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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE MEKONG BRIDGE AT PAKSE IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT

SUMMARY

JUNE 1996

NIPPON KOEI CO., LTD.
CONSTRUCTION PROJECT CONSULTANTS, INC.

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Note

Following exchange rates are applied in this report :

US$1.00 = Kip 920 = Yen 100 = Baht 24.0

Kip 1.0 = Yen 0.109

(As of November 1995)

PREFACE

In response to a request from the Government of the Lao People's Democratic Republic, the Government of Japan decided to conduct the Feasibility Study on the Construction of the Mekong Bridge at Pakse in the Lao People's Democratic Republic and entrusted the study to the Japan International Cooperation Agency (JICA).

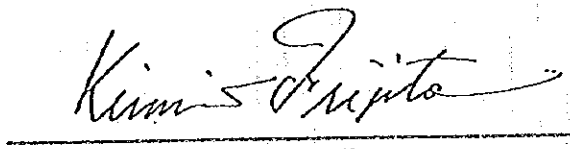
JICA sent to Laos a study team headed by Mr.Junji Mashiba and composed of the members of Nippon Koei CO., LTD. and Construction Project Consultants, INC. two times between July 1995 and March 1996.

The team held discussions with the officials concerned of the Government of Laos, 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 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 team.

June 1996



Kimio Fujita

President
Japan International Cooperation Agency

OUTLINE OF THE STUDY

1. Proposed Bridge Route

The proposed bridge route was selected from the three alternatives grading the appraised points on the evaluation items which consist of economic evaluation, engineering evaluation and environmental evaluation. The route is located at 2 km downstream of the existing ferry route.

2. Project Facilities

The outline of the project facilities is shown below:

(1) Bridge

- Location : 2 km downstream of existing ferry route
- Bridge width : Total width 11.8 m
  Carriageway 3.5 m each in both direction
  Shoulder 0.5 m each on both sides
  Sidewalk 1.5 m each on both sides
- Bridge length : 1,380 m
- Span length : Main spans 102 m x 10, 150 m, 100m
  Side spans 70 m, 40 m
- Bridge type : Continuous rigid frame PC (extra-dosed) box girder
- Foundation type : Extrusion type cast-in-situ RC pile

(2) Approach roads

- Road width : 11 m
- Carriageway : 3.5 m each in both direction
- Shoulder : 2 m each on both sides
- Total length : 3,030 m
  Pakse side 680 m
  Phontong side 2,350 m
- Pavement : DBST for carriageway and SBST for shoulder

3. Project Cost

The estimated project cost is shown below:

(Unit: US$1,000)

Classified Cost	Foreign Currency	Local Currency	Total
Construction Cost	42,884	9,884	52,768
Engineering Cost	3,324	369	3,693
Land Acquisition Cost		485	485
MCTPC' administration Cost	-	792	792
Contingency	8,622	2,036	10,658
Total	54,830	13,566	68,396

4. Project Feasibility

The project of the construction of the Mekong bridge at Pakse is technically feasible.

The Economic Internal Rate of Return (EIRR) of the project is estimated at 8.0%. This result is based on the only quantifiable direct benefits such as savings in river crossing time and savings in ferry waiting time. In addition to the direct benefits, the Pakse bridge will stimulate the regional economy and is expected to generate huge amount of indirect benefits. Considering such wide range and long term indirect benefits, the implementation of the Pakse bridge will be sufficiently justified.

5. Necessity of the Project

Necessity of the Mekong bridge at Pakse is emphasized from the following aspects:

1) Eliminating the bottleneck point at Mekong river and provide safety transportation facility
2) Formation of regional all-weather road network with other road improvement projects
3) Formation of international road network linking with neighboring countries
4) Promotion of regional and nationwide development (agricultural, industrial , commercial and tourism development)
5) Betterment in living conditions

6. Conclusions and Recommendations

6.1 Conclusions

NR 10 is the most important and only trunk road connecting directly southern provinces of Lao PDR with Thailand bearing the heavy trade traffic. However the traffic running on the route will be compelled to continue to spend many hours waiting for ferry crossing at Pakse, unless the Bridge to replace the existing ferry is constructed. Without the construction of bridge the increase in traffic volume across

the Mekong river will force to bring about demand for the increase in ferry facilities will result in higher investment of capital in the long run.

The future traffic volume on the existing ferry route is expected 5,700 vehicles, 2050 TRU equivalent according to the traffic demand forecast carried out in the course of the study, while the present traffic volume as of August 1995 was 600 vehicles, 230 TRU equivalent.

Based on the results of the study it is found that the Project of the construction of the Mekong bridge at Pakse is technically feasible. The construction of the Mekong bridge also is judged viable by the economic evaluation which shows an IRR of 8 % considering the present economic status in Lao PDR.

The Project will accompany various intangible benefits that will contribute to the development and well-being of the region in and around the project area.

The Project also will contribute to forming a prospective transportation network of the East West corridor formulation in Indochina.

The bridge route study has selected alternative Route-B, crossing over the Mekong river at 2 km downstream of the existing ferry route.

The proposed route, dual single lane, has the whole length of 4,410 m, composed of the bridge length of 1,380 m, the approach roads of 680 m on Pakse side and 2,350 m on Phonthong side.

The construction of bridge will not be anticipated to cause any serious technical, environmental and social issues in the course of bridge construction and after the completion.

It is found that the bridge should be designed and constructed with prestressed concrete structure supported with concrete shafts and cast-in-situ pile foundations of extrusion type to meet construction conditions in the Project site.

It is concluded that the Mekong Bridge construction at Pakse is an indispensable project and that it is a realistic solution for the development of economy as well as road transportation of the country.

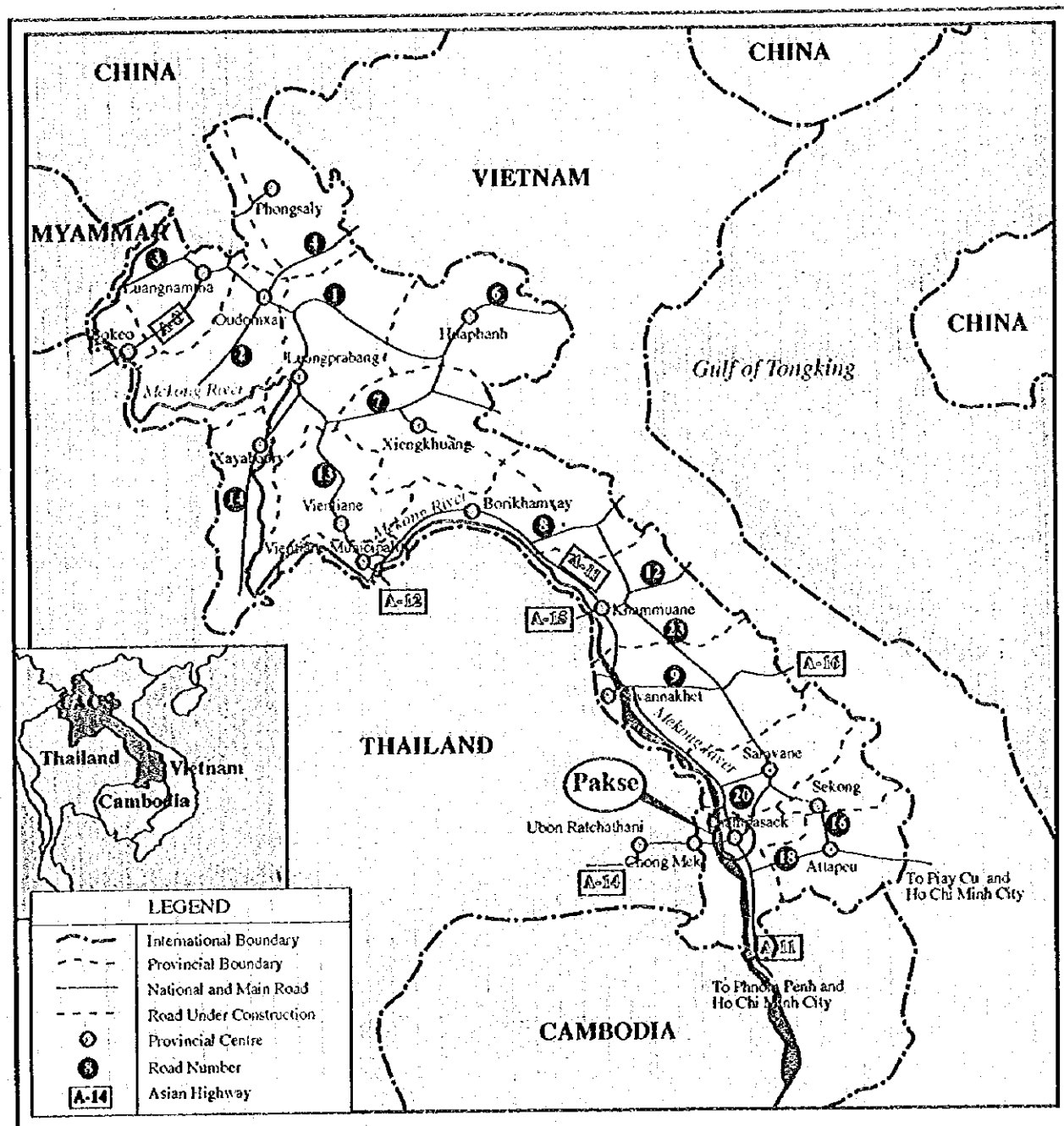
6.2 Recommendations

The Project is expected to proceed to implementation stage as soon as possible and it is advisable for financing the Project to get a generous grant or a soft loan of favorable condition at the earliest stage.

It is preferable that the completion date of the Project will be set taking into consideration the time of the completion of the relevant Projects ADB 7th projects going on currently.

The detailed design stage for the execution of the Project, the works of which comprise site investigation, design of roads and structures and preparation of tender documents should be started before the beginning of rainy season.

It is most desirable to raise at one time the fund needed for the whole cost of the Project, US$68.4 million, at the outset of the Project.

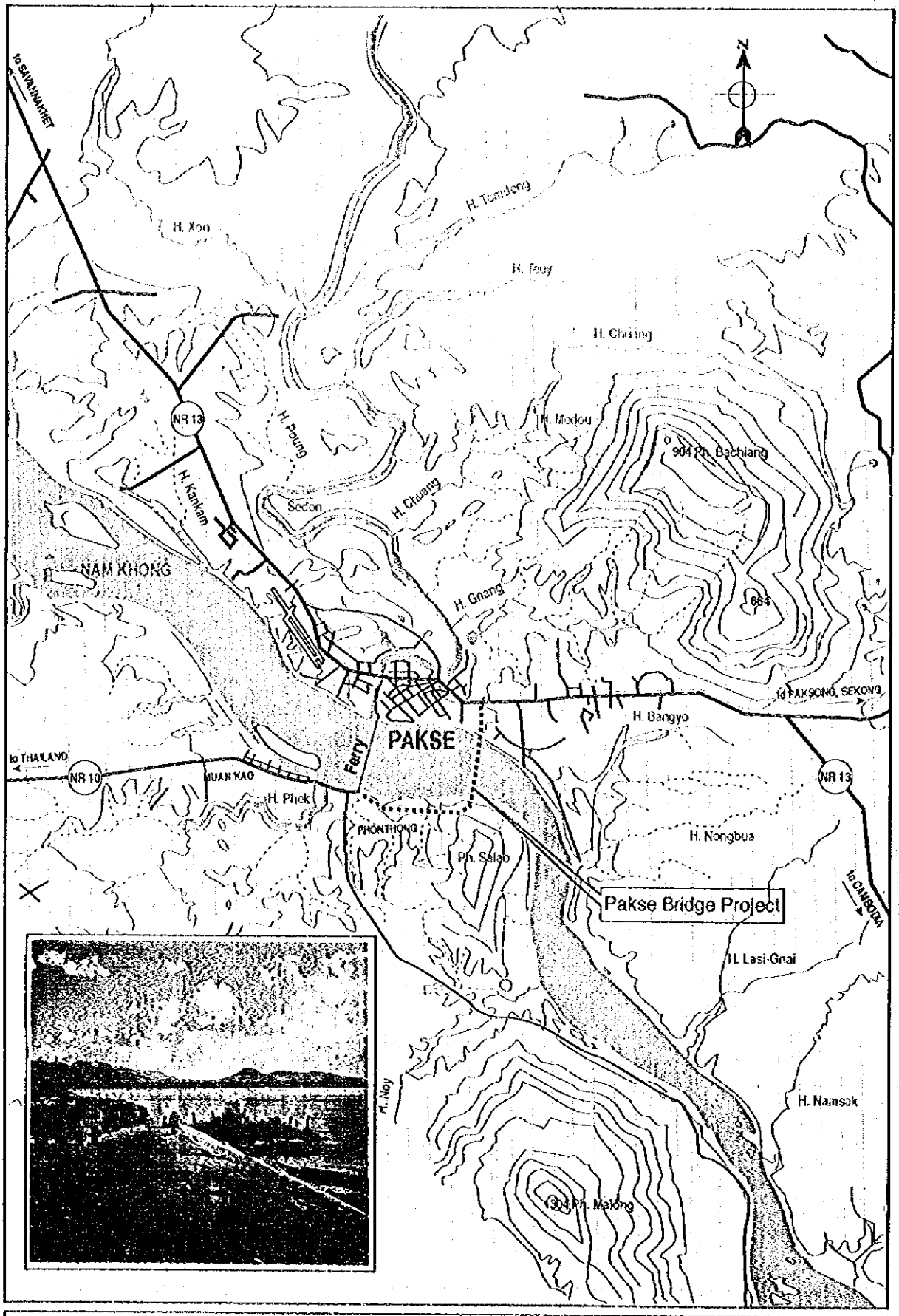


LOCATION MAP

PROFILE OF LAO P.D.R.

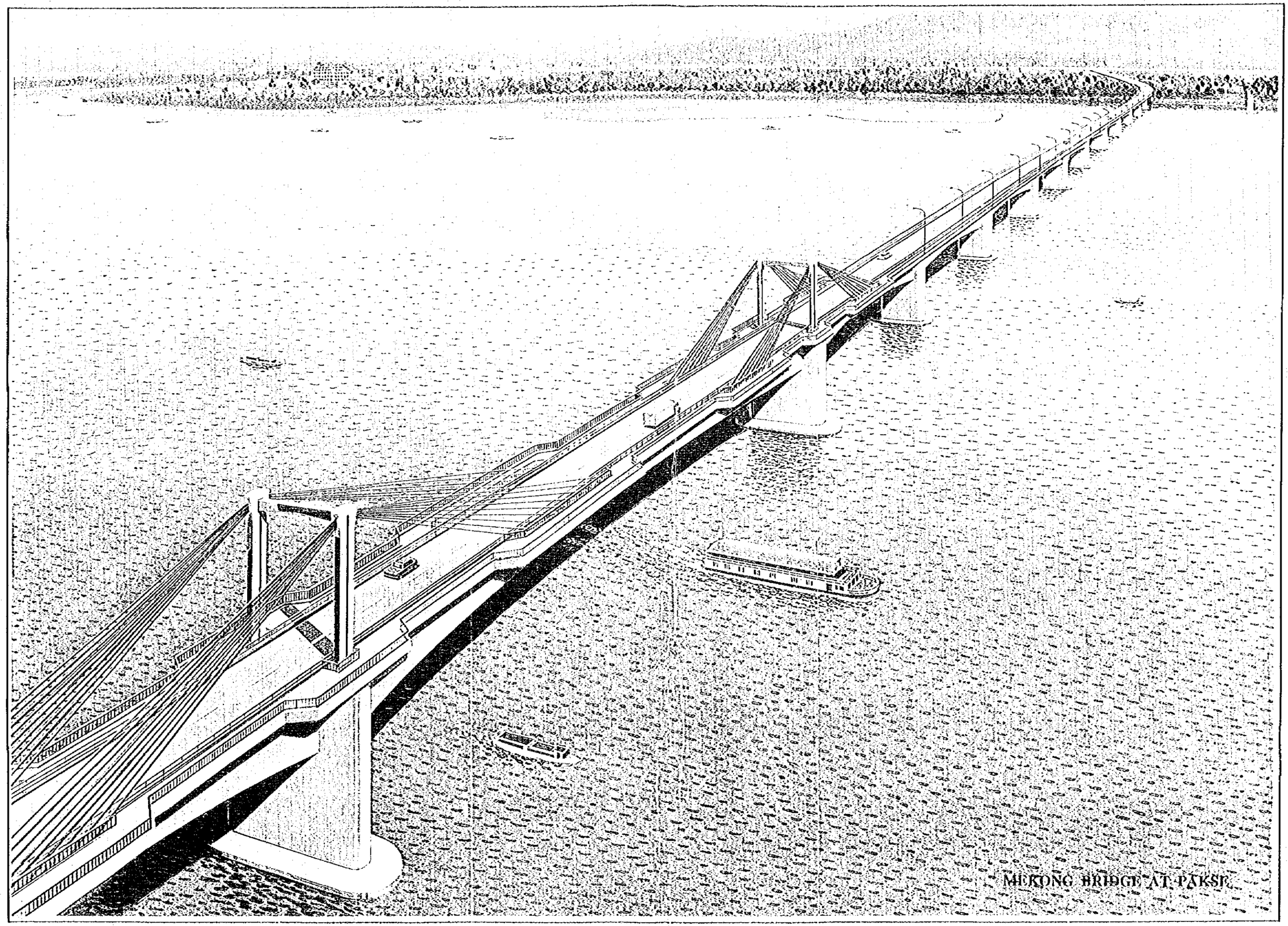
Area	: 237,000 km^2	GDP	: 1,108.6 billion Kip (1994)
Population	: 4.61 million (1995)	GDP per capita	: US$260 (1995)
Population Density	: 19/km^2 (1995)	Currency	: Kip
Capital	: Vientiane		US$1 = 920 Kip (Sept. 1995)

THE FEASIBILITY STUDY ON THE CONSTRUCTION OF THE MEKONG BRIDGE AT PAKSE



PAKSE BRIDGE PROJECT SITE

MEKONG BRIDGE PROJECT AT PAKSE



MEKONG BRIDGE AT PAKSE

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1. INTRODUCTION

1.1 Background

Since "New Economic Mechanism (NEM)" has been introduced as a policy for national socio-economic development in 1986, the Lao PDR has begun to step forword to reorganize her economy under the market economy principle. The new policy is expected to promote foreign investment, activate national economy and increase international trade with surrounding Indochia countries .

In order to stimulate and activate economy on the basis of an international trade with market economy countries, relationship with Thailand shall be focused on as the first priority, which recently keeps good economic performance and accumulates biggest economic power in the surrounding countries. In this sense, the Pakse Area and Mekong bridge at Pakse shall be paid special attention as a regional development center in the South Region with a short highway connection to Thai boarder.

Although the southern provinces of Lao PDR are rich in agricultural resources such as rice, coffee, fruit, crops, timber product, etc., and Pakse is located at only one hour distance from the Thai border, such commodities have not been transported efficiently because of a bottleneck to cross the Mekong river.

The crossing over the Mekong river was and is always a key issue for the improvement of road network in Indochina countries. The road rehabilitation projects in the Southern provinces such as National Road 13 and National Road 10 are under way by the assistance of Asian Development Bank (ADB) and efficient and all season international links will be completed with the construction of the Mekong bridge at Pakse.

Under such situation, the Government of Lao PDR requested to the Government of Japan for the feasibility study on Construction of Mekong Bridge at Pakse.

In response to the request, the Government of Japan has decided to conduct the Feasibility Study on Construction of Mekong Bridge at Pakse.

Accordingly, JICA the official agency responsible for the implementation of the technical cooperation program of the Government of Japan, undertook the Study and organized a study team. The Study Team commenced the study July 1995 and the study was completed in March 1996.

1.2 The Feasibility Study on the Construction of the Mekong Bridge at Pakse

1) Objectives of the Study

The objectives of the Study are to conduct the feasibility study for the construction

project of Mekong bridge at Pakse including its approaches for the period up to the year 2010 and to carry out technology transfer to the counterpart personnel of the Government of Lao PDR in the course of the Study.

2) Study area

The Mekong river basin in and around Pakse, Champasak province, is of the subject area for the Study.

3) Scope of the Study

The scope of the study is summarized as follows:

- Data collection and analysis
- Site survey which is composed of traffic survey, topographic/bathymetric survey and traffic volume survey
- Traffic forecast
- Environmental examination
- Comparative study and evaluation of alternatives on proposed bridge routes
- Preliminary design and cost estimate on the optimum bridge route
- Planning and scheduling of construction works
- Maintenance program
- Environmental impact assessment
- Economic and financial evaluation
- Implementation program
- Conclusions and recommendations

2. SOCIO-ECONOMIC CONDITIONS OF THE LAO PDR AND THE STUDY AREA

2.1 Present Conditions of the Lao PDR

(1) Population of the Country

The total population of the Lao PDR is about 4.6 million in 1995. An average annual growth rate of population from 1985 to 1995 was 2.4 % per annum. Population density of the whole country and Vientiane are 19 persons and 136 persons per km2 respectively.

(2) National Economy

The nominal Gross Domestic Product (GDP) has amounted to 1,108,620 million Kip and per capita GDP was estimated at about US$ 260 in 1994. The actual GDP in constant prices has recorded an average growth rate of 6.2% per year for the period of 1990 to 1994. A high growth rate of 8% p.a. was achieved in 1994. Since launching the New Economic Mechanism (NEM) program initiated in 1986, the Government has achieved remarkable success in economy shifting the system from the central planning and public ownership to a market-oriented economy and promoted the development investment to the infrastructure such as in road sector. Although agriculture is still a dominant sector in Laos, that share in GDP has decreased from 60.7% in 1990 to 56.4% in 1994. On the other hand, the industrial sector has expanded its share from 14.4% in 1990 to 17.5% in 1994. The following table shows a past trend of GDP at constant prices from 1990 - 1994.

TABLE 2.1 GROSS DOMESTIC PRODUCT (GDP) AT 1990 CONSTANT PRICES

GDP by Industrial Origin at 1990 constant prices (1990 - 1994)						
	1990	1991	1992	1993	1994	Average Growth Rate
GDP (Mill.Kip)	612,681.0	637,160.0	681,797.0	721,842.1	780,061.2	6.22%
Agriculture	371,835.0	365,347.0	395,537.0	406,233.5	439,786.5	4.29%
Industry	88,105.0	105,634.0	113,587.0	125,258.0	136,566.5	11.58%
Services	147,377.0	156,993.0	163,038.0	175,632.6	187,070.3	6.14%
Import Duties	5,364.0	9,186.0	9,635.0	14,718.0	16,637.9	32.71%
Yearly Growth Rate of GDP (1990 - 1994)						
GDP	6.7%	4.0%	7.0%	5.9%	8.1%	
Agriculture	8.7%	-1.7%	8.3%	2.7%	8.3%	
Industry	16.2%	19.9%	7.5%	10.3%	9.0%	
Services	-0.5%	6.5%	3.9%	7.7%	6.5%	
Import Duties	-34.0%	71.3%	4.9%	52.8%	13.0%	
Composition Ratio (%)						
GDP	100.0	100.0	100.0	100.0	100.0	
Agriculture	60.7	57.3	58.0	56.3	56.4	
Industry	14.4	16.6	16.7	17.4	17.5	
Services	24.1	24.6	23.9	24.3	24.0	
Import Duties	0.9	1.4	1.4	2.0	2.1	

Source: National Statistical Centre (NSC)

2.2 Present Conditions of the Study Area

The Study Area which would be affected directly and indirectly by the project bridge consists of the following four Provinces in the Southern part of the Lao PDR:

- Saravane province
- Sekong province
- Champasak province and
- Attapeu province

Pakse, the Provincial capital of the Champasak province, is at the strategic location from a view point of transportation and commodity flows accessing the Cambodia and Southern Vietnam via NR13, and accessing the Lao - Thai border via NR10.

(1) Population

Population in the Study Area is estimated at 913,000 in 1995 which is about 25% of the whole country. Among the provinces in the Study Area, the Champasak Province is a direct area of influence by the project and its population is about 500,000 which is 55% of the Study Area. Population of the Pakse district was about 60.000 with population density of 187.3 persons per km2 in 1994.

(2) Agriculture

Agriculture activities in the Study Area are dominated by rice cultivation. Harvested area for rice and its production are about 77% of total crops in the area and 25% of the whole country. The central feature is the Boloven Plateau which extends to the eastern part of Pakse. Production of coffee in the Plateau is about 90% of the whole country and exported to Thailand.

(3) Industry and Commerce

Small size establishments (fewer than 10 employees) dominate private businesses in the Study Area. There are 890 factories in the Champasak province at present of which 58% of factories are rice mills. Each of the district in the province has its own sawmill.

(4) Hydroelectric Projects

In addition to agricultural industry, development of hydroelectric schemes are the most important industry in the Study Area. At present, two hydroelectric power stations are under operation, one is 45 MW station at Xeset in the Saravane province and the other is Selabam 5 MW hydrostation in the Champasak province. From these stations, electricity ca be exported to Thailand in the rainy season.

(5) Road Network in the Study Area

The major road network in the Study Area consists of trunk roads NR13, NR16,NR18, NR10 and other provincial roads. Although the road improvements such as ADB projects are proceeding, present road conditions are still poor and some sections can not be passed in the rainy season. The trunk roads in the area are as follows :

1) NR13S passes through Pakse along the left bank of the Mekong river to the Laos – Cambodia border with 290 km long.

2) NR16 connects Saravane to Attapeu through B.Beng, Thateng and Sekong in the total length of 171 km. This road is not passable in rainy season.

3) NR 18 extends from Phatoumphon, located on NR 13S in the south of Pakse, through Attapeu to Vietnam border. This network also is difficult to pass vehicles in even dry season through whole section of 220 km.

4) Provincial road PR 13A starts from Pakse km 8 through Paksong to Thateng. The section between Paksong and Thateng is a seasonable road.

5) PR 20 connecting B. Houei and B.Beng is a paved road with bitumen of 72 km long.

6) NR 10 extends a section of 41 km long from Pakse crossing over the Mekong river by ferry to Chong Mek of Thai border. This road is a exit to Thailand of southern provinces.

2.3 Development Plans

(1) National Development Plan

The present economic policy in Laos is based on the New Economic Mechanism (NEM) program which was introduced since 1986. This program aims at transforming the conventional controlled economy into a more flexible market oriented economy. The Government promoted various policies such as the privatization of the majority of state–owned enterprises, a market–adapted commodity economy through the price reform. Some of these consequences are observed in the actual achievements activating and realizing stabilization of national economy.

Following the 3rd Five Year Plan (1991 – 1995), the Government of the Lao PDR has decided to embark on an ambitious policy agenda for the next five years up to the year 2000. These policies are reflected in the "Public Investment Program (PIP) 1994 – 2000" which was announced in 1994 and indicates that GDP growth will be maintained at 8% up to 2000. The program budget by PIP from the year 1994/95 to '99/2000 are shown below. In this Program, the highest amount of budget is to be allocated to the transportation sector

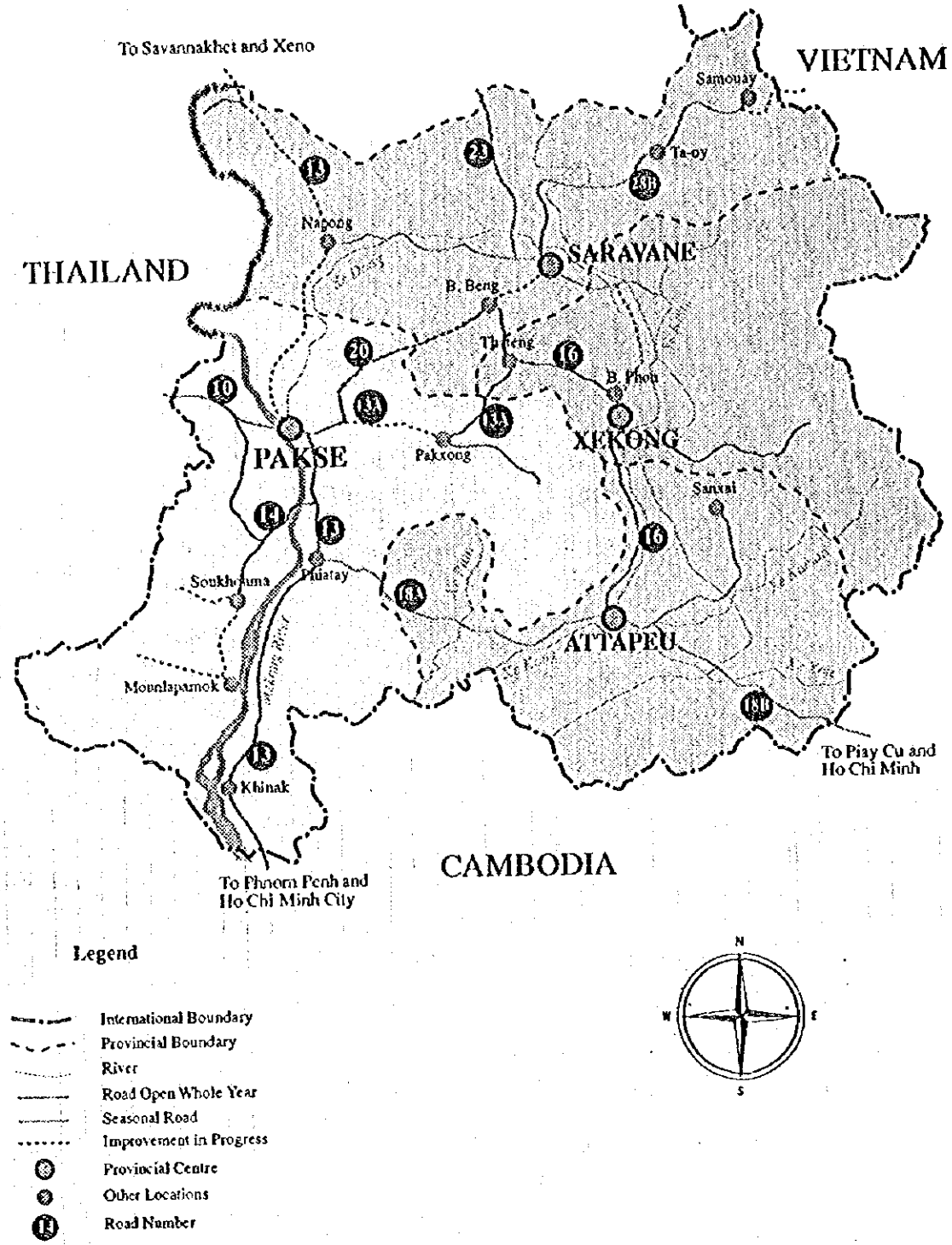


FIGURE 2-1 EXISTING ROADS IN THE STUDY AREA

TABLE 2.2 PROGRAM BUDGET (1994/95 - 1999/00)

PROGRAM	Total Funds Allocation (US$ million in 1994 prices)							Growth Rate per Annum	Composition of Total US$
	'94/5	'95/6	'96/7	'97/8	'98/9	'99/2000	TOTAL		
								(%)	(%)
(1) Agriculture & Forestry	23.7	32.5	40.9	50.7	54.5	61.0	263.3	20.8	19.65
(2) Industry (excl. Electricity)	1.3	6.0	8.0	8.5	7.5	8.0	39.3	43.8	2.93
(3) Electricity	15.0	13.5	14.0	14.0	13.0	15.0	84.5	0.0	6.31
(4) Transport	53.7	65.5	74.7	87.3	108.1	108.7	498.0	15.1	37.17
(5) Telecommunications	7.0	8.7	11.5	13.0	18.0	19.5	77.7	22.7	5.80
(6) Other Infrastructure (MCTPC)	12.0	12.0	12.0	13.5	17.0	20.0	86.5	10.8	6.46
(7) Culture (Ongoing Program)	4.0	4.3	4.6	5.0	5.4	5.8	29.1	7.7	2.17
(8) Education	20.3	21.8	23.1	24.3	23.5	26.5	139.5	5.5	10.41
(9) Health	9.7	13.5	17.8	20.8	23.8	26.8	112.4	22.5	8.39
(10) Economic Restructuring	0.0	2.5	3.5	3.5	0.0	0.0	9.5	-	0.71
TOTAL PIP	146.7	180.3	210.1	240.6	270.8	291.3	1339.8	14.7	100.00

Source: "Public Investment Program 1994-2000, Outline "June 1994

(2) Development Plans in the Study Area

1) Road and Bridge Projects

The road improvement projects in the Study area have been executed or are planned in the series of ADB2nd, 6th, 7th and IDA3rd improvement projects.

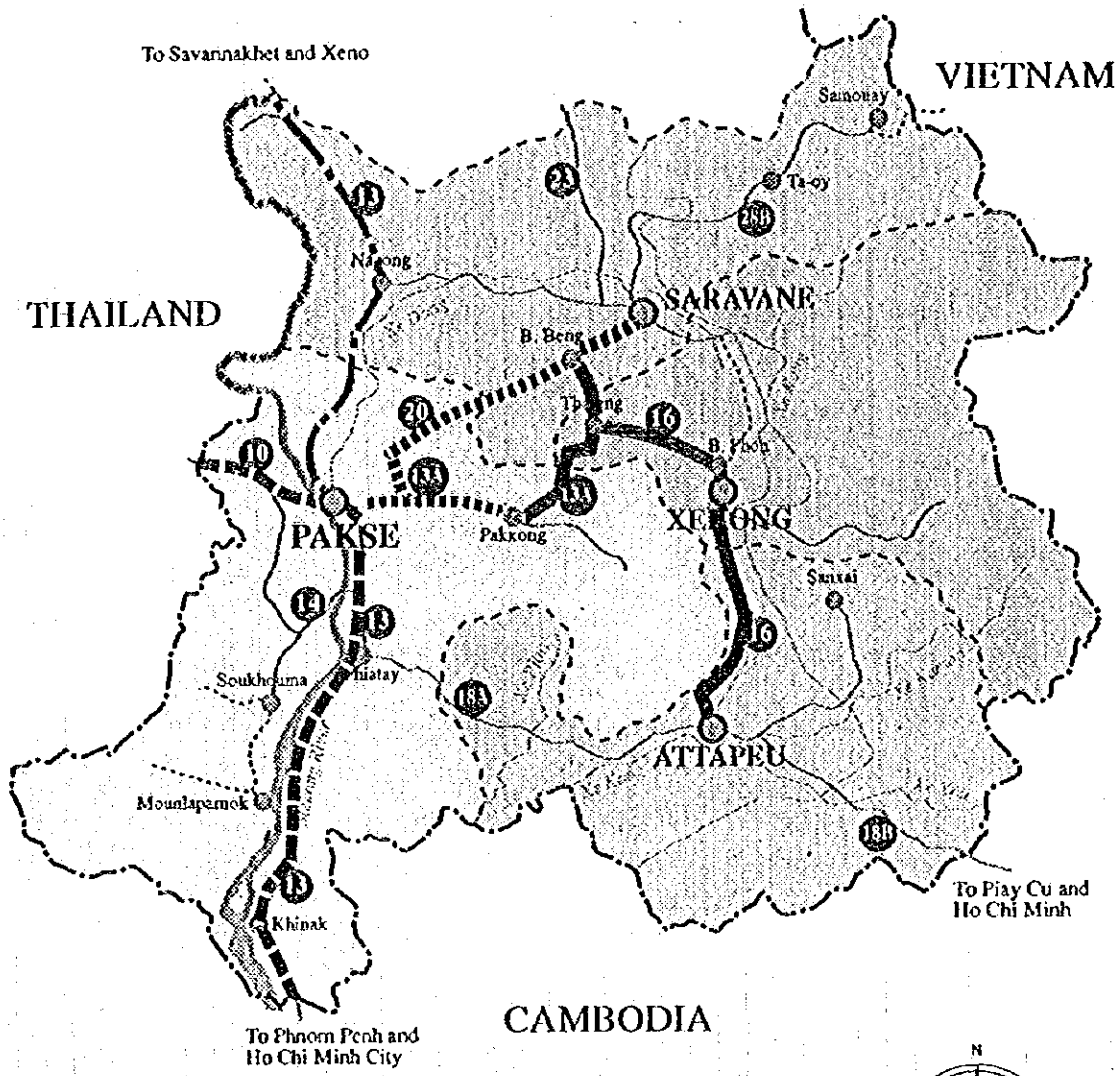
- ADB 2nd Project : (bituminous pavement work for PR 13A and PR20 from Pakse toSaravane/to Paksong, completed in 1995)
- ADB 6th Project : (improvement of PR13 from Paksong/B.Beng, and PR16 from Thateng/to Sekong/to Attapeu, will be completed by 1998)
- ADB 7th Project : (covers sections of NR 13S from Pakse to the Cambodia borderwith a 160 km long, and NR10 from Pakse to the Thai border with a 40km long, will be completed by 2000)
- IDA 3rd Project : (improvement of NR13 from Savannakhet to Pakse, will be completed by the end of 1996)

2) Agricultural Development Projects in the Study Area

The main agricultural projects in the Study area are summarized as follows :

- Lao Upland Agricultural Development Project (LUADP)
  The LUADP is financed by the World Bank and Lao PDR with technical assistance of the Australian and French Governments which are also taking a part of funding. The project aims at to increase farmers' income through introducing more suitable production techniques for coffee and field crops, vegetables, fruits and other economic trees.

- Swedish International Development Agency (SIDA) Project
  Main purpose of SIDA projects is to provide agriculture infrastructures in order to reduce slash and burn cultivation and to prevent deforestation.



Legend

- International Boundary
- Provincial Boundary
- River
- Road Open Whole Year
- Seasonal Road
- Improvement in Progress
- Provincial Centre
- Other Locations
- Road Number

Project	Mark	Length (km)	Implementation Schedule '90	'91	'92	'93	'94	'95	'96	'97	'97	'98	'99
ADB (2nd)		136											
IDA (1st & 3rd)		270											
ADB (6th)		193											
ADB (7th)		160											

FIGURE 2-2 ROAD DEVELOPMENT PROJECTS IN THE STUDY AREA

- Integrated Agricultural and Rural Development Project in Boloven Plateau
  The project area covers the Boloven Plateau with approximate area of 7,000 km^2. The ultimate objectives of the project are to increase farming output in the area through improvement and development of irrigation, drainage, rural infrastructures, and to achieve substantial and sustainable improvement in the living conditions of the habitants and their life improvement. The project is now at the stage of a master plan and feasibility study under the technical assistance of the Government of Japan through the Japan International Cooperation Agency (JICA).

3) Hydroelectric Projects

It is recognized that the Southern provinces of the Lao PDR have many candidate sites suitable for hydroelectric projects. Total 17 sites are identified in the Study area covering the Saravane, Attapeu and Sekong provinces.

3. NATURAL CONDITIONS AT PROJECT SITE

3.1 Meteo-Hydrology

3.1.1 Precipitation

The climate in the study area, which is distinctly divided into two seasons, is mainly influenced by the southwest monsoon and the northeast monsoon. The rainy season caused by the southwest monsoon begins in the middle of May and ends toward the end of October. The remaining period called the dry season has extremely no rainfall in the effect of the northeast monsoon. The average annual total precipitation amounts to around 2,000 mm, some 95% of which assemble in rainy season, while there is few record that the daily precipitation exceeds 100 mm. The annual total precipitation of 2,938 mm was recorded as the annual maximum in 1979 and the monthly precipitation of 923 mm as the maximum in August 1978, while the mean precipitation in the past August is some 500 mm.

3.1.2 Air Temperature

The monthly mean maximum and minimum air temperatures at Pakse are around 30°C and around 24°C respectively. The extremely highest air temperature, going on 40°C is recorded in around May and the extremely lowest one, less than 10°C, in around January.

3.1.3 Evaporation and Humidity

The annual total evaporation at Pakse is in a range of 1,100 mm to 1,900 mm and the mean is some 1,500 mm. The monthly evaporation exceeds the monthly precipitation for 7 months from November to May of next calendar year. The annual mean relative humidity is around 70% at Pakse. The change of the monthly average relative humidity shows that the highest of 93% is observed in June and the lowest of less than 50% in February and/or March.

3.1.4 Wind and Tropical Cyclones

The monthly maximum wind velocities are measured at 10 meters height at Pakse meteorological station. A maximum wind velocity of 40 m/sec, recorded two times, is the absolute maximum record during from 1957 to 1994. The prevailing wind direction shifts to the SE between February and September, while during the remaining period the wind direction shifts to N or NE. The maximum frequency of prevailing wind direction SE exceeds to 50% in March and 40% in September. During the period from 1951 to 1990 some of 21 tropical cyclones has passed through the Pakse area, however most of them are changing from a condition of tropical storm to a tropical depression.

3.2 River Hydrology

Around the north-west area of the Pakse city, the Mekong river presents a width broadly wide, around 1700 m, where some sediment deposits are observed in the middle and especially near the right riverbank. This conditions change gradually from the confluence of the Sedon river through the south-east area of Pakse city until the Mount Saleo side, about 2 km downstream. This narrow river section of the Mekong, the width of some 900 m, continue along the south-east approximately 5 km until the Mount Malong side where the river section becomes wide again and sediment deposits are observed. In the dry season the river water is of 2 or 3 m in depth at where the river width is wide and of 10 - 18 m in depth at narrow section. The water level rises from low water level by 10 - 15 m in rainy season.

The maximum flood discharge in 100-year return period is estimated at around 54,000 cubic meters. Annual average maximum discharge is around 36,000 cubic meters while the discharge at the lowest low water levels around 1,700 cubic meters. The water flow velocity in time of flood is 2.1 - 2.8 m/sec, while the mean velocity in dry season is less than 0.5 m/sec.

3.3 Geography and Geology

Pakse locates at 700 km downstream from Vientiane and 869 km upstream from the estuary of the Mekong river. Average land height of Pakse city area as well as the paddy fields extended along river banks is around 100 m from sea level. Generally the geography around the Project site presents the plains but Mount Saleo of 385 m height.

The base rock of sand stone and mud stone lays widely in the river side area around Pakse. Mount Saleo is a mountain of sandstone. The basalt of 5 - 6 m thickness covers partially the sandstone around left river bank in the area of southern part of Pakse city. On the plains around both river banks the laterite layers of around 10 m thickness deposits. In the river the sands and gravel of 2 - 20 m thickens deposit but hard sand stone exposes around the shore line near the foot of Mount Saleo.

4. PROPOSED ROUTES AND SITE SURVEYS

4.1 Selection of Alternative Routes

The proposed bridge route will be connected with NR10 in Phonthong side, and with NR 13 in Pakse side. The following aspects shall be considered in selecting the proposed bridge routes:

- contents of relevant development plans in and around the Project site,
- the route location shall be closer to Pakse town, but not to pass through Pakse town from the view point of road network efficiency in and around the Project site,
- the land acquisition and compensation shall be minimum, and
- avert of religious and/or traditional facilities.

Using the existing topographical map (scale of 1/20,000) several alternative routes were found, and among them three alternative route(Route-A, B, C) were selected as prospective route for comparative study to select the optimal route of the Project.

Route-A: Selected as upstream side route to Pakse town connected with NR 13 to the north of Pakse air port. The proposed bridge length is longest among the alternatives, but river water depth is shallowest. The total route length is 5,360 m.

Route-B: Selected as downstream side route to Pakse town. The closest to Pakse town. Both of the proposed bridge length and water depth are middle. The total route length is 4,410 m.

Route-C: Selected as the shortest bridge length route. The route location is faraway from Pakse town and the approach roads become long. The water depth is the deepest among alternatives. The total route length is 5,790 m.

4.2 Site Surveys for Alternative Routes

Along the three alternative routes topographic survey, bathymetric survey, water flow velocity survey and geological investigations were conducted.

The environmental examination also conducted along each alternative route to evaluate relatively the routes in the aspect of environmental assessment. The components of environmental site survey consist of biophysical environment(air, noise, water resource, fisheries resource, terrestrial resource, etc.), social environment (resettlement, land use, access restriction, visual intrusion, etc.), and public consultations.

5. TRAFFIC FORECAST

5.1 Methodology

Future traffic demands on the project bridge were forecast based on the following steps:

1) Collection and analysis of existing traffic data

The existing traffic data was available from the study results of the ADB6th and 7th Road Improvement Projects which included traffic data related to the Pakse bridge project such as Average Daily Traffic (ADT) and Origin - Destination Matrix (O-D Tables) in the area.

2) Traffic Survey

In order to analyze the present characteristics of the traffic crossing over the Mekong river by the Pakse ferry and to grasp a growing trend of traffic around the Pakse area, traffic surveys were carried out at three stations ,Pakse ferry terminals, NR13 (km 8) and NR10 (km 12). The surveys were traffic counting surveys for 24- hours and lasted continuously for 7 days (but, 12 - hour survey at the Pakse ferry terminals).

3) Establishment of Present O-D Matrix

The present O-D matrix crossing over the Mekong bridge at Pakse was established based on the results of traffic count survey conducted by the JICA Study Team and applying the O-D pattern at km12 NR10 surveyed by the "ADB 7th Road Improvement Project".

4) Establishment of Future Socio-Economic Framework

Future population was formulated on the basis of past trend and projection by "ADB 7th Road Improvement Project". The expected macro economic growth rates for Lao PDR and other surrounding countries were set based on the National Development Plans and related studies such as "Sub Regional Transport Sector Study, ADB" and "ADB 7th Road Improvement Study". The estimation results are shown below :

	1994-2000	2000-2010	2010-2020
Population Growth (Champasak province)	2.0%p.a.	1.7%p.a	1.2%p.a.
GDP Growth Rate	8.0	6.5	5.0

5) Forecasting Future O-D Matrix

A traffic growth model was estimated based on the historical traffic data and applying population of the Champasak province and GDP. The traffic growth rates were calculated through inputting future socio-economic indices as shown below :

	1995-2000	2000-2010	2010-2020
Light Vehicles (Car, Pickup, etc.)	13.3%p.a.	8.7%p.a.	5.5%p.a.
Truck	7.5	6.1	4.1

The future O-D matrix for the normal traffic was obtained applying the above overall growth rates and growth rates by traffic zone to the present O-D matrix. Furthermore, induced traffic (newly generated traffic through time reduction by the bridge)) was estimated constructing a induced traffic model which includes travel time as an explanatory variable. In addition, the following two kinds of traffic were forecast and incorporated into the O-D matrix of normal traffic :

- Development traffic that will be generated from the agricultural development projects in the Boloven Plateau.
- International trips between northern Thailand and southern Vietnam applying future goods movements.

6) Future Traffic Volume on the Project Bridge

Future traffic volume on the project bridge by alternative route were forecast through the procedure of traffic assignment of O-D tables on the road network of each target year.

5.2 Present Traffic Volume

(1) Traffic Volume by Existing Data

The ADB 6th Road Improvement Project (1992) has carried out traffic count surveys at 11 points in the Study area. According to the study, traffic volume on the selected road links are comparatively low and not more than 300 vehicles/day. The traffic survey by the ADB 7th Road Improvement Project indicates that the traffic volumes were 440 -1,035 vehicles on NR13 near Pakse and about 300 vehicles/day on NR10.

(2) River Crossing Traffic by the Pakse Ferry

The river crossing traffic volume surveyed by the Study Team (31 July 1995 - 6 August 1995) are summarized as follows :

Vehicle Type	Traffic Volume
Motorcycles	388 /day
Car,Pickup,etc.	95
Bus	14
Truck	99
(Sub-total)	(596)
Bicycle	274
Pedestrian	1,668

5.3 Results of Future Traffic Forecast

The results of traffic forecast are as shown below:

Route	Vehicles / day (ADT)			Growth rate per year	
	2000	2010	2020	2000-10	2010-20
A	1,467	3,474	5,775	9.0%	5.2%
B	1,460	3,451	5,737	9.0	5.2
C	1,448	3,422	5,691	9.0	5.2

Present traffic volume 596 vehicles (including motorcycles) will grow to about 5,700 vehicles in 2020 and it is about 9.6 times of the present traffic.

6. SELECTION OF OPTIMAL BRIDGE ROUTE

6.1 Preliminary Design for Alternative Routes

6.1.1 Design Conditions

(1) Fundamental Cross Elements

Taking into consideration the traffic volume of existing ferry, future traffic demand and ADB 7th project, the fundamental cross elements for proposed routes were determined as follows:

Number of traffic lane	:	Dual single lane
Carriageway width	:	3.5 m per each lane
Shoulder	:	2.0 m for approach roads 0.5 m for bridge
Sidewalk	:	1.5 m at both side (bridge section only)

(2) Live Loads : AASHTO HS 25

(3) Design Speed : 80 km/h

(4) Others

The existing design standards and design criteria, Road Design Manual compiled by MCTPC IN 1994, will be advantageously applied to the Project. However the international standards including Japanese also will be supplementary applied. Especially Road Bridge Specifications recompiled by Japan Road Association in 1992 will be applied for bridge design.

6.1.2 Determination of Bridge Length

The followings are considered to determine the proposed bridge length of each alternative route.

- Abutment shall be set back from the shore line of H.W.L(High water level) not to block the river flow.
- In case of the route crossing the narrow section of river, the location of abutment shall be set back from the shore line of F.W.L(Flood water level).
- River bank erosion shall be taken into consideration at the left bank of each alternative route and the right bank of Route-A. The bank erosion will be estimated at a rate of 1.0 m a year for design life of the bridge.
- The stability of abutments and approach road embankments should be maintain on the occurrence of the bank erosion estimated. It is proposed that the estimation of

quantity of river bank erosion will be counted for 50 years equivalent to a design life of the bridge.

The proposed bridge length of each alternative route was determined as follows:

Route-A:	1,560 m	(Total route length : 5,360 m)
Route-B:	1,380 m	(Total route length : 4,410 m)
Route-C:	1,100 m	(Total route length : 5,790 m)

6.1.3 Selection of Foundation Type

Considering the superstructure size and span length aimed, the foundation types applicable to site conditions of each alternative route are nominated as follows:

Route-A:	Direct foundation with spread footing Cast-in-situ pile foundation of extrusion type
Route-B:	Cast-in-situ pile foundation of extrusion type Inter-locking steel pipe pile well Open caisson
Route-C	Cast-in-situ pile foundation of extrusion type Inter-locking steel pipe pile well

Cast-in situ pile foundation of extrusion type, pile diameter of 1.5 m, was selected for all alternative routes in the aspect of construction cost and workability of foundation.

6.1.4 Proposed Bridge Type and Optimal Span Length

Selecting 8 superstructure types applicable to the Project as shown beneath, the economic span length was looked for by each type.

Steel bridge type:	Continuous steel box girder with RC deck Continuous steel box girder with steel deck Through type arch girder Continuous through type steel truss girder
PC bridge type:	Continuous PC box girder Continuous rigid frame PC box girder with center hinges Extra-dosed PC box girder Cable stayed PC box girder

As shown in Fig 6-1, Fig 6-2, the optimal bridge type and the optimal span length were found as follows:

Route-A:	Continuous rigid frame PC box girder, Span length = 100 m
Route-B:	Continuous rigid frame PC box girder, Span length = 100 m
Route-C:	Continuous rigid frame PC box girder, Span length = 150 m

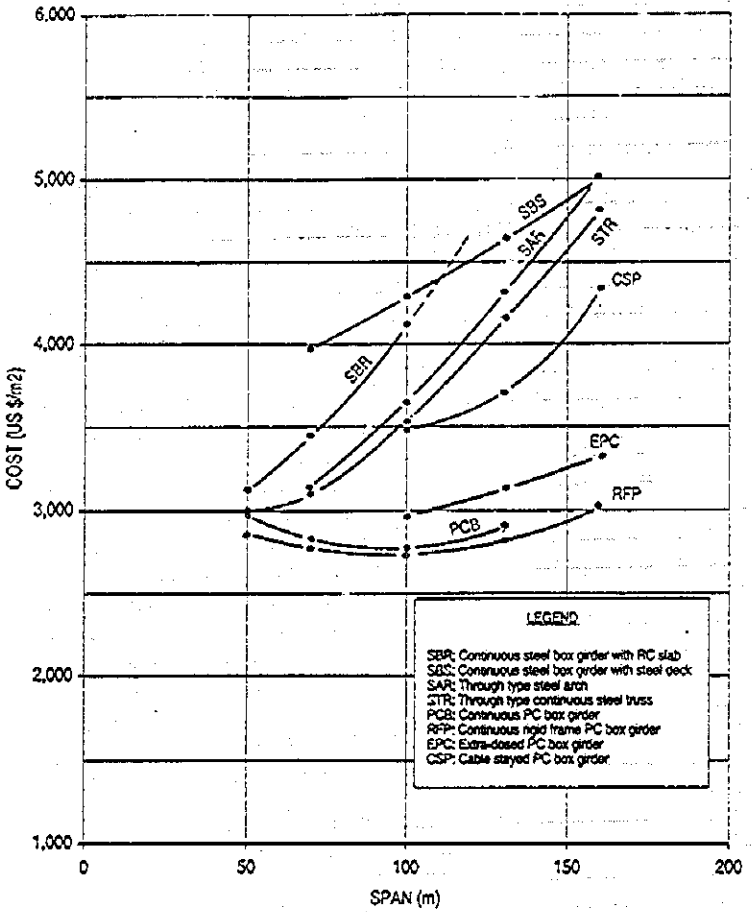


FIGURE 6-1 BRIDGE TYPES AND SPAN LENGTH RANGE (ROUTE-A&B)

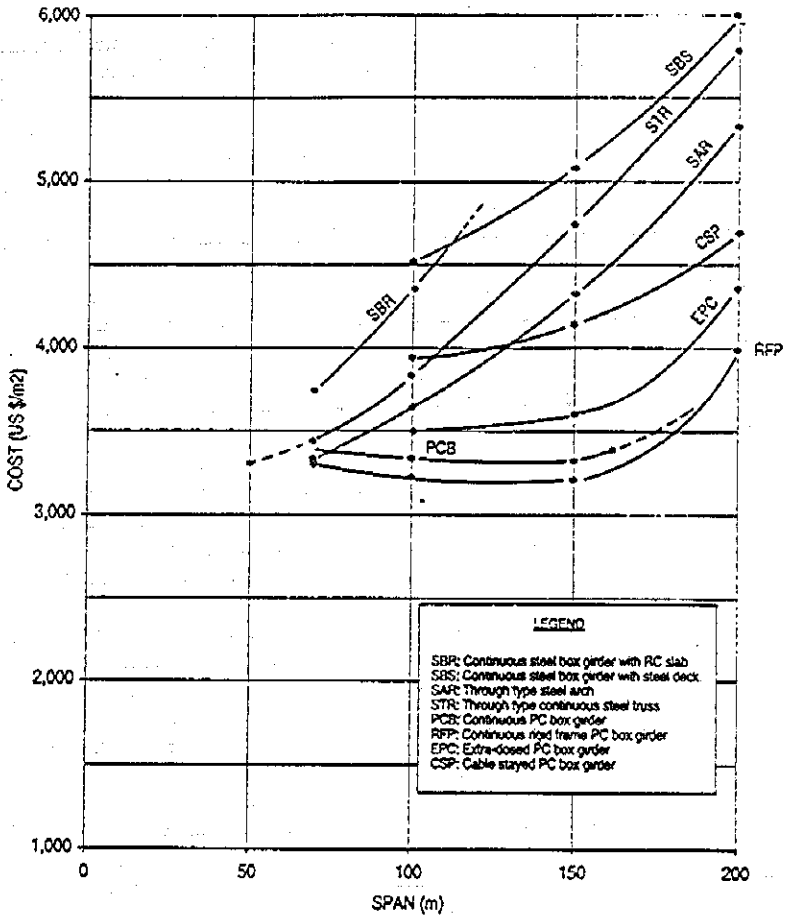


FIGURE 6-2 BRIDGE TYPES AND SPAN LENGTH RANGE (ROUTE-C)

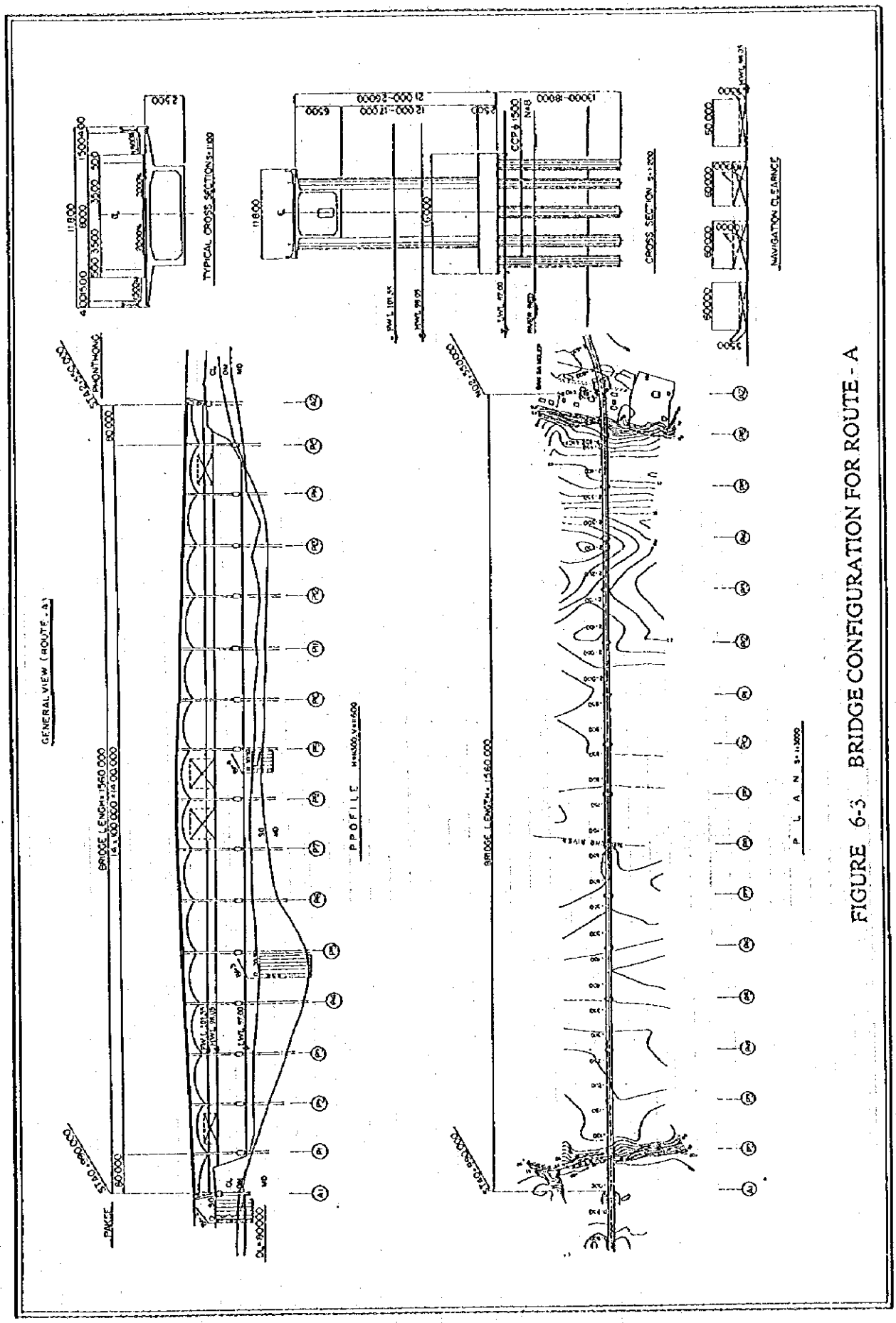


FIGURE 6-3 BRIDGE CONFIGURATION FOR ROUTE - A

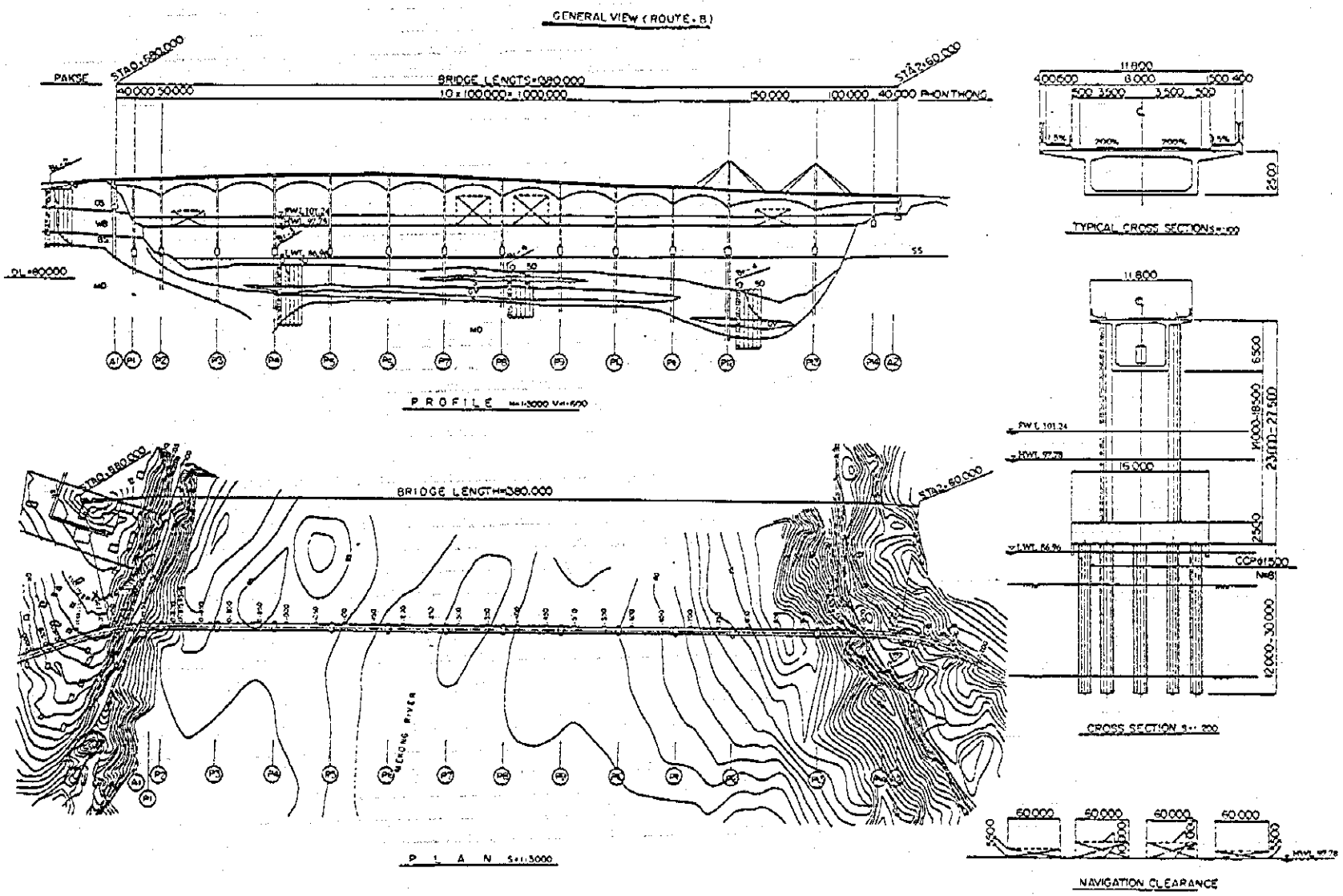


FIGURE 6-4 BRIDGE CONFIGURATION FOR ROUTE - B

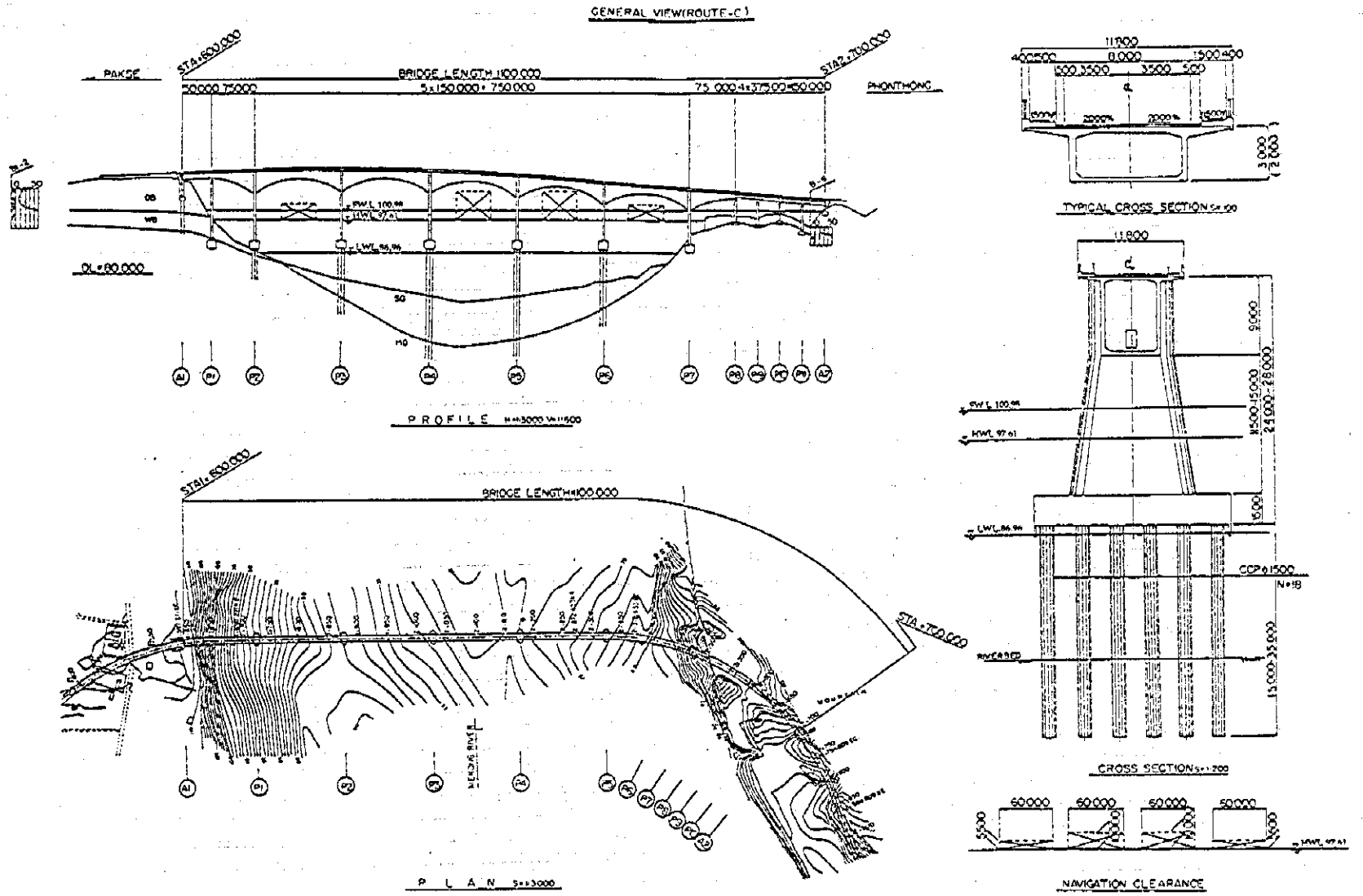


FIGURE 6-5 BRIDGE CONFIGURATION FOR ROUTE - C

For a section of Route-B having deep foundations the span length of more than 100 m which is given as the economic span for Route-C will be applied since the foundation conditions of Route-B around this section are similar to Route-C.

6.1.5 Bridge Configurations of Alternative Routes

The bridge configuration of each alternative route as a results of preliminary design are shown in Fig 6-3, Fig 6-4 and Fig 6-5.

6.1.6 Construction Costs of Alternative Routes

The construction cost of each alternative route were estimated based on the results of preliminary designs and the current unit prices applied in Laos and neigbor countries. The cost summary by alternative are shown in Table 6-1. Should the actual construction work start at the begining of dry season the construction periods of Route-A and Route-B wrere estimated at 34 months and Route-C estimated at 37 months.

TABLE 6-1 CONSTRUCTION COST OF ALTERNATIVE ROUTES

(Unit: US$ 1,000)

Item of Works	Route - A		Route - B		Route - C	
	Quantity	Amount	Quantity	Amount	Quantity	Amount
Construction Cost						
1. Bridge Construction		50,430		44,150		43,680
1) Substructure	A2, P15	13,860	A2, P15	11,870	A2, P11	14,370
2) Superstructure	17,160 m2	36,570	15,180 m2	32,280	12,100 m2	29,310
2. Approch Road Construction	3,800 m	12,510	3,030 m	8,520	4,690 m	8,480
TOTAL		62,940		52,670		52,160

6.2 Economic Benefits

(1) Economic Benefits of Bridge Construction

The main advantages of construction of a new bridge are the savings in time costs of traffic crossing over a river. The following four types of benefit are calculated in this preliminary economic analysis :

1) Savings in capital cost and time related cost of vehicles crossing over the Mekong river on the ferries.

2) Savings in crew cost of commercial vehicles (buses and trucks)

3) Savings in time cost of passengers in vehicles

4) Savings in future additional investment, operation, maintenance, repair costs for ferry boats and ferry terminal facilities.

In addition, distance-related Vehicle Operating Costs (VOC) such as fuel, oil, tire consumption were also calculated as negative benefits.

The unit VOCs were updated based on the same procedure as adopted by MCTPC since National Transport Study (NTS) and by inputting recent price data given in the "ADB 8th Road Improvement Project " and "East - West Transport Corridor Study, ADB).

The time values of passenger were estimated based on the income/expenditure data. The umber of additional boats needed in future were calculated at 10 boats for 20 year from 2000 to 2020 and the economic cost of a new ferry boat was set at US$ 215,000.

Estimated benefits by each benchmark year by alternative route are shown below :

TABLE 6.2 SUMMARY OF BENEFIT ESTIMATION

(US$1,000)

BENEFIT	ROUTE	TRAFFIC	2000	2010	2020
Users Cost Savings (VOC) (Time Costs)	A	Normal Traffic	(*) 684/2=342	1920	3924
		Induced Traffic	39/2=20	114	225
		Total	362	2034	4149
	B	Normal Traffic	(*) 742/2=371	2101	4275
		Induced Traffic	40/2=20	118	234
		Total	391	2219	4509
	C	Normal Traffic	(*) 660/2=330	1912	3880
		Induced Traffic	37/2=19	109	215
		Total	349	2021	4095
Savings in Ferry Service Costs	Operations		1562/2=781	3750	5823
	Investment		215	0	215
	Total		996	3750	6038

Note: (*) Opening timing of the Bridge is scheduled to be at the middle of 2000. A half of yearly benefits is reckoned.

(2) Economic Project Costs

The economic costs are calculated by deducting such transfer items as taxes and duties from market prices and expressed in constant 1995 price as presented below. The physical contingency is estimated at 10% of the construction cost and administration costs are at 3% of local currency portion.

TABLE 6.3 ECONOMIC PROJECT COSTS

(US$1,000)

ROUTE	YEAR / ITEM	Total ('96-2000) (1995 prices)	1996	1997	1998	1999	2000
ROUTE-A	- Direct Cost	62,940	0	21,085	19,826	17,623	4,406
	- Physical Contingency	6,294	0	2,108	1,983	1,762	441
	Subtotal	69,234	0	23,193	21,809	19,386	4,846
	- Engineering	4,406	1,386	800	971	971	278
	- Administration	944	0	316	297	264	66
	- Land Acquisition	104	0	104	0	0	0
	Total	74,688	1,386	24,414	23,078	20,621	5,190
ROUTE-B	- Direct Cost	52,670	0	17,644	17,539	14,748	2,739
	- Physical Contingency	5,267	0	1,764	1,754	1,475	274
	Subtotal	57,937	0	19,409	19,293	16,222	3,013
	- Engineering	3,687	1,160	669	813	813	232
	- Administration	790	0	265	263	221	41
	- Land Acquisition	275	0	275	0	0	0
	Total	62,689	1,160	20,618	20,369	17,257	3,286
ROUTE-C	- Direct Cost	52,160	0	17,474	17,369	14,605	2,712
	- Physical Contingency	5,216	0	1,747	1,737	1,460	271
	Subtotal	57,376	0	19,221	19,106	16,065	2,984
	- Engineering	3,651	1,148	663	805	805	230
	- Administration	782	0	262	261	219	41
	- Land Acquisition	647	0	647	0	0	0
	Total	63,456	1,148	20,793	20,172	17,089	3,254

The estimated annual operation and maintenance costs after opening of US$ 4 per meter per year are used for the approach roads.

(3) Preliminary Economic Evaluation

Assumptions for the preliminary economic evaluation are as follows :

- The opening timing of the project bridge (regardless of alternatives) is scheduled to be at the middle of the year 2000 in accordance with the implementation plan.
- The evaluation period of the project bridge is assumed as 30 years after opening year.
- Benefit streams between each benchmark years (2000, 2010 and 2020) are estimated by means of interpolation. Benefits after 2020 are estimated by means of extrapolation.
- The residual value 30 years after opening, is calculated to be at 40 % of the total construction cost. This amount is refunded in 2030, as a negative amount in cost flow. In addition, a 100 % of land acquisition costs are also counted as residual

value because a land is not depreciable and will remain as it is even after a long project life.

(4) Results of Economic Evaluation by Alternative Route

The cost benefit cash flows were tabulated in order to calculate the values of Economic Internal Rate of Return (EIRR) by each alternative and shown below.

Route	EIRR
Route - A :	6.8 %
Route - B :	8.0 %
Route - C :	7.8 %

The above results provide enough information to judge the priorities among the alternatives in the preliminary comparative study. In conclusion, the route B is the optimum route from an economic point of view if the EIRR criterion is strictly applied.

6.3 Optimal Bridge Route

The optimal bridge route is selected grading the appraised points on the evaluation items which consist of economic evaluation, engineering evaluation and environmental evaluation taking into consideration the results obtained from the previous subsections.

The examination method for evaluation:

(1) Evaluation components and Weighting

The weightings for the evaluation items are assigned attaching importance to economic component first and environment component second as follows:

Economic component	65 %
Engineering component	15 %
Environment component	20 %

(2) Sub-components

Each component has sub-components which are also allotted weighting. The appraisal score of component comes from the summation of sub-component scores.

(3) Score

Each score of sub component is given in inverse proportion to the appraisal ranking among 3 alternatives as follows:

Rank	Score
1	3
2	2
3	1

(4) Total score

The total score of each alternative route firstly is expressed in a range of the full mark of 3 as a summation of component scores. Finally the total scores are expressed in a range of the full mark of 100 as equivalent to raw scores.

The marking table is summarized as shown in Table 6.4. According to the evaluation result, it is concluded that Route-B should be selected for the optimal bridge route of this Project.

TABLE 6.4 EVALUATION TABLE FOR THE ALTERNATIVE ROUTES

		Alternatives		
		Route-A	Route-B	Route-C
Project Length (m)		5,360	4,410	5,790
Bridge Length (m)		1,560	1,380	1,100
Evaluation Items	Component and Sub component Weighting			
(1) Economic Evaluation	**0.65**	**0.65**	**1.69**	**1.56**
Economic Internal Rate of Return (EIRR %)	0.60	1 (6.8%)	3 (8.0%)	2 (7.8%)
Initial Capital Cost	0.40	1	2	3
(2) Engineering Evaluation	**0.15**	**0.32**	**0.44**	**0.15**
Alignment / Road Network	0.35	2	3	1
River Hydrology	0.10	3	2	1
Superstructure	0.05	2	3	1
Foundation	0.20	2	3	1
Construction Period	0.05	2	3	1
Future Maintenance	0.25	2	3	1
(3) Environmental Evaluation	**0.20**	**0.46**	**0.35**	**0.39**
Biophysical Environment	0.25	3	1	2
Human/Built Environment	0.40	3	2	1
Critical Development Restriction	0.15	1	2	3
Public Consultation Outcome	0.20	1	2	3
Summation		**1.43**	**2.48**	**2.1**
Score Out of the Full Marks of 100		**48**	**83**	**70**
Evaluated Priority Rank		**3**	**1**	**2**

7. ENGINEERING STUDY ON PROPOSED ROUTE

The proposed route selected as the optimal route of the Project is the alternative Route-B. The further engineering study on the proposed route following the preliminary design was carried out to clarify the Project features and to facilitate the data for the project evaluation and to establish the implementation plan.

7.1 Main Bridge

7.1.1 Span Arrangement

As for the span lengths of the main bridge around 100m in the river section of shallow water depth and around 150 m in deeper section are employed as the economic span length respectively. The span arrangement which decides a number of pier was reconsidered on the preliminary plan so that the first pier located on the left river bank slope is deleted by making the extreme side span length longer, and as a result the bridge has 14 spans supported with 12 piers in the river and one pier on land, which is consisted of 70 m span, ten 102 m spans, 150m span, 100m span and 40 m span. This span arrangement was made based on not only employing economic span length but aiming at the pier to locate away from the deepest section of the river.

7.1.2 Superstructure

The structural type selected is a 14-span continuous rigid frame PC box girder with center hinges having a main span length of 100 - 102 m and 150 m. The geometric main dimensions of box girder structure are determined for the span of 102 m length. The section of 150 m span length is reinforced with extra-dosed cables not to change the main dimensions of box girder determined for the section of 102 m span length. The towers supporting extra-dosed cables at piers and anchoring of extra-dosed cables into main girder are installed in the area between carriageway and sidewaik. For these spaces the bridge width is extended by 1.5 m at both sides from the normal section of 11.8 m width.

7.1.3 Substructure

(1) Pier

Since the pier shafts, except one pier supporting superstructure with movable shoes, constitute the members of rigid frame structural system for bridge, the working forces for design mainly are come out from the results of the analysis on superstructure. The member property of pier shaft was determined in the manner that the bending stiffness of pier shaft in the direction of longitudinal bridgo axis becomes low. The thickness of pier shaft determined is of 3.0 m and the effective width is selected as same dimension as the lower flange width of box girder. As the sides of pier shaft to face to river flow direction should be made in a semicircular shape the entire width of pier shaft including the flare portions becomes 11 m. The entire width of both piers supporting 150 m span

was estimated at 14 m to support the towers for extradosed cables.

(2) Foundation

Cast-in-citu pile foundation of extrusion type is selected as optimal foundation structure of the Project. The pile cap of this extrusion type, concrete footing, is constructed above low water level in dry season. The pile diameter of 1.5 m was found as a economical size due to comparative study on pile diameters in a range from 1.0 m to 2.0 m. For the construction of pile steel pipe casing is used in the section of water and river deposit. The bearing stratum for pile foundation is mud stone or sandstone. The pile tip is socketed into such bed rock in the river without any casing The socketing depth into rock is more than two times of pile diameter in length. The number of pile per pier to secure the stability of foundation was estimated at 8 in normal bridge section and at 11 - 14 in longer span section.

7.2 Approach Roads

7.2.1 Alignment

The junction with NR 13S of this route is located at KM 2+100 of NR 13S which is EL 101.75. This Pakse side approach extends in the residential area, which is not so congested, to the left river bank. It passes the west of Wat Phongsavat at a distance of around 100 m. The beginning point of the bridge at Pakse side is located at around 200 m upstream from Pakse Water Supply Station. The horizontal alignment of this section shifts the direction by an angle of 20 ° to cross the river at the shortest distance. The elevation of the bridge section varies EL 115.60 at the left bank to 107.87 at the right bank. The bridge section and the Phonthong side approach road are connected with the horizontal curvature of 400 m radius. This Phonthong side road passes behind the residential belt area located along the right river bank and connects the end point of NR 10.

7.2.2 Pavement

The pavement design has been carried out in accordance with "Pavement Design, Road Design Manual Part III, Lao PDR". The Pavement shall consist of Subbase Course, Base Course and Surface Course. Subbase Course having a 15 cm thickness shall be constructed with lateritic soil. On the other hand, the Base Course shall be a mixture of gravel with lateritic soil. It should have a thickness of 20 cm. Refer to Figure 11.2-4

The Road surface of the carriageway will be paved by DBST(Double Bituminous Surface Treatment) using screened gravel.

7.3 General Views of Proposed Route

The general view and cross sections of main bridge, the plan and profile for proposed route as a results of engineering studies are shown in Fig 7-1, Fig 7-2, Fig 7-3 ~5.

7.4 Construction Method and Schedule

For the reasonable construction period of the Project a term of around 3 years is proposed. As the foundation works should be done in dry season, August will be optimal commencement month considering a term of 3 months for preparatory works. It takes for 2 dry seasons for substructure to be constructed. The erection of superstructure can be started one year later the commencement of foundation construction. For the erection method of PC box girder precast segment method is recommended in the aspect of construction schedule management and quality control. The construction schedule of the project is proposed as shown in Fig 7-6.

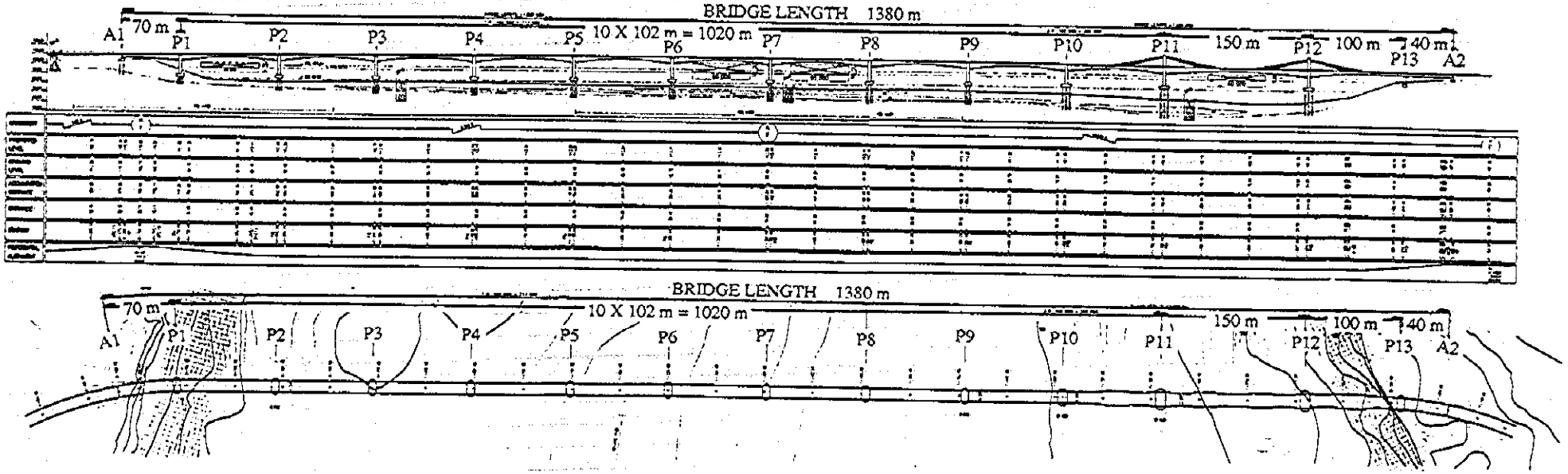


FIGURE 7-1 GENERAL VIEW OF BRIDGE

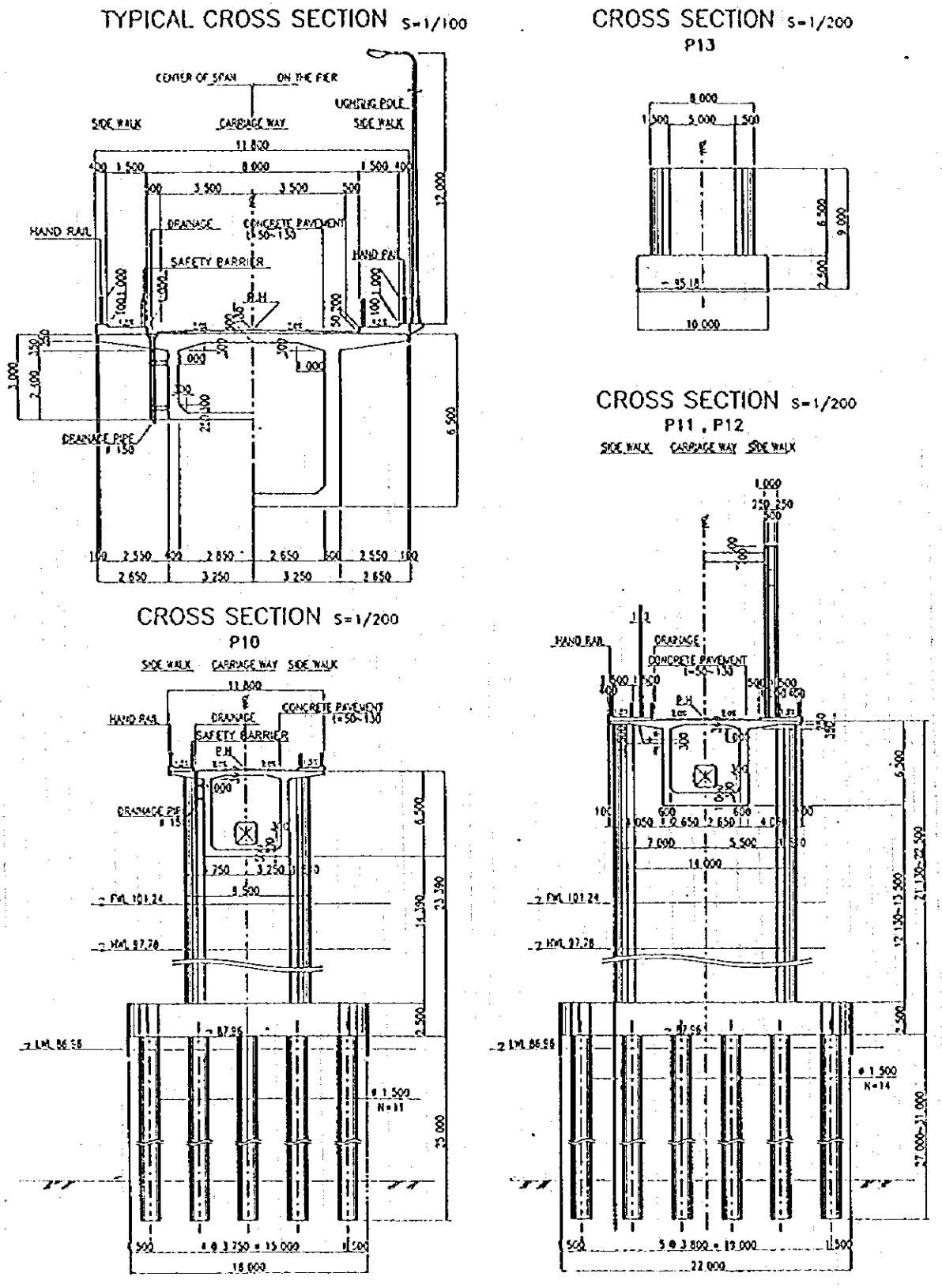


FIGURE 7-2 CROSS SECTION OF BRIDGE

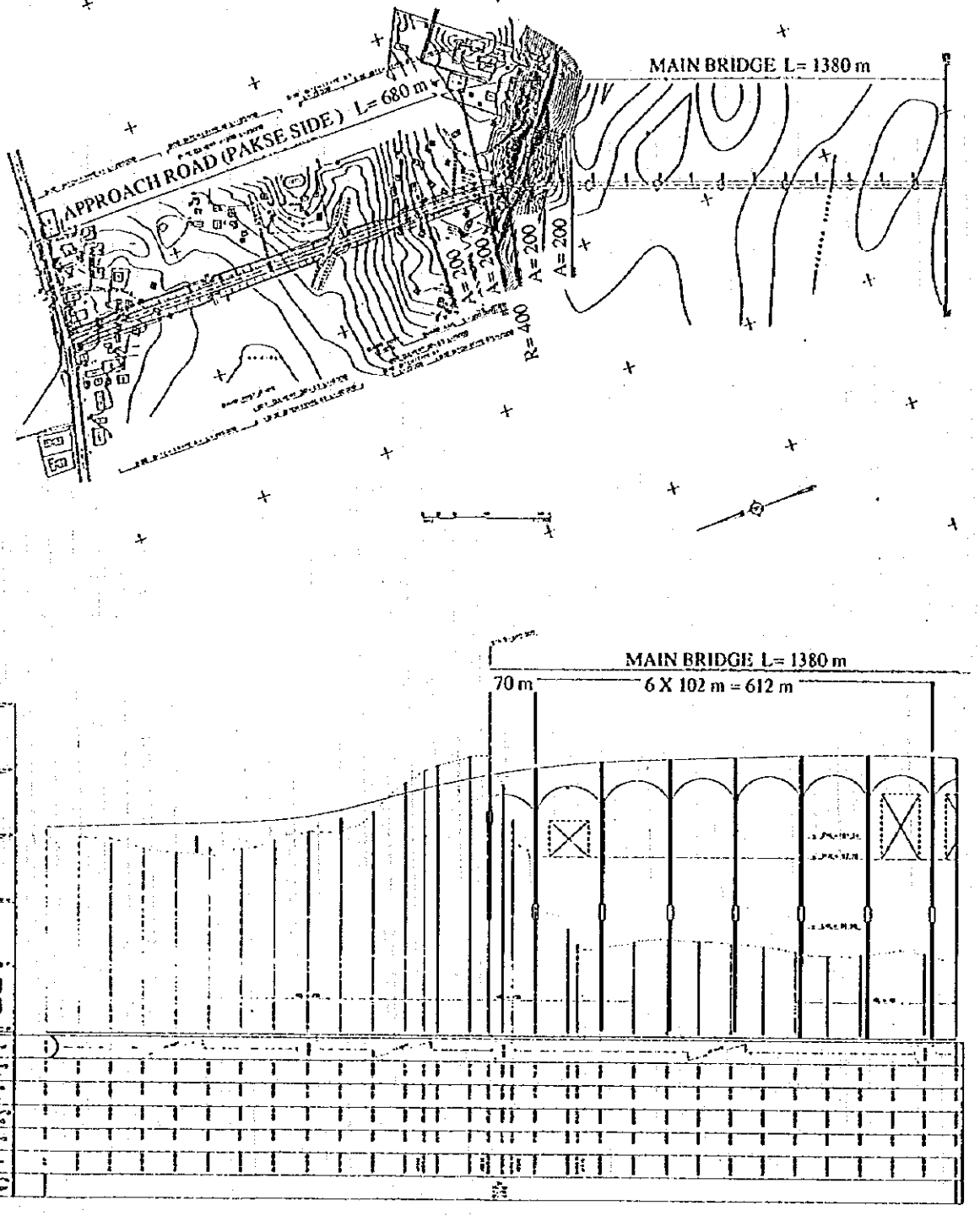


FIGURE 7-3 PLAN AND PROFILE (1)

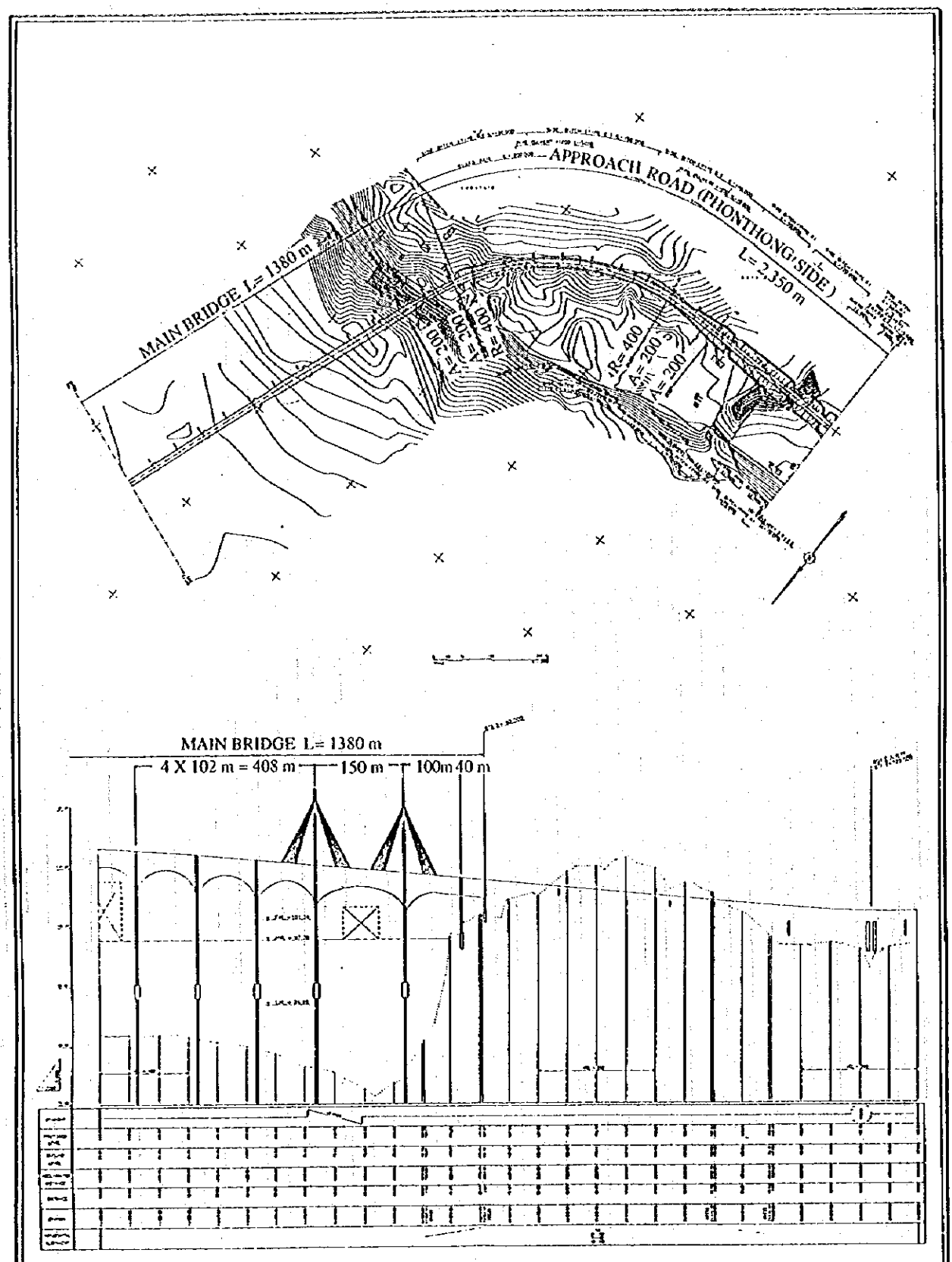
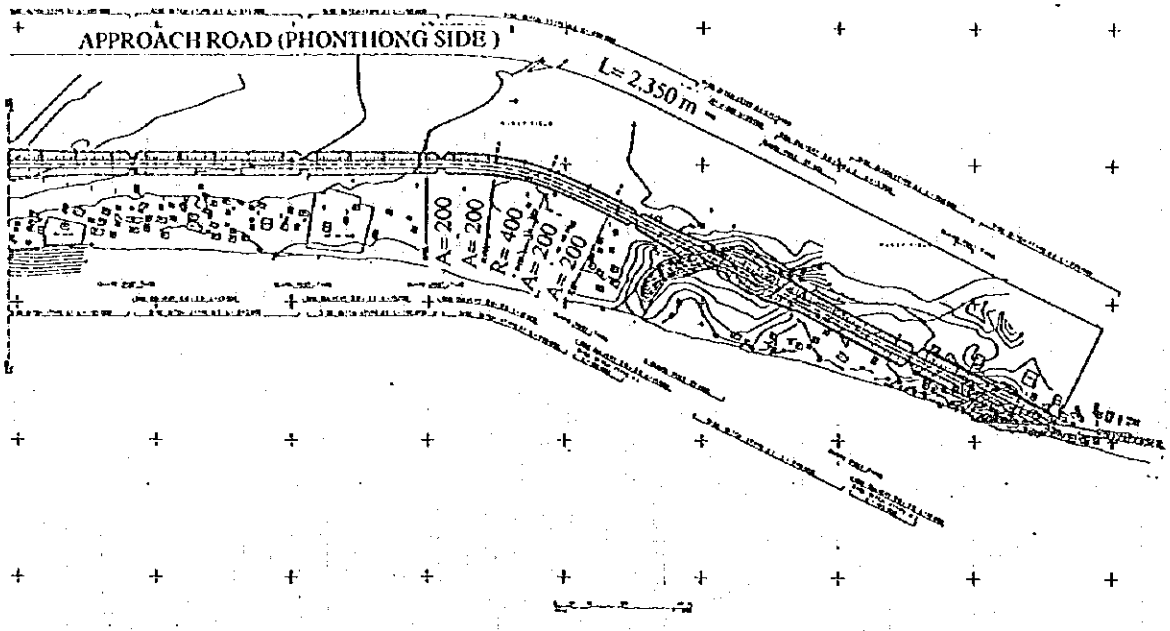


FIGURE 7-4 PLAN AND PROFILE (2)



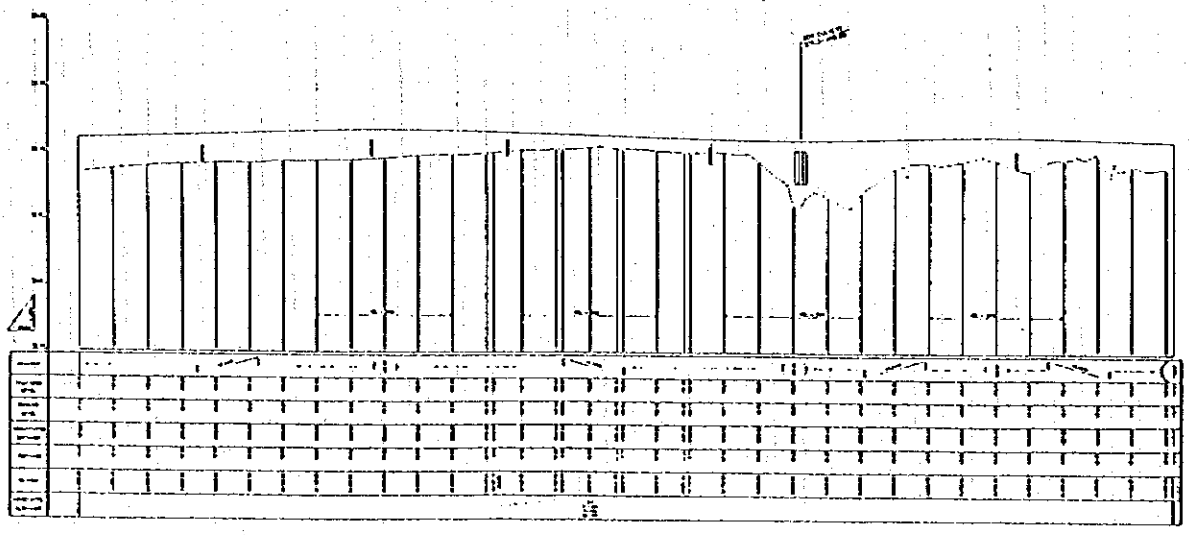
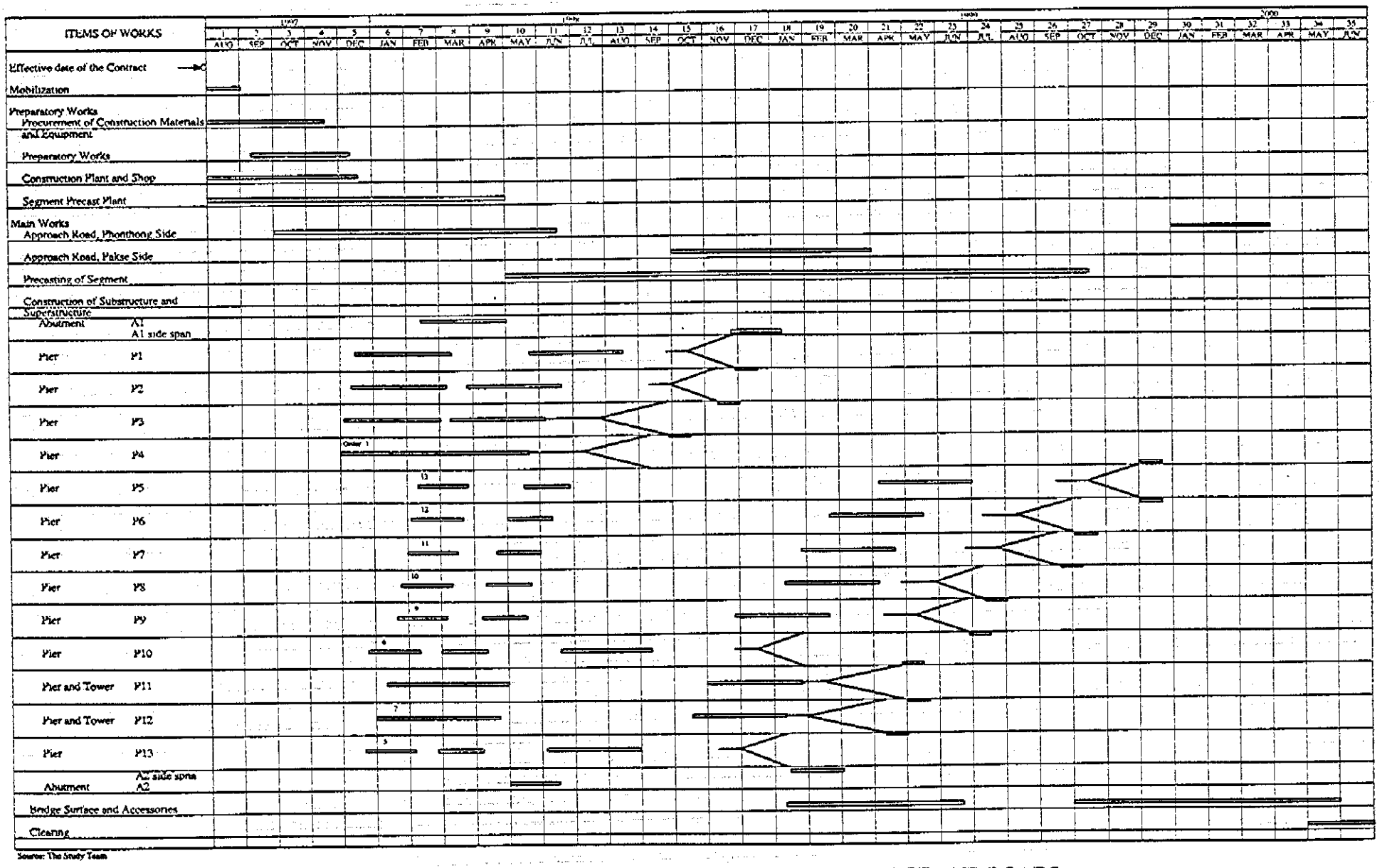


FIGURE 7-5 PLAN AND PROFILE (3)



Source: The Study Team

FIGURE 7-6 CONSTRUCTION SCHEDULE FOR BRIDGE AND ROADS

8 TOTAL PROJECT COST

8.1 Capital Cost

The Capital cost for the Project comprises the construction costs including bridge and approach roads construction, land acquisition and compensation costs, engineering services, project administration costs, and physical and price contingencies. The total project cost was estimated at US$69.0 million as shown in Table 8-1.

TABLE 8-1 PROJECT COST

(Unit: x 1000)

Item	L.C	F.C	Total
	US$	US$	US$
A. Construction Costs	9,884	42,884	52,768
1. Preparatory Works	816	4,887	5,703
2. Bridge Construction	7,551	35,909	43,460
1) Substructure	3,250	9,335	12,585
2) Superstructure	4,301	26,574	30,875
3. River Bank Protection	338	206	544
4. Approach Road Construction	1,179	1,882	3,061
B. Physical Contingency	988	4,288	5,277
C. Engineering Services	369	3,324	3,693
1. Detailed Design	146	1,314	1,460
2. Construction Supervision	223	2,010	2,233
D. Administration Costs	792	0	792
E. Land Acqusition and Compensation Costs	485	0	485
F Price Contingency	1,048	4,334	5,382
Total	13,566	54,831	68,397

8.2 Maintenance Cost

The maintenance cost comprise administration cost, routine and periodic inspection costs, routine maintenance cost and periodic maintenance cost. The annual maintenance cost of the bridge of a length of 1,380 m and the approach roads of a total length of 3.03 km (Pakse side: 0.68 km, Phontong side: 2.35 km) was estimated at US$15,000 per years.

9. PROJECT EVALUATION

9.1 Economic Evaluation

(1) Economic Project Costs

Economic costs of the selected route are summarized in the table below which were estimated based on the design work :

TABLE 9-1 ECONOMIC PROJECT COSTS (1995 PRICES)

(US$1,000)

YEAR / ITEM	Total ('96-2000) (1995 Prices)	1996	1997	1998	1999	2000
- Construction Cost	52,768		19,124	14,833	15,729	3,082
- Physical Contingency	5,276		1,912	1,483	1,573	308
Sub-total	58,044		21,036	16,316	17,302	3,390
- Engineering Service	3,693	1,387	520	826	804	156
- Administration	792	79	158	238	238	79
- Land Acquisition and Compensation	485		436	49		
TOTAL	63,014	1,466	22,150	17,429	18,344	3,625

The total construction cost is estimated at US$52,768,000 (1995 prices) and total project costs including land acquisition and compensation costs, engineering services, contingency and administration cost are estimated at US$63,014,000 in 1995 prices.

The annual maintenance costs after opening are estimated at US$15,000 per year.

(2) Economic Benefits

1) Direct Benefits of the Project

There exist many types of impacts on a society by the construction of a new bridge. Those are broadly classified into "Direct Benefits (or Users Benefits)" and "Indirect Benefits (or Non-users Benefits). Indirect benefits are kinds of induced effects generated through the direct benefits and realized as regional development effects.

The direct benefits of the project bridge consist of mainly the time savings of the traffic that will divert from the ferry boats to the new bridge. In addition to those benefits, the future ferry service costs which would be not needed after opening of the bridge are also counted as benefits from a view point of national economy. The calculated benefits including savings in future investment costs for the new slope type jetties in 2000 are summarized as follows :

TABE 9-2 BENEFIT ESTIMATION

(US$1,000)

BENEFIT	TRAFFIC	Year		
		2000	2010	2020
Users Cost Savings (VOC and Time Cost)	Normal Traffic	371	2,101	4,275
	Induced Traffic	20	118	234
	Sub-total	391	2,219	4,509
Savings in Ferry Service Costs	Operations	781	3,750	5,823
	Investment(Boats)	215	0	215
	Investment(Jetties)	500		
	Sub-total	1,496	3,750	6,038
TOTAL		1,887	5,969	10,547

2) Indirect Benefits of the Pakse Bridge Project

The Pakse bridge is expected to generate many kinds of indirect benefits through realization of non-waiting, continuous and all-weather traffic flows. The followings are expected long-term effects which will accrue from the implementation of the project bridge :

- Regional Development

a. Agricultural Development Effects

- It is reported that the four districts along the western bank of the Mekong River (Phontong, Champasak, Soukhouma and Mounlapamoke) tend to produce rice more than their self-sufficiency level and transport its surplus rice to Pakse and other districts located on the eastern bank where the rice production is not sufficient to cover district population. At present, transportation of rice and other agricultural products are relying on the ferry services only. Considering the demand and supply pattern of rice, the project bridge will provide the most reliable and effective means to transport rice from western bank to eastern bank.

- Many agricultural development projects are on-going or planned in future in the Boloven Plateau and its surrounding areas. The project bridge is indispensable for these agricultural development projects in order to transport smoothly their input and output without bottleneck at the Mekong River crossing. Among the products of agricultural development projects, coffee from the Boloven Plateau is exported to Thailand and will contribute to earn foreign currencies.

b. Industrial Development Effects

- Although present manufacturing industry in the study area is dominated by small size factories, saved transport time and costs by the bridge will reduce the costs of raw materials, and on-time delivery of produced commodities will stimulate new locations of other industries.

- In addition, the new bridge will give foreign investors strong incentive to investment in this area. Up to now, the investment by foreigners in the Champasak

province are counted at 14 companies. There are some more foreign investors continuing to do feasibility studies for some projects such as sugar factory, coffee processing factory and others. There was also a contract investment on hydropower project in Houei Ho by a private company from South Korea. Construction of the new bridge will accelerate this tendency and then increase employment opportunities in the study area.

c. Betterment in Living Conditions

- The major shopping markets are located in Pakse. Number of trips to the market in Pakse (for purchases) can be infrequent as once per month especially from the more distant villages in the districts on the Phontong side. Reduced travel time and cost by the new bridge will result in improved access to the regional markets and other amenities.

- The present number of hospitals or health care centers in the Champasak province are 91 including one provincial management hospital. However, the fully-equipped hospital is located only in Pakse. Small dispensaries are located in most villages, but are not staffed by qualified doctors. It is, therefore, clear that all-weather and 24-hour operated bridge is very important for those living in the western bank areas remote from Pakse particularly in the case of emergency.

d. Promotion of Tourism Development

- Tourism in Lao PDR has experienced a rapid growth. According to the National Tourism Authority of Lao PDR, the total number of tourists has increased from 4,900 persons in 1991 to 16,000 persons in 1994 with an average annual increase rate of 48%. Of those, approximately 1,200 persons visited Champasak Province and about 65% of those were from Thailand. The accommodation capacity in Champasak province is just 8 hotels with a total 158 rooms in 1994. However, there are notable tourist attractions in the area such as Wat Phu, Khon Phapheng Waterfalls, Khong Island and Bolaven Plateau. The number of tourists visiting Champasak province by roads will be influenced by the construction of the Pakse bridge and, at the same time, will influence the need for the project bridge because poor road conditions and the bottleneck of crossing over the Mekong river will suppress tourism.

- <u>International Link</u>

- About 130 persons and 33 trucks per day have crossed the Lao - Thai border at Chongmek in 1994. The number of trucks crossing border are forecast to increase to 60 vehicles per day in 2000. All coffee and a half of other agricultural products from the Boloven Plateau Agriculture Projects are estimated to be exported to Thailand through Chongmek. The new bridge at Pakse will play an important role as a gateway to/from Thailand and promote the economic development not only for the region but also for the whole country of Lao P.D.R.

(3) Results of Economic Evaluation

Based on the conventional Discount Cash Flow analysis, evaluation indicators were calculated as below :

	Discount Rate	7%	9%	10%
-	Net Present Value (NPV : US$1,000)	8,996	-6,374	-11,571
-	Benefit Cost Ratio (B/C)	1.18	0.87	0.75
-	Economic Internal Rate of Return (EIRR : %) = 8.0%			

EIRR of the project bridge is estimated at 8%. The results above are based on the only quantifiable direct benefits. In addition to the direct benefits, regionwide and nationwide development effects by the Project should be taken into account for the evaluation. Considering such wide range and long term indirect effects together with the direct benefits, the implementation of the Project will be sufficiently justified.

9.2 Sensitivity Analysis

The sensitivity tests were carried out by changing key factors within the probable range as shown below :

1) GDP Growth	EIRR
High case (10%, 8%, 6%)	8.5%
Base case (8%, 6.5%, 5%)	8.0
Low case (6%, 5%, 4%)	6.9

2) Traffic Demand	EIRR
+30%	9.8%
+20%	9.2
+10%	8.6
Base case	8.0
-10%	7.3
-20%	6.6
-30%	5.9

3) Time value (incl.VOC)	EIRR
+30%	8.8%
+20%	8.5
+10%	8.3
Base case	8.0
-10%	7.7
-20%	7.4
-30%	7.1

4) Ferry operation costs	EIRR
+30%	9.1%
+20%	8.7
+10%	8.4
Base case	8.0
-10%	7.6
-20%	7.2
-30%	6.8

5) Construction cost	EIRR
+30%	6.5%
+20%	7.0
+10%	7.4
Base case	8.0
-10%	8.6
-20%	9.3
-30%	10.2

9.3 Financial Analysis

The contents of the financial analysis are classified into the following two items :

- Possibility of introducing a toll system
- Financial bases for the implementation of the project bridge

(1) Possibility of Toll Bridge

1) Toll Rates and Toll Revenues

Imposing toll charges on bridge users will be justified from a point of "Beneficiaries Pay Principle" and originally ferry tariff has been levied on the river crossing traffic.

The following four cases were prepared to determine the toll rates and calculated toll revenues are shown below :

1) Case 1 : Present Pakse ferry tariff
2) Case 2 : User benefit per vehicle
3) Case 3 : 50% of user benefit per vehicle
4) Case 4 : Existing Friendship bridge (Vientiane - Nongkhai Bridge)

TABLE 9-3 TOLL RATE AND TOLL REVENUES

Case	Toll Rate by Vehicle Type (Kip/vehicle)				Toll Revenue (All vehicles) US$1,000		
	Motorcycle	Light Vehicle	Bus	Truck	2000	2010	2020
Case 1	300	3600	5500	7350	1411	3374	5081
Case 2	500	3200	3680	6000	1257	3002	4577
Case 3	250	1600	1840	3000	628	1501	2289
Case 4	-	900	1500	6000	851	2067	2936

2) Financial Return and Maintenance Cost Recovery

The values of Financial Internal Rate of Return (FIRR) were calculated for the Case 1 (highest revenue) and Case 3 (lowest revenue) and results are shown as follows :

- Constant price (1995) case : Toll structure Case 1 ; FIRR = 3.7%
  Toll structure Case 3 ; FIRR =-0.6%

- Toll revision at every 5-year interval (3% up per annum), Cost escalation at 3% per annum. Toll structure Case 1 ; FIRR = 6.4%
  Toll structure Case 3 ; FIRR = 2.0%

Above results indicate that the recovery of the initial investment costs with the toll revenues will be very difficult because of low financial returns. On the other hand, the annual maintenance costs can be covered sufficiently with the annual toll revenues.

(2) Financial Resources and Investment Capacity

1) Government Financial Situation

Since 1990, mainly as a result of increasing tax revenues, the deficit of the Government budget (excluding capital expenditures) has improved. In 1992, domestic tax and non-tax revenues covered nearly all current expenditures, leaving the financing of capital expenditures to loans and foreign assistance. Although the fiscal reform in Laos has produced more rapid and better results, the budget situation is highly dependent upon external assistance. All most all portions of tax and non-tax revenues are input to cover the current expenditures and not for the capital expenditures. In 1992, about 90% of the deficit was financed by foreign assistance.

TABLE 9-4 GENERAL GOVERNMENT BUDGET
(1990 - 1992)

(Kip million)

Year	1990	1991	1992
REVENUE	60,960	74,672	90,456
Tax	37,644	54,355	63,513
Non-tax	23,316	20,317	26,943
Grants	22,960	32,550	39,946
EXPENDITURE	143,447	151,079	174,641
Current	69,864	81,956	92,424
Capital	73,583	69,123	82,217
Overall Balance (Commitment basis)	-59,527	-43,857	-44,239
Clearance of arrears (net)	-5,920	-4,982	463
OVERALL BALANCE (Cash basis)	-65,447	-48,839	-43,776
Financed by			
Domestic financing (net)	5,107	19,287	4,828
Bank	107	13,793	1,448
Non-bank	5,000	1,200	2,348
Asset sales	0	4,294	1,032
Foreign financing (net)	60,340	29,552	38,948
TOTAL FINANCING	65,447	48,839	43,776

Source: "ANNUAL REPORT 1992" Bank of the Lao PDR

The same situation (shortage of budget by local fund) is observed in the road and bridge sector in MCTPC.

2) Future Road and Bridge Investment Plan

Future investment plan for road and bridge sector is presented in the " Public Investment Program (PIP : 1994-2000)". Comparing to the program budget by PIP with the disbursement schedule of the Pakse bridge project, the total costs of the Pakse bridge will be more than 14% of road and bridge sector by PIP and maximum 34% of annual budget of PIP.

TABLE 9-5 ROAD AND BRIDGE INVESTMENT PLAN

(US$ million)

Year	1994/5	1995/6	1996/7	1997/8	1998/9	1999/00	TOTAL
Public Investment Program (PIP)*							
Transport Sctor	53.7	65.5	74.7	87.3	108.1	108.7	498.0
[A] Road & Bridge Sector	51.0	60.2	66.0	75.7	92.5	93.5	438.9
[B] Pakse Bridge Project Costs Disbursement Schedule		1.47	22.66	17.49	18.36	3.59	63.57
(B/A) %		2.4%	34.3%	23.1%	19.8%	3.8%	14.5%

Source (*) : Public Investment Program 1994 - 2000, Outline, June 1994.

3) Investment Capacity

The size of the Pakse bridge project in terms of the project cost (63 US$ million) is about 10 times of the total local fund of MCTPC budget of 1994/95 and also 3.6 times of the total budget for all CTPC sectors . Considering such project size and the present Government financial situation, implementation of the project only by the local fund or local loans will impose a big burden to the Government budget.

9.4 Environmental Impact Assessment

The environmental impact caused by implementation of the Project and the proposed mitigation measures against the impact are summarized as shown in Table 9-6. Carrying out these mitigation measures described in the Table is seemed to be not so difficult while resettlement will be required for 44 families.

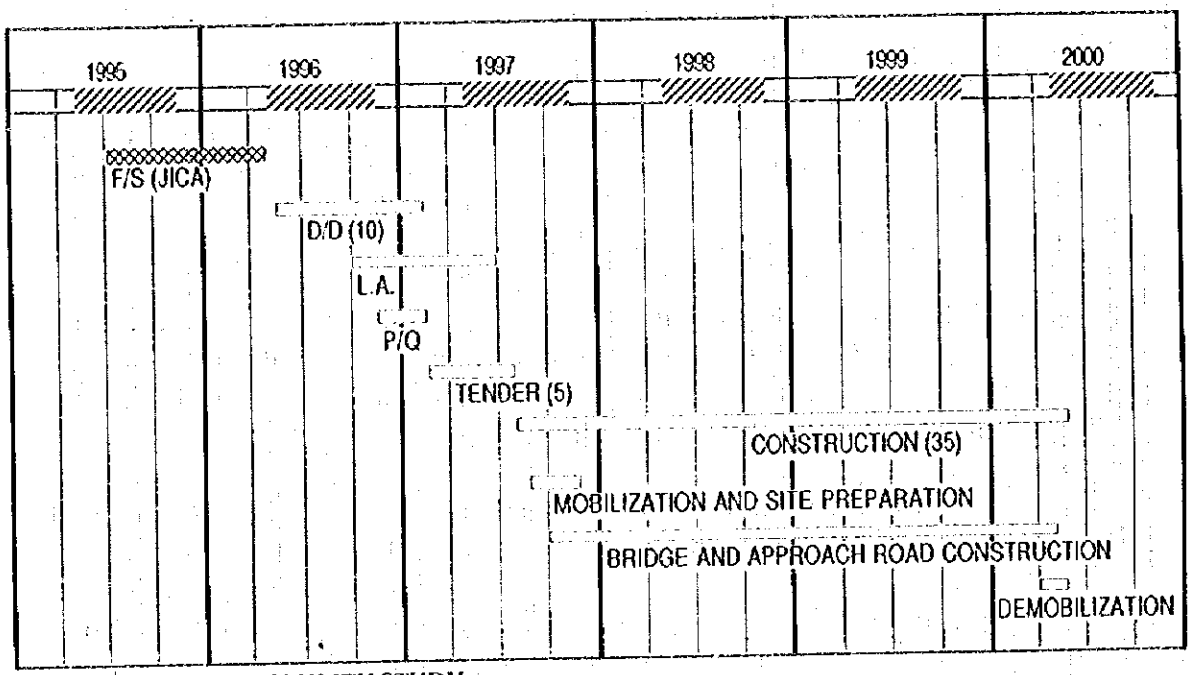
TABLE TABLE 9-6 SUMMARY OF PROPOSED MITIGATION MEASURES

Activity	Environmental Component Affected	Predicted Impact	Rating of Potential Impact and Severity	Proposed Mitigation Measure
Vehicle Traffic	Air	Periodic air pollution over Pakse Town	A	1. Good traffic management to prevent congestion at intersections 2. Establish landuse controls within ROW and within the 200m wide impact zone
	Noise	Increase in overall ambient noise level plus periodic annoying noise episodes	S	1. Provide vegetation buffers (plantings of trees, shrubs) 2. Create noise berms and use natural attenuation features
Capping of existing wells in ROW	Aquatic and Human	Loss of potable water supply	V	Reconnection of water supply
Resettlement	Human/Built	Community and family stress	V	Compensation and relocation assistance
		Relocation of 44+ families	V	Same
Clearing of ROW and approach road alignment	Human/Built and Agriculture	Removal of 70,000 m^2 of rice fields plus many market garden and grazing plots	V	Compensation and assistance Revegetation
Construction of a vertically elevated approach road	Human/Built	access restrictions to fields and property	V	Placement of nine 2.5m x 3m box culverts along approach road, with location based on engineering limits and consultation with residents. Specification of operational period maintenance needs
	Visual	Obstruction of views with embankment walls	S	Vegetation screens and buffer zones planted and maintenance of these once operational period begins

A: annoying but tolerable impact
S: significant degradation
V: very severe impact needing immediate mitigation to prevent occurrence .

10. IMPLEMENTATION PLAN

The implementation schedule of the Project was studied considering the optimal commencement time in a year for foundation construction in the river and using the condition that the construction project would be completed by middle of 2000. Prior to the commencement of the construction it is necessary to carry out such pre-construction works as soils and geological investigation, detailed design, land acquisition, financial arrangement, etc. The overall project implementation schedule considered above conditions is shown in Fig. 10-1.



Legend: F/S: FEASIBILITY STUDY
D/D: DETAILED ENGINEERING DESING
L.A.: LAND ACQUISITION AND COMPENSATION
P/Q: PREQUALIFICATION
////: REAINY SEASON

FIGURE 10-1 OVERALL IMPLEMENTATION SCHEDULE OF MEKONG BRIDGE CONSTRUCTION AT PAKSE

11. CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

NR 10 is the most important and only trunk road connecting directly southern provinces of Lao PDR with Thailand bearing the heavy trade traffic. However, the traffic running on the route will be compelled to continue to spend many hours waiting for ferry crossing at Pakse, unless the Bridge to replace the existing ferry is constructed. Without the construction of bridge the increase in traffic volume across the Mekong river will force to bring about demand for the increase in ferry facilities will result in higher investment of capital in the long run.

The future traffic volume on the existing ferry route is expected 5,700 vehicles, 2050 TRU equivalent according to the traffic demand forecast carried out in the course of the study, while the present traffic volume as of August 1995 was 600 vehicles, 230 TRU equivalent.

Based on the results of the study it is found that the Project of the construction of the Mekong bridge at Pakse is technically feasible. The construction of the Mekong bridge also is judged viable by the economic evaluation which shows an IRR of 8 % considering the present economic status in Lao PDR.

The Project will accompany various intangible benefits that will contribute to the development and well-being of the region in and around the project area.

The Project also will contribute to forming a prospective transportation network of the East West corridor formulation in Indochina.

The bridge route study has selected alternative Route-B, crossing over the Mekong river at 2 km downstream of the existing ferry route.

The proposed route, dual single lane, has the whole length of 4,410 m, composed of the bridge length of 1,380 m, the approach roads of 680 m on Pakse side and 2,350 m on Phonthong side.

The construction of bridge will not be anticipated to cause any serious technical, environmental and social issues in the course of bridge construction and after the completion.

It is found that the bridge should be designed and constructed with prestressed concrete structure supported with concrete shafts and cast-in-situ pile foundations of extrusion type to meet construction conditions in the Project site.

It is concluded that the Mekong Bridge construction at Pakse is an indispensable project and that it is a realistic solution for the development of economy as well as road transportation of the country.

11.2 Recommendations

The Project is expected to proceed to implementation stage as soon as possible and it is advisable for financing the Project to get a generous grant or a soft loan of favorable condition at the earliest stage.

It is preferable that the completion date of the Project will be set taking into consideration the time of the completion of the relevant Projects ADB 7th projects going on currently.

The detailed design stage for the execution of the Project, the works of which comprise site investigation, design of roads and structures and preparation of tender documents should be started before the beginning of rainy season.

It is most desirable to raise at one time the fund needed for the whole cost of the Project, US$68.4 million, at the outset of the Project.

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