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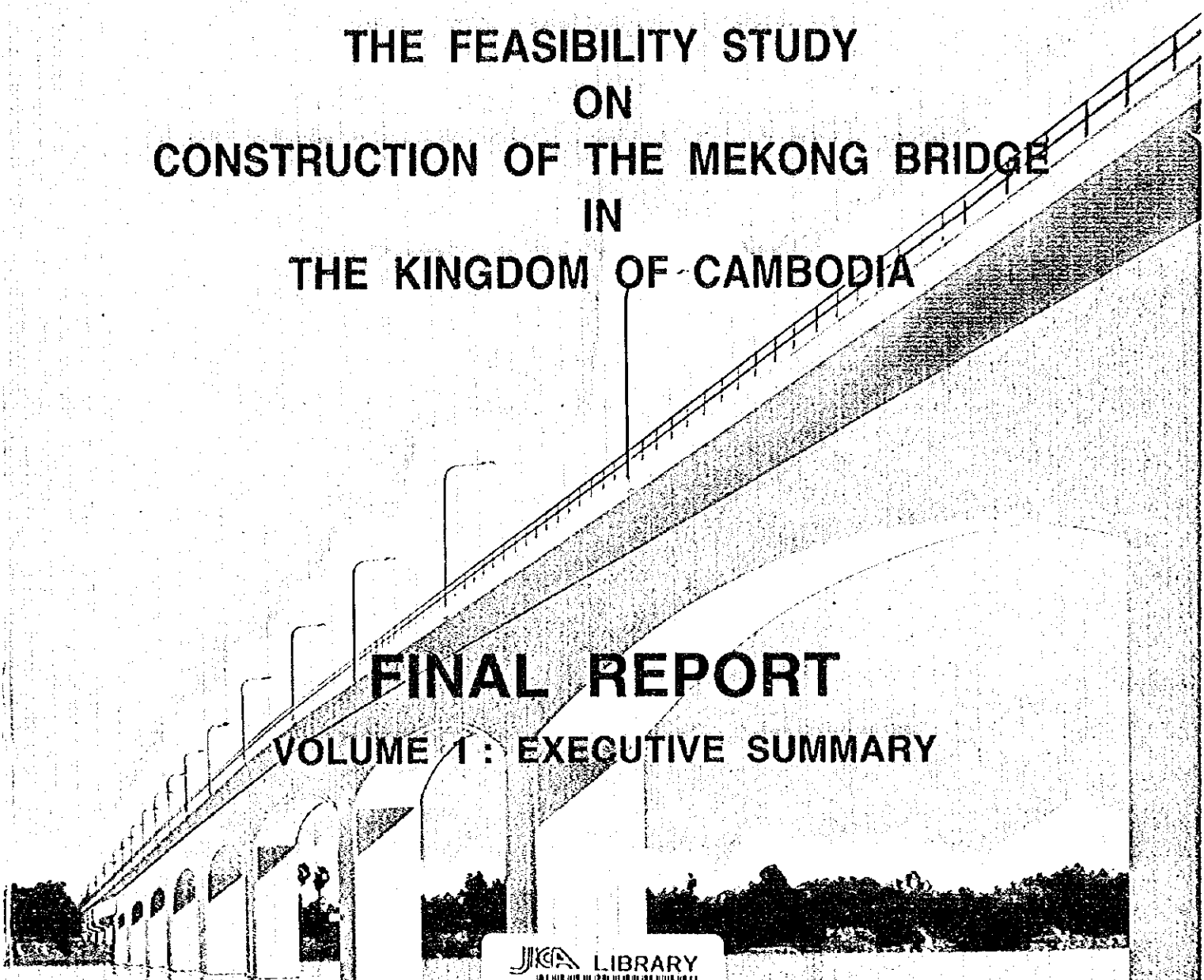
THE KINGDOM OF CAMBODIA
MINISTRY OF PUBLIC WORKS AND TRANSPORT

THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN THE KINGDOM OF CAMBODIA



FINAL REPORT

VOLUME 1 : EXECUTIVE SUMMARY

JULY 1996

NIPPON KOEI CO., LTD. and PADECO CO., LTD.
JAPAN INTERNATIONAL COOPERATION AGENCY

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Note

Following exchange rates are applied in this report :

US$1.00=Yen 104.85=Baht25.19

As of February 1966

PREFACE

In response to a request from the Government of the Kingdom of Cambodia, the Government of Japan decided to conduct the Feasibility Study on Construction of the Mekong Bridge in the Kingdom of Cambodia and entrusted the study to the Japan International Cooperation Agency (JICA).

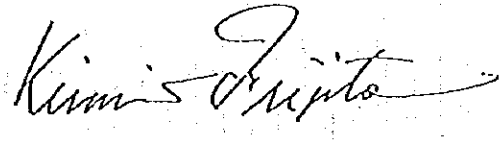
JICA sent to Cambodia a study team headed by Mr. HISASHI OHSIMA and composed of the members of Nippon Koei Co., Ltd. and PADECO Co., Ltd. four times between April, 1995 and May, 1996.

The team held discussions with the officials concerned of the Government of Cambodia, and conducted a field study 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 Kingdom of Cambodia for their close cooperation extended to the team.

July, 1996



Kimio Fujita
President
Japan International Cooperation Agency

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SUMMARY

SYNOPSIS

The Mekong River, which originates in the Tibetan Highlands and has a catchment area of 795,000 km2 and length of 4,200 km, divides Cambodia into two parts; an east side and a west side. Accordingly road-based transport modes crossing over the Mekong River depend on ferry operations at various points throughout the country, which is hindering the Government of Cambodia from planning not only fundamental establishment of the transportation sector but also overall socioeconomic program. The functions of a Mekong River Bridge can be considered the following: 1) Improvement of accessibility between Phnom Penh and remote areas in the eastern regions of the Mekong River, 2) Improvement of the international road network, 3) Promotion of a market-oriented economy, 4) Upgrading of living standards in rural areas, and 5) Promotion of agricultural development.

The traffic study included traffic counts at 17 locations relating to the candidate routes, an O-D survey, and traffic forecasts. According to the traffic count survey, average daily traffic was observed at Neak Loeung, Prek Tamak and Kompong Cham ferry stations respectively. According to the traffic surveys in May 1995, average daily traffic was observed to be 970, 80 and 260 PCU (not including motorcycles or non-motorized vehicles) at the Neak Loeung, Prek Tamak and Kompong Cham ferry stations respectively. Further average daily traffic in the year 2011 is expected to be 4,110, 390 and 1,890 PCU respectively at above mentioned locations. From the O-D survey results of the total cargo tonnage crossing the Mekong River by ferry average 37% has origin or destination in Phnom Penh and 14% has origin or destination in Vietnam.

In PHASE - I STUDY, the Study Team has investigated the most preferable location of the Mekong Bridge among three candidate locations, namely Neak Loeung, Prek Tamak and Kompong Cham, with two alternative routes each, totaling six alternative routes. Many kinds of studies and surveys: e.g. the above mentioned traffic study, topographic surveys, bathymetric surveys, geological surveys, river hydrological study, geological survey, topological survey, environmental examinations, road and bridge inventory surveys were conducted in order to select the optimum route. In planning main bridge crossing the Mekong River, one of the most significant factors influencing construction cost will be navigational clearance, especially the vertical clearance stipulated by the Mekong River Commission, organized by surrounding countries along the Mekong River. After meeting with the Steering Committee of Cambodia on the Study, the Study Team followed the stipulation made by the Mekong River Commission that the vertical clearance from the high water level should be secured at 37.5m at Neak Loeung, and 15.0m at Prek Tamak and Kompong Cham. As for the type of superstructure several kinds were examined for the sake of planning an economically feasible type suitable for each bridge alternative route. Configurations of substructures were also investigated reflecting current technical advancements together with achieving an economical substructure. In line with bridge comparisons, respective approach road plans were simultaneously carried out for cost estimates. According to the preliminary evaluation of the six alternative routes, taking into consideration project cost, EIRR and other important factors, it was concluded that the Kompong Cham route, which passes through nearby C-2 route, has significant advantages over the other five alternatives in terms of optimum case under budgetary constraint for future repairs and beneficial broad indirect effects.

PHASE - 2 STUDY, the route of the bridge was slightly shifted downstream by approximately 300m and named the selected route(C-3) according to the following reasons: 1) to minimize social impacts and reduce the cost of land acquisition and compensation on the Kompong Cham side due to construction of viaduct and approach road, 2) to avoid general scouring which could occur along the C-2 route, 3) to avoid construction of foundation in deep river channel. In addition, focusing on this selected route, topographic, bathymetric, and geological surveys and an environmental examination were then conducted to input preliminary design.

Prior to preliminary design of the bridge, a comparison between the continuous PC box girder and extra-dosed PC bridge, which are categorized as prestressed concrete bridge, was conducted. After scrutinizing characteristics of both types with criteria such as technical feasibility, construction cost, maintenance requirement and so on, it was determined that the continuous PC box girder is superior mainly because it is practically maintenance free. Further, the optimum span division was studied to establish an economical bridge plan, including approach roads, such that the span length should be 120m. As a result of comparisons between different kinds of substructures, a wall-shaped pier substructure supported by multi-column pile foundation was adopted as an optimum substructure configuration.

According to environmental study, some environmental parameters will be affected to some extent, while others have minor impacts. For example, some areas on bridge approach road need to be expropriated, causing human relocation problems, while impacts on the rest of parameters have been found minimal. All the environmental parameters will be adversely affected in some degree by the project implementation. However, adverse impacts on these environmental parameters can most likely be mitigated by the provision of proposed counter measures and monitoring programs; consequently no serious environmental problems are expected in the future.

The implementation schedule depends on the time of commencement for engineering activity and subsequent activities such as tendering and time of contract. Assuming these activities progress normally, substructure works would begin with the third dry season and whole works would end in the sixth dry season accounting for 42 months for actual construction works on the condition that initial mobilization works would commence 2 months in advance of entering the third dry season.

The total project cost was estimated to amount to 79.7 million US$ in which foreign portion is 64% and local portion is 36% respectively.

The economic evaluation demonstrated that the Mekong Bridge at Kompong Cham is economically viable with a EIRR of 9.5 per cent. Quantified benefits included (i) time cost savings; (ii) vehicle operating cost savings.

Based on results of the economic evaluation and the financial evaluation, which illustrated the severe financial constraints of servicing a domestic loan even under very favorable loan conditions, it is strongly recommended that external financing without debt service obligation be sought for the implementation of the Project.

In conclusion the Study Team states that construction of the Mekong Bridge at Kompong Cham is technically and economically feasible under proper finance and accordingly recommends that it be immediately implemented.

Profile of the Mekong Bridge of the Kingdom of Cambodia

Location	Kompong Cham
Project Cost	79.68 million US$
Construction Cost	64.80 Million US$
Navigational Clearance	Vertical Clearance: 15.0m (From high water level) Horizontal Clearance: 90.0m
Bridge Width	13.5m
Road Way	10.8m
Sidewalk	1.1m on both sides
Total Bridge Length	1,360 m
Main Bridge Type Span Arrangement	 Cast in Situ Prestressed Concrete Continuous Box Girder 80+7@120+80=1000m
Approach Bridge Type Span Arrangement Kompong Cham(West) Side East Side	 Prestressed Concrete Connecting T-Girder 5@40=200m 4@40=160m
Approach Roads Roadway Sidewalk Total Length Kompong Cham side East Bank side	 7.00m 0.75m 2,238 m 257 m 1981 m
Construction Period	42 months

CHAPTER 1 INTRODUCTION

1.1 Study Background

In response to the request from the Government of the Cambodia (GOC), the Government of Japan (GOJ) decided to conduct the Feasibility Study on Construction of Mekong Bridge in the Kingdom of Cambodia, herein after called " the Study, Accordingly, the Japan International Cooperation Agency(JICA), the official agency responsible for the implementation of technical cooperation programs of GOJ, organized a Study Team to execute the Study. The Study Team was dispatched to Cambodia in March 1995 to implement the Study, and is to submit the Final Report in June 1996.

1.2 Objectives of the Study

The principal objective of the Study is to conduct the feasibility study on construction of the Mekong Bridge in Cambodia including its approaches. The study shall cover the three areas; Neak Loeung, Prek Tamak and Kompong Cham.

1.3 Scope of Work

The scope of work covers several items as follows:

- Data collection and analysis regarding socio-economic data, traffic data, geological data, hydrological data, development plans and so on
- Site survey regarding traffic survey, geological survey, hydrological survey and so on
- Traffic forecast
- Preliminary comparative study of alternatives at 3 locations
- Evaluation of Alternatives
- Comparative study of alternatives and its evaluation concerning cost aspect, engineering aspect, construction aspect and so on.
- Preliminary design
- Planning and scheduling of construction works
- Cost estimate
- Environmental impact assessment

- Economic and financial evaluation
- Implementation program

1.4 Study Schedule

The Study Team conducted this Feasibility Study, following flow diagram presented in Figure1.1.

1.5 Reports

The following reports were submitted or are to be submitted to the Ministry of Public Works and Transport.

-	Inception Report	April	1995
-	Progress Report	July	1995
-	Interim Report (I)	September	1995
-	Interim Report (II)	December	1995
-	Draft Final Report	April	1996
-	Final Report	July	1996

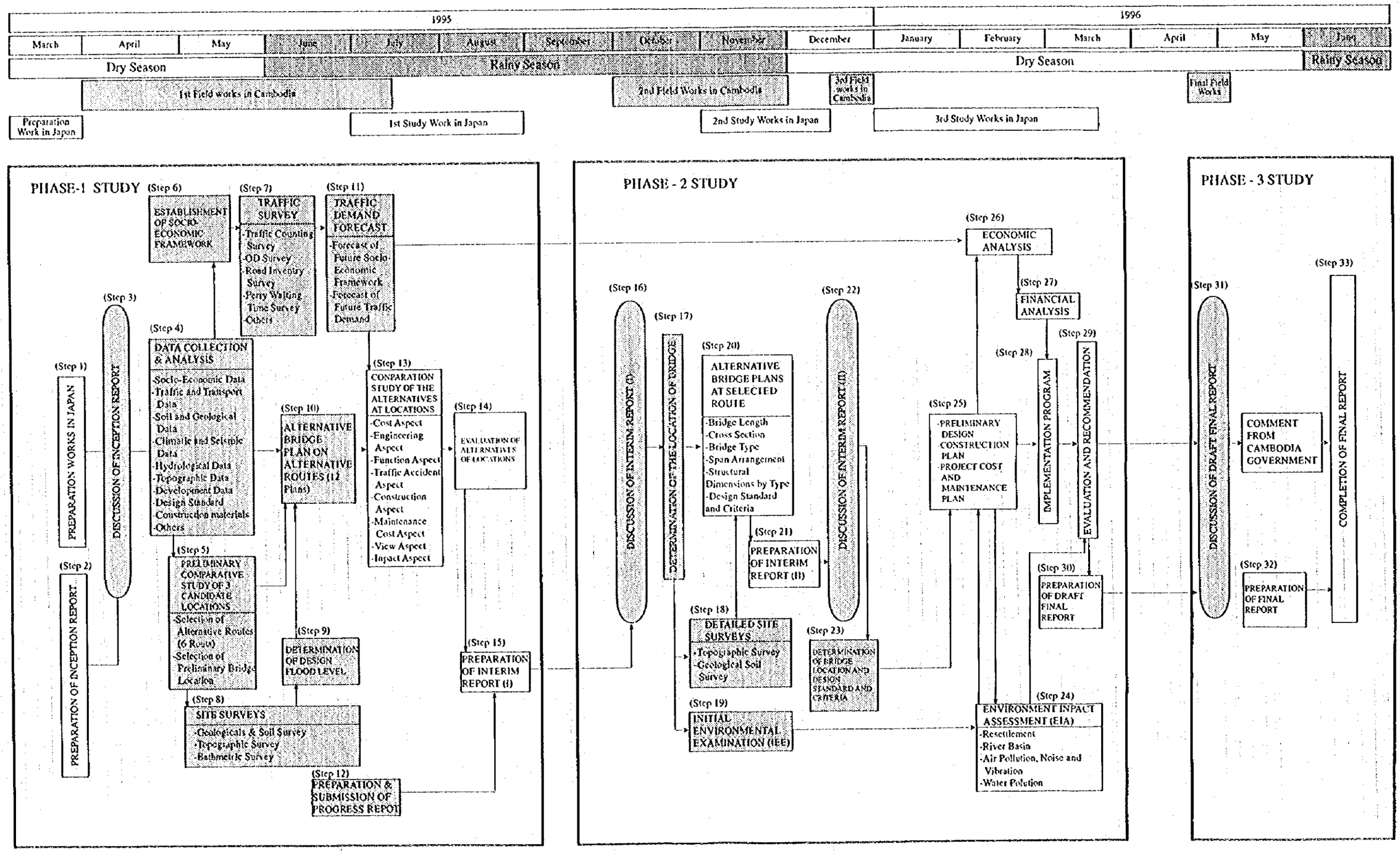


Figure 1.1 FLOW DIAGRAM OF FEASIBILITY STUDY ON CONSTRUCTION OF MEKONG BRIDGE

CHAPTER 2 ECONOMY AND TRANSPORTATION IN CAMBODIA

2.1 Current Transportation Policies

2.1.1 Policies and Strategies

Basic principles for a road network plan together with a conceptual regional development plan are identified in the *National Programme to Rehabilitate and Develop Cambodia*.

Growth poles, development centers, and a growth corridor constituting a future spatial regional structure are also referred to in the Programme. The three growth poles are Phnom Penh, Sihanoukville, and Siem Riep, and the growth corridor is the belt between Phnom Penh and Sihanoukville. Further, community development centers are proposed for rural development in the following 10 areas: Kompong Cham, Prey Veng, Svay Rieng, Kratie, Takeo, Battambang, Banteay Meanchey, Kampot, Siem Riep, and Pursat.

2.1.2 Transport Plans

The projects to which the Cambodian Government attaches high priority for rapid implementation in the transport sector are also referred to in the *National Programme to Rehabilitate and Develop Cambodia*.

As longer term objectives, in addition to restoration work, priorities with the following features are to be pursued:

- strengthening linkages with neighboring countries;
- upgrading the quality of domestic services; and
- expanding facilities in provincial and district areas in order to support rural economic and social advance.

Longer-term priorities concern:

- extending communication into the more remote areas of the country, but in ways that are sensitive to environmental and cultural pressures;
- upgrading the Cambodian sections of the Asian Highway, in particular, Routes 1 and 5 linking the Thai and Vietnamese networks and in addition, Routes 7/13 providing the Lao road network access to Sihanoukville Port and the sea;
- exploring other transborder initiatives to forge closer regional linkages and to expand regional markets, such as railway development and tourism; and
- upgrading and expanding the Sihanoukville Port and associated facilities to enable it to better handle containerized traffic.

As for the international road network, the *Economic Cooperation Programme in the Greater Mekong Subregion* was agreed upon in the fourth international conference held in Chiang Mai in 1994. This conference with ministerial level attendants of member countries was promoted by the Asian Development Bank for the promotion of economic cooperation among the six riparian countries in the Mekong River Basin.

2.1.3 Current Projects

MPWT's capability to fund or co-finance any major project is very limited because of its budget constraint of only 159 billion riel (about US$ 69 mil.) for 1995. Most of the local funds are used for emergency repairs for different provincial roads. Larger projects are usually typically by foreign aid organizations.

Among the foreign aid rehabilitation projects, ADB's Special Rehabilitation Assistance Project (SRAP) is the most extensive; it concerns emergency rehabilitation, i.e., the provision of critical equipment for roads, railways, and ports. The total budget is some US$ 35 million excluding the cost of technical assistance. This project commenced in mid-1993 and is expected to continue until the end of 1996. The World Bank also has a multi-sector Emergency Rehabilitation Project. Several countries including Japan are committed as bilateral donors.

2.2 Socioeconomic Situation

2.2.1 Economy in General

Overall GDP expanded at an annual rate of 6% over the 1991-1994 period. GNP per capita grew from about US$ 130 in 1990 to around US$ 200 in 1992. These upward trends are mainly due to the accelerated process of liberalization since 1989.

Agriculture contributes close to half of real GDP, followed by trade, non-governmental services, and construction, while the share of manufacturing is only about 7% of real output. Agriculture employs the largest proportion of the labor force (80%), followed by services and construction (15%), and manufacturing.

2.2.2 Budget

The 1994 national budget was US$ 405 million. Current expenditure accounts for 65% of the budget, against 35% for capital expenditure which will be financed in large part (almost 90%) with external resources. The Ministry of Public Works and Transport receives about 19% of the total budget in order to implement a large-scale public investment program, financed predominantly by external aid organizations, to rehabilitate transport infrastructure. The government suffers from budget deficit, and reduction of budget deficit and fiscal consolidation are the central themes of the new program.

2.2.3 Income and Prices

The Socio-Economic Survey in Cambodia-1993/4 sponsored by ADB and UNDP revealed that the average monthly household expenditure is US$ 125 in Cambodia and US$ 357 in Phnom Penh. Considering the average household size and number of income earners per household, the average monthly expenditure of income earners is estimated around US$ 100 in Phnom Penh and US$ 45 in Cambodia.

Data supplied by the National Bank of Cambodia show that consumer prices rose steeply from 1989 to 1993 with an average inflation rate of over 150%; however this unstable situation has settled down with an inflation rate in the previous year of minus 28.4 % (i.e., deflation).

2.3 Socioeconomic Policy

The Cambodian Government submitted its *National Programme to Rehabilitate and Develop Cambodia* to the Second International Committee on the Reconstruction of Cambodia, held in Tokyo in March 1994. This document clearly identified the Cambodian Government's strategies for rehabilitation and development and its priorities for both the medium term (3 years) and the short term (18 months).

The overriding objective of Cambodia is to achieve a fair, just, and peaceful society, and, through accelerating the rate of economic growth, to raise the living standards of all Cambodian people.

Key objectives are to sustain economic growth at 7-8% per annum from 1994, and to reduce annual inflation to under 10% in 1994 and 5% afterwards.

2.4 Development Potential of the Region

Considerations on development potential below focus on the area on the left bank of the Mekong River where it is supposed to be susceptible to the Mekong Bridge. Therefore, the provinces of Kandal, Prey Veng, Svay Rieng, Kompong Cham, Ratanakiri, Stung Treng, Mondulkiri, and Kratie are broadly considered as the influence area of the Mekong Bridge. An excellent source of technical information on development potential is *Cambodia Agricultural Development Options Review (Phase I)* by FAO/UNDP, 1994.

The influence area of the Mekong Bridge is well endowed with natural resources, including a diversity of agro-ecological zones suited to a wide range of crops and livestock, and rich biological resources. Soils developed over basalt in the east and in particular the red soils are well suited for rubber, and river bank soils are of relatively high fertility.

The cultivated area that is concentrated in the alluvial basin around the hydrographic network of the Mekong River has the high potential for agricultural development. The periodic flooding of the Mekong River provides many benefits, including siltation of an extended area for agriculture (with permanent maintenance of soil fertility) and the development of fisheries in the inundated forests.

Constraints to agricultural development include both natural/environmental limitations and those caused by years of war. The existing poor transport system is a major constraint to agricultural development.

2.5 Functions of a Mekong River Bridge

In addition to providing the missing link for road traffic, a Mekong Bridge (the first one in Cambodia) will play a much broader role than a simple local bridge. Its importance is assessed as follows:

Transport Functions

The main transport functions of a Mekong Bridge in Cambodia are:

- Improvement of Accessibility between Phnom Penh and Remote Areas in the Left Bank
- Improvement of the International Road Network

Effects on Regional Development

The Construction of a Mekong Bridge is expected not only to bring a drastic change in the arterial road network in Cambodia, but also to influence regional development through reductions in travel time and cost. The following are envisaged as principal effects:

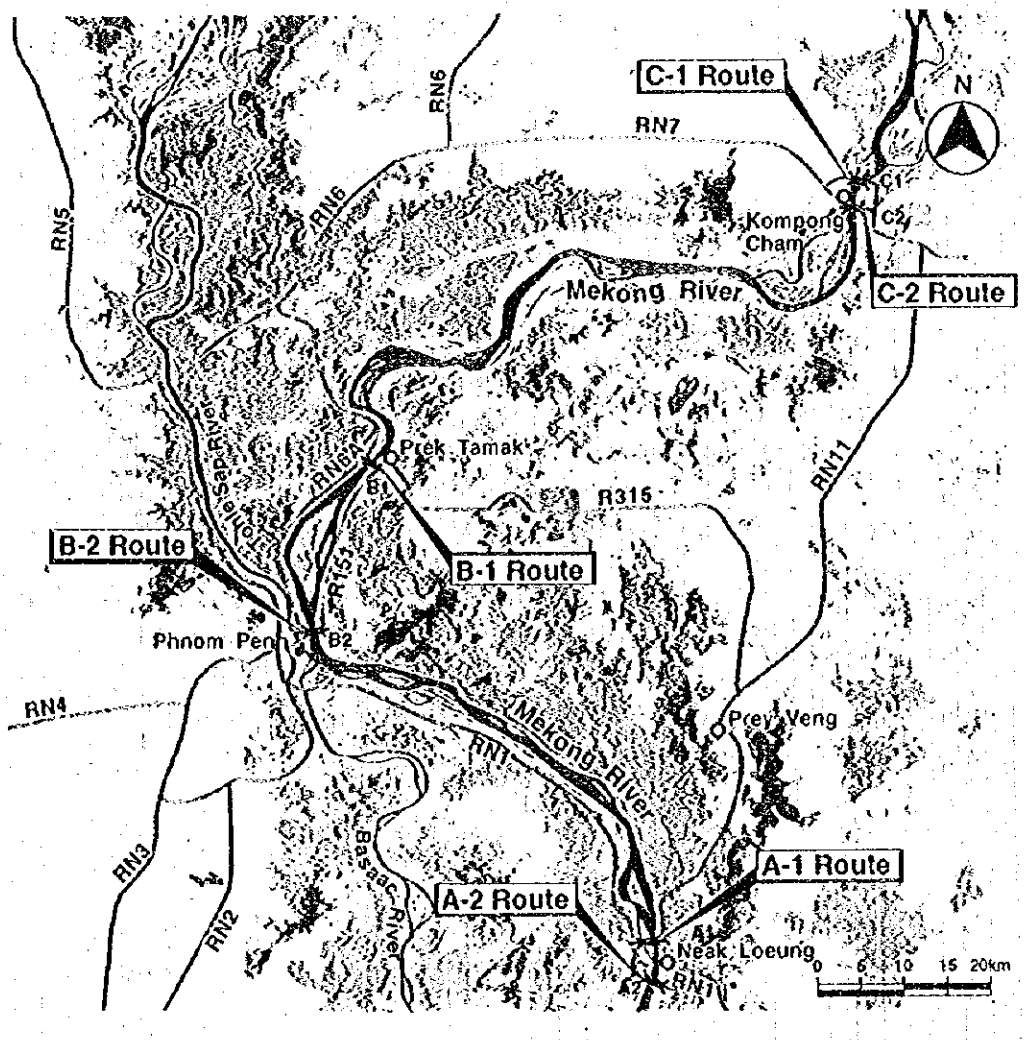
- Promotion of Open Markets and a Market-Oriented Economy
- Upgrading of Living Standards in Rural Areas
- Promotion of Agricultural Development
- Promotion of Resource Development
- Balanced Development of the Area

CHAPTER 3 CANDIDATE ROUTES AND SITES FOR THE MEKONG RIVER BRIDGE

3.1 Road Network in the Study Area

There are three candidate locations each at Neak Loeung, Prek Tamak and Kompong Cham, and each location has two alternatives totaling six alternative routes.

Road network in the Study Area relating to candidate routes is presented below.



3.2 Alternative Routes for the Main Bridges

Neak Loeung

The two alternative routes considered for this bridge are: A-1, north of the existing ferry line, over Phnum Khnong island; and A-2, south of the ferry, near the town of Neak

Loeung. The A-2 crossing is the shortest in the vicinity of Neak Loeung , with a river width of about 880 m. A-1 is considerably longer, about 1,800 m from river bank to river bank, consisting of two channels separated by Phnum Khnong island. The eastern, main channel is about 575 m wide, and the western, shallow channel is about 255 m wide, for a total river width of 850 m.

Prek Tamak

The two alternative routes were considered for this crossing: B-1 and B-2. The B-1 route is located north of the existing Prek Tamak ferry line and south of the town of Prek Tamak. The B-2 route is actually located some 20 km south of Prek Tamak, just north of the Svay Chrum ferry service near Phnom Penh. The river widths at B-1 and B-2 are about 900 m and 1,030 m, respectively.

Kompong Cham

The two alternative routes considered for this bridge are C-1 and C-2. Both are located north of the existing ferry lines. The Mekong river is about 820 m wide at C-1 and 1,200 m wide at C-2.

3.3 Road and Bridge Inventory Survey

All project area roads were visited several times by the Study Team in April, May, and June 1995. Surveys to assess the physical condition of roads and bridges in the project area were conducted in mid-May and early June 1995.

Road inventories were prepared for the pertinent sections of Routes 1, 6A, 6, 7, 11, 315, and 151, totaling about 505 km. Road characteristics noted by the Study Team include type of terrain; road width, type, and condition; shoulder width, type, and condition; embankment height, condition, and sufficiency; and the main features of the land within the immediate vicinity of the road.

A bridge inventory survey was conducted simultaneously during the carrying out of the road inventory survey to evaluate the physical condition of bridges along the following project area roads: Route 1 from Phnom Penh to Neak Loeung; Route 6A; Route 6 from the junction with Route 6A to that of Route 7; Route 7 from the junction with Route 6 to Kompong Cham and from Kompong Cham to the junction with Route 11; Route 11; and Route 315.

Bridge inventory work included following identification; bridge location on a map, bridge length, total width, carriage way width, bridge type, condition of bridge and photograph record.

CHAPTER 4 TRAFFIC FORECAST

4.1 Traffic Studies

Five types of traffic surveys were conducted in the study area encompassing the three potential bridge sites (i.e., Neak Leoung, Prek Tamak/Svay Chrum, and Kompong Cham). These traffic surveys included traffic count surveys, origin-destination (OD) interview surveys, ferry waiting time surveys, ferry operational characteristics surveys, and goods movement surveys.

Traffic counts were conducted for this study at 17 locations in the Study Area from 30 April to 14 May 1995, including the Neak Loeung Ferry, Svay Chrum Ferry, Prek Tamak Ferry, two Kompong Cham ferries (one private, one public), and Routes 1, 6A, 7, 11, 151, and 315; each location was surveyed for a seven day period, 12 hours per day (i.e., 06:00-18:00), with volumes recorded at hourly intervals for 13 different vehicle types. The highest vehicular traffic volumes were observed along Routes 1, 6A, and 7, with vehicular ADT volumes (including motorcycles and non-motorized vehicles) of 4,870, 5,440, and 4,420, respectively.

For the ferries, traffic is highest at Neak Loeung, followed by Kompong Cham, Prek Tamak, and Svay Chum. The majority of vehicular traffic crossing the Mekong River consists of non-motorized vehicles (NMVs) and motorcycles, with 25.2% and 58.8% vehicular traffic shares, respectively. By contrast, sedans, trucks, and minibuses/buses represent 6.4%, 1.9%, and 5.3% of the total vehicular river crossing volumes.

Vehicle utilization rates, determined from the OD survey results, were calculated for 10 different vehicle types at the Neak Loeung, Svay Chrum, Prek Tamak, and Kompong Cham (MPWT) ferry crossings. Most vehicles have relatively high person/passenger occupancy rates. Consider, for example, that the overall average occupancy is 1.5 persons for motorcycles, 4.5 for sedans, and 6.1 for four-wheel drives (4WDs) and standard pickups. Also, 3- axle and 3+ axle trucks at Neak Loeung tend to be heavily loaded with an average 8.6 and 17.4 tons of goods, respectively, significantly more than truck loads at Kompong Cham. The reason for this discrepancy appears to be that a significant number of empty trucks are hired in Kompong Cham; these empty trucks cross the Mekong via the Kompong Cham MPWT ferry to the east side of the river where they are subsequently loaded with materials, which the trucks then haul to Svay Rieng and/or Phnom Penh via Route 11.

The percentage shares of different vehicle trip purposes and types of commodities, also ascertained from the OD survey results, were determined for NMVs, motorcycles, sedans, and 4WDs/pickups at the four main ferries. In nearly all cases, trips made for personal business reasons are those most frequently observed at the four locations, with shares ranging from 27% to 87%. At the Neak Loeung, Prek Tamak, and Kompong Cham ferries, a relatively high proportion of 4WDs/pickups function as shared taxis: 32%, 26%, and 33%, respectively. Out of the our ferries, commuting trips represent the highest proportion of total trips at the Svay Chrum Ferry. Also, at the

Svay Chrum and Prek Tamak ferries, a relatively high proportion of trips made by sedans were for family/social reasons, with shares of 27% and 22%, respectively.

The percentage shares of different commodity types hauled by all vehicle classes at the four ferries were also calculated. Manufactured goods and agricultural products are frequently transported at all four ferries, with shares of manufactured goods ranging from 19% to 26% and those for agricultural products ranging from 17% to 35%. Construction materials are also commonly observed at Neak Loeung (18%), while food/drinks are prevalent at Svay Chrum (31%) and Prek Tamak (29%). The Kompong Cham (MPWT) Ferry had the highest proportion of goods classified as other (22%).

As referred to earlier, a comprehensive OD survey was conducted at the Neak Loeung, Svay Chrum, Prek Tamak, and Kompong Cham (MPWT) ferry locations in conjunction with the traffic count surveys for seven days, 12 hours per day, at each location. This survey, therefore, covered the majority of transport crossing the Mekong River. Drivers of vehicles waiting to board ferries at both sides of the river were questioned regarding (1) trip origin, (2) trip destination, (3) time left origin, (4) expected arrival time at destination, (4) vehicle capacity in tons, (5) load in tons, (6) type of cargo, (7) trip purpose, and (8) average number of round trips per week. Surveys also recorded the vehicle type, occupancy, and time of interview. A total of 21,523 interviews were conducted, making this survey the largest of its kind in at least 20 years.

A total of 34 zones were adopted; most zones correspond to provincial boundaries. For the purpose of this study; the provinces of Kandal and Kompong Cham were subdivided along the Mekong River, Kandal province was further divided into N.W. Kandal and S. Kandal at Phnom Penh. Prey Veng province was split into N. Prey Veng and S. Prey Veng to enable analysis of the potential diversion of trips between N. Prey Veng and Phnom Penh from the Neak Loeung Ferry to a possible bridge near Prek Tamak. The cities of Sihanoukville, Ho Chi Minh City, and Bangkok were designated with exclusive zone numbers, as well as the border towns of Bavet/Moc Bai (Cambodia-Vietnamese border) and Poipet (Cambodian-Thai border).

As expected, OD combinations vary by vehicle type, with NMVs traveling relatively short distances, motorcycles making medium-distance trips, and other motor vehicles (e.g., sedans, trucks) traveling longer distances. Daily tonnage from Phnom Penh makes up 43.5% of the total cargo tonnage crossing the river by ferry, and that to Phnom Penh represents 29.8% of the total. It is also of interest to note that the eastern half of Kompong Cham Province is a more significant generator/attractor of passenger trips and cargo tonnage than the western half, which contains the city of Kompong Cham.

During the carrying out of traffic count and O-D interview surveys, additional surveys were simultaneously conducted by the Study Team to determine the average passenger waiting and on-board times at the relevant ferries. The MPWT Kompong Cham Ferry provides the slowest service among the major ferries in terms of total river crossing time; the Prek Tamak Ferry has the fastest service.

With the preceding information, it is possible to estimate the capacities of the respective ferries for this time of year (i.e., low water level) assuming they operate under relatively good, trouble-free conditions. The estimated capacities of the Neak Loeung, Svay Chrum, Prek Tamak, and Kompong Cham (MPWT) ferries are, respectively, 120, 12, 12, and 18 cars and trucks per hour for both directions. These figures highlight the severely limited capacities of all ferries except Neak Loeung (the private Kompong Cham Ferry cannot transport vehicles larger than motorcycles).

4.2 Traffic Forecasts

Traffic forecasts were conducted for three future years (i.e., 2001, 2011, and 2021) for seven vehicle types (motorcycle: MC, passenger car: PC, light bus: LB, heavy bus: HB, light truck: LT, medium truck: MT, and heavy truck: HT). The forecast procedure involved the following:

- development of scenario of population, economy, international trade in Cambodia is prepared for initial base case;
- normal and development traffic demand in the form of OD matrices based on the estimated growth rates by zone and vehicle type are forecast for domestic passenger traffic, domestic freight traffic, international passenger traffic, and international freight traffic;
- diverted traffic from other modes are then forecast for domestic passenger traffic, domestic freight traffic, international passenger traffic, and international freight traffic;
- basic traffic matrices are forecast by summing the diverted traffic OD matrices and the normal and development traffic OD matrices;
- the reduction of travel time between cases with and without a Mekong bridge are estimated, and induced traffic in the future is forecast by applying elasticities with respect to the reduction of time to the basic traffic OD matrices;
- future traffic matrices by vehicle type are constructed by adding the induced traffic OD matrices to the basic future traffic OD matrices; and
- traffic volume at bridge and ferry points are then forecast by assigning the traffic OD matrices in passenger car units (PCU) to the various networks (i.e., without bridge, with Neak Loeung Bridge, with Prek Tamak Bridge, and with Kompong Cham Bridge).

The MINUTP software was utilized for handing OD matrices, performing Fratar calculations, and computing the traffic assignments. MINUTP is a suite of computer programs that provide the capability to perform the usual functions of traditional transport planning with regard to trip generation, distribution, and network assignment.

The results of the traffic forecast are summarized in the table below. These figures are for total traffic, excluding MCs and NMVs, expressed in PCU. Note that the relatively high volume of traffic at the Prek Tamak river crossing in 2021 for all cases except the Bridge at Neak Loeung scenario is due to the diversion of traffic from Neak Loeung, where traffic demand exceeds the maximum possible ferry capacity in that year.

Traffic Assignment Results for Normal and Induced Traffic in PCU (not including MC)

Year	Scenario	Neak Loeung River Crossing	Prek Tamak River Crossing	Kompong Cham River Crossing
2001	No Bridge	1,540	120	480
	Bridge at Neak Loeung	1,790	110	480
	Bridge at Prek Tamak	1,340	1,080	190
	Bridge at Kompong Cham	1,540	120	610
2011	No Bridge	4,110	390	1,890
	Bridge at Neak Loeung	4,730	340	1,890
	Bridge at Prek Tamak	3,510	2,280	940
	Bridge at Kompong Cham	4,100	390	2,300
2021	No Bridge	6,340	4,610	4,900
	Bridge at Neak Loeung	11,400	930	4,900
	Bridge at Prek Tamak	6,190	7,700	2,890
	Bridge at Kompong Cham	6,300	4,460	6,220

CHAPTER 5 RIVER HYDROLOGICAL STUDY

5.1 River Hydrogy

River hydrological study gives very important informations to not only evaluate the proposed bridge routes but also design the bridge structure including approach roads, because all of proposed six alternative routes are located in flood area of the Mekong River.

During the first field works in Cambodia conducted from May to June 1995, the Study Team collected basic hydrological data such as climatological records and hydrological records including gauge height at discharge on a daily basis observed at several gauge stations with cooperation by MPWT.

At the same time site investigation was often executed for the purpose of recognizing the actual conditions around the proposed routes.

Further, analysis on hydrological problems was elaborated on the base of these collected datum.

In designing and constructing the bridge structure, especially substructure, it will be considered that the most significant factor is determination of high and low water level at each proposed bridge site because the Mekong River has big water level difference between dry season and rainy season.

Referring to observed hydrological datum at gauge stations nearby proposed bridge site, probable flood and low water level was estimated as shown in Table 5.1 and 5.2

Table 5.1 Probable Flood Water Levels at Alternative Bridge Sites

Return Period (years)	Water Level (above MSL)					
	Kompong Cham (C-1)	Kompong Cham (C-2)	Prek Tamak (B-1)	Prek Tamak /Svay Chrum (B-2)	Neak Loeung (A-1)	Neak Loeung (A-2)
2	13.72	13.66	10.02	8.87	6.75	6.71
5	14.35	14.29	10.57	9.40	7.22	7.18
10	14.64	14.58	10.84	9.66	7.45	7.40
25	14.92	14.85	11.10	9.91	7.68	7.63
50	15.07	15.00	11.26	10.07	7.81	7.77
100	15.20	15.13	11.39	10.21	7.93	7.89

Source: JICA Study Team

Table 5.2 Probable Low Water Levels at Alternative Bridge Sites

Return Period (years)	Water Level (above MSL)					
	Kompong Cham (C-1)	Kompong Cham (C-2)	Prek Tamak (B-1)	Prek Tamak /Svay Chrum (B-2)	Neak Loeung (A-1)	Neak Loeung (A-2)
2	0.98	0.98	0.78	0.66	0.54	0.53
5	0.82	0.82	0.69	0.59	0.49	0.48
10	0.73	0.73	0.64	0.56	0.46	0.45
20	0.66	0.66	0.60	0.53	0.43	0.43

Source: JICA Study Team

5.2 River Morphology

River channel conditions were also studied at each six proposed bridge sites corresponded to six alternative routes, reflecting findings at site surveys together with results of bathmetric surveys.

In order to understand the flooded circumstances to the overall study area, the Land Sat Map using satellite remote sensing data was produced for analysis.

CHAPTER 6 GEOLOGICAL SURVEY FOR CANDIDATE ROUTES

Geological survey was conducted for six alternative routes. These geological drilling results show that the geology of the study area comprises Alluvium formation, Diluvium formation, Tertiary formation, and Mesozoic formation. Except for tertiary formation, these formations are each divided into the sand layer and clay layer.

Suitability for bridge foundation is shown in Table 6.1

Table 6.1 Geological Formation for Bridge Foundation

Geological Age	Formation	Description	Suitability for Foundation
Holocene	Alluvium	Clay (Ac), Sand (As)	Not suitable
Pleistocene	Diluvium	Clay (Ds), Sand (Ds)	Not suitable
Tertiary	Basaltic Lava	Basaltic Rocks (Tb)	Suitable
Mesozoic	Sandstone	Hard Clay (Mc)	Suitable
		Weathered Ss (Ms)	Suitable

Geological Site Conditions

(1) Neak Loeung

The geology can be described as Alluvium deposit (As), Diluvium sediment (Ds), and Mesozoic Sandstone (Ms) as the base rock along the A1 route. Alluvium deposit (As) composed of sand is observed on the ground surface. Diluvium sediment lies beneath the Alluvium deposit (As). Diluvium sediment (Ds) also comprises sand. Some drilling results show that the N-value of this sediment, according to the Standard Penetration Test, ranges from 10 to 40. The Mesozoic sandstone formation is distributed below the Diluvium sediment. This formation is formed by a hard clay layer and a weathered sandstone layer.

The geology can be also described by Alluvium deposit (As), Diluvium sediment (Ds), and Mesozoic Sandstone (Ms) as the base rock along the A-2 route. The Diluvium sediment (Ds) lies underneath the Alluvium deposit (As). Some drilling results show that the N-value of this sediment, according to the Standard Penetration Test, ranges from 10 to 40. The Mesozoic sandstone formation is distributed below the Diluvium sediment. This formation is formed by a hard clay layer and a weathered sandstone layer. Therefore, the foundation for the bridge would be 30m below the ground surface.

(2) Prek Tamak

The geological conditions along B-1 and B-2 route at the Prek Tamak Site are generally similar to those of the Neak Loeung site. Along the B-1 and B-2 routes, the thickness of Alluvium deposit (As ~ Ac) is estimated at about 10-15 m below the ground surface. The Diluvium sediment (Ds) lies below the Alluvium deposit (As ~ Ac). Some drilling results show that the N-value of this sediment ranges

from 10 to 40. The Mesozoic sandstone layer (Ms), is below the Diluvium sediment. The top surface line of the Mesozoic sandstone layer (Ms) is uneven due to past scouring of the old Mekong River.

(3) Kompong Cham

At the Kompong Cham site, the geological conditions are different between the C-1 and C-2 routes.

On the right-hand side of Mekong River (i.e., west bank), Basaltic lava (Tb) can be observed on the ground surface along the C-1 route. This lava (Tb) with several joints comprises hard basalt rocks of Late Tertiary Era. The steep slope of the western river bank demonstrates that the outcrops of this lava are on that slope. This lava (Tb) is suitable for bridge foundation.

On the left side of the river, the geological conditions can be described by Sandbar deposit (Sb), Alluvium deposit (As), Diluvium sediment (Ds), and Mesozoic Sandstone layer (Ds) as the base rock.

Basaltic lava (Tb) is not observed on the right-hand side of the Mekong River along the C-2 route. The geology along the C-2 route can be described by Alluvium deposit (As), Diluvium sediment (Ds), and Mesozoic Sandstone (Ms) as the base rock. The thickness of Alluvium deposit (As) is 10~20 m from the ground surface. The Diluvium sediment (Ds) lies underneath the Alluvium deposit. Some drilling results show that the N-value of this sediment, according to the Standard Penetration Test, ranges from 10 to 40; the thickness of the layer is greater than 10 m. The Mesozoic sandstone formation (Ms) as base rock is distributed below the Diluvium sediment. This formation (Ms) comprises a weathered sandstone layer. Although the Mesozoic sandstone formation (Ms) was confirmed by the drilling tests in the river, the top surface of the base rock on the right-hand side along the C-2 route is estimated to be about 50 m below the ground surface due to the scouring of the old Mekong River.

CHAPTER 7 PRELIMINARY PLAN OF THE BRIDGE AND ROAD FOR CANDIDATE ROUTE

The three main candidate locations subject to bridge plan comparisons are the Neak Loeung bridge route, the Prek Tamak bridge route, and the Kompong Cham bridge route. Each candidate location has two alternatives; therefore, there are six routes in total under the following bridge planning conditions.

(1) Navigation Clearance

Locations	Vertical Clearance (m)	Horizontal Clearance (m)
Neak Loeung	37.5	175
Prek Tamak	15.0	90
Kompong Cham	15.0	90

(2) Typical Cross Section

Bridge : Total Width 13.50 m
(Carriage way: 7.00 m, 2 motorcycle way: 2 x 1.90 = 3.80 m, and 2 pedestrian walk and rail: 2 x 1.35 = 2.70 m)

Approach : Total Width 13.50 m
(Carriage way: 7.00 m, 2 motorcycle way: 2 x 2.50 = 5.00 m and 2 Shoulder: 2 x 0.75 = 1.50 m)

Based on the results of bathymetric, geological and river hydrological surveys, each route was compared with two alternatives considering design span, structural aesthetics, construction period and method, maintenance aspect, construction cost etc. The superstructure for each route is selected as below:

Route	Type of Superstructure
A-1	Prestressed-Concrete Cable-Stayed Bridge
A-2	Prestressed-Concrete Cable-Stayed Bridge
B-1	Prestressed-Concrete Box-Girder Bridge
B-2	Prestressed-Concrete Box-Girder Bridge
C-1	Suspension Bridge
C-2	Prestressed-Concrete Box-Girder Bridge

Foundation concept was envisaged a multi-column pile foundation considering the variation between the highest and lowest water level (approximately 7.5 m ~ 14.5 m), deep water depth, and bearing layer overlaid by alluvial deposits.

Approach roads for each route were planned as below:

Unit: m

Route	Western Approach	Western Approach	Total
A-1	910	2,510	3,420
A-2	1,270	1,470	2,740
B-1	450	1,305 (59,000)	1,755
B-2	1,300	1,440 (65,500)	2,740
C-1	380	3,335	3,715
C-2	500	2,600	3,100

Remark: Figures between parentheses are length of connecting road to Route 11.

CHAPTER 8 PRELIMINARY EVALUATION FOR CANDIDATE ROUTES

Overall evaluation regarding six alternative routes has been summarized as shown below.

Final Evaluation was conducted, taking following criteria into considerations; i) Project Cost, ii) Economic Internal Rate of Return (EIRR), iii) Concordance with the National Regional Development Strategy, iv) Formation of an International Network and Promotion of an Open-Market Economy, v) Promotion of Public Welfare and vi) Environmental Impacts. After taking these critical factors into account, it can be conducted that C-2 route has significant advantages over the other five alternatives in the following points: i) Optimum Cases under Budgetary Constrains and ii) Broad Indirect Effects.

OVERALL EVALUATION OF ALTERNATIVES OF THE MEKONG RIVER BRIDGE

			NEAK LOEUNG				PREK TAMAK				KOMPONG CH	
General Information of Route	Bridge route crossing Mekong river		A-1		A-2		B-1		B-2		C-1	
	Width of river		1628m		848m		673m		934m		547m	
	Depth of River		approximately 25m		approximately 25m		Approximately 30m		Approximately 24m		approximately 55m	
	Existing Road to be connected		R-1		R-1		R-315		R-315		R-7	
	Vertical Navigational Clearance		37.5m		37.5m		15.0m		15.0m		15.0m	
	Horizontal Navigational clearance		175.0m		175.0m		90.0m		90.0m		90.0m	
Structural Aspects	Type of Structure		PC Cable Stayed Bridge(3span continuous 1 box girder)		PC Cable Stayed Bridge(3span continuous 1 box girder)		PC 5 Span Continuous 1 Box Bridge		PC 7 Span Continuous 1 Box Bridge		Single Span Suspension Bridge	
	Bridge Length	Main Bridge	430.00m		430.00m		90+3@150+90=630.00m		90+5@150+90=930m		500m	
		Approach Bridge	30@40+19@40=1960m		11@40+2@(80+150+100)+11@40=1540m		5@40+5@40=400m		5@40+6@40=440m		7@40+7@40=560m	
		Total	2390m		1970m		1030m		1,370m		1,060m	
	Bridge Width		13.50m		13.50m		13.50m		13.5m		13.5m	
	Maximum Gradient		4.00%		4.00%		4.00%		4.00%		4.00%	
Length of Approach Road			690+2,035=2,725m		980+1,100=2,080m		260+1,100=1,360m(and R-315=66.7km)		900+1180=2080m(and R-315=66.7km)		340+2,850=3,190m	
Construction Works	Superstructure	△	Prestressed Concrete Cable Stayed Bridge	△	Prestressed Concrete cable Stayed Bridge	◎	Prestressed Concrete Box Bridge	◎	Prestressed Concrete Box Bridge	△	Suspension Bridge(steel stiffened girder)	◎
	Substructure	△	deep water depth	△	deep water depth	△	deep water depth	△	deep water depth	×	big difference of water level between dry & rainy season; high water current; deep water depth	△
	Aproach Road	○		○		×	R-315 runs across flooding area	×	R-315 runs across flooding area	△	East side is flooding area	△
	Construction Period	○	48months	△	54months	○	42months	○	48months	○	42months	△
Maintenance Aspects		△	required Cable Stayed Bridge	△	required Cable Stayed Bridge	◎	not required special technical maintenance works	◎	not required special technical maintenance works	△	required periodical repaint works for Suspension Bridge	◎
Environmental Aspects	Air and Noise Pollution	○	Minor impacts caused by construction works and increased traffic volume	○	Minor impacts caused by construction works and increased traffic volume	◎	Although minor impacts caused by the increased traffic are anticipated, the number of pollution receptors are very small.	◎	Although minor impacts caused by the increased traffic are anticipated, the number of pollution receptors are very small.	○	Minor impacts are anticipated due to construction works and increased traffic volume.	○
	Water Quality and Aquatic Ecology	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○
	Cultural/Historical Properties and Environmental Aesthetics	△	Approach road close to school.	○	No significant impact	◎	No significant impact	◎	No significant impact	△	Approach road close to temple and some impacts on environmental aesthetics	○
	Human Resettlement	○	Few houses and farms are scattered.	○	Few houses and farms are scattered.	○	Few houses are scattered.	○	Few houses are scattered.	△	Some houses are scattered.	△
Traffic volume per day including bicycle and cycle			2305		2305		836		1276		1602	
Influence by Construction Works	Economic Impacts by locally procured materials	○	aggregate	○	aggregate	○	aggregate	○	aggregate	△	aggregate	○
	Technical Transfer	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○
	Employment Chance by Project	○		○		○		○		○		○
Effects by Bridge	Effects on Traffic: Accessibility to Remote Areas	○	Improvement of accessibility to eastern bank	○	Improvement of accessibility to eastern bank	◎	Improvement of accessibility to eastern bank	◎	Improvement of accessibility to eastern bank	◎	Improvement of accessibility to northeastern Cambodia	◎
	Effects on Traffic: Travel Time Stability	◎		◎		◎		◎		◎		◎
	Effects on Traffic: Saving in Ferry Operation Costs	◎		◎		○		○		◎		◎
	Effects on Traffic: Travel Time	○		○		○		○		◎	Large reduction of river-crossing time	◎
	Effects on Traffic: Savings in Travel Time Costs	◎	Large amount of travel time savings	◎	Large amount of travel time savings	◎	Large amount of travel time savings in rainy season	◎	Large amount of travel time savings in rainy season	◎	Large amount of travel time savings in rainy season	◎
	Effects on Traffic: International Network	◎	Network in GMS Economic Cooperation Program	◎	Network in GMS Economic Cooperation Program	△		△		◎	Network in GMS Economic Cooperation Program	◎
	Effects on Regional Development: Overpopulation in Capital	○		○		◎		◎		◎		◎
	Effects on Regional Development: Influenced Population	○		○		◎	Located near Phnom Penh	◎	Located near Phnom Penh	◎	Populous area in Cambodia	◎
	Effects on Regional Development: Agricultural/Resource Development	△		△		○	Agricultural development in the eastern bank	○	Agricultural development in the eastern bank	○	Promotion of development in northeastern Cambodi	○
	Effects on Regional Development: Market Oriented Economy	◎	Formation of International trade corridor	◎	Formation of International trade corridor	○		○		○	International trade corridor with Laos and Vietnam	○
	Effects on Regional Development: Balanced Regional Development	△		△		○	Promotion of Regional development in eastern bank	○	Promotion of Regional development in eastern bank	○	Regional development in Northeastern Cambodia	○
Total Project Cost(Million US$)			130.04		143.6		116.22(Bridge & Approach 77.41/R-315 38.81)		177.27(Bridge & Approach 105.23/R-315 72.04)		119.12	
Economic Evaluation (IRR)		○	9.40%	○	8.90%	○	8.30%	○	6.40%	△	6.00%	○
Overall Evaluation			○		△		○		×		△	

◎ : Very Good ○ : Good △ : Fair × : Bad

OF ALTERNATIVES OF THE MEKONG RIVER BRIDGE

	NEAK LOEUNG				PREK TAMAK				KOMPONG CHAM			
iver	A - 1		A - 2		B - 1		B - 2		C - 1		C - 2	
	1628m		848m		673m		934m		547m		978m	
	approximately 25m		approximately 25m		Approximately 30m		Approximately 24m		approximately 55m		approximately 32m	
	R-1		R-1		R-315		R-315		R-7		R-7	
	37.5m		37.5m		15.0m		15.0m		15.0m		15.0m	
ce	175.0m		175.0m		90.0m		90.0m		90.0m		90.0m	
	PC Cable Stayed Bridge(3span continuous 1 box girder)		PC Cable Stayed Bridge(3span continuous 1 box girder)		PC 5 Span Continuous 1 Box Bridge		PC 7 Span Continuous 1 Box Bridge		Single Span Suspension Bridge		PC 7 Span Continuous 1 Box Bridge	
	430.00m		430.00m		90+3@150+90=630.00m		90+5@150+90=930m		500m		90+5@150+90=930m	
	30@40+19@40=1960m		11@40+2@(80+150+100)+11@40=1540m		5@40+5@40=400m		5@40+6@40=440m		7@40+7@40=560m		5@40+5@40=400m	
	2390m		1970m		1030m		1,370m		1,060m		1,330m	
	13.50m		13.50m		13.50m		13.5m		13.5m		13.5m	
	4.00%		4.00%		4.00%		4.00%		4.00%		4.00%	
	690+2,035=2,725m		980+1,100=2,080m		260+1,100=1,360m(and R-315=66.7km)		900+1180=2080m(and R-315=66.7km)		340+2,850=3,190m		500+2,150=2,650m	
	△	Prestressed Concrete Cable Stayed Bridge	△	Prestressed Concrete cable Stayed Bridge	◎	Prestressed Concrete Box Bridge	◎	Prestressed Concrete Box Bridge	△	Suspension Bridge(steel stiffened girder)	◎	Prestressed Concrete Box Bridge
	△	deep water depth	△	deep water depth	△	deep water depth	△	deep water depth	×	big difference of water level between dry & rainy season; high water current; deep water depth	△	big difference of water level between dry & rainy season; high water current
	○		○		×	R-315 runs across flooding area	×	R-315 runs across flooding area	△	East side is flooding area	△	East side is flooding area
	○	46months	△	54months	○	42months	○	46months	○	42months	△	54months
	△	required Cable Stayed Bridge	△	required Cable Stayed Bridge	◎	not required special technical maintenance works	◎	not required special technical maintenance works	△	required periodical repaint works for Suspension Bridge	◎	not required special technical maintenance works
	○	Minor impacts caused by construction works and increased traffic volume	○	Minor impacts caused by construction works and increased traffic volume	◎	Although minor impacts caused by the increased traffic are anticipated, the number of pollution receptors are very small.	◎	Although minor impacts caused by the increased traffic are anticipated, the number of pollution receptors are very small.	○	Minor impacts are anticipated due to construction works and increased traffic volume.	○	Minor impacts are anticipated due to construction works and increased traffic volume.
ogy	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation	○	Minor impacts caused by excavation of foundation
d	△	Approach road close to school.	○	No significant impact	◎	No significant impact	◎	No significant impact	△	Approach road close to temple and some impacts on environmental aesthetics	○	Some impacts on environmental aesthetics
	○	Few houses and farms are scattered.	○	Few houses and farms are scattered.	○	Few houses are scattered.	○	Few houses are scattered.	△	Some houses are scattered.	△	Reliability developed commercial area
e	2305		2305		836		1276		1602		1602	
aterials	○	aggregate	○	aggregate	○	aggregate	○	aggregate	△	aggregate	○	aggregate
	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker	○	reinforcement worker/unskilled worker
	○		○		○		○		○		○	
mote Areas	○	Improvement of accessibility to eastern bank	○	Improvement of accessibility to eastern bank	◎	Improvement of accessibility to eastern bank	◎	Improvement of accessibility to eastern bank	◎	Improvement of accessibility to northeastern Cambodia	◎	Improvement of accessibility to northeastern Cambodia
lity	◎		◎		◎		◎		◎		◎	
ration Costs	◎		◎		○		○		◎		◎	
	○		○		○		○		◎	Large reduction of river-crossing time	◎	Large reduction of river-crossing time
Time Costs	◎	Large amount of travel time savings	◎	Large amount of travel time savings	◎	Large amount of travel time savings in rainy season	◎	Large amount of travel time savings in rainy season	◎	Large amount of travel time savings in rainy season	◎	Large amount of travel time savings in rainy season
ork	◎	Network in GMS Economic Cooperation Program	◎	Network in GMS Economic Cooperation Program	△		△		◎	Network in GMS Economic Cooperation Program	◎	Network in GMS Economic Cooperation Program
Capital	○		○		◎		◎		◎		◎	
tion	○		○		◎	Located near Phnom Penh	◎	Located near Phnom Penh	◎	Populous area in Cambodia	◎	Populous area in Cambodia
e Development	△		△		○	Agricultural development in the eastern bank	○	Agricultural development in the eastern bank	○	Promotion of development in northeastern Cambodi	○	Promotion of development in northeastern Cambodia
conomy	◎	Formation of international trade corridor	◎	Formation of international trade corridor	○		○		○	International trade corridor with Laos and Vietnam	○	International trade corridor with Laos and Vietnam
Development	△		△		○	Promotion of Regional development in eastern bank	○	Promotion of Regional development in eastern bank	○	Regional development in Northeastern Cambodia	○	Regional development in Northeastern Cambodia
	130.04		143.6		116.22(Bridge & Approach 77.41/R-315 38.81)		177.27(Bridge & Approach 105.23/R-315 72.04)		119.12		106.15	
	○	9.40%	○	8.90%	○	8.30%	○	6.40%	△	6.00%	○	6.50%
		○		△		○		×		△		◎

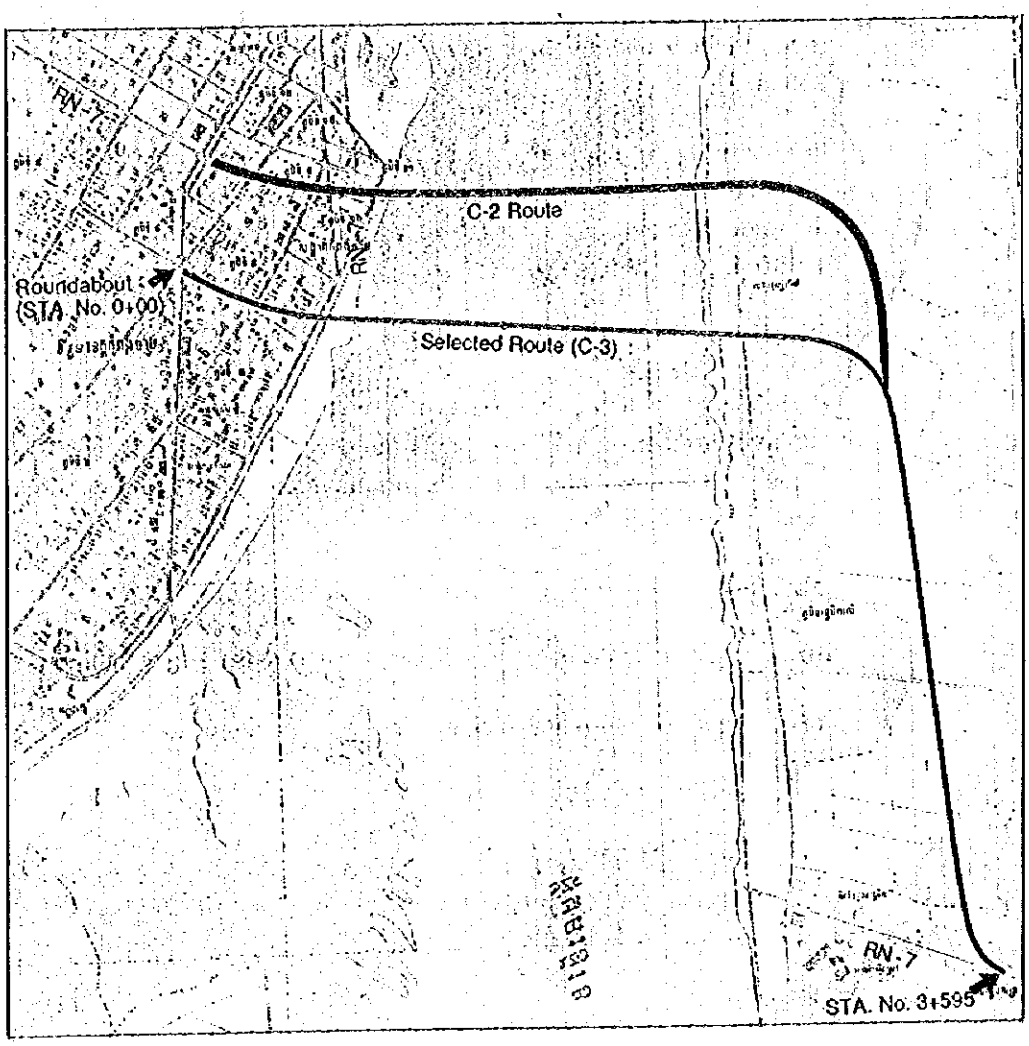
◎ : Very Good ○ : Good △ : Fair × : Bad

CHAPTER 9 DETERMINATION OF SELECTED ROUTE

The C-2 route was selected for the Mekong Bridge out of the six alternative routes in the previous chapter. Based on the detailed survey along the C-2 route, the Study Team was selected a new route (C-2) approximately 300 m downstream considering following points.

- Land acquisition and compensation costs could be minimized.
- General scouring (i.e., lowering of the bed level) could occur along the original C-2 route.
- Construction of foundations in the deep river channel could be avoided.
- Approach road with considerably large through traffic congestion.

The selected route is shown in the figure below.



CHAPTER 10 PRELIMINARY DESIGN AND COST ESTIMATE FOR SELECTED ROUTE

(1) Preliminary Design

The main components of the proposed Mekong Bridge will be the main bridge, approach bridges and approach roads.

In this feasibility study, the Japanese standards and criteria will be applied for the preliminary design, provided that wind, temperature, earthquake in the Japanese criteria will be modified accordingly based on the Cambodian natural conditions.

The main bridge is a 9 span continuous P.C. box girder (7 spans x 120 m = 840 m and 2 side span x 80 m = 160 m, total length 1,000 m). the western approach bridge is a 5 span connecting P.C. T-girder (5 spans x 40 m = 200 m) and the eastern approach bridge is a 4 span connecting P.C. T-girder (4 spans x 40 m = 160 m).

In western approach road, the retaining wall has been provided to contain the embankment, thus minimizing the impact on the adjacent properties and reducing the width of right of way. The length of approach road is approximately 256 m.

In eastern approach road, the conventional embankment will be applied with batters of 2 to 1. The embankment will be protected from erosion for full length of the embankment. The length of eastern approach road is approximately 1,980 m.

(2) Cost Estimate

Project cost estimate consists of construction cost, detailed design and supervision cost, non-eligible costs (land acquisition and compensation cost, taxes and duties, and MPWT's administration cost), and contingencies considering the following assumptions.

(a) The total period of construction is 3.5 years (42 months)

(b) Cost estimate is made at the price level as of the end of February 1996.

(c) The foreign currency exchange rates are assumed to be;

US$1.0 = Yen 104.85 = Bs 25.19

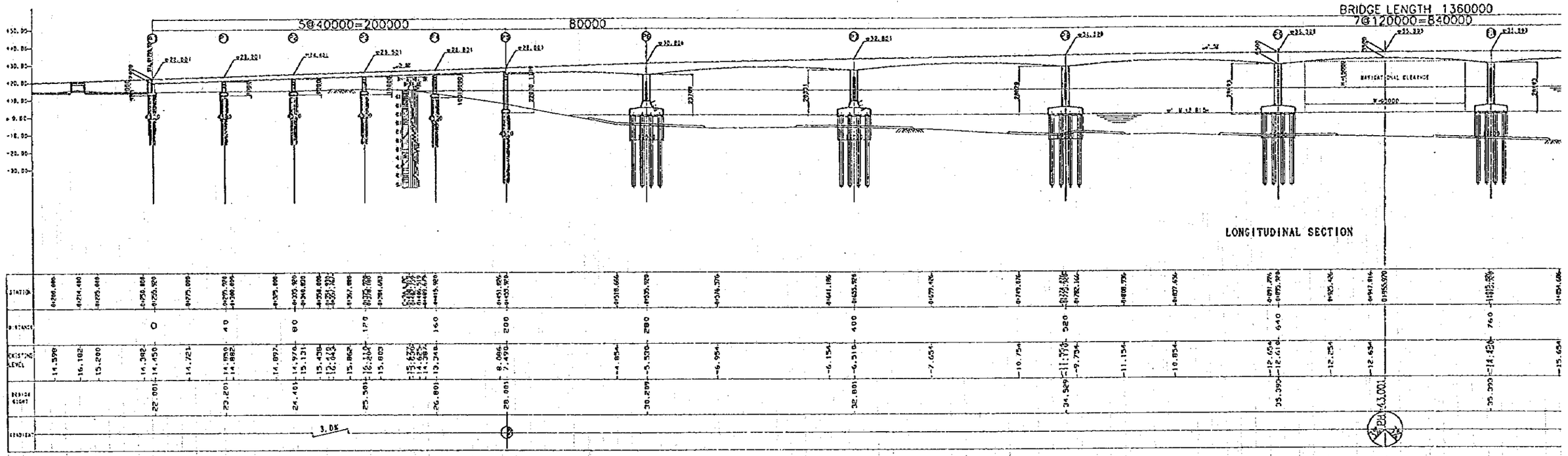
(d) Materials and equipment, which cannot be procured in Cambodia, and basically imported from Thailand, except special materials and equipment for large scale bridge.

(e) It is assumed that the project is undertaken by a International Contractor selected in a competitive tender under the supervision of a Japanese consultant.

The total project cost is estimated at US$79,678,000 (US$51,003,000 for foreign portion and 28,675,000 for local portion) and summarized below:

US$ x 10^3

No.	Items	Foreign	Local	Total
1)	Construction Cost	43,333	21,465	64,798
2)	Engineering Fee	3,033	1,503	4,536
3)	Non-Eligible Cost	-	3,100	3,100
	- Land Acquisition and Compensation Cost		1,020	1,020
	- Taxes and duties		1,899	1,899
	- Administration Cost of MPWT		181	181
4)	Contingencies	4,637	2,607	7,244
5)	Total Project Cost	51,003	28,675	79,678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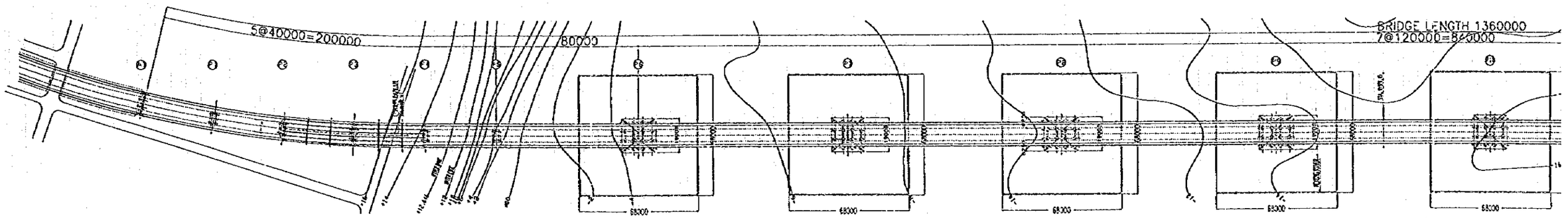
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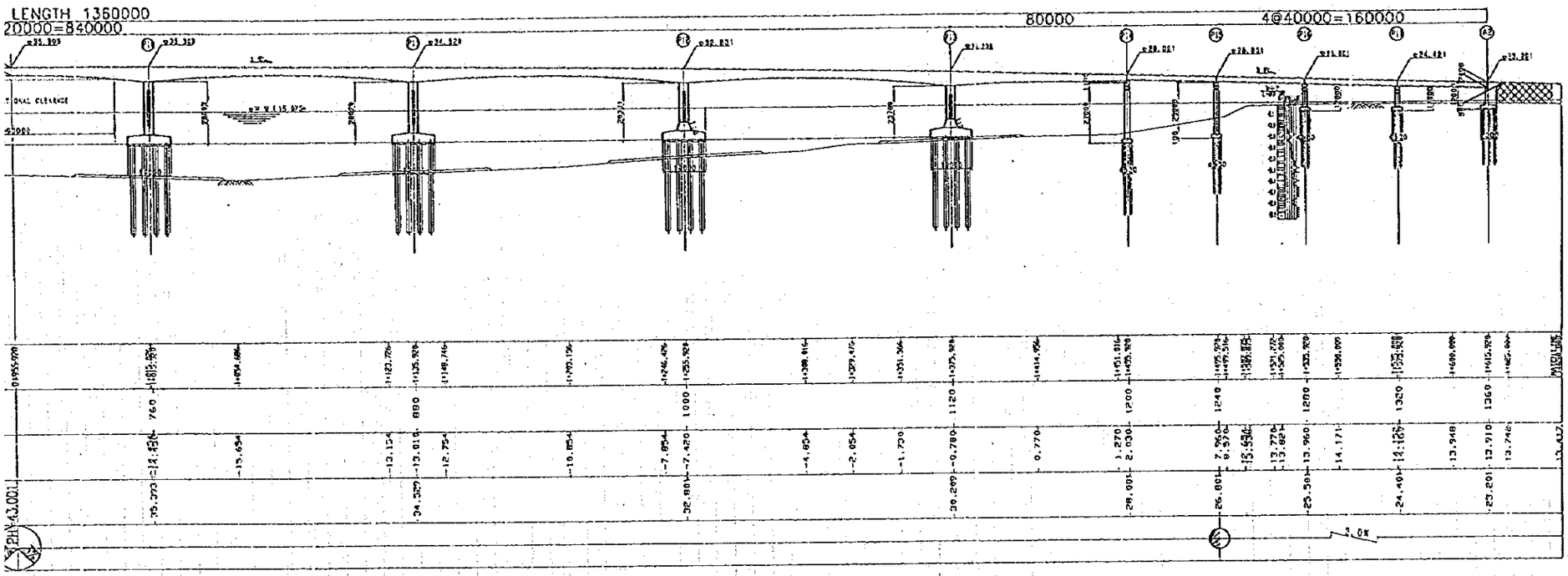
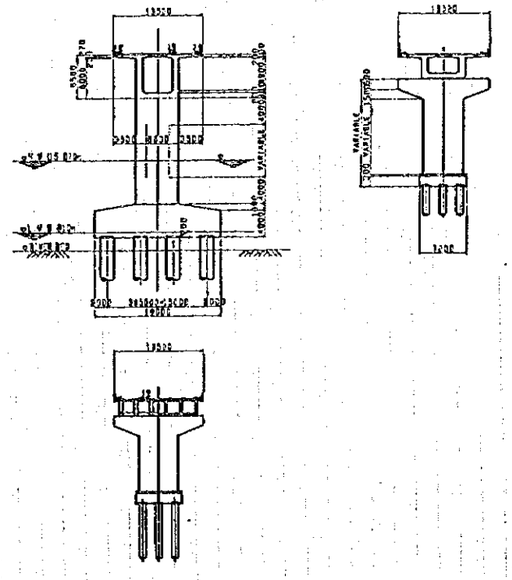
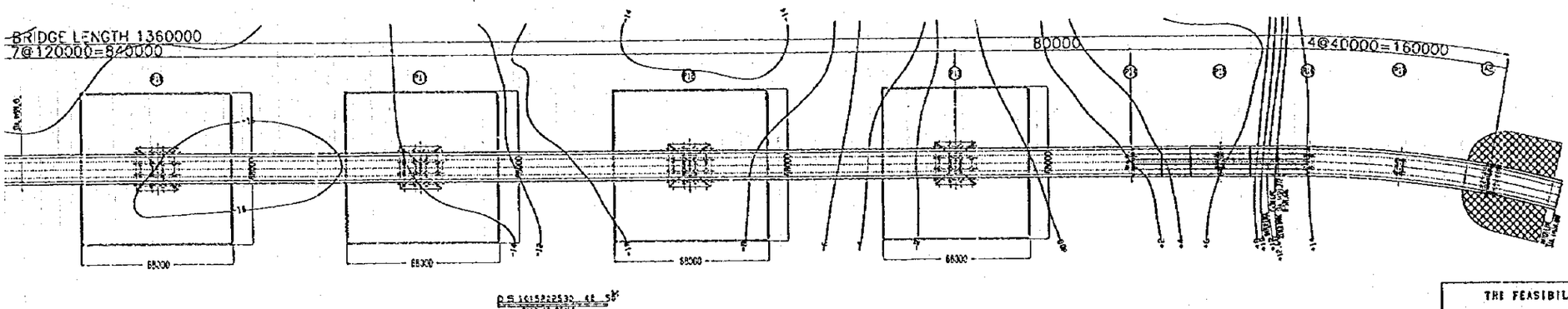




CROSS SECTION



THE FEASIBILITY STUDY ON CONSTRUCTION OF THE MEKONG BRIDGE IN KINGDOM OF CAMBODIA	FIGURE 14.9 CONFIGURATION OF THE PROPOSED BRIDGE JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 11 ENVIRONMENTAL IMPACT ASSESSMENT

Environmental impacts possibly caused by this bridge construction project have been studied at two different stages: Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA). These two studies are presented in Chapter 8 and 13 of this Draft Final Report, respectively.

IEE identifies probable environmental parameters which will be affected by the project implementation and evaluates the magnitude of impacts on the identified parameters, including air and noise population, water quality and aquatic ecology, human resettlement, soil erosion and siltation, cultural/historical properties, environmental aesthetics, and transportation system. IEE also concerns environmental ranking of originally proposed six candidate bridge construction locations and suitability of these alternatives are evaluated.

Based on the results of IEE, at EIA stage for the selected bridge construction location, existing conditions and predicted impacts on major environmental parameters are studied in depth, assessment of these impacts are made, and feasible mitigation measures and recommendations, as well as monitoring programs, are proposed.

It is studied from the entire analysis that the magnitude of adverse impact on the environment is mixed. Some environmental parameters will be affected to some extent, while others have minor impacts. For example, some areas on bridge approach roads need to be expropriated, causing human relocation problems, while impacts on the rest of parameters have been found minimal. All the environmental parameters will be adversely affected in some degree by the project implementation. However, adverse impacts on these environmental parameters can most likely be mitigated by the provision of proposed countermeasures and monitoring programs, and no serious environmental problems are expected in the future.

Consequently, overall environmental impact caused by this bridge construction project is evaluated to be minimal only if all the proposed mitigation measures and monitoring programs are properly implemented.

CHAPTER 12 ECONOMIC AND FINANCIAL EVALUATION

12.1 Economic Evaluation

The economic analysis has been conducted on the basis of a "with" and "without" comparison. The economic benefits of the Project have been quantified in terms of time cost savings afforded to passengers and freight that now cross the Mekong by ferry, and vehicle operating cost (VOC) savings in terms of reduced vehicle-kilometers traveled and avoidance of ferry fares by vehicles that now cross the Mekong by ferry.

Time costs savings were calculated for passengers and freight by vehicle type. It is important to note that the benefits as changes in consumer surplus for induced traffic were valued at half of that for normal traffic. The time cost savings for both passengers and freight were then estimated to be US$0.9 million in 2002, US$5.4 million in 2011, and US$17.2 million in 2021.

Vehicle operating cost savings were determined by vehicle type in terms of reduced vehicle-kilometers traveled and avoidance of ferry fares. Again, the benefits as changes in consumer surplus for induced traffic were valued at half of that for normal traffic. The VOC savings for reduced vehicle-kilometers traveled and avoidance of ferry fares were then estimated to be US$0.7 million in 2002, US$2.8 million in 2011, and US$6.2 million in 2021. Because this economic evaluation includes benefits due to the avoidance of ferry fares, the savings in avoidance of ferry operating and improvement costs were excluded.

Total costs include (i) the capital investment expenditures excluding taxes and duties disbursed over the five-year construction program period of 1998-2002 (total cost of US$77.8 million); (ii) periodic bridge and approach road maintenance and repair costs incurred in 2011, 2021, and 2031; and (iii) annual bridge and approach road maintenance and repair costs of approximately US$1,800 per year.

The EIRR was then estimated to be 9.5 per cent. The results of the sensitivity analysis indicate that the EIRR in the worst case scenario (i.e., costs increased by 10% and benefits reduced by 15%) is 8.0 per cent. The 9.5 per cent EIRR in the base case was determined via an analytical approach that adopted conservative cost and benefit figures as input data.

Although the bridge proposal appears to have a marginal economic return on investment, it is important to restate that the construction of a Mekong Bridge at Kompong Cham will not only reduce transport costs, but will also serve as a catalyst for economic growth. The potential for expanding agricultural and industrial production in this region is very high. In addition, the bridge will certainly induce an increase in value-added of various sectors of the economy other than agriculture and minerals, such as commerce and industry. However, quantification of these components is also extremely difficult given the level of usable data.

Although it was not considered possible to forecast the magnitude of development benefits with any confidence, they will most likely be significant. In light of these

potentially large development benefits and the base EIRR of 9.5 per cent (which does not include development benefits), it is believed that the Project is economically viable.

12.2 Financial Evaluation

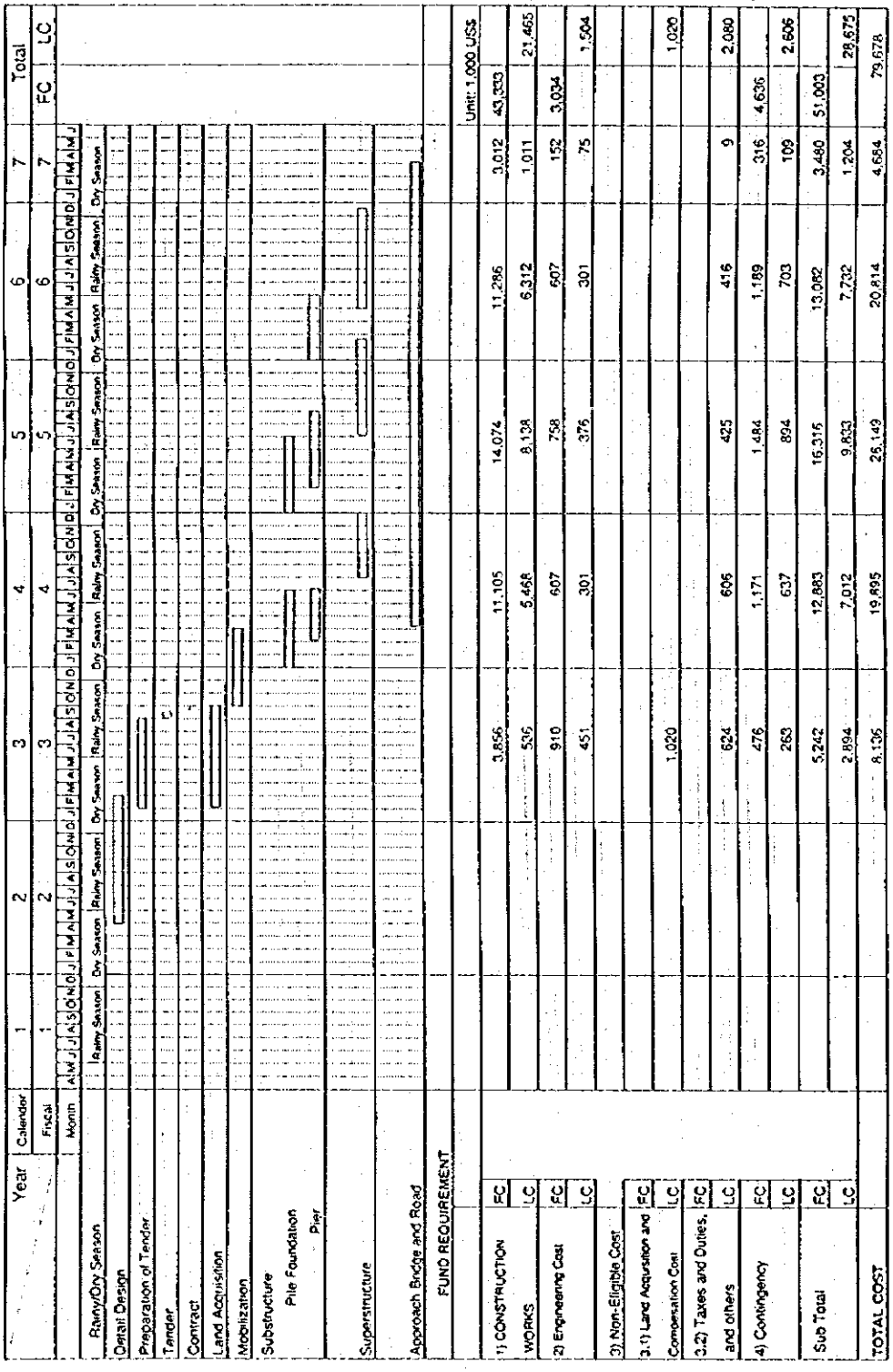
The Cambodian Government's fiscal position remains extremely weak as the tax regime and collection system have not been prepared in line with the changing economic structure. Although some progress has been made in recent years, it will take some time for the situation to significantly improve. Public revenue in 1994 was estimated at 7 per cent of GDP, whereas public expenditure was estimated at 15 per cent. Therefore, at present, foreign bilateral and multilateral aid accounts for about 40 per cent of the national budget. The Government will have to continue relying on foreign aid for some time to come.

Based on the required disbursements for each year of Project implementation, a total of US$51.0 million in foreign currency will be required, while the remaining Project cost of US$28.7 million should be paid in domestic currency. Estimated year by year disbursements are US$7.3 million in 1998, US$19.9 million in 1999, US$26.1 million in 2000, US$20.8 million in 2001, and US$4.7 million in 2002. These figures can be compared with the total national budget of US$460 million in 1995 and the total MPWT budget of US$12.2 million for 1994 and an estimated US$9.8 million for 1995.

After calculating a likely financing plan under very favorable loan conditions, it was determined that debt service would be more than 20 per cent of the entire MPWT budget from 2001 to 2011. This is clearly an untenable situation as far as MPWT's budgetary allocation is concerned. Therefore, it is strongly recommended that external financing without debt service obligation be sought for the implementation of the Project.

CHAPTER 13 IMPLEMENTATION PROGRAM

Assuming the time of commencement of this project is fixed an implementation program is prepared as shown below:



Year		1	2	3	4	5	6	7	Total	
		1	2	3	4	5	6	7	FC	LC
Rainy/Dry Season		Rainy Season / Dry Season	Rainy Season / Dry Season	Rainy Season / Dry Season	Rainy Season / Dry Season	Rainy Season / Dry Season	Rainy Season / Dry Season	Rainy Season / Dry Season		
Detail Design										
Preparation of Tender										
Tender										
Contract										
Land Acquisition										
Mobilization										
Substructure										
Pile Foundation										
Pier										
Superstructure										
Approach Bridge and Road										
FUND REQUIREMENT									Unit: 1,000 US$	
1) CONSTRUCTION	FC			3,856	11,105	14,074	11,286	3,012	43,333	
WORKS	LC			536	5,468	8,134	6,312	1,011		21,465
2) Engineering Cost	FC			910	607	758	607	152	3,034	
	LC			451	301	376	301	75		1,504
3) Non-Eligible Cost										
3.1) Land Acquisition and	FC									
Compensation Cost	LC			1,020						1,020
3.2) Taxes and Duties,	FC									
and others	LC			624	606	425	416	9		2,080
4) Contingency	FC			476	1,171	1,484	1,189	316	4,636	
	LC			263	637	894	703	109		2,606
Sub Total	FC			5,242	12,883	16,316	13,082	3,480	51,003	
	LC			2,894	7,012	9,803	7,732	1,204		28,675
TOTAL COST				8,136	19,895	26,149	20,814	4,684	79,678	

CHAPTER 14 CONCLUSIONS AND RECOMMENDATIONS

According to this Feasibility Study on Construction of Mekong Bridge in Kingdom of Cambodia, which presents the results of numerous economic and engineering studies (e.g., traffic surveys, topographic surveys, bathymetric surveys, geological surveys, river hydrological studies, environmental examinations, design calculations, and cost estimates), the following conclusions and recomendations are offered:

1. A bridge crossing the Mekong River will have crucial importance on not only accelerated development of the transportation sector but also on overall development of the economy in Cambodia and especially eastern regional development.

2. Functions of a Mekong Bridge can be expected as follows:

   1) Improvement of Accessibility between Phnom Penh and Remote Areas in the eastern regions

   2) Improvement of the International Road Network

   3) Promotion of a Market-Oriented Economy

   4) Upgrading of Living Standards in Rural Areas

   5) Promotion of Agricultural Development

   6) Promotion of Resource Development

   7) Balanced Development of the Country

3. According to the traffic surveys in May 1995, average daily traffic was observed to be 970, 80 and 260 PCU (not including motorcycles or non-motorized vehicles) at the Neak Loeung, Prek Tamak and Kompong Cham ferry stations respectively. Future Traffic in the year 2011 is expected to be 4,110,.390 and 1,890 PCU at the Neak Loeung, Prek Tamak and Kompong Cham without bridge.

4. There are three candidate locations, namely Neak Loeung, Prek Tamak and Kompong Cham. Each candidate location having two alternative routes was studied for the purpose of selecting the optimum route among these six alternatives. In consideration of project cost, EIRR, concordance with national regional development strategy, formation of an international network and promotion of an market-oriented economy, promotion of public welfare, and environmental impact, it was recommended that the Kompong Cham route, which passes through nearby C-2 route, has significant advantages over the other five alternatives.

5. In addition, the location of the final route was slightly shifted downstream by approximately 300 m from the C-2 route and named the selected route (C-3) according to the following reasons: 1) to minimize social impacts and reduce the

cost of land acquisition and compensation on the Kompong Cham side due to construction of viaduct and approach road, 2) to avoid general scouring which could occur along C-2 route, 3) to avoid construction of foundation in deep river channel.

6. Environmental study examines probable impacts of this bridge construction on the environment, regarding identified environmental parameters. All the environmental parameters will be adversely affected in some degree by the project implementation. However, adverse impacts on these environmental parameters can most likely be mitigated by the provision of proposed counter measures and monitoring programs; consequently no serious environmental problems are expected in the future.

7. As a result of the engineering studies and preliminary design, the following plan is recommended for the Mekong River Bridge:

Location of Bridge:	Kompong Cham
Navigational Clearance:	15.0m from high water level
Bridge Width:	13.5m
Road width:	10.8m
Sidewalk:	1.1m on both sides
Total Bridge Length:	1,360m

Main Bridge

Type: Cast-in-situ Prestressed Concrete Continuous Box Girder

Span Arrangement: 80+7@120+80=1,000m

Approach bridge

Type: Prestressed Concrete connecting T-Girder

Span Arrangement:

Kompong Cham side: 5@40=200 m

East Bank Side: 4@40=160 m

Approach Roads

Roadway:	7.00 m
Sidewalk	0.75 m on both sides
Total Length:	2,238 m

Kompong Cham side 257 m

East Bank side 1,981 m

8. Land acquisition and compensation is to be undertaken by the Government of Cambodia prior to the commencement of the construction works.

9. According to the hydrological study, the average difference between the highest and lowest water level is around 14 m at Kompong Cham. In order to make the best use of the dry season (from December to May) in the initial construction works, it is recommended that mobilization of the works be scheduled to begin with beginning of October.

10. Construction period is estimated to be 42 months (3.5 years) on the condition that actual commencement of mobilization works starts at October.

11. Total project cost is estimated to be US$79.678 million in the end of February 1996 prices in which foreign currency portion is 64% and local currency portion is 36%

12. The economic evaluation determined that the Mekong Bridge at Kompong Cham is economically justifiable. Although the bridge proposal appears to have a marginal economic return on investment when looking only at its impact on reduced transport costs, the Project will also serve as a catalyst for economic growth. While it was not considered possible to forecast the magnitude of development benefits with any confidence, they will most likely be significant. In light of these potentially large development benefits and the base EIRR of 9.5 per cent (which does not include development benefits), it is believed that the Project is economically viable.

13. Based on results of the economic evaluation and the financial evaluation, which illustrated the severe financial constraints of servicing a domestic loan even under very favorable loan conditions, it is strongly recommended that external financing without debt service obligation be sought for the implementation of the Project.

In conclusion the Study Team considers that construction of the Mekong Bridge at Kompong Cham is technically and economically feasible under proper finance and accordingly recommends that it be immediately implemented.

JICA