MINISTRY OF COMMUNICATION, TRANSPORT,
POST AND CONSTRUCTION
LAO PEOPLE'S DEMOCRATIC REPUBLIC

No. 1

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR RECONSTRUCTION OF BRIDGES
ON
THE NATIONAL ROAD ROUTE 13, PHASE II
IN
LAO PEOPLE'S DEMOCRATIC REPUBLIC

OCTOBER 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
ORIENTAL CONSULTANTS CO., LTD.
JAPAN OVERSEAS CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Government of the Lao People's Democratic Republic, the Government of Japan decided to conduct a basic design study on The Project for Reconstruction of Bridges on the National Road Route 13, Phase Ⅱ and entrusted the study to the Japan International Cooperation Agency (JICA).

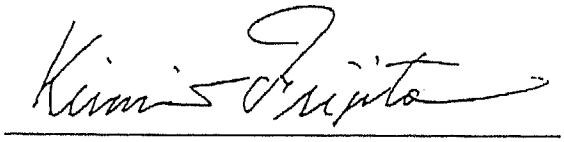
JICA sent to Lao a study team from February 2nd to March 24th and July 2nd to July 16th, 1997.

The team held discussions with the officials concerned of the Government of Lao, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Lao in order to discuss a draft basic design, and as this result, the present report was finalized.

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

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

October 1997



Kimio Fujita
President
Japan International Cooperation Agency

October, 1997

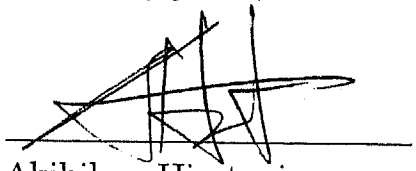
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Reconstruction of Bridges on the National Road Route 13, Phase II in the Lao People's Democratic Republic.

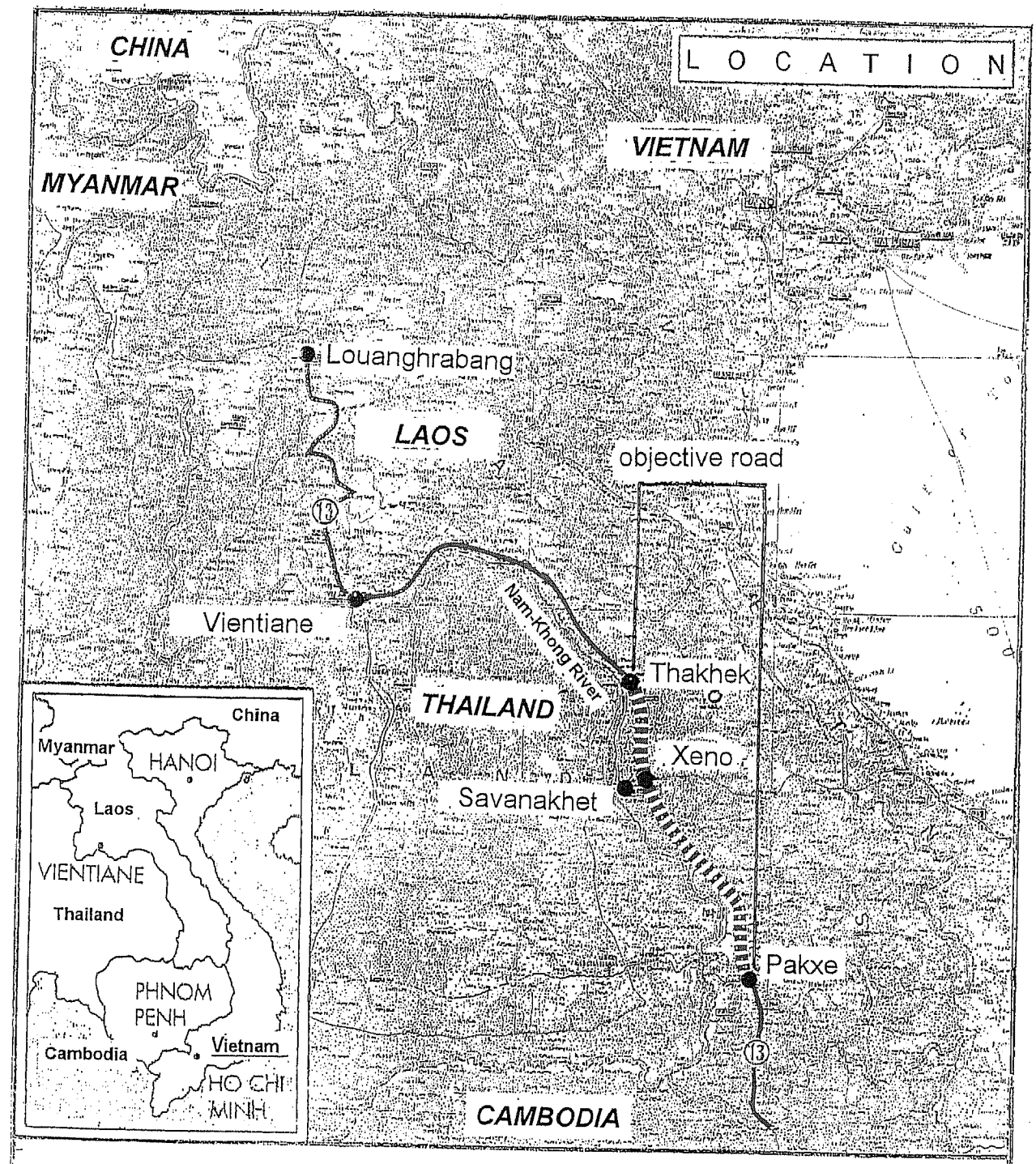
This study was conducted by Oriental Consultants Company Limited and Japan Overseas Consultants Company Limited under a contract to JICA, during the period from January 24th 1997 to October 14th 1997. In conducting the study ,
we have examined the feasibility and rationale of the project with due consideration to the present situation of Lao and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

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

Very truly yours,



Akihiko Hirotani
Project manager,
Basic design study team on
the Project for Reconstruction of Bridges
on the National Road Route 13, Phase II
Oriental Consultants Company Limited



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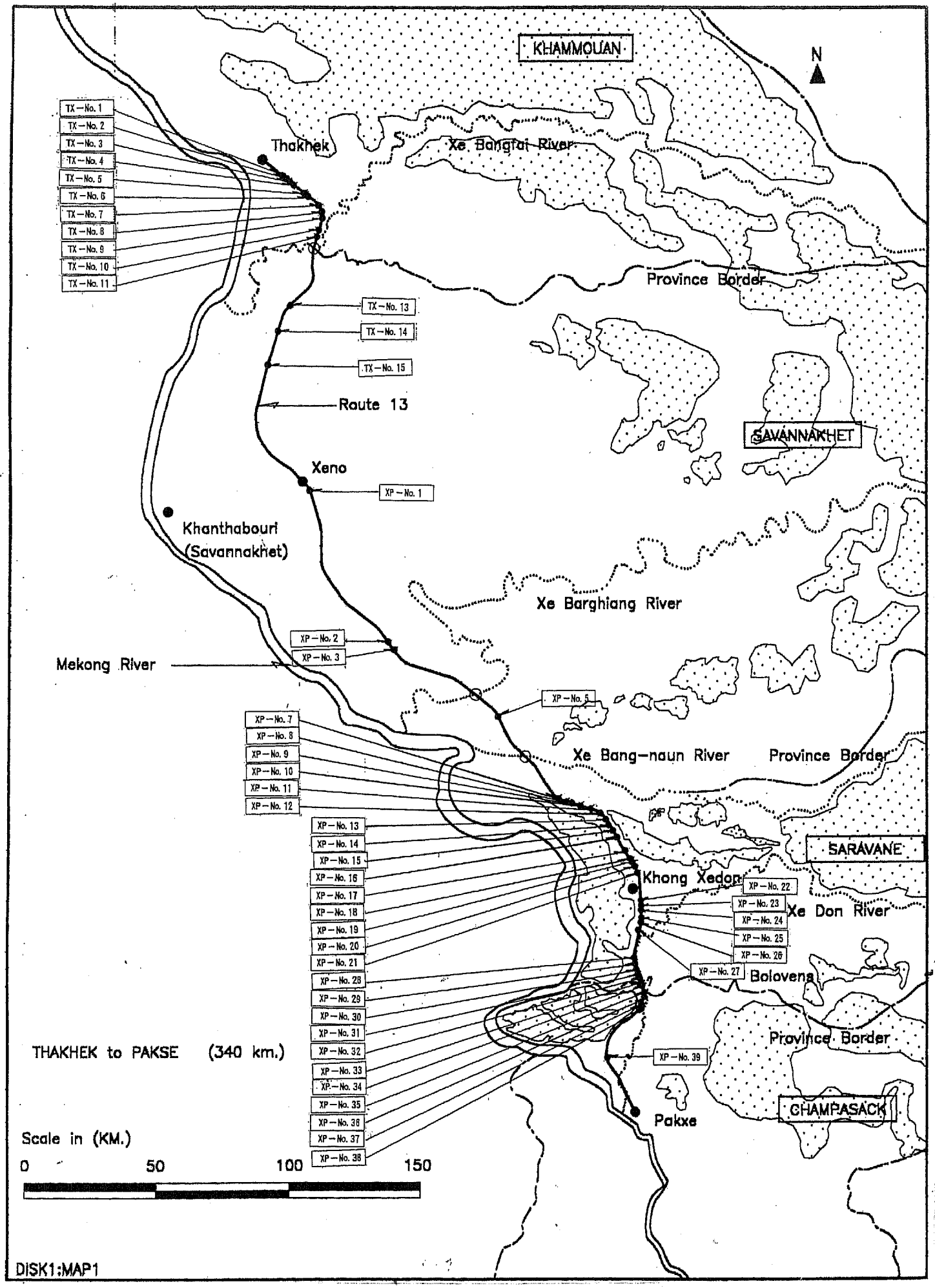
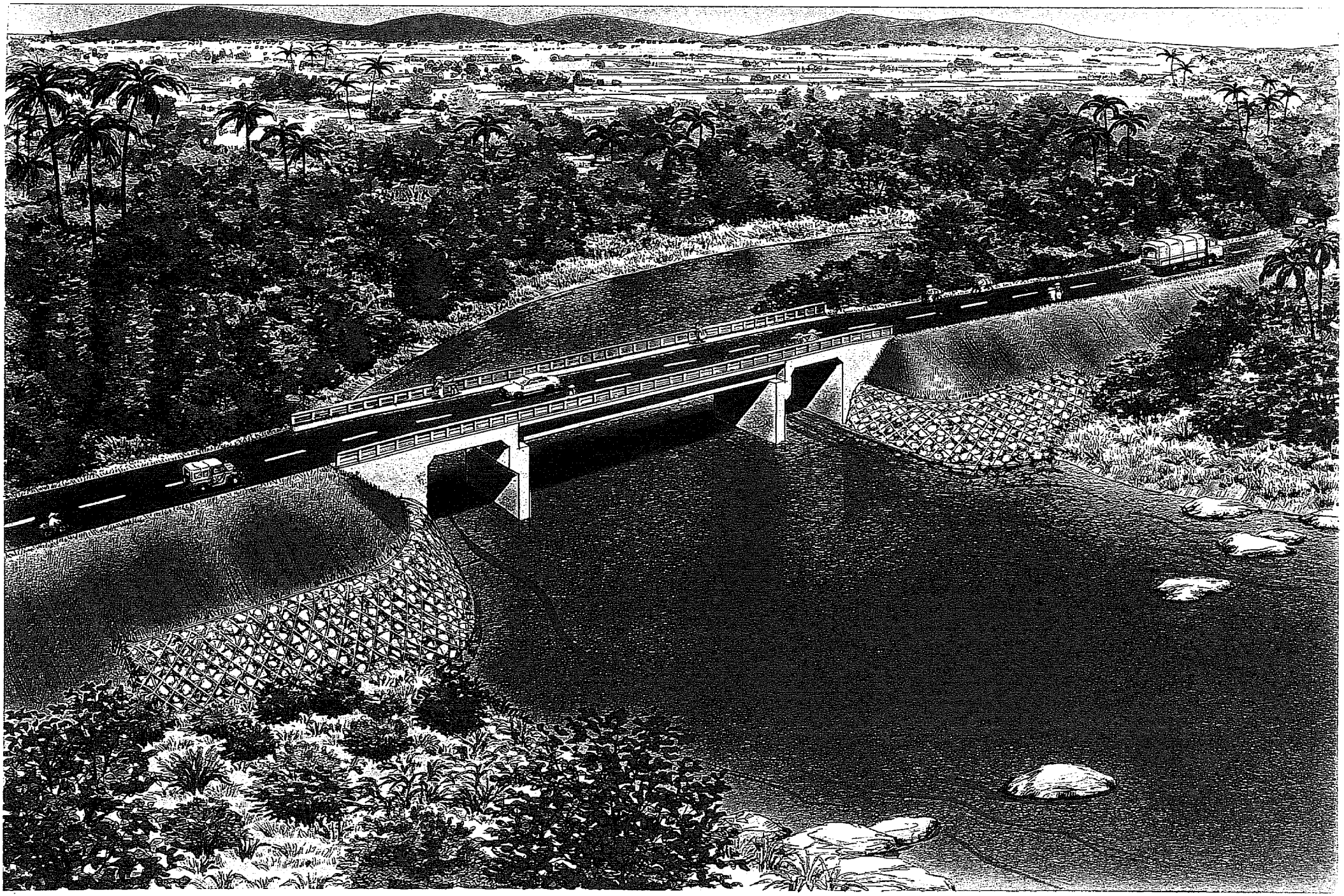


Location of Proposed Bridges



XP NO.10 Lamphong Bridge
Bridge Length = 30m

Definition and Abbreviation

A Authorities and Agencies

ADB	Asian Development Bank
IDA	International Development Association
JICA	Japan International Cooperation Agency
JRA	Japan Road Association
MCTPC	Ministry of Communication Transport Post and Construction
DCTPC	Division of Communication Transport Post and Construction
DOC	Department of communication

B Other Abbreviations

AADT	Annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
@	At the rate
B/D	Basic Design
BR	Bridge
BL	Bridge length
BST	Bituminous Surface Treatment
CBR	California Bearing Ratio
℄	Center Line
cm	Centimeter
cm^2	Square centimeter
D/F	Draft Final Report
$	Dollar
Ec	Young's modules of cement
Es	Young's modules of steel
Esp	Modules of elasticity
Ex	Existing
El	Elevation
H	Height
HWL	High water level
I	Coefficient of impact
Kgf/cm^2	Kilogram force per square centimeter
Kgf/cm^3	Kilogram force per cubic meter
Kgf/mm^2	Kilogram force per square mirimeter
Kh	Horizontal Seismic Coefficient
Km	Kilometer
Km^2	Square kilometer
Km/h	Kilometer per hour
L	Length
l	Length
LWL	Low water level
m	Meter
M	Million
m^2	Square meter
m^3	Cubic meter
m^3/s	Cubic meter per Second

MSL	Mean sea level
N	N-value or Number of wheel load application
n	Number of Ratio of Es to Ec
%	Percent
Φ	Diameter
PC	Prestressed concrete
PCU	Passenger car unit
PSI	Present serviceability index
RC	Reinforced concrete
RN	Route number of national road
S	Scale
SD	Deformed Steel
σ ck	Allowable stress of concrete
σ sa	Allowable stress of steel bar
Sta/St	Station
t	Ton or Thickness
W	Width
W.L	Water level

CONTENTS

Chapter 1: Background of the Project

Chapter 1 Background of the Project

1-1 Background of the Request

In Lao PDR, where 85% of the labor force works in agriculture and forestry, production of rice, beans, tobacco, and coffee account for60% of the GDP. Cultivated land is found only the valley areas surrounding the Mekong River and its tributaries, comprising a mere 4%of the nation's total area. Forestry comprises roughly 3% of the GDP and a high 32% of foreign currency earnings.

In such a social environment, Lao PDR road infrastructure consists of14,176 km of roads (1993), only 2,559 km (18.7%) of which are paved. Most of the roads in the country are gravel or unpaved. Gravel roads are barely passable in the dry season and practically impassable in the rainy season, while unpaved roads are difficult throughout the year and barely function in the rainy season.

It is extremely important for the economy of Lao PDR to obtain access to the Thai Gulf and South China Sea. National Route 13 runs parallel to the Mekong River, passing through Vientiane connecting the northern and southern regions as well as serving as the starting point for important east-west routes such as routes 8, 9, and 12. Furthermore, it isexpected that National Route 13 will further develop as a part of Asia Highway Route 11 which would connect Lao PDR with neighboring Thailand, Cambodia, and Viet Nam. In light of this, various international funding agencies such as the World Bank and the Asia Development Bank as well as governments such as Sweden, etc., are placing importance on projects which are concerned with the amelioration of roads and bridges involved. In particular, road construction being undertaken by funding from the World Bank between Thahkek and Savanahket is progressing at a quick pace, and bridge development is expected to follow.

Japan conducted the Basic Design Study on the Project for Reconstruction of Bridges on the National Road Route 13 in the years 1993 and 1994, completing the construction of 26 bridges between Namcading and Thahkek through grant aid by the end of 1997. In addition, in Pakxe (the intersection of National Routes 11 and 13), which is the terminal point of the basic project, the construction of the Pakxe Bridge (crossing the Mekong River) which was planned as an aid project by Japan, was carried out under a grant. The bridge project and PAKUSE Bridge construction of this project are directly connected with the "Southern Laos-Sihanoukville Road" which was proposed by Japan in the "Indochina Development Forum" as a north-south route for the Indochina region, also strengthening east-west links throughout southern Lao PDR, Thailand, and Viet Nam and supporting development of not only the three countries, but of the entire region of Indochina.

However, along the stretch of National Road Route 13 between Thahkek and Pakxe. The project area, there are 51 unimproved bridges with a width of no more than 3 m that are causing hindrance to effective use of the road. Structurally, almost all of these existing bridges are Bailey bridges built to replace former bridges in the 1960s. Bridge parts have suffered damage and are in extremely dangerous condition. Therefore, in consideration of the increasing traffic volume, the possibility of complete bridge failure is judged as great. Furthermore, damage suffered along Route 13's road and bridges has been great, particularly from recent flooding of 1986, 1995, and 1996. Inundation and scouring has brought about many unstable bridge locations and poor condition of bridges is interfering with the country's social and economic development.

The Lao government has therefore requested grant aid from the Japanese government with regards of the development of 51 bridges, including access, along the 340 km of the route from Thahkek to Pakxe.

Chapter 2: Contents of the Project

Chapter 2 Contents of Project

2-1 Objectives of the Project

The National Road Route 13 is a major arterial route traversing the Lao People's Democratic Republic (hereafter referred to as Lao PDR) from north to south and much anticipated as playing a major role in the social and economic development of the republic. This route, with a total length of 1,230 km, passes through ten of the republic's eighteen provinces. In particular, cities in the southern regions (Thakhek, Savannakhet, Pakxe, etc.) which are 700 km or more from Vientiane, require a full two-day journey by car. The central and southern regions, in which the second and third largest cities of the republic are located, require a self-sufficient social system which can support the basic needs of day-to-day living, health and sanitation, education, and economic activities. The improvement of the infrastructure which supports these activities is of utmost importance. The importance of a year-round all-weather transportation route as a part of this infrastructure, therefore, goes without saying. At the time of this writing, the section of Route 13 between Nam Kading and Thakhek has been completed as the first phase of road construction along the route. The improvement of Route 13, besides alleviating problems resulting from the isolation of the central and southern regions of the republic, will also greatly influence the development of adjacent regions in the following aspects as well:

① Basic human needs; living conditions
② Alleviation of poverty; establishment of economic base
③ Amendment of economic disparity among regions; role as international highway

Furthermore, it is anticipated that Route 13 will develop to serve not only as a major arterial in the Lao PDR, but as an important connecting route of Asia Highway Route 11, strengthening links with Thailand, Vietnam, and Cambodia.

The bridges found along this route were built in the 60-year period until 1953 by France when the present republic was a French colony. The Bailey bridges which exist along the route are said to have been constructed by the American army to replace colonial bridges for strategic purposes. Since then, the Government of Lao PDR has kept up maintenance of the bridges and have replaced a few, but in general most are in their original condition.

Flood damage has been observed at certain bridges and along certain stretches of road; most recently major flooding has been recorded resulting from heavy rains in 1986, 1995, and 1996, respectively, which have been the cause of inundation of roads and bridges as well as scouring of bridge foundations, causing instability in locations. Bridges are a problem in particular, where Bailey bridges are structurally only able to support 18 to 20 tons of load. These bridges are being operated under load regulations and therefore unable to keep up with the demand of shipping loads of today's growing economic standards. Therefore, in order to contribute to the economic development of the central and southern regions as well as fulfill basic needs which support the

local economy, 51 temporary bridges are to be replaced with permanent structures.

2-2 Basic Concept of the Project

2-2-1 General Design Specifications

① Design speed: 80km/h
② Total width: 9m, 11m (in village areas)
③ Composition: 0.75m + 0.50m + 3.50m x 2 + 0.50m +0.75m
(pedestrian way) (shoulder) (vehicle lane)
④ Typed pavement : BST pavement (alternating layers of asphalt / aggregrates)
⑤ Replacing bridges to be constructed to withstand greater vehicle loads
(B live load with Japanese Road Association)

2-2-2 Specifications of Bridges to be replaced

Basic structure and dimensions of bridges to be replaced are indicated in Table-2.2.1 below.

Table-2.2.1 Bridge Structure

Length	L<20m	20m≦L<30m
Bridge Type	RC(Reinforced Concrete)	PC(Prestressed Concrete)
Bridge Width(Effective)	8m or 10m	8m or 10m
Live Load	B Load	B Load
Substructure (Pier)	Oval Type	Oval Type
Substructure (Abutment)	Inverted-T or Box or Rigid-frame	Inverted-T or Box or Rigid-frame
Foundation Structure	Spread Foundation or Pile Foundation	Spread Foundation or Pile Foundation

2-3 Basic Design

2-3-1 Design Concept

(1) Basic consideration on design

The basic design survey carried out for this project was done so in the most appropriate manner considering the socioeconomic situation, natural conditions, environment, legal matters and the construction industry in the Lao PDR, in accordance with the scheme of Japan's grant aid assistance program.

① Factors of rainy and dry seasons

The existence of rainy and dry seasons is carefully considered. Generally speaking, the rainy season lasts from the middle of May to the middle of October, and the remaining part of the year can be considered the dry season. Around the end of May, heavy rain is experienced, followed by a brief interim, after which constant rains begin towards the middle of June. The rainy season does not imply that heavy rains fall for days in succession; on the contrary, there will be days when no rain falls at all. Even in June, the water level around the Sedon river is known to rise five to six meters in one night; therefore proper timing of construction is a matter of great importance. In particular, the rooting of the substructure should be procured at a sufficient depth and with proper protection carried out in order to prevent scouring.

② Establishment of road / bridge standards in consideration of present and future road use

The Route 13 is also Asia Highway Route 11, therefore increase in traffic volume is practically inevitable. Bridge improvements which took place in the 1960s (Bailey bridges) were intended for loads of 20 tons or less; bridges which have been replaced after failure through flooding are of basically the same design. However, Lao PDR is experiencing a notable growth in traffic volume as well as vehicle load accompanying recent economic growth. Live loads which exceed the design load of 20 tons are passing over the bridges and speeding up the damage process. Therefore, the live load adopted for the bridges of the Route 13 is AASHTO's HS25. The bridges designed by the IDA and Australian Grand Aid is adopted AASHTO's HS25. Furthermore, south of Pakxe in the ADB Project, AASHTO's HS25 is also adopted, thus the B live load (Japanese Road Association) is to be considered for the section of road within this project as well.

③ Effective use of local equipment and materials

Applicable construction equipment in Lao PDR is scarce; however, some equipment is available through local contractors by lease. In light of this situation, evaluations will be conducted to examine the ready availability of equipment.

④ Consideration of technical level of local engineers

There is more than a sufficient number of qualified engineers in Lao PDR, particularly in the MCTPC, however, due to lack of field experience, there is a tendency to rely on desk knowledge. In regards to this project, no great difficulty is foreseen due to experience with foundation and sub-structure in addition to approach roads in the first construction phase. Superstructure will consist of RC girders and PC girders, the construction during which a transfer of technical skills will be carried out. For this particular section of the construction, highly skilled technicians will be sent from Japan to Lao PDR.

⑤ Adoption of easily-maintained structural types

The DOC of Lao PDR has allotted a certain budget for maintenance of its routes, but in reality has not been able to keep up maintenance in areas such as paving, etc. Accordingly, in order to keep future maintenance / management at a minimum, sufficient review of methods, structure, materials, and forms should be conducted.

⑥ Reduction of construction cost and minimizing of construction period

In order to meet the requirements of the Japanese government's grant aid assistance program, the contents of construction must be reviewed to keep cost and construction time at a minimum.

(2) Applied standards and basic policy

1) Applied standards

Regarding bridge design standards for this project and their application, it is important to note that the Lao PDR has certain standards but that they in reality are in the preparation stages. The Route 13 is designed by IDA and Australian Grand Aid, the standards for live load being applied are mainly HS25 of AASHTO.

Furthermore, in light of the fact that AASHTO design standards are being used for the Route 13 designed by ADB in south of Pakxe, and that the live load adopted for parts of Asia Highway Route 11 is Japanese B live load, the Lao of PDR government has agreed to applying B live load as the live load and the standard of river law for this project.

2) Basic policy

As part of the basic design study, the following basic policies are adopted in consideration of the above circumstances.

① Project schedules are made in consideration of rainy and dry seasons. Work efficiency will decrease during the rainy season, and construction may be postponed under certain circumstances. In this project, no construction will take place within the riverbed during the rainy season.

② Japanese design standards are adopted. Bridge design will be conducted according to Japanese specifications.

③ Paving will be conducted in consideration of durability and ease of maintenance, and will be finished with BST (alternating layers of asphalt and gravel) which is commonly used in Lao PDR.

(3) Design Criteria

1) Road

a) Geometric Standard

The geometric standards shown in Table-2.3.1 are to be applied to the roads to be improved as a part of this project. Design standards: Lao PDR Road Design Standards (Draft).

Table-2.3.1 Applied values of Road Geometric Standard

Item		Unit	Design Value
Design Speed		km/h	80
Road Width		m	7(2 x 3.5)
Level	Minimum Radius	m	210
Vertical	Minimum Radius -∪	m	400
	Beginning Radius -∩	m	600
	Maximum Radius	%	4
Incline of one side		%	10

b) Cross Section

The width composition of approach roads corresponds to the IDA width composition already used in road work shown in Figure 2.3.1.

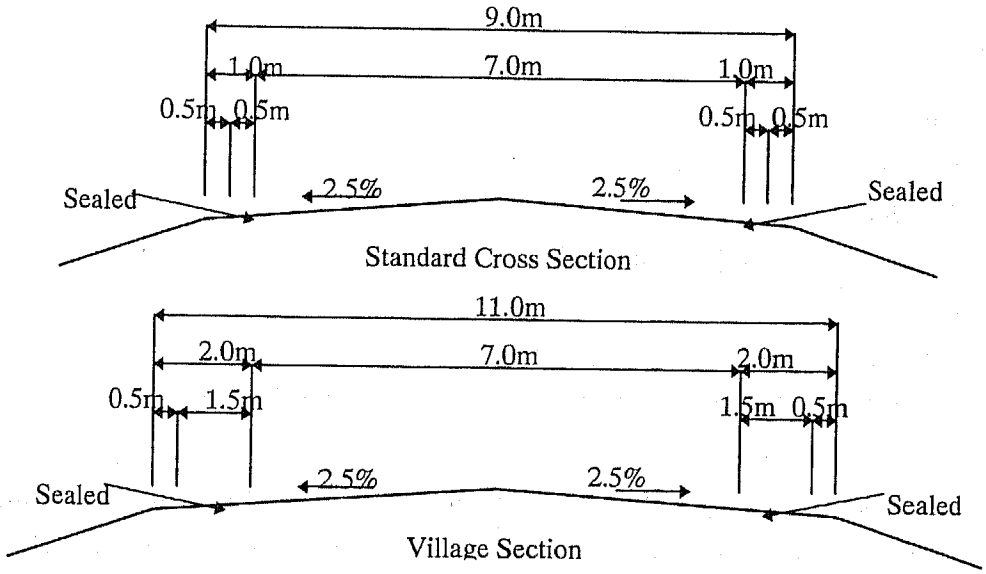


Figure 2.3.1 Cross Section

c) Pavement design standards

Pavement design corresponds to Lao PDR Road Design Standards (Draft).

2) Bridges

(a) Standards of application

'Design Specification for Roads and Bridges (JRA)' will be adopted.

(b) Load conditions

Conditions regarding load applied to bridge design are separated into divisions according to function of load, frequency of loading, primary load and secondary load as they effect the bridge, and other special types of load. Characteristics of the different types of load are shown below.

A Primary load

a Dead load

Concrete	2.5 tf /m^3
Steel	7.85 tf /m^3
Earth Embankment	1.8 tf /m^3

b Live load: B live load (JRA)

c Impact: The impact coefficients for concrete bridges "I" is calculated as

$$I=10/(25+ \text{span length})$$

B Secondary load

This type of load must be considered when speaking of combinations of loads.

a Wind load

Wind load is not considered a factor in Lao PDR as typhoons, etc. are not a problem.

b Effects of temperature changes (local standards)

Concrete: ± 25℃ (average 25℃, maximum 50℃, minimum 0℃)

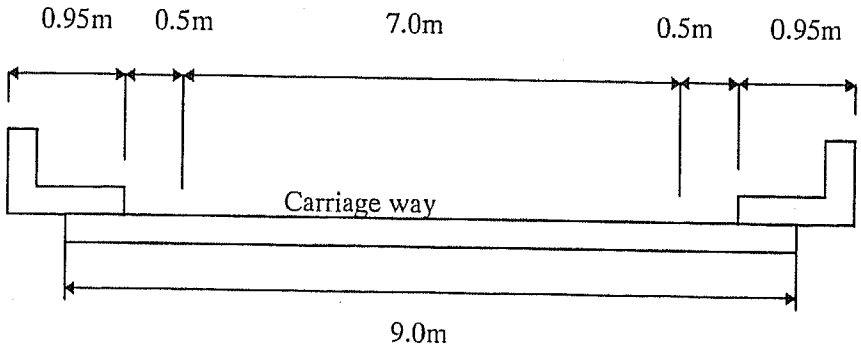
c Seismic effects

Virtually no seismic activity has been observed in Lao PDR, and no earthquakes have been reported in the southern region at all. However, in light of the fact that the Lao-Thai Friendship Bridge and bridges constructed with Australian aid along Route 13 have been constructed with seismic considerations, the bridges in this project will be planned with the following horizontal seismic intensity.

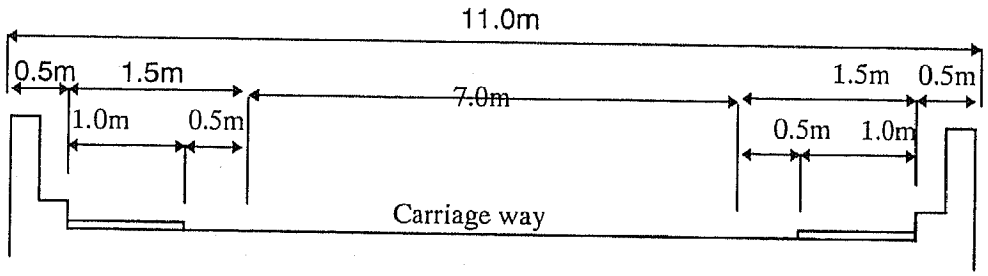
$$Kh = 0.06$$

(c) Conditions of superstructure design

① Bridge type: concrete
② Live load: B live load (JRA)
③ Width composition: road width (7.0m), shoulder (0.5m), pedestrian way (0.75m), handrail (0.2m),



Standard Cross Section



Village Section (XP No.11,12,22,24,39)

Figure-2.3.2 Cross Section of Bridge

④ Surface alignment: Basically in straight line
⑤ Cross fall: 2.5%
⑥ Bridge pavement: concrete (50 mm of future asphalt overlay are calculated into the load)
⑦ Method of bridge construction: mainly, gantry crane

(d) Conditions of substructure design

① Type of substructure

Abutment: rigid-type abutment, box-type abutment, inverted "T" type abutment

Pier: oval-type pier

Depth of foundation: except for places of bedrock, the top of the footing will be 2.0 m below the surface of the riverbed.

② Foundation structures

- spread foundation type

-pile foundation type

(e) Conditions of bank protection / riverbed protection design

As a result of interviewing and site reconnaissance, it was learned that flooding and overflowing of the river is basically caused by the following:

① The entire river area is flooding area to begin with, but the extra rise of river water level in times of rain is compounded due to the damming effect of road earthwork.

② As the road usually is situated along the foot of the mountain, the flow of rainwater is augmented as it flows from steep slopes.

These are the main causes of erosion of the natural banks, flooding of roads and bridges and destruction or washing away of slopes.

From the above, the following design standards will be fixed according to the Japanese River Law for riverbank and riverbed protection. Materials to be used are mat gabian, which is locally available.

a Bank protection

The height of the top of the bank protection is fixed by the Japanese River Law; however, to get the data of flooding records is not enough in Lao PDR as compare with Japanese data, a margin of 20% extra height will be included, and added to the figures in Table-2.3.2.

Table 2.3.2 Height of Bank Protection

Discharge Capacity (m^3/s)	200 <	200≦ <500	500≦ <2000	2000≦ <5000	5000≦ < 10000	≦ 10000
Standard value (m)	0.6	0.8	1.0	1.2	1.5	2.0
Design value (m)	0.75	1.00	1.20	1.45	1.80	2.40

b Riverbed protection

Riverbed protection will be implemented, including the areas surrounding the piers and abutments, upstream and downstream from the river.

3) Material Strength

a) Concrete

[Super Structure] PC girder: σ ck=350kgf/cm^2

RC slab, girder: σ ck=240kgf/cm^2

[Sub Structure] RC Pier, Pile: σ ck=240kgf/cm^2

Abutment:	σ ck=210kgf/cm^2
Pile:	σ ck=240kgf/cm^2

b) PC Standards

Ultimate strength	190kgf/mm^2
Yield strength	160kgf/mm^2
Rate of relaxation	5%
Young's modulus	Esp = 2.0 x 10^6 kgf/cm^2

c) Reinforcing bar

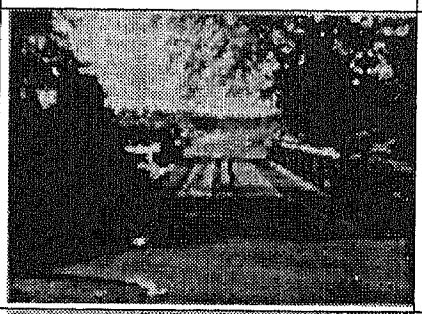
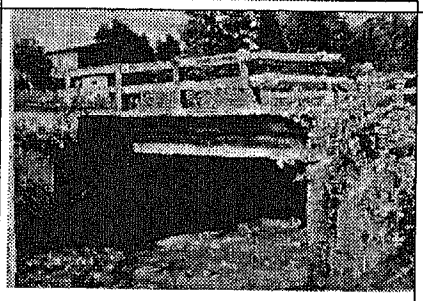
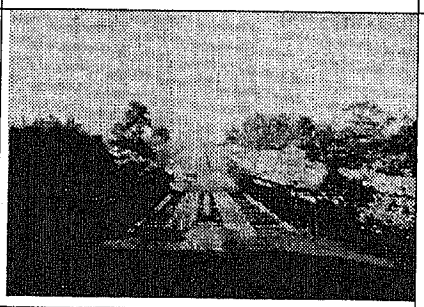
Standard	SD295,SD345
Yield strength	3,000kgf/cm^2
Young's coefficient	Esp = 2.1 x 10^6 kgf/cm^2
Young's coefficient ratio	n = Es/Ec = 15

2-3-2 Basic Design

(1) Basic Improvement Policy

As a result of site survey conducted on the bridges, it was found that 51 bridges along the route connecting Thakhek / Xeno / Pakxe are in need of replacement. The basic improvement policies for each bridge judged from site survey are shown in Tables-2.3.3 and Table-2.3.4.

Table 2．3．3 Basic Improvement Policies (Thakhek to Xeno 1／3)

Bridge Name	Present Condition	Structural Outline	Present Structure and Characteristics	Improvement Policies
TX NO.01 Location 12.0km from Thakhek		Length : 15.0m No. of spans : 1 (m+ m+ m) Lane width : 4.0m Superstructure type: Bailey bridge Substructure type: Superstructure load : 20ton Clearance : 4.0m	HWL (below road surface) : -1.5m Main girder : OK under load limits Slab : wood Handrail : Bailey girder Abutment: Sound Pier: - Bank protection : none River type : small river (unstable) Environment : Agricultural (rice paddies)	Live load : B live load Location : Same as present Clearance : 0.75m Effective width : 8.0m Superstructure : PC girder Substructure : Inverted "T" type abutment
TX NO.02 Location 13.0km from Thakhek		Length : 15.0m No. of spans : 1 (m+ m+ m) Lane width : 4.0m Superstructure type: Bailey bridge Substructure type: Superstructure load : 20ton Clearance : 5.0m	HWL (below road surface) : -2.0m Main girder : OK under load limits Slab : wood Handrail : Bailey girder Abutment: placed directly on ground Pier: - Bank protection : none River type : small river (unstable) Environment : Agricultural (rice paddies)	Live load : B live load Location : Same as present Clearance : 0.75m Effective width : 8.0m Superstructure : RC girder Substructure : Inverted "T" type abutment
TX No.03 Location 13.60km from Thakhek		Length : 5.5m No. of spans : 1 (m+ m+ m) Lane width : 4.0m Superstructure type: RCT girder bridge Substructure type: Superstructure load : 20ton Clearance : 3.0m	HWL (below road surface) : -0.6m Main girder : OK under load limits Slab : RC Handrail : RC (unstable) Abutment: fairly sound Pier: - Bank protection : none River type : small river (unstable) Environment : Agricultural (rice paddies)	Live load : B live load Location : Same as present Clearance : 0.75m Effective width : 8.0m Superstructure : RC girder Substructure : Inverted "T" type abutment
TX NO.04 Location 16.0km from Thakhek		Length : 21.0m No. of spans : 1 (m+ m+ m) Lane width : 4.0m Superstructure type: Bailey bridge Substructure type: Superstructure load : 20ton Clearance : 4.0m	HWL (below road surface) : -0.50m Main girder : OK under load limits Slab : wood Handrail : Bailey girder Abutment: placed directly on ground Pier: - Bank protection : none River type : small river (unstable) Environment : Agricultural (rice paddies)	Live load : B live load Location : Same as present Clearance : 0.75m Effective width : 8.0m Superstructure : PC girder Substructure : Inverted "T" type abutment
TX NO.05 Location 19.3km from Thakhek		Length : 18.0m No. of spans : 1 (m+ m+ m) Lane width : 4.0m Superstructure type: Bailey bridge Substructure type: Superstructure load : 20ton Clearance : 4.3m	HWL (below road surface) : -0.3m Main girder : OK under load limits Slab : wood Handrail : Bailey girder Abutment: placed directly on ground Pier: - Bank protection : none River type : small river (unstable) Environment : Agricultural (rice paddies)	Live load : B live load Location : Same as present Clearance : 0.75m Effective width : 8.0m Superstructure : RC girder Substructure : Inverted "T" type abutment

Clearance : between bottom of bridge and maximum flood water level.