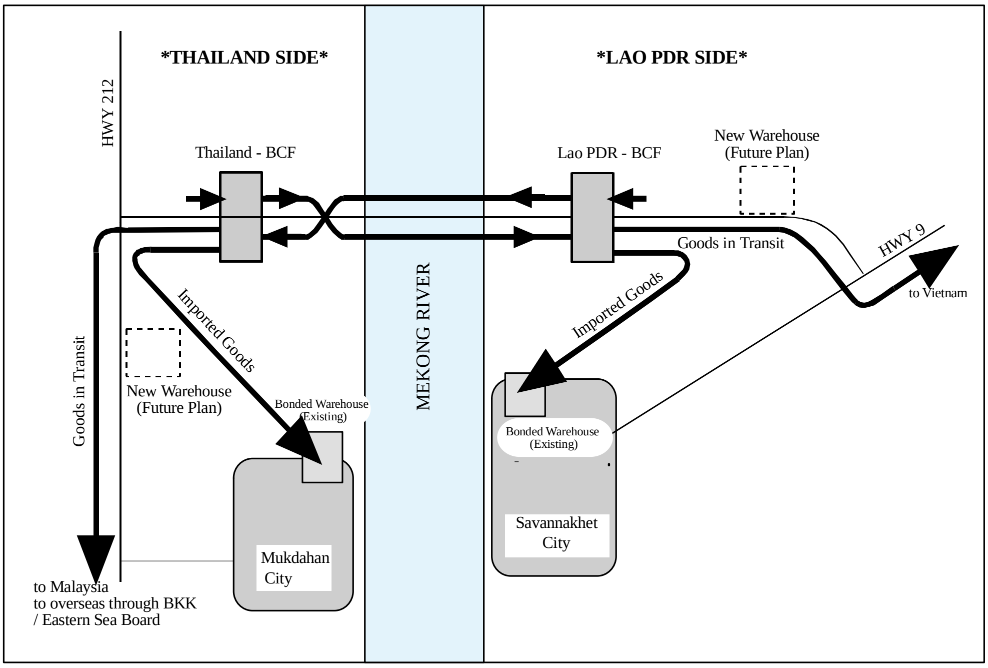


Figure 5.3.3
Flow of Cross Border Goods

5.4 DESIGN CONDITIONS OF THE BCF

5.4.1 General

The purpose of the Border Control Facilities (BCF) is to inspect the cross border passengers, various vehicles including loading and unloading trucks and import and export goods before leaving and entering both the Lao PDR and Thailand.

For attaining such tasks, the BCF should have various functions : immigration formalities, custom inspection, health control (quarantine) inspection and inspection to all kinds of goods, for which various buildings and works are involved and designed as discussed in the following Sections.

5.4.2 Buildings and Other Works to be Involved

The major buildings and other works to be involved in the design of the BCF are listed below.

- Main Offices (Immigration, Custom, Quarantine etc.)
- Public Toilets
- Inspection Booths (Immigration & Custom)
- Spacious Roof Structures
- Check Point and Gates
- Check and Toll Offices
- Officer's Parking Area with Roofs
- Inspection Pit and Truck Scale
- Vehicle Parking Areas
- Powerhouse and Water Receiving Tanks
- Land Reclamation
- Roadwork within the BCF
- Surface Drainage System
- Markings and Signs
- Landscaping
- Incidental Utilities

5.4.3 Space and Area Required

Various area in the BCF necessary for the immigration formalities, custom clearance, quarantine inspection, and waiting area for passengers are determined on the basis of analyzed figure in the survey report of "SAPROF" (OECF, 1998) and also by referring to current observations on the Friendship Bridges. The various office floor areas are allocated in accordance with the number of officials required by the authorities concerned.

5.4.4 Basic Flow of Formalities

The basic procedure for custom and immigration formalities is to be made by the shuttle bus passengers at the respective booths after getting out of the buses. Drivers arriving by cars do the same but remain in their cars at a separate lane. Loaded and non-loaded trucks also do the same in another inspection area away from the normal formality areas as shown on the layout plan.

5.4.5 Existing Facilities

The existing abandoned irrigation canal running through the site of the Lao PDR – BCF is left without modification. An existing 22kV transmission lines running across the same site are required to be re-routed before starting construction of the BCF.

5.4.6 Construction Materials

Considering easy operation and maintenance of facilities, a greater part of the construction materials used for BCF are designed and will be procured locally.

5.4.7 Laws, Codes, Standards and Units

The civil works for the BCF are basically designed by conforming to the design standard of the Department of Highways (DOH) in Thailand as well as TIS (Thai Industrial Standard) and other applicable local codes. All building works are designed basically in conformity with the following codes :

i) The Lao PDR - BCF

a) Applicable Local Building Laws and Codes
b) BAEL 91 and AISC for Structural Analysis
c) ACI Building Codes Requirements for Structural Concrete
d) TIS or other international laws or codes

ii) Thailand - BCF

a) Thailand Building Laws
b) ACI Building Codes for Structural Requirements
c) AISC or EIT (The Engineering Institute of Thailand) standard for Structural Analysis
d) TIS (Thai Industrial Standard)

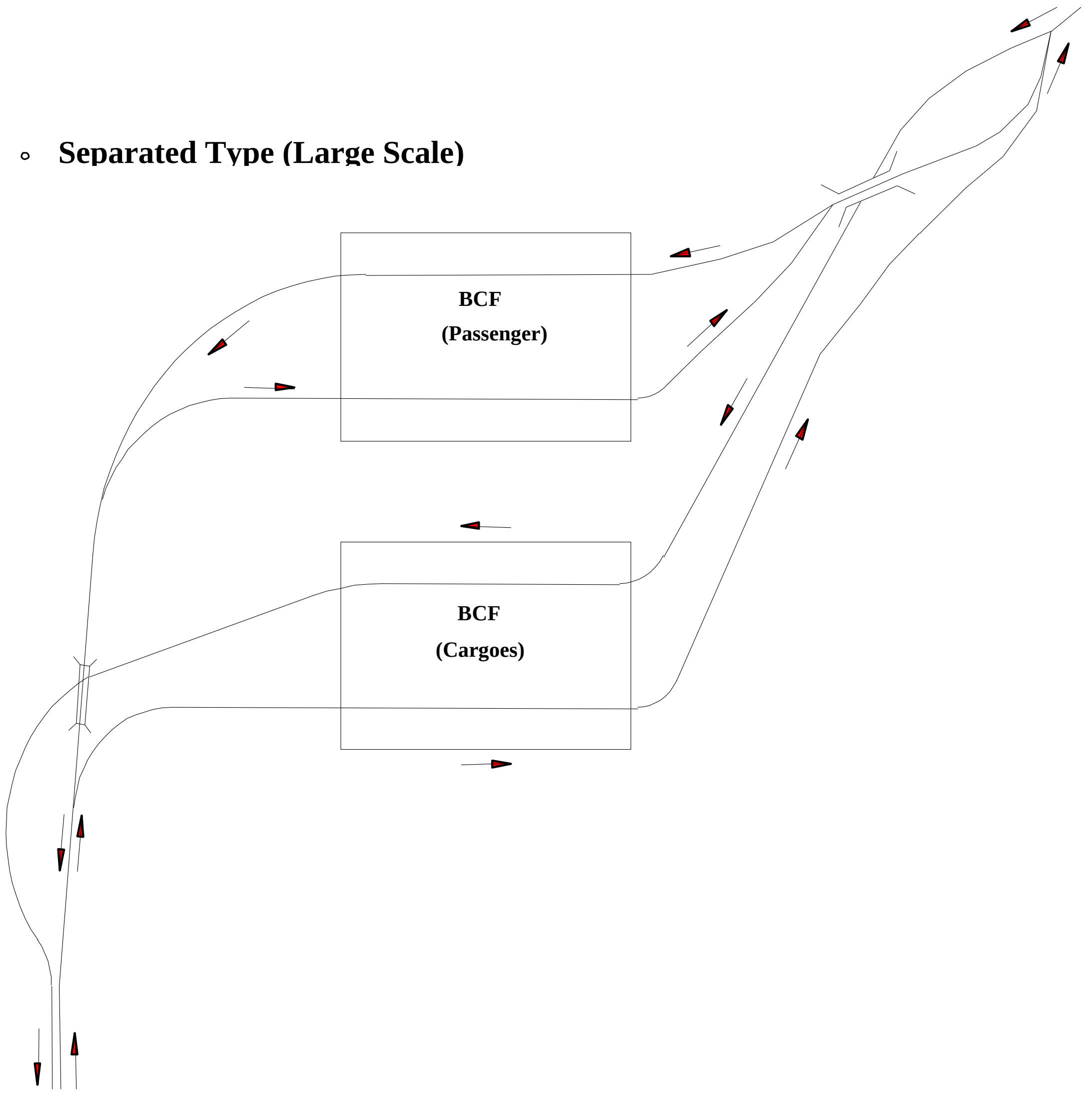
The units of measurement to be used for the Project are metric – ton systems since the Pascal and Newton systems are not prevailing in the engineering field in the Lao PDR and Thailand to date.

5.5 DESIGN OF THE BCF

5.5.1 Type of BCF

The cross border traffic systems have been discussed in the Section 4.3. However, various traffic passing through the border is further classified into two categories; (a) vehicle with passengers, and (b) trucks with cargoes. The type of the BCF is, therefore, categorized into two patterns : separate type (cargoes/passengers) and integrated (cargoes + passengers combined). The former may be employed in case sufficient land is available and there is a requirement to allow sizeable cargo and passenger traffic to cross the border smoothly. The latter has been proposed and accepted by the both governments considering minimization of operation and maintenance costs as well as the reason of comparatively minor traffic demand. Figure 5.5.1 shows the types of BCF.

- **Separated Type (Large Scale)**



- **Integrated Type**

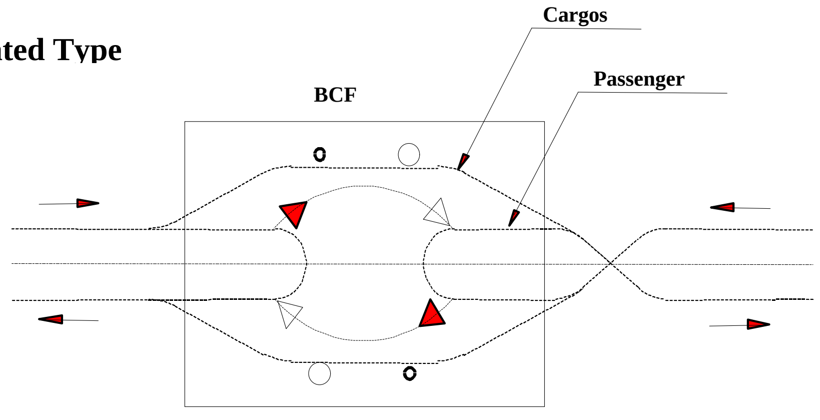


Figure 5.5.1
Type of the BCF

5.5.2 Flow of Passengers and Cars in the BCF

5.5.2.1 The Lao PDR - BCF

(a) Passengers by shuttle and tour buses

Departure side :

Passengers leaving the country by the local shuttle buses arrive from the existing city bus terminal and get out of local buses at the rotary located just before the immigration office in the BCF.

Various departure formalities (custom, immigration and health) will be done in the open area under the spacious roof shed, where custom counters, guide rails, immigration counters, and entry/exit fee booths are provided.

After formalities, the passengers will proceed and be transferred to the cross border shuttle bus stops and get on the shuttle buses, which just come from Thailand to pick up the departing passengers from the Lao PDR.

On the other hand, the passengers who use tour buses have their formalities carried out by the licensed bus company staff on behalf of the passengers.

Arrival side;

Passengers arriving from Thailand by using a shuttle bus will get out at the area just before the immigration / custom offices and proceed to carry out arrival formalities.
After formalities, the passengers will proceed to the adjacent public bus stops or parking lots for taking either the local shuttle bus, tuk-tuk or their friends' cars to go to their destinations.

(b) Passengers by cars

Passengers leaving the Lao PDR by cars will be inspected under the inspection shed provided at the center of the BCF while basically sitting in the car. After formalities, the cars will leave for Thailand or temporarily park at the parking lot provided (after the checking shed and beside the duty free shops).

(c) Cargo trucks

Cargo trucks are divided into two types : loaded and non-loaded in terms of the loading condition. The non-loaded trucks will be normally inspected under the inspection shed. On the other hand, the loaded trucks will have their goods inspected (timber, etc.) at the other inspection area located outside of the normal inspection area. This area includes the inspection pit, weighing scale (arrival side only) and wide parking area provided before and after the inspection shed, where grouped trucks can park and wait for their party.

5.5.2.2 Thailand BCF

(a) Passengers by shuttle and tour buses

Departure side;

Passengers leaving the country by using local shuttle buses arrive from the existing city bus terminal and get out of the buses at the bus parking lot located just before the immigration office in the BCF.

Various departure formalities (custom, immigration and health) will be done in the open area under the spacious roof shed protecting passengers from intense sunshine and rainfalls, where custom counters, guide rails, immigration counters and entry/exit fee booths are provided.
After formalities, the passengers will proceed to the waiting area and get on the cross border shuttle bus, which has just come from the Lao PDR BCF to pick up the departing passengers.
On the other hand, the passengers who have used tour buses arriving at the BCF will have formalities carried out by the licensed bus company staff on behalf of the passengers.

Arrival side;

Passengers arriving from the Lao PDR by using the cross border shuttle bus will get off at the area just before the immigration/custom offices and proceed for arrival formalities. After formalities are completed the passengers will proceed to the adjacent public bus stops and get on the public shuttle bus, or proceed to the parking lot and take a tuk-tuk or other car to go to their destinations.
Passengers using tour buses coming from the Lao PDR may cross the border while staying in the buses, and formalities can be done through papers by the licensed bus company staff on behalf of the passengers. However, declaration on custom clearance, if any, could be done beforehand.

(b) Passengers by cars

Passengers leaving the country by car will be inspected while sitting in the cars under the inspection shed provided at the center of the BCF. After formalities, the cars will leave for the Lao PDR BCF.

(c) Cargo trucks

Cargo trucks are divided into two types: loaded and non-loaded in terms of the loading condition. The non-loaded trucks will normally be inspected under the inspection shed. On the other hand, the loaded trucks will have their goods inspected (timber, etc.) at the other inspection area located outside of the normal inspection area. This area includes the inspection pit, weighing scale (arrival side only) and inspection shed, where grouped trucks can park and wait for their party.

5.6 CIVIL WORKS

The construction sites for the BCF need various civil work arrangement. The following are major civil items considered.

5.6.1 Earth Work

The BCF sites will be initially cleared and grubbed by cutting trees and removing existing roots in both the Lao PDR and Thailand BCF.

The Lao PDR BCF site needs to be applied with soft rock ripping in both north-west and south-east sides of the site, for which shortage of fill material could be covered by excess soil generated from the adjacent construction site of the connecting road, or borrow pits outside of ROW. The highest formation level of the Lao PDR BCF site has been set up at 151.5m above MSL in consideration of the adjacent levels of approach, connecting roads and the surface water flow as well as the reason for minimizing the rock excavation work of the site. Since the BCF has enough longitudinal slope, no transversal slope for surface drainage will be provided.

The Thailand side BCF will be leveled mainly by embankment. Formation level along the centerline of the BCF has been determined in consideration of the levels of the adjacent approach and connecting roads. Since the very gentle longitudinal slope is applied, 2% of transversal slope is provided for the purpose of surface water drainage.

In order to avoid damages to the embankment slope due to erosion, slope protection dikes will be provided along the shoulder of the slopes.

5.6.2 Surface Water Drainage System

The roads in the BCF have been designed to have the width ranging from 4.0m to 12m so as to meet with the traffic and operational conditions as shown on the layout drawings.

The surface water in the BCF premises will be collected into the road side drains which consist of RC V-ditches, RC pipe culverts, manholes and other miscellaneous drainage structures. Surface water collected by the road side drains will be led to slope chute drains and discharged into open channel provided along the toe of the slopes. Surface water in the outside leveling area will be blocked by the slope protection dikes and led to the slope chute drains and discharged into the open channel provided along the toe of the slopes.

In the Lao PDR BCF, all collected surface water will be discharged into the Mekong River through the road side ditches of the approach road in the west side and discharged into natural stream in the east side separately.

In the Thailand BCF, all collected surface water will be discharged into the adjacent river located at 100m east of the BCF through the road side ditches of the approach road.

For calculation of the run-off volume of the surface water, the following rational formula is applied. The figures applied for calculation are as follows :

$$Q = \frac{f \bullet r \bullet A}{360}$$

where Q = Run-off discharge (m^3/s)

f = Run-off coefficient (0.8~0.9)

r = Rain-fall intensity (=120mm/hr equivalent to 5-years return period propability)

A = Catchment area (ha)

5.6.3 Pavement

The traffic road in the premises as well as in the parking areas will be paved by the weld-mesh reinforced concrete slabs with 25cm thickness and provided with the expansion joint in both directions at about 10m intervals. Thickness and subgrades has been decided in conformity with the AASHTO design standard. Concrete curve stones will be provided at edges of the road pavement against the islands, walkways and sodding area.

The interlocking block pavement will be employed for the walkways and other accessible area by passengers in the premises. All slope sides of embankment and ripping area will be protected from the scouring by rainfalls with sodding .

5.6.4 Security Provision

Two-meter high fencing with barbed wire head is provided to all around the perimeters of the BCF. The fencing includes entrance gates and a check point facility at the connection point with approach and connecting roads.

5.7 BUILDING

5.7.1 General

The Border Control Facilities (BCF) contain various kinds of buildings and facilities for the purpose of executing immigration formalities, custom inspection, operation and maintenance of the facilities which are listed in Section 5.4.2. The design of the buildings have been done under the following consideration.

(1) Laws, Codes and Units

The laws, codes, standards and units used for designing have been discussed in the preceding Section 5.4.7.

(2) Floor Area

The floor area of the main office which involves custom and immigration office has been determined to have a moderate floor area to accommodate the following number of officials requested by the appropriate authorities (Table 5.7.1).

Table 5.7.1
Number of officials required for BCF

Main Offices	The Lao PDR BCF	Thailand BCF
Custom	20	20
Immigration	30	30+10 ∠1
Quarantine	5	5
Operation and maintenance	15 (Bridge Operation)	-
Total	**70**	**65**

∠1: ten officials may consist of 3 for labor, 2 for insurance, 3 for operation and maintenance, and 2 for travel information services.

The unit floor area employed for an official varies from 8.0 to 11m^2 depending on the working conditions.

(3) Structural Consideration

(a) Foundations

Based on the result of the geological investigation, the foundation of the buildings in the Lao PDR BCF are designed to have a spread footing resting on the stiff sand strata, except for the south area where the position of supporting strata seems to exist lower than the other area, and it is recommended to execute an additional geological investigation during the construction stage to verify its position. On the other hand, the Main Office buildings, toilets and spacious structural roofs in the Thailand BCF utilize prestressed concrete piles of approximately 300mmϕ x 18m long resting on the stiff substrata due to the existing loose substrata in the elevation.

The precast concrete piles with short length are used for minor such structures as diesel engine foundations, water receiving tanks, sign boards, garbage dust bins, islands to protect against possible uneven earth settlement.

(b) Meteorology Consideration

Various meteorological factors studied in the Area have been taken into consideration for designing of all facilities. The major items considered are as follows :

- Air Temperature
- Wind Velocity
- Seismic Coefficient

- Air Temperature :

Thermal effect on the structural steel design have been incorporated based on the past record at sites, of which variation used are as follows :

For concrete structure +10 to 40°C
For steel structure +10 to 55°C

- Wind Velocity :

Wind load have been considered specifically on the structural steel design by using the value of V50 = 48m/sec taken from the past record at sites. This load is also used for other facilities in the Project.

- Seismic Coefficient :

There have been no specific past seismic record around the site Area. However, for more safety, all facilities including Main Bridge have been considered under seismic effect with applying load equivalent to 6% of the dead load to the structures.

(c) Structural Materials and Loads :

↑ Loads

All dead load and live load were calculated in accordance with the EIT (The Engineering Institute of Thailand) or ASCE (American Society of Civil Engineer) standard.

↑ Structural Materials

The following structural materials are used for structural design :

- Reinforced concrete for all structural frames :
  (Cylinder compressive strength at 28 days)
  fc’ = 240 kg/cm^2
- Lean Concrete :
  fc’ = 150 kg/cm2
- Reinforced steel bars :
  Deformed bar SD = 40 (TIS 24 – 2527)
  Round bar SD = 24 (TIS 20 – 2527)
- Structural steel shaped and plates (TIS) :
  Fy = 2,500 kg/cm^2

5.7.2 Building Design Features

(1) Main Offices

The building contains various offices such as immigration, custom, quarantine, labor control, insurance and other incidental offices.

The main office at the Lao PDR BCF consists of three main bays : arrival office, departure office and center service office. Each office is designed to be a two-story reinforced concrete framing structure with a clay brick walls. All offices are linking with each other through the connection corridor provided on the 2nd floor. In the wide open area on the ground floor surrounded by the three offices, several inspection booths for processing formalities are provided. A vehicle inspection area including several islands is provided both in the north and south sides of the office block. All of those buildings and inspection areas are covered by the one-combined large structural steel roof.

The main building at the Thailand BCF consists of two main offices located at arrival and departure sides. Each office contains immigration, custom and other rooms and is designed to be a two-story reinforced concrete framing structure with clay brick walls. The offices are linking with each other by a large spacious steel roof, under which the arrival and departure formalities area with several inspection booths are provided.

The spacious structural steel roofs are designed to be a uniform spacious roof rigid frame fabricated by steel tube members and are covered by the formed steel roofing. The roof frames are supporting by several circular reinforced concrete columns.

(2) Public Toilet

A public toilet is 3.5m by 10m floor area containing men, women toilet rooms and a handicapped booth. The toilet is designed to be a single story reinforced concrete framing structure with clay brick walls, in which an appropriate number of sanitary ware such as water-closet, urinal, lavatory sink and mirror are provided. The interior of rooms are finished with a ceramic floor tiles, porcelain wall tiles and suspended rockwool ceiling boards.

(3) Bus Stops

A bus stop provided at the Lao PDR BCF is designed to have approximately 3m span by 64m long floor area with reinforced concrete columns and beams, on which steel framed conventional shape roof is provided to match appearance with the adjacent main office building.

(4) Officer's Car Parking Area

The car parking area contains an appropriate number of parking lot with a standard unit area of 2.5m by 5.0m. The car parking roof shed is design to be a steel tube framing construction on the concrete foundation to match appearance with main office building.

(5) Accommodation for Officers

The Lao PDR BCF contains the accommodation building for ten single and three family officers located in the south-east corner of the BCF site. The building consists of two ridges : for single and for family. Both of them are designed to be a single story rectangular shape building with reinforced concrete framing structure and steel formed roofing. Two buildings contain bed rooms and other necessary rooms and utilities. The buildings have a conventional style to match appearance with the main office building.

(6) Booths

Inspection Booths contain two cells for immigration and custom officers and designed to be a fabricated aluminum box with 2.4m by 4.0m long floor area. The booths are provided with an air-conditioned unit per cell and all other necessary accessories needed to its functions.

5.7.3 Finishes and Architectural Treatment

(1) Finishing

All buildings are finished with a local made ceramic tiles and paint to exterior walls. The roof of the main office and toilets are waterproofed by a urethane waterproofing membrane protected by a reinforced thin concrete covering. The glass fiber insulation sheet is provided on the underside of the roof slabs.

Most office rooms are finished with vinyl floor tiles, painting on cement plastered walls and suspended rockwool acoustical tile ceiling, while the ground floor corridor and staircase floor are finished with marble stone blocks for protecting against possible abrasion due to the traffic. Toilets and similar rooms or portions are finished with porcelain tiles to walls and unglazed ceramic tiles to floors. The toilets and similar rooms located on the second floor are waterproofed. All finish materials are selected for its best local quality, durability and easy maintenance.

(2) Architectural Treatment

The main office building in the Lao PDR BCF is considered to be a contemporary modern building with due consideration of the conventional Laotian style ornamentation. Incidentals of other buildings are also treated to match appearances with the main office building.

The main office and other buildings in Thailand BCF are given with a contemporary modern architectural treatment with functionality and simple appearance by decreasing unnecessary ornamentation.

5.8 UTILITY DESIGN CONDITION OF THE BCF

5.8.1 Laws and Codes

All utilities of the facilities are designed basically in conformity with the requirements of the local and other applicable international electrical and mechanical codes as follows:

- International Electromechanical Commission (IEC)
- Illuminating Engineering Society (IES)
- Thai Industrial Standard (TIS)

5.8.2 The Lao PDR Side

(a) Electrical Design Condition

(Power receiving)

- Rated receiving voltage : 22kV
- Phase : 3 (three)
- Frequency : 50 Hz
- Receiving from the Electricite du Laos (EDL)

(Power supply)

- Rated voltage : 380-220V
- Phase : 1 (one) and 3 (three)
- Frequency : 50 Hz

(Power supply area)

All utilities as follows:

- Buildings, booths and public toilets in the BCF
- Lighting
  Outdoor lighting in the BCF
  Roof structures
  Road from the BCF to the Route 9
  Road from the BCF to the Bridge
  Bridge (half of total, separated from Thailand at the center of the Bridge)
- Accommodation for officers
- Water supply system

(Telephone line)

- Receiving from the Lao PDR Telecom.

(b) Mechanical Design Condition

(Water source)

- City main pipe from the existing water purification plant in Savannakhet

(Water supply area)

- Main office in the BCF
- Public toilets in the BCF
- Accommodation for officers

(Air temperature)

- Maximum outdoor : 39.5 °C (April, mean)
- Recommended indoor : 26.0 °C

(Ventilation)

- Recommended air volume : 30 m^3/h*men

5.8.3 Thailand Side

(a) Electrical Design Condition

(Power receiving)

- Rated receiving voltage : 22kV
- Phase : 3 (three)
- Frequency : 50 Hz
- Receiving from the Provincial Electricity Authority (PEA)

(Power supply)

- Rated voltage : 380-220V
- Phase : 1 (one) and 3 (three)
- Frequency : 50 Hz

(Power supply area)

All utilities as follows:

- Buildings, booths and public toilets in the BCF
- Lighting
  Outdoor lighting in the BCF
  Roof structures
  Road from the BCF to the Bridge
  Bridge (half of total, separated from the Lao PDR at the center of the Bridge)
- Water supply system

(Telephone line)

- Receiving from the Telecommunication of Thailand (TOT)

(b) Mechanical Design Condition

(Water source)

- Well (new construction)

(Water supply area)

- Main office in the BCF
- Public toilets in the BCF
- Check point and toll office

(Air temperature)

- Maximum outdoor : 40.6 °C (April, mean)
- Recommended indoor : 26.0 °C

(Ventilation)

- Recommended air volume : 30 m^3/h*men

5.8.4 Utility Plan of the Lao PDR Side

Based on the design conditions of the BCF-utilities (Chapter 5.8.2), the utility plan for the BCF is described in the following chapter.

(1) Power Supply System

(a) General

The BCF receives the electric supply from EDL's (Electricite du Laos) transmission line (T/L) located in the provincial road running along side the Mekong River at the Disconnecting Switch (DS) mounted on the pole in the power house area.

(Power Source)

- Rated Voltage : 22kV
- Phase : 3 (three)
- Frequency : 50 Hz

The incoming power source is transformed from 22kV to 400/230V by the transformer (Tr) mounted on the pole at the 2 (two) point. The one point is power house area and the other is acommodation area. The power transformed at the power house area is distributed to each facility in the BCF (excluding the acommodation) and half of the Lao PDR side Bridge. On the other hand, the power transformed at the accomodation area is distributed to the facility in the acommodation and the road from BCF to Route 9. The high voltage transmission line (22kV) from the provincial road to the power house is constructed by EDL. The line from the power house to the acommodation is constructed by the Contractor. The share of expense for both sides are paid by the Contractor.

The electric meter will not be separated for the Immigration Office and the Custom Office since its account is covered by the operation system of the Lao PDR Bridge Operating Committee.

According to the BCF’s opening time (assumed to be from 6:00 hrs to 20:00hrs), some electric power loads may need to be covered by an emergency generator system. For easy maintenance, a diesel generator (DG) which has the following minimum required capacity will be installed in the DG room in the power house.

Minimum required load capacity

- Indoor emergency lighting
- Power outlet for computer system
- Water supply system
- Fire hydrant system
- Public announcing system
- Telephone system

(b) Load

(Power house area)

Indoor lighting	:	74.2	kVA
Air conditioner and Pumps	:	300.7	kVA
Other load	:	184.6	kVA
For DG (including above load)	:	66	kW

(Accommodation area)

Indoor lighting	:	21.6	kVA
Air conditioner	:	81.5	kVA
Other load	:	48.4	kVA

(c) Transformer Capacity

The load factor is as follows ;

- Indoor lighting	(under 10kVA)	:	100%
	(over 10kVA)	:	60%
- Air conditioner and Pumps		:	80%
- Other Loads		:	100%

According to the load requirement, the equipment load is as follows ;

(Power house point TR1)

10 x 100% + (74.2-10) x 60% + 300.7 x 80% + 184.6 x 100% = 483.4 kVA

(Acommodation point TR2)

10 x 100% + (21.6-10) x 60% + 81.5 x 80% + 48.4 x 100% = 130.6 kVA

According to the above calculation and future extention, one 500kVA transformer is installed in the power house area. On the other hand, one 500kVA transformer is installed in the acommodation area because of future plan for bonded warehouse.

(d) Emergency Diesel Generator System

(d)-1 Specifications

- Rated output voltage : 400 – 230 V
- Phase : 3 (three)
- Frequency : 50 Hz
- Fuel oil : Heavy Oil

(d)-2 DG Capacity

(d)-2-1 Total DG Load (K)

The total DG Load is 66 kW (Approx.).

(d)-2-2 Output Capacity Factor (RG)

The following factors will be calculated, the maximun factor will be selected for calculation of the DG capacity.

- RG1 : Rated Load factor
- RG2 : Feasible Voltage Drop factor
- RG3 : Short-time Overcurrent Capacity factor
- RG4 : Feasible negative-phase-sequence Current factor

(d)-2-2-1 Rated Load Factor (RG1)

RG1=1.47*D*Sf

D : Demand factor (=1.0)
Sf : Unbalanced load factor
Sf=1+0.6*(ΔP/K)
ΔP : Total of 1 phase unbalanced load [kW]
K : Total DG load [kW]

(d)-2-2-2 Feasible Voltage Drop Factor (RG2)

RG2= ((1-ΔE) / ΔE)*Xd'g*(ks/Z'm)*(M2/K)

ΔE	:	Feasible voltage drop of DG (20%=0.2)
Xd'g	:	Impedance at timing of load throwing (=0.25)
Ks	:	Starting method factor
Direct starting = 1.0		
Star-delta starting = 0.67		
Z'm	:	Load impedance at starting (=0.14)
M2	:	Output load which has maximum voltage drop at starting [kW]
K	:	Total DG load [kW]

(d)-2-2-3 Short-Time Overcurrent Capacity Factor (RG3)

RG3= (fv1/KG3)*(1.47d+((ks/Z'm)-1.47d)*(M3/K))

fv1 : Load throwing reduction factor by instantaneous rotation decline and voltage drop (=1.0)
KG3 : Short-time overcurrent capacity (=1.5)
d : Demand factor of base load (=1.0)
ks : Starting method factor
Direct starting = 1.0
Star-delta starting = 0.67
Z'm : Load impedance at starting (=0.14)
M3 : Output load which has maximum Short-time overcurrent capacity [kW]
K : Total DG load [kW]

(d)-2-2-4 Feasible Negative-Phase-Sequence Current Factor (RG4)

RG4= (1/KG4)*0.432*(R/K)

KG4 : Feasible negative-phase-sequence current factor of DG (=0.15)
R : Total of harmonic load [kW]
UPS = 35kW
K : Total DG load [kW]

RG4= (1/0.15)*0.432*(35/66)= 1.53

(d)-2-2-5 DG Capacity (G) [kVA]

G = RG*K

RG : Maximum RG
K : Total DG load [kW]
The capacity of the DG is 120kVA according to the above calculation.

(d)-2-3 Engine Output Capacity

The following factors will be calculated. The maximum factor will be selected for the calculation of the engine capacity.

- RE1 : Rated load factor
- RE2 : Feasible change rotation factor
- RE3 : Feasible maximum output capacity factor

(d)-2-3-1 Rated Load Factor (RE1)

RE1=1.3D

D : Demand factor (=1.0)

(d)-2-3-2 Feasible Changing Rotation Factor (RE2)

$RE2=fv2(1.206d*(1-(M'2/K))+(1.163/\varepsilon)*(ks/Z'm)*\cos\theta s*(M'2/K))$

d	:	Demand factor of base load (=1.0)
ε	:	Feasible throwing capacity of engine at no-load (=1.0)
ks	:	Starting method factor Direct starting = 1.0 Star-delta starting = 0.67
Z'm	:	Load impedance at starting (=0.14)
cosθs	:	Power factor of load at starting (=0.7)
M'2	:	Output load which has maximum changing rotation [kW]
K	:	Total DG load [kW]
fv2	:	Load throwing reduction factor by instantaneous frequency decline and voltage drop (=1.0)

(d)-2-3-3 Feasible Maximum Output Capacity Factor (RE3)

$RE3=(fv3/\gamma)*(1.368d(1-(M'3/K))+1.163*(ks/Z'm)*\cos\theta s*(M'3/K))$

fv3	:	Load throwing reduction factor by instantaneous frequency decline and voltage drop (=1.0)
γ	:	Short-time maximum output capacity of engine (=1.1)
d	:	Demand factor of base load (=1.0)
ks	:	Starting method factor Direct starting = 1.0 Star-delta starting = 0.67
Z'm	:	Load impedance at starting (=0.14)
cosθ s	:	Power factor of load at starting (=0.7)
M'3	:	Output load which has maximum output capacity of engine at throwing [kW]
K	:	Total DG load [kW]

(d)-2-3-4 Engine Output Capacity (E) [PS]

$E = 1.36RE*K*Cp$

RE	:	Maximum RE (=1.60)
K	:	Total DG load [kW]
Cp	:	Revising factor of engine output capacity (=1.06)

The output capacity of the engine is 150 PS according to the above calculation.

(2) Outdoor Lighting System

(a) General

The outdoor lighting system is installed outside of the buildings. The facilities with lighting are as follows:

- Road (power supply only)
- Parking lot
- Bridge (power supply only)
- Other facilities which require lighting

The following types of lighting fixture is installed in each Facility.

- High mast lighting fixture

HID (Sodium lamp) 400W x 10 with motor operation winch
High mast = 30m
Installed in the road, parking and other area in the BCF

- Pole lighting fixture

Mercury lamp 100W x 1
Lighting pole H=5.5m
Installed in the acommodation garden

b) Recommended levels of illumination

- Road in the BCF	:	22 lux
- Parking lot	:	22 lux
- Accommodation garden	:	10 lux

(3) Water Supply System

(a) General

The water supply system is used only for toilets and washing up. The drinking water is supplied using mineral water from the nearby market.
The city water from the water purification plant in Savannakhet will be received at the water tower-1. Then, the water will be distributed to the water tower-2, roof top tank, buildings, public toilets, outdoor faucets for sprinkle and other required place by gravity.
The water stored in the water tower-2 will be distributed to the accommodation and near area which require the water.
The water purification plant in Savannakhet has 4 (four) sets of pumps to provide the water into the surrounding area. The capacity of 1 (one) set of pump is as follows :

- Flow rate	:	350 (m^3/h)
- Lift head	:	45 (mH_2O)
- Power input	:	3 phase 380V
- Motor load	:	75 (kW)

(b) Water supply volume

(b)-1 Calculation for water supply volume (b)-1-1 Calculation by the number of men (qd) [l/d]

qd=N*q

N : Number of men
q : Necessary water supplying volume for one man per day[l/d]

(b)-1-2 Calculation for average water supplying volume per hour (qh) [l/h]

qh=qd/t

t : Average using time per day [h]

(b)-1-3 Total of ‘qh’ (Qh) [l/h]

Qh=qh1+qh2+ - - -
qh1,qh2, - - -: (For example) qh1 = Officer’s ‘qh’
qh2 =Guest’s ‘qh’

(b)-1-4 Maximum water supply volume per hour (Qhm) [l/h]

Qhm=K1*Qh

K1 : Factor of maximum water supply volume per hour

(b)-2 Calculation for receiving tank volume (QTW) [m3]

QTW=Qhm*t1/1000

Qhm : Maximum water supply volume per hour [l/h]
t1 : Storage time [h]

(b)-3 Calculation for tank volume (QTWH) [m3]

QTWH=Qhm*t2/1000

Qhm : Maximum water supply volume per hour [l/h]
t2 : Storage time [h]

(b)-4 Results of Calculation for the water tank (Incl. outdoor faucet volume)

Water tower-1 : $10m^3$

Water tower-2 : $5m^3$

(4) Waste Water Drainage System

(a) General

The waste water from the toilets and others will drain to the respective septic tanks. The water treated by septic tanks is discharged into the surface water drain manhole and discharged into the Mekong River finally.

(b) Regulation of the Discharged Water Quality

The regulation of the discharged water quality in the Lao PDR follows those of Thailand. According to the Thailand Building Code, the water quality requirements of the effluent which is able to be discharged to the river is as follows :

Table 5.8.1 Water Quality Requirements

Classification	BOD (mg/l)	SS (mg/l)
A	20	30
B	30	40
C	60	50
D	90	60

Remarks : Facility Area under roof (m^2) A.>55,000 >B>10,000>C>5,000>D

The BCF can be classified into ‘C’ (about 6,400m^2). Therefore, requirement of the water quality is under 60 (mg/l) in BOD and under 50 (mg/l) in SS.
Based on the above consideration, the specifications of the septic tank will be selected as follow:

BOD = under 60 mg/l
SS = under 50 mg/l

(c) Calculation of design number for treatment (n)

(c)-1 For office

n1 = 0.06 *A

A : Room area (m^2)

(c)-2 For public toilet

n2 = N *F

N : Number of passenger =13500person/day*one way
(SAPROF estimated)
F : Percentage of toilet user against N =0.5%

(c)-3 For residental

n3 = 5+(A-100)/30

A : Room area (m2)

(c)-4 Results of design number for treatment

The desing number for treatment is esstimated as follows base on the above calculation.

Main office	:	90 person
Check point office	:	1 person
Public toilet (Arrival side)	:	68 person
Public toilet (Departure side)	:	68 person
Accommodation (Family)	:	11 person
Accommodation (Single)	:	13 person

(5) Building Electric System

(a) Lighting System

The lighting system is installed in the inside of the buildings. The indoor lighting type is a fluorescent fixture in general. The facilities with lighting are as follows:

- Main office rooms
- Public toilet (arrival / departure)
- Booths and check point booths
- Accommodation
- Other facilities which require lighting

The required number of lighting is calculated by flux method. The recommended level of illuminance is based on the IES standard.

(b) Power Outlet System

The required number of power outlets is installed in indoor rooms. The power outlet which supplies power for the computer system is connected with the emergency Diesel Generator (DG) circuit through the Uninterrupted Power Supply (UPS).

(c) Public Announcing System

The announcing zone will be outside the BCF building. The sound source is a microphone or a tape recorder. The system is operated by the operation unit installed in the information counter of the arrival side of the immigration office.

(d) Private Telephone System

The required number of external / internal lines and outlets is installed in the Main Office.

(e) TV System

The UHF/VHF antenna, TV outlets and wiring is installed in the office buildings.

(f) Computer System

The scope of work is that only outlet and wiring will be installed in each computer room and booth. The wiring is connected to the DG circuit through the UPS. The scope of work covers only power outlet, power cable and empty conduit (for future LAN cable) which are installed in each computer room and booths which require a computer.

(g) Lighting Protection System

The required number of lightning rods are installed in several high-level places at the main office. Each lightning rod is connected to a grounding electrode which is only used for the lightning system (under 5 ohm).

(h) Grounding System

Several grounding electrodes are installed under the ground. All equipment which need power sources are connected to these grounding electrodes.

(6) Building Mechanical System

(a) Plumbing work

The PVC pipe shall be installed in the buildings which have toilet, kitchen and/or pantry. The PVC pipe classified 13.5 is used for water supply pipe, classified 8.5 is used for drainage pipe.

(b) Air-conditioner and Ventilation System

Air conditioner units and ventilation units will be installed in each room and booth. The air conditioner selected is the split type. The ceiling recessed type ventilations are used basically for the office rooms, meeting rooms, VIP rooms etc. and wall mounted type ventilations are used for other rooms.

(c) Fire Fighting System

The required number of hand held extinguishers are installed in the main office, booths and acommodation.
The fire hydrant system is installed in the BCF to protect and cover the main office building.

5.8.5 Utility Plan of Thailand Side

Based on the design conditions of the BCF-utility (Chapter 5.8.3), the utility plan of the BCF is described in this chapter.

(1) Power Supply System

(a) General

The BCF receives the electric supply from PEA's (Provincial Electricity Authority) transmission line (T/L) located in the national highways Route No. 212 (HWY 212) at the Disconnecting Switch (DS) mounted on the pole near the power house.

(Power Source)

- Rated Voltage	:	22kV
- Phase	:	3 (three)
- Frequency	:	50 Hz

The incoming power supply will be transformed from 22kV to 400/230V by the transformer (Tr) mounted on the pole. The transformed power will be distributed to each facility or equipment.
A separate electric meter will be supplied for Immigration, Custom and outdoor facility because of separate administration in each Department.
According to the BCF's opening time (assumed to be from 6:00 hrs to 20:00hrs), some electric power loads may need to be covered by an emergency generator system. For easy maintenance, a diesel generator (DG) which has the following minimum required capacity will be installed in the DG room in the power house.

Minimum required load capacity

- Indoor emergency lighting
- Power outlet for computer system
- Water supply system

- Public announcing system
- Telephone system

(b) Load

Indoor lighting	:	46.8	kVA
Air-conditioner and Pumps	:	219.3	kVA
Other load	:	166.2	kVA
For DG (included load above)	:	53	kW

(c) Transformer Capacity

The load factor is as follows ;

- Indoor lighting	(under 10kVA)	:	100%
	(over 10kVA)	:	60%
- Air-conditioner and Pumps		:	80%
- Other Loads		:	100%

According to the load requirements, the equipment load below is as follows ;

10 x 100% + (46.8-10) x 60% + 219.3 x 80% + 166.2 x 100% = 388.4 kVA

According to the calculation above, one number 500kVA transformer is installed in the power house area.

(d) Emergency Diesel Generator System

(d)-1 Specifications

- Rated output voltage	:	400 – 230 V
- Phase	:	3 (three)
- Frequency	:	50 Hz
- Fuel oil	:	Heavy Oil

(d)-2 DG Capacity

(d)-2-1 Total DG Load (K)

The total DG Load is 53 kW (Approx.).

(d)-2-2 Output Capacity factor (RG)

The following factors will be calculated. The maximun factor will be selected for calculation of the DG capacity.

- RG1 : Rated Load factor
- RG2 : Feasible Voltage Drop factor
- RG3 : Short-time Overcurrent Capacity factor
- RG4 : Feasible negative-phase-sequence Current factor

(d)-2-2-1 Rated Load factor (RG1)

RG1=1.47*D*Sf

D : Demand factor (=1.0)
Sf : Unbalanced load factor

Sf=1+0.6*(ΔP/K)

ΔP : Total of 1 phase unbalanced load [kW]
K : Total DG load [kW]

(d)-2-2-2 Feasible Voltage Drop factor (RG2)

RG2= (1-ΔE) / ΔE)*Xd'g*(ks/Z'm)*(M2/K)

ΔE : Feasible voltage drop of DG (20%=0.2)
Xd'g : Impedance at timing of load throwing (=0.25)
Ks : Starting method factor
Direct starting = 1.0
Star-delta starting = 0.67
Z'm : Load impedance at starting (=0.14)
M2 : Output load which has maximum voltage drop at starting [kW]
K : Total DG load [kW]

(d)-2-2-3 Short-time Overcurrent Capacity factor (RG3)

RG3= (fv1/KG3)*(1.47d+((ks/Z'm)-1.47d)*(M3/K))

fv1 : Load throwing reduction factor by instantaneous rotation decline and voltage drop (=1.0)
KG3 : Short-time overcurrent capacity (=1.5)
d : Demand factor of base load (=1.0)
ks : Starting method factor
Direct starting = 1.0
Star-delta starting = 0.67
Z'm : Load impedance at starting (=0.14)
M3 : Output load which has maximum Short-time overcurrent capacity [kW]
K : Total DG load [kW]

(d)-2-2-4 Feasible negative-phase-sequence Current factor (RG4)

RG4= (1/KG4)*0.432*(R/K)

KG4 : Feasible negative-phase-sequence current factor of DG (=0.15)
R : Total of harmonic load [kW]
UPS = 35kW
K : Total DG load [kW]

RG4= (1/0.15)*0.432*(35/66)= 1.53

(d)-2-2-5 DG capacity (G) [kVA]

G = RG*K

RG : Maximum RG
K : Total DG load [kW]

The capacity of the DG is 120kVA according to the above calculation.

(d)-2-3 Engine output Capacity

The following factors will be calculated. The maximum factor will be selected for the calculation of the engine capacity.

- RE1 : Rated load factor
- RE2 : Feasible change rotation factor
- RE3 : Feasible maximum output capacity factor

(d)-2-3-1 Rated load factor (RE1)

RE1=1.3D

D : Demand factor (=1.0)

(d)-2-3-2 Feasible changing rotation factor (RE2)

RE2=fv2(1.206d*(1-(M’2/K))+(1.163/ε)*(ks/Z’m)*cos θ s*(M’2/K))

d : Demand factor of base load (=1.0)
ε : Feasible throwing capacity of engine at no-load (=1.0)
ks : Starting method factor
Direct starting = 1.0
Star-delta starting = 0.67
Z’m : Load impedance at starting (=0.14)
cosθs : Power factor of load at starting (=0.7)
M’2 : Output load which has maximum changing rotation [kW]
K : Total DG load [kW]
fv2 : Load throwing reduction factor by instantaneous frequency decline and voltage drop (=1.0)

(d)-2-3-3 Feasible maximum output capacity factor (RE3)

RE3=(fv3/γ)*(1.368d(1-(M’3/K))+1.163*(ks/Z’m)* cosθ s*(M’3/K))

fv3 : Load throwing reduction factor by instantaneous frequency decline and voltage drop (=1.0)
γ : Short-time maximum output capacity of engine (=1.1)
d : Demand factor of base load (=1.0)
ks : Starting method factor
Direct starting = 1.0
Star-delta starting = 0.67

Z’m : Load impedance at starting (=0.14)
cosθ s : Power factor of load at starting (=0.7)
M’3 : Output load which has maximum output capacity of engine at throwing [kW]
K : Total DG load [kW]

(d)-2-3-4 Engine output capacity (E) [PS]

E = 1.36RE*K*Cp

RE : Maximum RE (=1.60)
K : Total DG load [kW]
Cp : Revising factor of engine output capacity (=1.06)

The output capacity of the engine is 100 PS according to the above calculation.

(2) Outdoor Lighting System

(a) General

The outdoor lighting system is installed outside of the buildings. The facilities with lighting are as follows:

- Road (power supply only)
- Parking lot
- Bridge (power supply only)
- Other facilities which require lighting

The following types of lighting fixture is installed in each Facility.

- High mast lighting fixture
  HID (Sodium lamp) 400W x 10 with motor operation winch

High mast = 30m
Installed in the road, parking and other area in the BCF

(b) Recommended levels of illumination

- Road in the BCF : 22 lx
- Parking lot : 22 lx

(3) Water Supply System

(a) General

The water supply system is used for only toilets and washing up. The drinking water will be supplied using mineral water from the nearby market.
The water from the well which shall be constructed in the power house area will be received at the water tower. Then, the water will be distributed to the buildings, public toilets, outdoor faucets for sprinkle and other required place by gravity.

(b) Water supply volume

(b)-1 Calculation for water supplying volume

(b)-1-1 Calculation by the number of men (qd) [l/d]

qd=N*q

N : Number of men
q : Necessary water supplying volume for one man per day[l/d]

(b)-1-2 Calculation for average water supplying volume per hour (qh) [l/h]

qh=qd/t
t : Average using time per day [h]

(b)-1-3 Total of 'qh' (Qh) [l/h]

Qh=qh1+qh2+ - - -

qh1,qh2, - - -: (For example) qh1 = Officer's 'qh'
qh2 = Guest's 'qh'

(b)-1-4 Maximum water supply volume per hour (Qhm) [l/h]

Qhm=K1*Qh

K1 : Factor of maximum water supply volume per hour

(b)-2 Calculation for receiving tank volume (QTW) [m^3]

QTW=Qhm*t1/1000

Qhm : Maximum water supply volume per hour [l/h]

t1 : Storage time [h]

(b)-3 Calculation for rooftop tank volume (QTWH) [m^3]

QTWH = Qhm*t2/1000
Qhm : Maximum water supply volume per hour [l/h]

t2 : Storage time [h]

(b)-4 Results of Calculation

Tank volume : $10m^3$

(4) Waste Water Drainage System

(a) General

The waste water from the toilets and others will drain to the respective septic tanks. The water treated by septic tanks is discharged into the surface water drain manhole and discharged into the existing stream (Khlong) between the BCF and the Mekong river finally.

(b) Regulation of the Discharge Water Quality

According to the Thailand building code, the water quality requirements of the effluent which is able to be discharged into the river is Table 5.8.1.
The BCF can be classified into 'C' (about 6,000m^2). Therefore, the requirement of the water quality is under 60 (mg/l) in BOD and under 50 (mg/l) in SS.
Based on the above consideration, the specifications of the septic tank will be selected as follow:
BOD = under 60 mg/l
SS = under 50 mg/l

(c) Calculation of design number for treatment (n)

(c)-1 For office

n1 = 0.06 *A

A : Room area (m^2)

(c)-2 For public toilet

n2 = N *F

N : Number of passenger =13500person/day*one way
(SAPROF estimated)
F : Percentage of toilet user against N =0.5%

(c)-3 For residental

n3 = 5+(A-100)/30

A : Room area (m^2)

(c)-4 Results of design number for treatment

The desing number for treatment is esstimated as follows base on the above calculation.

Main office (Arrival side)	:	32 person
Main office (Departure side)	:	32 person
Check point office	:	2 person
Public toilet (Arrival side)	:	68 person
Public toilet (Departure side)	:	68 person

(5) Building Electric System

(a) Lighting System

The lighting system is installed in the inside of the buildings. The lighting type is a fluorescent fixture in general. The facilities with lighting are as follows:
- Main office rooms
- Public toilet (arrival / departure)
- Booths and Check point booths
- Other facilities which require lighting

The required number of lighting is calculated by flux method. The recommended level of illuminance is based on the IES standard.

(b) Power Outlet System

The required number of power outlets are installed in the rooms. The power outlet which supplies power for the computer system is connected with the emergency Diesel Generator (DG) circuit through the Uninterrupted Power Supply (UPS).

(c) Public Announcing System

The announcing zone is outside the BCF building. The sound sources are microphone, tape recorder and/or other means. The system will be operated by the operation unit installed in the information counter of the arrival side of the immigration office.

(d) Private Telephone System

The required number of external / internal lines and outlets is installed in the Main Office. The external line for Immigration and Custom is separated.

(e) TV System

The UHF/VHF antenna, TV outlets and wiring is installed in the office buildings.

(f) Computer System

The scope of work is outlet and wiring only to be installed in each computer room and booth. The wiring is connected to the DG circuit through the UPS. The scope of work covers only power outlet, power cable and empty conduit (for future LAN cable) which are installed in each computer room and booths which require a computer.

(g) Grounding System

Several grounding electrodes are installed under the ground. All equipment which need power sources are connected to these grounding electrodes.

(6) Building Mechanical System

(a) Air-conditioner and Ventilation System

Air conditioner units and ventilation units will be installed in each room and booth. The air-conditioner selected is the split type. The ceiling recessed type ventilations are used basically for the office rooms, meeting rooms, VIP rooms and wall mounted type ventilations are used for other rooms.

(b) Fire Fighting System

According to the Thailand Building Code, the required number of hand held extinguishers are installed in the main office.

CHAPTER 6
Construction Planning

CHAPTER 6 : CONSTRUCTION PLANNING

6.1 GENERAL

This chapter states on the required construction materials, equipment, facilities, construction conditions and schedules. The construction planning is established to optimize the scale of works to be undertaken as a package of contracts containing construction of the Main bridge, Approach Viaducts, Approach Roads, Traffic Changeover, Border Control Facilities and Connecting Roads.

It is proposed that the entire Project be divided into three (3) contract packages as described below, considering the characteristics of the construction components and the size of contracts.

Package 1: Main Bridge, Approach Viaducts (the Lao PDR and Thailand sides), Approach Roads (the Lao PDR and Thailand sides) and Traffic Changeover (Thailand side).

Package 2: Border Control Facility and Connection Road in the Lao PDR side.

Package 3: Border Control Facility and Connection Road in the Thailand side.

Contractors for the above 3 Packages will be procured separately by the following manner.

- Package 1 will be divided into two portions. The one is the portion which belongs to the Lao PDR (the Lao PDR Portion), and the other belongs to Thailand (Thailand Portion). One (1) Contractor will be awarded for the entire scope of works of Package 1 and the Contractor will make contracts with both the Lao PDR and Thailand according to the scope of works of the Lao PDR portion and the Thailand portion, respectively.

- The Contractor of Package 2 will be procured through the International Competitive Bidding (ICB) and will make the contract with the Lao PDR Government.

- The Contractor of Package 3 will be procured through the Local Competitive Bidding (LCB) and will make a contract with the Thai Government.

6.2 CONSTRUCTION PLANNING CONDITION

6.2.1 Natural Condition

The climate in the Project area can be divided into two (2) seasons as follows.

Rainy season: from the middle of April until the middle of October.

Dry season : from the middle of October until the middle of April.

The water level of the Mekong River varies more than 10m within a year. Normally the highest water level occurs in August or September and the lowest water level occurs in March or April as shown in Figure 6.2.1 and 6.2.2.

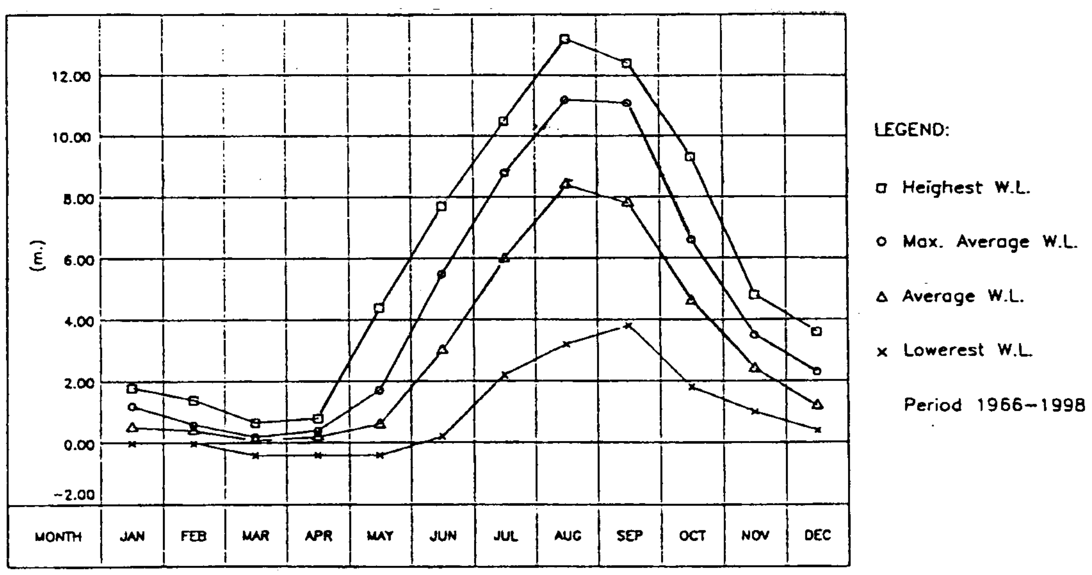


Figure 6.2.1
Gauge Height at Savannakhet Station

The annual fluctuation of the river water level must be carefully taken into consideration for determination of the level of the pile caps and the construction period of the Bridge substructure.

Figure 6.2.2 shows probable monthly maximum and minimum water levels at the Bridge site.

The bottom elevation of the pile caps was determined to secure four (4) month period for pile cap construction.

According to geological conditions, it is a distinct feature of the Project site that medium to hard rock surface exists at quite shallow depths under the ground and the riverbed. This fact will affect selection of methods and equipment proposed for the construction of foundations, piles, piers and abutments.

It should be noted that a limited number of borings were conducted during the Basic Design stage. Therefore, additional boring surveys at the pier locations shall be conducted by the Contractor prior to commencement of the pile construction. The length of the piles and the construction method shall be determined and confirmed based on additional boring surveys. Figure 6.2.3 shows the geological profile along the centerline of the Main Bridge based on the borings carried out at the design stage.

6.2.2 Social Conditions

Estimation of workable days and hours is closely linked to the labor regulations, weather conditions, kind of materials handled etc. Based on the result of surveys and studies, the following has been observed in both the Lao PDR and Thailand.

Labor regulations

According to the Labor regulations in the both countries, the basic working days and hours are 5 days per week and 8 hours per day. There will be no work on Saturdays, Sundays and National holidays without overtime payment.

The actual working days and hours during the construction are assumed to be 28 days per month and 8 hours per day including overtime. Two shifts with actual working hours of 6.5 hours each will be adopted for effective construction of the foundation and substructure in the dry seasons. The Contractor will have two full dry seasons to complete the foundation pile, pile caps and piers.

6.2.3 Construction Components

6.2.3.1 Package 1 (The Lao PDR and Thailand sides)

1) Main Bridge and Approaches

- Substructure (Main Bridge)
- Superstructure (Main Bridge)
- Approach Road from the Border Control Facilities to the Approach Viaduct (the Lao PDR and Thailand sides)
- Approach Viaducts (on both the Lao PDR and Thailand sides)
- Traffic changeover facility in Thailand side

2) Riverbank Protection Work

6.2.3.2 Package 2 (The Lao PDR side)

1) Connection Road from the National Highway Road Route 9 to the Lao PDR Border Control Facility.

- Earth work
- Drainage
- Pavement
- Lighting facilities and other incidental works

2) Border Control Facility

- Civil Works (land reclamation, surface water drainage, road works etc.)
- Building (office buildings and other buildings)
- Water supply and sewage systems (septic tank)
- Electric power supply system
- Communication system
- Lighting system

6.2.3.3 Package 3 (The Thailand Side)

1) Connection road from the national highway Route 212 to the Thailand Border Control Facility

- Earth work
- Drainage
- Pavement
- Lighting system and other incidental works

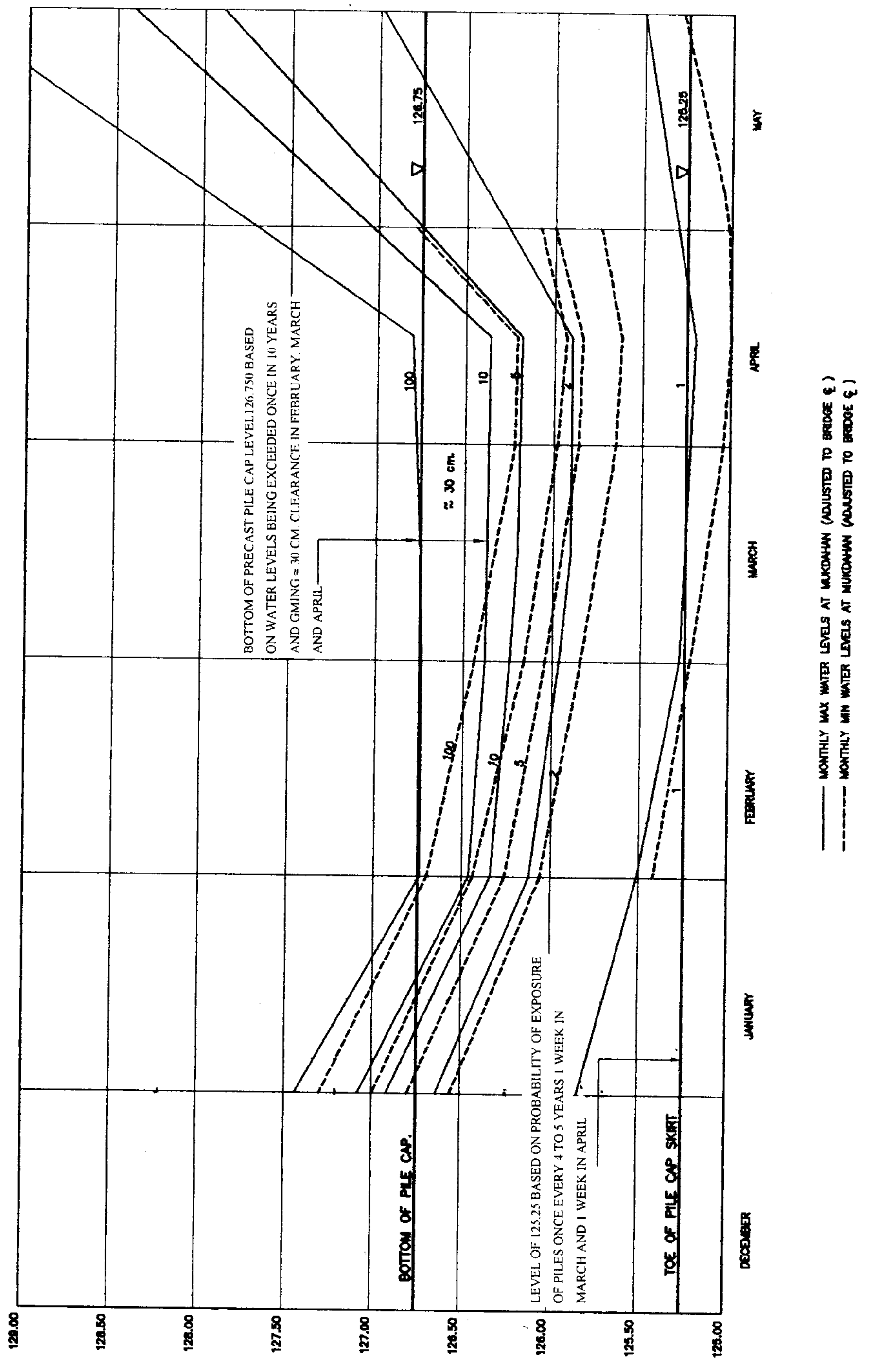


Figure 6.2.2 Probable Monthly Maximum and Minimum Water Level During the Dry Season

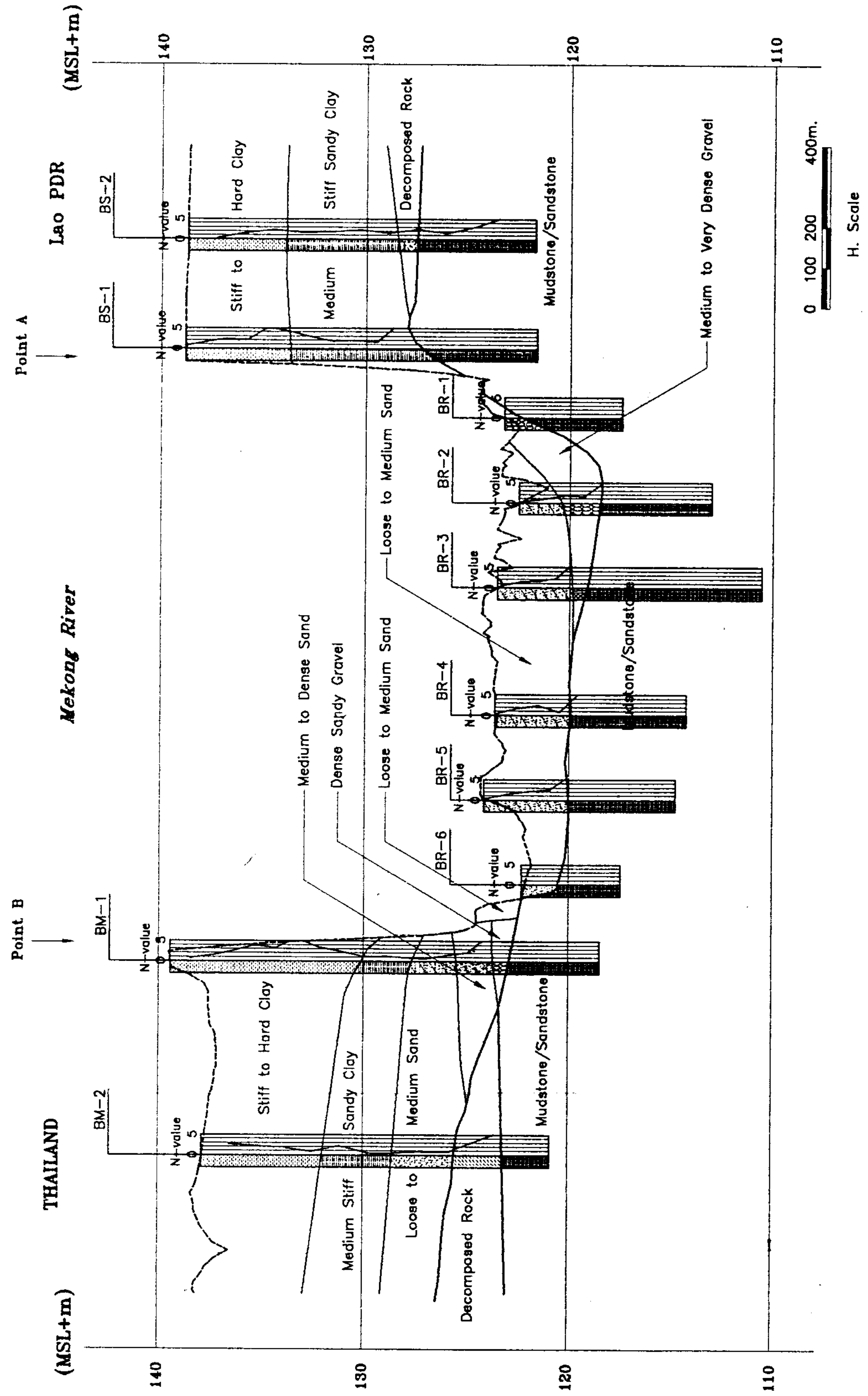


Figure 6.2.3
Geological Profile along the Bridge Centerline

2) Border Control Facility

- Civil Works (land reclamation, surface water drainage, road works etc.)
- Buildings (office buildings and other buildings)
- Water supply and sewage systems (septic tank)
- Electric power supply system
- Communication system
- Lighting system

6.3 PROCUREMENT PLANNING

6.3.1 Construction Material

(1) Concrete aggregate and stone materials

The raw materials for the concrete aggregate and road pavement are planned to be procured from local suppliers who collect them from the Mekong River using a dredging pump located at about 1 km downstream of the Bridge site. The raw materials procured will be washed and screened for concrete aggregate (25 to 5 and less than 5mm). The oversize materials (over 25 mm) will be crushed for road pavement aggregate at the screening plant in the construction yard. If the river aggregate is found unsuitable, it will be obtained from an approved quarry source, either in the Lao PDR or Thailand (see Figure 6.3.1).

Aggregates for high strength concrete, probably concrete with required strength of more than 400 kg/cm^2, shall be obtained from approved quarry sources only.

(2) Embankment materials

The embankment soil for the subgrade and the base course of the Connection Roads will be transported from the borrow areas near the construction site as shown in Figure 6.3.1.

(3) Wooden materials

The wooden materials for construction, such as logs, squares, planks, etc. are available at local saw mills in Savannakhet. Water-proof plywood for concrete formwork will be purchased in Thailand.

(4) Cement and Concrete admixtures

Cement is available in the Lao PDR, but sufficiency of its quality and quantity is not yet proved since these kind of structures need a high quality and a large quantity of cement. The cement is, therefore, planned to be procured in Thailand and it is available in bag packing at Mukdahan market. Cement can also be supplied in bulk by trailer direct from the cement factories near Bangkok.

Except for some special admixtures, almost all of the admixtures for concrete and mortar are available in Thailand. Unavailable admixtures can be readily imported.

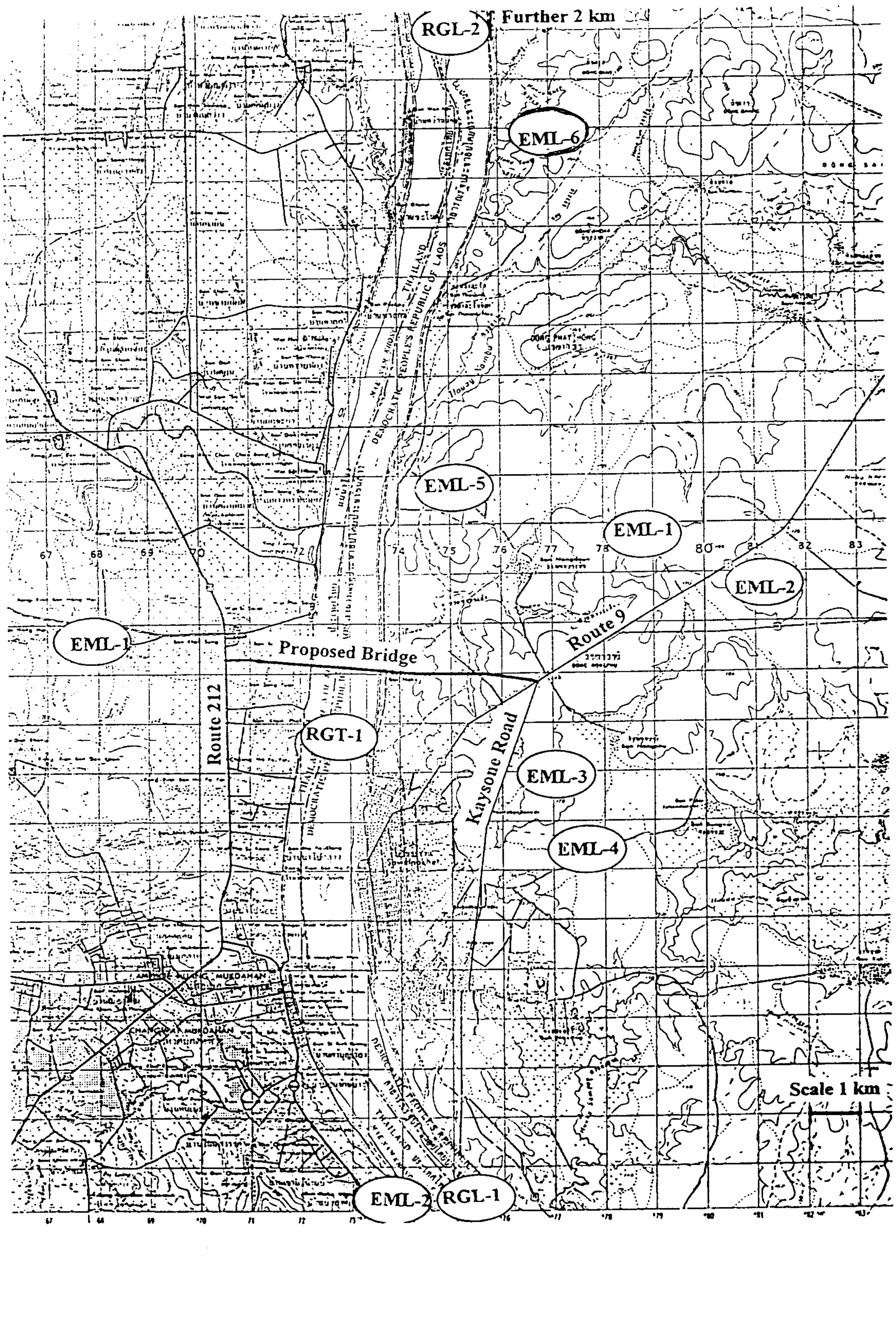


Figure 6.3.1 Location of Possible Soil Borrow Sites and River Gravel Dredging Points

EML = Borrow Site of Embankment Material

RGL = Quarry site of River Gravel and Sand

(5) Steel materials

Almost all of the common steel materials for construction will be procured from Thailand since its quality and quantity are insufficient in the Lao PDR. (The Lao PDR only manufactures a limited amount of small size deformed steel and reinforcing bars.)

PC strand for the box girder construction will be procured from Thailand and PC bars may be imported from Asian or from other countries. PC anchor sets for cables and bars will be procured in Thailand and other Asian countries as necessary.

(6) Others

Special construction material such as epoxy glue for joining the segments will be procured from Thailand and other Asian countries.

Imported or domestic construction materials and equipment through the Bangkok port will be transported by road via Nakhon Ratchasima and Ubon Ratchathani to Mukdahan, where it can then be distributed to the Lao PDR side or Thailand side as shown in Table 6.3.1.

Table 6.3.1
Quantities of Main Construction Materials

Name	Package 1	Package 2	Package 3
Cement (0.3 t/m ^{3})	123,000 ton	750 ton	600 ton
Aggregate for concrete (0.85 t/m^3)	34,000 m^3	2,200 m^3	1,700 m^3
Reinforcement bar (0.15 t/m^3)	6,100 ton	370 ton	300 ton
PC strand	1,300 ton	-	-
Embankment material for road	111,000 m^3	280,000 m^3	70,000 m^3
Asphalt Concrete	1,500 m^3	3,600 m^3	2,800 m^3

6.3.2 Construction Equipment

Heavy equipment to be used for the Bridge will be procured in Thailand. However, if the equipment is unavailable in Thailand, it will be procured from other Asian or neighboring countries. In general, the Bridge construction will be carried out using rental equipment from Thailand, Singapore and/or other countries. Major construction equipment necessary for the Project is shown in Table 6.3.2.

Table 6.3.2
Major Construction Equipment Necessary for the Project

Construction Equipment			
The Lao PDR		**Thailand and Other Countries**	
Bulldozer	15t	Bulldozer	25t
Vibration Roller	3 – 4t	Concrete Pump	11t
Generator	100 KVA	Road Roller	10t
Water Pump	Ø60 mm	Tire Roller	10t
Barge	200t	Asphalt Finisher	3.5m
		Crawler Crane	50 – 150t
		Truck Crane	25t
		Truck Mixer	5.0m^3
		Generator	200 – 600 KVA
		Air Compressor	100 cfm
		Hydro Breaker	
		Vibro Hammer	30 – 90 kW
		Reverse Circulation Drilling Machine	Ø 2,000 mm
		Concrete Plant	60 m^3/h
		Segment Plant	
		Water Pump	Ø100 mm – Ø150 mm
		Barge	200 – 1,000t
		Tug Boat	200 – 500 PS

6.3.3 Labor

Semi-skilled and common labor for the works will be recruited from the surrounding area of the job site in both the Lao PDR and Thailand. However, the number of skilled labor for construction of the large scale bridge is inadequate in the Lao PDR and they will have to be recruited from Thailand or possibly from other Asian countries.

Required labor input to carry out the project work is estimated as shown in Figure 6.3.2.

Peaks of the labor input will occur 2 times in the dry season when construction of the substructure is in progress.

6.4 CONSTRUCTION METHOD

6.4.1 Main Bridge

6.4.1.1 Substructure and Foundation

The Main Bridge portion has 16 number of piers (P7~P22) in the River and 2 number of piers (P6 and P23) in the riverbank. Cast-in-place RC pile with 2.0m diameter is used for the foundation of the piers in the River and a spread foundation is used for the foundation of the piers on the riverside (P6 and P23).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No. of Labor	50	50	50	112	216	320	372	346	308	230	170	170
No. of Labor	50	50	50	112	216	320	372	346	308	230	170	170

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No. of Labor	160	134	208	256	308	360	386	334	230	178	132	212
No. of Labor	160	134	208	256	308	360	386	334	230	178	132	212

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No. of Labor	212	212	200	200	200	188	188	188	188	178	98	98
No. of Labor	212	212	200	200	200	188	188	188	188	178	98	98

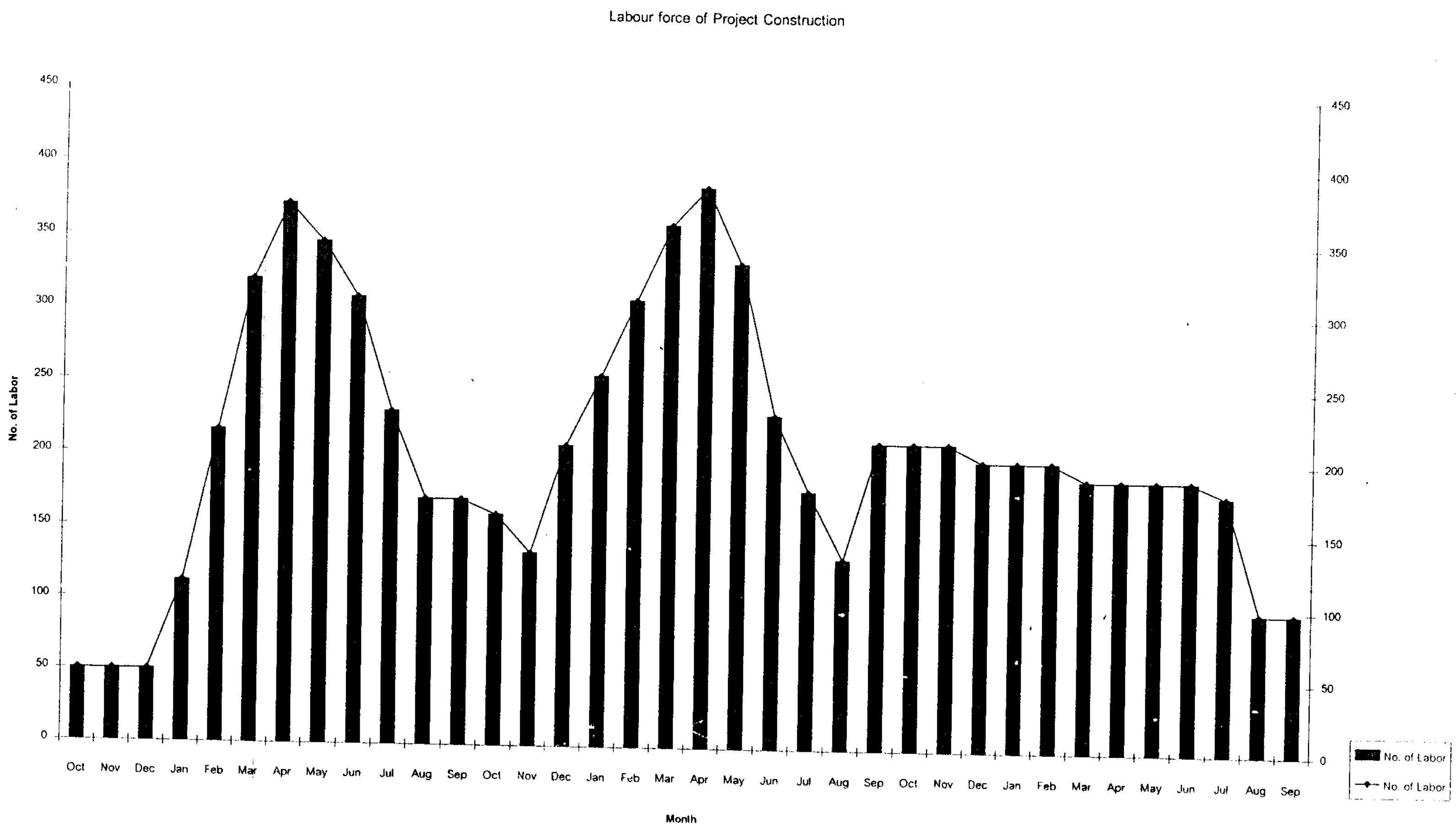


Figure 6.3.2 Labor force of Project Construction

(1) Construction of Substructure of P7 through P22 (Piers in the River)

a) Construction of cast-in-place piles

Construction of cast-in-place piles in the river shall be carried out using steel casing as a stand pipe and formwork. For the excavation of the riverbed material (sand and gravel) inside the casing, hammer grab excavation and the reverse circulation method can be considered. However, for the rock excavation under the riverbed material, the reverse circulation method with rock roller bit is only applicable under reason of geological characteristics of the foundation bed.

Construction of the cast-in-place piles will be basically executed by following the methods according to thickness of the riverbed layer (refer to Figure 6.4.1).

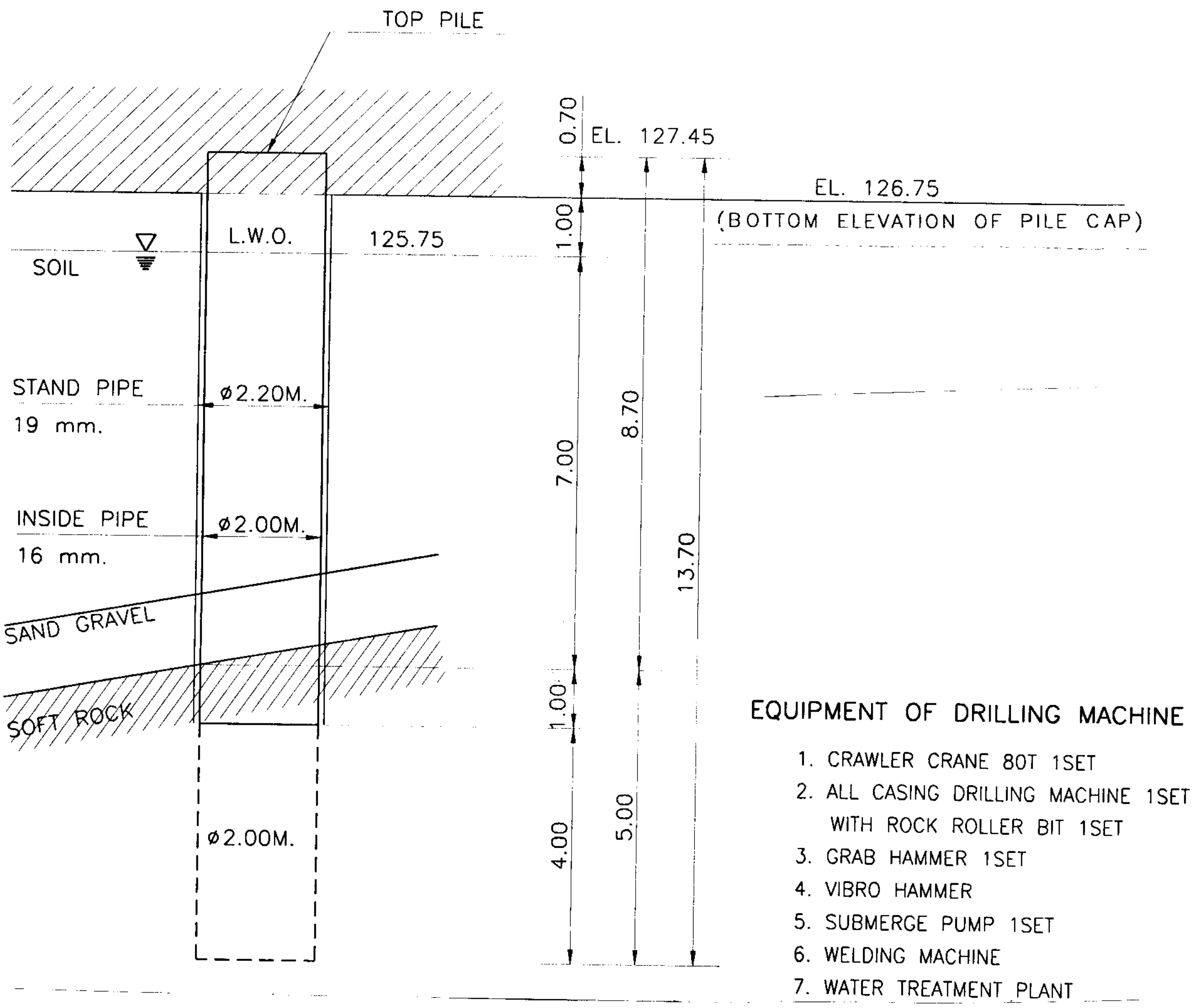


Figure 6.4.1
Excavation Method for Cast-in-Place Pile

Double steel casing pipe method

The riverbed sedimentary (gravel and sand) layer does not have enough thickness to support the permanent casing pipe; a double steel casing method will be recommended.

Firstly, an outer casing shall be installed to the bedrock surface by vibro-hammer or other means and it will be penetrated into rock layer as deep as possible. Materials inside the outer casing will be removed by grab hammer or the reverse circulation method.

Rock excavation will follow using a rock roller bit combined with the reverse circulation method. The effective rock excavation diameter shall be 2.0m. After rock excavation is completed, an inner casing will be installed. The inner casing pipe will be used only for the formwork at concreting. Subsequently, installation of reinforcement cages and concrete casting with use of a tremie pipe will be done.

The above construction work can be done only during the low water season, probably in the period from January to April. Two (2) low water seasons shall be required for the work.

For the working platform and the hauling road to the pier foundations, a temporary jetty will be recommended.

b) Construction of pile caps for P7 through P22

The bottom formwork of the pile cap will be done using pre-cast panels supported on steel members welded to the side of the pipe casing tops. A pre-cast skirt tied into the pile top will also be used as a side formwork.

Initially concrete of the bottom layer of the pile cap with certain thickness (about 50cm) will be placed. After concrete of the initial layer has sufficient strength to support the weight of the remaining concrete, remaining concrete of the pile cap shall be casted. The pre-cast skirt will also behave as the side formwork at this stage.

It should be noted that all piling and pile cap work can be conducted only in the low water season from December to May of each year. Therefore, two (2) dry seasons will be given in the construction schedule for the substructure work.

(2) Construction of the spread foundation for the riverside piers.

The spread foundation type was selected as the foundation of the riverside piers, taking into consideration of future recession of the riverbanks from erosion. Elevations of the base rock surface is estimated at EL127.3 and EL123.7 in the Lao PDR side and Thailand sides, respectively. These indicate that the bottom level of the spread foundation is lower than the LWL (= EL 125.5) in the Thailand side and higher than that level in the Lao PDR side.

Excavation for the foundation will be done by open-cut using sheet piles for the earth retaining support.

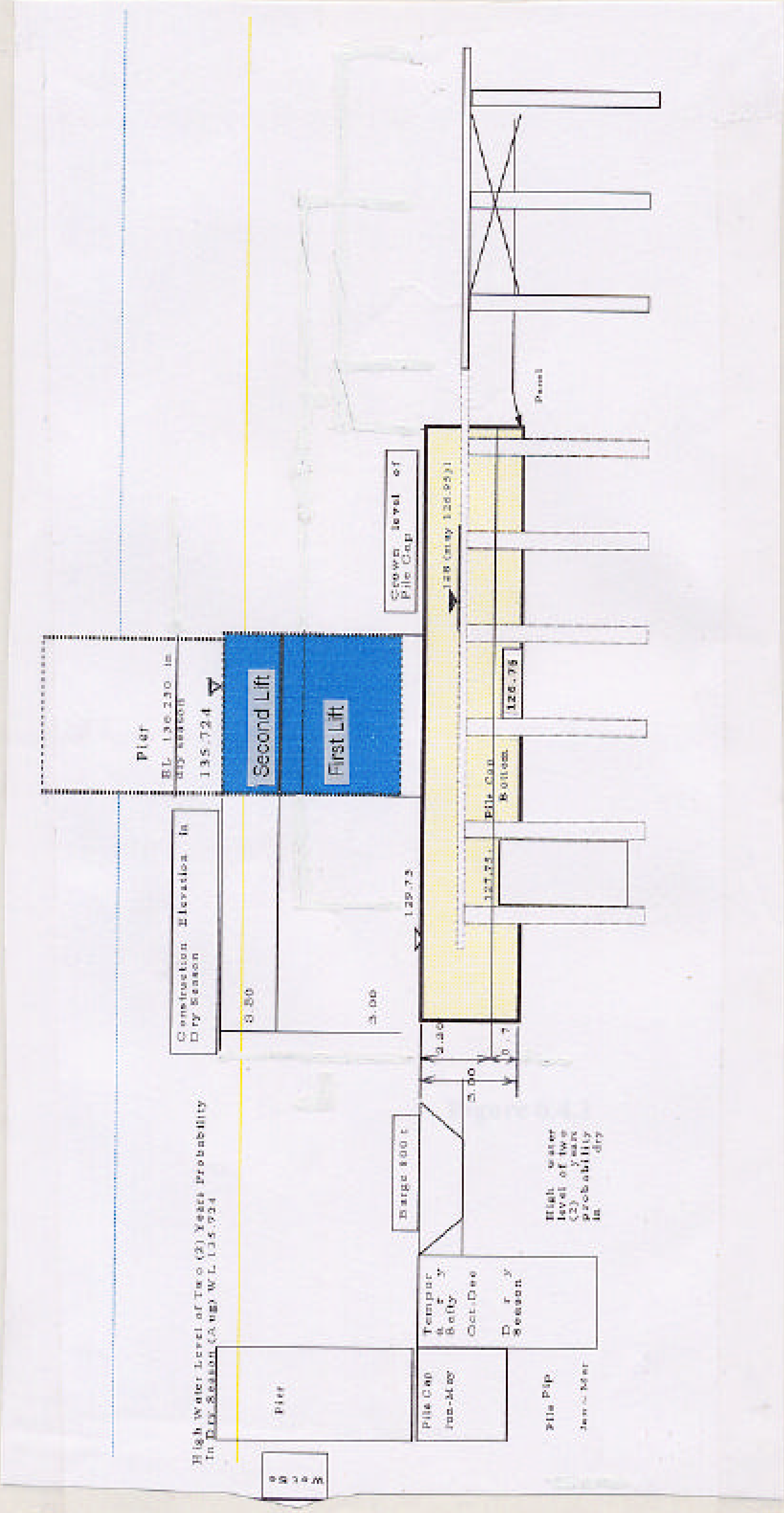


Figure 6.4.2 Construction Level of Substructure in dry season

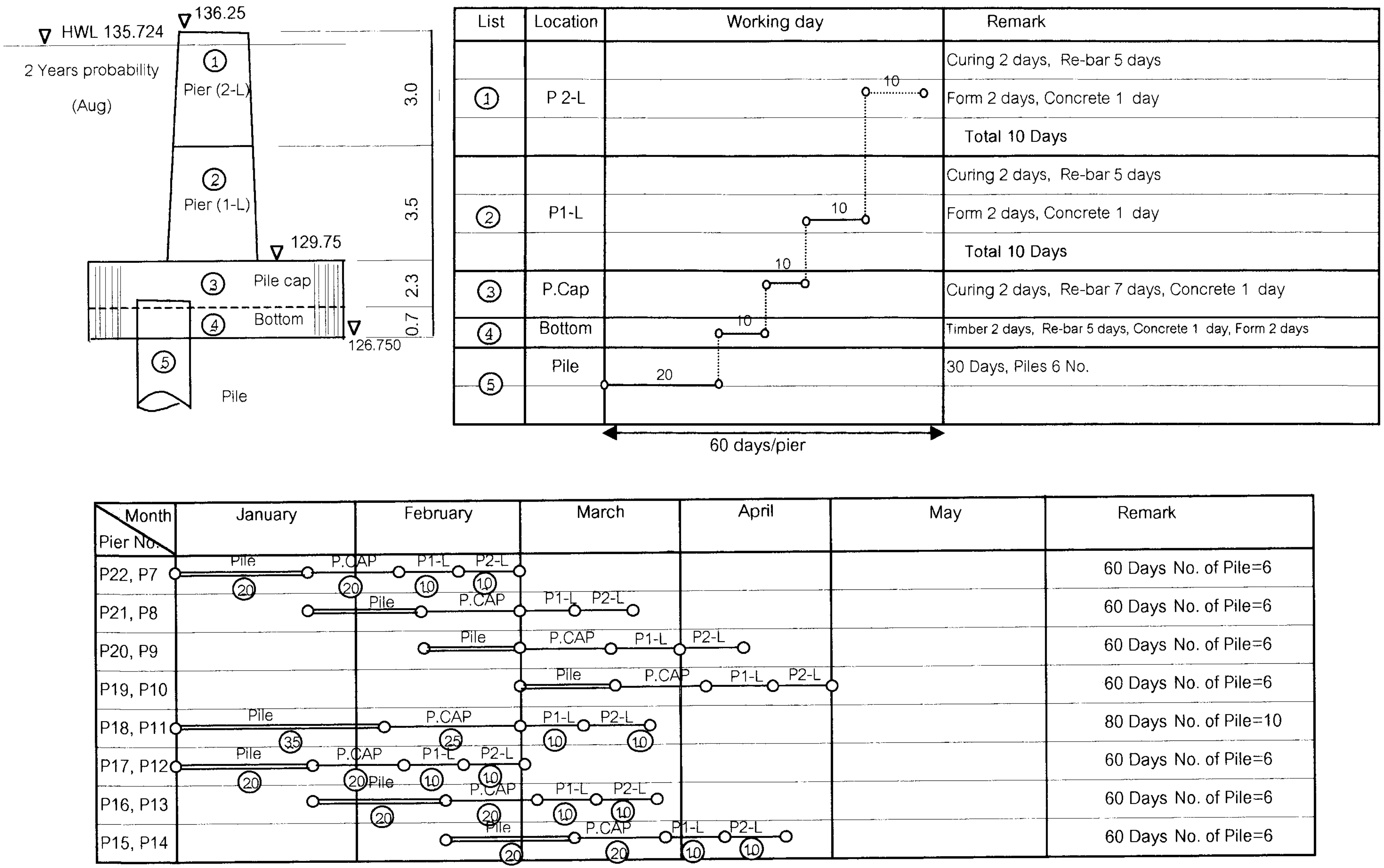


Figure 6.4.3 Construction Schedule for Substructure in Main Bridge (in Dry season)

For the foundation in the Thailand side, installation of another sheet pile boundary outside of the initial sheet piles and excavation area will be required to stop seepage from the River to the excavation site.

Reinforcement, concrete casting of the footing and pier wall as well as back-filling work will be proceeded after excavation.

6.4.1.2 Pier Construction

(1) General

a) Substructure work will be carried out over two(2) dry seasons in 2001 and 2002. Dry season extends from November to April. The low water season naturally extends from January to April.

b) The water levels for substructure construction are taken as follows.

   HWL 135.724 m.
   LWL 125.500 m.

c) The critical substructure levels are taken as follows based on the monthly maximum and minimum water levels at Mukdahan as shown in the enclosed figure 6.4.1.

   1) Pile top elevation of river piers EL 127.75 to 128.25.
   2) Bottom of pre-cast formwork of pile cap EL 126.75 to 127.25.
   3) Bottom of pre-cast skirt level EL 125.25.
   4) Top of pile cap EL 130.25.
   5) Top of Pier varies from approximately EL 147.00 to EL 152.00.
   6) Pier height to be completed up to EL 136.250 during the dry season.

Figure 6.4.3 show the water level for pile construction period and the Substructure construction period based on probable water levels.

(2) Construction Method of the Pile

The Bridge pile driving will be done from the deck of a temporary jetty constructed out to the pile locations in the River.

The pier construction will be done over two dry seasons and each pier constructed during the dry season must be completed to at least EL 136.250. Pier concrete above this level can be continued during the wet season by means of concrete transported to the pier location with barge and either pumped or lifted by crane into the structure.

After completion of the pier structure, the superstructure will be started from either side of the river the Contractor considers appropriate for his construction operation.

(3) Estimate of Foundation and Pier Construction Period in the Dry Season

a)	Pile Construction	-	January to May	5 months
b)	Pile Cap Construction	-	Mid January to Mid May	4 months

c) Pier Construction - Mid December to May 5.5 months
d) Temporary Jetty - Mid December to May 5.5 months
(EL 128.00)

(4) Construction Equipment

a) Selection of Construction Equipment is based on River conditions, sedimentary deposits and underlying rock; (about 200 kg/cm^2).
b) Pile driving of steel casings will be done from a temporary jetty or a sand embankment crossing the River. The level of the jetty or the embankment will be set approximately at elevation El.128.00. A jetty deck will be installed in December and removed in May for the dry season use only.
c) The reverse-circulation method will be used for driving of pile foundations.

Table 6.4.1
Selection of drilling machine for substructure
Relation between Rock Foundation and Drilling Machine
(Reverse Circulation Drilling Machine)

Classification of Rock Foundation	Compressive Stress Kgf/cm^2	Suitable Machine
Sand rock	200 (Job-site rock condition)	Roll Bit
Sand rock	300	All casing drilling machine
Sand rock	400	All casing drilling machine

Table 6.4.2
Recommendation on Drilling Machine at the Job-Site

(200kg/cm^2)

	Drop Hammer	Drilling Machine	Roll Bit
1.Drilling	Drilling is very difficult	Applicable	Applicable
2.Supporting of drilling machine	-	- Jack up platform is necessary to protect torque at the rotary table. - Arrangement of the jack up platform is very difficult at neighboring countries of Thailand	Roll bit is installed at the drilling hole bottom portion; torsion stress is low. (The recommended drilling machine)
3.Average drilling speed	-	0.2-0.25m/h	0.12m/h

d) Selection of Steel Casing Type (Single and Double Casing Pipes)

Since surface of rock foundation is expected to form the inclined rock surface, to protect the sliding of the steel pipe at the drilling operation double casings of the steel casing pipe is suitable as mentioned in Table 6.4.3.

Table 6.4.3 Comparison of Steel Casing Type

Driving Condition At foundation	Single Casing Pipe	Double (Stand Pipe and Inside Pipe)
Thickness of gravel deposit layer is about 2.5~3.0m	Drilling of pile is difficult to control the pile locations	After the cut side casing pipe is contacted to the rock surface, inclined rock surface will be leveled by roll bit or drop hammer. Outside casing pipe will be removed after rock drilling and concreting inside the casing pipe.

(5) Cycle Time of Drilling and Pile Cap

a) Drilling Equipment

i)	Crawler Crane	50 ton	1 No.
ii)	Vibro Hammer	90 kW	1 No.
iii)	Reverse-Circulation Drilling Machine	ϕ 2,000 m	1 No.
iv)	Roll Bit	2000	1 No.
v)	Drop Hammer		1 No.
vi)	Generator		1 No.
vii)	Submersible Pump	75 kW	1 No.
viii)	Welding Machine		2 No.
ix)	Water Treatment Unit		1 No.

b) Cycle Time of Pile Drilling

i)	Setting up guide pipe	1.0 hr.	
ii)	Excavating (sand, gravel)	2.5 hrs.	Per 5 meters
iii)	Excavating of soft rock	25 hrs.	Per 5 meters
iv)	Installing of steel pipe	1.0 hr.	
v)	Concrete placing	4.0 hrs.	
vi)	Removal of guide pipe	1.0 hr.	
	Total	34.5 hrs.	

Based on 10-hours per day, it requires 3.5 days.

c) Pile Cap

i)	Welding of formwork support to pile casing	4 days
ii)	Installing of pre-cast formwork for base	3 days
iii)	Installing of reinforcing bar	3 days
iv)	Installing of side formwork and skirt	3 days
v)	Pouring of concrete for 0.7 meter lift	1 day
vi)	Curing time for first lift	2 days
vii)	Pouring concrete for remainder	1 day
	Total	17 days

d) Cycle Time of Pier Construction

i)	Installing of rebar	4 days
ii)	Installing of formwork	2 days
iii)	Concrete work	1 day
	Total	7 days/3 meters lift

e) General Construction Schedule of Substructure

i)	First year (2001)	January to September	- Piling Pile Cap Pier
ii)	Second Year (2002)	January to September	- Piling Pile Cap Pier

6.4.1.3 Superstructure

(1) General

The Bridge is composed of the Main Bridge that crosses the Mekong River and the Approach Viaducts on both the Lao PDR and Thailand sides.

The Main Bridge is of the PC continuous box girder type with PC sail. The Bridge length is 1600 m. The standard span is 80m. The span at navigation channels has a longer span of 110m which is supported using members of PC sail tower.

The Approach Bridge on the Lao PDR side is designed as a 4-span continuous PC box girder bridge with a 200m length. The Approach Bridge on the Thailand side is designed as a 5-span continuous PC box girder bridge with a 250m length.

The pre-cast segmental balanced cantilever method is adopted as the recommended construction method of the Main Bridge after taking the following advantages into consideration.

a) This construction period can be shorter than any others since the segment can be cast throughout the year regardless of seasonal interruption.
b) The construction cost will be the same as or less than those of other methods.
c) More reliable quality control can be expected since production of the segments is done in the pre-cast yard equipped with good steel formworks and accurate arrangements of reinforcement steel with jigs.

(2) Production of the pre-cast segment

For production of the pre-cast segments, there are two (2) type match-casing methods; the one is the “long line casting” method and the other is the “short line casting” method. Comparison of the two methods is shown in Table 6.4.4.

Since the main girder height is constant, the short line method has advantages in labor-saving and reduction of production yard space. However, success will depend upon accuracy of adjustment of the match-cast segment. The long line method has advantages in simple setting out and control of the deck geometry. However, substantial space may be required. The minimum length is slightly more than half the length of the longest span. The standard production cycle for one segment is one day. The concept of segment production by the short line casting and the long line casting are shown in Figure 6.4.4 and 6.4.5.

Table 6.4.4
Comparison of Long Line Method and Short Line Method

Item	Topic	Long Line	Short Line
1.	**Facilities**		
	Production Yard	Total Production Yard 16,600 m^2	Total Production Yard 15,100m^2
	Facilities	Movable-type Mold 2 no. Rebar Jig 4 no. Gantry Crane 140t, width= 21 m Length = 275 m , 1 no.	Fix-type Mould 2 no. Rebar Jig ………………4 no. Gantry Crane 140t, width = 21m Length = 250 m - 1 no. Tower Crane 5t at 40m
2	**Quality Control**	**EASIER**	
	Geometry Control	Engineering support and supervision is required.	Fine tuned engineering support and supervision is necessary to control operations properly.
		Serious alignment error does not easily occur.	Difficult to find out alignment error if it occurs.
3.	**Production Period**	**17 months**	**17 months**
4.	**Cost Ratio**	**1.00**	**0.97**
			If additional cost for engineering and supervision are considered, total cost is almost same as that for the long line method.
General Applicability		**Suitable**	**Suitable**

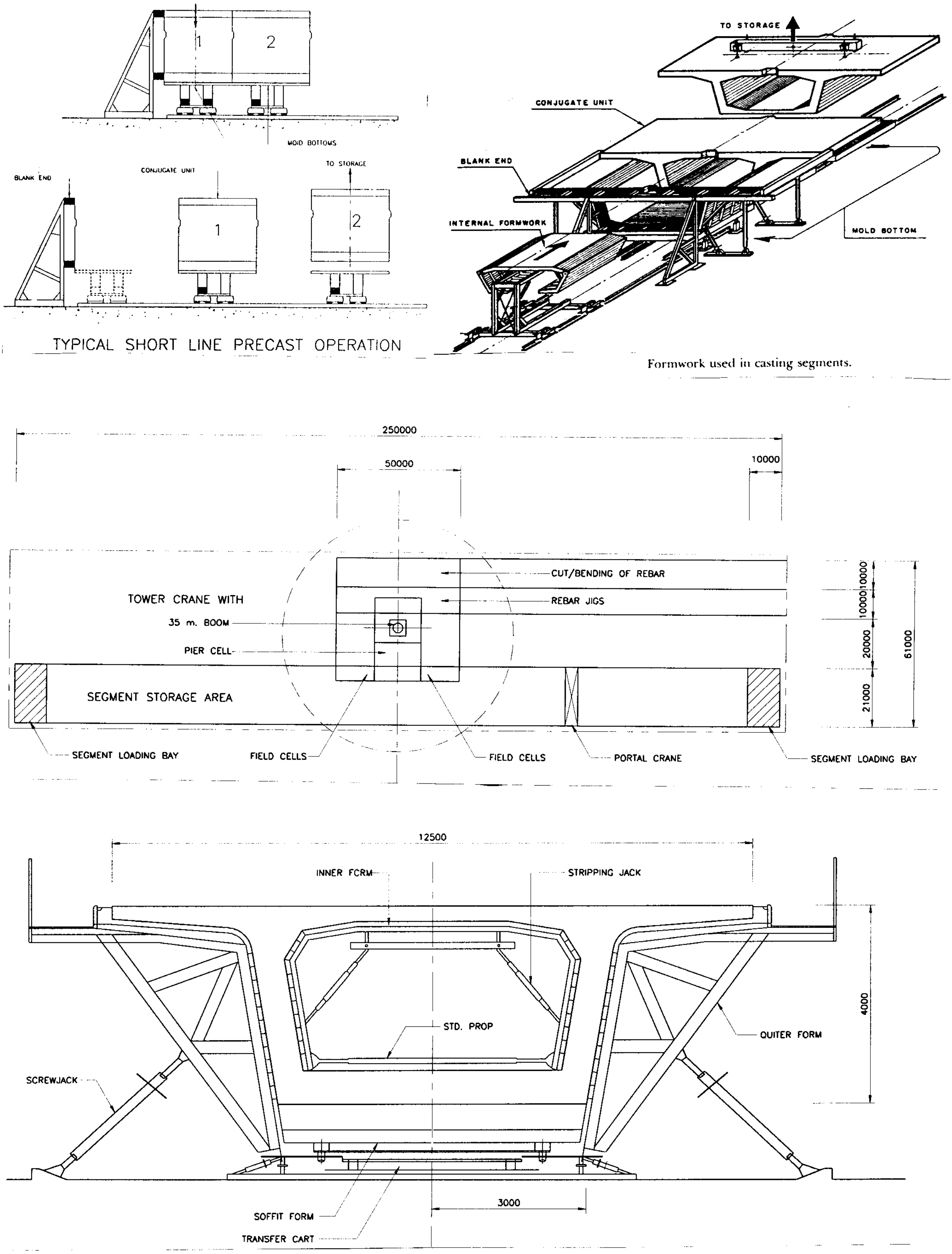


Figure 6.4.4 Outline of Short Line Casting Method

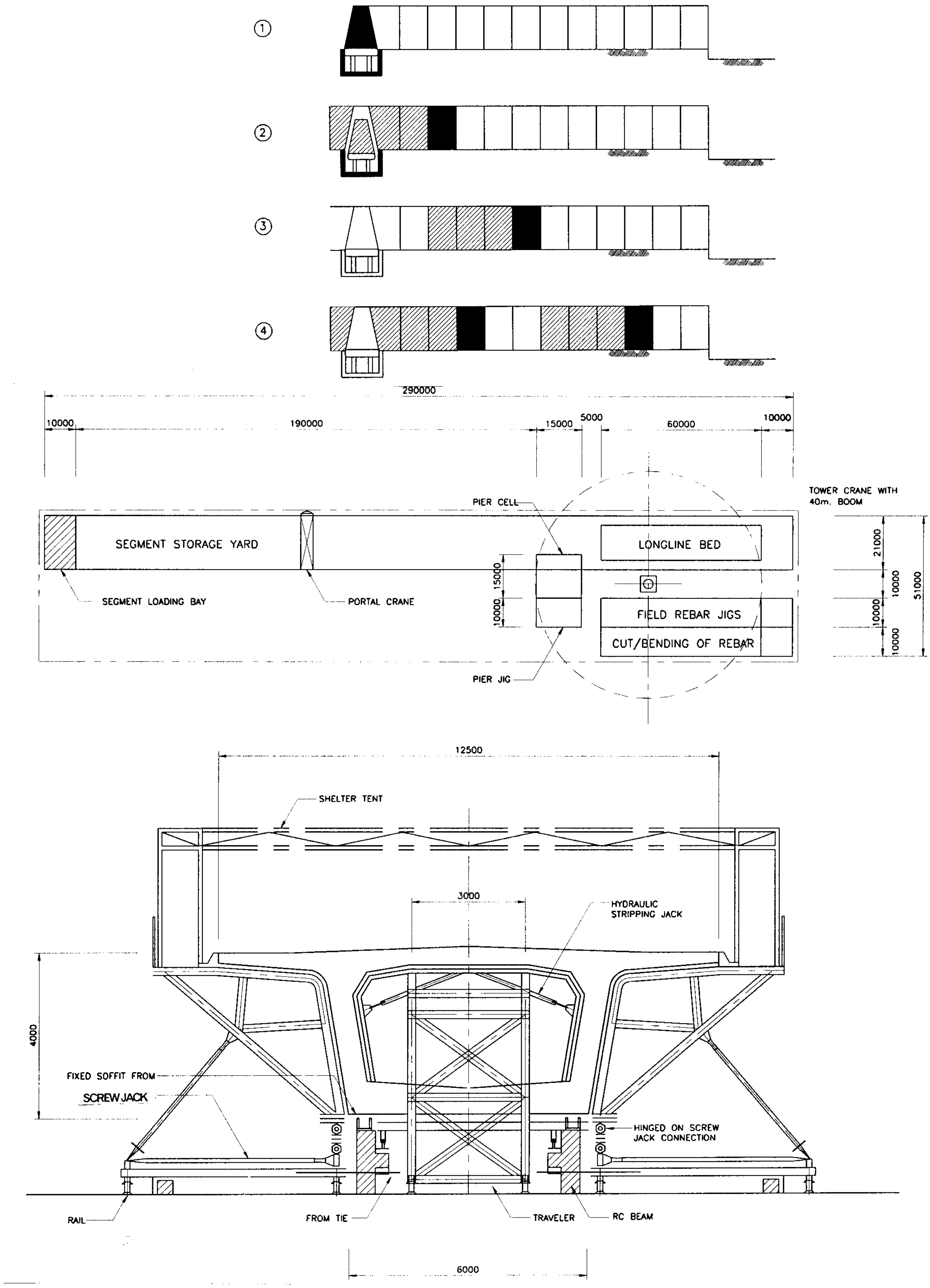


Figure 6.4.5 Outline of Long Line Method

The following equipment and facilities shall be required in the pre-casting yard.

- Segment movement transport mechanical equipment.
- Movement and transport equipment of the concrete formwork.
- Segment production staging equipment.
- Concrete mixing equipment.
- Concreting machine.
- Aggregate stockpiles and admixtures.
- Segment curing equipment.
- PC cable production machine.
- Reinforcement bar processing machine, assemble equipment.

(3) Pre-cast balanced cantilever erection method

Erection procedures of the Bridge are shown in Figure 6.4.6.
The procedures of the erection work are as follows:

1) Transporting segments from the stock yard to the place near the erection site.
2) Moving segments to the erection position.
3) Setting segments close to the prior segment.
4) Inserting PC cables.
5) Coating epoxy resin on the joining face of the segments.
6) Accurately placing segments against previous segments.
7) Prestressing PC steel to tie the segments together.

There are two erection methods for the pre-cast balanced cantilever erection:

1) Erection nose method
2) Launching gantry method

In case of construction by the launching gantry method, moving and setting of the segments are done using a gantry. On the other hand, in case of the construction by the erection nose method, moving of the segments is done by using a barge. Therefore, when such severe conditions of the Mekong River as high flow velocity (V=2.6m/s) in the rainy season and a large fluctuation of the water level are considered, the launching gantry method may be more preferable. Besides the above factors, since the launching gantry can move by itself from a pier to the next pier, erection of a segment can be done easier and more reliably.

The size of the launching gantry shall be suitable for both standard spans (80m) and the longest spans (110m) for navigation positions.

Girder erection can be started either from the Lao PDR side or the Thailand side. Erection from the Thailand side will have same advantage in material procurement point of view. It should be noted that the Detailed Design Drawings were prepared under the assumption that erection work will be carried out under the approved process of the working Drawings.

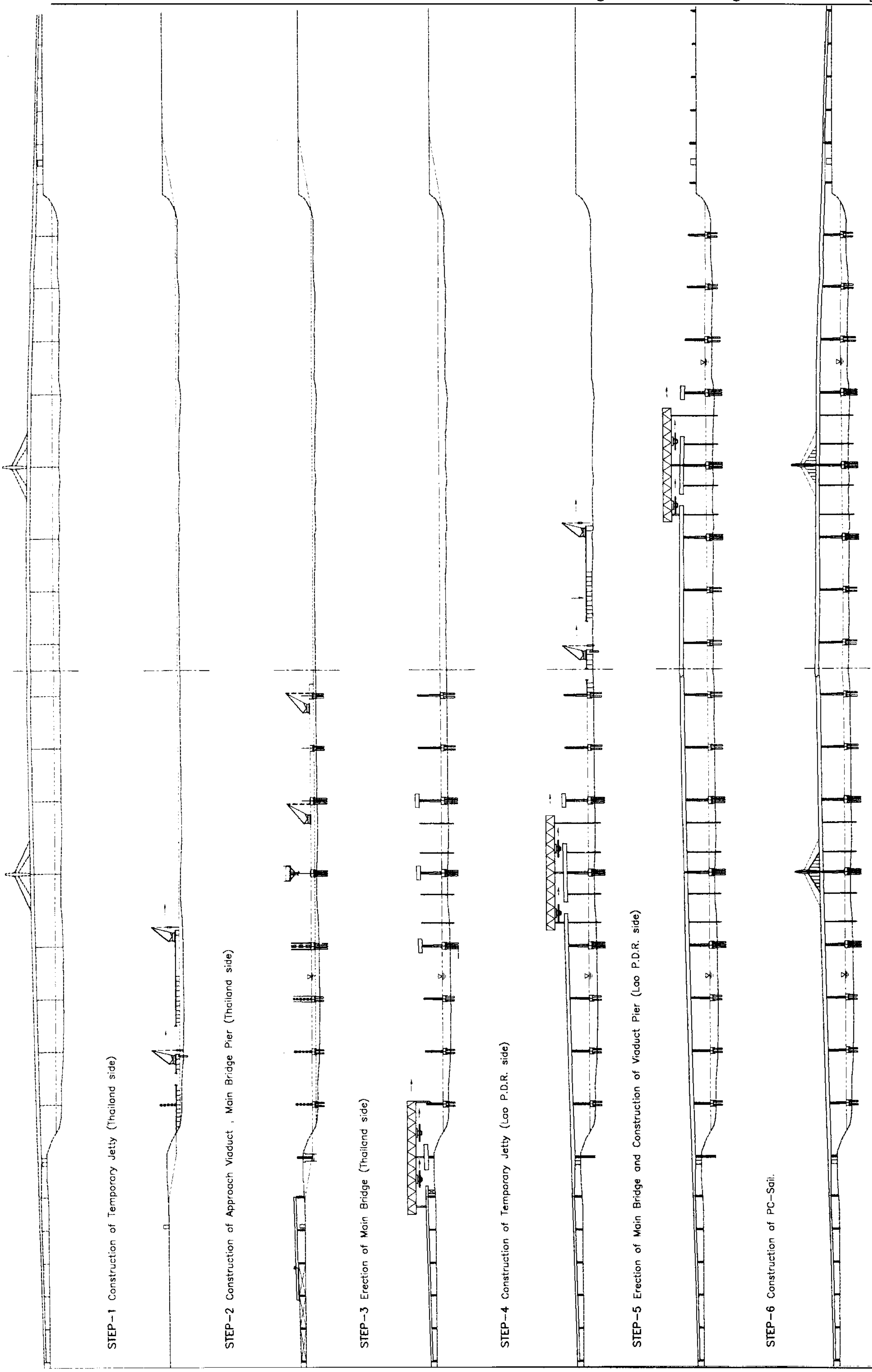


Figure 6.4.6 ERECTION PROCEDURE

(4) Construction of PC sail

Prestressing of the PC sail is divided into two stages. The primary prestress (30% of total prestress) is applied before concreting of PC sail after the segment is joined. The secondary prestress (70% of total prestress) applied by the PC steel after concreting of the PC sail.

6.4.2 Approach Viaduct

6.4.2.1 Substructure and Foundation

Cast-in-place RC piles with 1.0m diameter are specified for the foundation of the piers and abutments of the Approach Viaduct.

These piles shall penetrate at least 1.0m into the base rock. According to the boring data obtained at the construction site, hard silty clay layer with N-value above 30 exists at about 5m under the ground surface with a thickness of 4 m. Equipment for excavation shall be selected to meet with the above geological conditions and the reverse circulation method is recommended.

6.4.2.2 Superstructure

The PC continuous box girder type was adopted to the Approach Viaducts. The Approach Viaducts on Thailand side and the Lao PDR side consist of 5 spans and 4- spans of 50m each, respectively.

Since the length of these Bridges are relatively short and located on the land with a low elevation, the “All Staging Method” can be used for the in-situ construction of the continuous PC girders.

The Approach Viaduct on the side where the segment erection start will be used as the starting base of the launching girder. Therefore, construction of the Viaduct shall be completed before starting the segment erection.

6.4.3 Road

6.4.3.1 Construction Method

(1) Clearing

Prior to commencement of earth filling work, unsuitable materials such as grass, trees, roots, topsoil, loose soil and other harmful materials shall be removed by means of bulldozers, backhoes and manpower. Materials obtained from this operation will be disposed to outside of the ROW area by backhoe and dump truck.

If swamp, ponds or ditches with water are encountered within the range of the new embankment, water shall be pumped out in order to dry up the existing ground.

(2) Borrow Pit Excavation

Prior to opening of the borrow areas, samples of borrow materials will be sent to the laboratory for testing of the maximum dry density before being used in the work.

Borrow excavation will be done by backhoe. The excavated materials will be directly loaded to dump trucks which will haul to the filling area. The excavated materials determined to be unsuitable for any filling work will be disposed of in a designated area outside of the ROW.

(3) Sub-Grade Filling

Earth materials carried by dump trucks will be unloaded on filling areas in a uniform layer or windrow, then pushed and spread by a bulldozer or a motor-grader for each layer and compacted immediately. The materials will be finally compacted by tire or vibrating rollers to achieve the required percentage of compaction. The finished compacted thickness is specified at 30cm.

(4) Road-Bed Filling

Road-bed specified materials carried by dump trucks will be unloaded on filling areas in a uniform layer or windrow, then pushed and spread by bulldozer or grader for each layer and compacted initially. Finally it will be compacted by suitable specified compaction equipment to achieve the required percentage of compaction. The finished compacted thickness is 30cm.

(5) Slope Finishing

After completion of filling, the slope will be finished by a backhoe with a slope bucket in accordance with the final design shape.

(6) Sub-Base Course

Sub-base materials will be carried from the quarry site by dump trucks, will be unloaded on the filling in a uniform layer or windrow and then pushed and spread by a motor-grader for each layer and compacted immediately. Finally it will be compacted by a macadam roller or a tire roller to achieve the required percentage of compaction. The finishing compacted layer thickness is 20cm, and two-layer construction is required (i.e. 40cm).

(7) Base Course

Base materials carried from the quarry site by dump trucks will be unloaded on the filling in a uniform layer or windrow and then pushed and spread by motor-grader for each layer and compacted immediately. Finally it will be compacted by a macadam roller and a tire roller to achieve the required percentage of compaction. The finished compacted layer thickness is 15cm, and two-layer construction is required (30cm).

(8) Density Tests

Density tests will be carried out for each compacted layer. The next layer of embankment will be continued if and only if the density test result meets with the required percentage of the maximum dry density. In case of failure in the test result, compaction work will be repeated by adding or removing water, as necessary, to obtain the required density.

(9) Wearing Course

a) Asphalt pavement

i) Prime Coat

This work shall consist of preparing and treating on the prepared base course.

Prior to applying the prime coat, the surface of base course shall be brought to uniform grade, and swept free of all loose materials by using a motorized broom.

Water may be sprayed with a water truck for keeping the base course slightly damp. The prime coat shall be applied at a temperature from 10°C to 50°C on the prepared base course at a rate of 1.0 liter per square meter. The finished surface of the base course shall be checked carefully and defective parts, if any, shall be repaired or re-compacted. Any debris shall be taken away before application of the prime coat. The prime coat shall be applied to the base course when it is ready to spread for curing and traffic protection.

ii) Binder Course

This work shall consist of a surfacing of dense graded asphalt concrete construction on a prepared base in accordance with the designated lines, levels, grades, dimensions and cross sections.

Asphalt mixture from the mixing plant shall be transported by dump trucks with a tarpaulin cover to keep the asphalt at the desired temperature. Prior to placing the mixture, the under lying surface shall be cleaned. The mixture shall be placed and spreaded by an asphalt finisher to achieve an appropriate profile. The thickness shall be adjusted as necessary to obtain the design thickness.

After placing and spreading the mixture approximately 25 to 30 m long, the mixture shall be compacted 2 times with a macadam roller at a speed of 2 to 3km/h.

The temperature of the first breakdown rolling shall be high enough to achieve the desired compaction rate, and shall be approximately 110°C to 140°C.

The second rolling should immediately follow the breakdown rolling and be thoroughly conducted with a tire roller.

The final rolling is conducted while it is still possible to erase roller marks. The typical speed of macadam roller is 2 to 3km/h and that of a tire roller is 6 to 10km/h.

iii) Tack Coat

Tack coat shall be applied on the binder course and concrete deck slab of the Bridge. Before applying the tack coat, all loose materials and dust shall be removed from the surface using an air compressor. The tack coat shall be applied at a temperature of 10°C to 50°C on the surface at a rate of 0.3 to 0.6 litter per square meter within 24 hours before placement of the wearing course.

iv) Wearing Course

This work shall consist of a surfacing of dense graded asphalt concrete, constructed on a prepared base in accordance with the designated lines, levels, grades, dimensions and cross section.

The asphalt mixture from the mixing plant shall be transported by dump trucks with sufficient cover to keep the desired temperature. Prior to placing the mixture, the underlying surface shall be cleaned. The mixture shall be placed and spreaded by an asphalt finisher to achieve an appropriate profile. The thickness shall be adjusted as necessary to obtain the design thickness.

After placing and spreading the mixture approximately 25 to 30 m long, the mixture shall be compacted 2 times with a macadam roller at a speed of 2 to 3km/h.

The temperature of the first breakdown rolling shall be high enough to achieve the desired compaction rate, and shall be approximately 110°C to 140°C.

The second rolling should immediately follow the breakdown rolling and be thoroughly conducted by a tire roller.

Final rolling is conducted while it is still possible to erase the roller marks. The typical speed of macadam roller is 2 to 3km/h and that of a tire roller is 6 to 10km/h.

b) Concrete Pavement

i) Sand Cushion

This work shall consist of repairing and treating on the prepared base course.

ii) Wearing Course

This work shall consist of a surfacing of portland cement concrete without reinforcement, constructed on a prepared base in accordance with the designated lines, levels grades, dimensions and cross section.

Portland cement concrete shall consist of a mixture of portland cement, fine aggregates, coarse aggregates and water with or without admixture. The portland cement concrete from the mixing plant shall be transported by truck mixers. The mixing operation shall begin within 30 minutes after the cement has been added to the aggregates.

Concrete shall be placed only on a roadbed that has been prepared. Prior to placing the concrete, the underlying surface shall be cleaned. The concrete shall be placed and spread by a concrete finisher to achieve an appropriate profile. The thickness shall be adjusted to obtain the design thickness.

Immediately after final finishing, the concrete shall be cured for not less than 72 hours.

c) Shoulder Filling

Following the progress of sub-base, base course and asphalt pavement work, shoulder protection will be filled step by step with tire backhoes, vibration rollers, and soil compactors.

6.4.3.2 Construction Flow

The flow chart of the road construction is shown in Figure 6.4.7 as below

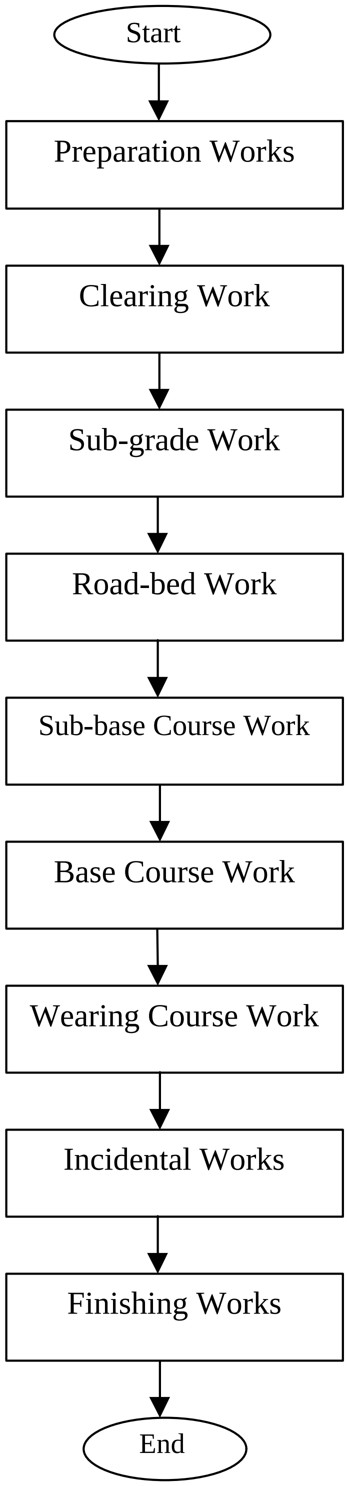


Figure 6.4.7
Flow Chart of the Road Construction

6.4.3.3 Construction Materials

(1) The Lao PDR side

a) Concrete Aggregates and Stone Materials
Raw materials for concrete aggregate and road pavement can be procured from the local licensed suppliers or obtained from the quarry areas near the construction site. In this situation, a crushing plant shall be set up at the quarry site.

b) Embankment Materials
Embankment soil for the sub-grade of the approach/connecting roads will be taken from the borrow areas near the construction site.

c) Wooden Materials
Wooden materials for construction, such as logs, squares, plank, etc. are available except waterproofed plywood for concrete formwork.

d) Bitumen Materials
Asphalt concrete for pavement of approach/connecting roads is not available in the Lao PDR and it will be imported. Asphalt plants shall also be set up near the construction site.

e) Concrete Materials
There is a cement mill in the Lao PDR, but its sufficiency in quality and quantity is not proved yet on this kind of structure which needs high quality and large quantity. Therefore, cement will be imported from Thailand and a concrete mixing plant shall be set up near the construction site.

(2) Thailand side

a) Concrete Aggregates and Stone Materials
The raw materials for the concrete aggregate and road pavement can be procured from local licensed suppliers or obtained from the quarry areas near the construction site. In this situation, a crushing plant shall be set up at the quarry site.

b) Embankment Materials
The embankment soil for the sub-grade of the approach/connecting roads will be obtained from the borrow areas near the construction site.

c) Wooden Materials

The wooden materials for construction, such as logs, squares, plank, etc. are available including waterproof plywood for the concrete formwork.

d) Bitumen Materials
The asphalt concrete for pavement of approach/connecting roads is available from an existing plant at 30 km west of Mukdahan.

e) Concrete Materials
There are many cement product companies in Thailand and its sufficiency in quality and quantity is proved. However, a large capacity mixing plant is not available near the construction site. A new concrete mixing plant shall be set up near the construction site.

(3) Borrow Pit

Suitability of soil and rock materials possibly available at the site, locations of probable soil borrow sites, river gravel dredging points as well as quarry sites are shown in Table 6.4.6 to Table 6.4.7.

6.4.3.4 Machinery

Major construction equipment necessary for road construction is shown in the Table 6.4.8.

Table 6.4.6 Suitability of the Soil and Rock Materials Available near the Site

Materials Available	Usage							
	Aggregate for concrete		Materials for pavement			Embankment material		River revetment material
	High Quality	Medium Quality	Surfacing	Base Course	Sub-base Course	Subgrade	Embankment	
River gravel from the Mekong River	with caution	Good if no alkaline reaction	Good	Fair	Fair	N/A	N/A	N/A
River sand from the Mekong River	Good if no alkaline reaction	Good if no alkaline reaction	N/A	N/A	N/A	with caution	with caution	N/A
Stiff to Hard Clay of river terrace	N/A	N/A	N/A	N/A	N/A	Fair	Good	N/A
Sandy Gravel/Gravel of river terrace	N/A	N/A	N/A	Fair	Fair	Fair	with caution	N/A
Residual Soils from the nearby low lying hills	N/A	N/A	N/A	N/A	N/A	Fair	Fair to Good	N/A
Sandstone from B. Nakhou	N/A	N/A	Fair for low grade pavement, Note A	Note A	Note A	Note A	Note A	Fair, Note A
Basalt from Surin	Good	Good	Good	Good	Good	N/A	N/A	Good
Limestone from Thakek	Good	Good	Good	Good	Good	N/A	N/A	Good

Note A: The sand stone quality needs to be checked carefully. Cementation of the rock may not always be strong in the sandstone. The weathered and weakened part can not be used for pavement materials but can be used as embankment materials.

Table 6.4.7(a)
Borrow Sites and Quarries Currently Operating near the Site (the Lao PDR side)

Type of Material	Location	Land Owner	Area (m^2)	Estimated Minable Volume (m^3)
Embankment Material (Laterite, Terrace clay and gravel)	9km, Route 9	Lao PDR Government	greater than 250,000	greater than 1million
	10km, Route 9	Private	10,000	30,000
	1km, Kaysone Road from junction with Route 9	Private	15,000	40,000
	3km, Kaysone Road from junction with Route 9	Private	10,000	30,000
	4km, Municipal road along Mekong river from the bridge site	the Lao PDR Government	250,000	greater than 1million
	12km, Municipal road along Mekong river from the bridge site	Private	100,000	0.5 million
River Gravel and Sand	Mekong River, 5km south of Savannakhet	Private	-	2-3 years' reserve
	Mekong River, 19km north of Savannakhet	Private	-	5 years' reserve
Sandstone	B. Nakhou, Route 13, 45km from Savannakhet	Private	150,000	0.4 million
Limestone	Thakhek, Route 13, 100km from Savannakhet	Private	greater than 40,000	greater than 1million

Table 6.4.7 (b)
Borrow Sites and Quarries Currently Operating near the Site (Thailand side)

Type of Material	Location	Land Owner	Area (m^2)	Estimated Minable Volume (m^3)
Embankment Material (Laterite, Terrace clay and gravel)	Bon Nong Hoi, about 4km west of the starting point of the proposed approach road at Route 212	Private	40,000	120,000
	Bon Bong Uthai, about 12km south of the bridge location	Private	50,000	150,000
River Gravel and Sand	2km south of the bridge location	Private	-	2 to 3 years' reserve
Basalt	Surin, some 250km from Mukdahan	Private	greater than 80,000	greater than 3million

Table 6.4.8
Combination of Machine (One Group)

Work Item	Machine	Quantity
1. Clearing for earth filling area		
1) Site clearing and compaction	Backhoe 0.6m^3	1 No.
	Bulldozer 21t or 15t	1 No.
	Tire roller (8-20t)	1 No.
2) Disposal	Dump truck 15t	3 No.
2. Earth filling (Road bed and Sub-grade)		
1) Excavation and loading at borrow pit	Backhoe 1.0m^3	1 No.
2) Transportation of soil (Hauling distance = 5km.)	Dump truck 15t	6 No.
3) Grading and compaction	Bulldozer 21t	1 No.
	Sprinkler lorry 5-6m^3	1 No.
4) Compaction	Tire roller 8-20t	1 No.
5) Slope finishing	Backhoe 0.6m^3 (with slope bucket)	1 No.
	Bulldozer 15t	
3. Earth filling (Shoulder)		
1), 2) Same as above		
3) Grading and Slope finishing	Tire backhoe 0.4m^3	1 No.
4) Compaction	Vibration roller 0.5~1.1t	1 No.
	Soil compactor	3 No.
4. Sub-base, Base Course		
1) Loading	Wheel-loader	1 No.
2) Transportation	Dump truck 15t	6 No.
3) Spreading	Motor-grader	1 No.
4) Compaction	Tire roller (8-20t)	1 No.
	Macadam roller (10-12t)	1 No.
5. Prime Coat	Power broomer	1 No.
	Sprinkler lorry (5-6m^3)	1 No.
	Compressor (10m^3/min.)	1 No.
	Asphalt distributer (6m^3)	1 No.
6. Binder Course	Asphalt plant (60t/R)	1 Unit
	Asphalt finisher (24~45m)	1 No.
	Macadam roller (10~12t)	1 No.
	Tire roller (8~20t)	1 No.
	Dump truck (10t)	10 No.
7. Tack Coat	Compressor (10m^3/min.)	1 No.
	Asphalt distributer (6m^3)	1 No.
8. Wearing Course (Asphalt concrete)	Same as binder course	
9. Wearing Course (Concrete)	Concrete plant	1 Unit
	Truck mixer	2 No.
	Vibration	5 No.

6.4.3.5 Quantity of Roadwork

Table 6.4.9
Quantity of Roadwork

		The Lao PDR Side		Thailand Side	
	Unit	**Connecting Road**	**Approach Road**	**Approach Road**	**Connecting Road**
1. Earth Works					
1.1 Clearing and Grubbing	sq.m	74,866	15,016	39,721	38,449
1.2 Excavation and Embankment, Earth	cu.m.	12,241	-	-	17,030
1.3 Excavation of Unsuitable Material	cu.m.	2,197	-	-	5,767
1.4 Embankment by Borrow Material	cu.m..	31,078	27,842	83,680	15,496
2. Subbase and Base Courses					
2.1 Subbase	cu.m.	9,956	1,038	1,849	7,852
2.2 Aggregate Base Course	cu.m.	7,651	788	760	5,720
3. Surface Courses					
3.1 Asphaltic Concrete for Wearing Course	cu.m.	1,786	204	210	1,365
3.2 Asphaltic Concrete for Wearing Course for Bridge	cu.m.	-	204	-	-
3.3 Asphaltic Concrete for Binder Course	cu.m.	1,814	112	48	1,387
3.4 Portland Cement Concrete Pavement, 25cm	sq.m.	-	-	4,765	-
4. Incidental Works					
4.1 Box Culvert, 2.40x2.40m, at Sta. 0+980.000 T	l.m.	-	-	42	-
4.2 Box Culvert, 3x3.60x3.60m, at Sta.1+017.000 T	l.m.	-	-	62	-
4.3 Box Culvert, 2.50x2.50m, at Sta. 4+781.000 L	set	25	-	-	-
4.4 Security Fence L	l.m.	-	450	-	-
4.5 Security Fence T	l.m.	-	-	1,150	-
4.6 10m Tapered Steel Pole with One High Pressure Sodium Lamp Type L	each	90	6	-	-
4.7 10m Tapered Steel Pole with One High Pressure Sodium Lamp Type T	each	-	-	28	70

6.4.4. Border Control Facilities

6.4.4.1 General

The Construction of the Border Control Facilities shall be carried out under the following requirements to maintain the required quality and the construction period.

1) Land leveling, pavement, water proofing and painting works shall be carried out during dry season.
2) Interference among the civil works, electrical/mechanical works and building works shall be considered carefully and necessary adjustment shall be made to avoid double works.
3) Since the project consists of many kind of construction works, the entire construction period should have a time for allowance.

6.4.4.2 Construction Method

There is no special construction work which require special construction technique and equipment for the construction of the Border Control Facilities. Construction procedures at each stage of the construction are briefly explained below.

(1) Reparation Works

Preparation works shall be started just after the mobilization of the Contractor at the beginning of the dry season. Such works as necessary official application and procedure, ground surveys and establishment of temporary construction yard shall be completed during this stage. The time for this stage is estimated at two (2) month.

(2) Land Leveling and Surface Water Drainage Works

Land Leveling works shall be commenced after ground survey is completed and carried out during dry season. The surface drainage works will follow the land leveling works. Underground conduit and pipes for the subsequent electrical works and water supply pipes shall be installed in advance of the construction of the surface drainage structure at intercrossing points. In the Lao PDR side BCF, there will be rock excavations which will required rippering and blasting by breaker.
The time required for the construction works is estimated at eight (8) months.

(3) Piling Works for Building and Roof Structure Foundation

It is not desirable but the piling works will be carried out during rainy season. Therefore necessary safety measures shall be provoded.

(4) R.C. Frame Work

Reinforced concrete works will be commenced following the piling works. Plumbing works shall be executed simultaneously. The time required for the construction works is estimated to be seven (7) months.

(5) Steel Frame and Painting Works

Assembling works of the steel frame shall be commenced at the beginning of the second dry season. Assembling and painting works shall be completed during dry season. The time for the construction is estimated at five to six (5-6) months.

(6) Finishing Works

Exterior finishing works and interior finishing works will follow the R.C. structure works during second dry season. Installation of machinery and equipment will be conducted simultaneously. The required time for the finishing works is estimated to be 12 months.

6.5 CONSTRUCTION SCHEDULE

According to the detailed study on the time required for the construction of the respective facilities, the following periods have been estimated for the Project construction.

1) Main Bridge and Approach Viaduct : 36 months
2) Approach Roads and Connection Roads : 24 months
3) Border Control Facilities : 24 months

The above construction time was estimated considering construction difficulty and suspension period during the rainy seasons into account.

It should be noted that the construction period of 36 months for the Main Bridge (which is the critical path in the whole Project) is estimated under the assumption that construction can commence at the beginning of the first dry season.

Table 6.5.3 shows construction schedule of the whole Project components and Table 6.5.4 and 6.5.5 show the detailed construction schedules of the Main Bridge and Approach Viaduct.

Basic conditions for the estimation of the above construction schedule are as follows

1) The works which cannot be conducted during rainy season

a. Main Bridge Construction
   R.C. Cast-in-place Piles (ϕ2.0 m) in the river, Pile caps work

b. Road Construction
   Earth works, Gravel course works

c. Border Control facilities
   Earth works, Gravel course works, Steel frame and painting works, Water proofing works, Exterior finishing work

2) Basic required construction time of major work Items

According to the detailed study on the required construction time of respective works item, following required time for the major work items are estimated.

a. Main Bridge and Approach Viaducts
   a.1 Substructure

Table 6.5.1
Construction Time of Substructure Works

Unit : days

Item	Main Bridge			Approach Viaducts	
	P6 & P23	P7-9 & P13-16	P10-12 & P17-19	Abutments	Piers
Piles	-	20	30	30	15
Pile Caps	70	20	30	30	30
Pier Columns	10 x 5 lifts = 50	10 x 5 lifts = 50	15 x 5 lifts = 75	30	10 x 3 lifts = 30
Total	120	90	135	90	75
Remarks	Direct Foundations	Movable piers	Rigid piers		Movable piers

a.2 Superstructure

- Fabrication of Segments : 1 segment per day
- Segment Erection : 2 segments per 2 day
- Segment Erection per span :

Table 6.5.2
Construction Time of Superstructure Works

Unit : days

Span length	Type of Pier	Segment Erection	Fixing at Pier Head	Fixing at Temporary pylon	Moving of Erection Truss	Total
80 m	Movable Pier	18	5	-	5	28
80 m	Rigid Pier	19	5	5	5	34
110 m	Rigid Pier	30	5	10	5	50

- Main Tower & P.C. Sail : 45 days for main tower and 60 days for P.C. sail
- Pier Head Construction : 60 days each (P10-12 & P17-19)
- Approach Viaduct : 30 days per span (60 meter)

b. Road Works
- Excavation and Embankment : 1st dry season (3-5 months)
- Cross drainage structure : 1st dry season
- Subbase course : 2nd dry season (1-3 months)
- Base course : 2nd dry season (1-3 months)
- Asphalt concrete : 2nd dry season (1-2 months)

c. Border Control Facilities
- Land leveling work : 1st dry season (6 months)
- Surface water drainage : 1st dry season/rainy season (5 months)
- Piling work : 1st rainy season (2-4 months)
- R.C. frame work : 2nd dry season (7 months)
- Steel frame work : 2nd dry season (5-6 months)
- Exterior/Interior works : 2nd dry/rainy season (9-10 months)
- Electrical/machnical works : 2nd dry/rainy season (12 months)

Table 6.5.3 Construction Schedule of the Whole Project

36 Months

	Item	Spec	Unit	Q'ty	Remark
Package 1	**Package 1**				
	Bridge				
	Preparatory Works		L.S.		
	Substructure (Foundation pile) work				
	a) Approach Viaduct (Thai Side)	Secion 7	Pile	59	ϕ 1.00 m.l=12 m
	b) Approach Viaduct (Lao Side)	〃	Pile	51	ϕ 1.00 m.l=12 m
	c) Main Bridge	〃	Pile	120	ϕ 2.0 m.l=13 m
	Superstructure work				
	a) Approach Viaduct (Thai Side)	Secion 6	m.	250	250
	b) Approach Viaduct (Lao Side)	〃	m.	200	200
	c) Main Bridge	〃	m.	1,600	1600
	Approach Road				
	Approach Road Thai Side	Section 2,3,4	m.	490	490
	Approach Road Lao Side	〃	m.	200	200
	River protection work				
	River protection work (Thai side)	Section 8	m.	300	300
	River protection work (Lao side)	〃	m.	300	300
Package 2	**Package 2**				
	Connection Road	Section 2,3,4	m.	1,864	
	Border Control facilities				
	Preparatory Works	Section 2	m2.	162,500	Earth Work
	Civil Works	〃	m3.	294,664	Earth Work
	Building Works				
	Electrical/Mechanical Works				1
Package 3	**Package 3**				
	Connection Road	Section 2,3,4	m.	520	
	Border Control facilities				
	Preparatory Works	Section 2	m2.	10,700	Earth Work
	Civil Works	〃	m3.	120,100	Earth Work
	Building Works				
	Electrical/Mechanical Works				1

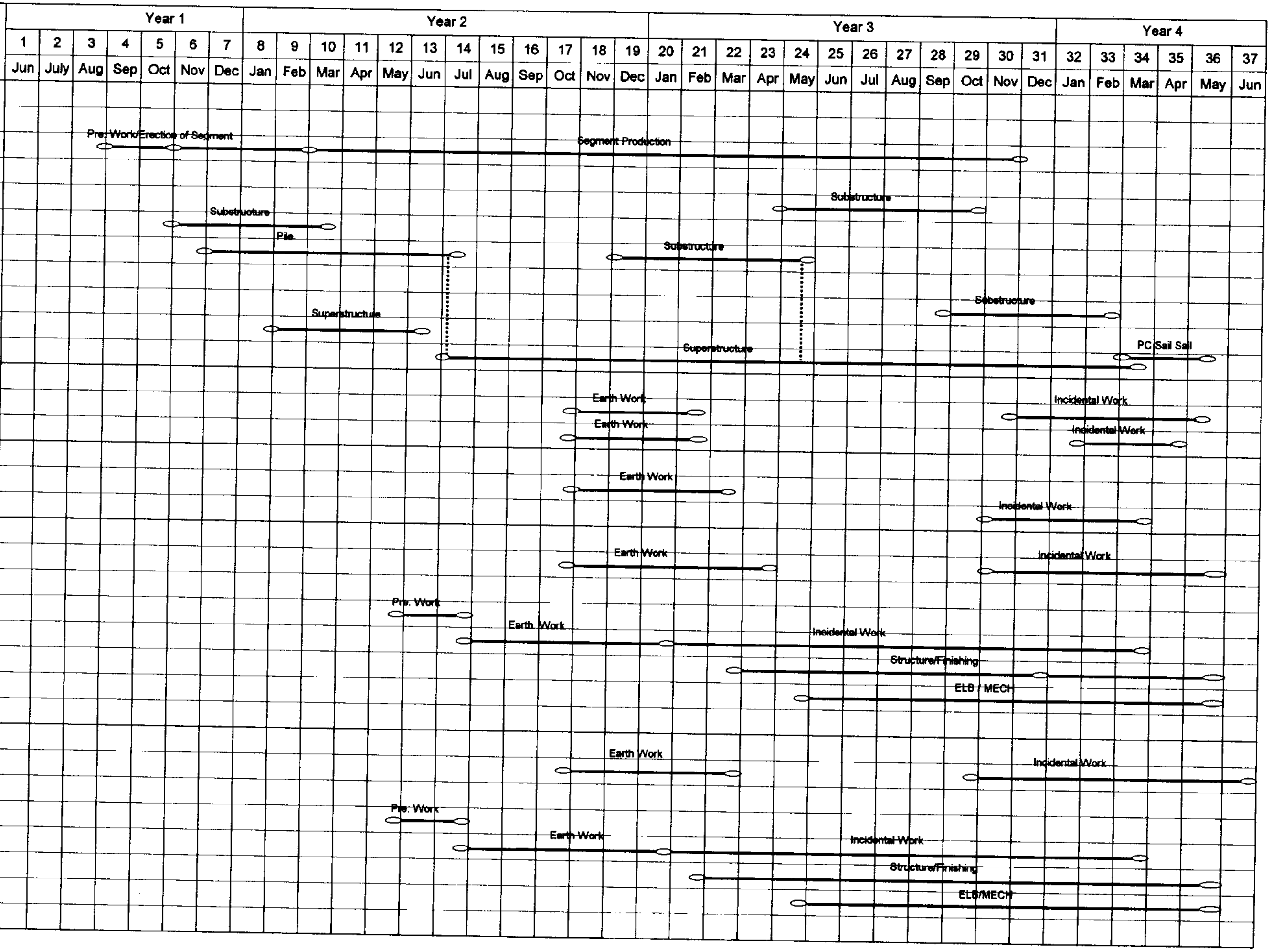


Table 6.5.4 Construction Schedule of the Bridge Case 1 (Starting from the Lao PDR. Side)

Item		Specification	Unit	Q'ty
1 Geological Survey			L.S.	1
2 Temporary Jetty				
3 Erection and Build up of Segment Plant			L.S.	1
4 Segment Production			L.S.	1
5 Working Schedule			L.S.	1
A1 Abutment				18
P1 Pier	Approach Viaduct	Land Work	no.	8
P2 Pier	Approach Viaduct	Land Work	no.	8
P3 Pier	Approach Viaduct	Land Work	no.	10
P4 Pier	Approach Viaduct	Land Work	no.	8
P5 Pier	Approach Viaduct	Land Work	no.	8
P6 Pier	Main Bridge	River Work	no.	0
P7 Pier	Main Bridge	River Work	no.	6
P8 Pier	Main Bridge	River Work	no.	6
P9 Pier	Main Bridge	River Work	no.	6
P10 Pier	Main Bridge	River Work	no.	10
P11 Pier	Main Bridge	River Work	no.	10
P12 Pier	Main Bridge	River Work	no.	10
P13 Pier	Main Bridge	River Work	no.	6
P14 Pier	Main Bridge	River Work	no.	6
P15 Pier	Main Bridge	River Work	no.	6
P16 Pier	Main Bridge	River Work	no.	6
P17 Pier	Main Bridge	River Work	no.	10
P18 Pier	Main Bridge	River Work	no.	10
P19 Pier	Main Bridge	River Work	no.	10
P20 Pier	Main Bridge	River Work	no.	6
P21 Pier	Main Bridge	River Work	no.	6
P22 Pier	Main Bridge	River Work	no.	6
P23 Pier	Main Bridge	River Work	no.	0
P24 Pier	Main Bridge	Land Work	no.	8
P25 Pier	Approach Viaduct	Land Work	no.	8
P26 Pier	Approach Viaduct	Land Work	no.	10
P27 Pier	Approach Viaduct	Land Work	no.	8
A2 Abutment	Approach Viaduct	Land Work	no.	18
B Bridge Accessory			L.S.	1

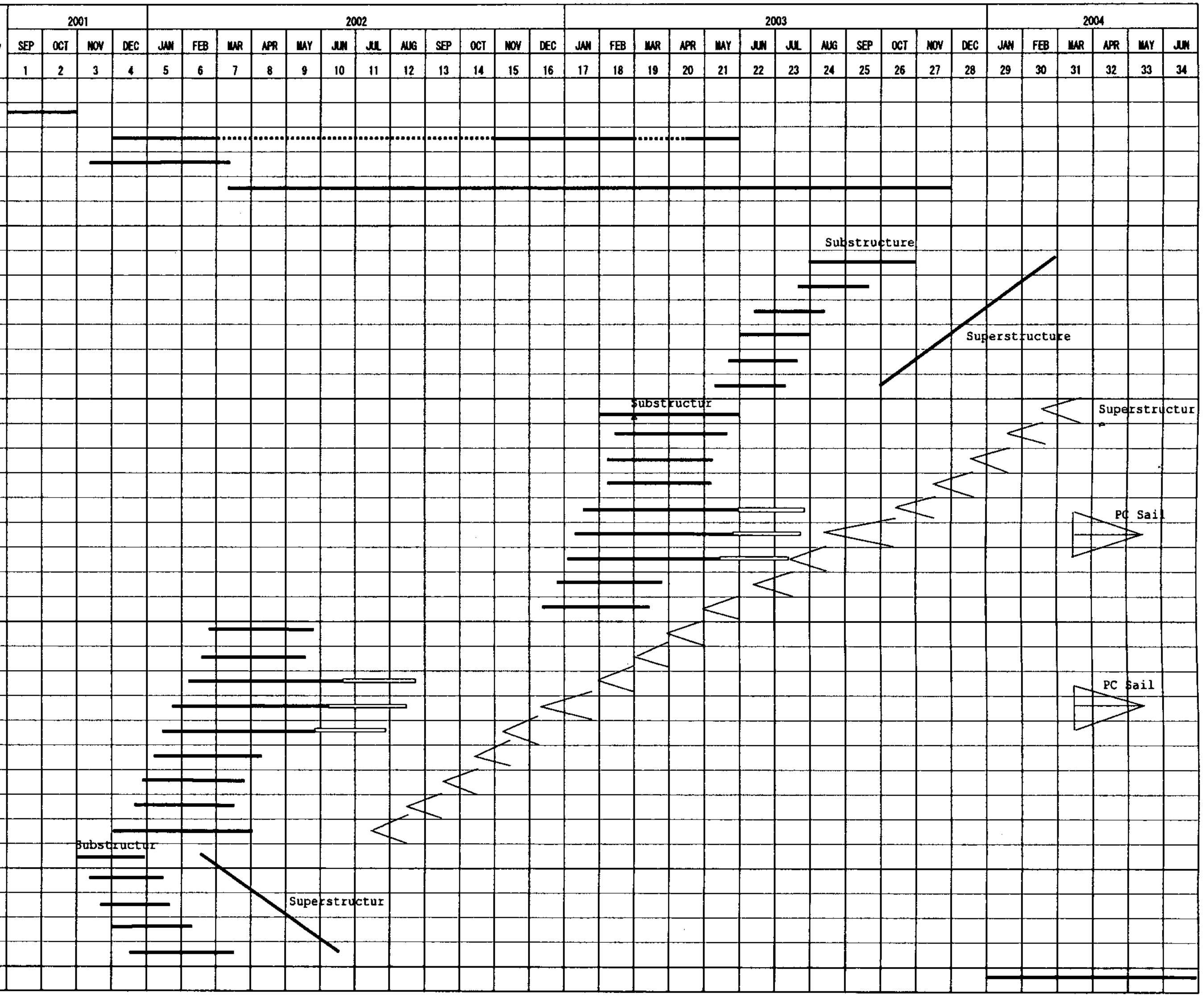
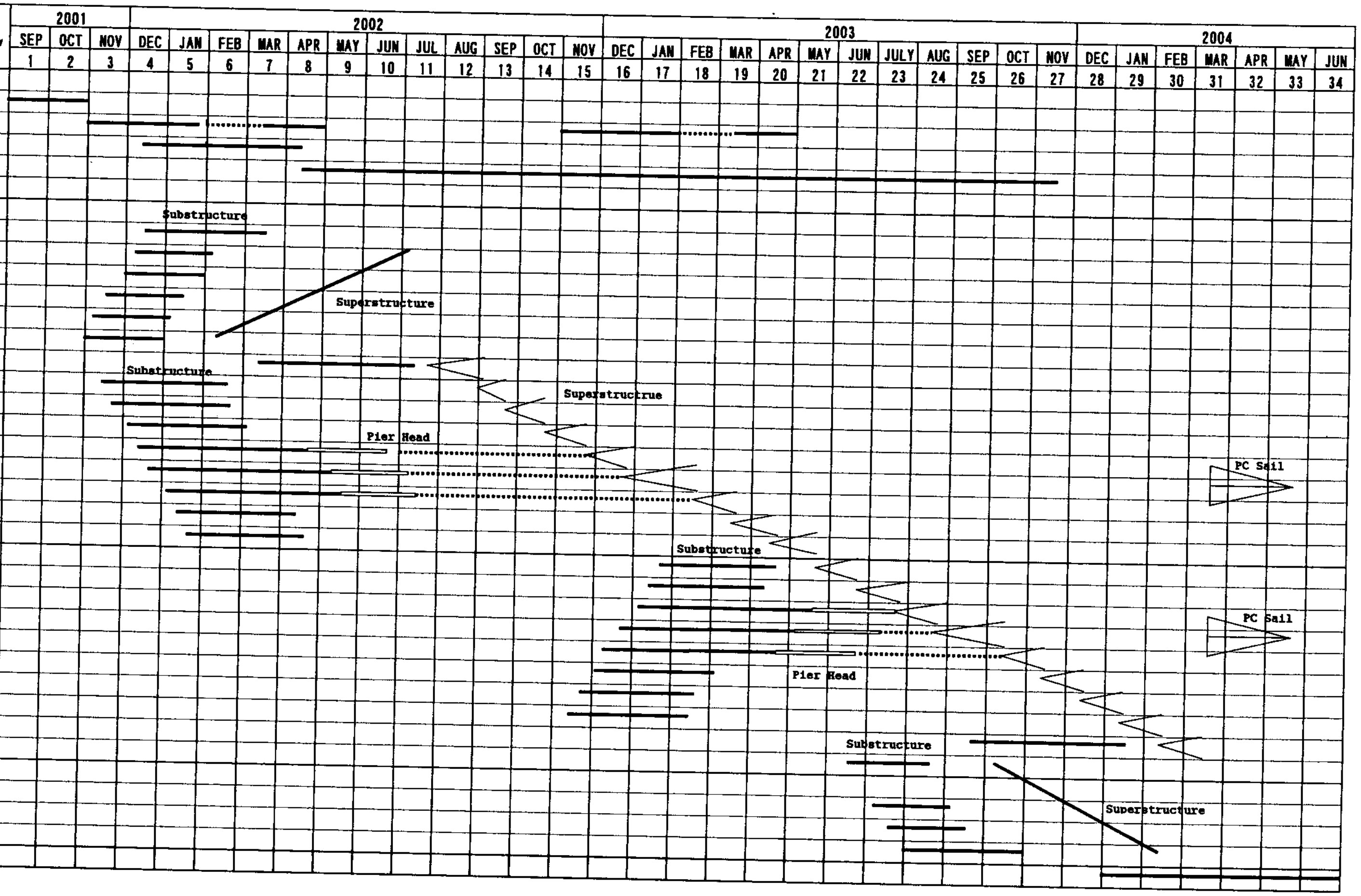


Table 6.5.5 Construction Schedule of the Bridge Case 2 (Starting from Thailand Side)

Item		Specification	Unit	Q'ty
1 Geological Survey			L.S.	1
2 Temporary Jetty				
3 Erection and Build up of Segment Plant			L.S.	1
4 Segment Production			L.S.	1
5 Working Schedule			L.S.	1
A1 Abutment				18
P1 Pier	Approach Viaduct	Land Work	no.	8
P2 Pier	Approach Viaduct	Land Work	no.	8
P3 Pier	Approach Viaduct	Land Work	no.	10
P4 Pier	Approach Viaduct	Land Work	no.	8
P5 Pier	Approach Viaduct	Land Work	no.	8
P6 Pier	Main Bridge	River Work	no.	0
P7 Pier	Main Bridge	River Work	no.	6
P8 Pier	Main Bridge	River Work	no.	6
P9 Pier	Main Bridge	River Work	no.	6
P10 Pier: Rigid, PC Sail	Main Bridge	River Work	no.	10
P11 Pier: Rigid, PC Sail	Main Bridge	River Work	no.	10
P12 Pier: Rigid, PC Sail	Main Bridge	River Work	no.	10
P13 Pier	Main Bridge	River Work	no.	6
P14 Pier	Main Bridge	River Work	no.	6
P15 Pier	Main Bridge	River Work	no.	6
P16 Pier	Main Bridge	River Work	no.	6
P17 Pier: Rigid, PC Sail	Main Bridge	River Work	no.	10
P18 Pier: Rigid, PC Sail	Main Bridge	River Work	no.	10
P19 Pier: Rigid, PC Sail	Main Bridge	River Work	no.	10
P20 Pier	Main Bridge	River Work	no.	6
P21 Pier	Main Bridge	River Work	no.	6
P22 Pier	Main Bridge	River Work	no.	6
P23 Pier	Main Bridge	River Work	no.	0
P24 Pier	Main Bridge	Land Work	no.	8
P25 Pier	Approach Viaduct	Land Work	no.	8
P26 Pier	Approach Viaduct	Land Work	no.	10
P27 Pier	Approach Viaduct	Land Work	no.	8
A2 Abutment	Approach Viaduct	Land Work	no.	18
8 Bridge Accessory			L.S.	1



6.6 CONCRETE, SEGMENT AND OTHERS TEMPORARY FACILITIES

6.6.1 Concrete and Segment Yard

The construction plant consists of offices, store houses for cement and other materials, an aggregate screening plant, a concrete plant, a steel pipe (for pile) fabrication yard, a PC segment pre-cast and stock yard, a reinforcement bar cutting and bending yard, a carpentry shop, a motor pool and a repair shop etc.

Land and temporary buildings required for the above yards are estimated as shown in Table 6.6.1. Locations of the construction yard are shown in Figure 6.6.1 and 6.6.2.

Table 6.6.1
Required Construction Buildings (m^2)

	Package				Remark
	1		2	3	
	Main Construction Yard Side	The Other Side	The Lao PDR	Thailand	
Employer's office	150	150			
Employer's accommodation	100	100			
Employer's mass hall	200	200			
Engineer's main office	300				
Engineer's sub office		150			
Laboratory	250	250			
Officer's complex	100	100			
Engineer's office/ room			40	40	
Contractor office	400	100	100	100	
Store house	500	500	500	500	
Concrete, segment plants	(60,000)	-	-	-	
Carpentry shop	200	200	150	150	
Re-bar processing	200	150	100	100	
Steel pipe fabrication	400	-	-	-	
Worker quarters	2,000	1,000	500	500	
Motor pool and repair shop	400	300	150	150	
Total	**5,200**	**3,200**	**1,540**	**1,540**	

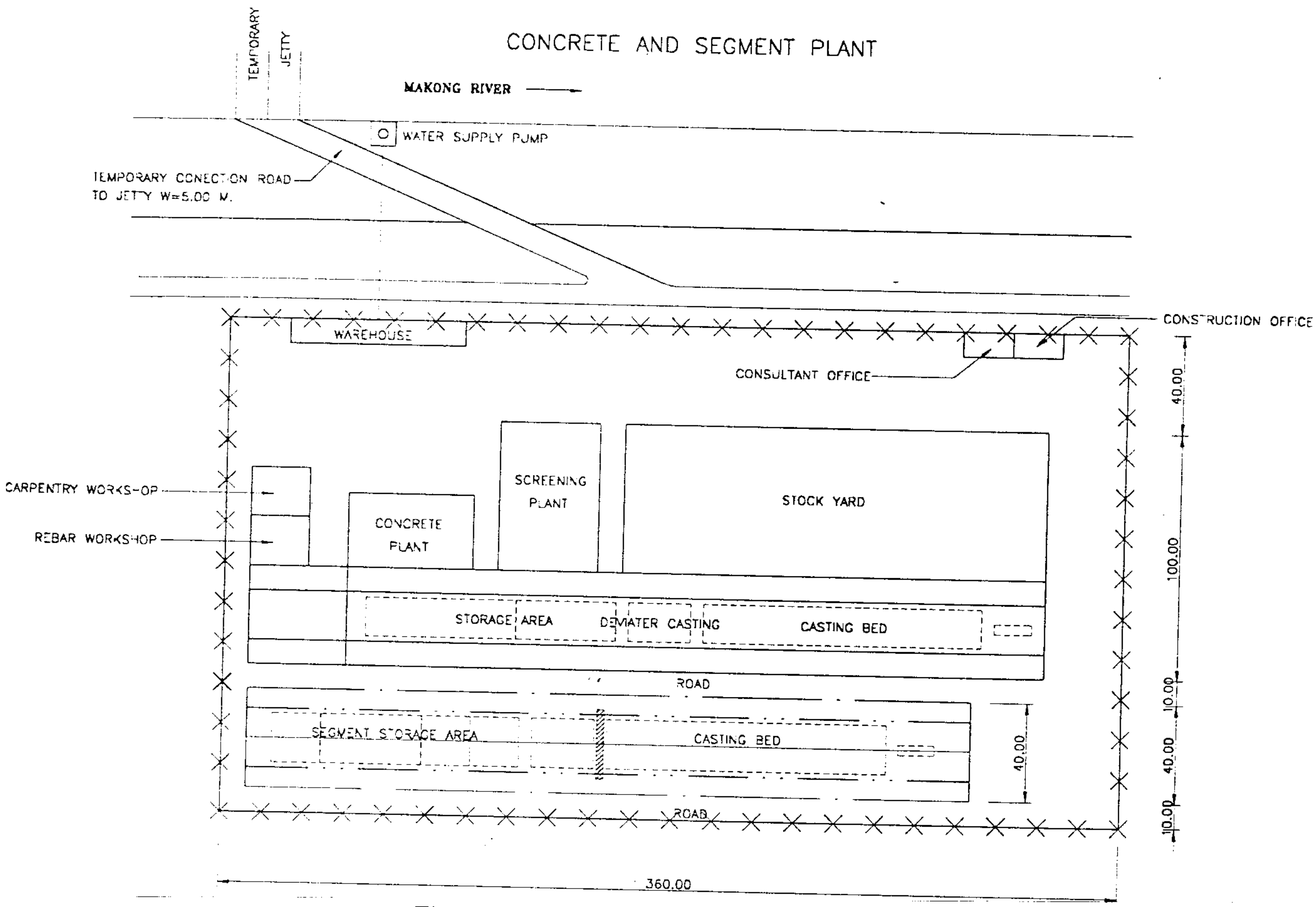


Figure 6.6.1 Concrete and Segment Plant

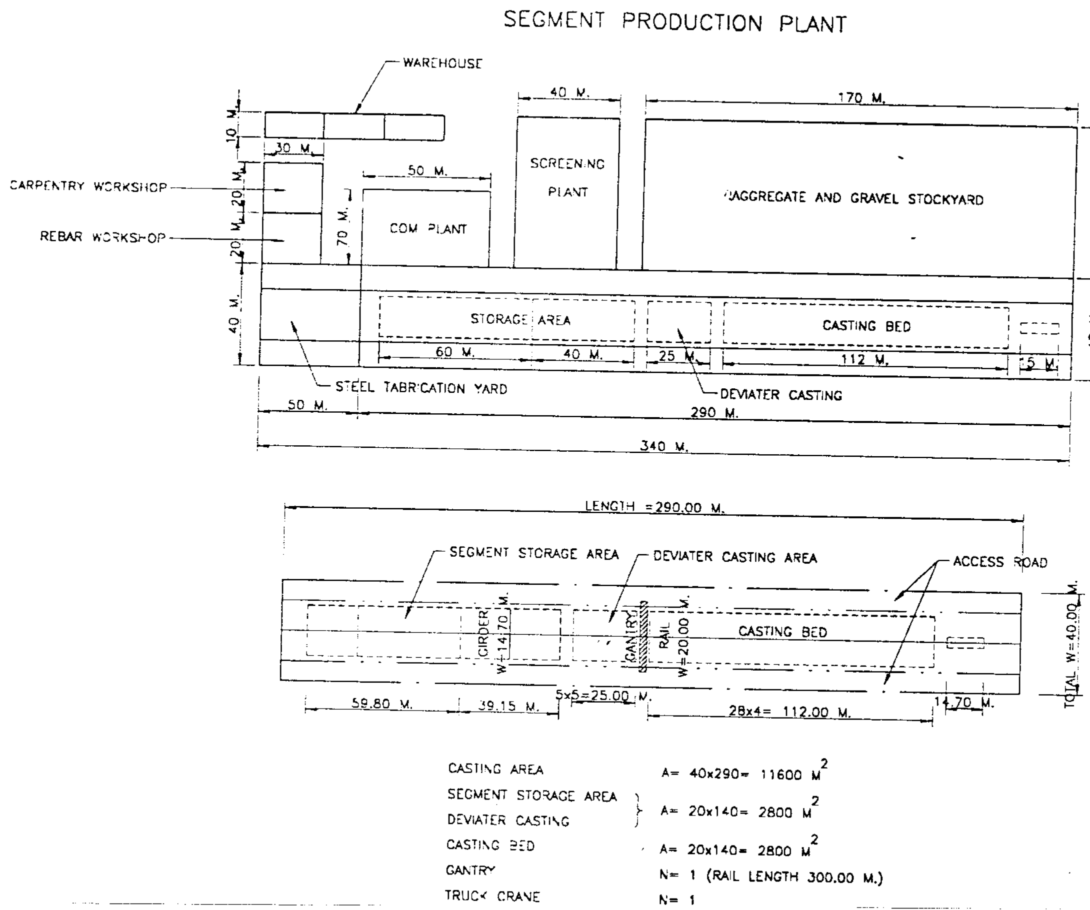


Figure 6.6.2 Segment Production Plant

6.6.2 Temporary Construction Facilities

General temporary construction facilities are shown in Figure 6.6.3.

The following temporary access roads in the Project area will be required for transportation of construction materials, equipment and embankment materials for the approach roads and Border Control Facility areas. These are shown in Table 6.6.2.

Table 6.6.2
Temporary Access Roads Required

Package			
1		2	3
Main Construction Yard Side	**The Other Side**	**Lao PDR Side**	**Thailand Side**
1) Inclined access road (new construction) from near the PC segment plant to the Mekong River Site (L=250m)	1) Inclined access road (new construction) from the Mekong River to construction site of the approach viaduct. (L=250m)	1) Access road (new Construction) from the provincial road A3 to the Border Control Facilities site along the existing electric transmission line (L=1,200m)	1) Access road (new Construction) from Road 212 to the Border Control Facilities site along the right bank of the connection road (L=90m)
2) Access Road at the Approach Viaduct (Detour Road of existing province road along the Mekong River side.) (L=200 m)	2) Access Road at the Approach Viaduct (Detour Road of existing province road along the Mekong River side.) (L=160 m)		
3) Access Road Connect between segment plant and Approach Viaduct L=120.0m			

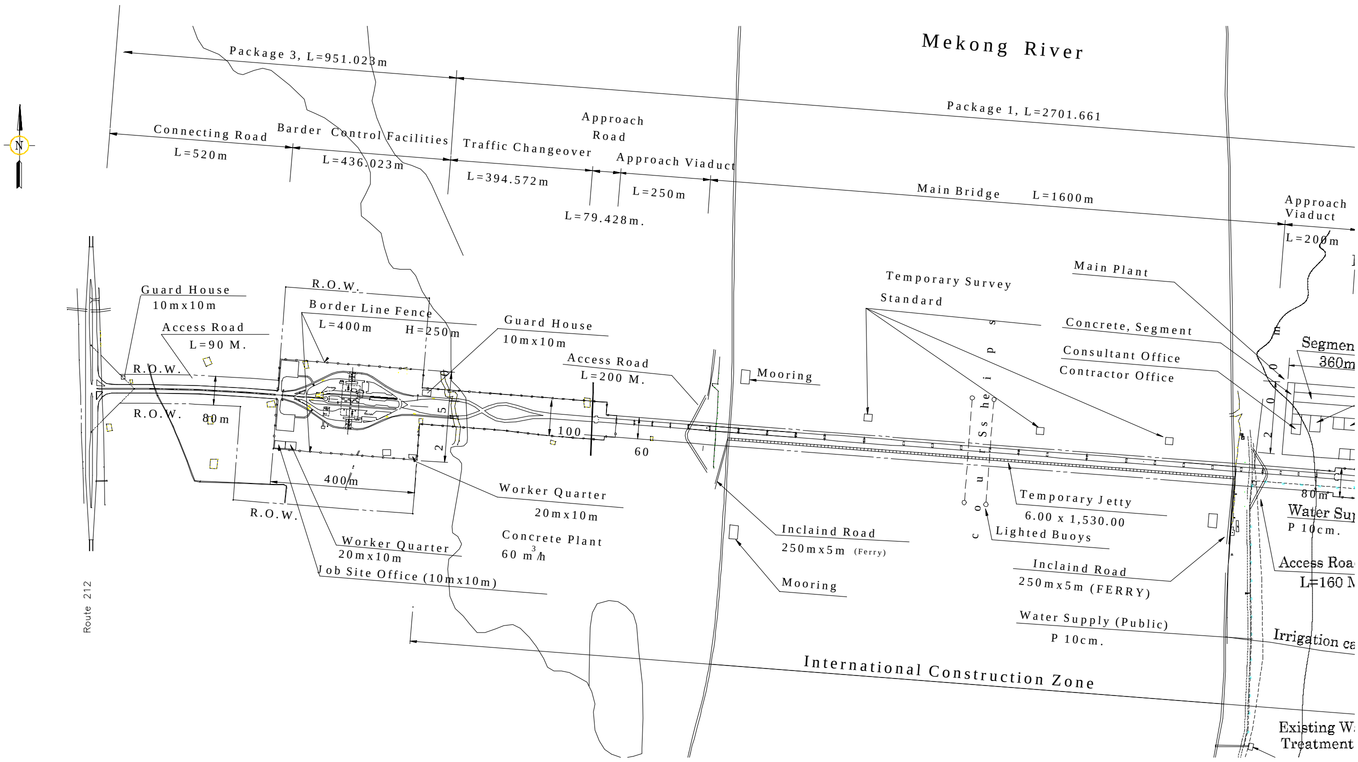
6.6.3 Utilities Supply

(1) Electric power supply system

The construction yard must be supplied with electric power for operation of the facilities installed during the whole construction period. The capacity required for the Project power supply is estimated as shown in Table 6.6.3 (1/2) and electric power supply systems at the project sites are shown in Table 6.6.3 (2/2).

Table 6.6.3 (1/2)
Capacity for Power Supply

Package			
1		2	3
Main Construction Yard Side	**The Other Side**	**The Lao PDR Side**	**Thailand Side**
132 KW	15 KW	70 KW	70 KW



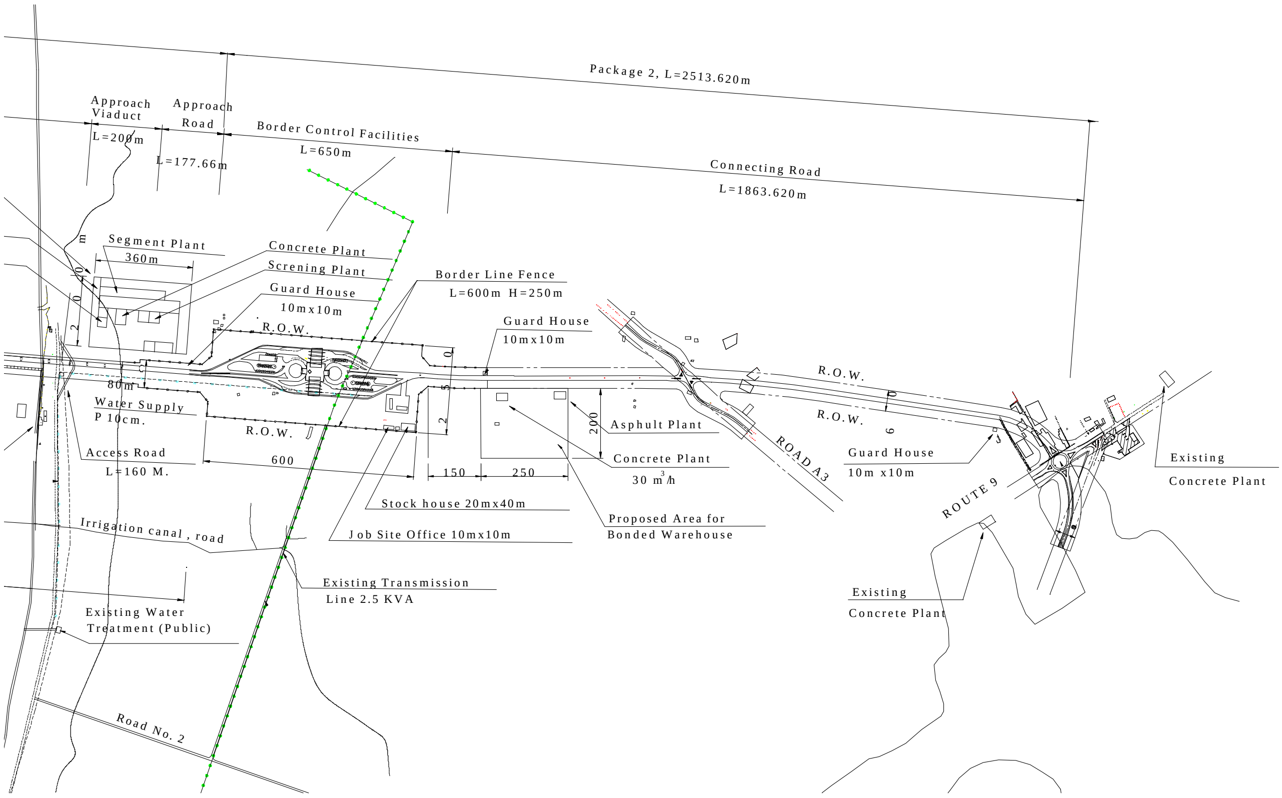


Figure 6.6.3(1/2) General Temporary Construction Facilities Plan (Starting from the Lao Side)

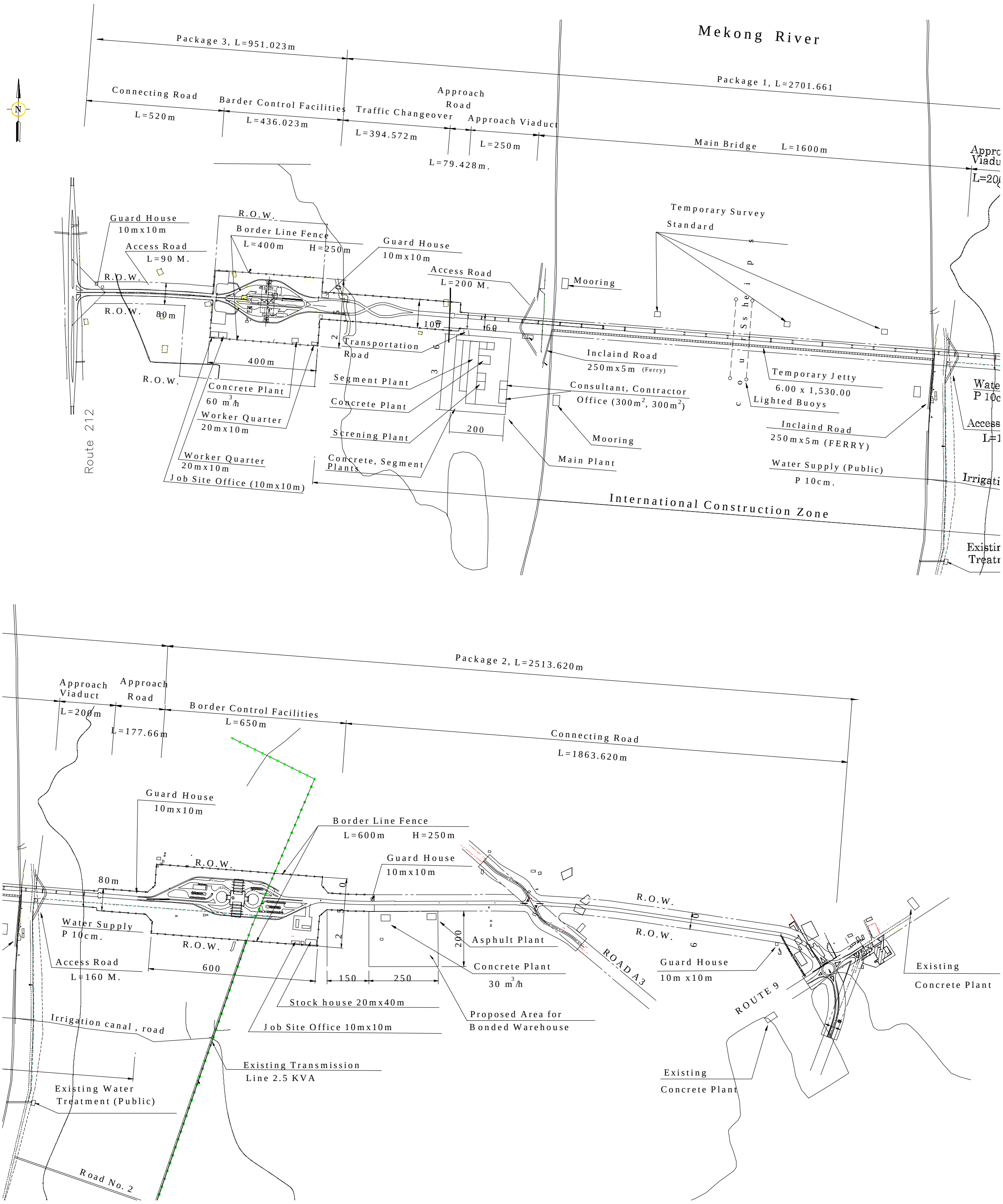


Figure 6.6.3 (2/2) General Temporary Construction Facilities Plan (Starting from the Thailand Side)

Table 6.6.3 (2/2)

Electric Supply System at Project Site

Package			
1		2	3
Thailand side	**the Lao PDR side**	**The Lao PDR side**	**Thailand side**
The power will be Distributed from the Existing power line at the National Road 212. (L = 500m)	The power will be distributed from the existing substation at a location upstream of the proposed Mekong Bridge (L = 500m)	The power will be distributed from the Existing substation at a location upstream of the proposed Mekong Bridge (L = 500m)	The power will be distributed from the existing power line at the National Road 212. (L = 500m)
Concrete Plant 60m^3/h (91kw)	-	Concrete Plant 30m^3/h 56kw	Concrete Plant 30m^3/h (56kw)
		Asphalt Plant 118kw	
		Total 174kw	

(2) Water supply system

Water required for the concrete and segment plants will be pumped up from the Mekong River and it is shown in Table 6.6.4. Drinking water supply system is shown in Table 6.6.5.

Table 6.6.4
Construction Work-Water Use

Package			
1		2	3
Thailand side	**The Lao PDR side**	**the Lao PDR side**	**Thailand side**
The water will be pumped up from the Mekong River (L = 150m)	The required water for concrete work will be pumped up from the Mekong River (L = 100m)	The required water for Concrete work will be pumped up from ground via bore hole wells	The required water for the concrete work will be pumped up from ground by bore hole wells.

Required volume of water for the construction are estimated at approximately 1.0 m ^{3}/s.

Table 6.6.5
Drinking Water

Package			
1		2	3
Thailand side	**the Lao PDR side**	**the Lao PDR side**	**Thailand side**
Groundwater will be used.	Public water supply system will be available.	Groundwater will be used.	Public water supply system will be available.

(3) Water sprinkling

The whole roads in and around the construction site during the dry seasons will be sprinkled with water by using water sprinkler trucks to remedy trouble from dust.

CHAPTER 7
Management and Maintenance

CHAPTER 7 : MANAGEMENT AND MAINTENANCE

7.1 GENERAL

This chapter briefly reflects and comments on the management and maintenance aspects of both the Second Mekong International Bridge and its Border Control Facilities. It also discusses two or more country agreements and other agreements which will become applicable as a result of the opening of the Bridge thus completing an important link in the so-called East West Corridor.

The crossing of the Mekong River at Mukdahan – Savannakhet and the upgrading of the national road Route No.9 both in the Lao PDR and Vietnam will signal a new era in cross border transportation and communication. In the months ahead Vietnamese trucks carrying dragon fruit and seafood will trundle through the streets of Bangkok while Thailand trucks loaded with textiles and canned food will ply the markets in Ho Chi Minh City, Hanoi and Vientiane.

Therefore, for the Border Control Facilities in all countries, concerned facilities and procedures must be streamlined and efficiently implemented so that local border crossing traffic, long distance traffic and tourists from other countries can enjoy easy and harmonious access from country to country.

7.2 MANAGEMENT AND MAINTENANCE

7.2.1 Introduction

The first attempt at management and maintenance of a Mekong River crossing bridge was at the Friendship Bridge between Nong Khai in Thailand and Vientiane in the Lao PDR. This bridge was constructed using Australian grant aid and was completed in 1994. The official opening was held on 8 April 1994 with the King of Thailand, President of the Lao PDR and the Prime Minister of Australia in attendance.

During the construction of the Friendship Bridge, management problems between the two countries basically did not exist as the Australian Government acted as the Employer and both the Contractor and the Engineer were also Australians. Construction and construction related decisions, therefore, were carried out independently of the Thai and Lao PDR governments but in accordance with the contract Documents which had previously been agreed to by the both governments.

7.2.2 Friendship Bridge

On completion of the Friendship bridge construction and on handing over of the bridge by the Australian Government to both the Lao PDR and Thailand Governments, an agreement between the two countries was formulated to set up a legal administration and maintenance structure for the bridge by each country as follows.

(a) A Permanent Committee (Legal Implementation Committee)

Each committee comprises of up to seven representatives from the concerned authorities at a high level and to be in charge of co-operating discussing and determining on any legal or political implication concerning the bridge.

This Legal Implementation Committee at the hand over time of the Friendship Bridge convened regularly to set up the procedures for the legal issues and also to establish a commission and bridge maintenance unit for each country. As all major legal issues between both countries have now basically been resolved and the other set up committees to carry out the administration and maintenance are operational, the Permanent Committee now rarely ever meets.

(b) A Commission or Bridge Co-ordination Committee

It comprises up to 7 members from each country. The Commissions ever met once every three months in the initial stages and the chairman of the Joint Commission meetings was to be on a rotation basis from each country.

The Commission or Bridge Co-ordination Committee had the following duties.

a) To discuss and consider on administration methods, use and maintenance of the bridge.

b) To stipulate, review and adjust regulations of administration, use and maintenance of the bridge.

c) To consult with the bridge maintenance unit and to review its assignment.

d) To issue the bridge's toll fees.

e) To monitor and review administration, use and maintenance of the bridge and works concerned so as to be in line with the policy and regulations set by the both Commissions for the effectiveness of the administration, use and maintenance of the bridge.

The Commission of each country has representatives from various Ministries concerned with the bridge. The chairman of the Lao PDR Commission is the Director of the Communication Department of the MCTPC while the Director General of the Department of Highways is the chairman of the Thailand Commission.

The Commission now normally only meet once a year to consider administration methods, review on toll fees and the annual maintenance budget.

(c) Bridge Maintenance Committee (Bridge Authority)

Each country has set up a Bridge Maintenance Committee and these committees meet as and when required (at least 2 times per year). The duties of these committees are as follows:

(a) To co-operate and co-ordinate in the administration, use and maintenance of the bridge so that they would be in accordance with the regulations and rules set up by the Commission.

(b) To control use, administration, maintenance and repair of the bridge.

(c) To arrange the yearly budget plan for maintenance and repair of the bridge.

(d) Other bridge related items

The Current committee structure for The Friendship Bridge is shown in Figure 7.2.1. and the current Lao PDR Management and Maintenance Structure in Figure 7.2.2.

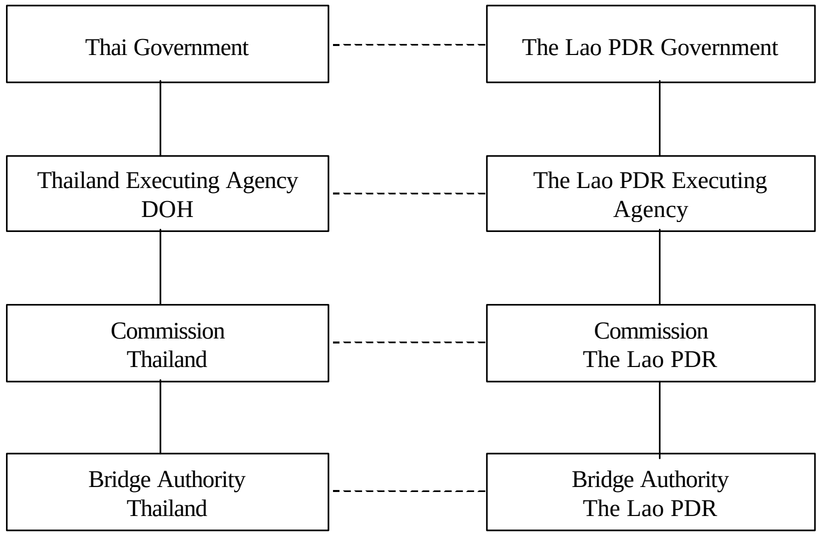


Figure 7.2.1 Organization Structure of the Friendship Bridge

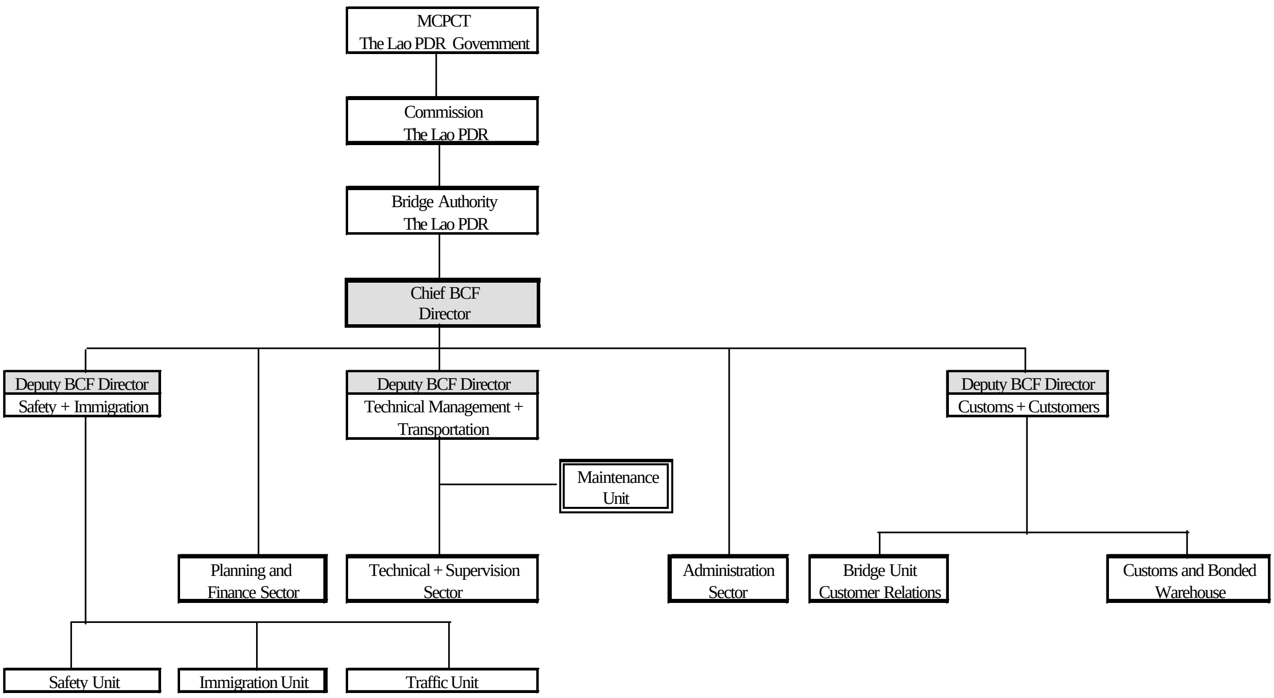


Figure 7.2.2
The Lao PDR Management and Maintenance Structure for the Friendship Bridge

The management and maintenance structure for both countries that has been implemented for the Friendship Bridge has generally worked although not perfect. However, the Second Mekong International Bridge, especially during the Construction stage, will be different as it will be under loan funded to both governments and it is not a grant aid. In this case there will be two Employers for both the Engineer and the Contractor to deal with, since it seems highly unlikely that a Joint Bridge Authority representing both countries can be formed to act as a single Employer during construction due to the major constitutional differences between the two countries.

7.2.3 Organization for Construction Project

For the design study, preconstruction and construction stages of the Project, both the Lao PDR and Thailand governments have each set up two committees to manage the Project. These committees are as follows :

(a) Project Co-ordination Committee

Comprising up to 7 members from each country. This committee is essentially the same as the Commission or Bridge Co-ordination Committee which is still in operation for the Friendship Bridge. The duties of the Committee will be as follows.

1. To proceed for the agreement for the bridge construction in terms of technical requirements, budget and legal issues.

2. To assign any concerned parties to operate in accordance with the conditions, duties and agreement for the bridge construction.

3. To set up meetings with parties of the other country to resolve any differences and to ensure each party contributes to a smooth implementation of the bridge construction.

4. Any other requirements.

(b) Bridge Management Committee (BMC)

Comprising of up to 7 members from each country. The following duties will be incharge.

1. To co-ordinate with parties of the other country to set up criteria to hire the Consultant for procurement, preparation of the Tender Documents, preparation of the Contract etc. in regard to the Bridge construction.

2. To ensure construction conforms with current laws and regulations and the agreement with the other country's party.

3. To collect all data and conditions that both parties cannot agree to and to submit these to the Project Co-ordination Committee for finalization.

4. To attend meetings with the other country's party to resolve any problems that may arise before and during the construction until completion of the Project.

The organizational structure for the Construction Project is given in Figure 7.2.3.

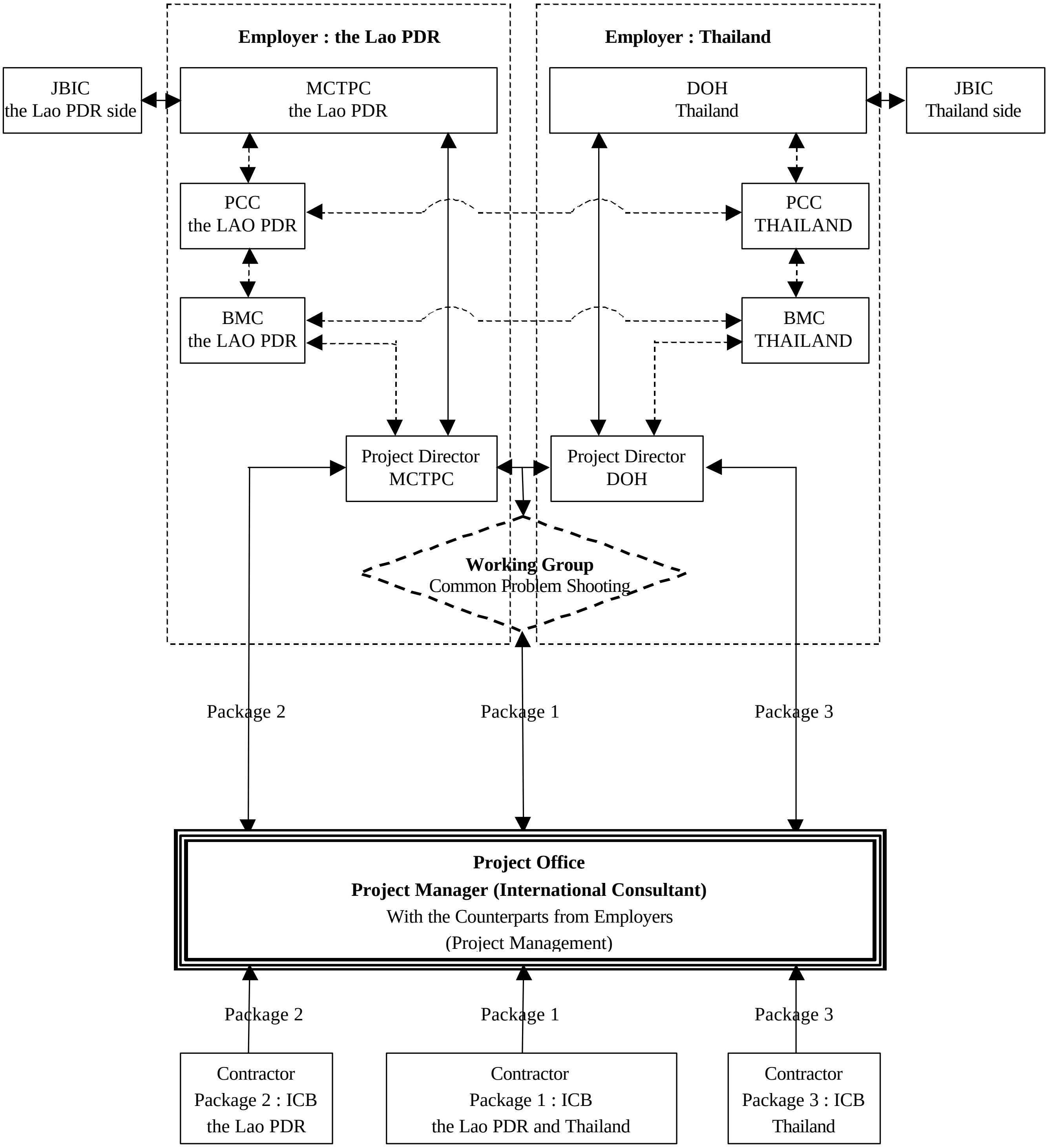


Figure 7.2.3

The Second Mekong International Bridge Construction Project Organization

Both the Lao PDR and Thailand would execute Project facilitation at an operational level dealing with the more detailed arrangements for a review of documentation, land acquisition, access, work areas, services etc. via Project Directors as the "Employer". These two Project Directors would be authorized and represent a legal authority for each country.

7.2.4 Management after Completion

Once the Bridge is completed it is recommended that each country set up a Legal Implementation Committee similar to that used on the Friendship Bridge. This committee can be effectively exploited once all the legal issues between the countries have been resolved.

The respective Project – Co-ordination Committees will remain as the "Commission" for the Second Mekong International Bridge once the Project has been completed and the Bridge Management Committees will be restructured to become the Bridge Management Authorities or just Bridge Authorities with the chairman being the respective district engineer or provincial governor. Bridge Management Authorities will report on a regular basis to each countries "Commission" on any administration or maintenance issue, that cannot be resolved or requires dealing with at a higher level. In addition, the BCF structure for the Lao PDR and Thailand would be similar to that shown in Figure 7.2.2

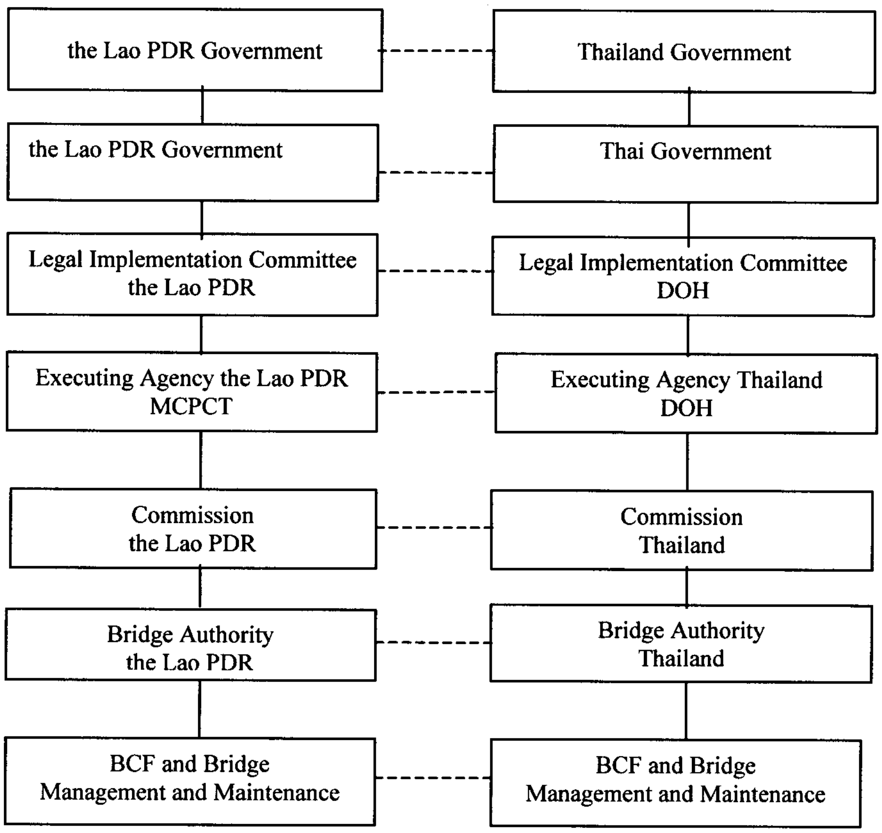


Figure 7.2.4 Organization of Bridge and BCFs on Completion

7.2.5 Operation and Maintenance

7.2.5.1 Operation

As it is not possible at present to establish a Joint Executing Agency from both countries, operation and maintenance will be carried out under the Bridge Management Authorities. The Bridge will be divided at its apex into the Lao PDR side and the Thailand side. It should be noted that the apex position may not coincide with the international boundary but it is the position where contract and maintenance costs will be separated between both countries.

The operation and maintenance of the Bridge will be carried out effectively under each country's Bridge Management Authority. Each country will be responsible for its connecting roads, Border facilities, Immigration, Customs etc.

7.2.5.2 Maintenance

For maintenance of the Bridge and roads, each authority will be responsible for the routine and periodical maintenance as follows.

(1) Routine Maintenance
- Cleaning of road surface and drainage.
- Upkeep of landscaping areas.
- Replacing of lighting.
- Other works.

(2) Periodic Maintenance
- Repairing of the road surface.
- Repair of railing.
- Replacing of slope protection.
- Repair of electric facilities.
- Other works with large expenditure.

The total annual maintenance cost is estimated as follows for both countries.

Routine Maintenance	Cost US$	
a) Administration	2,000	
b) Wages	6,000	
c) Routine + Maintenance	8,000	
d) Power costs	8,000	
Total	24,000	
Periodic Maintenance Costs		
a) Period cost over 8 years	$ 211,000	
Total Cost (Thailand and the Lao PDR)	$ 50,000	Per Annum

7.2.5.3 Inspection

It is important to identify defects at an early stage so that repair works can be carried out; Further deterioration of the defect might lead to more expensive repairs at a later date.

Inspection for maintenance will be classified into (a) daily inspection, (b) periodical inspection, and (c) special inspection.

a) Daily inspection is focused on anomalies visualized from the road during the road patrol etc. Therefore, principal objectives of such inspection will be states of pavement, drainage acceptability and facilities for traffic safety.

b) Periodical inspection is established under regular inspection items (refer to Table 7.2.1). The inspection will include anomalies or damage of structural members of bridges, buildings and other main structures and they are not visible at daily inspections. The result of inspection is recorded and must be preserved.

c) Special inspection is conducted to verify any irregularities of the structural members or the entire structure after collapse of vehicles, flooding, earthquake etc. It is applied to inquire in the structural safety, to justify for necessary traffic restriction or emergent repairing work.

Countermeasures to damage or anomalies discovered during inspection will be reviewed based on seriousness or criticality of the structural member. Traffic restriction or emergent repairing and others can be applied as necessary. In case the damage or anomalies require no immediate actions, their causes will be investigated or necessity of any further detailed investigations as well as repairing or reinforcement will be judged. If repairing or reinforcement is required, selection of the methods will be essential. A suitable method must be carefully determined under working conditions. Flowchart starting from such inspections to selection of repairing or reinforcement methods are shown in Figure 7.2.5.

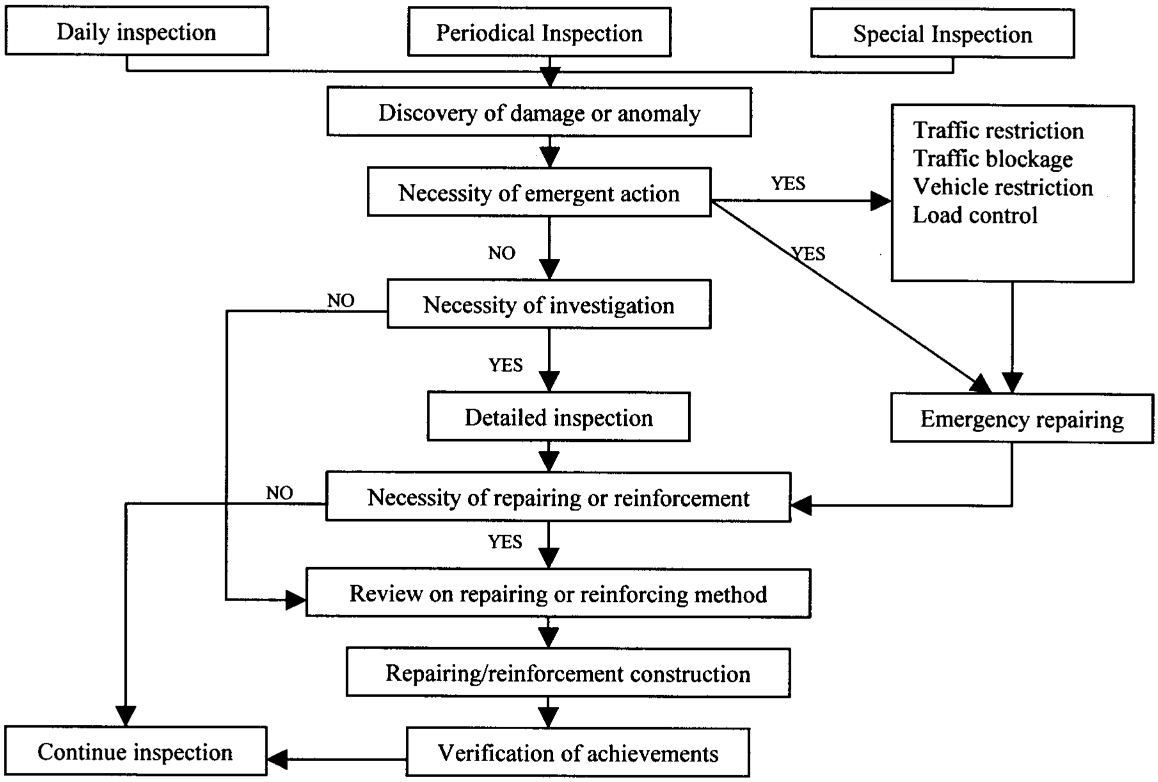


Figure 7.2.5 Procedures of Maintenance

Inspection frequency is once weekly for daily inspection, and once or more yearly for periodical inspection. Special inspection will be conducted immediately after flooding, earthquake or other serious occurrences as well as after discovery of critical anomalies during daily inspections or periodical inspections.

7.2.5.4 Maintenance of Road

A total length of this Project is approximately 6.2 km. Road sections excluding the Bridge and BCF area on both the Lao PDR and the Thailand sides are less than half of total length. The existing ground around approach roads is mostly paddy fields and level of ground is lower than the HWL of the Mekong River. Approach roads between the Bridge and each BCF on both sides and a part of the connecting road on the Lao PDR side are constructed on high embankment with more than 5 meter height.

Road infrastructure is composed of various elements such as embankment, cutting slope, pavement, curb, drainage, box culvert, pipe culvert, guardrail, fence, lighting, traffic signs, etc. These elements shall be maintained and repaired appropriately to keep safety of road condition and to extend a road life.

Objects, frequencies and method of each inspection for road maintenance are shown in Table 7.2.1 Objective positions and inspection items are shown in Table 7.2.2

Table 7.2.1 Classification of Inspection for Road

Class	Major Object	Frequency	Methods
Daily Inspection	Pavement Slope Embankment Shoulder Traffic Safety Facilities Guardrail, Handrail Security Fence	Weekly	Road patrol or Visual Inspection on foot
Periodical Inspection	U-ditch Side ditch Manhole Pipe Culvert	Monthly	Visual Inspection
	Box Culvert RC U-Wall	3 Monthly	Visual Inspection
Special Inspection	All Structure Embankment, Slope	Accident Disaster Serious Complaint	Visual or Mechanical Inspection

Table 7.2.2 Inspection Items for Road

	Objects	Principal Inspection Items
Pavement	Asphaltic Concrete Pavement Cement Concrete Pavement Concrete Block Pavement	Settlement Cracking Potholes Rutting Wave
Slope	Embankment Cutting Slope Shoulder	Landslide Erosion Scouring Rock Avalanche Cracking Washing Out
Drainage	U-Ditch Side Ditch Manhole Pipe Culvert Box Culvert RC U-Wall	Accumulation of Debris Settlement Collapse Cracking
Traffic Safety Facilities	Guardrail Handrail Traffic Signs Road Marking Street Lighting	Damage Disappear Breakdown
Fence	Security Fence	Damage Cracking

7.2.5.5 Maintenance of the Bridge

The most critical point on maintenance of a bridge is to be in control at all the time of most up to date information about states of this structure. Fundamentals source of information is inspection, that is, to realize an early discovery of irregularities from careful inspection, immediate repairing and others which are vital for safety and for avoidance of the bridge failure.

Since the bridge is composed of various structural members, inspections by observing all members will require long time. It is not really feasible in practice. Therefore, the inspection must be made under criteria of frequency, scope (positions and items) and accuracy based on structural member criticality, liability to harms, and difficulties in inspection.

Objects, frequencies and methods of each inspection for bridge maintenance are shown Table in 7.2.3.

Table 7.2.3 Classification of Inspection for Bridge

Class	Major Object Inspected	Frequency	Methods
Daily inspection	Pavement, Drainage, Expansion Joint, Concrete Barriers, etc.	Periodical at interval of 1 week	Road patrol (visual)
Periodical Inspection	All structural components	Periodical at interval of 1 or 5 years	Visual inspection
Special Inspection	All damaged structural components	Accident Disaster Serious Complaint	Visual or Mechanical Inspection

Table 7.2.4 shows objective positions and items at inspections. Among these, serious items for special attention are cracks of segment joint, diagonal shear crack of dapped hinge, displacement of expansion joints displacement of elastometric bearing, deforms of substructure, and scouring of ground foundation. In general, the support is largely harmed at earthquake. Guardrails or expansion joints will be easily destroyed from collision or impact from vehicles; they must be especially observed during daily inspections.

The damage ranking categorization for concrete member in a daily to periodical inspection is shown in Table 7.2.5.

Table 7.2.4 Inspection items for Bridge

	Structural member	Principal inspection items
Superstructure	Pavement	Steps, unevenness, hair cracks, bleeding, wearing, crack (linear, mesh patterns)
	Floor deck slab	Cracks, peels, angular break, exposed and corroded reinforcement, water leakage, deterioration, voids and dimples, lime segregation
	Main girder	Cracks, peels, exposed and corroded reinforcement, water leakage, deterioration, voids, dimples, lime segregation, installed device anomalies
	PC sail	Cracks, concrete coating deterioration
	Dapped hinge	Diagonal shear crack
	External cable	Sheath anomalies, cracks of deviator
	Paint	Irregular paint, deterioration, rust, corrosion
	Laminated bearing	Anchor bolt anomalies, soil sedimentation etc.
	Expansion joint	Performance inspection, noise, water leakage, damage
	Drainage system	Clogging, water leakage, cracks, corrosion
	Guardrail	Deforms, breakage, corrosion, cracks, fixture damage or cracks
	Lighting or appurtenant structures	Displacements, deforms, breakage, corrosion
Substructure	Pier and pile cap	Displacements, deforms, cracks, exposed and corroded reinforcements, scouring, riverbed deviations

Table 7.2.5
Damage Ranking Categorization for Concrete Member Damage Items

Damage Items	**Rank "A"**	**Rank "B"**	**Rank "C"**	**Rank "D"**
	Urgent repairs are necessary to secure the safety	Repairs are required	Damage, defects or deterioration is small and the necessary remedial measures are associated with routine maintenance	Virtually no repairs and no further study are required
Crack of reinforced concrete member	Cracks more than 0.3mm due to excessive bending or shear stress, together with water leakage, free lime and salt in certain cases, which causes a reduction in loading capacity	Cracks 0.3–0.2mm together with slight water leakage, which causes a reduction in durability	Cracks 0.2mm in width with no water leakage	Slight and local cracking, or no damage
Crack of segment (Joint) and PC member	Cracks more than 0.2mm	Cracks 0.2-0.1mm	Cracks 0.1mm	Same as above
Peel off	Serious peel off which affects the safety of third parties due to a possibility of concrete falling down	Wide rang of peel due to rebar corrosion which causes a reduction in loading capacity	Small range of peel due to external forces which affects the durability of the beams	Slight peel off which causes no negative effects, or no damage
Rebar exposure	Serious and wide range of rebar exposure together with corrosion which causes a reduction in loading capacity	Partial rebar exposure with corrosion due to expansion of rebars, peel off or honeycomb, which causes negative effects on loading capacity	Partial rebars exposure without corrosion which affects the durability of the beams	Rebars exposed in isolated areas without corrosion, or no damage
Honeycomb	Not applicable	Wide range of honeycomb with seriously corroded rebar which causes a reduction in loading capacity	Partial range of honeycomb which affects the durability of the beams	Partial and slight honeycomb, or no damage
Void	Not applicable	Wide range of voids with serious water leakage which causes a reduction in loading capacity	Wide range of voids which affects the durability of the beams	Partial voids, or no damage
Water Leakage	Serious and wide range of water leakage through cracks or voids which may progress and cause a reduction in loading capacity, together with segregation of free lime or salt	Serious and wide range of water leakage through cracks or voids which causes a reduction in durability, together with segregation of free lime or salt	Localized or partial water leakage which has negative affects on the beams	Slight and spot water leakage, or no damage

7.2.5.6 Maintenance of BCF's Facilities

Maintenanace of Border Control Facilities (BCF) shall be performed by the Contractor during the Contract by keeping the building structures and utilities in good conditions.

The maintenance of the BCF is substantially made in line with the pre-established Maintenance Manual which contains various items, period and procedural description as well as the name and telephone directory of manufactures construction materials. The maintenance will be mainly made to cleaning of building interior and exterior finishes, supply and feeding of lubricant and chemical and checking, repairing/replacing of electrical and mechanical facilities.

The principal inspection items and recommended approximate maintenance periods of the BCF are summarized below:

Table 7.2.6 Inspection items for Building

No.	Item	Period
1	Cleaning of floor finishes	Daily
2	Watering to lawn and planting trees	Daily
3	Cleaning of wall and ceiling	Yearly
4	Repainting of exterior walls	Every 3 years
5	Repainting to rusted portion	Every 3 years
6	Checking of level, vertical and horizontal alignment of the land and structures	Yearly
7	Visual checking of any cracks, water leakage and deterioration of materials	Anytime

Table 7.2.7 (1/2) Inspection Items for BCF's Facilities (The Lao PDR Side)

No.	Item		Period
1	Power receiving facility	Regular examination Grounding resistance measurement	6 months 1 year
2	Emergency diesel generator	Test running Regular examination	2 months 6 months
3	Uninterruptible Power Supply System	Battery replacement	5 years
4	High mast lighting	Lighting fixture cleaning Lamp replacement Grounding resistance measurement	6 months At all times 1 year
5	High bay lighting	Lighting fixture cleaning Lamp replacement	6 months At all times
6	Internal lighting	Lighting fixture cleaning Lamp replacement	1 year At all times
7	Lightning protection system	Grounding resistance measurement	1 year
8	Water tower	Tank cleaning Pump regular examination Grounding resistance measurement	1 year 2 months 1 year
9	Roof top tank	Tank cleaning Pump regular examination	1 year 2 month
10	Septic tank	Filter replacement Outlet water examination	Supplier recommend 6 months
11	Air-conditioner	Filter cleaning	3 months
12	Fire hydrant system	Test running Regular examination	6 months 6 months
13	Truck Scale	Regular examination	6 months

Table 7.2.7 (2/2) Inspection Items for BCF's Facilities (Thailand Side)

No.	Item		Period
1	Power receiving facility	Regular examination Grounding resistance measurement	6 months 1 year
2	Emergency diesel generator	Test running Regular examination	2 months 6 months
3	Uninterruptible Power Supply System	Battery replacement	5 years
4	High mast lighting+	Lighting fixture cleaning Lamp replacement Grounding resistance measurement	6 months At all times 1 year
5	High bay lighting	Lighting fixture cleaning Lamp replacement	6 months At all times
6	Internal lighting	Lighting fixture cleaning Lamp replacement	1 year At all times
7	Water tower	Tank cleaning Pump regular examination Grounding resistance measurement	1 year 2 months 1 year
8	Septic tank	Filter replacement Outlet water examination	Supplier recommend 6 months
9	Air-conditioner	Filter cleaning	3 months

7.3 CROSS BORDER ISSUES

7.3.1 Immigration Issues

One of requirements of the new Bridge will be to streamline immigration procedures especially for international travelers. The Lao PDR presently, at its land border crossings with Thailand, provides border pass facilities to the Lao PDR citizens who may travel only to a designated distance within Thailand unless they obtain special permission from the Thai Authorities. Similarly, Thailand border area citizens may use a border passes for border area travel within the Lao PDR.

International travellers from foreign countries, however, are at present unable to obtain a visa on entry at the Lao PDR land border posts. International travellers must apply for a visa at the appropriate Lao PDR Embassy for cross border travel. Entry to Thailand at a land border crossing travellers are readily given visas on entry. Therefore, to promote tourism for international travellers it is imperative that the issuance of visas on arrival at the land border crossing at the Lao PDR be made readily available even if a small fee is mandatory.

7.3.2 Customs and Transportation Issues

Customs control and regulations are an integral part of cross border transportation issues. In the past, bureaucratic difficulties have proved a major constraint to the freedom of inter – state and transit trade between the Lao PDR and Thailand. Previously the 1978 Transit Agreement required the use of Thai transport and transit facilities for the movement of the Lao PDR export and import trade through Thailand. A cartel arrangement existed whereby five Thai transporters were licensed by the Thai Government to move the Lao PDR sourced or oriented cargoes between the Thai ports and the Lao PDR border with Thailand, while the Lao PDR owned trucks were only permitted to cross the border to pick up or deliver goods at warehouses adjacent to border customs posts.

There was also a requirement under the 1978 Transit Agreement that all transit cargoes had to be moved to a special yard for customs verification resulting in significantly higher storage costs being incurred for international sourced or oriented cargoes than for domestic cargoes. The cost to the Lao PDR economy was estimated by an UNCTAD study which examined the alternative if the State Railways of Thailand was to institute a service between Bangkok and Nong Khai and provide transshipment to a bonded dry port in Vientiane. It was estimated that containerized goods could be transported between Thai ports and the Lao PDR at about one half the rates charges by Thai Transporters, so that an annual saving of around US$1.5 million could accrue on the Lao PDR external payments for transit shipments to and from Thai ports.

7.3.3 ASEAN Framework Agreement on the Facilitation of Goods in Transit

With the joining of Vietnam (1995) and the Lao PDR (1997) to ASEAN, it seemed more likely that a rolling back of the non-physcial barriers might be achieved by the "push pull" potential of the ASEAN group rather than by a concentration on the various bilateral agreements following a Draft ASEAN Trade and Transport Agreement which was implemented in August 1997.

This draft agreement was followed by Working Group Meetings in June and August 1998 and a formal signing of the ASEAN Framework Agreement on the Facilitation of Goods in Transit at the sixth ASEAN Summit in Hanoi (The Hanoi plan of Action) on 16 December 1998. The objectives of this Agreement are :

a) To facilitate transportation of goods in transit, to support implementation of the ASEAN Free Trade Area, and to further integrate the regional economies.
b) To simplify and harmonize transport, trade and customs regulations and requirements for the purpose of facilitation of goods in transit
c) To establish an effective, efficient, integrated and harmonized transit transport system in ASEAN

7.3.4 Agreement on Road Transport

As a result of the Hanoi Plan of Action and in particular the ASEAN Framework Agreement on the Facilitation of Goods in Transit at Bangkok on 5 March 1999, the Governments of the Lao PDR and Thailand signed an agreement that valids for one year on Road Transport. This agreement allows essentially for the unhindered transport of goods in transit through both countries by transporters of either country. However, although this agreement has been in operation for over 8 months to date, observations indicate that the previous transportation methods are not changed. It is understood that this is due to several protocols being not yet finalized.

7.3.5 Tripartite Cross Border Transport Agreement

On 26 November 1999, a historic cross-border transport agreement between Thailand, the Lao PDR and Vietnam was signed by the respective countries' Transport Ministers in Vientiane. The agreement mainly covers principles and protocols have yet to be worked out and drafted.

The objective of the agreement is to ease the flow of traffic by integrating the separate border controls so that inspections of peoples, vehicles and goods can be carried out jointly and speedily.

The new cross border agreement is part of the proposed US$350 million, 400 km East-West Transport Corridor which will join Mukdahan and Savannakhet via the Second Mekong International Bridge and then on to Lao Bao, Dong Ha and the port of Da Nang in Vietnam.

It is expected that if protocols are drafted and signed, Vietnamese Trucks will be able to travel directly to Bangkok in Thailand without off-loading to other transporters at border crossings and, similarly, Thai vehicles will be able to travel directly to major cities in Vietnam.

CHAPTER 8
Environmental Study

CHAPTER 8 : ENVIRONMENT

8.1 GENERAL

According to the system of Environmental Impact Assessment (EIA) in Thailand, this Project would not be the subject of the EIA. In the Lao PDR, the Law on Environmental Protection was approved by the parliament in May 1999. Although the Regulation on the EIA is under preparation now, it would not appear to have any necessity of EIA for this Project because the site in the Lao PDR is in flatland predominantly used for cropping along the Mekong River and does not include the wildlife reservation area, national park, wetland and cultural property which require international protection.

In Guidelines for Environmental Consideration of the JBIC (OECF), large, new or rehabilitation projects of road and railroad construction corresponds to “Category A: Submission of an EIA report is required and the Project is to be appraised in the light of the Guidelines.” Therefore, this environmental study is based on the JICA Guidelines and the objectives are to evaluate the environmental impacts and to establish mitigation plan and monitoring plan for this project.

This Environmental Study is divided into two bodies, that is, Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA). In the phase of the basic design of the Project, the Initial Environmental Examination (IEE) has been carried out with the review, analysis and assessment of the previous studies and field reconnaissance survey results, together with the studies on the environmental administration systems in the Lao PDR and Thailand. Then this study has been followed by a detailed field survey of the Environmental Impact Assessment (EIA) for Detailed Design of the Project.

8.2 INITIAL ENVIRONMENTAL EXAMINATION (IEE)

8.2.1 Environmental Parameters and Potential Impacts

The environmental parameters for the IEE are confirmed through examination of the Project activities during the Basic Design Study period. Impacts and influence on these parameters due to implementation of the Project were examined based on the results of the environmental survey in the Lao PDR and Thailand considering relationship among the Project activities.

Through the examination, a few environmental components could be affected by the planned Basic Design of the Project as given in Table 8.2.1 which shows the IEE Matrix (Project Activities-Environmental Parameters Matrix), mainly considering the negative impacts caused by the Project.

8.2.2 Overall Evaluation

The overall evaluation of the environmental impacts of the Second Mekong International Bridge Construction Project is considered to be minor.

The environmental evaluation and mitigation measures are summarized in Table 8.2.2.

Table 8.2.1
IEE Matrix

Activities which may cause impacts / Category of environment	Construction Period		Operational Stage	
	Passage of Construction Vehicles	**Construction of Bridge and Connecting Roads**	**Existence of Bridge and Connecting Roads**	**Passage of Vehicles**
1.Social Environment				
Social Aspects				
Resettlement				
Community severance				
Substantial changes in way of life				
Conflict among communities or people				
Land use				
Landscape				
Water supply system				
Transportation and Traffic				
Land transportation				
Local navigation				
Economic Activities				
Relocation of bases of economic activities				
Occupational change, loss of labor opportunity				
Increase in income disparities				
Fishery				
Public Health				
Outbreak of contagious diseases				
Prevalence of epidemic diseases				
Increase in domestic and other human waste				
Cultural Issues				
Impairment of historic remains and cultural assets				
2.Natural Environment				
Biological and Ecological Issues				
Deterioration or degradation of vegetation				
Degradation of flora/fauna/ecosystem				
Degradation of aquatic life				
Proliferation of exotic and/or hazardous species				
Soil and Land Resources				
Soil erosion				
Hydrology and Air and Water Quality Issues				
<Hydrology>				
Changes in water flow conditions				
Soil sedimentation				
Riverbed degradation				
<Water Quality and Temperature>				
Water contamination and deterioration of water quality				
<Atmosphere>				
Air pollution				
Noise and Vibration				

Note: : The activity which has a potential environmental impact

Table 8.2.2
Overall Environmental Evaluation and Mitigation Measures

Period	No.	Items	Precondition	Impact without measures	Mitigation measures	Evaluation
Construction period	1)	Resettlement	Resettlement will be minimal.	+	-	+
	2)	Land use	Resettlement will be minimal.	+	-	+
	3)	Water supply system	Discharging sediment during piling activity	++	Adoption of steel stand piping method	+
	4)	Land transportation	Increase of construction traffic on local road	+++	Construction of access road and preparation of traffic management	++
	5)	River navigation	The project sites don't interfere with the local ferry service.	+	-	+
	6)	Fishery	There are no professional fisheries	+	-	+
	7)	Public health	Risk of diseases in labor camp	++	Ensuring proper sewage treatment and disposal etc.	+
	8)	Cultural assets	There are no significant cultural assets in and around the project sites	-	-	-
	9)	Soil erosion	Earthwork of the connecting road	+++	Installation of sediment collection ponds	++
	10)	Water contamination	Arising from the sediment discharge in piling activity	+++	Adoption of steel stand piping method	++
	11)	Air pollution	Impact of dust fall to some villages located near the construction site	+++	Dust suppression measure	++
	12)	Noise/Vibration	Impact of noise/vibration to some villages located near the construction site	+++	Restriction of pile driving work in daylight hours	++
Operational period	1)	Community severance	The Bridge and connecting road will interfere with traffic on the major local roads.	++	Construction of underpass for human use	+
	2)	Landscape	Part of connecting road might be visible from surrounding villages and temples.	+++	Replantation	++
	3)	Land transportation	The connecting road will connect with national roads in both countries, so there is no effect on local traffic conditions	+	-	+
	4)	Flora/Fauna/Eco-system	No reserved forest, wildlife sanctuary, national park or nationally declared as significant conservation area in the Project sites.	++	-	++
	5)	Aquatic life	The Bridge piers will not impede ability of fish to migrate.	++	-	++
	6)	Changes in water flow conditions	The total cross-sectional area of the bridge is estimated as small.	+	-	+
	7)	Air pollution/Noise/ Vibrations	The estimated traffic volume level is low.	++	-	++

Note:
++++ : Significant
+++ : Moderate
++ : Minor
+ : Insignificant
- : None

8.3 ENVIRONMENTAL IMPACT ASSESSMENT

8.3.1 Existing Environmental Study

8.3.1.1 Water Quality

(1) Objectives

- To investigate the existing water quality of the Mekong River.
- To evaluate the changes in water quality due to the Project.
- To recommend appropriate mitigation measures and monitoring program during the construction and operation phases.

(2) Methodology

Methodology of the study is identification of the Mekong River at 2 sampling stations (see Figure 8.3.1) as 1,000 m upstream and 1,000 m downstream of the Second Mekong International Bridge Construction Project. Parameters for water sampling consist of temperature, pH, turbidity, conductivity, DO, COD, BOD_5, SS, oil & grease, lead and fecal coliform bacteria.

(3) Results of the Study

The analysis results are shown in Table 8.3.1.

Table 8.3.1
Existing Water Quality

ITEMS	UNIT	Station 1	Station 2
Temperature	°C	24.5	24.5
PH		7.83	7.86
DO	mg/l	7.94	7.76
Turbidity	NTU	339	321
Conductivity	mS/cm	199.7	196.8
Suspended Solids	mg/l	352	283.5
Fat, Oil &Grease	mg/l	N.D.	N.D.
BOD 5 days	mg/l	3.6	3.6
COD	mg/l	15.74	27.56
Lead (Pb)	mg/l	0.0044	0.0014
Fecal Coliform Bacteria	MPN/100ml	23	33
Class		4	4

Remark : Station 1 = 1,000m upstream of the Bridge
Station 2 = 1,000m downstream of the Bridge

The BOD_5 of 3.6 mg/l is considered high. Although it is lower than the MOSTE surface water quality standard, the water quality is considered to be poor. This is due to discharge of polluted water from the communities, industry and agricultural areas. The SS content (283.5-352.0 mg/l) and turbidity (321-339 NTU.) were significantly high.

Comparing water quality of both stations with OEPP surface water quality standard, it was found that the water quality of the samples was within class 4 (for industry or consumption but special water treatment process is required before use).

8.3.1.2 Aquatic Life

(1) Objectives

Objectives of the study are to collect the existing aquatic ecology, to evaluate some impacts on aquatic ecology, and to recommend on appropriate mitigation measures and monitoring program during construction and operation phases.

(2) Methodology

Methodology of the study is to collect sampling water organism comprising plankton organism and benthic organism. Sampling was conducted along the Mekong River at 2 sampling stations (see Figure 8.3.1).

(3) Results of the Study

-Plankton Organism

Concerning identification analysis of plankton samples, the results showed total of 1 phylum of phytoplankton and 3 phyla of zooplankton.(refer to Table 8.3.2)

-Benthic Organism

No benthic organism was found at each sampling station. The water current in the Mekong River was very rapid and the riverbed of the Mekong River was mostly sand and gravel. Therefore, the benthic organism is flushed downstream easily. These results are common in the flood season.

8.3.1.3 Air Quality

(1) Objectives

- To collect and to analyze the local meteorological data around the Project area which influence air pollutant dispersion.
- To evaluate the existing air quality around the Project area which may be affected.
- To predict air pollution emission from the Project activities both in the construction and operation phases and to estimate air quality impact due to the Project operation via mathematical model.
- To recommend on mitigation measures and monitoring programs during both construction and operation phases.

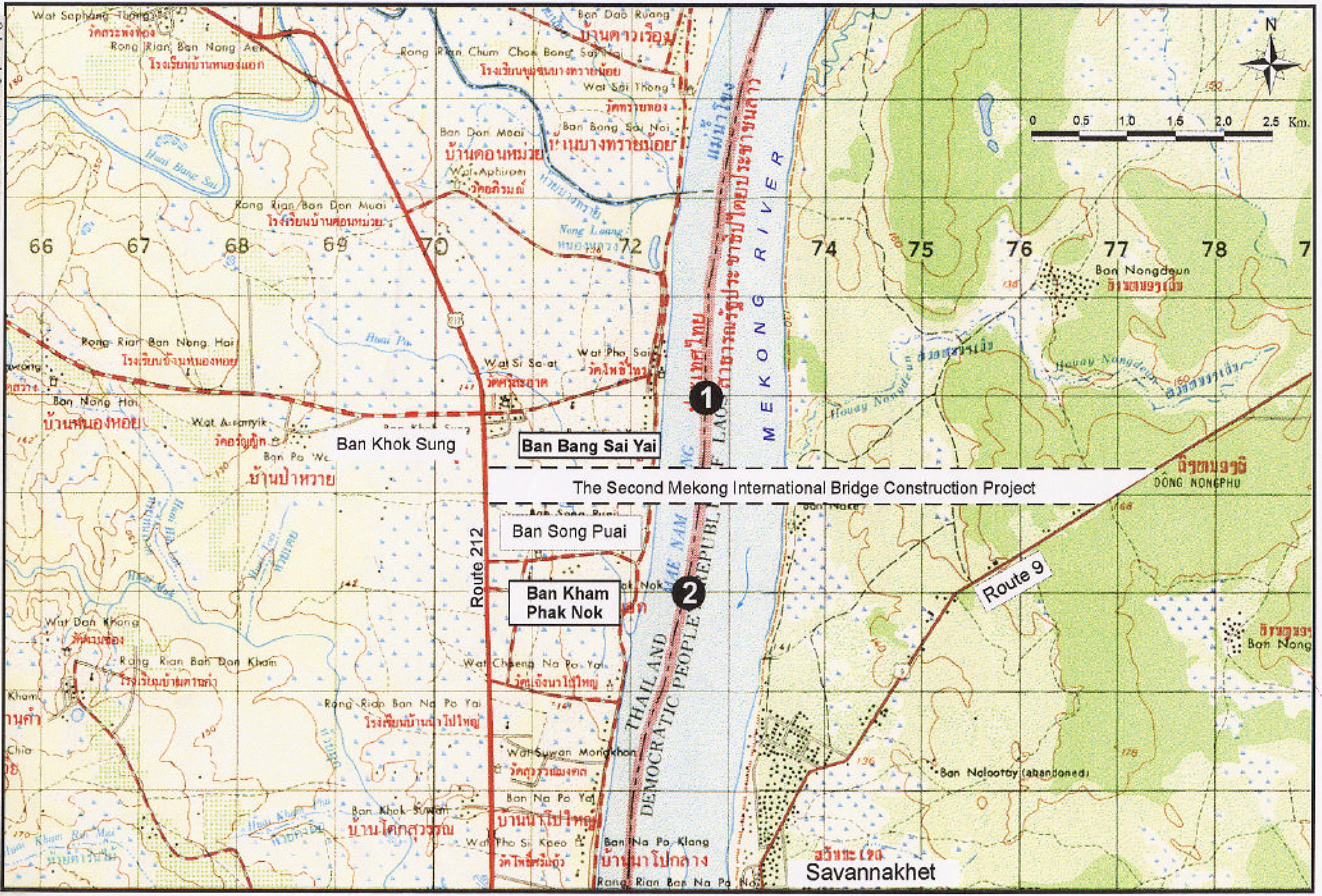


Fig. 8-3-1 Sampling Stations of Water Quality and Aquatic Life

Table 8.3.2
Existing Aquatic life

Scientific Name	Station 1	Staion 2
PHYTOPLANKTON		
Phylum Bacillariophyta (Diatoms)		
Diatoma elongatum Agardh	49,500	143,000
Melosira granulata (Ehrenberg) Ralfs	-	5,500
Navicula radiosa Kuetzing	-	5,500
Surirella robusta var. splendida (Her.) Van Heurck	22,500	11,000
Synedra acus Kuetzing	4,500	11,000
Subtotal of Phytoplankton	76,500	176,000
Diversity Index	0.81	0.73
ZOOPLANKTON		
Phylum Protozoa (Protozoans)		
Arcella vulgaris Ehrenberg	-	5,500
Centropyxis aculeata Stein	13,500	5,500
Difflugia globulosa Dujardin	4,500	-
Phylum Rotifera (Rotifers)		
Nothoca acuminata (Ehrenberg)	4,500	-
Phylum Arthropoda (Arthropods)		
Insect larva	4,500	-
Subtotal of Zooplankton	27,000	11,000
Diversity Index	1.24	0.69
Grand total	103,500	187,000
Percentage	35.6	64.4

Remark : Station 1 = 1,000m upstream of the Bridge
Station 2 = 1,000m downstream of the Bridge

(2) Methodology

- Collect meteorological data of a period from 1966 to 1995 at Mukdahan weather station which is the nearest station to the Project site and then analyze the stability class, frequency of wind direction and speed by the pre-processing meteorological program.
- Measure the existing air quality around the Project areas at 3 stations (2 stations in Thailand and 1 station in the Lao PDR) for 3 consecutive days at each site. The sampling stations are presented in Figure 8.3.2.

The parameters measured the carbon monoxide (CO), nitrogen dioxide (NO_2), total suspended particulate (TSP), particulate matter (PM-10), lead (Pb) and sulfur dioxide.

(3) Results of the study

The six air quality parameters, TSP, PM-10, NO_x, CO, Pb and SO_2 were measured continuously for 3 consecutive days at each site. Results of air quality are shown in the Table 8.3.3 and described as follows :

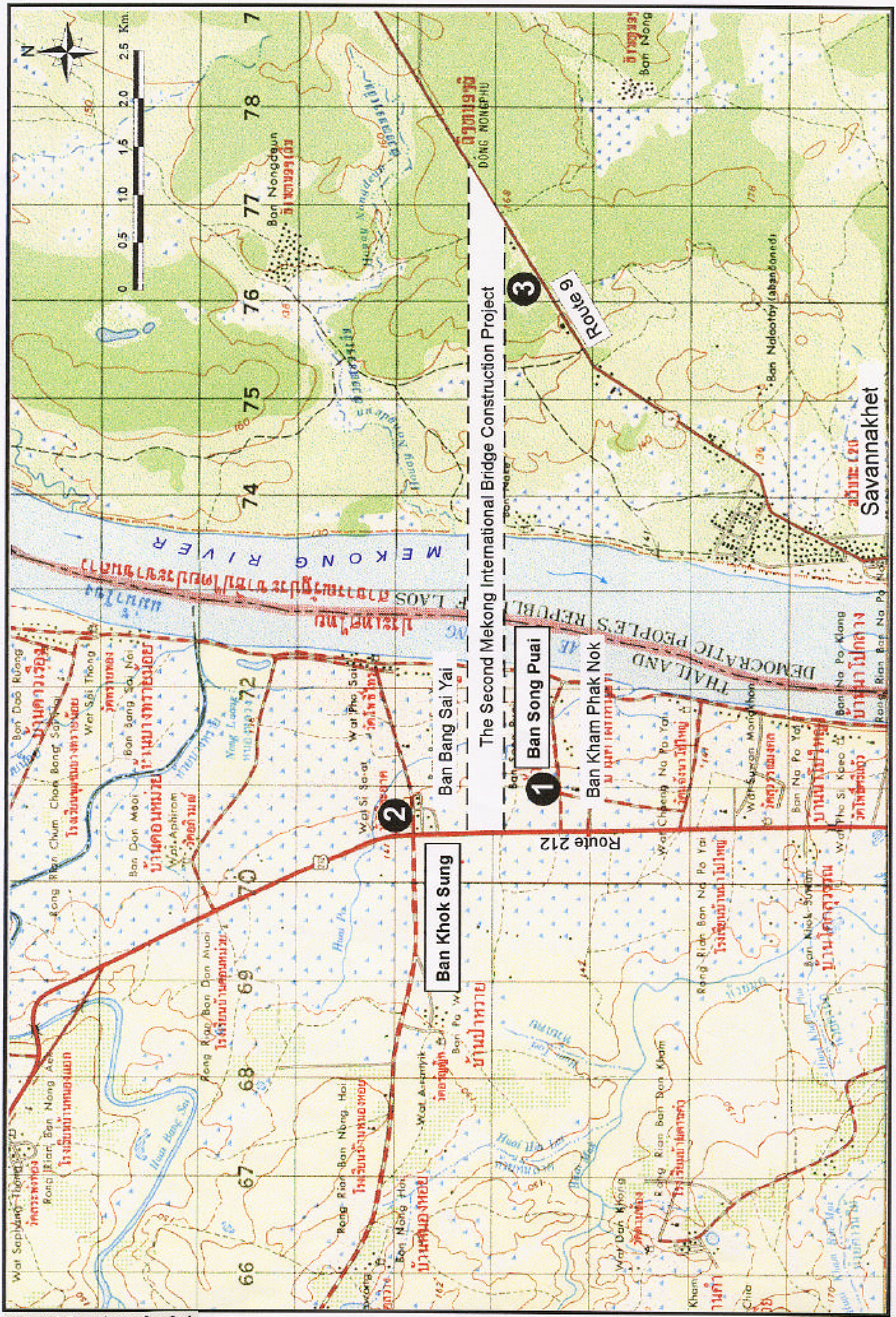


Fig. 8-3-2 Sampling Stations of Air Quality, Noise and Vibration Level

Table 8.3.3
Present Air Quality

Concentration	Station No.1	Station no.2	Station No.3	Standard of MOSTE MOSTE
TSP@	0.046 - 0.056	0.070 - 0.086	0.069 - 0.106	0.330@
PM-10@	0.030 - 0.038	0.052 - 0.053	0.042 - 0.085	0.120@
NO2@@	0.003 - 0.005	0.003 - 0.012	0.002 - 0.003	0.320@@
CO#	0.40 - 0.70	0.40 - 0.80	0.40 - 0.70	30.0#
SO2@	0.001	0.001	0.001	0.300@
Pb##	0.040 - 0.063	0.051 - 0.061	0.040 - 0.064	1.50##

Note : @ Average Concentration –24hr., mg/m^3
Average Concentration – 1hr., ppm
@@ Maximum Concentration – 1hr., mg/m^3
Average Concentration – 1 month, $\mu g/m^3$

From this study of air quality, it may be concluded that the existing air quality is acceptable by the emission standards of The Ministry of Science, Technology and Environment because the air pollution parameters such as TSP, PM-10, SO_2, NO_2, CO and Pb values are much lower than those in the given standards or only 0.33% to 70.80% of standard values.

8.3.1.4 Noise

(1) Objectives

- To measure the existing noise level around the Project area.
- To predict the noise level during the construction and operation phases.
- To evaluate the noise impact due to the Project development.
- To recommend on appropriate mitigation measures and monitoring programs during the construction and operation phases.

(2) Methodology

Measure the existing noise level (equivalent sound level 24 hours) along the project at 3 stations (2 station in Thailand and 1 station in the Lao PDR) for 3 consecutive days especially at the sensitive receptors below. The sampling stations are shown in Figure 8.3.2:

(3) Results of the study

The existing noise level in terms of Leq-24 hr. and Ldn for 3 consecutive days and the 3-day average for each sampling station are summarized as Table 8.3.4 :

Table 8.3.4
Results of Noise Level

Sampling Stations	Duration	Noise Levels (dB(A))	
		Leq-24 hr.	Ldn.
Station 1	15-18 Nov. 99	52.7-53.4	57.9-59.4
3 Day Average		52.97	58.40
Station 2	15-18 Nov. 99	52.6-53.1	56.5-57.0
3 Day Average		52.77	56.83
Station 3	20-23 Nov. 99	53.0-53.2	59.6-60.1
3 Day Average		53.13	59.87

Note : Station 1 : Ban Song Puai
Station 2 : Ban Khok Sung
Station 3 : Interchange of Route No.9 & Kaysone Road

From the noise level measurement (Leq-24 hr.) on November 19, 1999, it can be concluded that the noise level was still within the standards of The Ministry of Science, Technology and Environment (MOSTE 1997, Leq-24 hr.= 70 dB(A)), the Ministry of Interior (MOI, 1976) as 91 dB(A) for a high density population area at day time, the Occupational Safety and Health Act (OSHA, 1975, Leq-8hr=90dB(A), and the community noise level standard of ISO (Leq-24 hr. = 70 dB(A)).

8.3.1.5 Vibration

(1) Objectives

- To measure vibration along the Project at the stations of noise measurement.
- To evaluate the vibration impact during the construction and operation phases.
- To recommend appropriate mitigation measures and monitoring program during the construction and operation phases.

(2) Methodology

The vibration along the proposed route is measured by velocity transducers at 3 stations (2 stations in Thailand and 1 station in the Lao PDR) for 3 consecutive days at each site. The sampling stations are shown in Figure 8.3.2.

(3) Results of the Study

The results of vibration study are summarized as Table 8.3.5 :

Table 8.3.5
Results of Vibration

Sampling Stations	Duration	Vibration Levels (mm/s.)
Station 1	15-18 Nov. 99	0.20-0.90
3 Day Average		0.37
Station 2	15-18 Nov. 99	0.30-0.60
3 Day Average		0.42
Station 3	20-23 Nov. 99	0.70-1.20
3 Day Average		0.97

Note : Station 1 : Ban Song Puai
Station 2 : Ban Khok Sung
Station 3 : Interchange of Route No.9 & Kaysone Road

From the above table, it is found that for all sampling stations, the peak particle velocity of the existing vibration level was very low along the Second Mekong International Bridge Project (0.20 to 1.20 mm/s).

8.3.1.6 Social Environmental Survey

(1) Objectives

- To study household socio-economic conditions of those who are directly and indirectly affected by the Project
- To evaluate people's awareness and attitudes toward the Project and the expected impact of the Project and measures to minimize negative impacts
- To collect opinions and suggestions benefiting the Project operation particularly those concerning with compensation payment

(2) Methodology

In the Lao PDR side, total 38 directly affected households were interviewed and further 68 households were selected as samples of indirectly affected persons (total 106 samples), while in Thailand 120 persons were selected for interview as samples of indirectly affected persons.

(3) Results of the Study

The results of the interview survey are summarized as follows:
(the Lao PDR)

- All respondents were well aware of the Project.
- Regarding land price evaluation, 100% of them proposed to follow the market price.
- As advantages of this Project, they pointed out on better transportation and communication and the local economy improvement. On the other hand, they pointed out on air and noise pollution as disadvantages.
- Over 90% of the respondents agreed with the Project.
- Others

(Thailand)

- All respondents were well aware of the Project.
- With respect to the land expropriation, 73.4 % of interviewees anticipated no problems under the condition of fair compensation.
- As an advantage of this Project, 54.2 % of them pointed out the improvement in the local economy. On the other hand, they pointed out on loss of land as a disadvantage.
- Over 90% of the respondents agreed with the project.
- Others

8.3.2 Impact Assessment

8.3.2.1 Water Quality

(1) Construction Period

According to calculation of additional suspended solids into the waterways, the calculated SS is only 0.017% higher than the existing condition of SS. Therefore, the actual impact of additional SS in the waterway is insignificant.

With provision of a regular maintenance program which includes oil changing, lubricating and others, the potential impacts from oil contamination will be negligible.

(2) Operation Period

During the normal operation of the Second Mekong International Bridge, there should not be any adverse impacts on water quality. At the Border Control Facilities area (BCF), sanitary latrine will be equipped to treat human waste from the working rooms. Therefore, no contamination on nearby waterways is expected.

8.3.2.2 Aquatic life

(1) Construction Period

Blockage of photosynthetic reaction due to additional suspended particle will be minor. Temporary impacts from construction activities will not be harmful to aquatic lives in the concerned waterways.

(2) Operation Phase

At the Border Control Facilities area (BCF), sanitary latrine will be equipped to treat human waste from the working rooms. Therefore, no contamination on nearby the Mekong River/waterway is expected.

8.3.2.3 Air Quality

(1) Construction Phase

The negative impacts on air quality due to construction activities of the Second Mekong International Bridge project are fugitive dust and toxic gas from heavy machinery, equipment and material transportation vehicles.

From the pollutant emission rate for construction equipment determined by US. EPA, the concentration of the concerned parameters is much lower than the limit in the standards of The Ministry of Science, Technology and Environment (1995). Therefore, the impact due to particulates dispersion is negligible.

(2) Operation Phase

From the results of simulation in the both worst cases (D Class and F Class), the maximum ground level concentration of CO and NO_2 at year 2020 will be 1.348 and 0.181 mg/m^3, respectively. They are within the standard of air quality on the atmosphere of MOSTE (1995). Therefore, the impact on air quality due to the Second Mekong International Bridge Construction will be minor.

8.3.2.4 Noise

(1) Construction Period

The noise level at a distance of 50 m from the source of construction activities are predicted to be 78.9 to 89.3 dB(A). The predicted noise levels will be acceptable in comparison to ISO criteria and OSHA criteria (1975) .

(2) Operation Phase

By the year 2020 which is expected to be the maximum traffic volume, the maximum noise levels at distances of 10 m., 30 m., 50 m., 100 m. and 1,000 m. from the curb are predicted to be 69.3, 65.8, 63.8, 60.8 and 47.2 dB(A), respectively. This study indicates that it is unlikely to cause loud noise that affect sensitive receptors according to the criteria of ISO and The Ministry of Sciences, Technology and Environment (1997).

8.3.2.5 Vibration

(1) Construction Period

The main potential impact from vibration level during the Second Mekong International Bridge construction is pile driving. Recommendation here is to maintain peak particle velocity at less than 2 mm/s, which is the level required to protect historical/ancient buildings by the criteria of vibration effect on buildings of DIN 4150. Most types of pile driving will produce less vibration than this level at a distance of 30 m.

(2) Operation Period

By the year 2020 which is expected to be maximum traffic volume, the vibration levels at distance of 1 m, 3 m, 5 m and 10 m from curbs are predicted to be 0.239, 0.134, 0.101 and 0.066 mm/s, respectively. Therefore, they are unlikely to cause vibration effect to human life and properties according to Reichter and Meister Scale and DIN 4150.

8.3.2.6 Social Environment

(1) Construction period

- Impacts from land expropriation
- Impact on intra- and inter-community traveling
- Expected conflicts between local people and construction workers
- Impact on occupation of the agriculturalist living close to the construction areas

(2) Operation period

- Impact on farmers' occupation
- Impact on inter-community travel
- Impact on land price

8.3.3 Mitigation Measures

8.3.3.1 Aims of Environmental Conservation

In order to examine the mitigation measures for the negative impacts caused by the Project, it is necessary to establish the aims of environmental conservation. In general, mitigation strategies are focused on avoidance, minimization, restoration or rehabilitation, preservation and/or compensation or replacement. In this Project, the basic policy on minimization of the negative impacts caused by the project has been mainly adopted.

With the aim of environmental conservation, the items mentioned below have been established.

- In the construction period: To reduce the negative impacts of water quality, air quality/noise/vibration as much as possible.

- In the operation period: To maintain the existing environmental quality referring to the existing data and environmental standards.

- With respect to the social environment: To ensure security, amenity and convenience of lives of the local population.

8.3.3.2 Water quality

(1) Construction period

- Inspect machinery and equipment weekly to prevent any oil leakage.

- Construct wastewater treatment facility for maintenance facilities
- The Contractor must raise a dike at 30-50 cm above the level of the land surrounding the construction areas, must provide for a drainage system and settlement pond along the construction areas, and must maintain the drainage system to prevent clogging.
- Plant native vegetation at the disturbed Mekong River bank to speed up the recovery period.
- Others

(2) Operation period

- Inspect the wastewater treatment facilities at the Border Control Facilities (BCF) every year.
- Monitor effectiveness of the garbage collection system in the Border Control Facilities (BCF) every week to prevent any waste dumping into the Mekong River/waterway.

8.3.3.3 Aquatic life

(1) Construction period

- Inspect machinery and equipment weekly to prevent any oil leakage.
- Construct wastewater treatment facility for maintenance facilities
- The Contractor must raise a dike at 30-50 cm above the level of the land surrounding the construction areas, must provide for a drainage system and settlement pond along the construction areas, and must maintain the drainage system to prevent clogging.
- Establish an area width of about 1 m from the waterway as a buffer zone.
- Others

(2) Operation period

- Inspect the wastewater treatment facilities at the Border Control Facilities (BCF) every year.
- Monitor effectiveness of the garbage collection system in the Border Control Facilities (BCF) every week to prevent any waste dumping into the Mekong River/waterway.

8.3.3.4 Air quality

(1) Construction period

- The fugitive dust dispersion from the construction activities may disturb the nearby communities, temples or schools. Therefore, water spraying should be applied twice a day to minimize particulate from the construction activities
- The equipment and machinery should be regularly checked at least once a week to minimize pollution emissions.
- Dust dispersion in the transportation of construction materials should be controlled by covering the trucks with canvas.
- Others

(2) Operation period

- Fuel quality and emission control should be improved in order to reduce the predicted impact.

- In case of lead due to use of gasoline, impacts are not expected since use of lead-free gasoline will be enforced.
- To reduce the pollution emission from exhaust system, the regular flow and speed should be maintained

8.3.3.5 Noise

(1) Construction period

- The noise level not exceeding 90 dB(A) should be designed for each machine type.
- Regular inspection and maintenance of equipment should be done to reduce noise to the lowest level and not to exceed 90 dB(A) at the point source.
- In the case of unavoidable noise level, there should be proper warnings posted to the public before starting the activities.
- Others

(2) Operation Period

It is anticipated that the Second Mekong International Bridge Project will not generate higher noise levels than the relevant standards.

8.3.3.6 Vibration

(1) Construction Phase

Low vibration generating pile driving machines and methods, e.g. hydraulic pressure and vibratory pile drivers (frequency up to 100 Hz), as well as bore piling, are recommended at sensitive areas. In addition, the appropriate design and construction methods shall be employed to minimize vibration.

(2) Operation Phase

Vibration mitigation is not necessary if the designed buffer zone is maintained and the road surface condition is maintained regularly. As part of regular maintenance procedures, potholes shall be promptly repaired, and connecting junctions between sections maintained to provide a smooth interface. Over-weight vehicles shall not be allowed because road/bridge surface damage is mainly caused by these vehicles in the operation phase.

8.3.3.7 Socio-economic Conditions

(1) Construction period

- Before compensation fee is paid, a meeting between the people who are affected by the Project and the relevant authorities should be held.
- The Contractor must be careful not to cause inconvenience to local people except where absolutely necessary.
- The public should be informed before carrying out activities that cause inconvenience to normal travelling, and signs indicating change of ways should be shown clearly.

- The Contractors must strictly supervise their workers and officers not to interfere with local affairs or quarrel with local people.

(2) Operation period

- As for those who have such difficulties that can't do their occupation as usual and/or wish to sell/exchange the problematic land caused by the Project, the authority should assist them.

8.3.4 Environmental Monitoring Plan

The purpose of the Environmental Monitoring Plan is to ensure that the mitigation measures proposed during the construction, and operation stages of the Bridge and approach roads are carried out in an environmentally sensitive and responsible manner, and to ensure that institutional structures and responsibilities are in place so that the Project is monitored adequately for environmental compliance.

The monitoring activities should be carried out by the Contractor during the construction period and the operation period. The activities should be followed by the authorities of both countries (MCTPC in the Lao PDR and DOH in Thailand) It is recommended that the authority will be supported in terms of technical aspects by The Science, Technology and Environment Organization (STENO) in the Lao PDR and Ministry of Science, Technology and the Environment (MOSTE) in Thailand, respectively.

CHAPTER 9
Cost Estimation

CHAPTER 9 : COST ESTIMATION

9.1 GENERAL

9.1.1 Packaging of the project

The Project will be divided into three (3) construction packages according to the scope of work between the two countries.

Package 1 will be an International Bidding package with one Contractor and two contracts; the one with the Lao PDR and the other with Thailand.

The construction cost estimation of the Package 1 has been conducted separating the work quantities into 2 portions, one portion is the Lao PDR portion and the other is the Thailand portion. The work quantity of each portion was calculated separating the total quantity basically at the center of the Main Bridge.

(1) Package 1 (the Lao PDR and Thailand sides)

a) Main Bridge (the Lao PDR and Thailand sides)
b) Approach Viaducts (the Lao PDR and Thailand sides)
c) Approach Roads (the Lao PDR and Thailand sides)
d) Traffic Changeover (the Thailand side)

(2) Package 2 (the Lao PDR side)

a) Connecting Road
b) Border Control Facilities

(3) Package 3 (the Thailand side)

a) Connecting Road
b) Border Control Facilities

9.1.2 Cost Components

The project costs for the following components were estimated respectively.

A. Portions covered by the JBIC loan

1) Direct Construction Cost
2) Direct temporary works
3) Common temporary works
4) The Contractor's site expense
5) Shipping cost for the imported goods
6) Contractor's overhead and profit (percent basis)
7) Engineering services for pre-construction activity and supervision

B. Portion covered by the Local Budget

1) Tax and duties
2) Land acquisition and compensation cost
3) Government administration cost

The above cost was finally divided into the local currency portion and the foreign currency portion.

9.1.3 Basic Date and Exchange Rate of Currency

All the construction costs were estimated at the price level ruling as of December 1999.

The currency exchange rates adopted to the cost estimate were based on the monthly average of the year 1999 (January 1999 – December 1999).

1	US$	=	37.914	Baht
1	Yen	=	0.334	Baht
1	US$	=	114.147	Yen
1	US$	=	7183.969	Kips

9.2 BASIC PRICE INVESTIGATION

The basic prices for labor, construction material and construction equipment were investigated during the detailed design stage.

(1) Labor Cost

The labor costs used for the cost estimate were based on the current market average prices obtained. The prices were verified by the Government standard price for the minimum wages.

(2) Material Cost

Prices for the construction materials were based on the current standard local market prices, when the materials are available in the local market. The prices for the materials to be imported for the Project were based on the price in Japan. In case of the Project, only rubber bearing shoes and steel sheet piles, type 5 (temporary use) will be the material to be imported.

(3) Equipment Cost

The common construction equipment used for the Project can generally be procured in the Lao PDR and Thailand. The cost for these equipment were based on the leasing prices in the markets.

The prices for the special equipment which are not available or difficult to procure in the local markets were based on the standard equipment prices in Japan and shipping costs were separately estimated. These equipment will be;

- Reverse circulation drilling machine (Dia. 2,000)
- All-casing drilling machine (Dia. 1,000)
- Main girder production facilities
- Gantry Crane (130t)
- Main girder erection facilities
- Crawler crane (>80t)
- Vibration hammer (90kw), etc

9.3 CONSTRUCTION COST ESTIMATE

Estimation of the construction cost, which includes direct construction works and direct temporary works, has been done in the following manner.

9.3.1 Construction Cost Estimate for Main Bridge and Approach Viaduct

Since the local standard for cost estimate of the Main Bridge are not available in both the Lao PDR and Thailand, cost estimates for direct construction works and direct temporary works have to be based on the Japanese standard established by the Ministry of Construction, Japan and other relevant agencies with adjustment of manpower input. According to the study on the manpower requirements, it is concluded that double amount of the manpower than that of the Japanese standard shall be used for the construction cost estimate.

9.3.2 Construction Cost Estimate for Other Structures

For the common earth works, road works and concrete works, the local cost estimate standard/manual, especially the cost estimation manual of the DOH, is available for use. Such items as manpower and equipment input and daily possible work volume will be based on the local standard with supplement by the Japanese cost estimate standard where necessary.

9.4 COST ESTIMATE FOR COMMON TEMPORARY WORKS

Cost for the common temporary works was estimated for the following works.

- Establishment of the common temporary construction yard and the International Construction Zone including the Employers office, the Engineer's office, the Contractor's office, stockyards, concrete plants, temporary fence, etc.
- Construction of the temporary survey stands
- Dredging during the construction
- Other temporary works not covered by the direct temporary work

9.5 COST ESTIMATE FOR THE CONTRACTOR'S SITE EXPENSE

Cost for the Contractor's site expense was estimated for the following items.

- Cost for the foreign and local engineers of the Contractor stationed at the project site

- Cost for supporting staff and common use labors of the Contractor
- Maintenance and operation cost for the temporary construction yards and International Construction Zone.
- Maintenance and operation cost for common facility and vehicles of the Contractor and the same provided to the Employer and the Engineer by the Contractor
- Running cost for offices and other temporary facilities

9.6 COST ESTIMATE FOR THE SHIPPING COST

Shipping and packing costs for the goods which will be imported from overseas for the Project was estimated based on the price investigation during the detailed design stage. The shipping and packing cost was estimated for the following items.

(1) Materials

- Rubber Bearing shoes
- Steel Sheet piles, type 5

(2) Equipment

- Reverse circulation drilling machine (Dia. 2,000)
- All-casing drilling machine (Dia.1,000)
- Main girder production facilities
- Gantry Crane (130t)
- Main girder erection facilities
- Crawler crane (>80t)
- Vibration hammer (90kw)

9.7 COST ESTIMATE FOR ENGINEERING SERVICES

According to the discussions between the MCTPC, the DOH and the JICA study team about the project implementation, it was confirmed that the Consultant shall conduct full scale of the supervision services employing such field supervision staffs as inspectors, surveyors and laboratory technicians. The consultant shall also carry out tender assistant works during the pre-construction period.

The cost for the engineering services was estimated based on the above conditions.

9.8 LAND ACQUISITION AND COMPENSATION COST

Lands inside of the Right of Way of the Project are required to be acquired by both the Lao PDR and the Thai authorities. Compensation for houses and factories are also required but the number of houses and factories is limited.

The land acquisition and compensation costs were estimated as shown in Table 9.8.

Table 9.8
Land Acquisition and Compensation Costs
(Reference only)

Categories	Area (m^2)	Unit Cost ($)	Amount ($)
The Lao PDR			
Land			
- Rice fields	102,775.45	1.35	138,746.86
- Under the tree	2,100.00	1.10	2,310.00
- Garden land	47,543.00	0.85	40,411.55
- Residential area	31,589.00	2.60	82,131.40
- Bush or thicket	72,415.30	0.60	43,449.18
- Dense forest	36,700.00	0.60	22,020.00
- Others			
Sub total	293,122.75		329,068.99
Building			
- House (Concrete)	1,275.09	152.50	194,451.23
- House (Concrete + Wood)	335.00	145.00	48,575.00
- House (Wood)	914.50	140.00	128,030.00
- Factory	6,243.25	112.50	702,365.63
- Guest house	189.00	152.50	28,822.50
- Hut	189.25	55.00	10,408.75
- Shop	283.00	125.00	35,375.00
- Others		65.00	
Sub total	9,429.09		1,148,028.10
Thailand			
Land (a)	34,649.00	5.40	187,104.60
Land (b)	34,000.00	3.38	114,920.00
Land (c)	240,000.00	2.70	648,000.00
Land (d)	32,500.00	1.70	55,250.00
Land (e)	6,600.00	0.38	2,508.00
Total	347,749.00		1,007,782.60

* Costs are provisional only and subject to confirmation by authorities
Remark: Land (a) = About 40m. from route No. 212
Land (b) = Between 40m. and 140m. from Route No. 212
Land (c) = About 40m. from Mekong River
Land (d) = Between 40m. and 140m. from Mekong River
Land (e) = Other land

9.9 ADMINISTRATION COSTS

The Administration costs of the MCTPC and the DOH is estimated at 2.0% of the total construction cost.

9.10 TAX AND DUTY

In the current taxation system of the Lao PDR and Thailand, the import tax of both the Lao PDR and Thailand and the Value Added Tax (VAT) of Thailand are subjected to the Project.

(1) Import Tax

It was confirmed that the Lao PDR will exempt any import tax imposed on the goods imported into the Lao PDR for the Project. On the other hand, it also was confirmed that the RIG will not exempt any import tax on the goods imported for the project. Therefore the amount of the import tax which will be imposed on the imported goods to Thailand was estimated separately. The DOH will have his own local budget to refund the same amount of the import tax to the Contractor.

(2) Value Added Tax (VAT)

Any VAT was not considered as a part of the project cost because of the following reasons.

- No VAT system in current taxation law in Lao PDR
- VAT will be exempt for the goods imported for the project which is implemented by a foreign financial assistance under the current taxation law in Thailand

9.11 DIVISION OF THE COST INTO FOREIGN CURRENCY PORTION AND LOCAL CURRENCY PORTION

According to the basic prices investigation on materials, equipment and labors used for the Project, it was found that these prices are mainly linked to Thai Baht and US Dollar. Therefore the project cost was divided into the Baht portion (local currency portion) and the US Dollar portion (foreign currency portion) respectively. The method applied to divide into two currency portions is presented in Appendix 9.1 in this report.

CHAPTER 10

Draft Bidding Documents

CHAPTER 10 : DRAFT BIDDING DOCUMENTS

10.1 GENERAL

The Second Mekong International Bridge Construction Project will be divided into three contract packages according to the scope of work within the two countries. Each contract package comprises the bidding documents for procuring the Contractors.

The documents shall be prepared for three complete sets for each bid of the contract packages.

The draft bidding documents for the construction packages hereunder including the Pre-qualification Procedures were prepared.

The contract packages (bidding types) are as follows:

Package 1:

Bridge Section including approach viaducts and roads of both the Lao PDR and the Thailand sides **(International Competitive Bidding)**.

Package 2:

Connecting Road, Border Control Facility and associated facilities on the Lao PDR side **(International Competitive Bidding)**

Package 3:

Connecting Road, Border Control Facility and associated facilities on the Thailand side **(International Competitive Bidding)**

The bidding documents shall be prepared on the basis of the Guidelines for Procurement under JBIC ODA Loans October, 1999.

The Sample Bidding Documents under JBIC ODA Loans for Procurement of Civil Works has also been published in November 1999. The sample documents are prepared in accordance with the general principles and procedures laid down in the JBIC Guidelines. The Bidding Documents for this project shall be based on JBIC sample bidding documents as much as possible.

The DOH may apply Local Competitive Bidding for the Contract Package 3. However, the documents shall in principle be prepared corresponding to International Competitive Bidding (ICB).

10.2 DETERMINATION OF BIDDING METHODS

10.2.1 Bidding Methods

A two envelope system is proposed by the JICA Study Team. The system is generally used to secure an appropiate quality of construction and is also recommended in the JBIC guidelines.

The reasons why a two envelope system is preferred are as follows.

1) The use of a two envelope bidding system ensures that any bidders with inadequate prequalification update, bid documentation and technical proposal will be disqualified from the bidding process and that no consideration whatever can be given to their bid price as their bid envelope remains unopened.

2) Due to the technical and administrative difficulties of constructing this major civil Project within an International Construction Zone, it is imperative during the bidding process for the bidders to adequately demonstrate that they have the necessary capability to undertake the Project. To select a bidder without this capability solely on the lowest price can ultimately cause overruns in Project cost and time, and reduction in quality.

The Draft Bidding Documents for each package have been prepared based on the folowing bidding methods.

Contract Package 1: Two Envelope System (the Lao PDR and Thailand)

Contract Package 2: One Envelope System (the Lao PDR side)

Contract Package 3: One Envelope System(Thailand side)

10.2.2 Two Envelope Bidding System

1) Technical Proposal

To adequately evaluate each bidder's capability to execute the works, each bidder is required to submit the following information as part of their technical proposal:

(1) Pre-Qualification Update

Bidders should be required to update the information submitted with their original pre-qualification submission to ensure that the circumstances of their financial, workload and resources have not significantly been changed so as to diminish their capability to undertake the Project.

(2) Documentation

Bidders are required to submit the following documentation:

i) Bid Security
ii) Schedules of Supplementary Information
iii) Any clarification or substantiation required by the Employer

(3) Substantially Responsive Bid

Bidders must ensure that their bids conform to all the terms, conditions and specifications of the bidding documents without material deviations, or reservations.

(4) Technical Proposals

The bidder is required to submit, but not be limited to, a detailed technical proposal of their:

i) Construction Method
ii) Construction Time Schedule
iii) Quality Control System
iv) Labor and Materials
v) Safety Measures

The above information is extensive and necessary to enable the Employer to adequately analyze each bidder's capabilities. This process can be time consuming but will ultimately help to ensure that only bidders with sufficient capability have the opportunity for their bid price to be considered.

2) Evaluation Method

The technical evaluation shall be based on whether the above mentioned technical proposal meets the technical specifications of the Second Mekong International Bridge or not.

The Engineer will evaluate the responsiveness to the Specifications, Drawings, and other requirements for the Project concerning the several criteria specified by the Engineer.

The Contractor who has passed the technical evaluation and has offered the Lowest Bid Price shall be given first priority for contract negotiation. The opening of the priced bid shall be in public in the presence of those technically capable bidders.

3) Conclusion

Through the proposed two envelope system the Employer can:

- award to the Contractor who can construct the International Bridge securing the required quality without any serious defects.

- ensure the fairness and transparency of the bidding in accordance with the final public bid opening in the presence of capable bidders. (Without the two envelope system there would always be the undesirable possibility of a low bid from a technically deficient bidder.)

- ensure the highest level of technical ability without any effects on the proposed Priced Bid.

- ensure smooth concurrence of JBIC.

Furthermore, the practical construction plan, actual procurement of equipment, material, and construction time schedule can be clarified by evaluating the technical proposal incorporated as part of the Contract Documents and the Project will benefit properly from being bid by technically competent contractors only.

10.3 PREQUALIFICATION DOCUMENTS

10.3.1 Basic Policy

Preparation of the Prequalification Documents will be on the basis of the Guidelines for Procurement under JBIC ODA Loans; and

Selection of Applicants whose capability shall be sufficient to execute the construction of an international bridge that spans over two countries from a viewpoint of experience, technical capability and financial capability; and

Selection of internationally well-experienced Applicants in various fields, who shall be capable of managing the Project, taking the peculiarity of the international bridge into serious consideration, including differences in type and size of contract, socio-cultural aspects etc; and

Taking the risk of rapid changes in external circumstance such as the Asian financial crisis fully into account, Applicant's aggregate and stable power to raise the necessary funds and capacity of material procurement respectively.

10.3.2 Evaluation Criteria Setting

The evaluation criteria shall have two step screening systems which make obvious and precise evaluation.

The Initial Evaluation for the first evaluation is as follows.

Satisfaction of the overall policy above being the prerequisite, managerial scale (turnover), ability in management (experience as a prime Contractor) and performance (experience in similar projects) shall be the minimum requirement of applicants for this Project.

The further evaluation for the first evaluation is as follows.

Taking all the above mentioned into account, managerial scale, ability in management and performance are classified into the following:

- Financial Capability
- Technical Capability
- Particular Experiencs

1) Financial Capability

Making the applicant's financial healthy and trustworthiness as an evaluation criterion, applicant's audited balance sheets and lines of credit shall be assessed.

a) Submission of Balance Sheets

b) Submission of Lines of Credit (equivalent to amount of Advanced Payment)

2) Technical Capability

In order to assess the applicant's construction capability, its competence to procure appropriate human resources, materials, machinery and existence of quality control system shall be the items for evaluation.

a) Personnel Capability (Personnel Plan & Experience)
b) Equipment Capability (List of material & machinery proposed by the applicant)
c) Quality Control (ISO 9000 Series)

3) Particular Experience

Analysis of applicant's experience, which meet the special characteristics of this Project, in terms of project scale and similarity.

The evaluation criteria shall adopt scoring on the numbers of experiences that are similar to this Project in terms of scale and technical aspects.

Those applicants who have passed the initial evaluation stage shall be assessed in the further evaluation stage by being scored on the evaluation criteria. Those applicants obtaining more than pre-set points in total shall be invited to bid.

10.4 COMPONENTS OF THE DRAFT BIDDING DOCUMENTS

The JBIC sample bidding documents have been provided for the procurement of civil works for large or complex projects through international competitive bidding.

The bidding documents will conform to the JBIC sample documents and comprise the following complete set.

<The Components of the Bidding Document>

Volume 1

Invitation for Bids
Section 1. Instruction to Bidders
Section 2. Part I- General Conditions
Section 3. Part II- Conditions of Particular Application

Volume 2

Section 4. Technical Specifications

Volume 3

Section 5. Forms of Bid, Appendix , Bid Security and List of Eligible Countries of JBIC ODA Loans
Section 6. Bill of Quantities
Section 7. Form of Agreement
Section 8. Form of Security
Section 9. Schedule of Supplementary Information

Volume 4

Section 10. Drawings

Note that the bidding documents for Contract package 1 will be as follows.

The Contact Package 1 contains the Main Bridge, Approach Viaducts, Approach Roads and Changeover facility. One bidding should be carried out and entered into two Contracts in Package 1. The Contractor shall carry out the complete construction and will reserve payments from the both governments. The bidding documents shall entirely cover the contract conditions relating to the both countries.

10.5 PREPARATION OF BIDDING DOCUMENTS

10.5.1 Basic Policies

(1) Internationalization shall be emphasized wherever is possible on Technical Specifications, Payment Method, Bill of Quantities, etc.

(2) Where there is a strong local practice, this shall be considered and may be taken into account where applicable.

(3) The JBIC Sample Bidding Documents shall be used as much as possible.

(4) The bidding documents for Package 1 shall be compiled to recognize one bid for two contracts.

(5) Strong elements of local practice shall be considered in making out the contract conditions.

10.5.2 Instruction to Bidders

The Bidding procedure shall comply with the International Competitive Bidding according to the JBIC Guidelines for Procurement under JBIC ODA Loans.

Instruction to Bidders shall be prepared on the basis of JBIC Sample Bidding Documents which can propose the bidding procedures to correspond to both governments which have been followed with different bidding procedures respectively.

Also, all the forms for bidding and contract shall be basically used of modified version of the JBIC Sample Bidding Documents.

10.5.3 Conditions of Contract

The conditions of contract shall be the Fourth Edition of FIDIC which are applicable for general use for the purpose of construction of such works where bidders are invited on an international basis such as the bid for the Second Mekong International Bridge Construction Project.

The conditions, subject to minor modification, are also suitable for use on domestic contracts.

The Clauses must necessarily vary to take account of the circumstances and locality of the Works. The Clauses of general applications have been grouped together and are referred to as PART I-

General Conditions. They have been printed in a form which will facilitate their inclusion when the contract documents are normally prepared.

The General Conditions are linked with the Conditions of Particular Application, referred to as PART II, by corresponding numbering of the Clauses, so that PART I and PART II together comprise the conditions governing the rights and obligations of the Parties.

10.5.4 Technical Specifications

Technical specifications shall be prepared on the basis of the following policies.

1) Civil Works

a) The Technical Specifications shall be exclusively for the Second Mekong International Bridge Construction Project.

b) The Technical Specifications shall be composed of the clauses that are amended on the basis of the Standard Specifications for Highway Bridges Sixteen Edition in 1996 adopted and published by AASHTO (American Association for State Highway and Transportation Officials) Division II – Construction as well as local practices in both countries.

c) The Standards which are used in the Technical Specifications apply to the Japanese Industrial Standards (JIS) and Thai Industrial Standards (TIS) according to the practical procurement of the material required for the detailed design.

2) Architectural Work (Border Control Facilities)

a) The Technical Specifications shall be exclusively for the Second Mekong International Bridge Construction Project.

b) The Architectural Technical Specifications shall basically conform to the following standards.

The Lao PDR

- BAEI9I and AISC for Structural Analysis
- ACI Building Codes Requirements for Structural Concrete
- TIS or other international laws or codes

Thailand

- Thailand Building Laws
- ACI Building Codes for Structural Requirements
- AISC of EIT (The Engineering Institute of Thailand) for Structural Analysis

10.5.5 BILL OF QUANTITIES

1) Items of Bill of Quantities (BQ)

The BQ shall be itemized according to the finished items given to provide a common basis for bidding. The basis of payment will be the actual quantities of works ordered and carried out, as measured by the Contractor and verified by the Engineer and valued at the rates and prices tendered in the priced Bill of Quantities.

2) The Priced Bill of Quatities

The whole costs of complying with the provisions of the Contract shall be included in the items provided in the priced Bill of Quantities. Where no items are provided, the cost shall be deemed to be distributed among the rates and prices entered for the related items of works.

3) BQ including General Requirements (Overhead and Profit)

The general requirements for the works such as concrete batching plant, common temporary works including Contractor's and Engineer's office and provided vehicles etc. will be estimated as the indirect cost. The rates on indirect cost shall be worked and entered into each BQ as the additional percentage for the overhead and profit.

4) The Separate Bill of Quantities in Package 1

The Bill of Quantities for Package 1 shall be separated at the center of Main Bridge which marks the point of change of ownership. Unit prices in priced Bill of Quantities shall be same between the contracts, and that overhead and profit shall be shared by the amount of the Bill of Quantities.

5) Currency

The Bid Currency and other payable currency shall be as follows:

Package 1: Yen (payable currencies: Yen, US dollars, Thai Baht and Lao Kip)
Package 2: Lao Kip(payable currencies: Yen, US dollars, Baht and Lao Kip)
Package 3: Thai Baht (payable currencies: Yen, US dollars, Baht and Kip)

10.6 FINALIZATION OF BIDDING DOCUMENTS

The Draft Bidding Documents have been drafted by the JICA Study Team prior to the conclusion of the Exchange of Notes (E/N) and the Loan Agreements (L/A). The documents shall be finalized by the Supervision Consultants consulting both the MCTPC and the DOH regarding the contractual issues arising in the Package 1 for the International Bridge Construction. They will be necessary for the contract Package 1 to set out the Specific Conditions of Contract as specified below.

1) Special Conditions for adjustment of the FIDIC Conditions to this Project

These include, but are not limited to, the following conditions being coordinated and defined as mutual agreements between the two governments before finalizing the Bidding Documents.

- Labor Conditions
- Certificates and payment arrangements
- Law in force between the two countries
- Taxation requirements
- Settlement of Dispute
- Arbitration

2) Special Conditions of Border Crossing Arrangements (Free Construction Zone)

For the international bridge construction to proceed efficiently, it is essential that special provisions shall be made as specified below.

a) A Free Construction Zone (FCZ) shall be treated as a free international zone, where goods entering from either the Lao PDR or Thailand shall be deemed not to cross an international boundary. Similarly, project personnel shall be deemed as still in their country of origin.

b) The FCZ in land section shall be surrounded by fencing. the FCZ in river section shall be marked by lighting pole or buoy.

c) Gates shall be installed at the entrances of the FCZ, and the public thoroughfares within the FCZ shall be kept open. The gates shall have checkpoints to ensure authorized access only.

d) Entry and Exit to/from the FCZ shall be via agreed checkpoints staffed by the Lao PDR and Thai Government Customs, Immigration and Security Personnel.

e) A special tax regulation shall be set out for the purpose of tax clearance. (Import Duties, Custom Duties etc)

f) A Joint Management Arrangement shall be set out in order to make agreed decisions by both Employers.

g) All accredited project personnel (see below) shall be issued with special construction zone ID cards for access and across the border of the countries through the FCZ at all times. The accredited personnel shall be as follows:

- Execution Agencies (Employer 1A and 1B)
- Consultants (Expatriate and Local Supervision Consultants)
- Counterparts from respective Execution Agencies
- Contractor for Package 1 (including Laotian and Thai sub-contractors)
- Other officers as assigned by the both governments

CHAPTER 11
Implementation Program

CHAPTER 11 : IMPLEMENTATION PROGRAM

11.1 GENERAL

The Ministry of Communication, Transport, Post and Construction (hereinafter referred to as the “HCTPC”), Government of the Lao People’s Democratic Republic (hereinafter referred to as the “GOL”) and the Ministry of Transport and Communications, Royal Thai Government (hereinafter referred to as the “RTG”) have applied for loans from the Government of Japan (hereinafter referred to as the “GOJ”) toward the cost of the Second Mekong International Bridge Construction Project hereinafter referred to as the “Project”against a Loan Pledge made by the Government of Japan in July 1998.

The Loan Pledge contained an Implementation Program indicating the completion date for the Project at the end of 2003. However, the Exchange of Notes and the Loan Agreements between the GOJ and the GOL, and between the GOJ and the RTG have not yet been concluded as at this day and the Implementation Program shall be renewed. In clause 11.2, the Implementation Program is presented without showing calendar year taking the seasonal conditions into account which require the commencement of foundation works in the river in December to make use of the low water level period for the Mekong River. It has also been taken into account that the Detailed Design and the basic construction planning have been completed including the Main Bridge, Border Control Facilities and connecting roads by the JICA Study Team as of March 2000. In clause 11.3, the project organization is presented in order that the two Governments may proceed one Project smoothly and effectively with the assistance of the Consultant. In clause 11.4 a disbursement plan is indicated.

11.2 IMPLEMENTATION PLAN

The Revised Implementation Program, with a Project Commencement date at the beginning of June of year-1 and a completion date at the end of June of year-6, the tenure of which will come up to 5 years and 1 month from the date of the Loan Agreement till the Project completing opening, was established in Table 11.2. on the following basis:

1) This schedule of the Project construction is set out on the basis of utilizing the low water season of the Mekong River effectively, i.e. the Contract of the Package-1 will be awarded at the beginning of July and the river work will commence at the beginning of low water level season of December, after proper duration for preparation and mobilization.

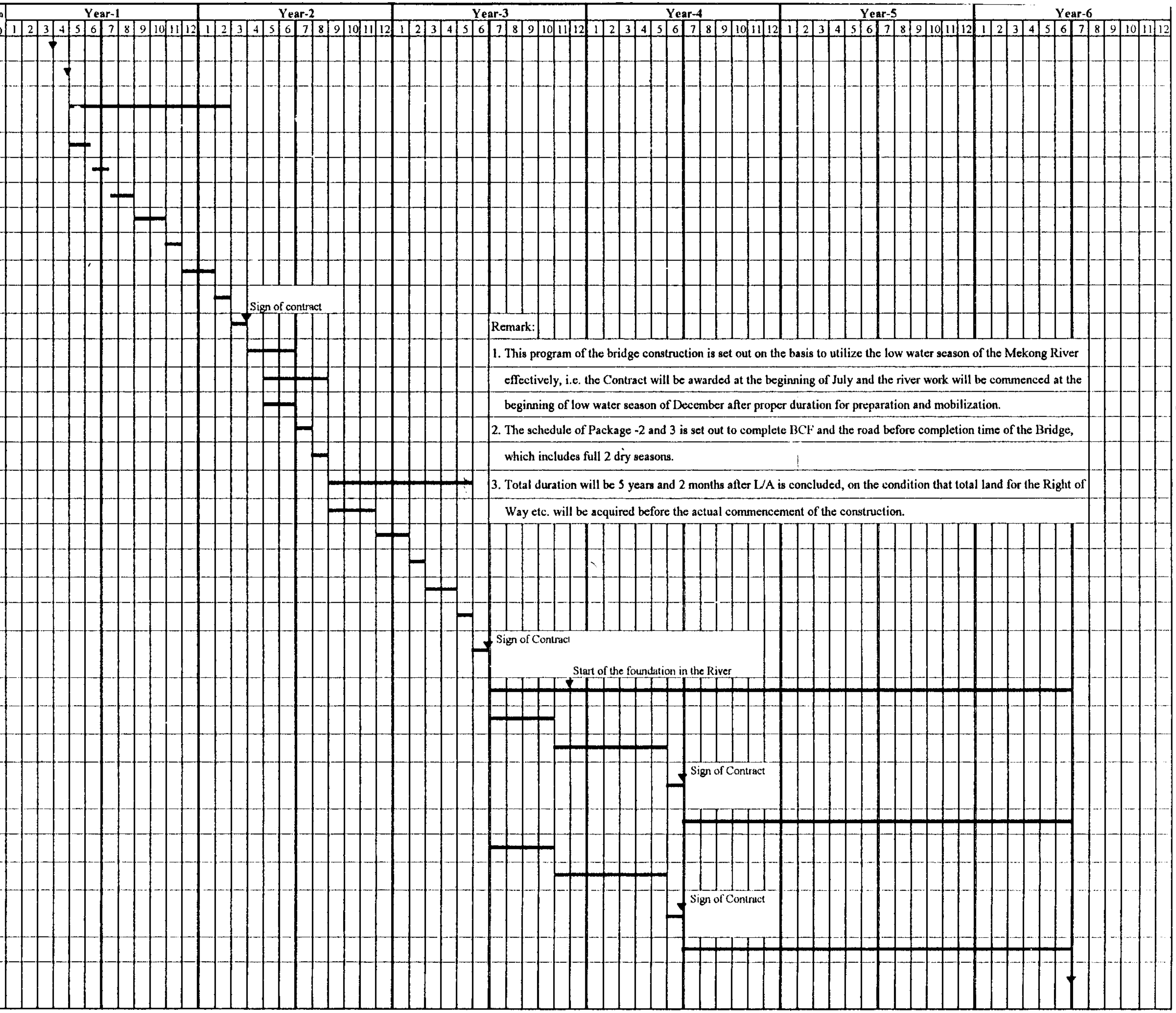
2) The schedule of the Package 2 and the Package 3 is set out to complete the BCF and roads before the completion time of the Bridge, which includes two full dry seasons.

3) Standard procedure and document processing time are adopted for scheduling from the past experience of the DOH and Japan Bank for International Cooperation (hereinafter referred to as the “JBIC”).

4) The bidding documents may have to be revised in accordance with the Exchange of Notes and the Loan Agreement between the GOJ and the respective Governments and the Agreement between the GOL and RTG regarding details of the legal framework of the Project. This activity for finalization of bid documents can proceed in parallel with the Prequalification to some extents.

Table 11.2 Implementation Program

No	Description	Duration (Month)
1	E/N	
2	L/A	
3	Procurement of consultant firm (Procurement & Supervision)	10
	-Short listing	(1.5)
	-JBIC concurrence	(1)
	-Bid period	(1.5)
	-Evaluation of bid	(2)
	-JBIC concurrence for bid evaluation	(1)
	-Contract negotiation	(2)
	-JBIC concurrence for the Contract	(1)
4	Opening of L/C	1
5	Finalization of bidding documents	3
6	Prequalification (Package-1)	4
	-PQ announce & close	(2)
	-Evaluation	(1)
	-JBIC concurrence for qualified bidder	(1)
7	Procurement of the contractor (Package-1)	9
	-Bid period	(3)
	-Evaluation	(2)
	-JBIC concurrence for bid evaluation	(1)
	-Contract negotiation	(2)
	-JBIC concurrence for the Contract	(1)
8	Opening of L/C - Commencement of the work (Package-1)	1
9	Bridge Construction (Package-1)	36
10	Prequalification (Package-2) (the Lao PDR)	4
11	Procurement of the Contractor (Package-2)	7
12	Opening of L/C - Commencement of the Work (Package-2)	1
13	Construction (Package-2)	24
14	Prequalification (Package-3) (Thailand)	4
15	Procurement of the contractor (Package-3)	7
16	Opening of L/C - Commencement of the work (Package-3)	1
17	Construction (Package-3)	24
18	Opening of the border bridge between Savannakhet and Mukdahan	



Remark:

1. This program of the bridge construction is set out on the basis to utilize the low water season of the Mekong River effectively, i.e. the Contract will be awarded at the beginning of July and the river work will be commenced at the beginning of low water season of December after proper duration for preparation and mobilization.
2. The schedule of Package -2 and 3 is set out to complete BCF and the road before completion time of the Bridge, which includes full 2 dry seasons.
3. Total duration will be 5 years and 2 months after L/A is concluded, on the condition that total land for the Right of Way etc. will be acquired before the actual commencement of the construction.

5) The duration of 36 months for the completion period for the Package-1 including the mobilizing time is proposed as possible and appropriate by the JICA Study team.

6) Land acquisition for the project by the both Governments shall be completed prior to the commencement of each contract for the Project.

7) Procurement of consultant firm will start after the Exchange of Notes and the Loan Agreement have been signed by the respective Governments.

8) Detailed agreement between the two Governments shall be reached regarding rules and regulations for the Free Construction Zone before announcing the bid for the Package 1.

11.3 PROJECT ORGANIZATION

After conclusion of the Loan Agreements, the both Governments shall become responsible for proceeding with the Project and shall commence the procurement of a supervision consultant and a construction Contractor for the Package 1 jointly, and a construction Contractor each for the Packages 2 and the Package 3. Project Organization for the preconstruction stage is given in Figure 11.3.1 .

Each Organization shall have the responsibilities and authorities, which are shown in Table 11.3.1. Proceeding of the Project in this pre-construction stage shall require an efficient organization to allow for the particular demands of the Project relating to two Governments closely such as quick and unanimous decisions to be made by the both Governments.

The Project Director from each of the both Governments shall organize a Joint Evaluation Committee (hereinafter referred to as the “JEC”). The JEC should commence the short listing of consultant firms, call for the bid and award a contract to a Consultant Firm, which shall organize a Project Office comprised of a Project Manager from the Consultant and counterparts from both Governments.

The JEC shall manage procurement activities with the assistance of the Project Manager, which shall help both Project Directors not only in the procurement but also in supervision of the work till the end of the Project. Necessary steps shall be taken sequentially during the pre-construction stage (after conclusion of Loan Agreements and before award of the Contract for Package-1).

Award of the Contract for the Package 1 shall be concluded before June in year-3, then the Contractor will be able to prepare and mobilize their resources for smooth starting up of the foundation work in the Mekong River.

Procurement of the Package 2 and the Package 3 shall be carried out by each respective Project Director severally with the assistance of the Project Manager. Prequalification shall be commenced before July of year–3 in order to complete each package before the completion of the Project.

The Package 1A and the Package 2 will be managed by the Project Director of the MCTPC and the Package 1B and the Package 3 will be managed by the Project Director of the DOH. Close cooperation and coordination shall be established between both Project Directors throughout the construction stage. Whenever some common issues arise, a working group shall immediately be organized from the members of each BMC and other offices in order to make joint decisions and to give joint instructions. The Project Manager shall supervise the entire Project during the construction stage coordinating the common issues related to both Governments. Both Project Directors will dispatch respective counterparts to the Project Office to keep close contact between the Employer and the Consultant.

11.4 Disbursement Schedule

The disbursement schedule of the Second Mekong International Bridge Construction Project given in the Table 11.4 has been established in accordance with the Implementation Program as shown in the Figure 11.3.

The disbursement schedule shall be based on following circumstances:

1) The disbursement shall be started after the signing of the consultant agreement and ended by the final payment after issue of Completion Certificate.

2) The disbursement schedule has been set out by each contract package and the Engineering Services.

3) The figures given in the Graphs are indicated as the percentage of the Contract amount.

4) The Engineering Services has been equivalently disbursed for each month excluding the advance payment (10% of Contract Price).

5) The contract has been equivalently disbursed for each month in accordance with the construction items and the time schedule excluding the advance payment (10% of Contract Price).

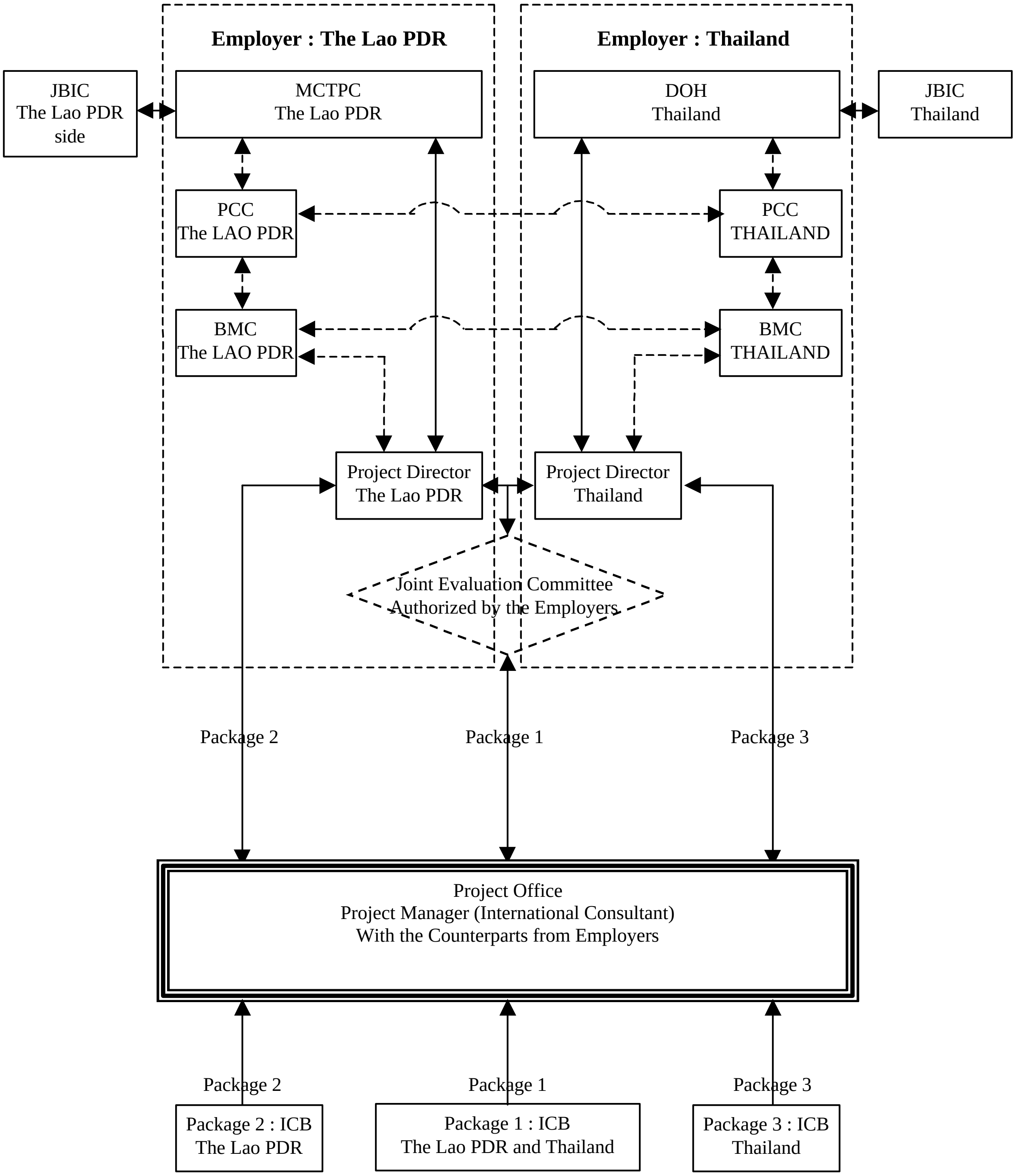


Figure 11.3 (a) Organization for the Preconstruction
The Second Mekong International Bridge Construction Project

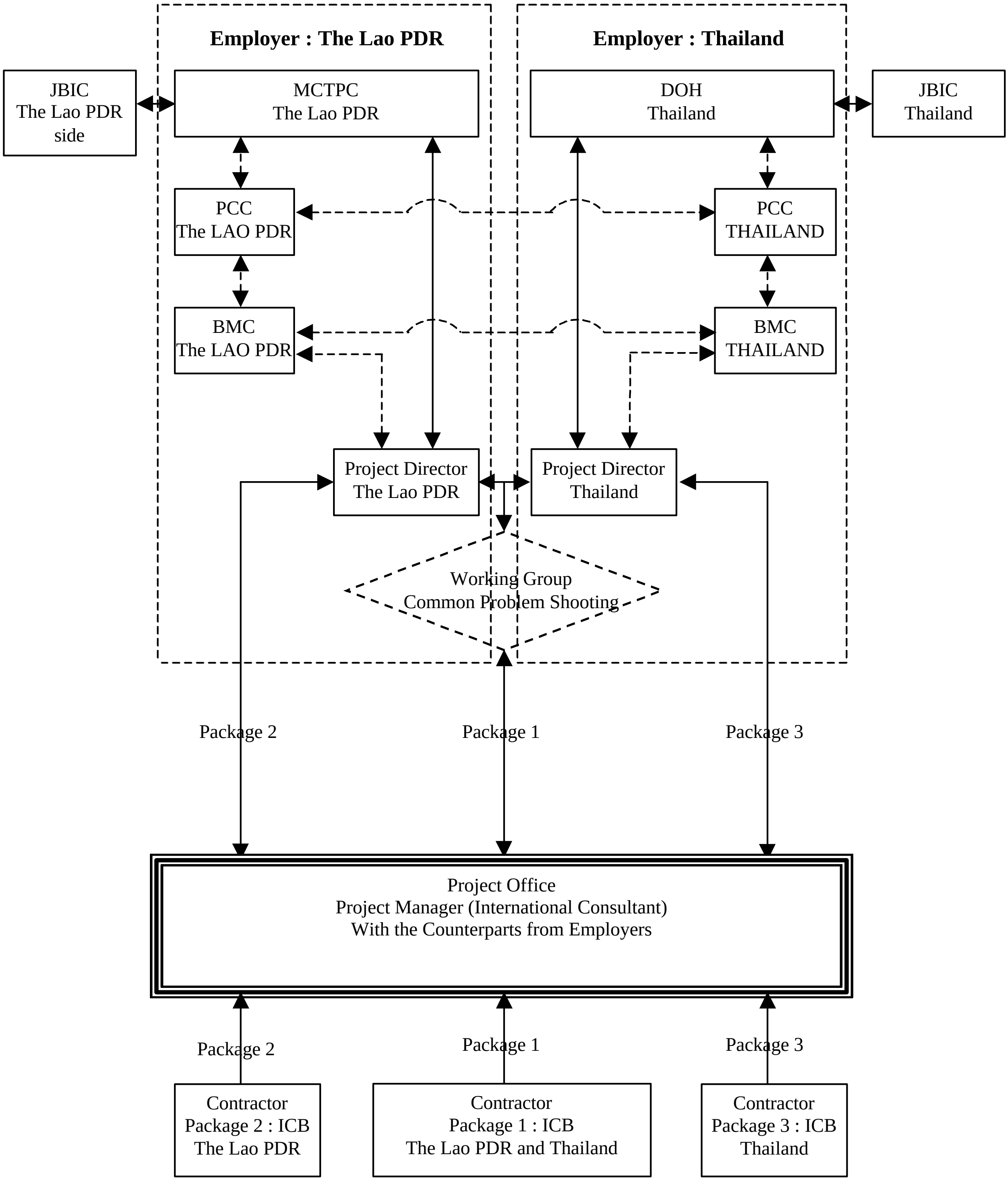
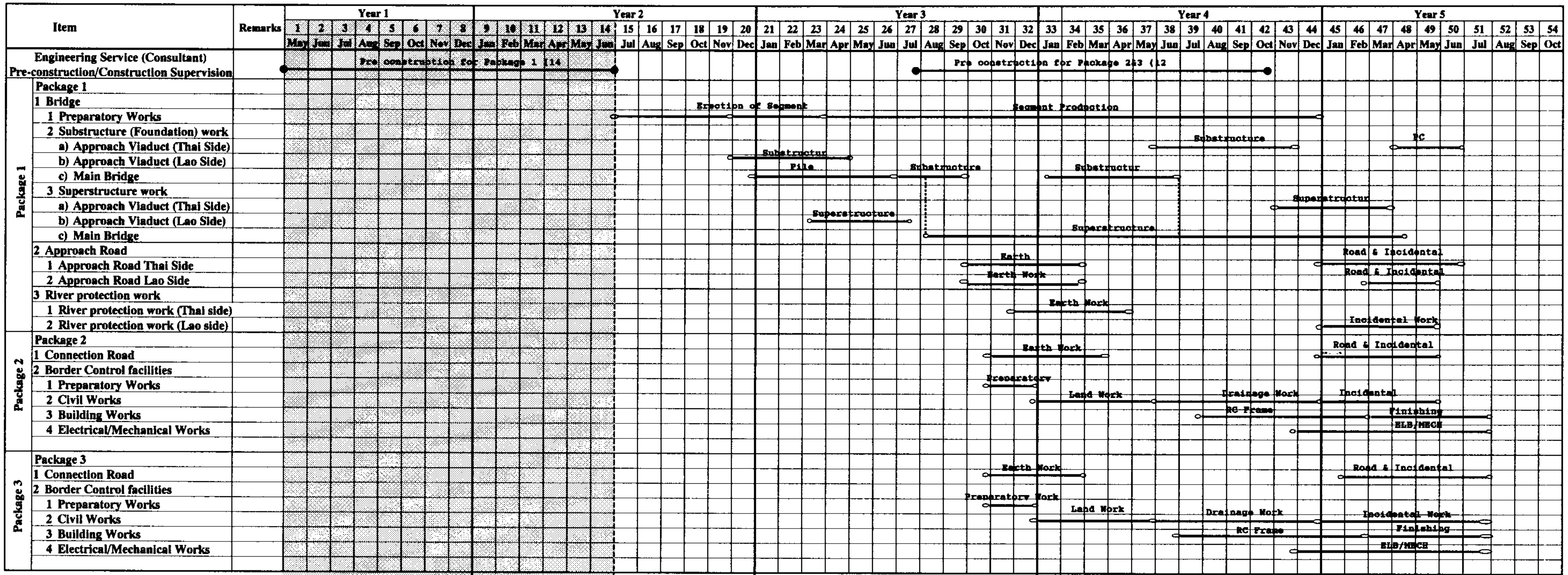


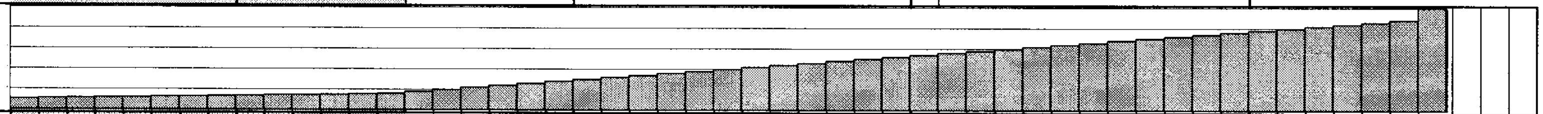
Figure 11.3 (b) Organization for the Construction Supervision
The Second Mekong International Bridge Construction Project

Table 11.3 Responsibilities and Authorities

Parties	Proposed Personnel	Appointment	Responsibilities and Authorities			
			Pre-bid Preparation	Pre-Construction: Pre-Qualification	Pre-Construction: Bid	Construction
Employer:1A (Project Director Office) **Directly appointed by and responsible to Ministry of Communication, Transport, Post and Construction (MCTPC)**	1: PD 2:Eng 1:Sec 1:Typ Total 5	Higher Authority or Ministry	-	Joint Final Approval of JEC Recommended Bidders List .	1. Joint Final Approval of JEC Technical Proposal Recommendation. 2. Joint Final Approval of JEC Bid Recommendation. 3. Issue Letter of Acceptance to Successful Bidder.	Administration of Contract Package 1A. Co-ordination and Liaison of Common issues between Employers for Packages 1A and 1B.
PCC/BMC Lao PDR (When special issue arises)	PCC/BMC Member	Employer	Jointly Review the JEC Recommendation.	Co-ordination among Lao PDR	Co-ordination among Lao PDR	Co-ordination among Lao PDR
Employer: 1B (Project Director Office) **Directly appointed by and responsible to Department of Highways (DOH)**	1: PD 2:Eng 1:Sec 1:Typ Total 5	Higher Authority or Ministry	-	Joint Final Approval of JEC Recommended Bidders List.	1. Joint Final Approval of JEC Technical Proposal Recommendation. 2. Joint Final Approval of JEC Bid Recommendation. 3. Issue Letter of Acceptance to Successful Bidder.	Administration of Contract Package 1B. Co-ordination and Liaison of Common issues between Employers for Packages 1A and 1B.
PCC/BMC Thailand (When special issue arises)	PCC/BMC Member	Employer	Jointly Review the JEC Recommendation.	Co-ordination among Thailand	Co-ordination among Thailand	Co-ordination among Thailand
Joint Evaluation Committee (JEC) or Working Group for Common Problem Shooting	3:Eng(Lao) 3:Eng(Thai) 1:PM(Cons) 1:Secretary Total 8	Employers	Review the Bidding Documents and issue JEC Recommendation to the Employers.	1. Review PM Report and issue Bidders List recommendation to Employers 2. Coordination between Employers	1. Review PM Technical Proposal Report and Issue Recommendation to Employers. 2. Jointly Publicly Open Bid Price Proposal. 3. Review PM Bid Evaluation Report and Issue Bid Recommendation to the Employers.	1. Review PM Report. 2. Confirm the Payment Certificates.
Consultant: Project Office(PO) Project Manager(PM) (International Consultant)	*PM *Asst. PM *Exp. Engineers *Clerk *Accountant *Secretary *Counterparts from Employers Total 40	Employers	Finalise Bidding Documents	1. Review and finalizing PQ document 2. Issue PQ Documents to Bidders 3. Review Submissions 4. Issue Report to JEC including the Bidders List recommendation to JEC.	1. Review and finalizing Bidding Documents. 2. Issue Invitation to Bids 3. Issue Bid Documents and collect bid fees on Employers behalf. 4. Issue any necessary amendments or clarifications to Bidders 5. Receive Bids 6. Review Technical Proposals and Issue Report confirming Eligible Bidders to JEC. 7. Jointly Publicly Open Bid Price Proposals 8. Evaluate Bid Price Proposals and Issue Report to JEC.	1. Supervision and Administration of Contract Packages 1A and 1B. 2. Report to WG on the procedure of the construction. 3. To measure the quantities of work executed and check payment certificates to the Contractors.

Table 11.4 Disbursement Schedule





Item		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Engineering Service (Consultant) Pre-construction/Construction Supervision — Disbursement /Month	(%)	11	11	11	12	12	13	13	13	14	14	15	15	15	16	18	20	22	24
Package 1: 1 Bridge 1) Substructure (Foundation) work 2) Superstructure work 2 Approach Road 3 River protection work — Disbursement / Month	(%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10
Package 2: 1 Connection Road 2 Border Control facilities 1) Civil Works 2) Building Works 3) Electrical/Mechanical Works — Disbursement / Month	(%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Package 3: 1 Connection Road 2 Border Control facilities 1) Civil Works 2) Building Works 3) Electrical/Mechanical Works — Disbursement / Month	(%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Item		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Engineering Service — Disbursement /Month	(%)	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
Package 1 — Disbursement / Month	(%)	11	11	12	14	18	21	24	27	29	32	34	37	40	45	50	54	58	62
Package 2 — Disbursement / Month	(%)	0	0	0	0	0	0	0	0	0	0	0	0	10	12	16	20	24	26
Package 3 — Disbursement / Month	(%)	0	0	0	0	0	0	0	0	0	0	0	0	10	12	15	18	19	20

Item		37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Engineering Service — Disbursement /Month	(%)	62	64	66	68	70	72	74	76	78	80	82	84	86	88	100			
Package 1 — Disbursement / Month	(%)	65	68	70	73	76	80	83	86	89	93	95	97	99	100				
Package 2 — Disbursement / Month	(%)	28	30	32	36	40	44	47	53	60	67	75	82	89	95	100			
Package 3 — Disbursement / Month	(%)	21	23	24	28	32	36	40	46	52	60	68	76	84	92	100			

CHAPTER 12
Evaluation and Recommendation

CHAPTER 12 : EVALUATION AND RECOMMENDATION

12.1 GENERAL

This chapter briefly comments on the study and the important issues which have arisen out of the Study. The conclusion of the Project is briefly assessed and the relevant comments made on the conclusion and the effect of the Project on future access among ASEAN countries. Brief remarks are made on certain Project items, the method of the Border Control Facilities and the Bridge Design parameters. An evaluation of the significant Project items is briefly mentioned with regard to their effects on the Project as a whole.

The requirements of the concerned authorities including both the Ministry of Communications Transport Post and Construction and the Department of Highways are reviewed. Future status and control of concerned authorities such as customs or immigration are also briefly discussed related to their requirements.

Finally, an assessment as to implementation on procurement of the supervision consultant, the prequalification and tendering process and implementation of various construction contracts are discussed and recommendations are made. A technology transfer program including seminars and/or lectures and an oversea's training program for both the Lao PDR and Thailand personel are included as well.

12.2 CONCLUSION OF THE PROJECT

The Project has been concluded in the end of February 2000 in accordance with the requirements laid down in the Inception Report of March 1999, and in accordance with the related minute of meetings among Ministry of Communication Transport, Post and Construction (MCTPC) of the Lao PDR, the Department of Highways (DOH) of Thailand, and the Study Team of the Japan International Co-operation Agency (JICA).

The conclusion of the Project will represent a major forwarding step in the implementation of the East-West Corridor between Thailand, the Lao PDR and Vietnam. The Bridge crossing has been uniquely designed and shown with the cultural effect of both countries as represented by two towers on the Main Bridge structure; one tower being on the Lao PDR side and the other on Thailand side. The towers depicting the “clasping of hands” has unique cultural implications in the both countries.

The Border Control Facilities have also been successfully designed in accordance with the requirements of the Lao PDR and Thailand and with the close co-operation of the counterpart team of each country. The facilities will represent a significant and substantial improvements to the existing border facilities at Savannakhet and Mukdahan.

12.3 EVALUATION OF PROJECT ITEMS

A brief summary of Project Item evaluation is listed below.

(a) Study Comments – Detailed and clear mentions of objectives. A clear opening to the Study.

(b) Roads – Concisely and clearly defined. Compromises of the ASEAN Highway conditions with the requirements of both countries (the Lao PDR and Thailand).

(c) Main Bridge – An effort has been made to design a unique structure at a reasonable cost. The Bridge towers convey an aesthetic and cultural beauty for both the Lao PDR and Thailand sides.

(d) Border Control – Designed to be functional and to convey the culture and architecture of both countries as well.

(e) Viaducts – Used instead of high embankment which would be obstracles to the local people from forming a community division at the Bridge site. Culverts are used as a cheaper alternative to minor bridges.

(f) Construction Planning – Considers 3 construction packages. Plans consider working from any direction.

(g) Management & Maintenance – Reviews on past situations at the Friendship Bridge and attempts to improve on these matters.

(h) Environment Issues – Clearly covers both social and ecological issues as a result of the Project conditions.

(i) Cost Estimate – It is clearly listed and detailed for all the three Contract Packages.

(j) Draft Bidding Documents – Considerable work involved in preparing specifications. Local Thai firms are employed to help with bid documents. Unique documentation for Package 1 has 1 Contractor but two Employers.

(k) Implementation Program – Lists the necessary reasons for starting the Project as soon as possible; it is critical to start and finish within 2003 for East West Corridor scheme implications.

12.4 REQUIREMENT OF CONCERNED AUTHORITIES

The Study team has a close liaison with both the Bridge Management Committee and the Counterpart teams of the Lao PDR and Thailand. The two Committees and counterpart teams were especially set up at the start of study for the Project. The Study team has discussed all major design criteria with their respective counterparts and also as required by the Bridge Management Committee staff. If applicable and wherever possible, requirements of the counterparts and other concerned people were incorporated into the design.

Discussions between the Study team and other authorities such as immigration and customs have taken place through the counterpart officers. These discussions have set up the requirements for the Border Control Facilities in both countries. Architectural features for the BCF in the both countries have been agreed and designed accordingly.

As a result of the co-ordination with and the generous assistance of the concerned authorities, the design, reports and drawings for the Project have been completed on time.

12.5 RECOMMENDATIONS

As the design, drawings and documentation have now been completed, it is recommended that implementation of the construction phase of the Project takes place as soon as possible.

In the both countries and the regions, there is interest that procurement of a Consultant be undertaken as soon as possible so that preconstruction works can be undertaken. It is essential to issue prequalification documents at the earliest date so that the most suitable contractors may be invited to tender.

Procurement of a Consultant is essential for issuing the bid documents, reviewing bids and making the appropriate recommendations to both the Lao PDR and Thai governments.

The strong recommendation is, therefore, that preconstruction and supervision Consultant be procured as soon as possible, and that bidding for construction be called by mid 2000 so that contracts for the Bridge and Border facilities can start no later than October 2000 so that the Project can be completed by the end of 2003.

Completion of the Project by this date is essential since the Route number 9 highway contracts in the Lao PDR and Vietnam under the JICA and the ADB will be completed by this time. Such the projected completion would allow an effective East-West Corridor from the Myanmar-Thailand Border to the Vietnamese central-east coast and would allow for the development of all the four countries in this region.

12.6 TECHNOLOGY TRANSFER PROGRAM

As presented in the Inception Report for the Second Mekong International Bridge Construction Project dated March 1999, it is necessary (and indeed most desirable) to pursue technology transfer to both the GOL and the RTG counterpart personnel during the course of the Study. It will be the Study team's intention to provide technology transfer during the design stage and to recommend that it further be implemented during the Construction Supervision stage of the Project, while a trip to Japan or other countries of counterpart personnel for at least 2 weeks to study about advanced technology and methods currently being applied to newly constructed bridges.

EXECUTIVE SUMMARY OF BASIC DESIGN

EXECUTIVE SUMMARY OF BASIC DESIGN

A. INTRODUCTION

This Basic Design Report (hereinafter referred to as the BDR) covers all data and findings of the Second Mekong International Bridge Construction Project during the first 4 months after the study inception. It includes the study and work covered by progress report No. 1 (PR (1)) and it describes the study and conclusions for the basic design. The study and works carried out during the period April 1999 to July 1999 are mentioned as follows:

(1). Inception Report

- Preparation, submission and discussion of the inception report to MCTPC, DOH and the Bridge Management Committee.

(2). Progress Report No. 1

- Preparation, submission and discussion of the Progress Report No. 1 to MCTPC, DOH and the Bridge Management Committee.

Progress Report No. 1 also includes the following data and study reviews.

(a) Preliminary Study

- A review of previous studies conducted by ADB and OECF.
- Collection of data, interviews and analysis.
- Site reconnaissance: Mekong River, road networks, relevant townships etc.
- Project appreciation and investigation of the socio-economic conditions.
- Administration, regulations, the Mekong Committee of UN etc.

(b) Natural Condition Summary

- Topographic survey.
- Hydrological and hydraulic investigation.
- Soil / Materials and geotechnical investigation.
- Meteorological and seismic investigation.

(c) Basic Design

- Review of the Friendship Bridge, the Pakse Bridge and the Kompong Cham Bridge.
- Determination of design criteria and standards.
- Examination of the alignment of the Bridge and roads.
- Examination of the cross-section of roads and type of intersections.

(d) Initial Environmental Examination

- Impacts of construction to environment.
- Specifications for further study on environmental issues.

B. BASIC DESIGN REPORT

The Basic Design Report covers the following studies and works.

Chapter 1. Study Contents

Study objectives, study background, schedule and study structure including the related organizations of each country are described in this chapter.

Chapter 2. Project Appreciation

An appreciation of the Project and an investigation of the socio-economic conditions of both the Lao PDR and Thailand including the roads and adjacent city areas are described.

Development policy and plans for transportation, road networks and traffic situation in each country as well as the project area are discussed. Relevant comments of previous major studies are also included in this chapter.

Chapter 3. Natural Conditions

The following surveys were carried out to obtain natural conditions for design of the Bridge, Border Control Facilities and connecting roads.

- Topographic Survey:

The profile survey, cross-sectional survey and topographic mapping has been carried out along and on each side of the centerline of the Bridge, border facilities and connecting roads, in both the Lao PDR and Thailand. Topographic drawings have been completed by the Study Team.

- Geological / Materials Survey

Boring tests in 10 locations (6 in the River and 4 on land) have been completed. Auger boring at 50 m intervals along the centerline have been carried out as well as material tests on aggregates from both the River and borrow pits. Borrow pits and quarries have been identified and the location of materials checked.

- Hydrological and hydraulic survey

A sounding survey has been carried out along the centerline of the Bridge and over a 200 m width (100m on each side of the centerline) in the Mekong River.

The high water level (HWL) has been calculated from records of flood level near the site, and the following parameters have been set.

- HWL of a 1 in 100 years average recurrence interval (ARI) flood water level is adopted at +139.60 m for the Main Bridge design.
- HWL of a l in 25 years ARI flood water level is adopted at +138.50 m for the approach and connecting roads.

- Meteorology and Seismic Survey

These surveys have been carried out and the following data have been used in the basic design study.

- Wind velocity of 48 m/sec is applied to the design.
- Seismic force coefficient of 0.06 has been calculated from available seismic records within a 500 km radius of the site.

Chapter 4. Social Conditions

Social conditions such as land acquisition, river navigation, environment and design standards for the Bridge and connecting roads are discussed. International aspects of the construction packages are briefly reviewed. It is recommended that an international construction zone (ICZ) be applied after detailed discussion on its implications. Recommendations are made for the Main Bridge package and 2 other packages that combine the Border Control Facilities and connecting roads in the Lao PDR and Thailand.

Design standards that will be used on both the Bridge and connecting roads are outlined in this chapter.

Navigation and river transportation aspects are briefly mentioned while the environmental impact on the border cities of Mukdahan and Savannakhet are anticipated.

The construction plan for the three construction packages are given in this section together with details on transactions in the construction industry and taxation in both the Lao PDR and Thailand.

Chapter 5. Bridge and Roads

Natural conditions and control points of the Bridge and road alignment are discussed in this section. Alternative comparisons of both roads and the Bridge are outlined, and recommendations for the final type of roads, the Bridge, and viaducts are made.

5.1 Road

(1).Design Conditions

The design standards and basic design conditions of the road are given in Table 5.1.1. Design standard of carriageway (Table 5.1.2) and traffic changeover (Table 5.1.3) were adopted as the most suitable plans, after studying standards of many counties.

(2).Horizontal and Vertical Alignment

The crossing of the Bridge is the point proposed by the Study Team based on the route in SAPROF study. The Bridge will be located perpendicular to the Mekong River axis to minimize the bridge length.

The horizontal alignment of the Bridge and routing of the various alternative approach roads are discussed in details. Recommendations are made for the best connecting road alternative on the Lao PDR side. The vertical alignment of the connecting roads and the Bridge are analyzed using various controlling design parameters. Different grades and applicability of their implications on the design are reviewed.

Table 5.1.1: Design Standards and Road Design Conditions on Basic Design Report

Item	Understanding	Reference
a. Design Standard Basis	- The design standard of connecting roads is on the basis of the road design standard of the Asian Highway Class II-Flat Terrain classification. - Design speed is at 80km/h.	
b. Proposed Design Standard	- Proposed design standard for the carriageway is as shown in Table 5.1.2 and Figure 5.1.1. - Proposed design standard for the traffic changeover section is as shown in Table 5.1.3 and Figure 5.1.2. - Proposed standard cross-section for earthwork is as shown in Figure 5.1.1 - Proposed standard for intersections shall be on the basis of standards in each country. Furthermore, missing items from these standards are applied on the basis of the relevant standards such as Road Structure Ordinance of Japan or AASHTO.	Table 5.1.2 Figure 5.1.1 Table 5.1.3 Figure 5.1.2 Figure 5.1.1
c. Minimum Road Height	- The minimum elevation of the pavement structure shall be 0.3m above 25 year ARI flood water level (=138.50m).	Figure 5.1.3
d. Traffic Changeover Facility	- An at-grade crossing shall be used for the traffic changeover facility.	
e. Design Conditions for Intersections	- The National Road Route 9 intersection in the Lao PDR shall be designed according to the existing road geometry. - The Provincial Road A3 intersection in the Lao PDR shall be designed as the A3 to be improved in the future. - The National Highway Route No.212 intersection shall be designed according to the road design plan which is provided by DOH.	

Table 5.1.2
The Proposed Design Standard for the Carriageway

	Lao PDR Standard	Thailand Standard	Asian Highway Standard	Japanese Standard	Friendship Bridge	Second Mekong Brige (Proposed)
Standard	Road Design Manual (1996)	Standard Drawings (1994)		Road Structure Ordinance (1993)	-	-
Class *	Class III - L	Class II - L	Class II - L 2-lane road	3 - 1	-	**Asian Highway Class II - L**
Design Speed	80km/h	90 - 110km/h	80km/h	80km/h		**80km/h**
Min. Horizontal Curve Radius	250m	300m	210m	400m		**400m**
Min. Horizontal Curve Radius (without Transition Curve) (without Superelevation)	-	-	-	900m 3,500m		**900m 3,500m**
Min. Horizontal Curve Length	-	-	-	140m		
Min. Vertical Curve Radius (Crest) (Sag)	5,000m 2,000m	-	-	3,000m 2,000m	3,000m 2,000m	**5,000m 2,000m**
Max. Gradient	6.0%	4.0%	4.0%	4.0%		**4.0%**
Max. Superelevation	10.0%	10.0%	10.0%	10.0%		**10.0%**
Carriageway Width	3.5m * 2 = 7.0m	3.5m * 2 = 7.0m	3.5m * 2 = 7.0m	3.5m * 2 = 7.0m	3.5m * 2 = 7.0m	**3.5m * 2 = 7.0m**
Shoulder Width (Traffic Side)	2.0m	2.0m	2.5m	1.25m	2.5m	**2.5m**
Shoulder Width (Center Side)	-	-	-	-	0.25m	**-**
Verge Width	-	-	-	0.5m * 2	1.5m * 2	**0.5m * 2**
Median Width	-	-			0.5m	
Formation Width	11.0m	12.0m	12.0m	10.5m	16.0m	**13.0m**
Crossfall	2.0 - 3.0%	2.0 - 3.0%	2.0%	2.0%		**2.0%**
Right of Way	50m	40 - 60m	40m	-		**50m (Lao PDR) 60m (Thailand)**

* L = Level Terrain

Base Standard → Proposed Standard

Table 5.1.3
The Proposed Design Standard for the Traffic Changeover

	Lao PDR Standard	Thailand Standard	Asian Highway Standard	Japanese Standard	Friendship Bridge	Second Mekong Brige (Proposed)
Standard	Road Design Manual (1996)	AASHTO	-	Road Structure Ordinance (1993)	-	-
Class	-	-	-	Grade-B	-	**Japanese Grade-B**
Design Speed	-	60km/h	-	50km/h		**50km/h**
Number of Lanes	-	1	-	1		**1**
Min. Horizontal Curve Radius	-	115m	-	90m		**90m**
Min. Horizontal Curve Radius (without Transition Curve) (without Superelevation)	-	- 1,110m	-	220m 1,300m		**220m 1,300m**
Min. Horizontal Curve Length	-	80m	-	90m		**90m**
Min. Vertical Curve Radius (Crest) (Sag)	-	-	-	800m 700m		**5,000m 2,000m**
Max. Gradient	-	7.0%	-	7.0%		**4.0%**
Max. Superelevation	-	8.0%	-	10.0%		**10.0%**
Lane Width	-	3.0m	-	3.25m	3.5m	**3.5m**
Shoulder Width (Traffic Side)	-	1.5m	-	1.5m	2.5m	**2.5m**
Shoulder Width (Center Side)	-	1.5m	-	0.75m	1.0m	**1.0m**
Verge Width	-	-	-	0.5m * 2	1.5m * 2	**0.5m * 2**
Formation Width	-	6.0m	-	6.5m	10.0m	**8.0m**
Crossfall	-	1.5 - 2.0%	-	2.0%		**2.0%**

Base Standard → Proposed Standard

Base Standard   Proposed Standard *

* Conformed with the Carriageway Geometry

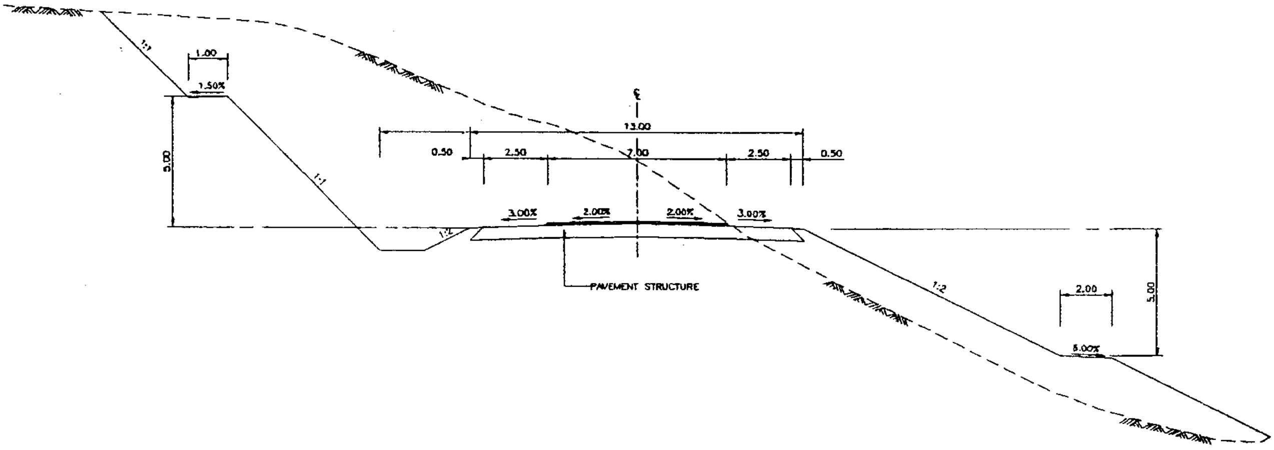


Figure 5.1.1 Proposed Cross-section for the Carriageway at Earthworks

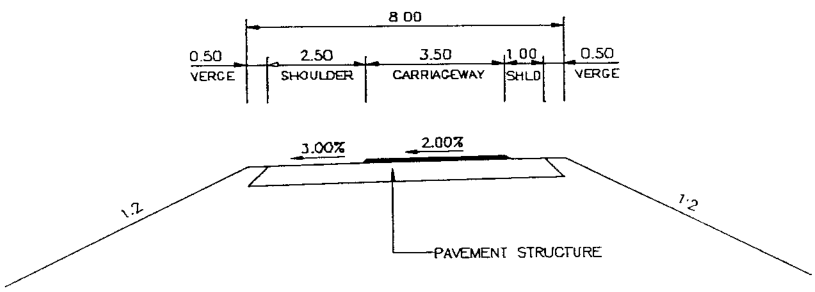


Figure 5.1.2 Proposed Cross-section at the Traffic Changeover

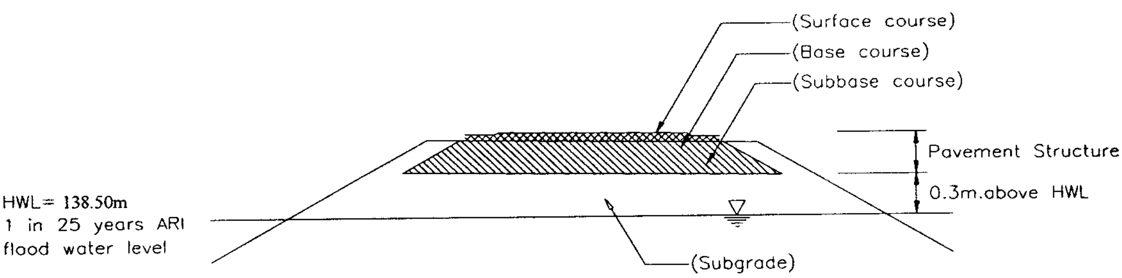


Figure 5.1.3 Necessary Elevations of the Pavement Structure

(3) Traffic Changeover

The traffic changeover is planned on the Thailand side of the Mekong River. The approach road length between the BCF and the Bridge is sufficient for the traffic changeover, otherwise uniting the traffic changeover with the national highway Route No.212 intersection is another alternative. Owing to preconditions, the following three types of the traffic changeover shall be considered.

- Type A : At-grade crossing between the Bridge and the BCF
- Type B : Grade separated crossing between the Bridge and the BCF
- Type C : The changeover is united with the national highway Route No.212 intersection

Type A is selected and its characteristics are agreed by the Lao PDR and the Thailand authorities and the Study Team with the following reasons:

a) The at-grade crossing traffic changeover is established on the Friendship Bridge.
b) The at-grade crossing type is a simple structure, thus it is economic compared to other types of changeover.
c) A grade separated crossing shall also be considered when traffic volume is increased in the future.

(4) Intersections

The connecting roads links the national road Route 9 in the Lao PDR with the national highway Route No. 212 in Thailand. Moreover, it contains an at-grade intersection with the Provincial Road A3 in the Lao PDR. Connecting roads also across through the roads along the riverbank. However, these crossings are planned as overpassed by use of embankment. Therefore, the following three intersections are to be considered.

(a) The National Road Route 9 (Roundabout) Intersection in the Lao PDR

The crossing angle of connecting roads and the national road Route 9 is approximately 42 degree, the crossing angle of the Kaysone Road is approximately 37 degree. However, the crossing angle is stipulated as more than 60 degrees in the AASHTO standard or in the Road Structure Ordinance of Japan. The crossing angle must be accordingly amended to be more than 60 degree. Under preconditions of the national road Route 9 intersection, the following type were considered.

- Type A : A regular four-leg intersection crossing at the existing location
- Type B : A regular four-leg intersection with an easy curve
- Type C : A roundabout intersection

According to results of the comparison, Type C was selected and its characteristics were agreed by both the Lao PDR authorities and the Study Team under the following reasons:

a) It agrees with the common habit of drivers in the Lao PDR.
b) Traffic through the intersection must stop, thus traffic control devices such as signals will not be necessary.
c) A monument can be established on the center island; it may supply an accent for cityscape (request of MCTPC).

(b) The Provincial Road A-3 Intersection in the Lao PDR

The crossing angle of connecting roads and the Provincial Road A3 is approximately 42 degree. However, the crossing angle is stipulated as more than 60 degrees in the AASHTO standard or in the Road Structure Ordinance of Japan. It shall be amended to be more than 60 degree accordingly. Under the preconditions of the Road A-3 intersection, the following types are be considered.

- Type A : Improvement of crossing angle
- Type B : Crossing separation

According to results of the comparison, Type A was selected for its superior characteristics by the Lao PDR authorities, that is,

a) It is convenient for the traffic through the Road A3.
b) Traffic conflict through connecting roads will be reduced.

(c) The National Highway Route No. 212 Intersection in Thailand

The crossing angle of connecting roads and the national highway Route No.212 is approximately 89 degree.

Therefore, design of the intersection is in accordance with standard design of the three-leg intersection on the basis of the DOH Standard Drawings in Thailand.

(5) Pavement Structures

The carriageway section shall be paved with asphalt concrete. The traffic changeover and BCF sections are reinforced concrete pavement because the traffic passing through these sections often stop and apply braking forces to the pavement.

Intersections in the rural area shall be paved with asphalt concrete in accordance with the DOH standards in Thailand.

For the pavement design, the annually average daily traffic volume on connecting roads is available from results of the traffic survey by SAPROF study.

Method of pavement was compared based on road design manuals of DOH and JRA in consideration of traffic volume increasing ratio, heavy vehicle ratio and design CBR is finaly decided.

The cement concrete pavement is referred to Manual for Concrete Pavement (JRA, 1984), and Asphalt concrete pavement to Manual for Asphalt Pavement (JRA, 1992).

The geological survey for ground conditions at construction site and conditions of embankment materials were carried out. For pavement design, results of laboratory soil tests and embankment materials are obtained.

(6) Drainage Systems

A site investigation for drainage plan of the connecting roads was carried out under consideration of the drainage system and the topographic conditions.

Drainage structure such as U-drains, ditches, culverts are be established along connecting roads. Concrete U-drain are set beside embankment slope, V-ditches beside the cutting slopes. A pipe culvert shall be set across the roadway to connect drainage facilities. For avoiding obstruction to the water flow through canals or small stream, box culvert will be set as necessary.

5.2 Bridge

(1) Design Condition

The study results on other Mekong River Bridges by ADB study as well as SAPROF study were reviewed. Basic design conditions are discussed in details and definite recommendations are made on feasible superstructure and foundation types as the results of these processes. The design standard and basic design conditions of the Bridge are shown in Table 5.2.1.

(2) Length of Bridge

The Main Bridge length is 1,600m, which is the sum of lengths between riverbanks and approximately 70m offset on each side.

The position of the end pier of the Main Bridge is decided after considering the following conditions (refer to Figure 5.2.1)

1) Riverbank erosion; The riverbank due to flooding is eroded at a rate of about 10m in 50 years as confirmed at interviews with local people. The eroded distance is about 20m in 100 years.

2) Existing road; There are existing roads on each riverbank. The right of way of these roads is 40m.

3) The position of the footing at the end pier front face must satisfy with the above 2 conditions. The distance from the front face of the end pier to the riverbank must be more than 40m and 20m erosion allowance for the footing configuration.

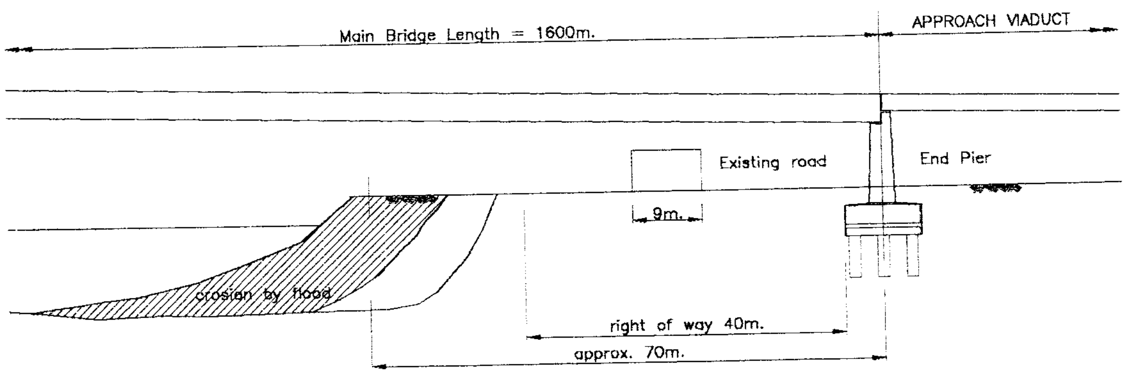


Figure 5.2.1 Position of End Pier

Table 5.2.1 (1/3) : Design Standards and Bridge Design Conditions

Item	Bridge Design Standard and Conditions	Reference
a. Design Standard	The design standard of the Bridge is the Japan Road Association: Specifications for Highway Bridge (JRA-SHB).	
b. Design Load	- Vehicular live load for the carriage-way is 80% of B-live load by the JRA-SHB. - Pedestrian live load: under AASHTO - Dead load : under JRA-SHB Steel material : 77kN/m^3 Reinforced concrete : 24.5kN/m^3 Prestressed concrete : 24.5kN/m^3 Plain concrete : 23kN/m^3 Asphalt concrete : 22.5kN/m^3 Handrail : 500N/m on each side Electronic cable including future services load : 500N/m each side - Seismic load : horizontal load of 6.0% of dead load equivalent static horizontal load in any directions - Ship impact load : equivalent static force of 3400KN acting in any directions. - Wind load: standard velocity of 48m/s -Hydrodynamic force : calculated under JRA-SHB, maximum river flow velocity 2.6m/s - Thermal effect : average concrete structure between 10°C and 40°C, steel structure between 10°C and 55°C - Dry shrinkage and creep of concrete : at 75% relative humidity. - Handrail load : lateral force of 2.45kN/m as specified in JRA-SHB - Differential settlement : not considered - Combination of load : under JRA-SHB	Adjusted to AASHTO Maintenance purpose only From investigation From previous studies Refer to survey Calculated from River velocity Refer to survey Refer to survey Rock foundation

Table 5.2.1 (2/3) Design Standards and Bridge Design Conditions

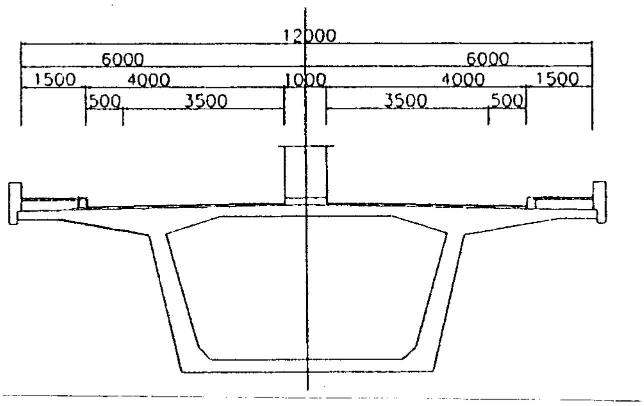
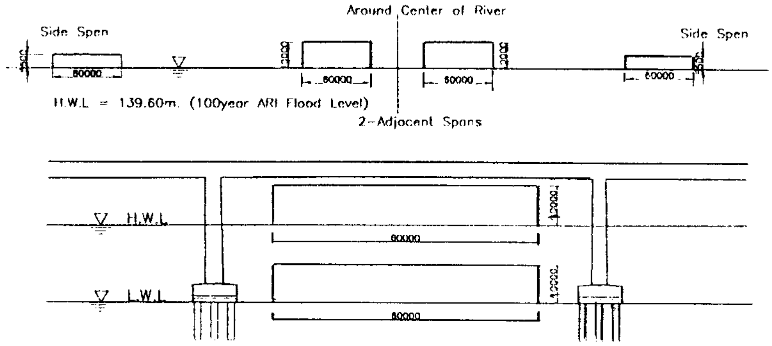
Item	Bridge Design Standard and Conditions	Reference
c. Deck Layout and Bridge Attachment	The Bridge deck width between edge barriers is 12.0m. The footpath width is 1.5m. The traffic lane width is 3.5m. Shoulder width on the curbside is 0.5m. The mountable median width is 1.0m. The drainage crossfall of the road is 2.0%, of sidewalks 1.5%. The road pavement is asphalt concrete pavement, with a thickness of 50mm. The interval of the drainage pits will be calculated on the basis of rainfall records. 	Refer to SAPROF
d. Navigation Clearance	- Vertical navigation clearance For 2 spans around the center of the Bridge: Not less than 10.0m For the side spans (excluding the extreme side spans) Not less than 5.5m, These clearances shall be based on the HWL (1 in 100 year average recurrence interval (ARI) level) of the River. - Horizontal navigation clearance For all spans (excluding the extreme side spans) Not less than 60.0m 	Refer to SAPROF

Table 5.2.1 (3/3) : Design Standards and Bridge Design Conditions

Item	Bridge Design Standard and Conditions	Reference
e. Minimum Span	- The minimum span between piers is 80m. (to secure navigation clearance at HWL and LWL; and to secure clearance from debris during flooding)	Refer to Law of Japan River Management
f. Preferable Span	- The preferable span between piers is 110m. (to secure future development space for navigation and making span identical to other Mekong Bridges)	Refer to Law of Japan River Management
g. Design Water Level	- HWL is 139.6m (1 in 100 year ARI flood water level) - LWL is 125.5m (1 in 2 years water level)	From Investigation
h. Position of the End Pier of the Main Bridge (Main Bridge Length)	- The Main Bridge length between the center of the end piers in both the Lao PDR and Thailand is 1,600m.	From Investigation
i. Bridge Material and Structural Type	- The Bridge type is the PC (prestressed concrete) continuous box girder bridge.	Refer to SAPROF
j. Clearance of Existing Roads near the Riverbank	- The road height clearance will be 5.5m. - The road width will follow the present conditions.	Refer to DOH Standard
k. Bridge Facility	- Bridge lighting, navigation lighting - Emergency telephone	Request by the Lao PDR and Thailand
l. Material Properties	- Steel Reinforcing bar (JISG3112) SD345, Yield strength $\sigma sy \geq 350 N/mm^2$ Strand cable for pre-stressing (JIS G3109) Main girder inner cable 12S15.2 (SWPR7BL) Main girder external cable, PC sail 19S15.2 (SWPR7BL) Deck slab, Dapped hinge 4S15.2 (SWPR7BL) - Concrete Compressive strengths of concrete by structure items are as follows: Prestressed concrete structure: $\sigma ck = 400 N/mm^2$ Pier, footing, pile cap and abutment: $\sigma ck = 240 N/mm^2$ Cast-in-place RC pile: $\sigma ck = 300 N/mm^2$ The specified strength is the compressive strength of concrete cylinders at an age of 28 days.	Refer to JRA-SHB

(3) Superstructure of the Main Bridge

1) Selection of the Structure Type

The type of the Main Bridge was agreed by the Lao PDR and Thailand to be a prestressed concrete box girder bridge of the basic spans of 80m with the PC sail type wider spans of 110m at two locations (total of four spans) through the process as follow:

a) SAPROF study of OECF with a base span of 107m was set as an initial base plan. An alternative base span of 110m was selected to agree with other Mekong bridges and to secure spaces for future possible development of navigation channel.

b) Following the findings from geo-technical investigation of bearing strata which is shallow, other comparative spans were 110m, 80m, and 70m. As it is shown in Table 5.2.2, the basic span of 80m is the most economical, although differences among the alternatives are insignificant.

c) Provision of navigational channel of 110m at two locations (total of four spans) to avoid central sand bar for sake of safety was strongly requested by the Lao PDR and the Thai authorities.

d) The Study Team studied two new alternatives, one with varying girder depth and the other with PC sail type as shown in Table 5.2.3. Both types had no significant difference in structure, construction, maintenance, economy, navigation safety, etc.

e) PC sail type span was selected for monumental purpose by the both governments of the Lao PDR and Thailand.

2) Basic Design

The selected structural type is a 19-span continuous box girder with main span lengths of 80m and 110m. The principal geometric dimensions of the box girder structure are determined for the span length of 80m. The shape of the girder cross section is the single box type with cantilever slab decks that makes the bridge deck width of 12.8m. The section of 110m span length is strengthened with the PC sail so as not to vary the main dimensions of the box girder from those of the 80m span length sections. The tower supporting the outer PC cables above the piers and the anchoring of the outer PC cables into the main girder are both installed at the center of the box girder cross section.

Table 5.2.2 Evaluation of Bridge Types at Spans of 110m, 80m and 70m

Bridge Structure	Basic Plan; PC continuous box girder bridge (Span length =110m)	Alternative-1; PC continuous box girder bridge (span length = 80m)	Alternative-2; PC continuous box girder bridge (span length = 70m)
Structural Style **Span (m)** **Number of Pier (Nos)**	• Continuous box girder bridge • 50+90+12@110+90+50 = 1600 m • 15	• Same as the left • 2@60+17@80+2@60 =1600 m • 20	• Same as the left. • 2@50+20@70+2@50 = 1600 m • 23
■ Structural Outlines	• Structure type is standard PC bridge proposed by SAPROF • Rigid frame combined PC box girder and RC pier • Movable support at the side span for reducing the section force by the temperature, shrinkage and creep of concrete	• Same as the left • Same as the left • Same as the left	• Same as the left • Same as the left • Same as the left
■ Structural Characteristic	• Rigid frame is good for earthquake resistance • Little influence for the structure by the creeping displacement of girder, because of the precast segment ♦ Evaluation; A	• Same as the left • Same as the left ♦ Evaluation; A	• Same as the left • Same as the left ♦ Evaluation; A
■ Aesthetics Monument Effect	• Match with the horizontal line of the box girder and the water surface of the Mekong River • Making rhythm by the changing height of box girder • No characteristic; PC continuous girder is orthodox ♦ Evaluation; A	• Same as the left • Same as the left. ♦ Evaluation; A	• Same as the left • Same as the left. ♦ Evaluation; A
■ Outlines of Erection Method	• Precast segment will be made in the casting yard • No influence to the River water level, because of the segment erection work using the erection girder	• Same as the left • Same as the left	• Same as the left • Same as the left
■ Saving of Labor and Period in Construction	• Systematic segment making with precast segment method • Speedy execution is possible at segment erection • Easy construction management without weather influence for the temporary girder work • Concentrated control is possible by separation of production and erection of girder • Few transport of materials to the erection point ♦ Evaluation; A	• Same as the left • Same as the left • Same as the left • Same as the left • Same as the left ♦ Evaluation; A	• Same as the left • Same as the left • Same as the left • Same as the left • Same as the left ♦ Evaluation; A
■ Maintenance	• Getting high quality concrete • Required maintenance is a minimum and easy to do. ♦ Evaluation; A	• Same as the left • Same as the left. ♦ Evaluation; A	• Same as the left • Same as the left. ♦ Evaluation; A
■ Navigation	• Number of main navigation channel is one. ♦ Evaluation; A	• Same as the left. ♦ Evaluation; A	• It is difficult to secure the navigation channel during the dry season. ♦ Evaluation; C
■ Construction Quantities **Concrete(m^3)** **Re bar (t)** **PC steel (t)** **Pile (m)**	Superstructure / Substructure 20,000 / 15,000 2,400 / 2,900 1,300 / / 1,940	Superstructure / Substructure 17,000 / 18,400 2,000 / 3,200 1,100 / / 1,810	Superstructure / Substructure 16,500 / 20,200 1,900 / 3,500 1,050 / / 1,990
■ Construction Cost	• (100%) ♦ Evaluation; B	• Construction Cost is the lowest.(95%) ♦ Evaluation; A	• (98%) ♦ Evaluation; B
■ Overall Evaluation	♦ Total Evaluation; B	¨ **Total Evaluation; A**	♦ Total Evaluation; C

Table 5.2.3 Evaluation of Bridge Type with Varying Depth Girder and PC Sail Type

Bridge Structure	Alternative 3; PC continuous box varying depth girder bridge with two main navigation channels	Alternative 4; PC sail type continuous box girder bridge with two main navigation channels
Structural Style **Span (m)**	• Continuous box varying depth girder bridge • 60+4@80+2@110+5@80+2@110+4@ 80+60 = 1600 m	• Continuos box girder bridge + PC sail type at two locations. • Same as the left.
■ Structural Outlines	• Structure type of PC box non-constant girder PC bridge was proposed by SAPROF • Rigid frame combination of PC box girder with RC pier • Movable support at the side span for reducing the section force by temperature, shrinkage and creep of concrete	• PC sail type concrete wall in center-span with continuous box girder bridge. • Same as the left • PC sail uses the cable cability by putting the out-cable in the supporting point of the PC continuous box girder bridge out of the girder with large eccentricity
■ Structural Characteristic	• Rigid frame is good for earthquake resistance • Little influence of creeping to girder displacement because of the precast segment ◆ Evaluation; A	• Same as the left • Tower height of PC sail bridge is lower than that of a cable stayed bridge. Therefore stress variation of PC cable is smaller than that of cable stayed structure. No need of excellent anchor against fatigue strength ◆ Evaluation; A
■ Aesthetics Monument Effect	• Match with the horizontal line of the box girder and the water surface of the Mekong River • Making rhythm by the changing section of box girder • No characteristic; PC continuous girder is orthodox ◆ Evaluation; B	• Same as the left • Two PC sails and tower make the total appearance and monumental effect. ◆ Evaluation; A
■ Outlines of Erection Method	• Precast segment will be made in the casting yard • No influence to the River water level, because of the segment erection work using the erection girder	• Same as the left • Same as the left
■ Saving of Labor and Period in Construction	• Systematic segment making with precast segment method • Speedy execution is possible by the segment erection • Easy construction management without weather influence for the temporary girder work • Concentrated control is possible by the separation of production and erection of girder • Few transport of materials to the erection point ◆ Evaluation; A	• Same as the left • Same as the left • Same as the left • Same as the left • Same as the left ◆ Evaluation; A
■ Maintenance	• Getting high quality concrete • Maintenance required is a minimum and easy to do. ◆ Evaluation; A	• Same as the left • Same as the left. ◆ Evaluation; A
■ Navigation	• Number of main navigation channel is two. ◆ Evaluation; A	• Same as the left. ◆ Evaluation; A
■ Construction Quantities **Concrete(m^3)** **Re bar (t)** **PC steel (t)** **Pile (m)**	Superstructure: 17,500 / 2,060 / 1,110 Substructure: 18,300 / 3,600 / 1,810	Superstructure: 18,000 / 2,160 / 1,130 Substructure: 17,500 / 3,100 / 1,800
■ Construction Cost	• Construction Cost is same as Basic Plan (99%) ◆ Evaluation; A	• Construction cost is same as Basic Plan (98%) ◆ Evaluation; A
■ Overall Evaluation	◆ Total Evaluation; B	¨ **Total Evaluation; A** • **Construction cost is same as the Alternative-3.** • **Superior from the total appearance and Monumental effect.**

The girder depth of 4.0m is employed by aiming at a ratio of 1/20 of the span length of 80m. The girder depth was also determined with regard to the effective section properties against the applied section forces.

The cross section for the PC sail type bridge is shown in Figure 5.2.2.
For the PC sail type bridge the total width is to be widened for the main tower and the wall. The total width is widened from 12.0m to 13.9m. Therefore, shifting of the edge of the superstructure in the transverse direction is 0.95m.

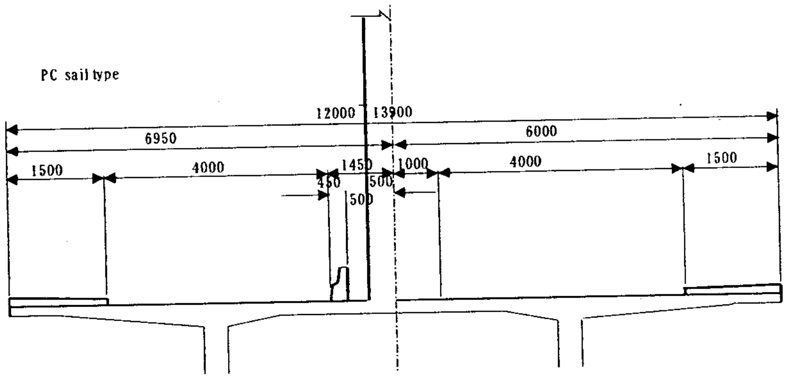


Figure 5.2.2 Cross-Section for PC Sail Type Attachment Part

The standard shift length for the widening corresponds to a design speed of 80 km/h is 80m under the Thai standard and 85m under the Japanese. In consideration of the traffic safety, the Japanese Standard is used rather than the Thai standard. To avoid a collision with the concrete wall, flexible poles are installed at the front and back of the wall. (Refer to Figure 5.2.3)

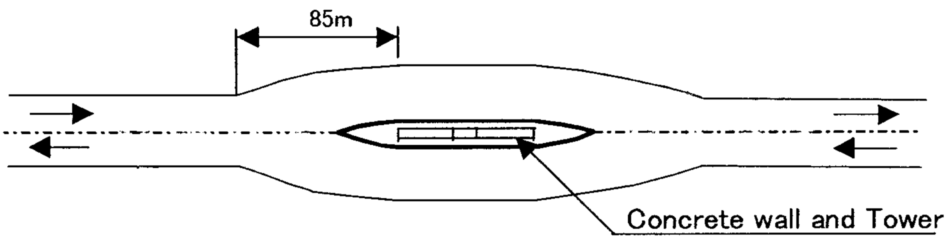


Figure 5.2.3 Collision Prevention Measures

(4) Substructure of the Main Bridge

1) Selection of the foundation type

For the Main Bridge, a comparative study for 3 foundation types was carried out. The study was carried out taking as a sample the foundation of the main tower of the PC sail bridge.

-Plan No.1 : Pile foundation

-Plan No.2 : Direct foundation

On these foundation types, a structural calculation was done to decide on the size of footing and the number of piles. One foundation type was selected after investigating the economic efficiency, construction efficiency and structural efficiency.

2) Basic Design

In this Bridge, it is designed to use piles due to the riverbed structure and the water depth.

- The underside of the pile cap will be constructed so that it is located 1.0m above the low water level. (LWL)

- The foundation type will be a piled foundation. The soil (sand layer etc) above the rock foundation has the possibility of scouring and, therefore, it will not be considered in the design.

- The pile protrusion, pier and footing must be designed and considered for water pressure and seismic inertia force.

- The piles must be cast-in-site reinforced concrete piles, with an embedment into the rock stratum of 1m + 2D (D : pile diameter).

(5) Approach Viaduct

Approach viaducts, total length of 200m in the Lao PDR side and 250m in Thailand side, are requested in order to reduce adverse effect to local community because of too high embankment. The span length of 50m was used to harmonize with the Main Bridge structure.

The comparative evaluation result regarding the Bridge and the embankment is shown in Table 5.2.4.

Table 5.2.4 Comparison of Embankment and Bridge

	Embankment	PC box girder bridge	PC I-girder bridge
Structural type	· Soil structure. · Height; about 9m ~ 6m.	· PC continuous box girder bridge. · Span; 50m.	· PC composite simple I-girder bridge. · Span; 30m.
Structural characteristic	· Expected total settlement is 450 to 500mm.Consolidation is 270 to 320mm.Consolidation settlement(U=90%) time is 11 month. · There is possibility to be eroded in the rainy season and flood time.	· Foundation is pile foundation. Because of this, settlement does not occur. · The river water is possible at the flood.	· Same as the left. · Too many bearings. · Too many expansion joint. · Same as the left.
Construction	· The settlement control and soil material control are difficult.	· No problem.	· Same as the left.
Maintenance	· There is the possibility of differential settlement in level results in the reverse side of the abutment. · Maintenance control is difficult.	· No problem.	· Same as the left.
Aesthetics	· Being seen like a slightly elevated hill visibility is interrupted.	· The continuation nature of the span and girder side form of a main bridge are able to be secured due to PC box girder.	· The span is short and the whole view is inferior in comparison with PC box girder. · Side view of I-girder not so good.
Construction Cost	· Economic in comparison with a bridge.	· Not economic in comparison with embankment.	· Lower than PC box girder bridge, but embankment is still cheaper.
Overall evaluation	· There are many problems of settlement and also maintenance control. ◆Total Evaluation ; C	· No problem of subsidence · The whole view is good due to matching with main bridge. ◆Total Evaluation ; A	· The whole view is inferior. ◆Total Evaluation ; B

6) Riverbank Protection

The riverbank protection will be installed only to protect substructures of the Main Bridge.

(7) Construction Plan

Required construction materials, equipment, facilities, and construction conditions and schedule are described. All the construction planning is established to optimize the scale of construction to be undertaken as a package of contracts containing the construction of the Main Bridge, approach viaducts, approach roads, traffic changeover, border facilities and connecting roads.

The Study Team recommended the Project be divided into three construction packages according to work details below. Package 1 will be an International Package with one tenderer and two contracts, the one with the Lao PDR and the other with Thailand.

1) Package 1 (The Lao PDR and Thailand sides)
-Main Bridge and approaches
-Revetment work

2) Package 2 (The Lao PDR side)
-Connecting road from the national road Route 9 to the Lao PDR border facilities boundary.
-Border Control Facility

3) Package 3 (The Thailand side)
-Connecting road from the national highway Route No.212 to the Thailand border facilities boundary
-Border Control Facility

The construction schedule is based on an appropriate construction period considering site conditions that vary between a high and low water level, the size of the Project and other conditions at the construction site. The total construction period is estimated at 36 months.

1) As the construction work extends over 3 years, preparatory and temporary works, the foundation works of the Main Bridge and the initial casting of the superstructure segmental members will be in the first year.

2) The second year is for completion of the foundations, superstructure, approach viaducts, approach and connecting roads and border facilities works.

3) The third year is for superstructure completion, pavement, Border Control Facilities and accessories works.

The Lao PDR and Thailand requested that the completion of construction should be within year 2003 on condition to promote this Project to JBIC.

5.3 Allocation of Facilities

Allocation of facilities such as connecting roads, Border Control Facilities, approach roads, approach viaducts, traffic changeover facility and interchanges is as set at the Record of Discussion. (Refer to Figure 5.3.1)

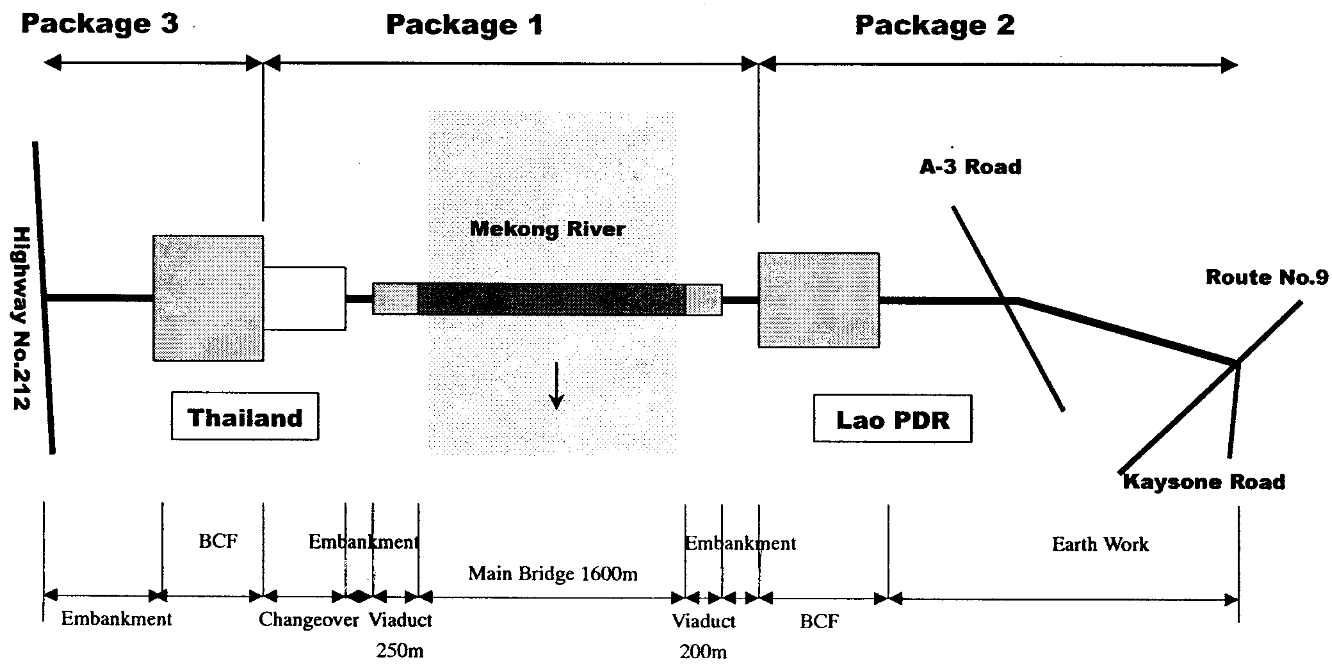


Figure 5.3.1 Allocation of facilities

Chapter 6. Border Control Facilities

6.1. Natural and Social Conditions:

(1) The Lao PDR – BCF

1) The Location and Area required

The Lao PDR Border Control Facility (BCF) will be located between 470 and 1,070 m from the Mekong riverbank and it is contained in an area of approximately 600 x 250m=150,000sq.m or 15 Hectares.

* The location has been determined in consideration of the same of other facilities e.g connecting road and approach road as well as the reasons of minimizing the volumes of the fills and cutting.

2) Topographic and Geological Conditions

From the geotechnical surveys, soft rock is located only 3m below the existing ground surface and, therefore, rock excavation will be required especially in the north- west side of the land. The land slopes generally upwards in the north direction.

3) Ground Formations

Approx. 149m above MSL

4) The Social Effects

The land consists of secondary forest and scrub areas and there is little or no crop cultivation within the BCF area. Only two dwellings on the north-west edge of the BCF area are affected together with one or two small huts. No relocation of people will be required.

5) Existing Facilities

There is an abandoned irrigation canal which runs through the site in the north-south direction and it is diverted along the marginal lines by the pipe culvert under the Project. An existing 22kV transmission line also runs through the site which is required to be re-routed before starting the construction works.

(2) The Thailand – BCF

1) The Location and Area required

The Thailand Border Control Facility (BCF) will be located 800 and 1200 m from the Mekong riverbank and from 500 to 900m from the National Highway Route No.212 and are contained in an area of 500m x 600m=300,000sq.m or 30 hectares.

* The location had been determined in consideration of the same of other facilities e.g. connecting road and traffic changeover as well as the reasons of minimizing the disturbances to the private property in the area.

2) Topographic and Geological Conditions

From the geotechnical surveys in the area the original ground lines varies between 137.5 and 142.5m above MSL. The ground or pavement area of the BCF will be set at approximately 144m above MSL in consideration of the adjacent roads levels so that only fill is required.

3) Ground Formations

Approx. 144m above MSL

4) Social Effects

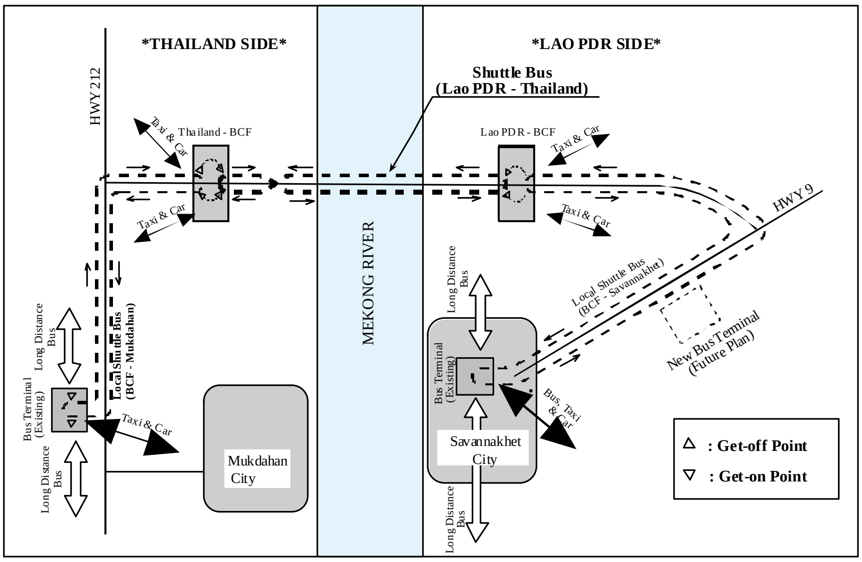
The land mostly consists of paddy fields and uncultivated area. Only 2 minor temporary houses in the BCF are affected together with one or two agricultural huts. Therefore, relocation of people will not be required. The construction site is also far from the highly populated areas.

5) Existing Facilities

Within the BCF area, there are no social or artificial issue which will affect construction.

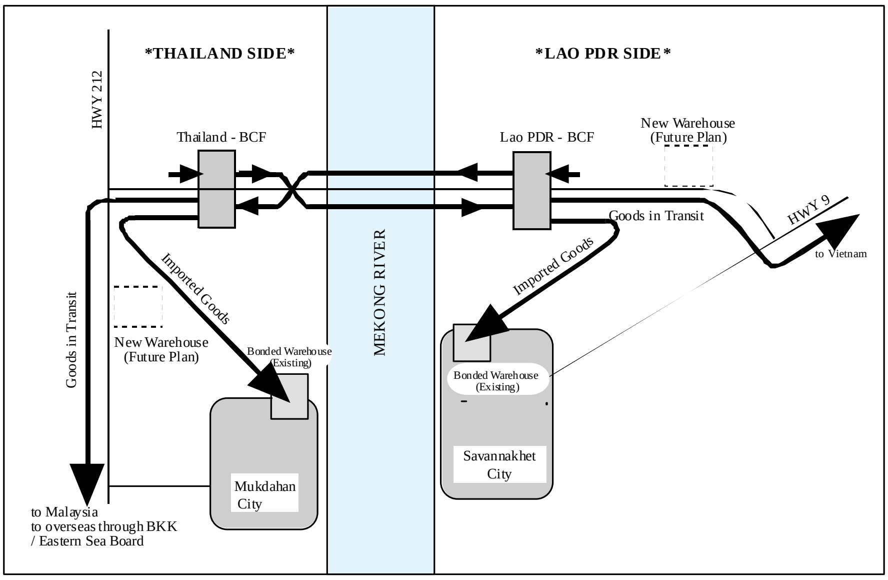
6.2 Cross Border Traffic System

Three modes of transports (Transfer type, Through type and Separated types) were proposed and the transfer type (use of cross border shuttle buses) had been unanimously accepted by both governments after in depth discussion. (Refer to Figure 6.2.1 and 6.2.2)



PASSENGER FLOW - CROSS BORDER SHUTTLE BUS (CBSB)

Figure 6.2.1 Passenger Flow – Cross Border Shuttle Bus (CBSB)



FLOW OF CROSS BORDER GOODS

Figure 6.2.2 Flow of Cross Border Goods

6.3 Design Condition

(1) General

1) Objectives

The purpose of construction of various facilities for the BCF are to inspect the cross border passengers, vehicles and goods before leaving and entering both the Lao PDR and Thailand.

2) The Buildings and Other Works to be involved

The following major works to be involved had been fully discussed and agreed with the appropriate authorities:

- Custom and Immigration Offices
- Public Toilets
- Inspection Booths
- Spacious Roof Structures
- Check Point and Gates
- Check and Toll Booths
- Officers' Parking Area with Carport
- Inspection Pit and Weighing Scales
- Vehicle Parking Areas
- Powerhouse for Diesel Generator and Electric Panels
- Earthworks
- Road within the BCF
- Storm Drainage System
- Marking and Signs
- Landscaping
- Incidental Utilities

3) Space and Area required

Various area in the BCFs necessary for the immigration formalities, custom clearance and waiting area have been determined on the basis of analyzed figure in the survey report of "SAPROF" (JBIC) and office floor area have been determined relative to the number of officials to be accommodated as requested by the Lao PDR and Thailand. (Lao PDR: 70, Thailand: 65 officials).

4) The Basic Flow of Formalities

The basic procedures for custom and immigration formalities by the shuttle bus passengers are to be made at the respective booths after getting out of the buses. Drivers arriving by cars do the same but they remain in their seat at a separate lane. Loaded and non-loaded trucks also do the same in another inspection area away from the normal formality areas.

5) Land Reclamation

The BCFs' sites will be set up to the same levels as the adjacent roads. The levels have been established in consideration of the surface water flow as well as the reasons for minimizing the ripping and fill volumes of the sites.

6) The Existing Facilities

There are an existing small irrigation canal and a 22kV transmission power line in the Lao BCF area and the former will be diverted by means of a new pipe culvert and the latter be re-routed before starting construction works.

7) Drainage Systems

The storm water from the roads and parking areas in the BCFs will be collected into the pipe culverts provided along side of the roads and discharged to the peripheral open culvert.

8) Security Provision

A two-meter high security fencing with barbed wire head will be provided to the perimeter of the BCFs with entrance gates and check point facilities at the connection with the approach and connecting roads.

9) Construction Materials

Considering the easy operation and maintenance of the facilities, a greater part of the construction materials will be designed and procured locally.

(2) Design of the BCF

1) The Type of BCF

Different kinds of traffic will arrive and leave the BCFs. The traffic is largely classified as follows:

- Shuttle buses (cross-border)
- Shuttle buses (local and public)
- Trucks and trailers (loaded and non-loaded)
- Tour buses (Inter- ASEAN)
- Private cars

The type of the BCF may be categorized into two types i.e. separate type (cargoes/ passengers) and Integrated (cargoes + passengers combined). The former may be employed in case suficient land is available and sizeable cargo and passenger traffic are required to cross the border smoothly. The latter has been proposed and accepted by both governments for minimization of operation and maintenance costs as well as the reason of comparatively minor traffic demand.

2) Flow of Traffic

The BCFs have been designed to allow various traffic to make smooth entry and exit formalities after in depth discussion with the appropriate authorities.

(3) Civil Works

As it is mentioned in the previous sections the BCFs need various civil works e.g. earthwork for construction of BCFs' sites, drainage system for storm water, pavement of roads and car parkings, security provision for boundary lines and treatment of the existing facilities.

(4) Building Works

All building facilities in the BCF will be designed in conformity with the following considerations:

1) Laws and Codes

The requirements of local and other applicable international building laws and codes will be conformed.

2) Floor Area

The building floor areas have been determined to have an appropriate floor area to accommodate the number of officials required by both Governments as shown in Table 6.3.1.

Table 6.3.1 Number of Officials required for BCFs

Main Offices	Lao PDR BCF	Thailand BCF
Custom	20	20
Immigration	30	30 + 10
Quarantine	5	5
O/M	15 (bridge operation)	-
Total	70	65

3) Structural Considerations

The buildings except for the spacious roof are designed to have structural concrete frameworks with masonry concrete block partition walls while the large spacious roof frame is designed to be a fabricated structural steel roof trusses supported by reinforced concrete columns.

In the Thailand BCF, most buildings are required to provide precast concrete piles, 32cm x 32cm x 18m long, to their foundations due to the existing loose substrata in the area as read from the geological investigation results.

4) Construction Materials

For easy maintenance of the buildings, a greater part of construction and finish materials will be designed and procured locally.

5) Meteorology Considerations

For design of all facilities, various meteorological factors will be taken into consideration. The major items to be considered are as follows:

- Air Temperature
- Precipitation and Rainfall Intensity
- Humidity
- Wind Velocity
- Seismic Coefficient

6.4 UTILITIES

(1) Utility Plan of the BCF – the Lao PDR

The facilities which will be installed in the Lao PDR side BCF are described in the following chapter.

1) Power Supply System

The BCF receives the electric supply from EDL's (Electricite du Laos) transmission line (T/L) and distributes to the each facility that require the power supply. The emergency diesel generator system (DG) will be installed in the power house for protection of the commercial power interruption.

(Power supply system data)

- Rated Voltage : 22kV
- Phase : 3 (three)
- Frequency : 50 Hz

2) Outdoor lighting system

The outdoor lighting system will be installed on the outside of the buildings. The lamp type is generally a HID sodium lamp fixture.

3) Water Supply System

The water supply system is used only for toilets and washing up. The city water from the water purification plant in Savannakhet will be received at the receiving tank.

4) Wastewater Drainage System

The wastewater from the toilets and others will be treated with septic tanks.

5) Building Electric System

The major electric work items to be involved are as follows:

(a) Lighting System
(b) Power Outlet System
(c) Public Announcing System
(d) Private Telephone System
(e) TV System (outlet and wiring only, exclude antenna)
(f) Computer System (outlet and wiring only)

(g) Lightning Protection System
(h) Grounding System

6) Building Mechanical System

The major mechanical work items to be involved are as follows:

(a) Air-conditioning and Ventilating System
(b) Water supply and Waste Water Drainage Systems
(c) Fire Fighting Systems (fire extinguishuers, fire hydrant systems in the Lao PDR BCF only)

(2) Utility Plan of the BCF – Thailand

The facilities which will be installed in the Thailand side BCF is described in the following paragraph.

1) Power Supply System

The BCF receives the electric supply from PEA's (Provincial Electricity Authority) transmission line (T/L) and distributes to the each facility that require the power supply. The emergency diesel generator system (DG) will be installed in the power house for protection of the commercial power interruption.

(Power supply system data)

- Rated Voltage : 22kV
- Phase : 3 (three)
- Frequency : 50 Hz

2) Outdoor lighting system

The outdoor lighting system will be installed on the outside of the buildings. The lamp type is generally a HID sodium lamp fixture.

3) Water Supply System

The water supply system is used for only toilets and washing up. The ground water from wells will be pumped into a receiving tank.

4) Wastewater Drainage System

The wastewater from toilets and others will be treated by the septic tanks.

5) Building Electric System

(a) Lighting System
(b) Power Outlet System
(c) Public Announcing System
(d) Private Telephone System
(e) TV System
(f) Computer System (outlet and wiring only)

(g) Lightning Protection System
(h) Grounding System

6) Building Mechanical System

(a) Air-conditioning and Ventilating System
(b).Fire Fighting System
(c) Fire extinguishers

Chapter 7. Relocation /Resettlement Plan

This chapter describes the system of land and property acquisition in each country. Criteria to evaluate compensation are assessed while notification, negotiation and grievance issues are discussed. Since the negligible number of dwellings are encountered on the Project alignment, resettlement of people will not be required on the Lao PDR and the Thailand sides.

Chapter 8. Environment

The structure of the environmental agency in each country is discussed and outlined. The present condition of the natural environment is dealt with in details and the socio-economic environmental issues considered in accordance with the guidelines of both the JICA and the OECF.

1) EIA not Requested

- Environmental Impact Assesment is confirmed as not required for this particular project on basis of laws and regulations of both the Lao PDR and Thailand.

2) Initial Environmental Examination

- Environmental study was carried out according to requirements of both the JICA and the OECF.

- Initial Environmental Examination of this project showed little influence; all of which can be minimized by appropriate mitigation measures as shown in Table 8.1.

3) Further Environmental Study

- Further study will be conducted in accordance with guidelines of both JICA and the OECF on air quality, water quality, aquatic life and social environment to obtain basic data for further investigation.

Table 8.1 Overall Environment Evaluation and Mitigation Measures

Items			Precondition	Impact without measures	Mitigation measures	Evaluation
Construction period	1)	Resettlement	Resettlement will be minimal	+	-	+
	2)	Land use	Resettlement will be minimal	+	-	+
	3)	Water supply system	Discharging sediment during piling activity	++	Adoption of steel stand piping method	+
	4)	Land transportation	Increment of construction traffic on local road	+++	Construction of access road and preparation of traffic management	++
	5)	Local navigation	The project sites is far from the public local navigation route	+	-	+
	6)	Fishery	There are no professional fisheries	+	-	+
	7)	Public health	Risk of diseases in labor camp	++	Ensuring proper sewege treatment and disposal etc.	+
	8)	Cultural assets	There are no significant cultural assets in and around the Project sites	-	-	-
	9)	Soil erosion	Earth work of the connecting road	+++	Installation of sediment collection ponds	++
	10)	Water contamination	Arising from the sediment discharge in piling activity.	+++	Adoption of steel stand piping method	++
	11)	Air pollution	Impact of dust fall to some villages located near the construction site	+++	dust reduction measure	++
	12)	Noise/Vibration	Impact of noise/vibration to some village located near the construction site	+++	limitation of piling driving work in daylight hours	++
Operational period	1)	Community severance	The Bridge and connecting road will intefere with traffic on the dominant local roads.	++	construction of underpass for human use	+
	2)	Landscape	The part of connecting road might be visible from surrounding villages and temples.	+++	replantation	++
	3)	Land transportation	The connecting road will connect with national road in both countries; there is no affect on local traffic conditions	+	-	+
	4)	Flora/Fauna/Eco-system	No reserved forest, wildlife sanctuary, national park or nationally declared siginificant conservation area in the Project sites	++	-	++
	5)	Aquatic life	The Bridge piers will not restrict fishes to migrate	++	-	++
	6)	Changes in water flow conditions	The total cross-sectional area of the Bridge is estimated as small.	+	-	+
	7)	Air pollution/Noise/ Vibrations	The estimated traffic volume level is low.	++	-	++

Note:

++++ : Significant
+++ : Moderate
++ : Minor
\+ : Insignificant
\- : None

Chapter 9 Public Relations & Technology Transfer

The issue of a good relationship with the public both during the design and at the construction stage is emphasized.

A technology transfer program is proposed with oversea training during the construction stage.

APPENDIX

CONTENS OF APPENDIX

PART III SPECIFICATIONS FOR CONCRETE BRIDES
CALCULATION METHOD OF CONCRETE BRIDGES

CHAPTER 2: GENERAL PROVISIONS OF DESIGN CALCULATION

2.1 DESIGN CALCULATION

2.1.1 Principles of Design Calculation

It is a general principle in design of members to confirm the safety by means of examination for stresses, strength, etc of all sections at both the service load working state and the ultimate load working state

The combinations of the loads for the service load working state and the ultimate load working state described in the above shall be as follows, respectively.

(1) The combinations of the loads for the service load working state shall be such combinations as specified in Article 2.2 in PART I: Common Specifications.

(2) The combinations of loads for the ultimate load working state shall be as follows.

1) 1.3D + 2.5 (L + I)

2) 1.0D + 2.5 (L + I)

3) 1.7 (D + L + I)

2.1.2 Calculation of the Stress Resultant

The stress resultant of the members shall be in principle calculated by the theory of elasticity. In this case, the gross concrete sections without the consideration of the steels can be applied to calculate the flexural, shear and torsional rigidity of the member.

2.2 MEMBERS SUBJECT TO FLEXURAL MOMENT AND AXIAL FORCES

2.2.1 Examination for Stresses and Safety to Failure of Sections

(1) The stress of concrete and steels at all sections of members in the service load working state shall not exceed the allowable stresses specified in chapter 3.

(2) The ultimate resistant bending moments specified in 2.2.4 at all sections of members shall not be less than the bending moment at the ultimate load working state.

2.2.3 Calculation of Stress at Cross Sections of Member

Concrete and steel stresses occurring at all sections of members shall be calculated in accordance with the following assumptions.

(1) Reinforced concrete member

1) Fiber strain is proportional to the distance from the neutral axis

2) Tensile strength in concrete is neglected.

3) Young's modulus ratio between reinforcement and concrete is 15.

(2) Prestressed concrete member

1) Fiber strain is proportional to the distance from the neutral axis.

2) All of the concrete area may be considered as an effective. However, the effective compression flange width specified in Article 2.2.2 shall be considered.

When the tensile stress calculated with all of the concrete area exceeds 30 kgf/cm^2, the area where tensile stress occurs shall preferable be neglected, instead of the assumption that all of the concrete area is effective.

3) Young's modulus ratio between prestressing steel and concrete is calculated by the value shown in Tables 3.3.1 and 3.3.3 of PART I: Common Specifications

(3) When members are subjected to flexural moment at longitudinal and transverse axis simultaneously the examination of stress may be carried out in consideration of such conditions.

2.2.4 Ultimate Resistant Bending Moment at a Cross Sections of a Member

(1) The ultimate resistant bending moment at a cross section of a member shall be calculatted in accordance with the following assumptions.

1) Fiber strain is proportional to the distance from the neutral axis.

2) Tensile stress of concrete is neglected.

3) Stress- strain relation ship of concrete may be utilized as given in fig 2.2.2. For the ultimate strain of concrete, the values as given in Table 2.2.2 shall be applied

4) Stress-strain relationship of steels may be utilized as given in Fig. 2.2.3, in principle.

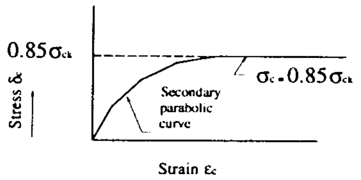


Fig. 2.2.2 Stress-strain curve of concrete .

Where, σ_{ck} : Specified compressive strength of concrete (kgf/cm^2)

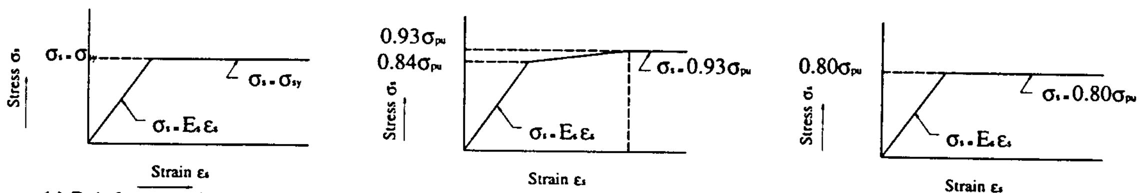
σ_c : Stress of concrete (kgf/cm^2)

ε_c : Strain of concrete

ε_{cu} : Ultimate strain of concrete

Table. 2.2.2 : Ultimate Strain of Concrete

Specified compressive strength of concrete σ_{CK} (kg f/cm^2)	$\sigma_{CK} \leq 500$	$500 < \sigma_{CK} < 600$	$600 \leq \sigma_{CK}$
Ultimate Strain εcu	0.0035	interpolated between 0.0035 and 0.0025	0.0025



(a) Reinforcement (b) Prestressing wire wire strand and bar No. 1 (c) Prestressing bar No. 2

Where, σ_{sy}: Specified yield stress of reinforcing bar (kgf/cm^2)

σ_{pu}: Specified tensile strength of prestressing tendon (kgf/cm^2)

σ_s, σ_p: Stress of steel (kgf/cm^2)

E_s, E_p: Young's modulus of steel (kgf/cm^2)

ε_s, ε_p: Strain of concrete

Fig. 2.2.3: Stress-strain of steel

(2) For a member subject to combined flexure and axial force, the ultimate resistant moment shall generally be calculated with considering the axial force which is acted at ultimate load working state and in accordance with the provisions in Article. (1).

2.3 MEMBERS SUBJECT TO SHEAR FORCES

2.3.1 Examination for Shear Forces

Examination for shear forces shall be carried out at both the service load working state and ultimate load working state in accordance with the following provisions.

(1) Service load working state

1) If the mean shear stress of concrete at the sections of member not exceed the values as given in table 2.3.1, shear reinforcement which is more than minimum reinforcement specified in Article 4.3.3 shall be placed.

Table 2.3.1: Mean shear stress can be bearded by concrete (kgf/cm^2)

Specified Compressive Strength	210	240	270	300	400	500	600
Average shear stress bearded by concrete	3.6	3.9	4.2	4.5	5.5	6.5	7.0

2) If the mean shear stress at the sections of members exceed the values as given in Table 2.3.1, shear reinforcement specified in Article 2.3.3 shall be placed

3) As for the prestressing concrete members, in addition to the examination specified in Article 1) and 2), it shall be confirmed that the diagonal tensile stress of concrete at sections not exceed the allowable diagonal tensile stress of concrete specified in table 3.3.3.

However, for the combinations of loads including earthquake loading, the diagonal tensile stress need not be examined.

4) The thin members in acting direction of shear force shall be examined as specified in below. However the shear reinforcements specified in Article 2.3.3 and article 4.3.(3) need not be placed.

(a) As for the reinforced concrete members, the mean shear stress of concrete at sections shall not exceed the values as shown in Table 2.3.1

(b) As for the prestressed concrete members, the diagonal tensile stress of concrete at sections shall not exceed the allowable diagonal tensile stress of concrete specified in table 3.3.3. However, for the combinations of loads including earthquake loading, the diagonal tensile stress need not be examined.

(2) Ultimate load working state

1) The mean shear stress of concrete at the sections of members shall not exceed the values as shown in table . 2.3.2

Table 2.3.2 limits of mean shear stress of concrete (kgf/cm^2)

Specified compressive strength	210	240	270	300	400	500	600
Limits mean shear stress of concrete	28	32	36	40	53	60	60

2) As for the thin prestressed concrete members subjected to shear force, the mean shear stress of concrete at sections shall not exceed the value obtained by multiplying the values specified in table 2.3.1 by K calculated from equation (2.3.1).

$$\left.\begin{aligned} k &= 1+\frac{M_o}{M_d} \\ but, k &\le 2 \end{aligned}\right\} \quad \text{.................................... (2.3.1)}$$

Where,

k : Increasing coefficient for mean shear stress bearded by concrete in prestressed concrete members.

M_d : Bending moment on sections at ultimate load working state (kgf cm)

M_o : Decompression moment which the fiber stress of concrete due to prestressing force and axial forces become 0. (kgf cm)

2.3.2 Calculations of Stress at Cross Sections of Member

The mean shear stress and the diagonal tensile stress of concrete at the sections of members shall be calculated from equations (2.3.2) and (2.3.3), respectively.

(1) Mean shear stress of concrete

$$\tau_m = \frac{S_h - S_p}{b_w.d}$$

(2) Diagonal tensile stress of concrete

$$\sigma_I = \frac{1}{2}(\sigma_x + \sigma_y) - \sqrt{(\sigma_x + \sigma_y)^2 + 4\tau^2}$$

$$\tau = \frac{(S - S_p).Q}{b_w.I}$$

Where, τ_m: Mean shear stress of concrete at the sections of a members (kgf/cm^2)

σ_I : Diagonal tensile stress of concrete at the sections of a member (kgf/cm^2)

τ: Shear stress of concrete at the sections of a member (kgf/cm^2)

σ_x: Longitudinal axial compressive stress (kgf/cm^2)

σ_y: Transverse axial compressive stress (kgf/cm^2)

S_h : Shear force with consideration of the effect of change in the effective depth of a member (kgf)

$$S_h = S - \frac{M}{d}(\tan\beta + \tan\gamma)$$

S_p : Component of prestressing force in the acting direction of the shear force (kgf)

For reinforced concrete member: $S_p = 0$

For prestressed concrete member: $S_p = A_p \cdot \sigma_{pe} \cdot \sin\alpha$

S : Shear force at the sections of a member (kgf)

M : Bending moment at the sections of a member (kgf cm)

d : Effective depth of the sections of a member (cm) (See Fig. 2.3.1)

b_w : Web thickness of the sections of a member (cm)

β : Angle between the extreme compressive fiber and member axis (See Fig. 2.3.1)

γ : Angle between tension steels and member axis (See Fig. 2.3.1)

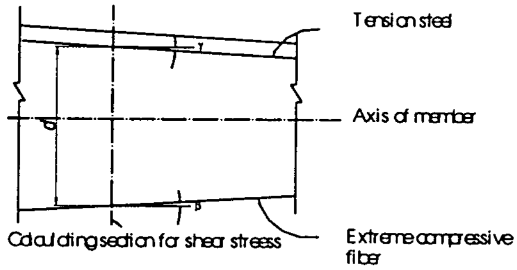
Q: Geometrical moment about the centroid axis which is enclosed extreme fiber and the fiber under consideration (cm^3)

I : Moment of inertia about the centroid axis of sections (cm^4)

A_p: Area of prestressing steels at the section of a member (cm^2)

σ_{pe}: Effective tensile stress of prestressing steel at the section of a member (kgf/cm^2)

α : Angle between prestressing steel and member axis



(Note) : β and γ are positive when the effective depth increases in compliance with the increase of the bending moment in absolute value, and negative when decreases.

Fig. 2.3.1: Description of β, γ and d

2.3.3 Shear Reinforcement

When the shear reinforcement is placed by the provisions of article 2.3.1, amount of shear reinforcement shall be calculated from the equation (2.3.4). However, calculated values for its shall not be less than the minimum reinforcement specified in Article 4.3 (3).

When the amount of shear reinforcement is calculated from equation (2.3.4), both service load working state and ultimate load working state shall be considered for a reinforced concrete members, and the ultimate load working state for a the prestressed concrete members respectively. As well, when both bent bars and stirrups are applied as shear reinforcement for reinforced concrete members, at least 50% of the shear force provided by shear reinforcement shall be carried by stirrups.

$$\left.\begin{aligned} A\omega &= \frac{1.15S'_h}{\sigma_s . d(\sin\theta + \cos\theta)} \\ S'_h &= S_h - S_p - S_c \end{aligned}\right\} \quad \text{............................ (2.3.4)}$$

Where,

A_ω: Required amount of shear reinforcement as placed at space "a" and angle to member axis "θ" (cm^2)

S'_h: Shear force carried by the shear reinforcement (kgf)

S_h: Design shear force in consideration of change in effective depth of member. (kgf)

$$S_h \quad = S' - \frac{M}{d}(\tan\beta + \tan\gamma)$$

S: Shear force acting at the sections of a members (kgf)

M: Bending moment acting at the sections of a members (kgfcm)

Sc: Shear force carried by concrete (kgf)

$$S_c = k.\tau_c.b_w d$$

$$but, k = 1 + \frac{Mo}{Md} \leq 2$$

Sp: Component of the prestressing force in the acting direction of shear force (kgf)

For reinforced concrete members: Sp =0

For prestressing concrete members: Sp = A_p. σ_{pe}. sin α

τ_c: Mean shear stress carried by concrete (See Table 2.3.1, kgf/cm^2)

However, this values shall not be increased depending on the combinations of loads. (provisions for the increment of the allowable stress as given in chapter 3 shall not be applied)

Md: = M (kgfcm)

Mo: Decompression moment which the fiber stress of concrete due to prestressing force and axial forces become 0 (kgf cm) d: Effective depth at the sections of members (cm)

a: Spacing of shear reinforcement in the member axis (cm)

θ: Angle between shear reinforcement and member axis

β: Angle between extreme compressive fiber and member axis (See Fig. 2.3.1)

γ: Angle between tension steel and member axis

α: Angle between prestressing steel and member axis

A_p: Area of prestressing steels at the section of member (cm^2)

σ_{pe}: Effective tensile stress of prestressing steels at the section of member (kgf/cm^2)

σ_s: Specified stress of shear reinforcement for each load working state (kgf/cm^2)

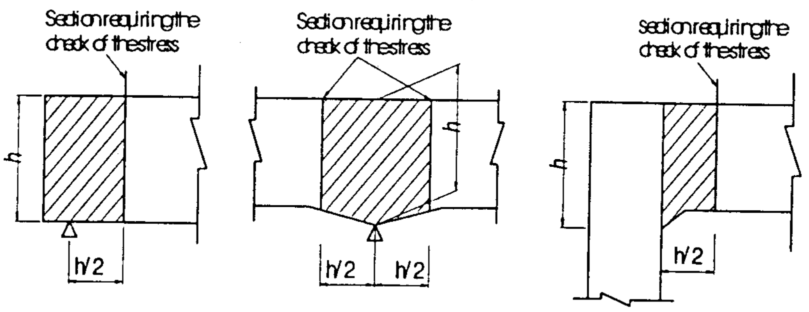
For service load working state: allowable stress (See table 3.2.3)

For ultimate load working state: specified yield strength.

2.3.4 Shear Design for Support of a Girder and Connection Parts of Rigid-Frame Structure

(1) The mean shear stress of concrete near supports of a girder of near connection parts of a rigid frame structures shall be examined at sections of a member shown in Fig. 2.3.2, in principle.

(2) The shear reinforcements placed in the sections near supports of a girder of connection parts of a rigid-frame structure (shaded-portion in Fig. 2.3.2) shall have the amount not less than the amount which is calculated for the section specified in Article. (1).



(a) Girder with constant depth (b) Girder with varied depth (c) Rigid-frame

Fig. 2.3.2: Sections to be examined for shear force

CHAPTER 3: ALLOWABLE STRESS

3.1 GENERAL

(1) The allowable stress to the stresses due to the principal loads and the particular loads corresponding to principal loads shall be the values specified in Article 3.2.1, 3.2.2 for reinforced concrete members and 3.3.1, 3.3.2, 3.3.3 for prestressed concrete members, respectively.

(2) When the subsidiary load and the particular load corresponding to the subsidiary load are taken into account, allowable stress shall be increased as multiplying the allowable stress specified in Article 3.2.1, 3.2.2, 3.3.1, 3.3.2 and 3.3.3 by the incremental coefficient given in Table 3.1.1 However, wind load or earthquake loading during construction is taken into account, the incremental coefficient shall specially be determined with consideration of the condition of construction site, the structural system under construction and so on, irrespective of the values given in Table 3.1.1.

(3) When the subsidiary load and the particular load corresponding to the subsidiary load are taken into account, allowable tensile stress of concrete for prestressed concrete members shall be the value specified in Article 3.3.4 , irrespective of Article (2).

(4) When the subsidiary load and the particular load corresponding to the subsidiary load are taken into account, allowable tensile stress of prestressing steels shall not be greater than 90% of the specified yield strength of prestressing steels.

(5) Allowable stress at transfer prestressing specified in Article 3.3.1 and 3.3.2 shall not be increased.

Table 3.1.1: Incremental coefficient for allowable stress

Combinations of loads	Incremental coefficient
(1) P + PP + T	1.15
(2) P + PP + W	1.25
(3) P + PP + T + W	1.35
(4) P + PP + Bk	1.25
(5) P + PP + CO	1.50
(6) P' + EQ	1.50
(7) W	1.20
(8) ER	1.25

Where,
P : Principal load
PP: Particular load corresponding to principal load
T : Thermal force
W : Wind load
BK: Breaking force

CO: Collision force
P' : Principal load excluding live load and impact
EQ: Earthquake force
ER: Temporary load during construction

3.2 ALLOWABLE STRESS FOR REINFORCED CONCRETE MEMBERS

3.2.1 Allowable Stress of Concrete

(1) Allowable compressive stress and punching shear stress of concrete shall be as given in Table 3.2.1, respectively. The allowable stress for the bi-axial moment working conditions shall be the values which is added 10kgf/cm^2 to the values given in Table 3.2.1

Table 3.2.1: Allowable compressive stress and punching shear stress of concrete (kgf/cm^2)

Kind of stress \ Specified compressive strength of concrete		210	240	270	300
Compressive stress	1) Flexural compressive stress	70	80	90	100
	2) Axial compressive stress	55	65	75	85
3) Punching shear stress		8.5	9.0	9.5	10.0

(2) Allowable bond stress of concrete shall be as given in Table 3.2.2 for reinforcing bars not greater than 32 mm in diameter.

Table 3.2.2 Allowable bond stress of concrete (kgf/cm^2).

Type of reinforcement \ Specified compressive strength of concrete	210	240	270	300
(1) Round bar	7.0	8.0	8.5	9.0
(2) Deformed bar	14.0	16.0	17.0	18.0

A_c: Total load distributed area of the surface of concrete on which the load is locally applied. (cm^2)

A_b: Loaded contact area of the surface of concrete on which the load is locally applied (cm^2).

σ_{ck}: Specified compressive strength of concrete (kgf/cm^2)

3.2.2 Allowable stress of reinforcement

Allowable stress of reinforcement shall be as given in Table 3.2.3 for reinforcing bars not greater than 32 mm in diameter.

Table 3.2.3: Allowable stress of reinforcement (kgf/cm^2)

Kind of stress or member \ Kind of reinforcement			SR 235	SD295 A SD295 B	SD345
Tensile stress	For loading combinations excluding collision force or earthquake force	1) for ordinary members	1400	1800	1800
		2) for deck slab and slab bridge with span length not greater than 10 m	1400	1400	1400
	3) Basic value for combination of loads including collision force or earthquake force		1400	1800	2000
	4) Basic value for calculating length of lap splice or development of reinforcement		1400	1800	2000
5) Compressive stress			1400	1800	2000

3.3 ALLOWABLE STRESS FOR PRESTRESSED CONCRETE MEMBERS

3.3.1 Allowable Stress of Concrete

(1) Allowable compressive stress of concrete shall be as given in Table 3.3.1

Table 3.3.1: Allowable compressive stress of concrete (kgf/cm^2)

Kind of stress \ Specified compressive strength of concrete			300	400	500	600
At transfer	Flexural compressive stress	1) for rectangular section	150	190	210	230
		2) for T or box section	140	180	200	220
	3) Axial compressive stress		110	145	160	170

Others	Flexural compressive stress	4) for rectangular section	120	150	170	190
		5) for T or box section	110	140	160	180
	6) Axial compressive stress		85	110	135	150

The allowable compressive stress for the members subjected to the bi-axial moment shall be added 10 kgf/cm^2 to the allowable stress of the rectangular section.

(2) Allowable tensile stress of concrete shall be as given in Table 3.3.2.

Table 3.3.2: Allowable tensile stress of concrete (kgf/cm^2)

Kind of stress \ Specified compressive strength of concrete			300	400	500	600
Flexural tensile	1) At transfer		12	15	18	20
	2) Principal loads excluding live load and impact		0	0	0	0
	Principal load and particular load to be regard as principal load	3) for deck slab or joint of pre-casted segmental bridge	0	0	0	0
		4) Others	12	15	18	20
	5) Axial tensile stress		0	0	0	0

(3) Allowable diagonal tensile stress of concrete shall be as give in Table 3.3.3.

Table 3.3.3: Allowable diagonal tensile stress of concrete (kgf/cm^2)

Kind of stress \ Specified compressive strength of concrete	300	400	500	600
1) Considering only shear force or torsional moment	8	10	12	13
2) Considering shear force and torsional moment simultaneously	11	13	15	16

(4) Allowable bond stress of concrete shall be as given in Table 3.3.4 for reinforcing bars not greater than 32 mm in diameter.

Table 3.3.4: Allowable bond stress of concrete (kgf/ cm^2)

Type of reinforcement \ Specified compressive strength of concrete	300	400	500	600
1) Round bar	9	10	10	10
2) Deformed bar	18	20	20	20

(5) Allowable bearing stress shall be as specified in Article 3.2.1 (3).

3.3.2 Allowable Stress of Prestressing Steels

Allowable tensile stress of prestressing steel shall be as given in Table 3.3.5

Table 3.3.5: Allowable tensile stress of prestressing steel

Condition of stress	Allowable tensile stresses	Note
During prestressing	$0.8\sigma_{pu}$ or $0.9\sigma_{py}$, whichever is smaller	σ_{pu}: Specified tensile strength of prestressing steels (kgf/mm^2) σ_{py},: Specified yield strength of prestressing steels (kgf/mm^2)
At transfer	0.7 σ_{pu} or 0.85 σ_{py}, whichever is smaller	
Service load working state	0.6 σ_{pu} or 0.75 σ_{py}, whichever is smaller	

3.3.3 Allowable Stress of Reinforcement

Allowable stress of reinforcement shall conform to Article 3.3.2.

CHAPTER 4: STRUCTURAL DETAILS

4.1 APPLICATION

This chapter shall be applied to the general structural details for the design of concrete bridges.

4.3 MINIMUM AMOUNT OF STEEL

(1) At any section, bonded steel of 0.15 % or more of the area of the member shall be placed in principle.

(2) The area of axial tensile primary reinforcements placed in reinforced concrete members shall not be less than the value calculated from equation (4.3.1).

1) Girder $A_{st} \geq 0.005\ b_w.\ d$.........................(4.3.1)

2) Member in which diagonal tension reinforcements cannot be placed because of thin thickness in acting direction of shear force.

$A_{st} = 0.01\ b_w.d$.......................................(4.3.1)

Where, A_{st}: Amount of axial tensile primary reinforcements (cm^2)

b_w: Web thickness of the beam (cm)

d: Effective depth of the beam (cm)

However, if the amount of reinforcement is placed greater than 4/3 of the required amount of reinforcement in girder, provision of Article (2).1) shall not be applied.

(3) The minimum shear reinforcement for girders shall be as follows

Deformed bars applied: $A_w \geq 0.002.\ b_w.a.\ \sin\theta$
Round bars applied: $A_w \geq 0.003\ .\ b_w\ .\ a\ .\ \sin\theta$ ....(4.3.2)

Where: A_w: The required minimum amount of shear reinforcement as placed at space "a" and angle to member axis "θ" (cm^2)

b_w: Web thickness of girder (cm)

a: Space of shear reinforcement in member axis (cm)

θ: Angle between shear reinforcement and member axis

4.4 ARRANGEMENT OF STEELS

4.4.1 Concrete Cover

(1) The concrete cover for steels shall be greater than the value given in Table 4.4.1.

(2) The concrete cover for reinforcements shall be under the Article (1) and also be greater than the diameter.

Table 4.4.1: Minimum concrete cover (cm)

Kind of member / Environmental condition	Slab, Curb, Railing slab bridge with span length less than 10m	Girder	
		Precast members produced in factory	Other members and bridge
Minimum concrete cover	3	2.5	3.5

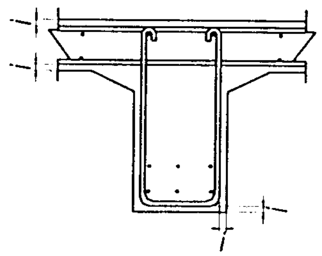


Fig. 4.4.1: concrete cover "i"

4.4.5 Splices of Reinforcement

(1) Proper splices of reinforcement shall be selected in consideration of such factors as kind and diameter of reinforcements, stress condition, locations of splices, etc.

Location of splice and method of splice shall be shown in drawings, in principle.

(2) The location of splices shall not be concentrated in principles at the same cross section. Location of splices shall preferably avoid at a section subjected to high stresses.

(3) When the lap splice is applied to the tension reinforcements, the reinforcement shall be lapped greater than the calculated length (la) from equation (4.4.1) or 20 times not modified of reinforcement in diameter. Lap splices shall be strengthen by two or more reinforcements which is placed perpendicular to the splices.

$$l_a = \frac{\sigma_{sa}}{4\tau_{oa}}\phi \text{.................}(4.4.1)$$

Where, la: lap splice length determined by bond strength (cm)

σ_{sa}: allowable tensile stress of reinforcement (kgf/cm^2)

τ_{oa}: allowable bond stress of concrete (kgf/cm^2)

ϕ: diameter of reinforcement (cm)

(4) When the lap splice is applied to the compression reinforcements, the reinforcement shall be lapped greater than the 80 percent of the calculated length (la) from equation (4.4.1) or 20 times not modified of reinforcements.

(5) When the lap splice is applied to the round bars, semicircular hook shall be provided at that end.

(6) When the control is carried out enoughly, gas-pressure welding joint can be applied as a splice.

(7) When mechanical splice, sleeve splice and welded splice, etc. are applied to tension reinforcements, the strength of the splice parts shall be determined in consideration of the kind and diameter of bars, stress conditions, location of splices, etc.

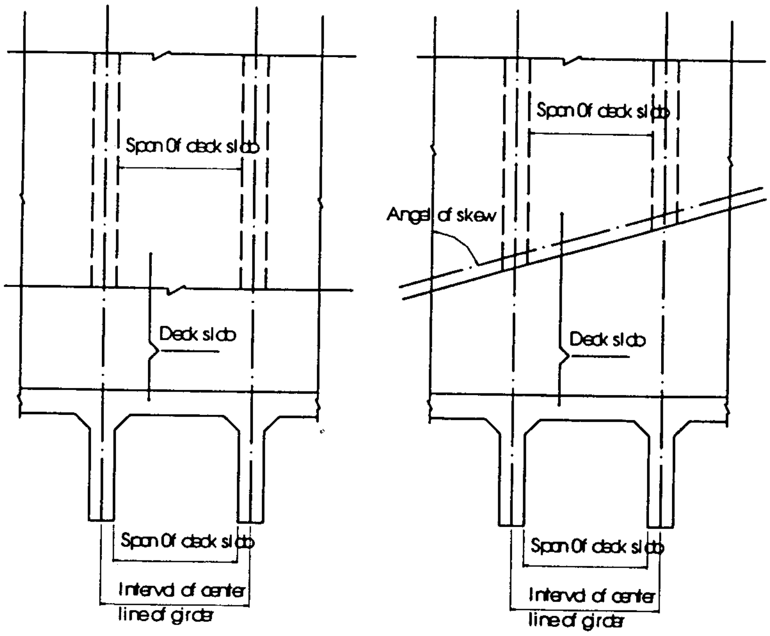
CHAPTER 5: DECK SLAB

5.1 APPLICATION

This provisions shall be applied to the design of a reinforced or prestressed concrete deck slab supported by concrete girders, whose ratio of the longer span to shorter span is not less than two.

5.3 SPAN LENGTH OF DECK SLAB

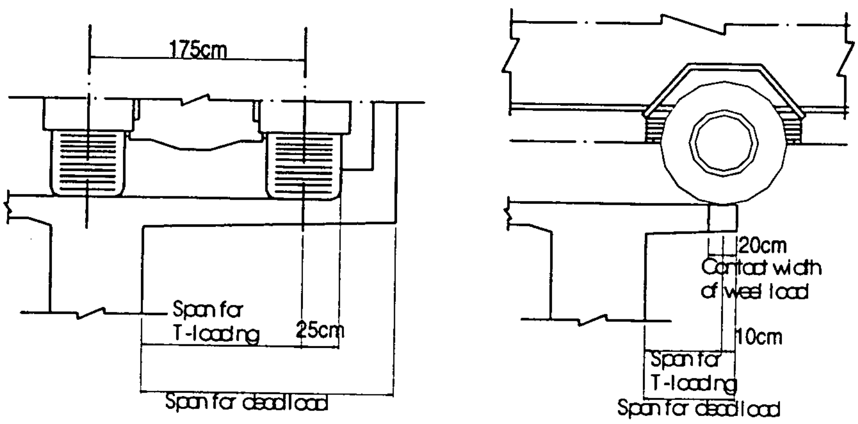
(1) Span length for dead load and T loading on simply or continuously supported deck slabs shall be as shown in Fig.5.3.1



(a) Right Bridge (b) Skewed Bridge

Fig. 5.3.1: Span length for simply or continuously supported bridge

(2) Span length for dead load and T loading on cantilever deck slab shall be shown in Fig. 5.3.2



(a) Perpendicular to the vehicle running direction. (b) Parallel to the vehicle running direction.

Fig. 5.3.2 Span length for cantilever deck slab

5.4 MINIMUM THICKNESS OF DECK SLAB

Table 5.4.1: Minimum thickness of Deck Slab at Roadway (cm)

Direction of span in deck slab (see note) / Kind of deck slab		Perpendicular to the vehicle running direction	Parallel to the vehicle running direction
Simply supported slab		$4\iota + 11$	$6.5\iota + 13$
Continuously supported slab		$3\iota + 11$	$5\iota + 13$
Cantilever slab	$\iota \leq 0.25$	$28\iota + 16$	$24\iota + 13$
	$\iota > 0.25$	$8\iota + 21$	

Where, ι: Span length of deck slab for T loading specified in Article 5.3. (m)

5.4.2 Presstressed Concrete Deck Slab

(1) The thickness of a deck slab in the roadway shall be as specified in below.

1) The thickness of a deck slab in the roadway shall not be less than 16 cm any region.

2) The thickness of cantilever deck slab at the free end shall be as specified in Article 1) and also not less than 50% of the minimum thickness of the cantilever deck slab given in Table 5.4.1.

3) When prestressing are applied to only in one direction of the deck slab, the minimum thickness of the deck slab in the roadway shall be as specified in Article 1) and Article 2) and also as given in Table 5.4.2. The minimum thickness for a cantilever deck slab is defined as the thikness at the web side of the main girder.

Table 5.4.2: Minimum thickness of deck slab in roadway with Prestress applied to only in one direction (cm)

Direction of span (see note) / Direction of prestressing	Perpendicular to the vehicle running direction	Parallel to the vehicle running direction
Parallel to the direction of the span of deck slab	90% of the value in Table 5.4.1 applied that the direction of the span in deck slab is perpendicular to the vehicle running direction	65% of the value in Table 5.4.1 applied that the direction of the span in deck slab is parallel to the vehicle running direction
Perpendicular to the direction of the span of deck slab	The value in Table 5.4.1 applied that the direction of the span in deck slab is perpendicular to the vehicle running direction	The value in Table 5.4.1 applied that the direction of the span in deck slab is parallel to the vehicle running direction.

5.5 DESIGN BENDING MOMENTS AND EXAMINATION OF STRESSES FOR DECK SLAB

5.5.1 Design Bending Moments for Deck Slab

(1) In designed by B-live loading, design bending moment per unit width (1m) for deck slab due to T-loading (included impact) shall be calculated from the equations given in Table 5.5.1

For simply supported deck slab, continuously supported deck slab and cantilever deck slab with direction of span which is perpendicular to the vehicle running direction, the design bending moment in the span direction shall be the calculated values from the equation as given in Table 5.5.1 multiplied by the increment coefficient given in Table 5.5.2 and Table 5.5.3.

(2) In designed by A live loading, design bending moment for deck slab may be reduced 20 percent from the values which is calculated form the equations given in Table 5.5.1

Table 5.5.1: Design bending moments per unit width (1m) for deck slab due to T-loading (including impact)

(kgfm/m)

Type of deck slab	bending moment	Structures	Direction of span in deck slab (see Note) / Direction of bending moment / Application	Perpendicular to the vehicle running direction: Direction of span	Perpendicular to the vehicle running direction: Direction perpendicular to span	Parallel to the vehicle running direction: Direction of span	Parallel to the vehicle running direction: Direction perpendicular to span
Simply supported deck slab	Bending moment in span	RC	0≤ ι ≤4	+ (0.12ι + 0.07) P	+ (0.10ι + 0.04)P	+ (0.22ι + 0.08)P	+ (0.06ι + 0.06)P
		PC	0≤ ι ≤6				
Continuously supported deck slab	Bending moment in span	RC	0≤ ι ≤4	+(80% of simply supported deck slab)	+ (80% of simply supported deck slab)	+ (80% of simply supported deck slab)	+ (80% of simply supported deck slab)
		PC	0≤ ι ≤6				
	Bending moment at supports	RC	0≤ ι ≤4	- (0.15 ι + 0.125) P	-	- (80% of simply supported deck slab)	-
		PC	0≤ ι ≤6				
Cantilever deck slab	Bending moment at supports	RC	0≤ ι ≤1.5	$-\frac{P.}{1.30\,\iota + 0.25}$	-	_ (0.7 ι + 0.22)P	-
		PC	0≤ ι ≤1.5				
			1.5≤ ι ≤3.0	-(0.6 ι - 0.22)P			
	Bending moment near the free end	RC	0≤ ι ≤1.5	-	+ (0.15 ι + 0.13)P	-	+ (0.16ι + 0.07) P
		PC	0≤ ι ≤3.0				

Where,
- RC : Reinforced concrete slab
- PC: Prestressed concrete slab
- ι : Span length of deck slab for the T-Loading specified in Article 5.3. (m)
- P: One axle load of T-loading specified in Article 2.1.3 in PART I. 10,000 kgf)

Note: The direction of the span in deck slab is accordance to Fig. 5.4.1.

Table 5.5.2: Increment coefficient for bending moment in the span direction at simply or continuously supported deck slab with span direction perpendicular to vehicle running direction.

Span length: ι (m)	ι≤ 2.5	2.5 < ι≤ 4.0	4.0 < ι≤ 6.0
Increment coefficient	1.0	1.0 + (ι- 2.5) / 12	1.125 + (ι- 4.0) / 26

Table 5.5.3: Increment coefficient for longitudinal bending moment in cantilever deck slab with span direction perpendicular to vehicle running direction

Span length: ι (m)	$\iota \leq 1.5$	$1.5 < \iota \leq 3.0$
Increment coefficient	1.0	$1.0 + (\iota - 1.5) / 25$

(3) Design bending moments per unit width (1m) for deck slab due to the uniform dead load shall be calculated from the equations given in Table 5.5.4 in principle.

Table 5.5.4: Design bending moments for deck slab per unit width (1m) due to uniform dead load

(kgfm/m)

Type of deck slab	Kind of bending moment	Bending moment in the direction of span for deck slab	Bending moment in the direction perpendicular to the direction of span for deck slab
Simply supported deck slab	Bending moment in span	$+\frac{\omega l_d^2}{8}$	May be ignored
Cantilever deck-slab	Bending moment at supports	$-\frac{\omega l_d^2}{2}$	
Continuously supported deck slab	Bending moment in span	$+\frac{\omega l_d^2}{10}$	
	Bending moment at supports	$-\frac{\omega l_d^2}{10}$	

Where, ω: Uniform dead load (kgf/m^2)

ι_d: Span length of deck slab of dead load specified in Article 5.3. (m)

(4) Design bending moment due to the thrust for railing and collision force for traffic guard railings shall be calculated in accordance with Article 4.2.1 and Article 4.2.2 specified in Part I. Common Specifications.

(5) When prestressing applied to deck slab, the redundant force statically in determinate forces due to the prestressing force shall be considered in principle. However, if the prestressing steels are arranged so as to become small redundant force, it can be ignored in design.

CHAPTER 8: BOX GIRDER BRIDGE

8.1 APPLICATION

This chapter shall be applied to the design of bridges with box shaped cross section

8.2 DESIGN GENERAL

(1) The cross beams and diaphragms shall be provided at the support of main girders.

(2) One or more intermediate cross beams and diaphragms shall be provided at the main girder in principle.

(3) Web thickness for the calculation of shear stress shall be thickness in direction of perpendicular to the web axis.

(4) When the box sections has a wide flange as compared with thickness of the web or the flange, examination for the horizontal shear force may be carried out at the connections between flange and web.

8.3 STRUCTURAL ANALYSIS

(1) The stress resultant for single cell or multi-cells box girder bridge can be analyzed by beam theory.

(2) Skew box girder bridges and multi-box girder bridges shall be analyzed by the grillage girder theory in principle.

8.4 DESIGN OF CROSS SECTIONS

(1) Stress resultant at the bottom flange and web may be analyzed by the assumptions as rigid frame structures which is consisted by web, top flange and bottom flange.

(2) Stress resultant at the bottom flange and web for the reversed trapezoidal box girder bridges and box girder bridges with stiffening ribs for deck slab shall be analyzed in consideration of the effects by the inclination web and being the stiffening ribs.

(3) 50 percent amount of web reinforcement for the bending moment in cross section can be utilized as the shear reinforcement of main girder.

8.5 DESIGN OF CROSS BEAMS AND DIAPHRAGMS

As for the design of cross beams and diaphragms at the support, the structural analysis model shall be assumed in compliance with the support conditions and connected conditions of members. And stress resultant may be analyzed by beam theory.

8.6 STRUCTURAL DETAILS

(1) Minimum thickness of bottom flange shall be 14 cm

(2) The reinforcing bars shall be placed not less than 13 mm in diameter and center-to-center distance less than 25 cm at the longitudinal direction of web and at the longitudinal and transverse direction of both upper and lower part of bottom flange.

(3) When the openings is provided, around of openings shall be reinforced.

CHAPTER 15: PRECAST SEGMENT BRIDGE

15.1 APPLICATION

This chapter shall be applied to the design of the bridges which is constructed by the segmental construction methods with epoxy resin adhesives at the joint of the segments.

15.2 CONCRETE

Specified compressive strength of concrete for the main girder of the precast segmental bridges shall be not less than 400kgf/cm^2, in principle.

15.3 DESIGN GENERAL

(1) In design of precast segment bridge, addition to the ordinary design procedures, the stress and resistance capacity at the joint of the segments shall be examined.

(2) Precast segments shall be examined the stress which is occurred during construction such as lift up, transportation and erection.

15.4 JOINTS DESIGN

15.4.1 Examination for Flexural Stress

(1) A joint of precast segments shall be designed so as to avoid the tensile flexural stress at the all stages, such as during construction and service load working state.

(2) A joint of precast segments shall be examined the stresses calculated by the equation (15.4.1). Allowable flexural tensile stress for this examination shall be 25kgf/cm^2 to the specified compressive strength at 400kgf/cm^2.

1) for girder : $\sigma_o + 1.7.\ \sigma_{L,g}$

2) for deck slab : $\sigma_0 + 1.7.\ \sigma_{L,S} + 0.5\sigma_{L,g}$

where, σ_o : Flexural tensile stress of concrete due to the principal load excluding the live load and the impact (kgf/cm^2)

$\sigma_{L,g}$: Flexural tensile stress of concrete at the main girder due to the live load (L-loading) and the impact (kgf/cm$_2$)

$\sigma_{L,s}$: Flexural ten sile stress of concrete at the deck slab due to the live load (T-loading)and the impact (kgf/cm$_2$)

15.4.2 Examination for Shear

(1) Examination for shear at a joint in the precast segment bridge shall be carried out at the construction stages and ultimate load working state.

Shear force acting on a shear keys shall be not exceed the shear resistance capacity of shear keys.

(2) Shear force at the joint of precast segment in the ultimate load working state may be calculated in consideration of the friction resistance force due to prestressing force.

15.4.3 Examination for Torsional Moment

(1) In design of the precast segment bridge subjected to the torsional moment, the shear force due to torsional moment at the shear keys shall be considered, in principle.

(2) A bonded longitudinal prestressing steels for the torsional moment shall be arranged at the joint of precast segment subjected to the torsional moment.

15.4.4 Design of Steel Shear Key

(1) A steel shear key shall be designed at the construction stages and ultimate load working state in consideration of its carrying capacity for the shear stress.

(2) A concrete bearing stress at the embedded parts of shear key shall be examined.

15.4.5 Design of Concrete Shear Key

(1) A trapezoidal concrete shear key shall be examined shear force at the construction stages and ultimate load working state and reinforcing steel bars shall be placed in order to carry the shear force.

(2) Joint surface of multiple shear key and wavy shear key shall be examined for the shear stresses at the construction stage and ultimate load working state.

15.5 STRUCTURAL DETAILS

(1) A joint surface of precast segment shall be provided at right angle to the member axis of main girder, in principle.

(2) The end of the precast segment and the area around the shear key shall be reinforced by the reinforcing steel bars such as reinforcements or vertical prestressing bars.

(3) A shear key at the joint of segment shall be the structures with a function which can be certainly connected with each segment and transmitted to the shear force between each segment.

(4) A shear key shall be placed at right angle to the joint surface and dispersed more than one at each joint of precast segment.

PARTIV SPECIFICATIONS FOR SUBSTRUCTURES
CALCULATION METHOD OF PILE FOUNDATION

CHAPTER 10 DESIGN OF PILE FOUNDATION

10.1 Basic requirements of design

(1) Axial reaction of each pile head to be generated by loads acting on a pile foundation shall not exceed allowable bearing capacity of that pile.

(2) Displacement of a pile foundation shall not exceed allowable displacement.

10.2 Load sharing

(1) Vertical loads shall be borne, in principle, only by piles.

(2) Horizontal loads shall be borne, in principle, only by piles. However, if both piles and embedded portions of a footing collaborate to share the loads, their sharing ratio shall be fully reviewed.

10.3 Arrangement of piles

10.3.1 Principle of pile arrangement

Piles shall be arranged in a manner to uniformly bear loads continuing over a long period.

10.3.2 Minimum distance between pile centers

Minimum distance between pile centers shall be, in principle, 2.5 times the pile diameter.

If a minimum distance between pile centers is small, influences produced by group piles become larger: it is necessary to reduce axial bearing capacity, coefficient of horizontal subgrade reaction, etc. less than in the case of a single pile. If a value of 2.5 times the pile diameter is exceeded, the designers may expect that influences as group piles will be relatively reduced (See Subsection 10.7.4). This provision has been adopted, because, if a distance between pile centers is set to more than 2.5 times the pile diameter, no special problems are posed in driven, bored, and cast-in-place piles from a viewpoint of their workability.

If a footing is forced to be smaller due to restricting conditions in a construction site, a value less than 2.5 times may be adopted, but possible influences of group piles should be fully reviewed in such a case.

A distance from a center of an outermost pile to a footing external edge may be 1.25 times the pile diameter for driven and bored piles and 1.0 times for cast-in-place ones. (See Fig. Ex. 10.3.1.)

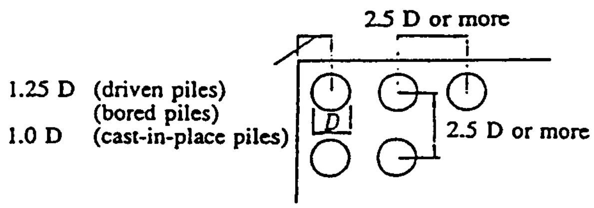


Fig. Ex. 10.3.1 Minimum distance between pile centers

10.4 Allowable bearing capacity of piles

10.4.1 Axial allowable push-in bearing capacity of a pile

(1) Axial allowable push-in bearing capacity of a pile shall be computed by using Formula (10.4.1).

$$R_a = \frac{\gamma}{n}(R_u - W_s) + W_s - W \quad \cdots\cdots (10.4.1)$$

where

R_a : axial allowable push-in bearing capacity of a pile at a pile head (tf)
n : safety factor as given in Table 10.4.1
γ : corrective coefficient of safety factor depending on differences in ultimate bearing capacity-estimating methods
R_u : ultimate bearing capacity of a pile to be determined by soil layers (tf)
W_s : effective weight of earth to be substituted by a pile (tf)
W : effective weight of a pile and earth in its interior (tf)

However, R_a shall not exceed axial allowable push-in bearing capacity to be determined by allowable displacement.
Should the gravity of a pile be small, Formula (10.4.2) may apply.

$$R_a = \frac{\gamma}{n} R_u \quad \cdots\cdots (10.4.2)$$

Table 10.4.1 Safety factor

Types of loading time \ Types of piles	Bearing piles	Friction piles*
During normal time	3	4
During earthquake	2	3

*: The safety factor for bearing piles shall apply to those friction piles whose safety is equivalent to that of the bearing piles.

(2) Ultimate bearing capacity of a pile to be determined by soil layers shall be computed by using a bearing capacity-estimating formula after conducting appropriate ground surveys, or shall be obtained by conducting vertical load tests.

(2) 1) When estimating ultimate bearing capacity by means of calculation, the following method may be used by referring to appropriate ground survey results. It is desirable to identify the bearing capacity by reviewing the calculation results while consuiting load test results in similar soil layers.

$$R_u = q_d A + U \Sigma l_i f_i \quad \text{(Ex. 10.4.1)}$$

where

R_u : ultimate bearing capacity (tf) of a pile to be determined by soil layers

A : area of a pile tip (m^2)

q_d : ultimate bearing capacity per unit area to be borne by a pile tip (tf/m^2)

U : circumferential length of the pile (m)

l_i : thickness of a layer for which skin frictional force is taken into account (m)

f_i : maximum skin frictional force per unit area of a layer for which skin frictional force is taken into account (tf/m^2)

i) Ultimate bearing capacity per unit area at a pile tip q_d

(ii) Cast-in-place pile

This section provides for an ultimate bearing capacity per unit area q_d at a tip of a cast-in-place pile as given in Table Ex. 10.4.2, considering that, generally speaking, the pile is greatly affected by disturbance of soil layers which may be caused by construction work.

Table Ex. 10.4.2 Table for estimating q_d for cast-in-place piles

Type of soil layers	Ultimate bearing capacity per unit area at a pile tip (tf/m^2)
Gravelly and sandy layers (N ≥ 30)	300
Hard cohesive soil layers	$3\ q_u$

where, q_u : unconfined compression strength (tf/m^2)

ii) Computing maximum skin frictional force per unit area f_i acting on pile periphery

Maximum skin frictional force per unit area acting on pile periphery may be estimated from Table Ex. 10.4.4 in accordance with a pile construction method and type of soil layers.

Table Ex. 10.4.4 Maximum skin frictional force per unit area

(tf/m^2)

Construction method / Type of soil layers	Driven pile method	Cast-in-place pile method	Bored pile method
Sandy soil	0.2N (≤ 10)	0.5N (≤ 20)	0.1N (≤ 5)
Cohesive soil	C or N (≤ 15)	C or N (≤ 15)	0.5C or 0.5N (≤ 10)

Note: No skin frictional resistance should be taken into account in soft layers with N ≤ 2 for lack of reliability.

10.4.2 Axial allowable pull-out force of a pile

(1) Axial allowable pull-out force of a pile shall be computed by using Formula (10.4.3).

$$P_a = \frac{1}{n} P_u + W \quad \cdots\cdots (10.4.3)$$

where

P_a : axial allowable pull-out force of a pile at its head (tf)
n : safety factor given in Table 10.4.2
P_u : ultimate pull-out force of a pile to be determined by soil layers (tf)
W : effective pile weight (tf)

Table 10.4.2 Safety factor

Ordinary time	During earthquake
6	3

(2) Ultimate pull-out force of a pile to be determined by soil layers shall be calculated as sum total of maximum skin frictional forces of each layer to be estimated by referring to ground survey results or be obtained by conducting a pull-out test.

10.4.4 Consideration to group piles

(1) Bearing capacity of group piles against axial push-in force shall not exceed allowable bearing capacity of an imaginary caisson foundation which the whole pile foundation is assumed to be. Settlement of the group piles against axial push-in force shall be also reviewed.

(2) Influences of the group piles corresponding to a distance between pile centers shall be reviewed as to bearing capacity of the group piles in a rectangular direction to the axis.

(2) If group piles are subjected to a force rectangular to their axes, loads shared by piles become different as a result of mutual interference among them, thereby their total efficiency being reduced when compared with a case of single piles. Load sharing and group pile efficiency differ depending on classifications of soil layers, pile construction methods, and numbers of piles. Generally speaking, however, influences of group piles will appear when a distance between pile centers becomes less than 5D (D = pile diameter), and less load is shared by piles at farther rows than those at the foremost row or by piles nearer to the center than those at both sides. Efficiency of a single pile is reduced further as the distance between pile centers is reduced more and more.

When considering complexity of actual ground conditions, not a sufficient amount of experimental data have been available to independently treat influences of respective factors leading to efficiency reduction of group piles. Moreover, it has been recognized that difference in load sharing among piles falls within a range of a design safety factor. A matter of horizontal resistance of group piles which should be taken into account in a designing process includes efficiency reduction in accordance with the distance between pile centers. Coefficients of horizontal subgrade reaction for a single pile have been conventionally used as they are, without any practical inconveniences, if the distance between pile centers is about 2.5D.

This is based on judgment that slight differences in coefficients of horizontal subgrade reaction do not impart so large in fluences upon stresses and that some degrees of safety are taken into account in a stage to estimate the coefficients of horizontal subgrade reaction. Should it be unavoidable to further reduce a distance between pile centers, possible reduction in the coefficients of horizontal subgrade reaction should have to be considered in the design process.
To reduce the coefficients, the designers should multiply a coefficient of horizontal subgrade reaction to be obtained under Section 10.5 by the following corrective coefficient μ.

$$\mu = 1 - 0.2\left(2.5 - \frac{L}{D}\right) \quad [L < 2.5D] \qquad \text{(Ex. 10.4.10)}$$

where

L : distance between pile centers (m)
D : pile diameter (m)

The above-mentioned formula has been established by considering practical design processes and based on experimental results using model piles and existing horizontal load test data on group piles.

10.6 Spring constants of piles

10.6.1 Axial spring constant of a pile

> An axial spring constant of a pile shall be obtained either by means of an estimation formula based on past vertical load tests, from results of soil tests, or from a load-settlement curve based on the vertical load tests.

An axial spring constant K_V of a pile is designed as pile axial force which generates a unit displacement at the pile head. This value is used in computing pile reaction as described in Section 10.7 and in estimating an elastic settlement of a pile foundation. When applying the value K_V to computation of pile reaction, it may affect both a pile head moment and axial pull-out force, depending on shapes and dimensions of the pile foundation. Especially when a footing tends to rotate like the case with a small distance between pile centers and a small number of pile rows, their pile head moment and other factors may be changed enormously depending on what value is taken for K_V. In such a pile foundation, the designers must adopt an appropriate value for the K_V after fully comprehending characteristics of the K_V.

It is desirable to obtain the K_V from a pile head load to pile head settlement curve which is to be prepared by vertical load tests of piles, but this section provides that like bearing capacity it may be obtained by using an estimation formula in ordinary designing of pile foundations.

1) An estimation method based on past load tests is to count back the item "a" in Formula (Ex. 10.6.1) from a value of K_V actually measured in many load test results and to attach importance to its relationship with the embedment ratio of l /D among types of piles and types of construction methods. Formula (Ex. 10.6.2) indicates the estimation formula.

$$K_V = a \frac{A_P E_P}{l} \quad \text{......} \quad \text{(Ex. 10.6.1)}$$

where

K_V : axial spring constant of a pile (kg/cm)
A_P : net sectional area of the pile (cm^2)
E_P : Young's modulus of the pile body (kgf/cm^2)
l : pile length (cm)
a : to be computed from Formula (Ex. 10.6.2) formula

$$\left.\begin{array}{ll} \text{Driven steel-pipe piles} & a = 0.014\ (l/D) + 0.78 \\ \text{Driven PC and PHC piles} & a = 0.013\ (l/D) + 0.61 \\ \text{Cast-in-place piles} & a = 0.031\ (l/D) - 0.15 \\ \text{Bored steel-pipe piles} & a = 0.009\ (l/D) + 0.39 \\ \text{Bored PC and PHC piles} & a = 0.011\ (l/D) + 0.36 \end{array}\right\} \quad \text{......} \quad \text{(Ex. 10.6.2)}$$

10.6.2 Radial spring constants of a pile

Radial spring constants of a pile shall be computed by using a coefficient of horizontal subgrade reaction and based on a theory of a beam on an elastic floor.

Radial spring constants K_1 to K_4 of a pile are defined as below:

K_1, K_3 : radial force (tf/m) and bending moment (tf•m/m) to be applied on a pile head when displacing the head by a unit volume in a radial direction while keeping it from rotating,

K_2, K_4 : radial force (tf/rad) and bending moment (tf•m/rad) to be applied on a pile head when rotating the head by a unit volume while keeping it from moving in a radial direction.

These spring constants can be obtained from a relationship between load and displacement to be computed based on the theory of a beam on an elastic floor using a coefficient of horizontal subgrade reaction.

1) Piles with a semi-infinite length ($\beta l \geq 3$)
If a coefficient of horizontal subgrade reaction is constant irrespective of depths and if an embedded depth of a pile is sufficiently long, the constants can be computed from Table Ex. 10.6.1 by using the Hayashi-Chang Theory.

Table Ex. 10.6.1 Radial spring constants of a pile

	Rigid frame of pile head		Hinged frame of pile head	
	$h \neq 0$	$h=0$	$h \neq 0$	$h=0$
K_1	$\dfrac{12EI\beta^3}{(1+\beta h)^3+2}$	$4EI\beta^3$	$\dfrac{3EI\beta^3}{(1+\beta h)^3+0.5}$	$2EI\beta^3$
K_2, K_3	$K_1 \cdot \dfrac{\lambda}{2}$	$2EI\beta^2$	0	0
K_4	$\dfrac{4EI\beta}{1+\beta h} \cdot \dfrac{(1+\beta h)^3+0.5}{(1+\beta h)^3+2}$	$2EI\beta$	0	0

where

β : characteristic value of a pile, $\beta = \sqrt[4]{\dfrac{k_H D}{4EI}}$ (m^{-1})

λ : $h + \dfrac{1}{\beta}$ (m)

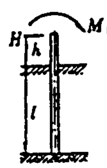
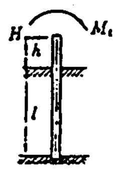
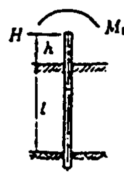
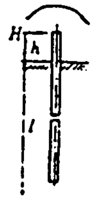
k_H : coefficient of horizontal subgrade reaction (tf/m^3)

D : pile diameter (m)

EI : bending rigidity of the pile ($tf \cdot m^2$)

h : axial length of the pile above design ground surface (m)

2) Piles with a finite length ($1 < \beta l < 3$)
A radial displacement and sectional force of a pile with a finite length need the designers to consider bearing conditions of the pile tip, since they are affected by these conditions. However, if the pile tip is embedded into a good quality bearing layer to a depth similar to the pile diameter, the pile can be generally regarded as hinged (pile tip).
If it is possible to assume that a coefficient of horizontal subgrade reaction (k_H)is constant in the direction of depth, the displacement method can be calculated by using values $K_1\phi_1$, $K_2\phi_2$, $K_3\phi_3$ and $K_4\phi_4$ which are obtained by multiplying the radial spring constants K_1, K_2, K_3, and K_4 by a corrective coefficient ϕ_i.
This corrective coefficient ϕ_i is a function of βl and βh and has values as shown in Fig. Ex. 10.6.1.
However, Fig. Ex. 10.6.1should be applied within a range of $1 < \beta l < 3$.

Conditions of a pile tip	Piles of finite lengths ($1 < \beta l < 3$)			Piles of semi-infinite lengths ($\beta l \geq 3$)
	Free (f)	Hinged (h)	Fixed (c)	
Schematic drawing				
Spring constants	$K_1\phi_1^f$ $K_2\phi_2^f$ $K_3\phi_3^f$ $K_4\phi_4^f$	$K_1\phi_1^h$ $K_2\phi_2^h$ $K_3\phi_3^h$ $K_4\phi_4^h$	$K_1\phi_1^c$ $K_2\phi_2^c$ $K_3\phi_3^c$ $K_4\phi_4^c$	K_1 K_2 K_3 K_4

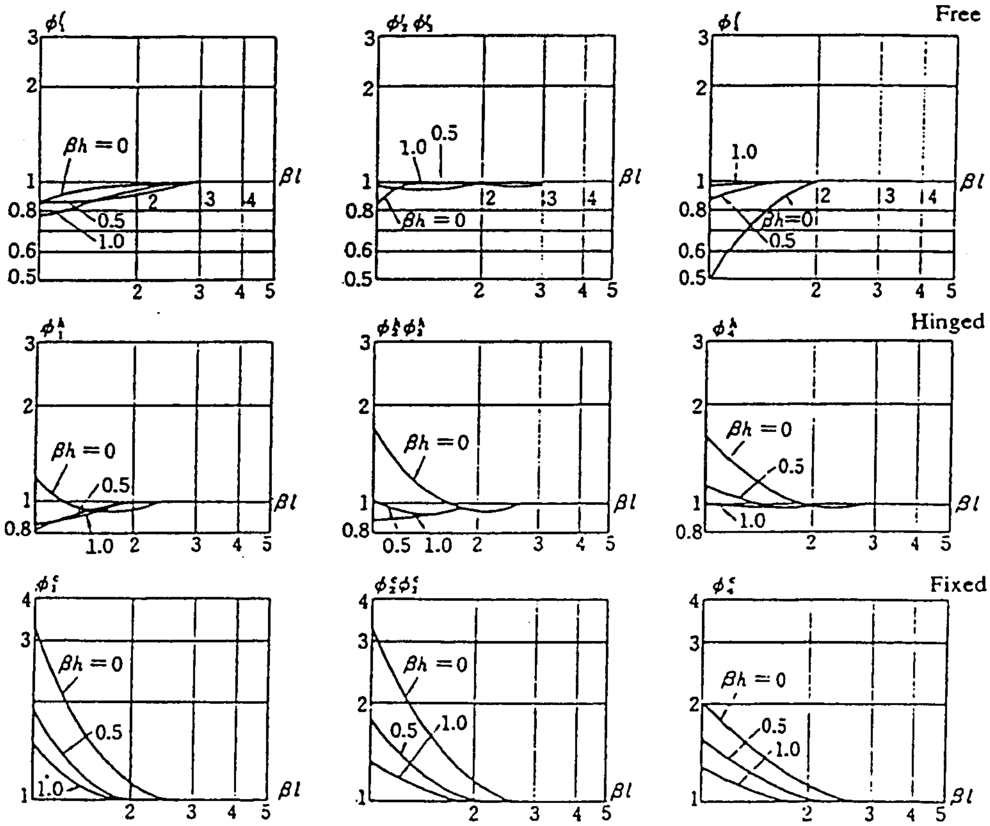


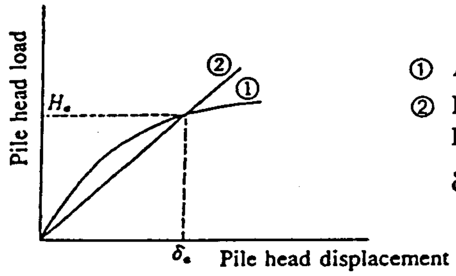
Fig. Ex. 10.6.1 Corrective coefficients of radial spring constants of piles of finite lengths

10.7 Calculation of pile reaction and displacement

> Pile reaction and displacement shall be calculated, in principle, by assuming a footing as rigid body and based an elastic analysis (displacement method) which takes footing displacement (vertical, horizontal, and rotational displacement) into account.

1) This section indicates the principle that pile head reaction should be based on a displacement method which solves a formula balancing displacement of the whole pile foundation (or displacement of a footing) with horizontal and vertical forces and rotational moment working on the pile foundation as a whole by means of a spring matrix.

Regarding nonlinearity of coefficients of horizontal subgrade reaction, there will be no practical inconveniences even if they are treated by assuming as if they were linear within allowable displacement and considering nonlinear behaviors of a pile as apparently linear. (See Fig. Ex. 10.7.1)



① Actual load-displacement curve
② Load-displacement curve assumed to be linear
δ_a : allowable displacement

Fig. Ex. 10.7.1 Assuming linearity of pile behaviors

2) Calculation based on a displacement method

i) Computational assumption in the displacement method
For computational convenience, pile reaction and footing displacement are assumed in the displacement method as follows:

(i) A pile foundation is assumed to be a quadratic structure.

(ii) Piles are linearly elastic in push-in, pull-out, and bending displacements, and both axial and radial spring constants at a pile head are constant, irrespective of loads.
The same spring constant is applied to push-in and pull-out displacements.

(iii) Footings are rigid and rotates around the centroid of group piles.

ii) Calculating method
In a calculation using the displacement method, form a coordinate as shown in Fig. Ex. 10.7.2, set an origin at an arbitrary point O of a footing, determine external forces working on the Point O as illustrated in the figure, and set displacements δ_x, δ_y at Point O in the direction of the coordinate axis and rotation α to the directions as illustrated.

The origin O may be selected from any arbitrary points, but it is recommended to coincide it with the centroid of group piles below the footing.
In this case, the displacement of the origin can be obtained by solving the following simultaneous equation with three unknowns.

$$\left.\begin{aligned} A_{xx}\cdot\delta_x + A_{xy}\cdot\delta_y + A_{x\alpha}\cdot\alpha &= H_0 \\ A_{yx}\cdot\delta_x + A_{yy}\cdot\delta_y + A_{y\alpha}\cdot\alpha &= V_0 \\ A_{\alpha x}\cdot\delta_x + A_{\alpha y}\cdot\delta_y + A_{\alpha\alpha}\cdot\alpha &= M_0 \end{aligned}\right\} \quad \text{.................................. (Ex. 10.7.1)}$$

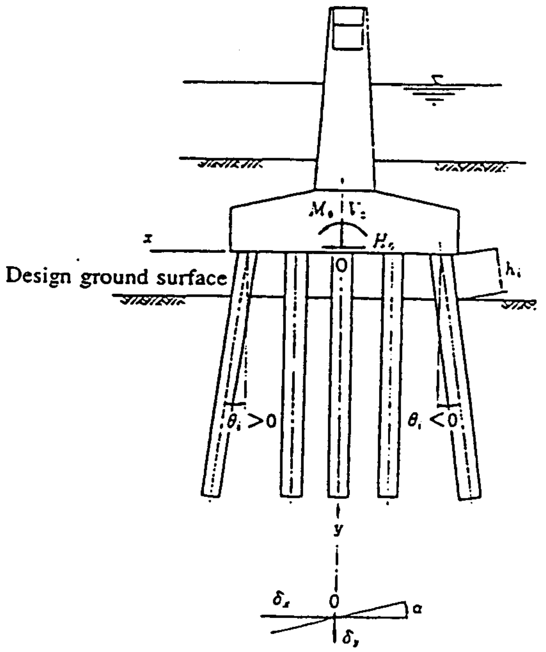


Fig. Ex. 10.7.2 Computational coordinate in the displacement method

Assuming that the footing bottom is horizontal, each coefficient can be obtained by using the following formulas:

$$\left.\begin{aligned}
A_{xx} &= \Sigma\,(K_1 \cdot \cos^2\theta_i + k_V \cdot \sin^2\theta_i) \\
A_{xy} &= A_{yx} = \Sigma\,(K_V - K_1) \cdot \sin\theta_i \cdot \cos\theta_i \\
A_{x\alpha} &= A_{\alpha x} = \Sigma\,\{(K_V - K_1)\,x_i \cdot \sin\theta_i \cdot \cos\theta_i \\
&\quad - K_2 \cdot \cos\theta_i\} \\
A_{yy} &= \Sigma\,(K_V \cdot \cos^2\theta_i + K_1 \cdot \sin^2\theta_i) \\
A_{y\alpha} &= A_{\alpha y} = \Sigma\,\{(K_V \cdot \cos^2\theta_i + K_1 \cdot \sin^2\theta_i)\,x_i \\
&\quad + K_2 \cdot \sin\theta_i\} \\
A_{\alpha\alpha} &= \Sigma\,\{(K_V \cdot \cos^2\theta_i + K_1 \cdot \sin^2\theta_i)\,x_i^2 \\
&\quad + (K_2 + K_3)\,x_i \cdot \sin\theta_i + K_4\}
\end{aligned}\right\} \quad \text{(Ex. 10.7.2)}$$

where

H_0 : horizontal loads acting above a footing bottom (tf)
V_0 : vertical loads acting above a footing bottom (tf)
M_0 : moment of external forces around the origin (tf•m)
δ_x : horizontal displacement at the origin O (m)
δ_y : vertical displacement at the origin O (m)
α : rotational angle of the footing (rad)
x_i : x coordinate of the i th pile head (m)
θ_i : angle of a vertical axis from the i th pile axis (degree). Signs to be in accordance with Fig. Ex. 10.7.2.

If coefficients of horizontal subgrade reaction are constant irrespective of depths, radial spring constants K_1, K_2, K_3, and K_4 of a pile can be obtained by using Fig. Ex. 10.6.1 or Table Ex. 10.6.1.

By using displacements (δ_x, δ_y, α) at the footing origin obtained from the results of the above-mentioned calculations, pile axial force P_{Ni}, pile radial force P_{Hi}, and moment M_{ti} acting on each pile head can be obtained by using the following formulas:

$$\left.\begin{aligned} P_{Ni} &= K_V \cdot \delta_{yi}' \\ P_{Hi} &= K_1 \cdot \delta_{xi}' - K_2 \cdot \alpha \\ M_{ti} &= - K_3 \cdot \delta_{xi}' + K_4 \cdot \alpha \end{aligned}\right\} \cdots\cdots \text{(Ex. 10.7.3)}$$

$$\left.\begin{aligned} \delta_{xi}' &= \delta_x \cdot \cos\theta_i - (\delta_y + \alpha x_i) \cdot \sin\theta_i \\ \delta_{yi}' &= \delta_x \cdot \sin\theta_i + (\delta_y + \alpha x_i) \cdot \cos\theta_i \end{aligned}\right\} \cdots\cdots \text{(Ex. 10.7.4)}$$

where

δ_{xi}' : radial displacement at the i th pile head (m)
δ_{yi}' : axial displacement at the i th pile head (m)
K_V : pile axial force which generates a unit volume of axial displacement to the pile head (pile's axial spring constant) (tf/m)
K_1, K_2, K_3, and K_4 : radial spring constants of the pile
x_i : x coordinates of the i th pile head (m)
θ_i : angle of a vertical axis from the i th pile axis (degree)
P_{Ni} : axial force of the i th pile (tf)
P_{Hi} : radial force of the i th pile (tf)
M_{ti} : moment as external force acting on the ith pile head (tf•m)

Among the values obtained as above, M_{ti} represents moment as external force distributed on pile heads, and a bending moment M_{bi} as internal force on the pile heads is a value with the opposite sign. (Namely, $M_{bi} = -M_{ti}$)
Then, pile head vertical reaction V_i and horizontal reaction H_i are given by the following formula, and are used in calculating reinforcement arrangement of footings:

$$\left.\begin{aligned} V_i &= P_{Ni} \cdot \cos\theta_i - P_{Hi} \cdot \sin\theta_i \\ H_i &= P_{Ni} \cdot \sin\theta_i + P_{Hi} \cdot \cos\theta_i \end{aligned}\right\} \cdots\cdots \text{(Ex. 10.7.5)}$$

Since the following formula must hold effective, it helps the designers to check whether or not the calculating process is correct:

$$\left.\begin{aligned} &\Sigma H_i = H_0 \\ &\Sigma V_i = V_0 \\ &\Sigma (M_{ti} + V_i \cdot x_i) = M_0 \end{aligned}\right\} \cdots\cdots \text{(Ex. 10.7.6)}$$

iii) Vertical piles with symmetric arrangement

Followings are practical calculation formulas handling symmetrically arranged vertical piles ($\theta_i = 0$), which are calculations most often used, with the spring constants K_1, K_2, K_3, and K_4 and K_V being same among the piles.

Assuming that the total number of piles is n,

$$\left.\begin{aligned}
\delta_x &= \frac{H_0 + \dfrac{nK_2}{K_V \Sigma x_i^2 + nK_4} M_0}{nK_1 - \dfrac{(nK_2)^2}{K_V \Sigma x_i^2 + nK_4}} \\
\delta_y &= \frac{V_0}{nK_V} \\
\alpha &= \frac{M_0 + \frac{1}{2}\lambda H_0}{K_V \Sigma x_i^2 + n\left(K_4 - \dfrac{K_2^2}{K_1}\right)}
\end{aligned}\right\} \quad \text{(Ex. 10.7.7)}$$

$$\left.\begin{aligned}
P_{Ni} &= \frac{V_0}{n} + \frac{M_0 + \frac{1}{2}\lambda H_0}{\Sigma x_i^2 + \dfrac{n}{K_V}\left(K_4 - \dfrac{K_2^2}{K_1}\right)} x_i \\
P_{Hi} &= \frac{H_0}{n} \\
M_{ti} &= \frac{1}{n}(M_0 - \Sigma P_{Ni} \cdot x_i)
\end{aligned}\right\} \quad \text{(Ex. 10.7.8)}$$

where

$$\lambda = h + \frac{1}{\beta}$$

$\frac{1}{2}\lambda H_0 = 0$, in case of a hinged frame.

10.9 Design of pile body

10.9.1 Design of piles against load after completion

(1) Regarding axial push-in force and axial pull-out force, axial forces of each portion of a pile shall be obtained by considering properties of soil layers.

(2) Bending moment and shearing force of each portion of a pile to be caused by radial forces and pile head moments shall be obtained by considering the pile body as a beam on an elastic floor.

(3) Each portion of a pile shall have to be safe against axial forces, bending moments, and shearing forces. A pile which is embedded in the ground to its whole length shall be designed as a short column.

10.9.3 Connection between a pile and a footing

> Connection between a pile and a footing shall be designed, in principle, by adopting a pile head rigid connection and shall be designed to assure safety against stresses to be generated at the connection.

Methods to connect a pile head generally include rigid and hinged connections. This section provides that these connections in bridge foundations should be designed, in principle, as rigid one. This is because the pile head rigid connection is more favorable when its design is controlled by horizontal displacement and because safety in earthquake-resistant properties can be regarded higher due to higher degrees of redundancy.

1) Connecting methods

A pile and a footing should be connected by using either of the following two methods:

Method A: Embed a pile in a footing to a specific depth and cause the embedded portion to resist the pile head bending moment. The embedded depth of the pile head should be equal to or more than the pile diameter. This is applicable to steel-pipe, PC • PHC, and RC piles.

Method B: Embed a pile in a footing as shallowly as possible and cause reinforcement mainly composed of steel bars to resist the pile head bending moment. The embedded depth of the pile head should be 10 cm.
This is applicable to steel-pipe, PC • PHC, RC and cast-in-place piles.

2) Basic design requirements

A connection between a pile and a footing should be designed as rigid connection so that it may resist all the external forces working on the pile head, including push-in forces, pull-out forces, horizontal forces, and moments.
When taking concrete examples, the designers should review vertical bearing stress punching shear stress, horizontal bearing stress of the footing concrete.
They should also review horizontal punching shear stress for piles at the footing ends. If reinforcing the pile head with steel bars under Method B above, they should review stress of the concrete and the reinforcement by assuming cross sections of reinforced concrete.

ii) Method B

(i) Details of structure of steel-pipe piles are shown in Fig. Ex. 10.9.6.

a. Steady rests inside a pile should be installed in the manner as described in Method A above.

b. A clearance between the rest and a reinforcement bar should generally be 15 mm or more, and that between the pile and the bar should be equal to or more than the bar diameter.

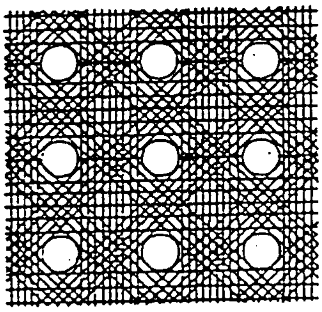


Fig. Ex. 10.9.5 Arrangement of reinforcement in a footing

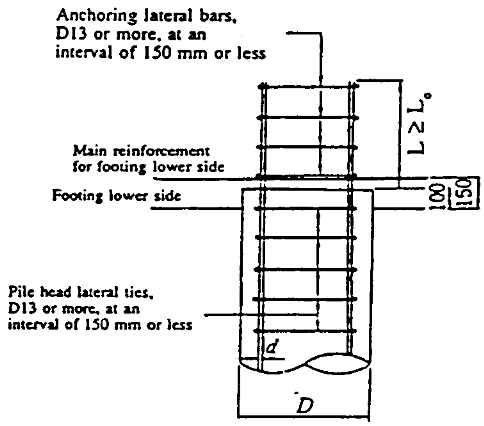


Fig. Ex. 10.9.8 Method B, cast-in-place piles

c. Anchoring length of the reinforcement

$$L_0 = \frac{\sigma_{sa} A_{st}}{\tau_{0a} U} \quad \text{(Ex. 10.9.8)}$$

Generally, the length $L_0 \geq 35d$ is acceptable.

where

L_0 : required anchoring length of reinforcement (cm)
A_{st} : sectional area of the reinforcement (cm^2)
τ_{0a} : allowable boud stress in concrete (kgf/cm^2)
U : circumferential length of the reinforcement bar (cm)
σ_{sa} : allowable tensile stress in the reinforcement bar (kgf/cm^2)
d : bar diameter (cm)

d. Additional filled reinforcement under the steel-pipe pile. Method B should be in principle in a form of a reinforcing bar cage. If it is unavoidable to weld additional bars along the external periphery of a pile, either reinforcement SD 30B or SD 35 whose weld ability has been specified should be employed, and each bar should be securely welded one after another. Details of the structure in this case should be in a form of a reinforcing bar cage.

e. If an inclined pile is employed, an embedded depth of the pile into a footing should be at least 10 cm.

3.1B Structure Analysis Program CONST

CONST is a program for the design calculation of concrete highway bridges such as ; girder bridge, cable stayed bridge, truss bridge, and arched bridge.

There are the following features in this program.

- The support conditions of the construction process can be optionally selected. The section force in each construction process and after its completion, stress intensity and deformation are able to be calculated.
- The concrete creep, drying shrinkage and PC steel relaxation can be analyzed of every construction stage. The relevant creep theories are also applicable to this program.
- The designs in the Standard Specification for Road Bridges (Japan Road Association) can be calculated.
- The effective-prestress can be calculated at each interval of concrete age.

■ Analytical Theory

The analytical theory of this program is based on the stiffness method. The deformation of concrete creep, drying shrinkage and relaxation of PC steel including the effect of restraining bonded steel are taken into consideration. It can also analyze the progress of construction stages.

■ Scope of Application

- Structure Type

  For the construction of the superstructure, this program can calculate the changes of the width of the carriage way including several construction designs of the concrete highway bridge of different cross section types.

  For the construction of the substructure, the design of RC cross sections of various shapes can be calculated as well.

  Member connecting condition and support condition are options.

- Cross section of main girder

  This program contains the following five basic types of cross sections. Apart from them, the optional cross sections can also be specified.

  A) 1-3 box sections
  B) 1 box section with brace
  C) 3 inclined box sections
  D) 1 box with reinforced strut
  E) Hollow slab section

- Other cross sections apart from the main girder (Pier, tower)

  The program contains the following 4 types of cross sections.

  A) 1-3 box sections
  B) 1 box section with brace
  C) 3 inclined box sections
  D) 1 box with reinforced strut
  E) Hollow slab section

■ Load Conditions

The load conditions specified in the Standard Specification for Road Bridge of Japan Road Association have been taken into consideration.

1. Self-load (Main girder and protection wall, bridge pier)
2. Dead-load excluding self-load (Kerb stone, guard-rail, sidewalk, pavement, etc.)
3. Live-load (Vehicle load, etc.)
4. Collision load
5. Prestress force
6. Concrete creep and drying shrinkage
7. Temperature change (Yearly change and daily change)
8. Earthquake loads
9. Snow load
10. Foundation change and support movement
11. Construction load (Construction vehicle, machinery, etc.)

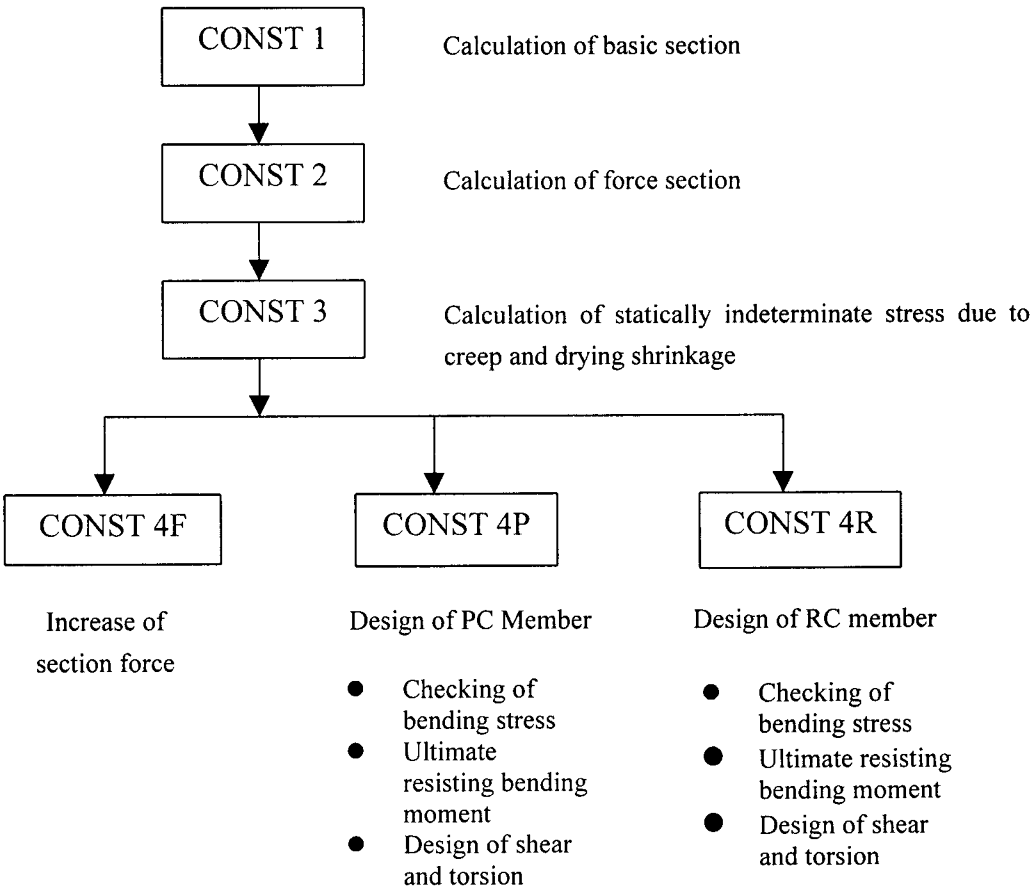
■ Steps of Constructions

If the number of construction steps are lower than 400, the optional construction steps are applicable.

■ Creep and Shrinkage Coefficient

Basic models such as temperature around the member, shaping dimension of member in the cross section and the concrete age stipulated in the Standard Specification for Road Bridges have been taken into account. Other theories (for example, CEB manual, 1984) can be analyzed too.

■ Structure of Program



■ Input Topics

(CONST 1)

- Controlled data (Number of sections, members, and member length, etc.)
- Data of main girder section (Girder height, shaping dimension section, etc.)
- Data of member section excluding the main girder (Shaping dimension section, etc.)

(CONST 2)

- Data of joint member excluding the main girder
- Element data (Stiffness of member, numbers of sections excluding the main girder, etc.)
- Data of every construction stage (Changed member, loading, etc.)
- Data of loading after completion (Bridge surface, earthquake, member age, etc.)

(CONST 3)

- Factor of basic flow and basic shrinkage coefficient

(CONST 4)

- Determination of increased element number

(CONST 4P and 4R)

- Section number of shear checking

3.2A Selection of Main Bridge Supporting Condition

1. Policy

The supporting condition of the main bridge must possess an appropriate structure, good vehicle comfort, easy maintenance and cost effectiveness. In order to achieve such policies;

- the main girder must be connected as long as possible
- the main girder and pier at the center part of main bridge must be rigidly connected as much as possible.

2. Validity of Structure Adopted for Each Supporting Condition Type

1) Selection of Basic Structure

The comparison of supporting structures considered to be appropriate are shown in Figure 1 and the evaluation of supporting structures in Table1.

2) Comparison of Stable Structure

The following three types of supporting structure are considered appropriate for comparison.

1. Type 1-2 : The main girder and pier are rigidly connected. Four hinges (expansion part) are inserted in order to reduce the restraint.

2. Type 2-1 : The area of rigid structure at the central part of the main bridge should be as large as possible. The remaining structure area is to be supported by bearings.

3. Type 2-2 : The main tower and the piers to the tower will adjacent rigidly built.

3) Evaluation

The following is the evaluation of each structure type. Please see the conclusive evaluation in Table 1.

1. Type 1-2 :

- As all spans consist of a rigid frame structure, earthquake resistance and structural stability are high.
- An addition of four hinges does not accord with the policies stated earlier.
- Due to these four hinges, the maintenance is not so easy as Type
- 2-2.

2. Type 2-1 :

- Due to its continuous span, the structure and vehicle comfort are excellent.
- As the supporting restraint underneath the pier is 2950tf per pier, it exceeds the limitation of rubber laminated bearings. In case of using steel bearings, it will require special specification which leads to a large initial investment and specific maintenance.

3. Type 2-2 :

- Inspite of the long span and the large supporting reaction, the rigid connection of the pier and main tower has highly stabilized the structure.
- Since there is only one hinge, the nine spans (800 m) are continuously connected resulting in a smooth vehicle comfort.
- As there is only one hinge, it needs less maintenance than Type 1-2.
- In conclusion, type 2-2 is considered the most suitable structure.

3. Hinge Designing Concerns

Theoretically, adopting a hinge is rational but there are some weakness concerning the structure and maintenance.

The center hinge at the central part of the span can easily lead to creep deflection, and if it does, the deflection will continue and the future maintenance will be considerably troublesome. In the case of Type 2-2, to solve the problem of creep deflection, the hinge is set to be zero bending moment point of the span. The creep deflection would effect only 3 spans, therefore the shear force is comparatively small.

Table-1 Comparative Evaluation Table of Supporting Condition (1/2)

Type	Structure, Earthquake Resistance, Vehicle comfort	Maintenance	Construction Cost	Evaluation
1-1 Rigid frame structure with several center hinges (The center hinge will be inserted after the completion of the rigid frame structure with several hinges.) (Pakse bridge has adopted this model.)	● Number of bearing = 2 Number of C hinge = 4 Expansion joint = 6 ● The vehicle comfort is worse than other types. ● The earthquake resistance is good because of its high degree of redundancy. ● The damage can easily occur due to the movement of live load and the repetitive creep deflection at the center hinge.	● The maintenance measures to prevent the bending at the center hinge is to camber this point in advance, overlay the pavement, and strengthen the cable outside. However, it is still difficult to prevent the continuity of deflection. ● Replacement at center hinge is difficult.	● Bearing : 2 pieces ● Expansion joint : 6 pieces ● C hinge : 4 piece **Ratio : 100**	● Structure : Excellent ● Vehicle comfort : Fair ● Maintenance : Poor **Evaluation : Fair**
1-2 Rigid frame structure with several Gerber hinge (Make hinge of Type 1-1 to be at the zero bending moment)	● Number of bearing = 2 Number of G hinge = 4 Expansion joint = 6 ● There are 4 Gerber hinges which are much more than Type 2-2. ● The continuous rigid frame structure is indeterminate, so it helps resisting earthquake. ● Vehicle comfort is fair.	● There are four Gerber hinges which are considered too many.	● Bearing : 2 pieces ● Expansion joint : 6 pieces ● G hinge : 4 pieces **Ratio : 91**	● Structure : Fair ● Vehicle comfort : Fair ● Maintenance : Fair **Evaluation : Fair**

Table-1 Comparative Evaluation Table of Supporting Condition (2/2)

Type	Structure, Earthquake Resistance, Vehicle comfort	Maintenance	Construction Cost	Evaluation
2-1 Continuous rigid frame structure at the central part of bridge (Kompong Cham Bridge has adopted this model.)	● Number of bearing = 16 Number of C hinge = 0 ● The structure and vehicle comfort are excellent. ● As the reaction force of the main towers P11 and P18 is large (up to 5900tf), the size of bearing must be very large as well. (Average force of 80m span is 2700tf) ● It then exceeds the capability of rubber bearing. So a special steel pot bearing is required.			● Structure : Fair **Evaluation : Fair**
2-2 Insertion of Gerber Hinge at the central part of bridge (Reduce the rigid connection of the pier in order to minimize the restraint)	● Number of bearing = 14 Number of G hinge = 1 Expansion joint = 3 ● The main bridge is divided into two parts by G hinge, so the restraint and expansion of the girder can be reduced. ● Since the large restraint of the main tower and the adjacent piers has continued, the earthquake resistance is high. ● Although the G hinge has some structural weakness, it can be covered by the design.	There is one hinge between P14 and P15. As there is some weakness regarding the structure and the maintenance, the moment at the girder hinge is to be zero. Replacement of the bearing and space for recess block out must be taken into consideration.	● Bearing : 14 pieces ● Expansion joint : 3 pieces ● G hinge : 1 piece **Ratio : 88**	● Structure : Fair ● Vehicle comfort : Excellent ● Maintenance : Fair **Evaluation : Excellent**

Notes: G Hinge : Gerber Hinge
C Hinge : Center Hinge

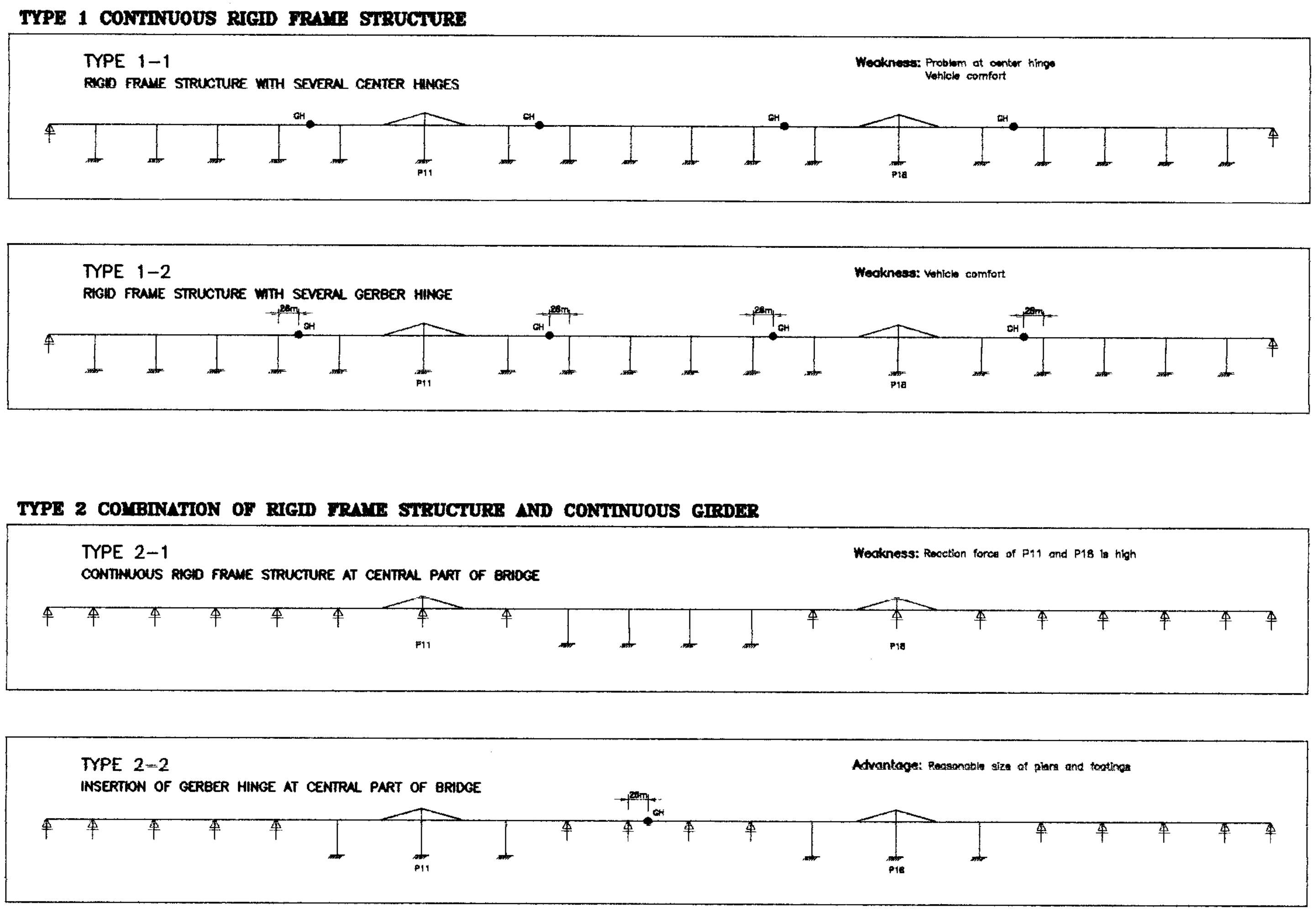
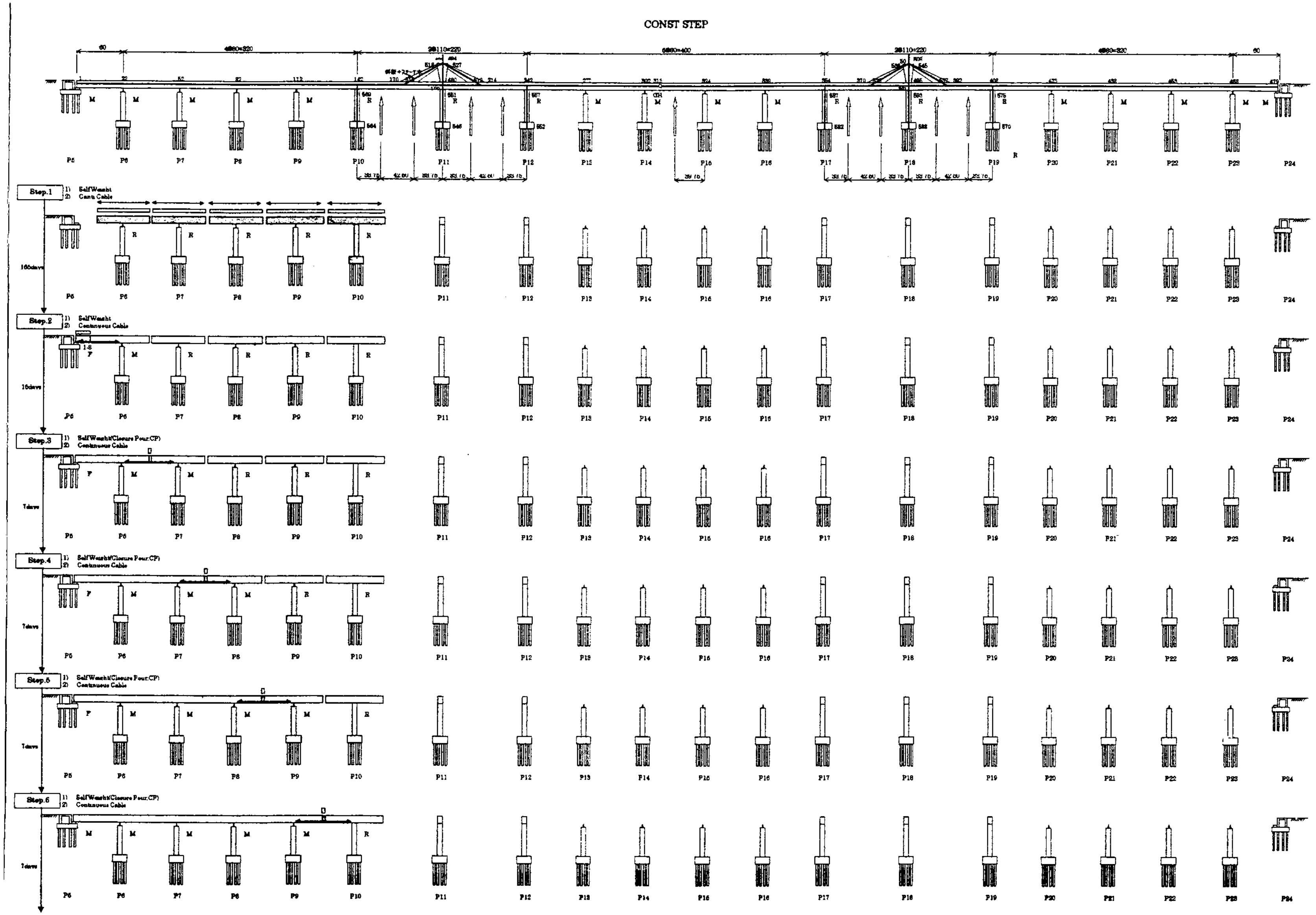


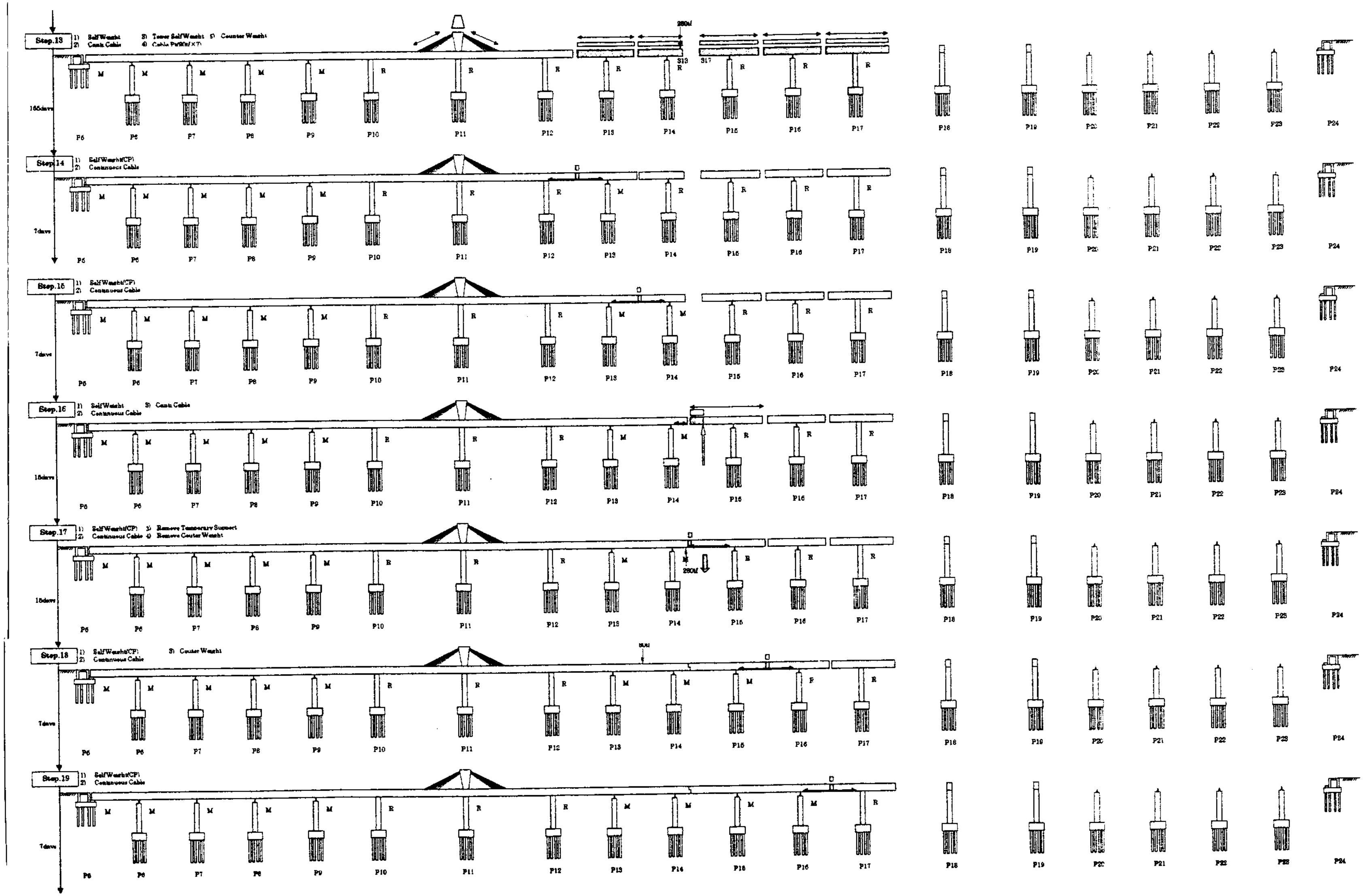
Figure – 1 Support Condition

3.2B Structural Analysis Step

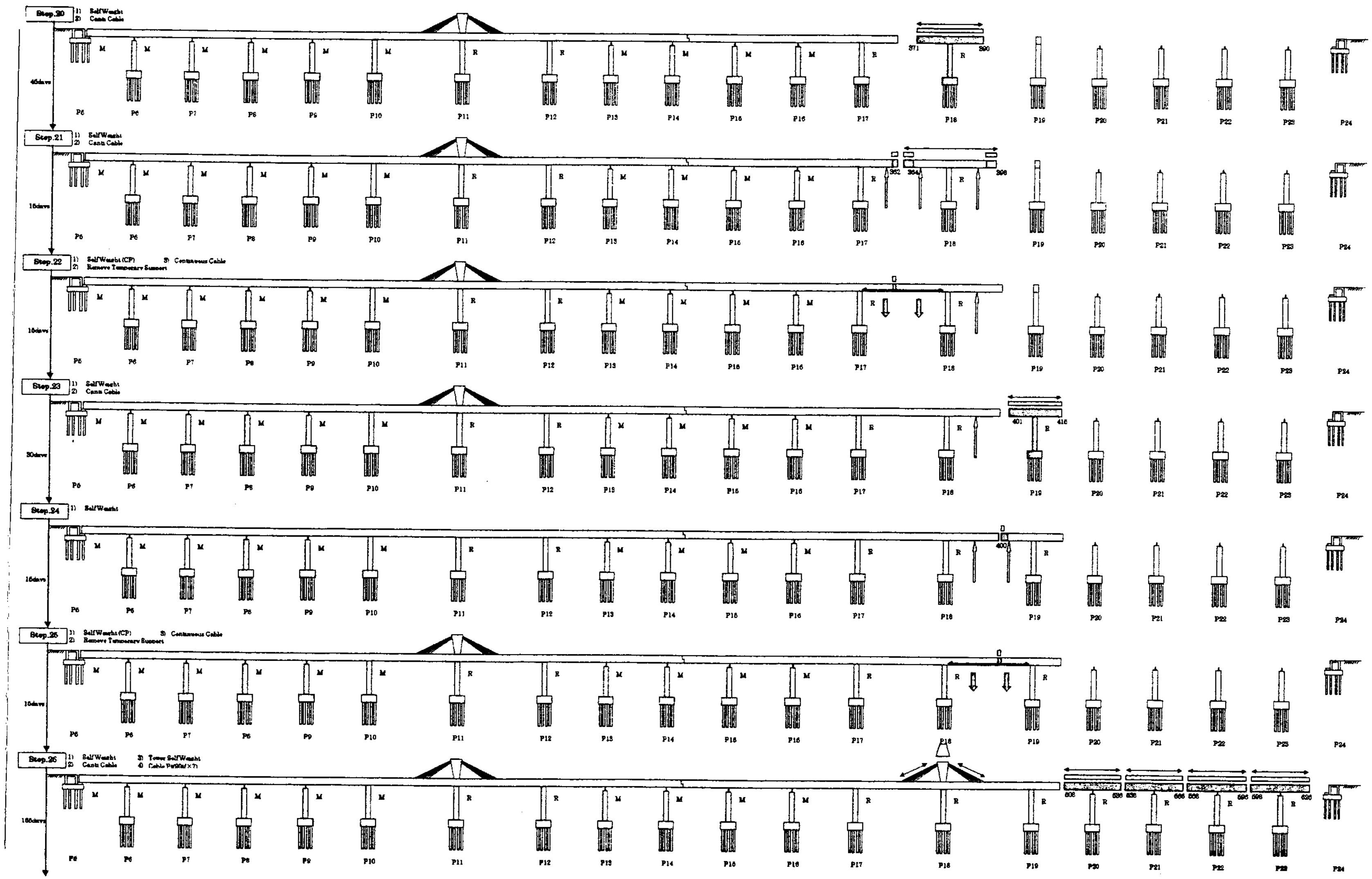


Structural Analysis Step (Step. 1 – 6)

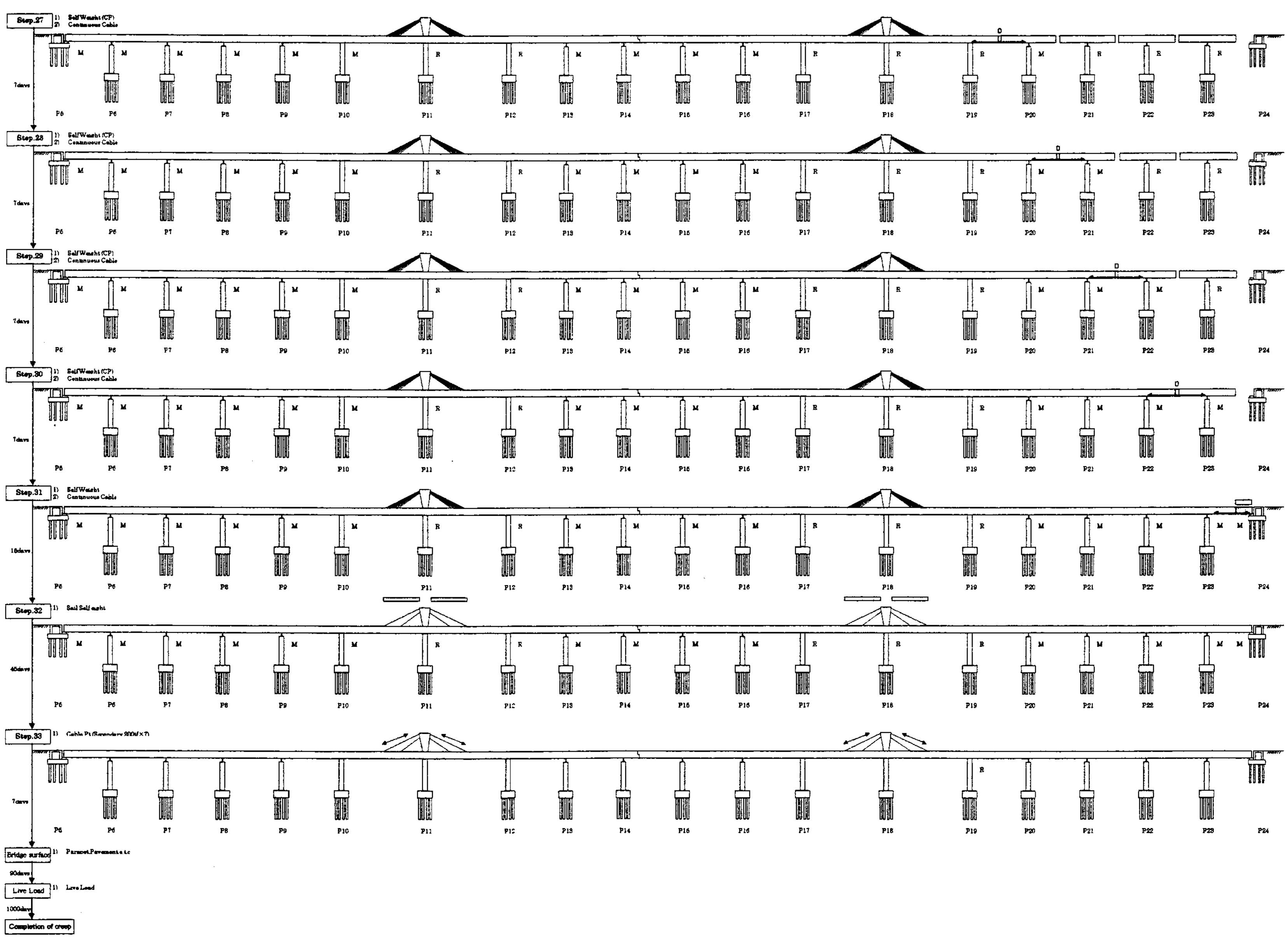
Structural Analysis Step (Step. 7 – 12)



Structural Analysis Step (Step. 13 - 19)



Structural Analysis Step (Step. 20 - 26)



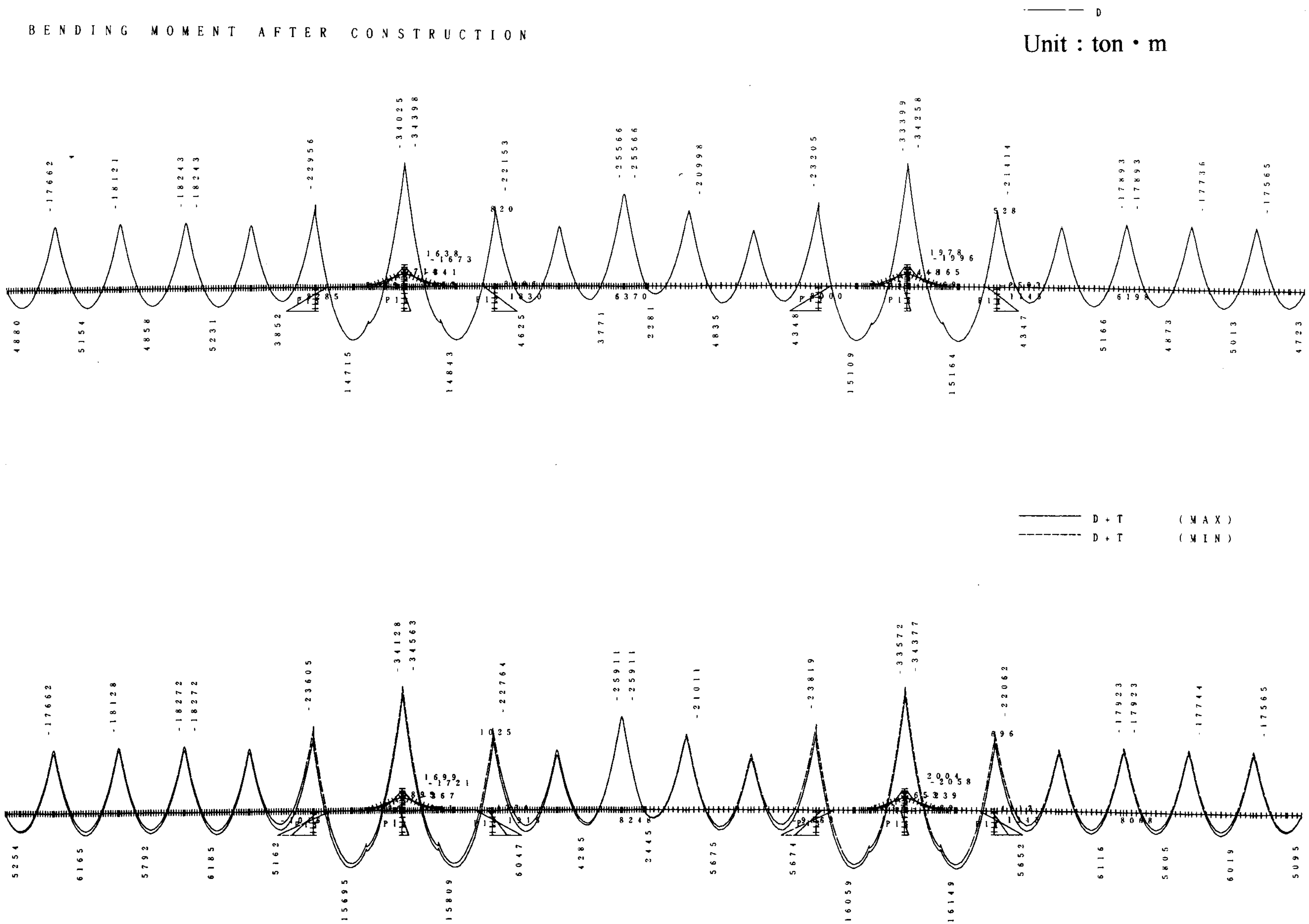
Structural Analysis Step (Step. 27 –33)

3.2C Support Reaction

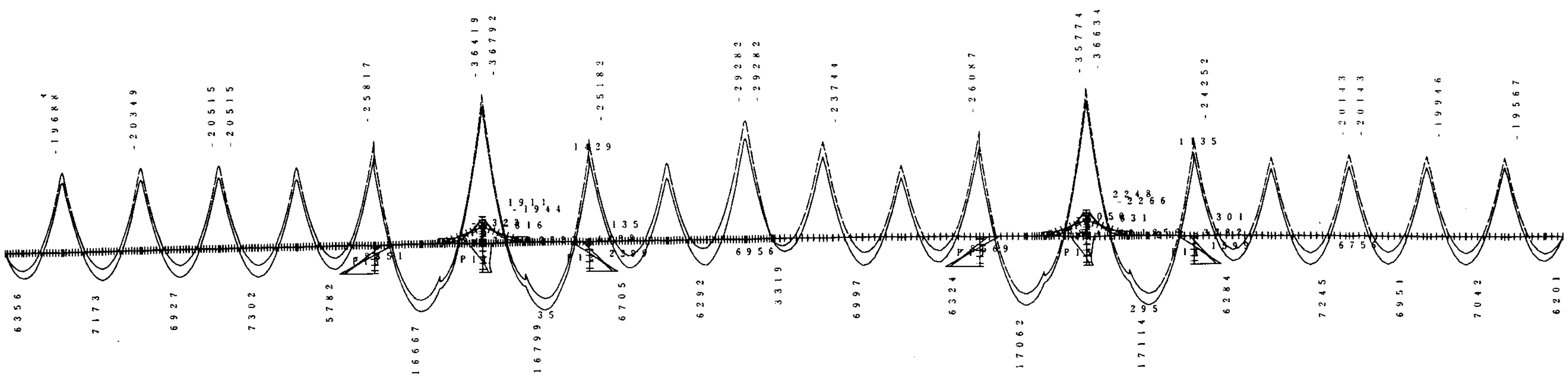
	P5	P6	P7	P8	P9	P13	P14	P15	P16	P20	P21	P22	P23	P24
	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)	RY (ton)
D, After erection	480	1944	1971	1972	1927	1904	2456	2109	1845	1959	1954	1952	1952	462
D, Under bridge deck	555	2237	2268	2272	2215	2164	2804	2412	2124	2244	2254	2250	2242	540
D, End of Creep	556	2238	2265	2275	2201	2143	2800	2423	2107	2208	2262	2250	2233	547
*** RY Maximum***														
D	556	2238	2265	2275	2201	2143	2800	2423	2107	2208	2262	2250	2233	547
D+L(+)	691	2540	2583	2597	2520	2478	3151	2740	2431	2527	2582	2567	2534	683
D+L (-)	531	2207	2219	2226	2150	2043	2745	2376	2046	2158	2213	2204	2202	523
D+T (Max)	575	2238	2270	2278	2218	2152	2833	2424	2117	2225	2264	2255	2233	566
D+T (Min)	556	2215	2265	2271	2190	2111	2799	2413	2096	2197	2257	2249	2210	547
D+L+T (Max)	710	2540	2588	2599	2537	2488	3184	2741	2441	2544	2584	2572	2534	702
D+L+T (Min)	531	2184	2218	2222	2139	2012	2744	2365	2035	2147	2208	2203	2180	523
D+T (year) (Max)	556	2238	2266	2278	2211	2152	2801	2424	2117	2219	2264	2251	2233	547
D+T (year) (Min)	556	2238	2265	2273	2190	2133	2799	2422	2097	2197	2260	2249	2233	547
D+L+T (year) (Max)	691	2540	2584	2599	2531	2487	3152	2741	2440	2536	2584	2568	2534	683
D+L+T (year) (Min)	531	2207	2218	2224	2139	2034	2744	2374	2036	2147	2211	2203	2202	523
D+EQ	556	2241	2263	2291	2149	2189	2785	2440	2057	2261	2246	2252	2229	547
D-EQ	556	2234	2268	2260	2253	2096	2815	2406	2156	2156	2277	2247	2236	547

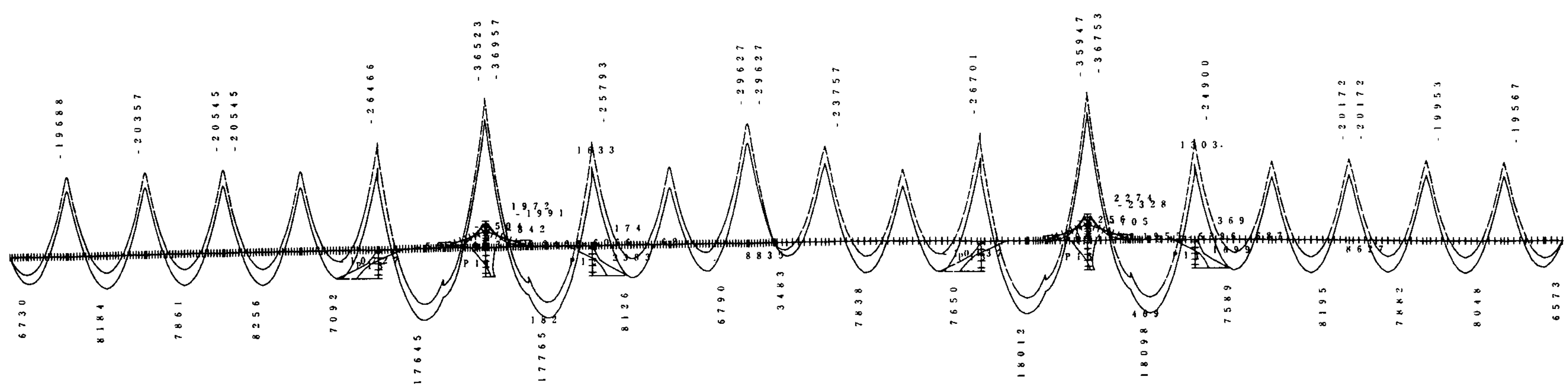
	P11			P12			P10			P17			P18			P19		
	RX (ton)	RY (ton)	RM (tm)	RX (ton)	RY (ton)	RM (tm)	RX (ton)	RY (ton)	RM (tm)	RX (ton)	RY (ton)	RM (tm)	RX (ton)	RY (ton)	RM (tm)	RX (ton)	RY (ton)	RM (tm)
D After erection	-91	9355	-1789	-185	5829	-3962	276	5787	6037	-134	5715	-3022	230	5875	5080	-96	9341	-1330
D Under bridge deck w	-88	9915	-1773	-190	6191	-4109	278	6140	6161	-140	6073	-3230	235	6231	5247	-95	9900	-1321
D End of Creep	-83	9930	-1830	-311	6204	-6370	395	6141	8285	-300	6107	-6198	375	6243	8000	-74	9896	-1145
*** RY Maximum***																		
D	-83	9930	-1830	-311	6204	-6370	395	6141	8285	-300	6107	-6198	375	6243	8000	-74	9896	-1145
D+L(+)	-86	10381	-1824	-304	6553	-6266	384	6481	8155	-288	6446	-6056	365	6584	7877	-73	10345	-1161
D+L (-)	-71	9892	-1735	-315	6136	-6452	416	6077	8522	-322	6044	-6441	393	6178	8220	-84	9859	-1224
D+T (Max)	-86	9981	-1884	-196	6218	-4491	274	6155	6410	-180	6119	-4327	261	6255	6132	-69	9945	-1079
D+T (Min)	-78	9886	-1746	-414	6190	-8012	501	6120	9914	-406	6087	-7814	476	6224	9618	-80	[illegible]	1227
D+L+T (Max)	-89	10431	-1878	-189	6566	-4388	263	6495	6280	-168	6459	-4185	251	6596	6009	-68	10395	-1095
D+L+T (Min)	-66	9848	-1650	-418	6121	-8094	522	6056	10151	-427	6023	-8057	494	6160	9838	-90	9817	-1306
D+T (year) (Max)	-89	9972	-1914	-197	6217	-4501	275	6153	6418	-181	6118	-4334	261	6254	6138	-68	9936	-1062
D+T (year) (Min)	-78	9889	-1746	-425	6192	-8239	515	6130	10152	-420	6096	-8061	489	6232	9863	-80	9855	-1227
D+L+T (year) (Max)	-92	10422	-1908	-189	6565	-4397	263	6493	6289	-168	6458	-4193	251	6595	6015	-67	10386	-1078
D+L+T (year) (Min)	-66	9851	-1651	-429	6124	-8321	536	6066	10389	-441	6033	-8304	507	6167	10083	-90	9819	[illegible]
D+EQ	834	9931	8060	291	6263	804	1054	6081	15979	364	6169	1592	984	6185	15272	853	9894	8882
D-EQ	-1001	9930	-11721	-914	6146	-13544	-264	6202	591	-966	6045	-13988	-233	6301	729	-1002	9897	[illegible]
*** RM Maximum***																		
D	-83	9930	-1830	-311	6204	-6370	395	6141	8285	-300	6107	-6198	375	6243	8000	-74	9896	-1145
D+L(+)	-15	10098	-1344	-241	6348	-5709	457	6234	8870	-229	6255	-5567	433	6338	8586	-8	10063	-673
D+L (-)	-151	10099	-2314	-372	6307	-6974	323	6289	7650	-362	6200	-6775	307	6390	7352	-140	10065	-1614
D+T (Max)	-75	9892	-1715	-184	6218	-4255	516	6128	10161	-165	6111	-4073	489	6230	9868	-68	9934	-1061
D+T (Min)	-89	9974	-1915	-426	6191	-8248	259	6147	6163	-421	6095	-8068	247	6249	5881	-81	9865	-1245
D+L+T (Max)	-6	10060	-1229	-115	6361	-3595	578	6221	10745	-94	6259	-3443	548	6326	10455	-2	10101	-589
D+L+T (Min)	-157	10143	-2399	-487	6293	-8852	188	6294	5528	-482	6187	-8645	179	6396	5233	-147	10034	-1713
D+T (year) (Max)	-78	9889	-1746	-197	6217	-4501	515	6130	10152	-181	6118	-4334	489	6232	9863	-68	9936	-1062
D+T (year) (Min)	-89	9972	-1914	-425	6192	-8239	275	6153	6418	-420	6096	-8061	261	6254	6138	-80	9855	-1227
D+L+T (year) (Max)	-9	10056	1260	-127	6360	-3840	577	6222	10736	-110	6266	3704	547	6327	10449	-2	10103	-590
D+L+T (year) (Min)	-157	10140	-2398	-486	6295	-8843	203	6300	5783	-482	6188	-8638	194	6402	5489	-146	10025	-1696
D+EQ	834	9931	8060	291	6263	804	1054	6081	15979	364	6169	1592	984	6185	15272	853	9894	8882
D-EQ	-1001	9930	-11721	-914	6146	-13544	-264	6202	591	-966	6045	-13988	-233	6301	729	-1002	[illegible]	[illegible]

3.2D Bending Moment and Shearing Force Diagram



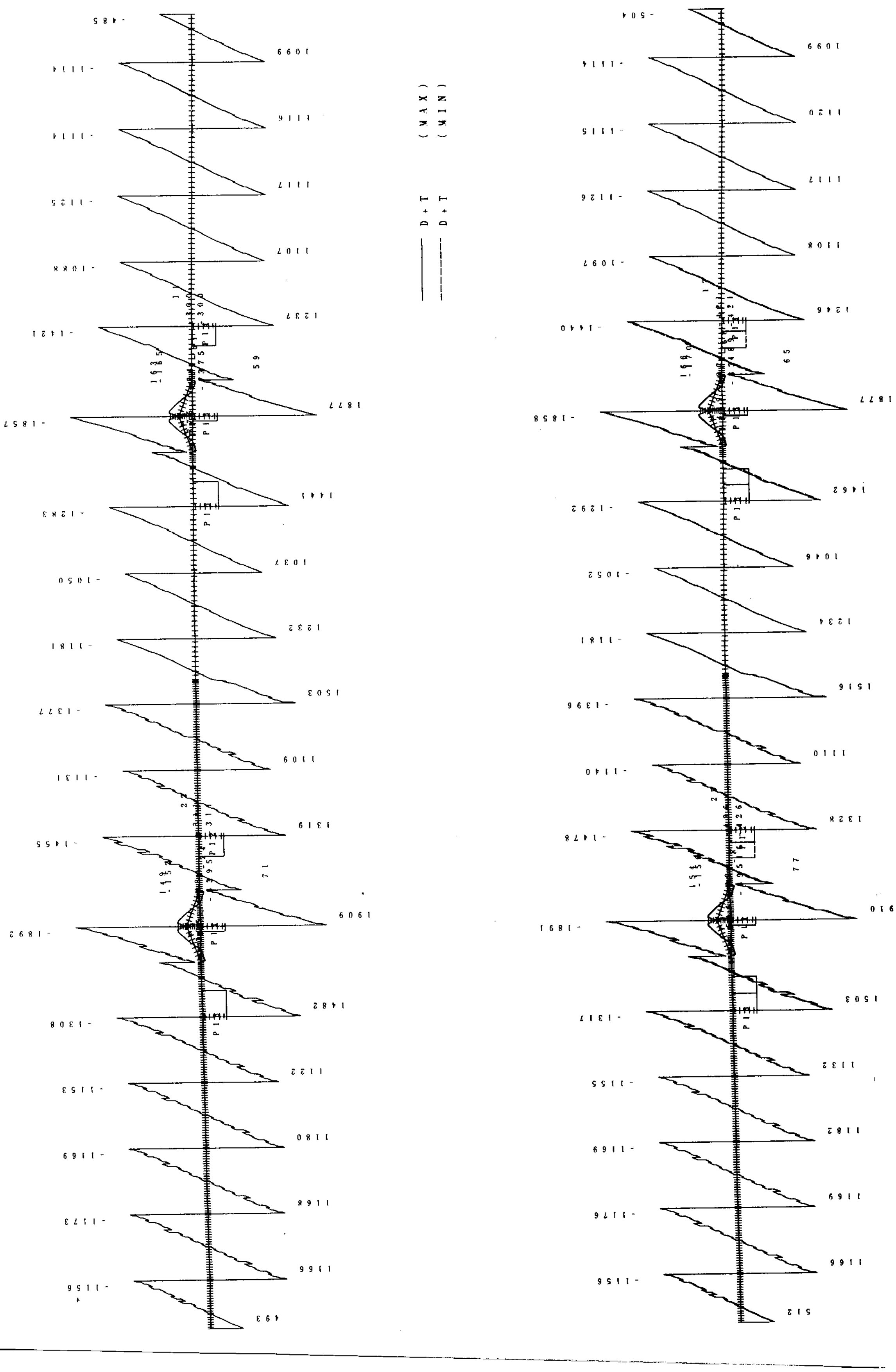
BENDING MOMENT AFTER CONSTRUCTION



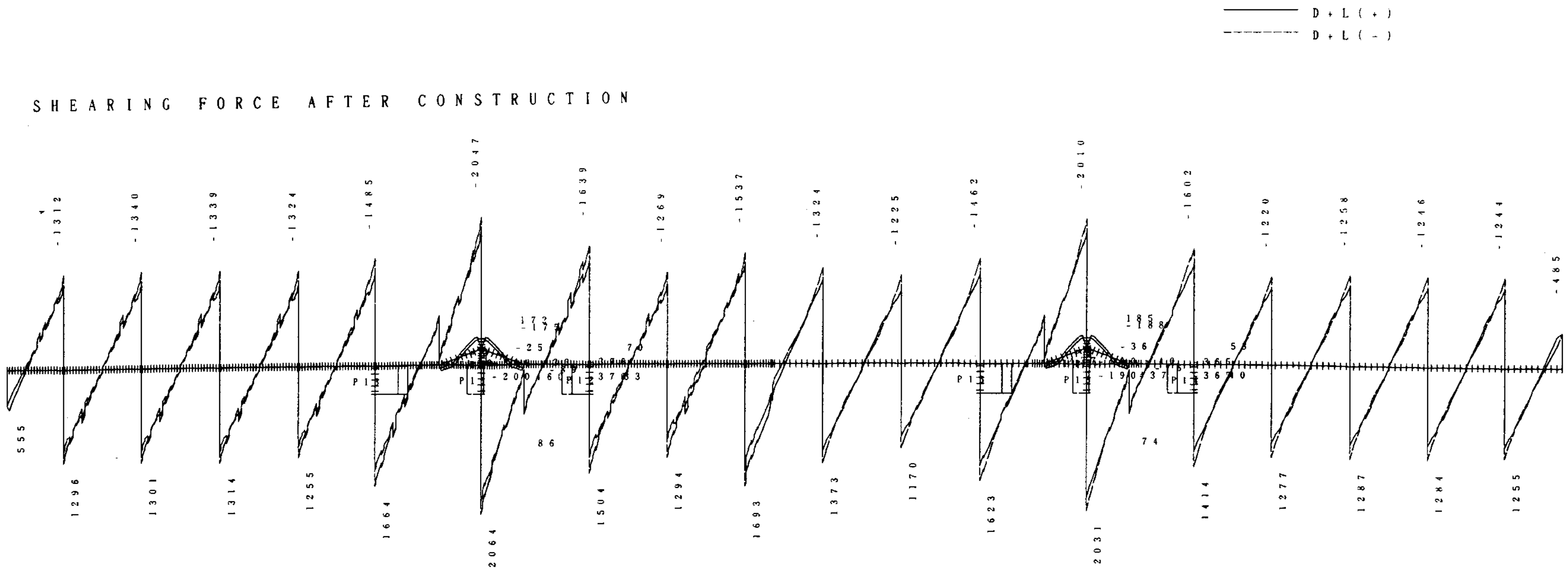


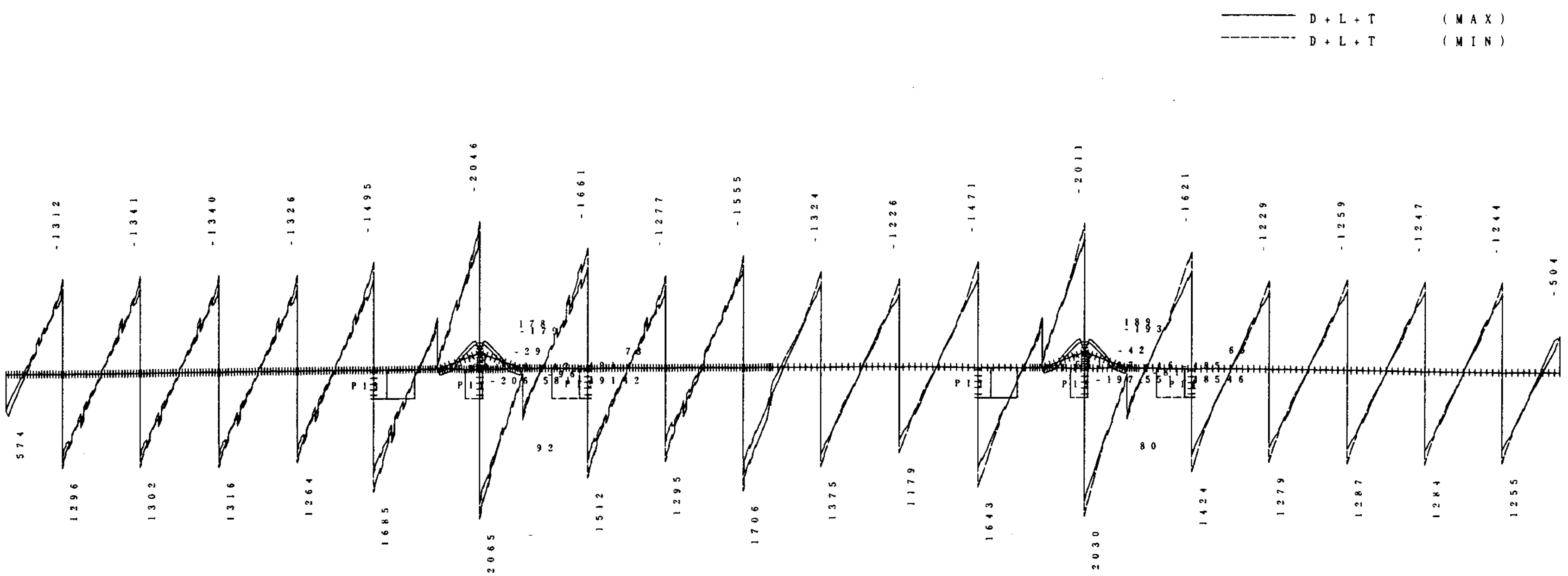
SHEARING FORCE AFTER CONSTRUCTION

Unit : ton



SHEARING FORCE AFTER CONSTRUCTION

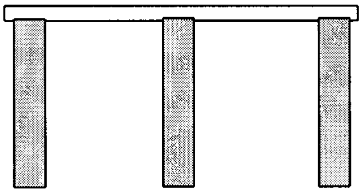
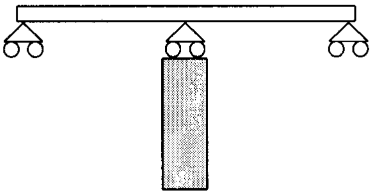




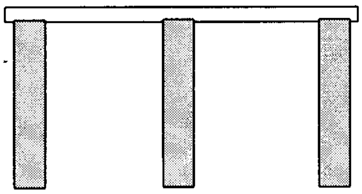
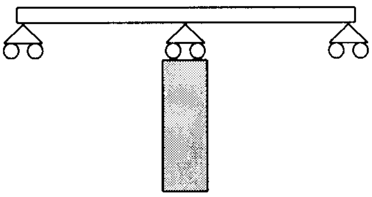
3.3A Horizontal Force by Temperature and Earthquake

Section Force on Pier Head

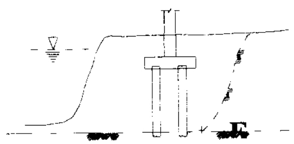
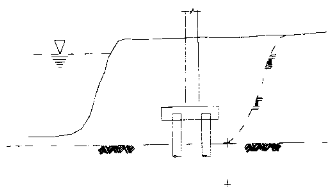
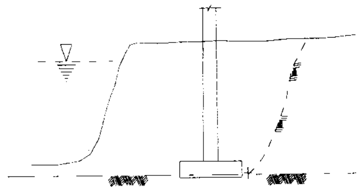
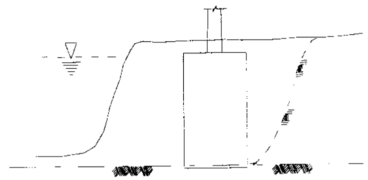
Bridge Axis Direction

Structural Type		Load Case			Design Apply
Type	Design Model	Normal Time	Temperature Time	Earthquake Time	
Rigid Pier		Based on Superstructure Calculation	Same as left	Same as left	P17,P18
Move Pier		N = Rd H = 0 M = 0	N = Rd H = fs*Rd M = fs*Rd*h	N = Rd H = Kh*Rd M = Kh*Rd*h	P6,P14, P20,P23

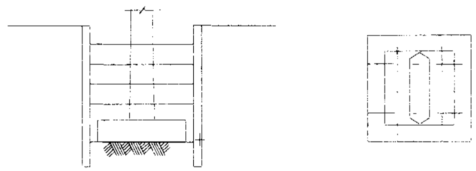
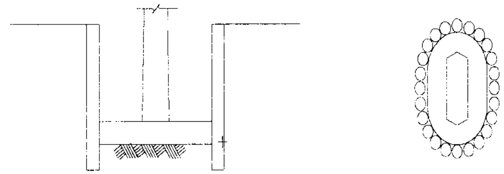
Bridge Transverse Direction

Structural Type		Load Case			Design Apply
Type	Design Model	Normal Time	Temperature Time	Earthquake Time	
Rigid Pier		Based on Superstructure Calculation	Same as left	Same as left	P17,P18
Move Pier		N = Rd H = 0 M = 0	Not Use	N = Rd H = Kh*Rd M = Kh*Rd*h	P6,P14, P20,P23

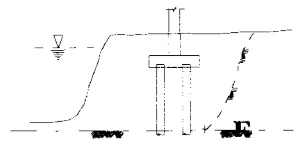
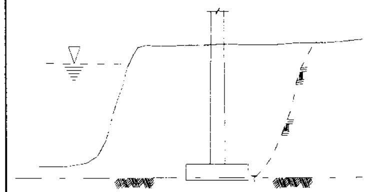
3.3B Comparison of Foundation t Types

■ Foundation Types	 PILE FOUNDATION TYPE 1	 PILE FOUNDATION TYPE 2	 SPREAD FOUNDATION	 OPEN CAISSON
■ Structural Stability and Aesthetics after Erosion	■ Protrusion type pile foundation is not good for stability to the flood and aesthetics. ◆ Evaluation : C	■ Structural stability is good. ◆ Evaluation : A	■ Same as the left ◆ Evaluation : A	■ Same as the left ◆ Evaluation : A
■ Construction Method	1. Cast-in-situ pile 2. Excavation 3. Pile cap	1. Cast-in-situ pile 2. Cofferdam 3. Excavation 4. Pile cap	1. Temporary shuttering or cofferdam 2. Excavation 3. Spread foundation	1. Make caisson shoe 2. Sink caisson
■ Construction Problem	■ Workability of rock drilling ◆ Evaluation : A	■ Workability of cast-in-situ pile and rock drilling ◆ Evaluation : B	■ Deep excavation ■ Stability of shuttering ◆ Evaluation : B	■ Trouble in the sinking of caisson ◆ Evaluation : A
■ Construction Cost	◆ Evaluation : A	◆ Evaluation : B	◆ Evaluation : A	◆ Evaluation : C
■ Total Evaluation	◆ Evaluation : C	◆ Evaluation : B	■ Better ◆ Evaluation : A	◆ Evaluation : C
■ Selection			■ Selected	

3.3C Comparison of Temporary Work Method of Spread Foundation

	Steel Sheet Pile	Concrete Cofferdam
■ **Temporary Work Structure**	 STEEL SHEET PILE	 CONCRETE COFFERDAM
■ **Construction Method**	1. Steel sheet pile 2. Excavation and steel strut 3. Footing and pier 4. Remove of Temporary member	1. Concrete cofferdam 2. Excavation 3. Footing and Pier
■ **Construction Problem**	■ Safety of temporary work ◆ Evaluation : B	■ Difficulty of cofferdam ◆ Evaluation : A
■ **Construction Cost (Ratio)**	■ 1.0 ◆ Evaluation : A	■ 3.5 ◆ Evaluation : C
■ **Total Evaluation**	◆ Evaluation : A	◆ Evaluation : C
■ **Selection**	■ Selected	

3.3D Comparison of Foundation Type (P6 and P23)

Pile Foundation Type 1		Comparison of Construction Cost Type 1 and Spread Foundation	Spread Foundation
■ Foundation Types	 PILE FOUNDATION TYPE 1		 SPREAD FOUNDATION
A. Piling works ∅2.0m	Cost Baht	A. Cofferdam cost	Cost Baht
For 1 pile (a) Drive casing	19,500	(a) Earthworks excavate and backfill	490,000
(b) Excavate in casing	45,000	(b) Sheet piling and associated costs	321,000
(c) Excavate in rock	112,500	(c) Crane costs 3 months	900,000
(d) Steel pipe for casing 7.82 t@20,000/3 (3 uses 1 casing)	52,000	(d) Bracing and pumping costs	320,000
			2,030,000
(e) Remove casing	5,000	B. Pier cost to pile cap level	
(f) Concrete $60m^3$@2,500	150,000	(a) Concrete $223m^3$@ 2,000	446,000
(g) Rebar 14T@13,000	182,000	(b) Rebar 25T@13,000	325,000
(h) Incidentals	20,000	(c) Form $257m^2$@500	128,500
For 1 pile	596,000		900,000
For 6 piles	3,576,000	C. Footing Costs	
		(a) Ground preperation-lean concrete	50,000
B. Pile cap		(b) Form $105m^2$x500	52,500
(a) Concrete $324m^3$@2,000	648,000	(c) Concrete 10x11x2.5x2,000	550,000
(b) Steel 28T@13,000	364,000	(d) Rebar 14Tx13,000	182,000
(c) Form $126m^3$@500	63,000		834,000
(d) Lean concrete and base	35,000		
(e) Excavation and $50/m^3$	E 64,000		
backfill $100/m^3$	B 90,000		
Total Cost	4,840,000	Total Cost	3,765,000

3.4A Riverbank – Thailand Side Bridge Location

- Top of riverbank
- Most unstable under flood conditions
- Easily eroded

- Higher area which is more prone to erosion.
- Silty clay area

- Lower riverbank are slope 1:3 to1:4.
- Area planted and with vegetation, although sandy relatively stable.

3.4B Riverbank – the Lao Side Bridge Location

- Top of riverbank
- Most unstable under flood conditions
- Easily eroded

- Higher area which is more prone to erosion.
- Silty clay area

- Lower riverbank are slope 1:3 to1:4.
- Area planted and with vegetation, although sandy relatively stable.

3.4C Stability Calculation at Savannakhet

			Exist	Place
Minimum Safety		Fs	(A) 1.25	(B) 1.90
Min. Safety	Lallice Co-ordinate	X (m)	21.33	21.33
	Do	Y (m)	141.33	141.33
	Slide Circle radius	R (m)	5.00	6.00
Resistance Moment		MR (tf/m)	51.69	63.98
Mobile Moment		MD (tf/m)	41.31	33.60

No.	Block	(tf/m^3)	CO (tf/m^2)	kl (tf/m^3)	ϕu (°C)
1	Layer – 1	2.00	0.50	0.00	32.00
2	Layer - 2	2.00	10.00	0.00	0.00
3	Layer – 3	2.00	5.00	0.00	0.00
4	Layer - 4	2.00	0.00	0.00	32.00
5	Layer - 5	2.00	0.00	0.00	35.00

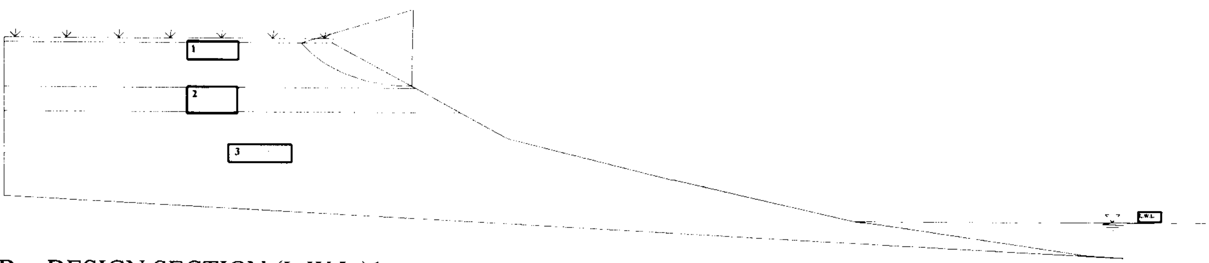
$$Fs = \frac{\Sigma\{(N - ul)\tan\phi + cl\}}{\Sigma S}$$

Where :

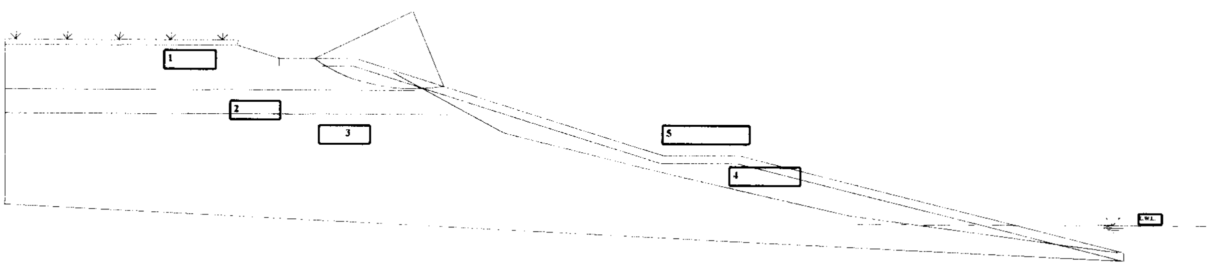
S = $W_v \sin\alpha + W_h \cos\alpha$

N = $W_v \cos\alpha + W_h \cos\alpha$

A. EXISTING SECTION (L.W.L.)



B. DESIGN SECTION (L.W.L.)1



3.4D Design of Geotextile Filter for Revetment System

The design proposal given below is based on Polyfelt design booklet on geotextile revetment filters for riverbank and coastal erosion protection. Reference should be made to this manual at all times on the design and the equations used.

1. Assumption of design parameters

Cohesive soil as back fill material, $I_p > 20\%$
Permeability co-efficient of silty clay = 5×10^{-6}cm/s

2. Geotextile design proposal

2.1 Filtration and Permeability Criteria (cl 1.4)

a) Soil retention criteria – cohesive soils (cl 1.4.3)

From equation 3, with $I_p > 20\%$
$O_{90}(D_w) \leq 0.11$mm
$t_g \geq 1.5$mm

Select Polyfelt TS60, $O_{90}(D_w) = 0.09 < 0.11$mm
$t_g = 2.2 > 1.5$mm

b) Permeability criteria – cohesive soils (cl 1.4.4)

Use equation 5, polyfelt design manual

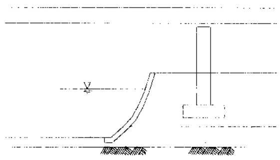
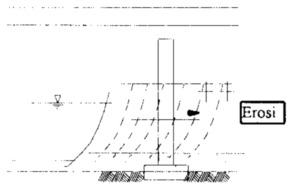
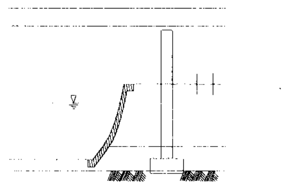
From equation 5, with $k_{geo} \geq 100\ k_s$ where k_{geo} = permeability of geotextile
k_s = permeability of soil

Select polyfelt TS60 $k_{geo} = 0.3$ cm/s > 0.005 cm/s

2.2 Puncture resistance of geotextile

Puncture resistance of the geotextile is not a problem since the riprap of size 0.3m would be put to rest into the gabion cage.

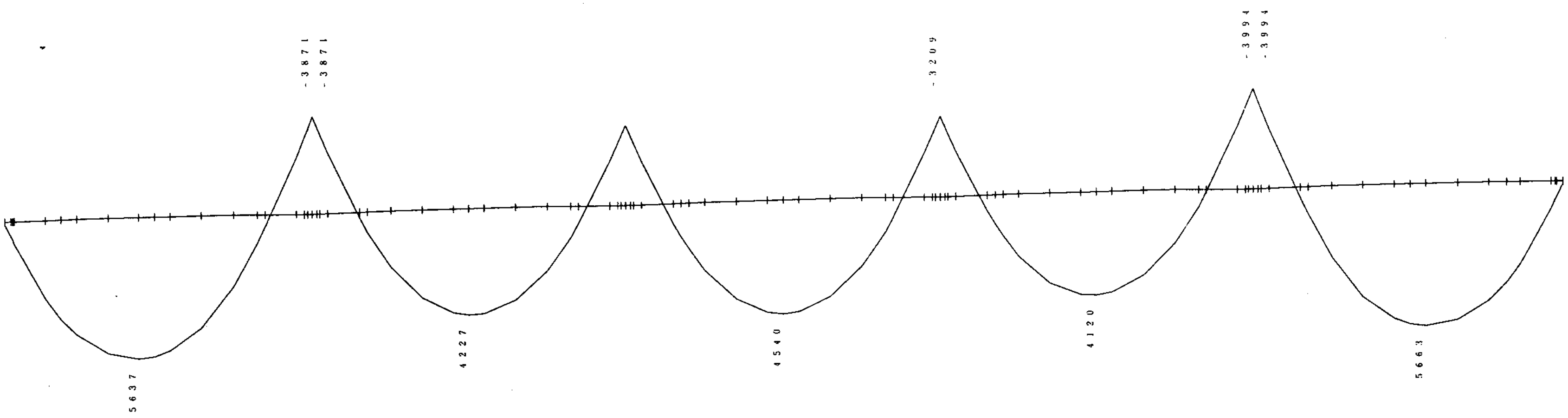
3.4E Types of Pier Foundation and Revetment Necessity

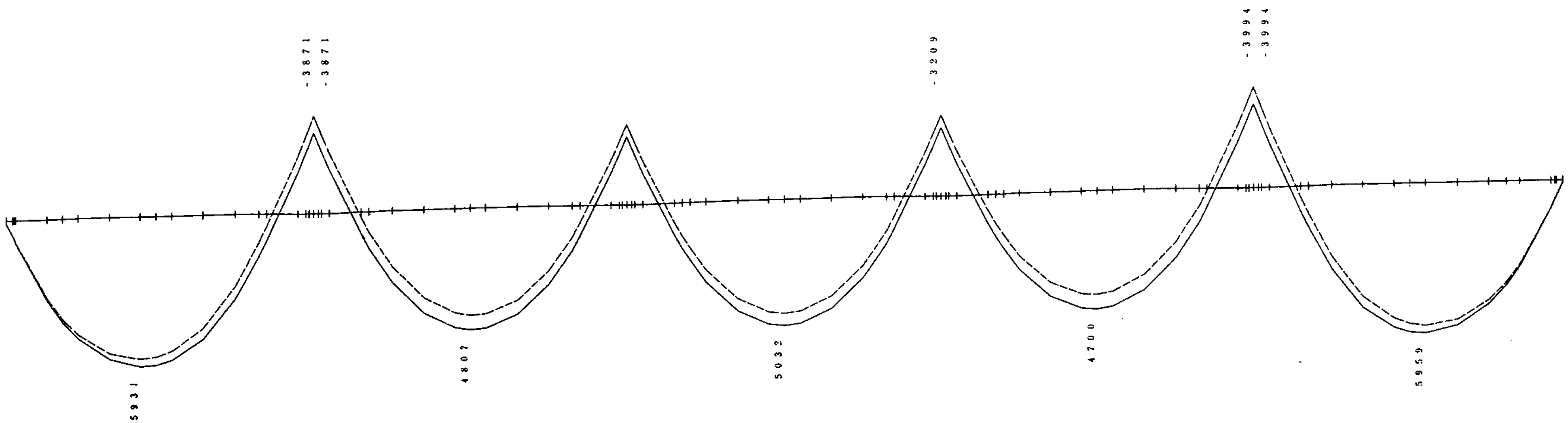
	TypeI : Design of pier foundation without protection of erosion	TypeII : Design of pier foundation with protection of erosion	
		II-1 Without riverbank protection	II-2 With riverbank protection
Design policy of pier foundation	 ● The pier foundation is designed based on the existing ground around the pier. The foundation is not on rock.	 ● The erosion of riverbank caused by flood is considered. The pier foundation is still stable although the soil layers around the pier have been taken away.	 ● Same as the left
Design policy of revetment	● Concrete revetment is required for perfect erosion protection.		● Use of gabion mattress is taken into consideration.
Safety of structure when hit by an abnormal flood.	● The soil layer around the pier foundation will be eroded. As a result, the stability of the structure is effected. ● A dangerous situation will be created. ♦Evaluation : C	● The pier foundation is stable although the riverbank has eroded and the soil near the foundation has been taken away. ● It is not so dangerous even when hit by unexpected big floods. ♦Evaluation : B	● Same as the left ● Same as the left ● The erosion problem is less than the other type. The pier foundation is highly stabilized. ♦Evaluation : A
Necessity of revetment	● Existing riverbank will have the soil loosened by pier construction (excavation piling etc.). Therefore erosion will be accelerated. ● The scour of riverbed and the flow of water direction at the pier next to the bank may also accelerate such erosion.	♦Evaluation : C	● Same as the left ♦Evaluation : B
Maintenance of Revetment	● In order to prevent the erosion of riverbank around the pier, the maintenance of the revetment is very important. ● Maintenance is necessary. ♦Evaluation : A		● Basically, maintenance is not necessarily required. But it is better to do to ensure the efficiency of the revetment. ♦Evaluation : B
Revetment Cost	● Initial cost $5{,}000^{BT}/m^2$=21,500,000 Baht ♦Evaluation : B		● Initial cost $1{,}600^{BT}/m^2$=7,000,000 Baht ♦Evaluation : B
Total evaluation	♦Evaluation : C	♦Evaluation :B	♦Evaluation : A
Selection			Selected

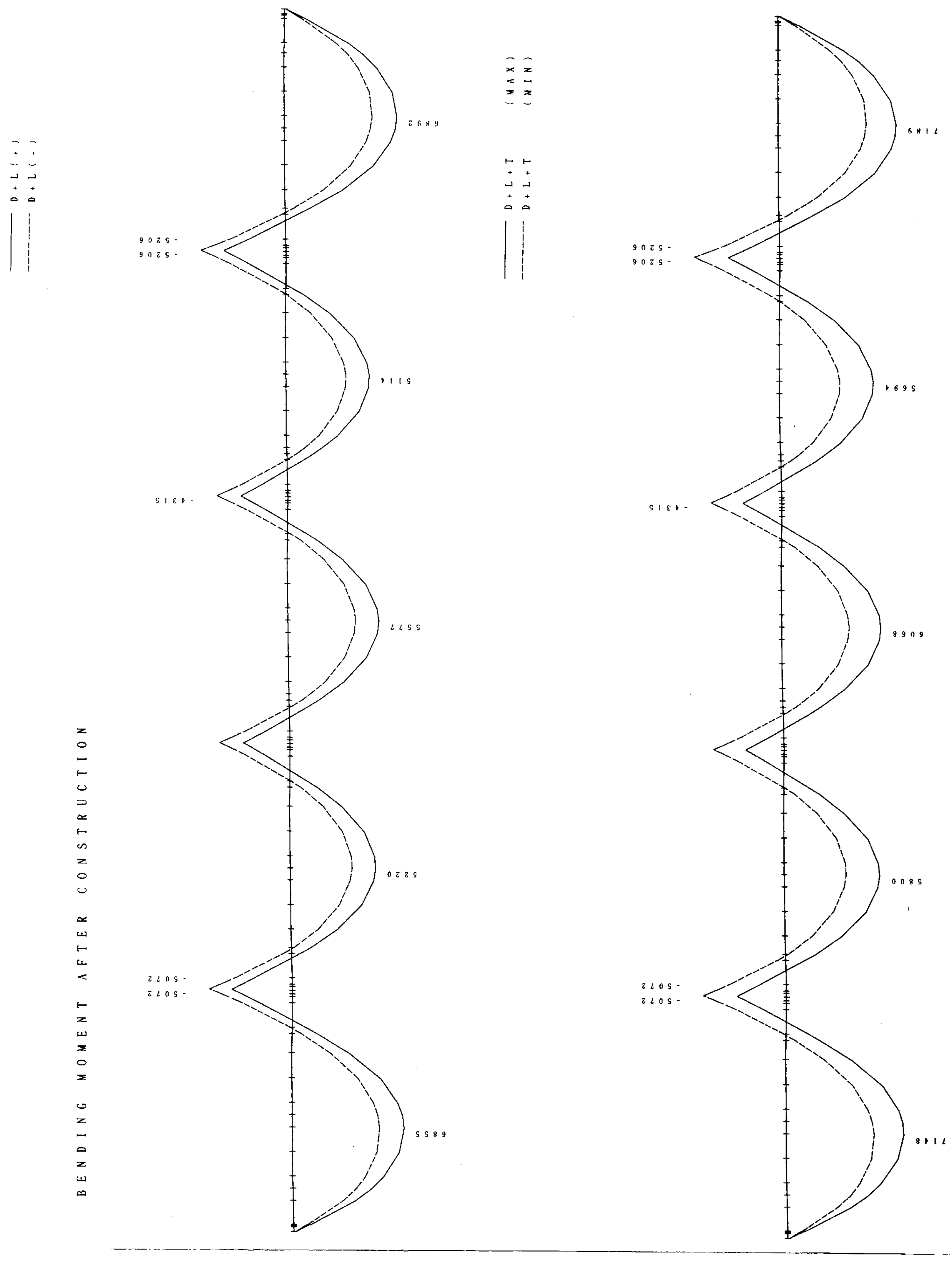
4.2A Bending Moment and Sharing Force Diagram

Unit : ton • m

BENDING MOMENT AFTER CONSTRUCTION

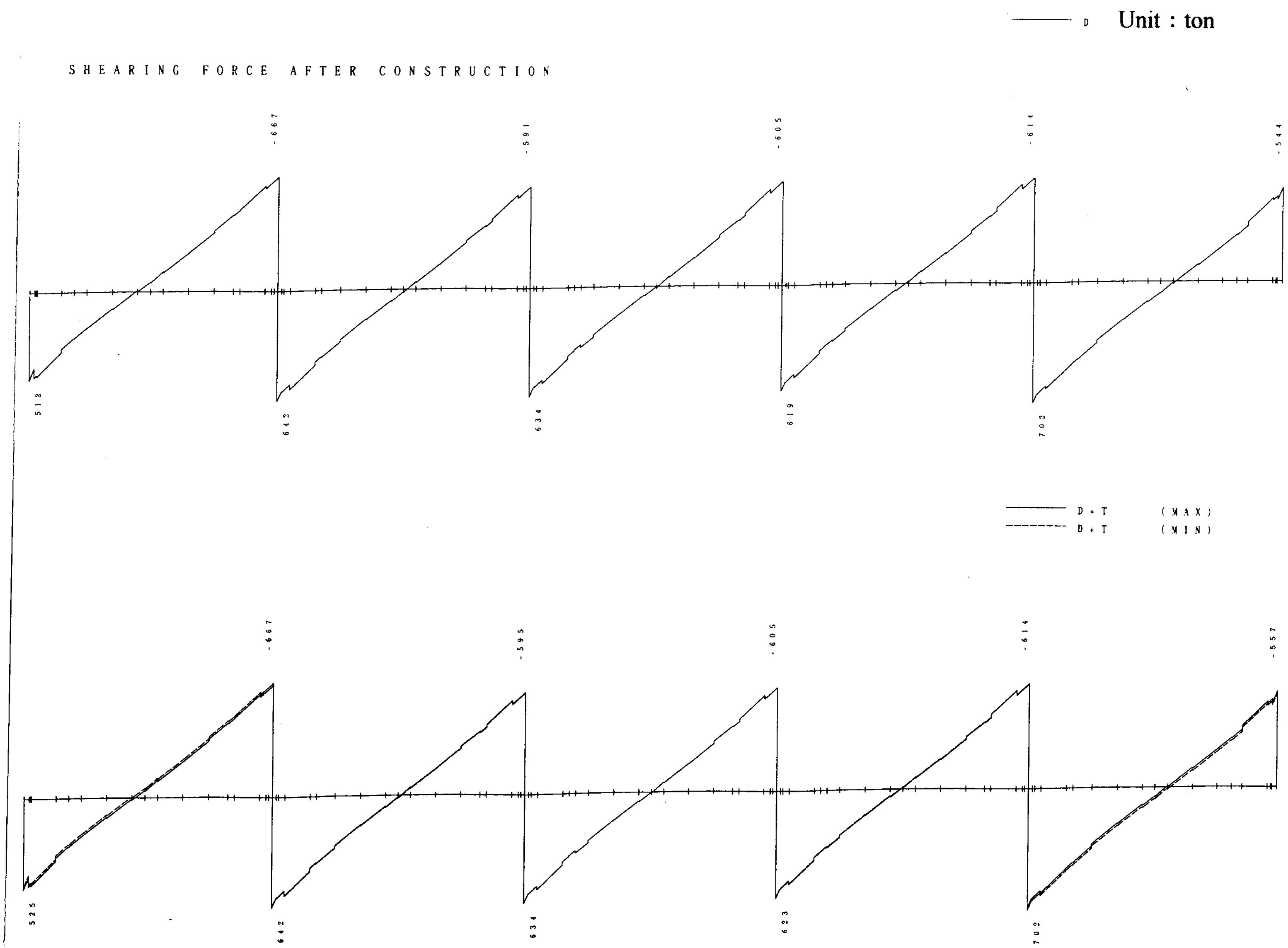




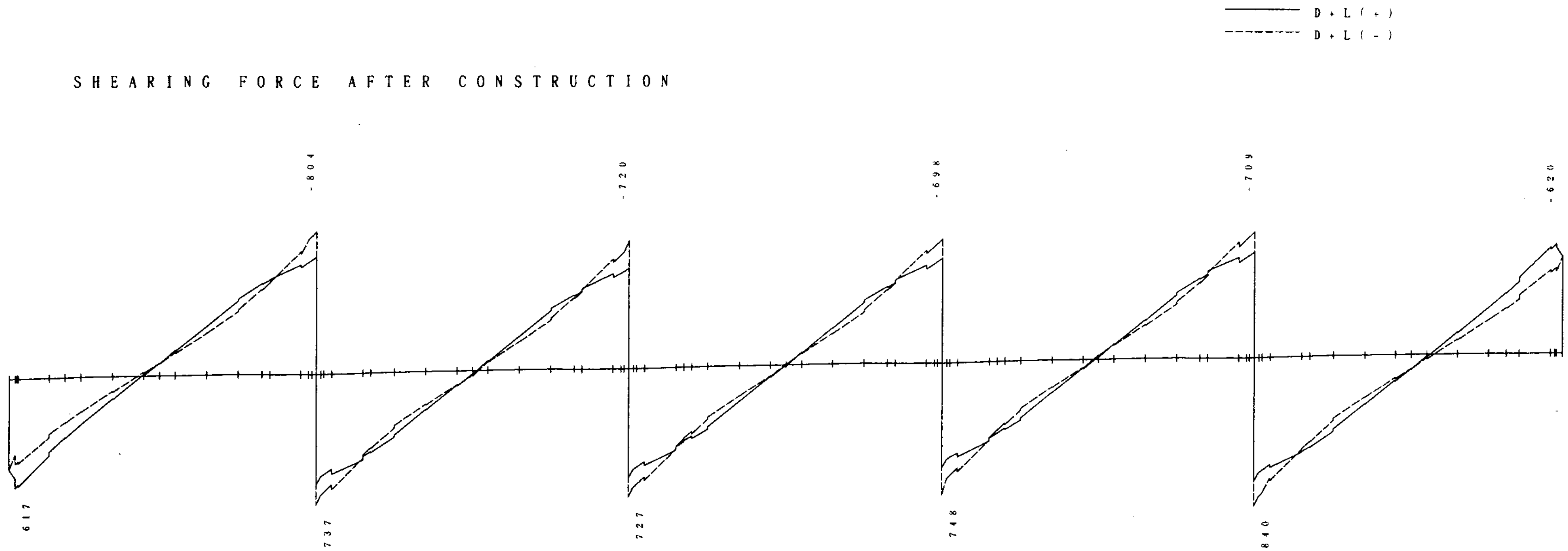

BENDING MOMENT AFTER CONSTRUCTION
D+L(+)
D+L(-)
D+L+T (MAX)
D+L+T (MIN)
6892
-5206
-5206
5114
-4315
5577
5220
-5072
-5072
6855
7189
-5206
-5206
5694
-4315
6068
5800
-5072
-5072
7148

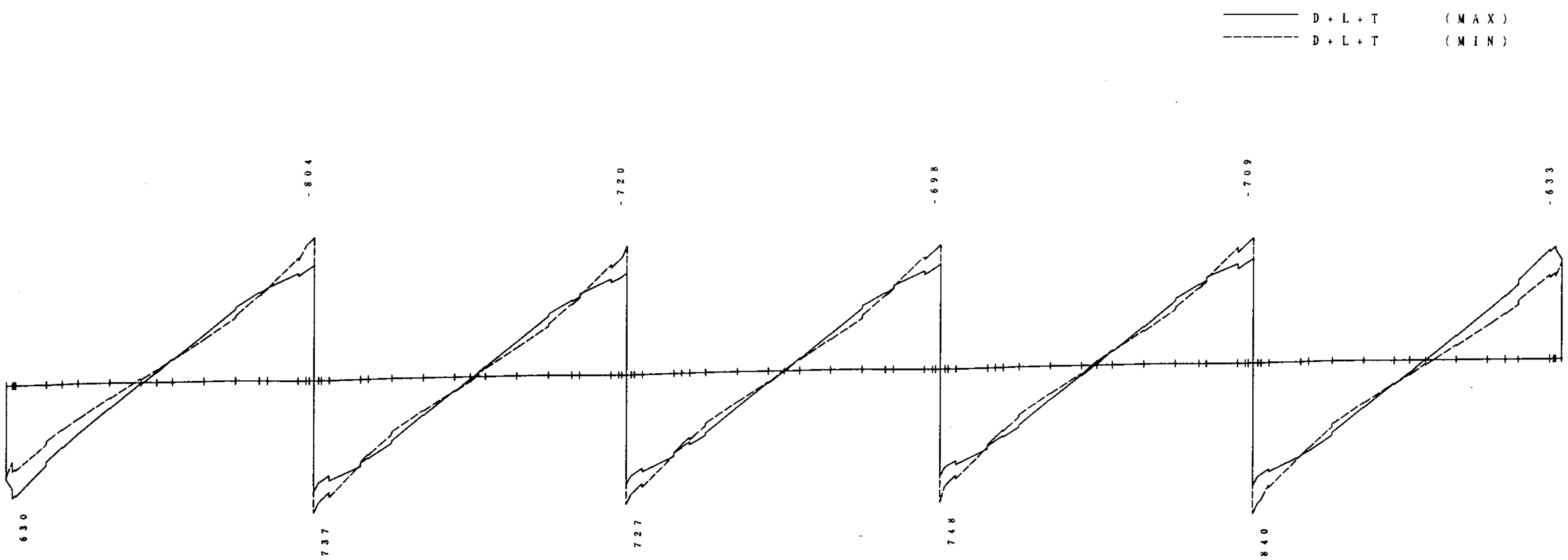
Unit : ton

SHEARING FORCE AFTER CONSTRUCTION



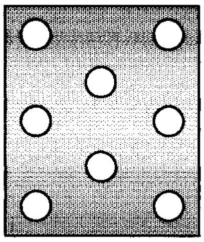
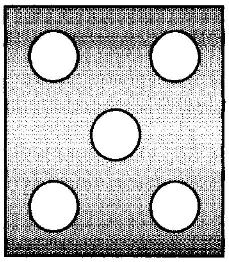
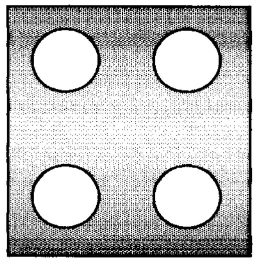
SHEARING FORCE AFTER CONSTRUCTION





4.3A Comparison of Cast-in-situ Pile of Approach Viaduct

Comparison of Cast-in-situ Pile

Pile diameter	ϕ 1.0m	ϕ 1.5m	ϕ 2.0m
Pile Location			
Pile Number	8-piles/pier	5-piles/pier	4-piles/pier
Pile Cap Size (axis*transverse)	7.500m * 8.500m	9.000m * 8.500m	9.000m * 9.000m
Economical Efficiency	A	B	C
Ease of Construction	A	B	C
Evalution	A : Adoption	B	C

8.1A Questionnaire for Interview Form

QUESTIONAIRE
SOCIO-ECONOMIC AND ATTITUDE TO THE PROJECT

ENVIRONMENTAL SURVEY
FOR
THE DETAILED DESIGN
OF
THE SECOND MEKONG INTERNATIONAL BRIDGE
CONSTRUCTION PROJECT
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC
AND
THE KINGDOM OF THAILAND

NAME .... DATE ....

HOME NUMBER ....VILLAGE .... INTERVIEW BY : ....

SUB-DISTRICT ....

DISTRICT.. CHECK BY : ....

PROVINCE ....

1. General Information

1.1 Age .... years

1.2 Gender

1. Male 2. Female

1.3 Education Attainment

01. Illiterate

02. Highest Education

    2.1 Primary School
    2.2 Junior High School
    2.3 High School
    2.4 Diploma
    2.5 Bachelor Degree or Equal
    2.6 Master Degree or Higher

1.4 What religious do you respect ?

1. Buddhism 2. Christ

3. Muslim 4. Others...............................

1.5 What status are you in your family ?

1. Head 2. Wife

3. Son/Daughter/Son in law/ Daughter in law

4. Relative 5. Others...............................

2. Information of household member

2.1 Number of household member

1. Male .... persons
2. Female .... persons

2.2 Age of household member

1. > 60 and unemployed .... persons
2. < 6 .... persons
3. 6-13 (Age to be a subject of education) .... persons
4. 14-60 or upper (but still working) .... persons

2.3 Occupation of household member

1. Base on economic
2. Non-based on economic

3. Socio-Economic Information of household

Use this code to answer the question 3.1-3.2

1. Trader/Merchant	2. Government Employee
3. Private Company Employee	4. Ownership
5. Agriculture	6. Student/College student
7. Transportation	8. Others..............................
9. Unemployed	10. No answer

3.1 Major Occupation...

3.2 Minor Occupation...

3.3 Average Income of household/month (Approximately)

1. < 5,000 Baht	2. 5,001 - 10,000 Baht	
3. 10,000 - 15,000 Baht	4. 15,001 - 20,000 Baht	
5. 20,001 - 25,000 Baht	6. 25,001 - 30,000 Baht	
7. 30,001 - 40,000 Baht	8. 40,001 - 50,000 Baht	
9. 50,001 - 60,000 Baht	10. 60,001 - 70,000 Baht	
11. 70,001 - 80,000 Baht	12. 80,001 - 90,000 Baht	
13. 90,001 - 100,000Baht	14. > 100,000Baht	
15. Unemployed/No answer		

3.4 Type of household earning

1. Stable Earning
2. Pretty Stable Earning
3. Unstable

3.5 Average Expenditure of household/month (Approximately)

1. < 5,000 Baht	2. 5,001 - 10,000 Baht
3. 10,000 - 15,000 Baht	4. 15,001 - 20,000 Baht
5. 20,001 - 25,000 Baht	6. 25,001 - 30,000 Baht
7. 30,001 - 40,000 Baht	8. 40,001 - 50,000 Baht
9. 50,001 - 60,000 Baht	10. 60,001 - 70,000 Baht
11. 70,001 - 80,000 Baht	12. 80,001 - 90,000 Baht
13. 90,001 - 100,000 Baht	14. > 100,000 Baht
15. Unemployed/No answer	

3.6 Type of Building

01) Appearance of house

- 1.1 Single house
- 1.2 Townhouse
- 1.3 Commercial Building
- 1.4 Apartment
- 1.5 Others..............................

02) Purpose of using this building

- 2.1 For living only
- 2.2 For commercial purpose only
- 2.3 For both
- 2.4 Others..............................

03) Right of possessing in house/building

- 3.1 Owner
- 3.2 Parents' own
- 3.3 Leasing

04) Value of Land and Property

4.1 Value of House Structure ____________
4.2 Value of House Ground ____________
4.3 Value of Economic Trees ____________

4. Environmental Location

4.1 Distance from home to workplace

1. At/Adjacent to home   2. < 500 m.
3. 0.5 - 1.0 km   4. 1.0 - 5 km
5. > 5 km

4.2 Convenience Travelling (from home to workplace)

1. Very Convenience   2. Pretty Convenience
3. Not so Convenience   4. Hard

4.3 Convenience Travelling (from home to market/District)

1. Very Convenience   2. Pretty Convenience
3. Not so Convenience   4. Hard

4.4 Fertilizer of infrastructure and public service in your community

4.4.1 Electricity	:	1.	Provide	2.	Non-provide
4.4.2 Water Supply	:	1.	Provide	2.	Non-provide
4.4.3 Garbage Pick up Service	:	1.	Provide	2.	Non-provide
4.4.4 Public Telephone	:	1.	Provide	2.	Non-provide

4.5 Environmental in living place

1. Good   2. Fair
3. Bad

4.6 Safety in life and property

1. Very Safety   2. Fair
3. Dangerous

4.7 Relationship in your community

1. None   2. Few
3. Moderate   4. Much

4.8 Desirable Satisfication in your community

1. Very Satisfy   2. Satisfy
3. Still   4. not so satisfy

4.9 What character of community do you prefer ?

1. Living Place Areas   2. Trading/Business Areas
3. Rural Areas/Agriculture Area

4.10 Opinion on moving out of your place

1. None

   Why ?

   1. Not acquaintance to new location
   2. Occupation/Income
   3. Education for Children
   4. Moving Expenses
   5. Loose neighbourhood
   6. Others

2. Willing

   Why ?

   1. Not so convenience in travelling
   2. Worse Environment

5. Land utilization and type of farm holding land

5.1 Farm size ____________ Rai/household

5.2 Land Utilization (rai/house hold)

Paddy land ____________
Under field crops ____________
Under fruit tree ____________
Under vegetable ____________
Grass land ____________

Other land ______________

5.3 Right of possessing in land holding

1. Owner 2. Leasing
3. Using in others' own for free

5.4 Land Tennurial Status ______________

5.5 Assess in land

1. Unknown
2. Known ; About ______________ Baht/wah^2
   Remark : the wah is a linear measure equivalent to two meters

5.6 Price of land sale

1. Unknown
2. Known ; About ______________ Baht/wah^2

6. Information about Project

6.1 Do you get information about this project ?

1. No
2. Yes From
   - 2.1 Survey officer
   - 2.2 District officer
   - 2.3 neighbourhood

6.2 Opinion about project after you get information ?

1. Silent/Narmal
2. Anxiety about
   - 2.1 General
   - 2.2 Investment
   - 2.3 Expropriate lands.

6.3 Do you want add information about this project ?

1. No
2. Yes about
   - 2.1 Steady route.
   - 2.2 Project characteristic
   - 2.3 Project detail
   - 2.4 Compensation
   - 2.5 Impact from this project

7. Attitude about Project

7.1 Advantage and remainder from this project

7.1.1 Advantage -

1. Good transportation and communication
2. Development community
3. Good economic
4. No opinion

7.1.2 Remainder

1. Lose residence and land
2. Traffic jam
3. Pollution
4. No opinion

7.2 Opinion about this project

1. Approve because
   - 01 Good transportation
   - 02 Good economic
2. Not approve because
   - 01 Lose residence and land
   - 02 Community don't get advantage
   - 03 Not necessary
3. Hesitate because
   - 01 Information about project is not clear.
   - 02 Information about impact is not clear.

8. Expectation about impact from this project

8.1 What do you expect about impact/damage from this project? (Answer more than 1)

1. Lose your home
2. Lose land for agriculture.
3. Lose residence
4. Lose building
5. Lose orchard

8.2 Do you think this project make you to migration?

1. Yes because 01 Lose whole of land -
   02 Lose land for agriculture
   (If you answer Yes, to No.8.3-8.4)

2. No because 01 Your residence is not expropriate.
   02 Other...

8.3 Migration

8.3.1 If you're migrated. Where do you want to stay ?

1. Nearby Village. Because ....
2. Other place. Distance from village .... kms.

8.3.2 Can you find new living place. ?

1. Yes
2. No
3. Uncertain -

8.3.3 What do you think about problem of migration. ?

1. No problem
2. Yes because 01 ....
   02 ....
   03 ....

8.4 What do you want to help from government for migration? (Answer more than 1)

1. Provide new residence
2. Provide land for agriculture and support occupation.
3. Pay for indemnity.
4. Provide Infrastructure in new place.
5. Education for childen.
6. Market for agriculture product.
7. No opinion.

9. Opinion on Environmental Impact from this Project During Construction and Operation

9.1 Environmental Impact During Construction

1. No Impact
2. Receive Impact (To No. 9.1.1)

9.1.1 Characteristics of Impact (Multiple Answers Possible)

01 Noise Pollution

02 Vibration

03 Dust

04 Obstruction on Path

05 Occupation

 5.1 Advantages

  1. Increase Income
  2. Others (Please Specify)..

 5.2 Disadvantages

  1. Not so convenience in travelling -
  2. Lose land for agriculture
  3. Change your occupation
  4. Others (Please Specify)..

06 Safety in Life and Property

 1. Supervisory on project
 2. Others (Please Specify)...

9.1.2 Recommendation to Reduce Impact

01 Noise Pollution

 1. Construction on Daytime
 2. Solved by Constructor
 3. Hasty Construction
 4. No Opinion
 5. Others (Please Specify)..

02 Vibration

 1. Solved by Constructor
 2. Hasty Construction
 3. Construction on Daytime
 4. No Opinion
 5. Others (Please Specify)..

03 Dust

 1. Solved by Constructor
 2. Hasty Construction
 3. Construction on Daytime
 4. Inject by Water
 5. No Opinion
 6. Others (Please Specify)..

04 Obstruction on Path

 1. Solved by Constructor
 2. Hasty Construction -
 3. Construction on Daytime
 4. Inject by Water
 5. No Opinion
 6. Others (Please Specify)..

05 Occupation

 1. To Construct the temporary road.
 2. Prefer the government provides alternative residence
 3. No Opinion
 4. Others (Please Specify)..

06 Safety in Life and Property

9.2 Environmental Impact During Operation

 1. No Impact
 2. Receive Impact (To No. 9.2.1)

9.2.1 Air Pollution

01 Impact

 1. Better
 2. Worse
 3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. To plant on road shoulder
2. Monitoring after the project is operated
3. Others (Please Specify)...

9.2.2 Noise Pollution

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. Monitoring after the project is operated
2. Installed Noise Barrier
3. No Opinion
4. Others (Please Specify)...

9.2.3 Travelling from home to land for agriculture

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. To construct the new road
2. To construct the cross way
3. No Opinion
4. Others (Please Specify)...

9.2.4 Travelling from home to market/district

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. To construct the new road
2. To construct the cross way
3. No opinion
4. Others (Please Specify)...

9.2.5 Visual Aesthetics

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. To plant
2. To construct the cross way
3. No opinion
4. Others (Please Specify)..

9.2.6 Occupation

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. Prefer the government provides alternative residence
2. No opinion
3. Others (Please Specify)..

9.2.7 Economics/Trade of Locality

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. Supervisory on Project
2. No opinion
3. Others (Please Specify)..

9.2.8 Land Value

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations

1. No opinion
2. Others (Please Specify)..

9.2.9 Relationship in Your Community

01 Impact

1. Better
2. Worse
3. No Impact

02 Level of Impact

1. High
2. Moderate
3. Low

03 Recommendations
1. No opinion
2. Others (Please Specify)...

9.2.10 Mentality

01 Impact
1. Better
2. Worse
3. No Impact

02 Level of Impact
1. High
2. Moderate
3. Low

03 Recommendations
1. Reduced Pollution
2. Monitoring after the project is operated.
3. No opinion
4. Others (Please Specify)...

9.2.11 Safety in Life and Property

01 Impact
1. Better
2. Worse
3. No Impact

02 Level of Impact
1. High
2. Moderate
3. Low

03 Recommendations
1. No opinion
2. Others (Please Specify)...

10. Opinion on expropriate and compensation

10.1 Opinion on expropriate
1. Pleasure (no conditions)
2. No Problem if the government fairly compensates
3. Uncertain
4. Do not want the expropriate

10.2 Opinion on compensation
1. Cash compensation
2. Prefer the government provides alternative residence
   2.1 Desired Area
      1.) Around
      2.) Convenience Travelling
   2.2 Type/Character of building
      1.) Commercial Building
      2.) Single house
3. Some cash and provide alternative residence

10.3 Period of compensation in the cash compensation case
1. whole compensate in one time
2. with in .... months.

10.4 The appropriate assess land method
1. Consider follow the present assess of Department of land.
2. Consider with present sale price

10.5 The appropriate compensation method

1. Supported who have no own lands.
2. Fairly compensate for buying new land.
3. Compensates equal to the land that is expropriated
4. Deal with the officer whom may be concerned in direct.
5. No opinion

10.6 Other Need (except the compensation, land, property and moving expenses)

1. Monitoring after the project is operated
2. Provide infrastructures in the alternative residence
3. Compensate for the time to find new residence
4. Provide the residence with home
5. No opinion

Comment : ....

....

....

....

....

....

....

8.1B Environmental Monitoring Program

Environmental Quality	Location/ Sampling Station	Monitoring Parameter	Period/Frequency	Estimated Expence	Responsible Agency
1. Water Quality	1. 1,000 m. upstream of the Bridge 2. 1,000 m. downstream of the Bridge	1. Temperature 2. pH 3. Turbidity 4. Conductivity 5. DO 6. COD 7. BOD_5 8. SS 9. Oil & Grease 10. Faecal Coli Form Bacteria	Construction Phase - 3 times/year in dry season (Feb. to May), winter season (Nov. to Jan.) and rainy season (Jun. to Oct.). Operation Phase - 3 times/year in dry season (Feb. to May), winter season (Nov. to Jan.) and rainy season (Jun. to Oct.) for the first 3 years of operation phase after that sampling frequency will be modified. Modification will be depend on the first 3 years results.	- 50,000 baht/station/time (300,000 baht/year)	- Construction phase by Contractor - Operation phase by DOH & MCTPC
2. Aquatic Ecology	1. 1,000 m. upstream of the Bridge 2. 1,000 m. downstream of the Bridge	1. Plankton 2. Benthic Organisms	Construction Phase - 3 times/year in dry season (Feb. to May), winter season (Nov. to Jan.) and rainy season (Jun. to Oct.). Operation Phase - 3 times/year in dry season (Feb. to May), winter season (Nov. to Jan.) and rainy season (Jun. to Oct.) for the first 3 years of operation phase after that sampling frequency will be modified. Modification will be depend on the first 3 years results.	- 40,000 baht/station/time (240,000 baht/year)	- Construction phase by Contractor - Operation phase by DOH & MCTPC

Environmental Quality	Location/ Sampling Station	Monitoring Parameter	Period/Frequency	Estimated Expence	Responsible Agency
3. Air Quality	1. Thai Side - Ban Song Puai - Ban Khok Sung 2. Lao Side - Interchange of Route No.9 & Kaysone Road.	1. Total Suspended Particles (TSP-24 hr.) 2. Particle Matter (PM-10 (24 hr.)) 3. Nitrogen Dioxide (NO_2) 4. Carbon Monoxide (CO)	Construction Phase - 2 times/year in dry season (Febuary-May) and winter season (November-January) - Each sampling period must be carried out for 3 consecutive day. Operation Phase - 2 times/year in dry season (Feb. to May) and winter season (Nov. to Jan.) for the first 3 years of operation phase after that sampling frequency will be modified. Modification will be depend on the first 3 years results. - Each sampling period must be carried out for 3 consecutive day.	- 150,000 baht/station/time (1,350,000 baht/year)	- Construction phase by Contractor - Operation phase by DOH & MCTPC
4. Noise Level	1. Thai side - Ban Song Puai - Ban Khok Sung 2. Lao side - Interchange of Route No.9	1. Leq-24 hr. 2. Ldn.	Construction Phase - 2 times/year in dry season (February-May) and winter Season (November-January) - Each Sampling period must be carried out for 3 consecutive day. Operation Phase - 2 times/year in dry season (Feb. to May) and winter season (Nov. to Jan.) for the first 3 years of operation phase after that sampling frequency will be modified. Modification will be depend on the first 3 years results. - Each sampling period must be carried out for 3 consecutive day.	- 120,000 bath/station/time (720,000 baht/year)	- Construction phase by Contractor - Operation phase by DOH & MCTPC

Environmental Quality	Location/ Sampling Station	Monitoring Parameter	Period/Frequency	Estimated Expence	Responsible Agency
5. Vibration	1. Thai side - Ban Song Puai - Ban Khok Sung 2. Lao side - Interchange of Route No.9	1. Peak Particle Velocity (PPV) 2. Frequency	Construction Phase - 2 times/year in dry season (February-May) and winter Season (November-January) - Each Sampling period must be carried out for 3 consecutive day. Operation Phase - 2 times/year in dry season (Feb. to May) and winter season (Nov. to Jan.) for the first 3 years of operation phase after that sampling frequency will be modified. Modification will be depend on the first 3 years results. - Each sampling period must be carried out for 3 consecutive day.	- 120,000 bath/station/time (720,000 baht/year)	- Construction phase by Contractor - Operation phase by DOH & MCTPC
6. Socio-economic	Households nearby the construction site (About 100 samples)	1. The project information perception 2. The impact during construction period 3. Opinion and attitude toward the project 4. Problems and needs and Suggestion Proposed for the project's consideration	Construction Phase - Every 6 months Operation Phase - Every 6 months for the first 3 years of operation phase after that sampling frequency will be modified. Modification will be depend on the first 3 year results.	- 50,000 baht/time (100,000 baht/year)	- Construction phase by Contractor - Operation phase by DOH & MCTPC

APPENDIX 9.1

ESTIMATION OF EACH CURRENCY COMPONENTS OF THE CONSTRUCTION COST

The Construction cost will be estimated by dividing the cost into foreign portion in US$ and local portion in Thai Baht according to assumed actual procurement sources of the construction material, equipment and manpower. The method how to divide the cost into the respective currency portion is introduced hereinafter.

1. DIRECT COST

1.1 Material Cost

a. Materials which will be newly imported for the Project

95 % of the material cost is deemed to be foreign portion considering such local portions as cost of custom duty and inland transportation.

e.g. Bearing shoe

There is no material corresponding to this kind of material in Package 2 and 3.

b. Material which will be procured in the local market

Assumed shadow cost related to the foreign material, equipment and fuel in its total production cost is deemed to be foreign portion. Ratio of the foreign portion of the material will be assumed respectively.

Ratio of the Components (tentative)

e.g. Item	Foreign(%)	Local (%)
Cement	20	80
Re-bar	40	60
P.C. strand	60	40
Sand & Gravel	30	70

1.2 Machinery and Equipment Cost

a. Common Construction Equipment Available in the Local Market

50 % of its depreciation cost is deemed to be foreign portion, if the equipment was imported before.

Note; Equipment cost for these equipment will be based on the rental price of the local market.

b. Special Construction Equipment newly imported from overseas for the Project

100% of its depreciation cost deemed to be foreign portion.

e.g. Reverse circulation drilling machine(Dia.2,000)

All-casing drilling machine (Dia.1,000)

Main girder production facilities

Gantry Crane (130t)

Main girder erection facilities

Crawler crane (>80t)

Vibration hammer (90kw) , etc

Note; Equipment cost for these equipment will be based on standard equipment prices in Japan

1.3 Labor Cost

a. Common Construction Works

All labor cost are deemed to be local portion.

Note; Labor cost will be based on local market prices.

b. Special Construction Works

Labor cost of foreman and skilled labor is deemed to be foreign portion.

e.g. Main girder production work (inclu. P.C. work)

Main girder erection work (inclu. P.C work)

R.C. Cast in place pile (Dia. 2,000 and Dia. 1,000)

Main tower and P.C sail (concrete and P.C. works)

Note; Labor cost of the foreman and the skilled labor will be based on the standard price in Japan

2. Indirect Cost

Considering the condition that bidding will be done by the I.C.B procedure, 75 % of the total indirect cost, which is assumed to correspond to the following items, is deemed to be foreign portion.

- Head office management cost
- Contractor’s profits
- Foreign engineer’s cost at site
- Foreign component in common temporary works