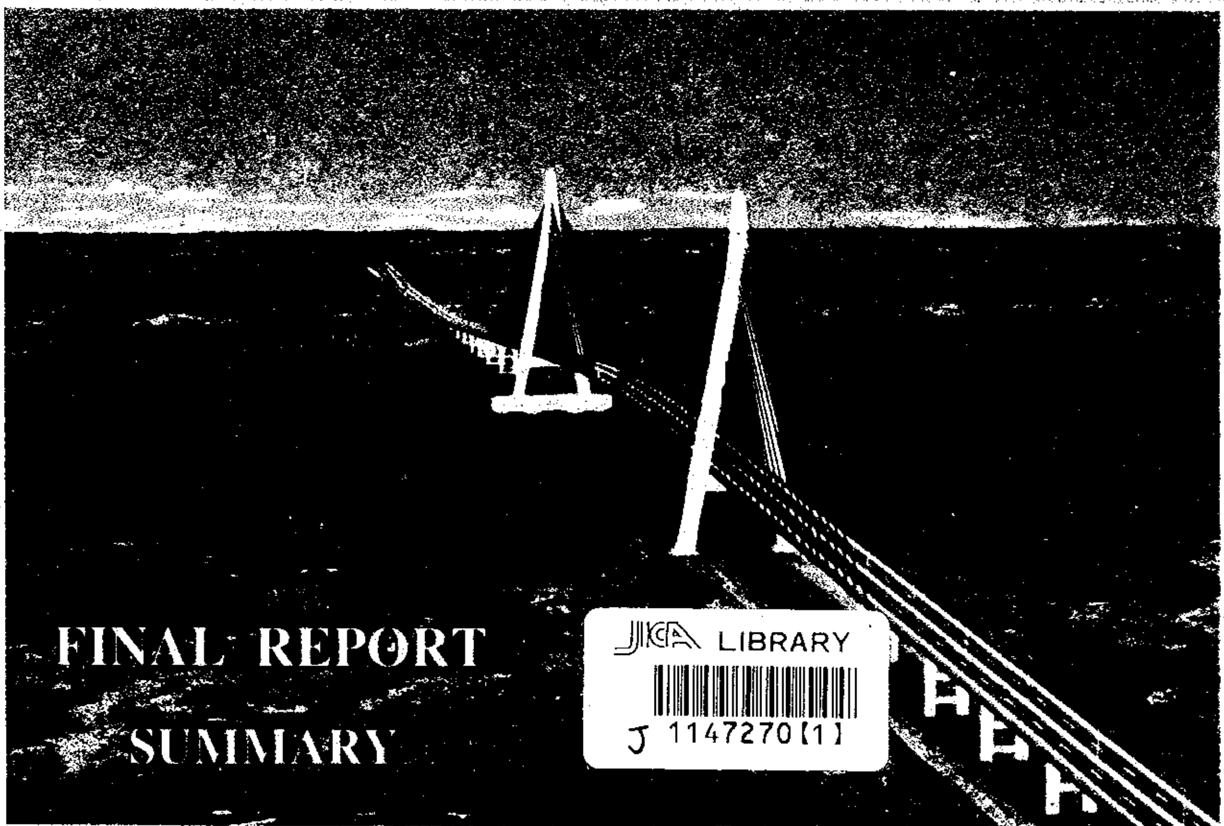
社会開発調査部報告書

No. 2

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT
SOCIALIST REPUBLIC OF VIET NAM

THE FEASIBILITY STUDY ON THE CAN THO BRIDGE CONSTRUCTION IN SOCIALIST REPUBLIC OF VIET NAM



September 1998

NIPPON KOEI CO., LTD.
and
PADECO CO., LTD.

THE FEASIBILITY STUDY ON THE CAN THO BRIDGE CONSTRUCTION IN SOCIALIST REPUBLIC OF VIET NAM SUMMARY September 1998 NIPPON KOEI CO., ...

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF TRANSPORT
SOCIALIST REPUBLIC OF VIET NAM

THE FEASIBILITY STUDY ON THE CAN THO BRIDGE CONSTRUCTION IN SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

SUMMARY

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1 US $ = 12,950 VN Dong

PREFACE

In response to a request from the Government of Viet Nam, the Government of Japan decided to conduct a feasibility study on the Can Tho Bridge Construction in the Socialist Republic of Viet Nam and entrusted to study to the Japan International Cooperation Agency.

JICA selected and dispatched a study team headed by Mr. Koji Enomoto and Mr. Katsufumi Matsuzawa of Nippon Koei Co., Ltd. and consist of Nippon Koei Co., Ltd. and PADECO Co., Ltd. to Viet Nam, three times between August 1997 and September 1998. In addition, JICA set up an advisory committee headed by Mr. Yoshinobu Hayashi, assistant auditor of Honshu - Shikoku Bridge Authority, between July 1997 and September 1998, which examined the study from specialist and technical points of view.

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

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

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

September 1998

Kimio Fujita

President
Japan International Cooperation Agency

September, 1998

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

Letter of Transmittal

Dear Sir:

We are pleased to submit you the report on the Feasibility Study on the Can Tho Bridge Construction in Socialist Republic of Viet Nam. The report contains the advice and suggestions of the concerned authorities of the Government of Japan and your agency as well as the comments made by the concerned authorities in Socialist Republic of Viet Nam. The report consists of a main report, an executive summary, an annexure and a drawing volume.

The feasibility study concludes that the proposed project to build a Can Tho Bridge will be technically and economically feasible and will be acceptable from the environmental aspects, and will contribute to the improvement of transportation network in Viet Nam.

We wish to take this opportunity to express our sincere gratitude to your agency, the Ministry of Foreign Affairs, the Ministry of Construction and Honshu Shikoku Bridge Authority of the Government of Japan. We also wish to express our deep gratitude to the Ministry of Transport, Project Management Unit My Thuan and other concerned agencies of the Government of Viet Nam for the close cooperation and assistance extended to us during our study. We do hope this report will contribute to the development of Viet Nam.

Very truly yours,

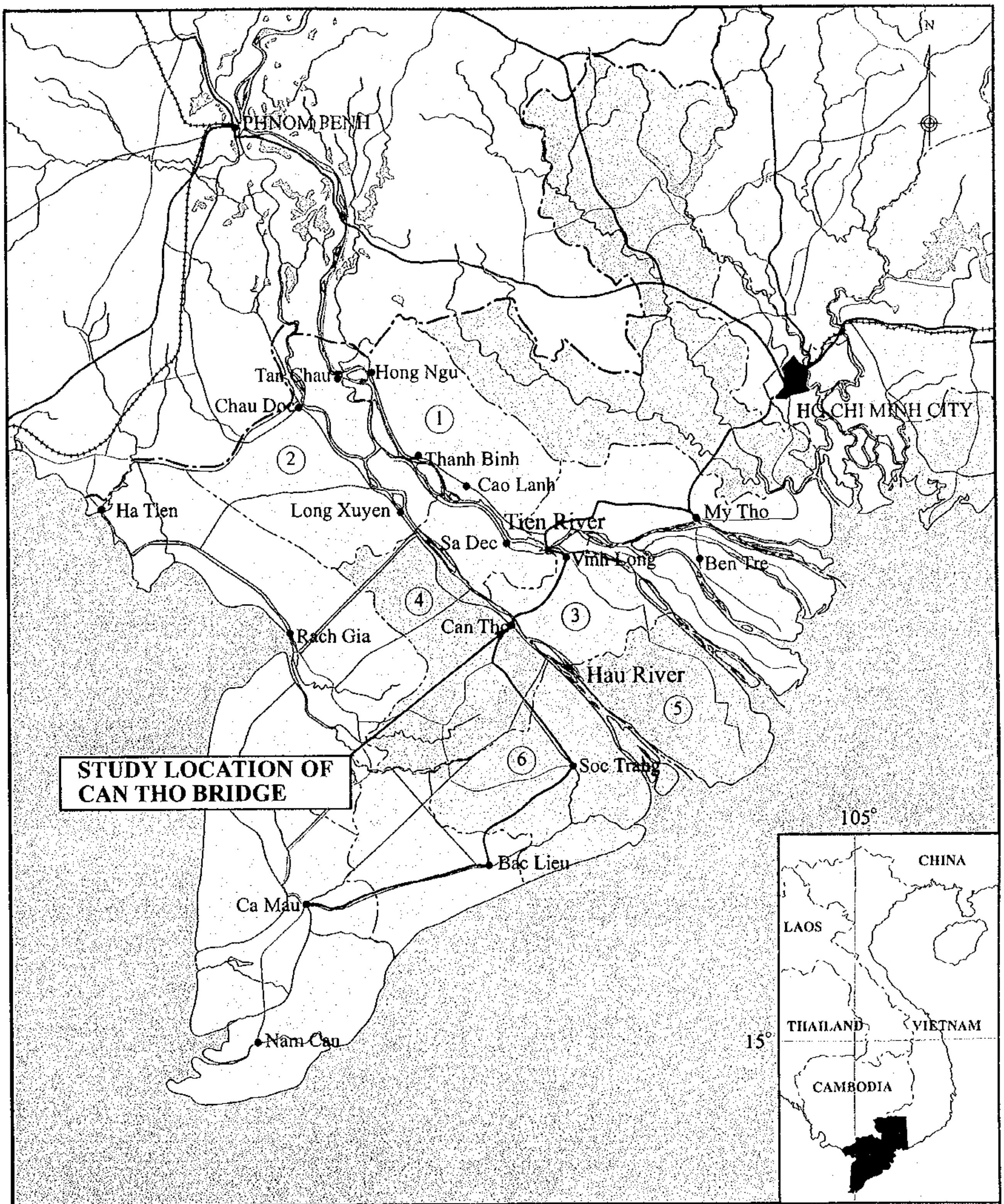
September, 1998

Katsufumi Matsuzawa

Team Leader
The Feasibility Study
on
the Can Tho Bridge Construction in
Socialist Republic of Viet Nam

1993.02.12 Landsat TM True Color Image
Red - Band3 Green- Band2 Blue-Band1

GENERAL LOCATION MAP



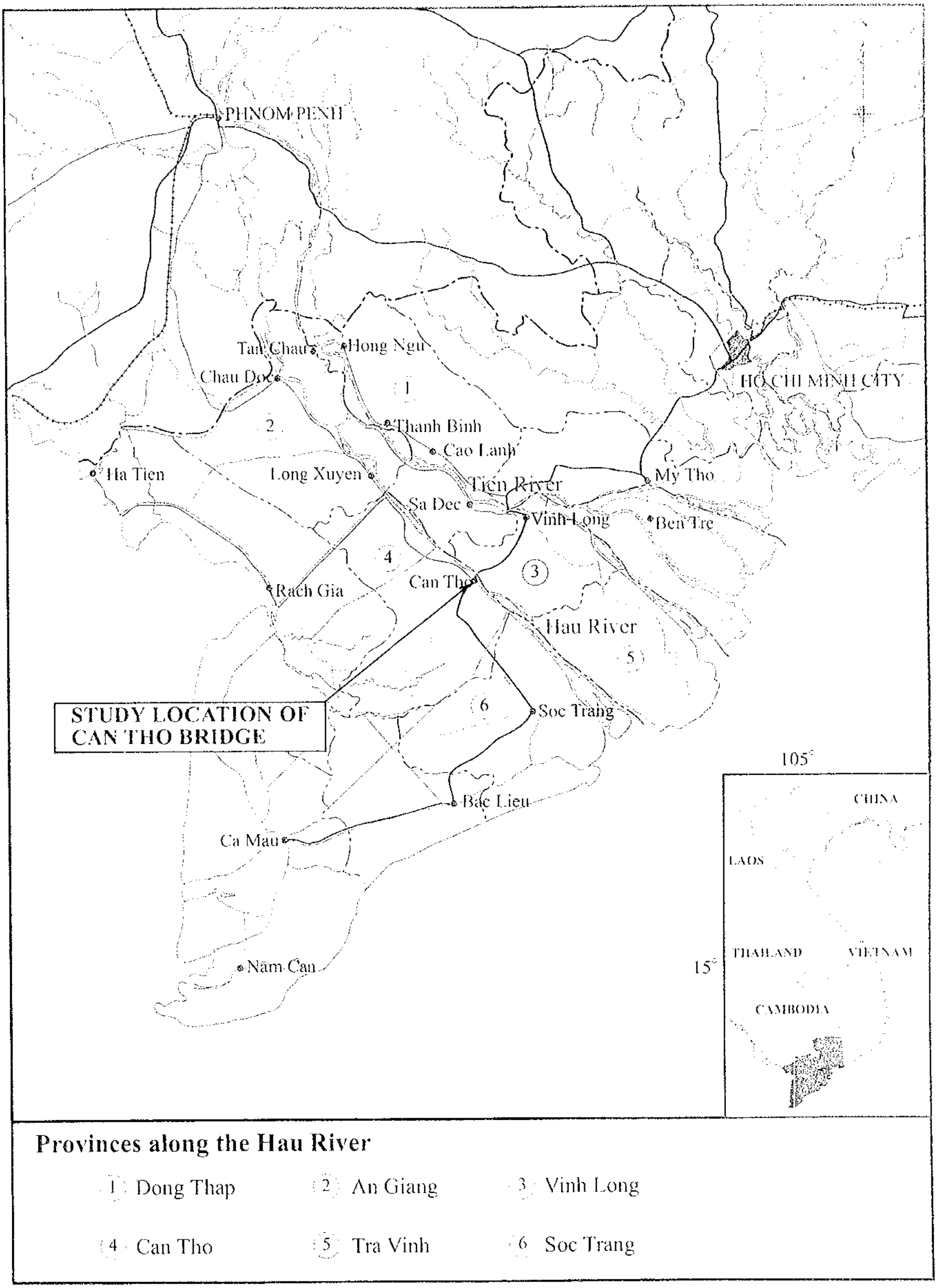
Provinces along the Hau River

① Dong Thap	② An Giang	③ Vinh Long
④ Can Tho	⑤ Tra Vinh	⑥ Soc Trang

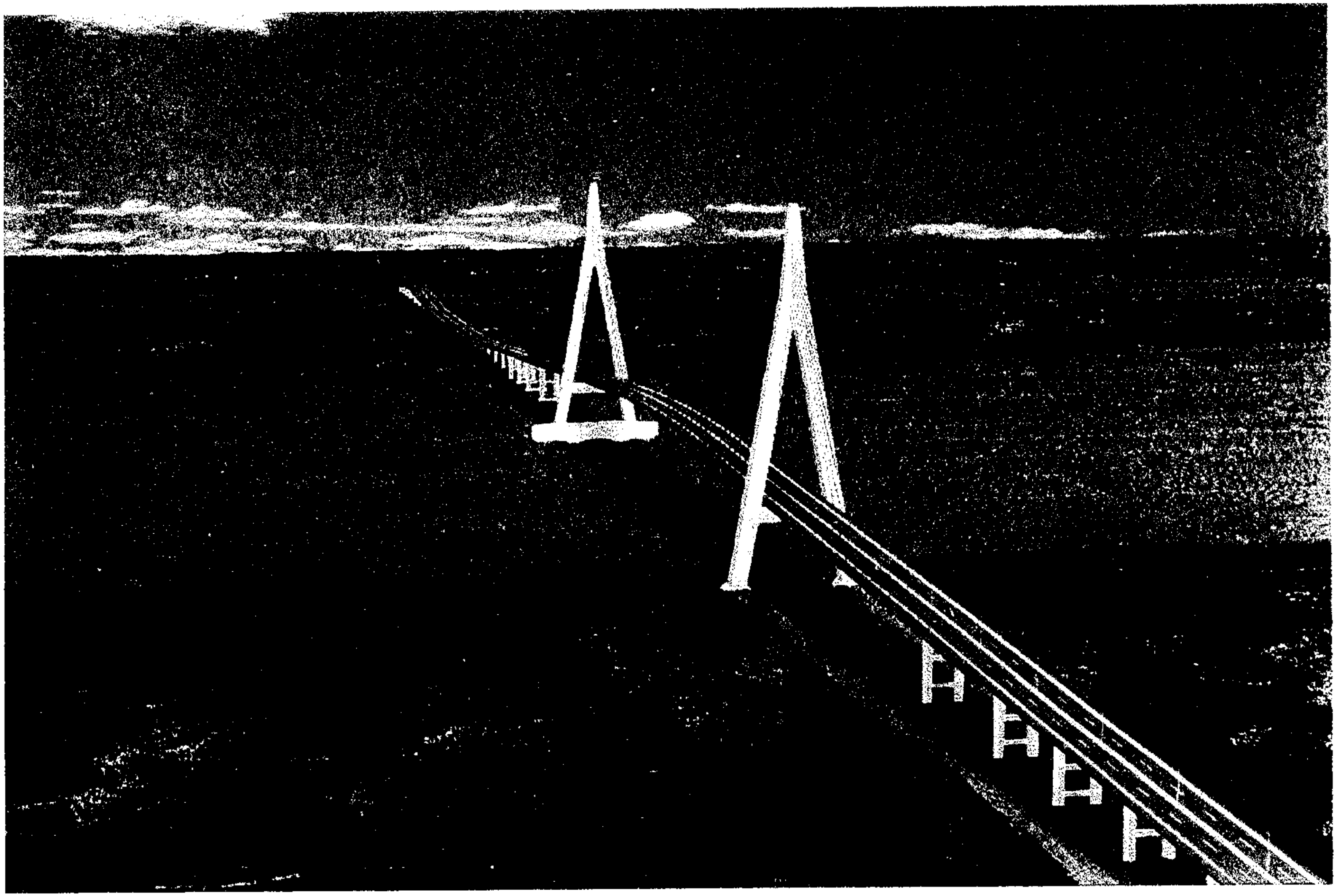
STUDY LOCATION

1993.02.12 Landsat TM True Color Image
Red - Band3 Green- Band2 Blue-Band1

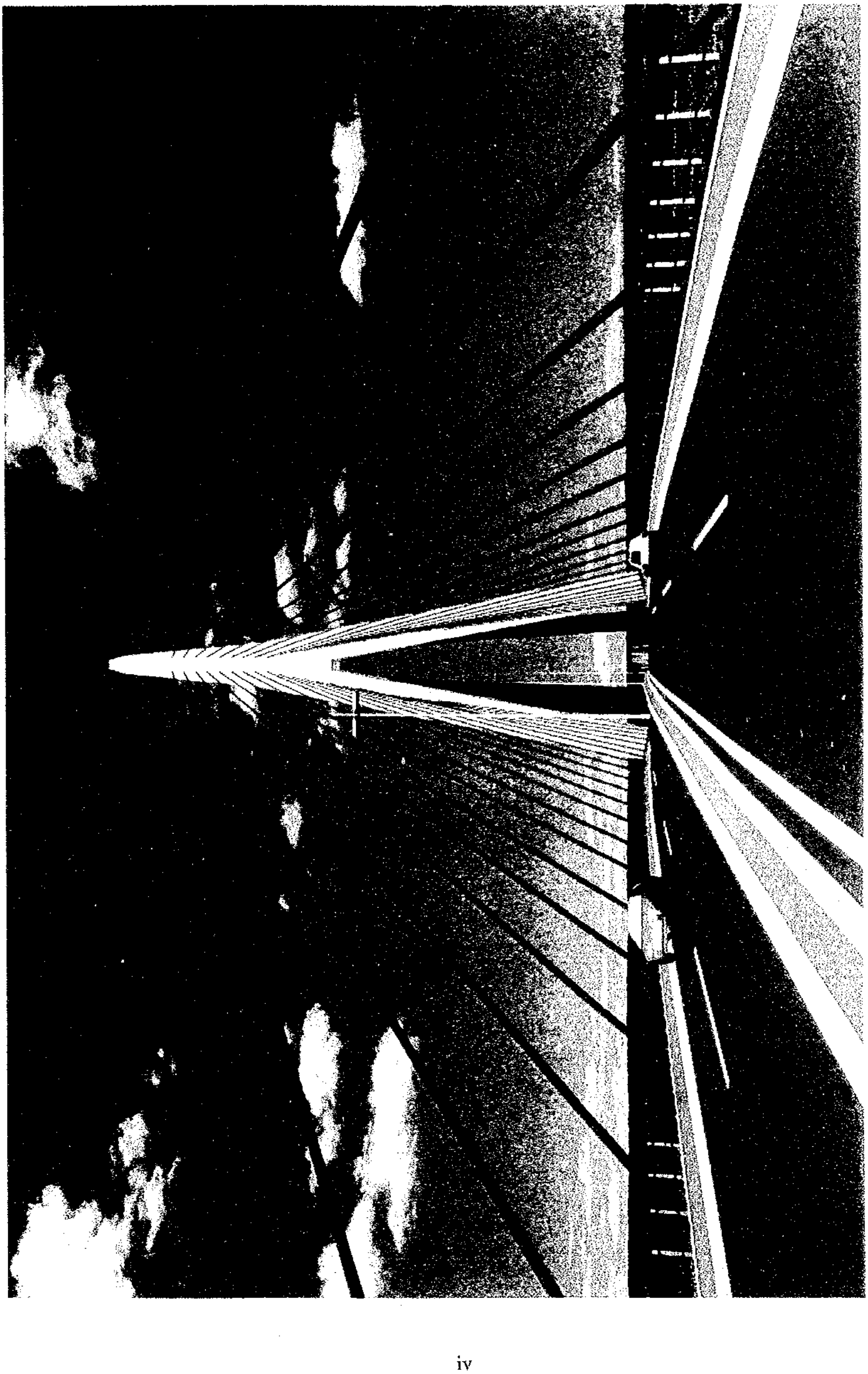
GENERAL LOCATION MAP



STUDY LOCATION



PERSPECTIVE 1



PERSPECTIVE II

CONTENTS

Abbreviations and Acronyms

AASHTO	American Association of State highway and Transportation Officials
ADB	Asian Development Bank
B/C	Benefit Cost
DWT	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
Fig.	Figure
GD	Government Decree
GDP	Gross Domestic Product
GDRP	Gross Domestic Regional Product
GPS	Global Positioning System
HWL	High Water Level
IEE	Initial Environmental Examination
JICA	Japan International Cooperation Agency
MOT	Ministry of Transport
MSL	Mean Sea Level
N.H.	National Highway
NPV	Net Present Value
OD	Origin-Destination
OECF	Overseas Economic Cooperation Fund of Japan
PC	Prestressed Concrete
PMU	Planning Management Unit
p.a.	Per Annum
WB	World Bank

SYNOPSIS

National Highway (N.H.) No. 1 is an arterial road running about 2,300 km through Viet Nam from the border with China in the north to Namcan in the south. The rehabilitation and improvement of N.H. No. 1 is the top priority project in the infrastructure development strategy of Viet Nam to the year 2010. Can Tho City is located 167 km southwest of Ho Chi Minh City, and it is the largest and most important city in the Mekong Delta. The Can Tho ferry, which crosses the Hau River and connects the cities of Vin Minh and Can Tho, experiences heavy traffic and is a bottleneck of N. H. No. 1. Therefore, the construction of a Can Tho Bridge is a must for improving transportion and promoting the development of the economy and society of neighboring areas and Viet Nam.

The objectives of this feasibility study were to assess the feasibility of Can Tho Bridge construction and to conduct technology transfer to Vietnamese counterparts.

The study was scheduled in two stages. In the first stage, the bridge location was studied, and in the second stage the feasibility of the project for the selected location was studied. The first stage comprised review and analysis of existing data and information, natural condition survey, traffic study, navigational condition survey, initial environmental examination, preliminary economic analysis, and selection of optimum route and bridge type. The items of the second stage were preliminary design, environmental impact assessment, construction planning and cost estimate, economic and financial analysis, preparation of implementation program, and comprehensive evaluation and recommendation.

For setting up the alternative routes, site visits and data collection were conducted at the beginning of the first stage of work in Viet Nam. Three alternative routes (called Routes A, B and C) and their several options were established, considering not only natural and environmental conditions but existing local transport plans: Route A and B entered directly into Can Tho City and Route C bypassed the central part of Can Tho City.

Planning conditions of the bridges, including high water level and design discharge, were established. In the hydrological and hydraulic survey, the flooding characteristics of the Mekong Delta, and erosion and sedimentation of the Hau River were investigated. The scouring depth was calculated as

32m and utilized to design the foundations of the main bridge. The required minimum center span length of the main bridge was determined to be approximately 600m for Route A and B, 500m for Route C. Route C has the most suitable hydrological condition for bridge location.

An Initial Environmental Examination (IEE) was conducted to clarify the impacts of each alternative route on the regional natural and socio-economic environment. The results of the examination reinforced Route C as superior to the other alternatives.

Geotechnical survey was investigated to certify the bearing stratums, especially for the design of the main bridge. Twelve bore holes were drilled and laboratory test of collected sample soil were done. As the results, the open caisson (L=90m) was adopted for the foundations of the tower of the main bridge, and cast-in-place piles (L=72m) and steel pipe piles (L=80m) were adopted for the other substructures.

Socio-economic frame work and future traffic demand in consequence of traffic study were prospected. The future traffic volume was forecasted as 29,629 pcu/day in 2010 and it indicated that a four-lane facility (two lanes in each direction) will need to be designed.

Based on the above results, a preliminary economic evaluation was carried out and it showed Route C to be the most appropriate route.

Through the detailed examination of each route's conditions, an optimum route was selected among the derived options. Route C-2/3, which was located 2.9km downstream from the existing ferry line, was recommended and accepted as most suitable in terms of less compensation on land acquisition and resettlement of houses, traffic congestion in Can Tho City, and road alignment.

The required navigational (vertical) clearance under the main bridge was determined based on existing relevant data for the Mekong River, the navigable conditions of the Hau River, the characteristics of the existing and future Can Tho ports, and assessment of the case study including the dredging volume of riverbed. Navigational clearance of 39.0 m above the flood level with a 5% frequency (20-year return period) was concluded for the preliminary design at the Steering Committee Meeting held on 27 March 1998. This clearance satisfied the comments on the document sent by the

Mekong River Commission of Viet Nam on 8 April 1998, and was identified as the final design condition for the Feasibility Study in the Steering Committee Meeting held on 9 July 1998 in Hanoi.

In the second stage, the bridge was preliminarily designed based on analysis of the optimum span length, hydrodynamics, and economics. The recommended hybrid (steel and concrete) cable-stayed bridge design was accepted by the Vietnamese side.

The Environmental Impact Assessment (EIA) Study was also conducted in the latter part of second stage work in Viet Nam. The adverse impacts on the natural environment and socio-economic environment of the project area including resettlement due to land acquisition seemed to be of small scale and could be easily mitigated. However, a monitoring program was proposed to be implemented from the early stage of construction to ensure that all sources of contaminants generated by the construction sites could be appropriately controlled and managed, to minimize all adverse impacts on the existing ecosystem of the study area.

The construction planning schedule and cost estimates were developed based on the results of the preliminary design. The construction cost is estimated at 200.0 million USD consisting of bridges and approach roads, while the project cost is estimated at 239.8 million USD including costs for engineering services, administration, environmental monitoring, land acquisition, compensation and physical contingency. The tentative construction schedule is 45 months from 2001 to 2005.

The basic case for the Project has an EIRR of 13.5%. In addition to being economically viable, this case is both technically and environmentally sound. It is expected that the Project can be profitable with favorable financing conditions and government subsidies. It is recommended to select a long-term loan with generous financing conditions concerning the interest rate, grace period, repayment period, and applicable work items.

As a part of the technology transfer, a seminar and a video presentation was conducted. The seminar was conducted at the PMU My Thuan office on 21 January 1998, for the Vietnamese personnel involved in the Study. Topics of technology transfer at the seminar were, "Advanced Technology for Bridge Construction in Japan" and "Construction Methods for Deep Bridge Foundation". At a late stage, the Study Team produced a video movie that contains the highlights of the respective activities of the Study Team as well as the study conclusion, and this video was presented on 9 July 1998 at the occasion of submission and discussion of the Draft Final Report.

In conclusion, the Study Team found that the construction of the Can Tho Bridge is technically and economically feasible under proper financing, and accordingly recommends that it should be immediately implemented.

Project Outline

1. Bridge Location : 2.9 km downstream from the existing ferry line
2. Bridges Feature
   1) Total Bridge Length: 2,615 m
      - Main span bridge: 1,040 m
      - Vinh Long side approach span bridge: 350 m
      - Can Tho side approach span bridge: 1,225 m*

      *: inclusive 175 m of the substream bridge
   2) Bridge Width:22.1 m (4-lane carriageway)
   3) Main Span Bridge
      - Superstructure Type: Hybrid (Steel and Prestressed Concrete) Cable-Stayed Girder
        70 m+200 m+500 m+200 m+70 m = 1,040 m
      - Foundation Type: Reinforced Concrete Open Caisson
        Cast-in-place RC Pile, Steel Pipe Pile
   4) Approach Span Bridge
      a) Vinh Long Side
      - Superstructure Type: Prestressed Concrete Box Girder
        7 @ 50.0 m = 350 m
      - Foundation Type: Cast-in-place RC Pile

      b) Can Tho Side
      - Superstructure Type: Prestressed Concrete Box Girder
        18 @ 50 m = 900 m
        Prestressed Concrete Cantilever Box
        50 m + 75 m + 50 m = 175 m
        Prestressed Concrete Box Girder
        3 @ 50 = 150 m
        Total 1,225 m
      - Foundation: Cast-in-place RC Pile, Steel Pipe Pile

3.	Approach Roads		
	- Total Length	:	11,907 m
			Vinh Long Side 4,990 m
			Can Tho Side 6,917 m
4.	Intersections		
	1) Vinh Long Side	:	Double-Y-shaped type (Grade Separation)
	2) Can Tho Side	:	T-shaped type (At-grade)
	3) Roundabout	:	Rotary type
5.	Service Area	:	Vinh Long Side: 15,000m2
			Can Tho Side: 15,000m2
6.	Project Cost	:	239,820.57 thousand USD
7.	Economic Feasibility	:	EIRR = 13.5 %
8.	Financial Viability	:	FIRR = 7.6% (Full Cost Recovery)
			* Loan Condition (Long-term):
			interest rate: 1.8%
			loan portion: 85% of the Project Cost
			Toll Charge Level: at 1.5 times of Can Tho Ferry charge level
9.	Construction Period	:	45 months
10.	EIA	:	Socio-economic environmental countermeasure
			- Resettlement Area
			- Service Area
			Environmental countermeasure for ecosystem
			- Environmental Monitoring Programs

CHAPTER 1 INTRODUCTION

1.1 Background

N.H. No. 1 is an arterial road running about 2,300 km through Viet Nam from the border with China in the north to Namcan in the south. The rehabilitation and improvement of N.H. No. 1 is the top priority project in the infrastructure development strategy of Viet Nam to the year 2010. At present, WB and ADB are providing funds for rehabilitation and improvement projects to this road and OECF is funding bridge improvement and reconstruction projects. There still remain two unsolved large river-crossings in the southern section of N.H. No. 1, namely, My Thuan crossing the Tien River and Can Tho crossing the Hau River. The My Thuan Bridge construction was commenced in the middle of 1997, funded mainly by grant aid from Australia.

For the realization of a continuous N.H. No. 1 before 2010 as in the Transport Development Strategy and to meet the transportion demand for promoting socio-economic development in the Cuulong (Mekong) Delta and Indochina, it is necessary to conduct the Feasibility Study on the Can Tho Bridge. Consequently, the Government of the Socialist Republic of Viet Nam ("the Government of Viet Nam") made a request for the Feasibility Study on the Can Tho Bridge Construction on December 1996.

In response to the request of the Government of Viet Nam, the Government of Japan decided to implement the Feasibility Study on the Can Tho Bridge Construction in Socialist Republic of Viet Nam ("the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, Japan International Cooperation Agency ("JICA"), the official agency responsible for implementation of technical cooperation programs of the Government of Japan, undertook the Study, in close cooperation with the authorities concerned of the Government of Viet Nam. Project Management Unit My Thuan of the Ministry of Transport ("MOT") acted as the counterpart agency to the Japanese Study Team ("the Team") and also acted as the coordinating body with other relevant organizations for the smooth implementation of the Study on behalf of the Ministry of Transport of the Socialist Republic of Viet Nam.

1.2 Objectives of Study

The objectives of Study are:

1) To conduct the Feasibility Study of the project for the Can Tho Bridge construction including its approaches for the period up to the year 2010.

2) To transfer technology to the Vietnamese counterparts.

1.3 Scope of Study

The work of the Feasibility Study can be phased into four stages in Japan, including preparatory work, and three stages in Viet Nam. Fig. 1.1 shows the work flow of the studies.

I. 1st Year (1997 Fiscal Year)

[1] Preparatory Work in Japan

(1) Collection and Analysis of Relevant Data
(2) Study Policy, Methodology, Work Schedule, etc.
(3) Preparation of Inception Report

[2] 1st Stage Work in Viet Nam

(1) Submission and Discussion of Inception Report
(2) Review of Existing Relevant Data
(3) Collection and Analysis of Relevant Data
(4) Traffic Survey and Analysis
(5) Forecast of Future Traffic Demand
(6) Setting up Alternative Routes
(7) Natural Condition Surveys
(8) Initial Environmental Examination (IEE)
(9) Setting up Design Criteria
(10) Preparation of Progress Report (I)
(11) Submission and Discussion of Progress Report (I)

[3] 1st Stage Work in Japan

(1) Study of Alternative Routes, based on traffic demand and natural data collected in Viet Nam

(2) Preliminary Cost Estimate for Each Alternative Route
(3) Preliminary Economic Analysis
(4) Selection of Optimum Route and Bridge Type
(5) Preparation of Interim Report

[4] 2nd Stage Work in Viet Nam

(1) Submission and Discussion of Interim Report
(2) Additional Natural Condition Survey
(3) Preliminary Design
(4) Construction Planning
(5) Maintenance Programming
(6) Cost Estimate
(7) Environmental Impact Assessment (EIA)
(8) Preparation of Progress Report (II)
(9) Submission and Discussion of Progress Report (II)

II. 2nd Year (1998 Fiscal Year)

[5] 2nd Stage Work in Japan

(1) Economic Analysis
(2) Financial Analysis
(3) Implementation Programme
(4) Comprehensive Evaluation and Recommendations
(5) Preparation of Video-Tape for Draft Final Report
(6) Preparation of Draft Final Report

[6] 3rd Stage Work in Viet Nam

(1) Submission and Discussion of Draft Final Report

[7] 3rd Stage Work in Japan

(1) Preparation and Submission of Final Report

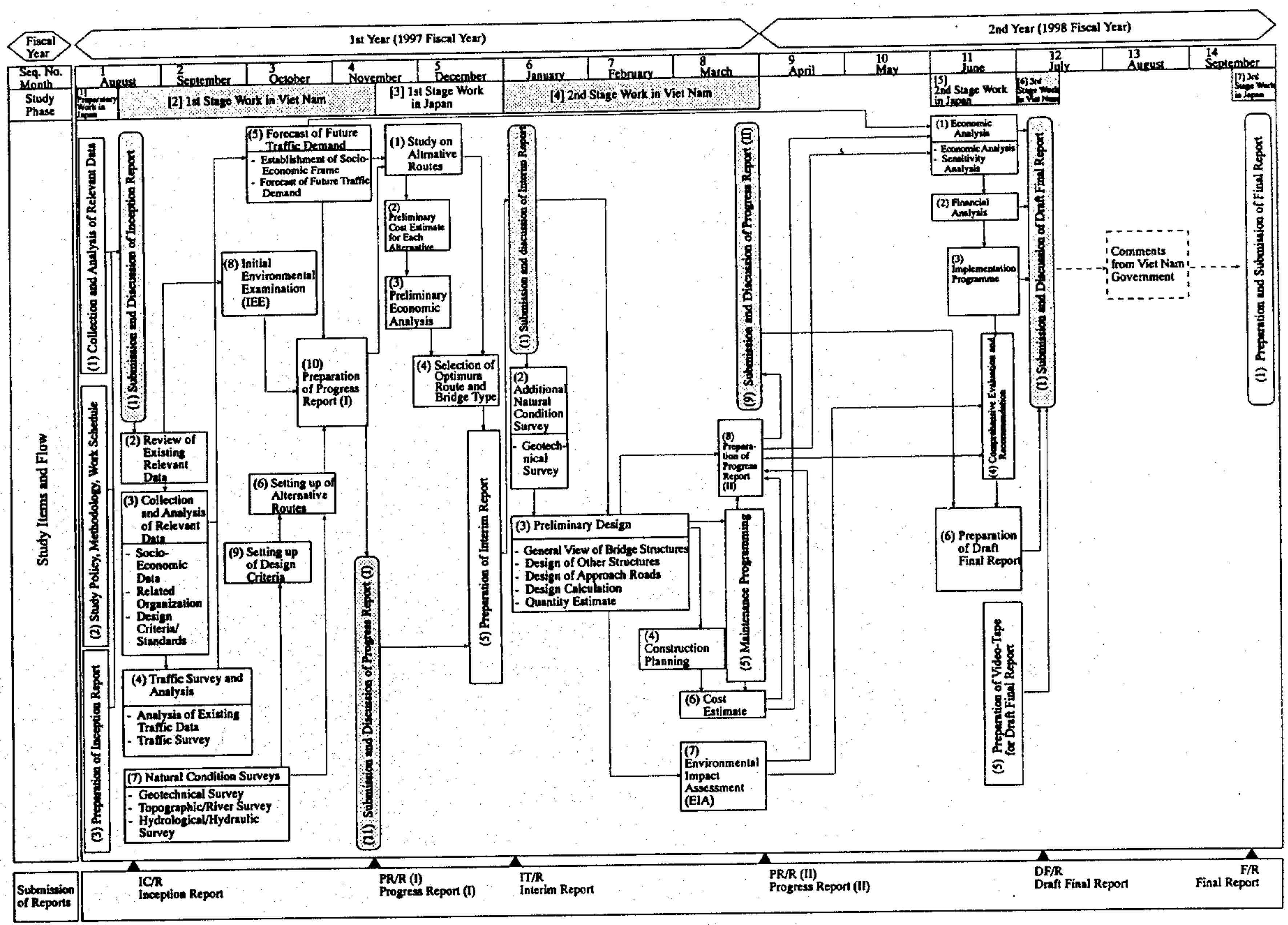


Fig. 1.1 Work Flow Chart of the Studies

CHAPTER 2 STUDY AREA

2.1 Natural Conditions

(1) Location

Total land area of Viet Nam is 325,490 sq. km, out of which 75% is mountainous. Lowlands are relatively few, and highly distributed in the Mekong Delta in the southwest of the country.

Can Tho Province is situated in the central part of the Mekong Delta. This is an extremely flat area, where the elevation typically ranges only between 2 to 3 meters. Soil in this area is alluvial mostly washed and deposited from the Hau River during the flooding season. The total area of the Province is about 2,970 sq. km, out of which 83% is agricultural land. Forest areas are only 1% of the total surface area.

(2) Climate

The climate of Can Tho follows the typical monsoon weather pattern. Humid seasonal wind from the southwest prevails from May to October, and dry wind from the northeast prevails from November to March. These two seasons show a very distinguishable rainy season, which is associated with heavy inundation. Data acquired from the Can Tho Observation Center has been analyzed, and the general weather patterns are summarized below;

a) Temperature and Humidity

The annual average temperature of the area is 26.7°C, with a maximum of 36.5°C and a minimum of 17.7°C. The temperature difference between wet season and dry season is quite small. The humidity stands at 87% in the wet season and 77% during the dry season.

b) Rainfall

The weather pattern of Can Tho can be distinguished into two seasons; wet and dry. The wet season which prevails from May to November is characterized by representing 90% of the annual precipitation and 15-20 rainy days per month.

c) Wind

The characteristics of wind data in Can Tho is that the wind speed is around 2.5 ~ 3.5m/s due to influence of southwest monsoon during the wet season from June to September. Therefore, a strong southwest wind prevails in this season.

2.2 Transport System

(1) Roads

The total length of the road network in the Mekong Delta is about 30,000 km. These roads are classified into national roads, provincial roads, and rural or feeder roads. Provincial and rural or feeder roads connect provincial capitals with district towns, or link the district town to the national roads. Judging from the current road network density of 0.77 km per sq. km., the road network is well spread over the delta.

According to the traffic counts conducted under this Study, the majority of vehicular traffic crossing the Hau Giang via the Can Tho Ferry consists of non-motorized vehicles and motorcycles, with vehicular volumes of 2,339 veh./day and 4,416 veh./day, respectively. By contrast, vehicular river crossing volumes of sedans, minibuses/buses, and trucks at this location were relatively small, showing 623 veh./day, 565 veh./day, and 724 veh./day, respectively.

(2) Inland waterways

There are many canals, waterways, and rivers in the delta. According to the Transport Infrastructure Survey in 1994, the navigable length is about 2,700 km out of 5,000 km of waterways. The density of the waterway network is 0.68 km per sq. km. Waterways are still functioning as a major means of transportation for economic and inhabitants' daily activities, due to the flooding in the rainy season which is linked to the traditional farming system in the delta.

(3) Ports

The Can Tho port has been constructed with the status of an international port, and it can accommodate 5,000 DWT capacity vessels and handle some 300,000 tons per year. However, only fully loaded

3,000 DWT vessels can reach the port due to the shallow depth at Dinh An mouth. Larger vessels have to wait at low tide.

(4) Transport Pattern

Transport modes in the Mekong Delta are inland waterways, roads, sea, and air. The Railway has suspended its operations. Roads serve as the major passenger transport means, and inland waterways serve as the major freight transport means.

The main commodity types of long distance freight transport are agricultural products and processed agricultural foods to other regions or foreign countries, and goods for livelihood, chemical fertilizer, and construction materials from other regions to the delta.

Rice and construction materials dominate the cargo transport by inland waterways. Although roads and waterways compete with each other for the transport of agricultural products, an informal supplementary cooperation system throughout the year can be observed in the delta.

2.3 Socio-economic Situation

(1) Population

The population in the delta was 16.2 million in 1995, and the overall population growth rate between 1991 and 1995 was around 2.1% p.a.

The Mekong Delta with an area of 39,600 sq.km covers about 12% of the country's total area, and had a population density of 409 pers./sq.km in 1995. The delta is scarcely urbanized, with only 15% of the population classified as urban population.

(2) Economic Activities

Viet Nam has been traditionally regarded as an agrarian country, with 70% of the labor force working in agricultural sector. In the Mekong Delta, cultivable areas cover 64% of the delta and forests cover only 5-6%. The cropped area is mostly used for paddy production. It provides 10 to 13 million tons of paddy or nearly 50% of the national paddy production. The region has contributed to the national economy by exporting surplus rice and processed fishery products. Although the agricultural sector continues to grow, the industrial and service sectors have grown faster to contribute to recent remarkable economic growth.

The GDRP growth rate in the Mekong Delta in 1989 constant price terms between 1991 and 1995 was 10.2% p.a., which surpassed the national GDP growth rate of 8.8% p.a. Growth in the delta has been confined to the primary sector output and agro-industry and has been accelerated by domestic and international trade.

(3) Financial Situation

In the 1990s a series of new taxes were introduced in Viet Nam, and the reformed taxation system has been successful at raising revenue. The budget deficit has been kept small at below 2% of GDRP. In Viet Nam the transport sector has suffered from underfunding and disinvestment. For instance only one fourth of necessary road maintenance expenditures can be funded each year.

CHAPTER 3 ALTERNATIVE ROUTES

At present, N.H. No.1, connecting with Vinh Long Province on the left bank of the Hau River and Ca Mau in the southern part of Viet Nam, crosses the river by ferry and runs from north to south through Can Tho City.

To replace the ferry, that is causing a bottleneck in the road traffic, with a bridge that crosses the river and allows a continuous road network, the following three alternative routes have been planned and examined:

- Alternative Route A: Crosses the river about 3.3 km upstream from the existing ferry.
- Alternative Route B: Crosses the river about 750 m downstream from the existing ferry.
- Alternative Route C: Crosses the river and goes through the sandbar about 2.9 km downstream from the existing ferry.

Basically, these routes branch off from N.H. No.1 and then join N.H. No.1 again. Characteristics of each route are:

- Route A: Crosses the Hau River, and joins N.H. No.91 and then N.H. No.1. Thus, Route A uses part of N.H. No.91 after crossing the river, consequently requiring many cases of resettlement along N.H. No.91 due to maintaining the road width for four lanes toward N.H. No.1.
- Route B: Crosses the Hau River, and goes into the Can Tho City urban area. For about 1.5 km from this point this route joins Nguyen Trai street and proceeds up to N.H. No.1. A new road needs to be constructed through a dense residential area, requiring many cases of resettlement.
- Route C: Requires minimum cases of resettlement and evades the maximum area of the ecosystem, having the functions of a bypass road smoothly branching off and joining N.H. No.1. Compared with Routes A and B mentioned above, Route C requires fewer cases of resettlement but goes through more soft ground zones, and requires about 1.5 to 2.2 times more

road extension. However, this route is far superior to the other two routes as (a) the bypass for Can Tho City as seen from the existing traffic network and (b) the approach to the Southern Industrial Zone that has been outlined in the City Master Plan.

- Depth of the Hau River:
  The maximum depth measurements of the Hau River, taken along the three routes mentioned above, were: -18 m for Route A, -25 m for Route B, and -16 m for Route C.

Furthermore, for each route as represented in Fig. 3.1 and Fig. 3.2, there are two or three options of which the alignment of approach roads are different without changing the location of the bridge over the Hau River.

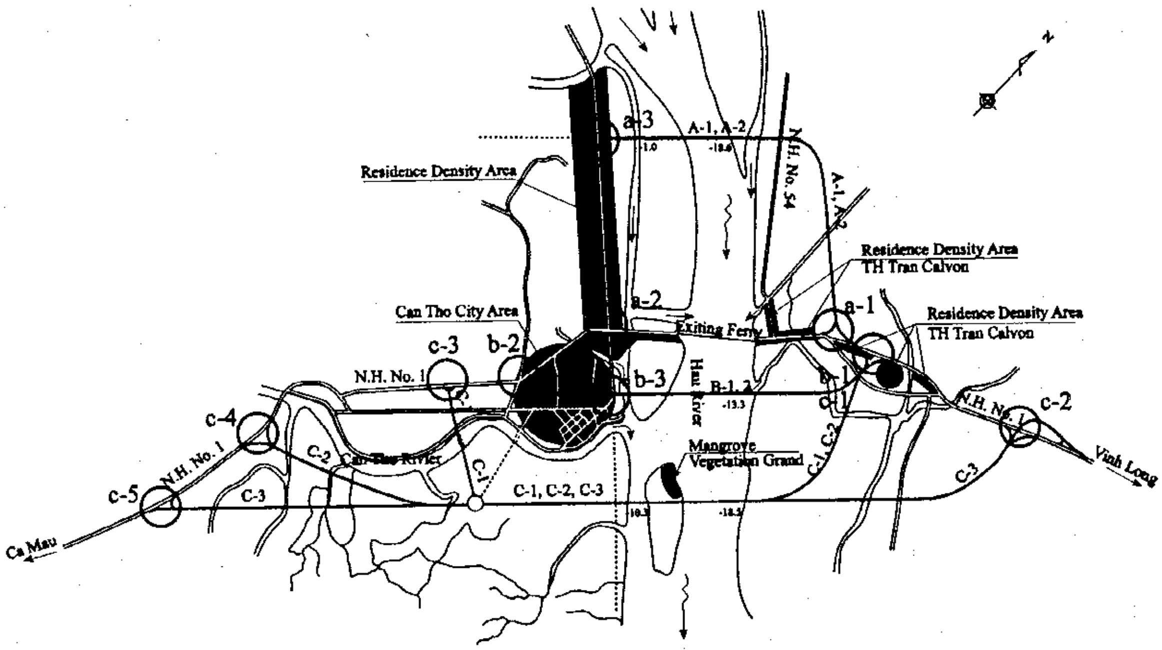


Fig. 3.1 General Alignment of Alternative Routes and Options

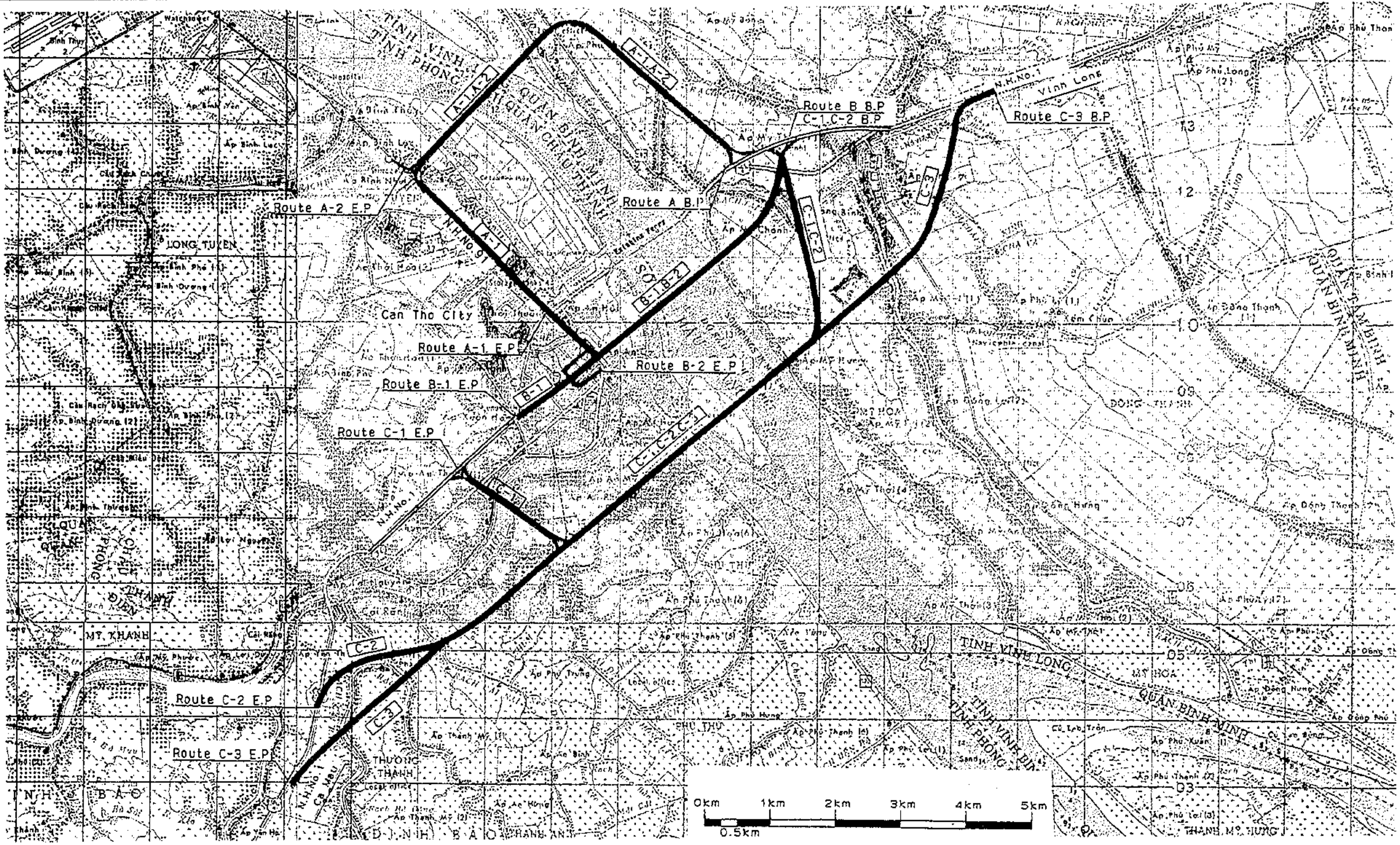


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Fig. 3.2 Alternative Routes and Options

JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 4 NATURAL CONDITIONS ON THE ALTERNATIVE ROUTES

4.1 Hydrological and Hydraulic Conditions

The hydrological and hydraulic conditions summarized below were considered for bridge planning, especially for determining the bridge opening and location of the central span of the main bridge. The flood water analysis was based on log-normal distribution, and a 100-year return period (1% frequency) flood and 20 year return-period (5% frequency) were used for the design flood water levels and critical water level of ship navigation, respectively.

Table 4.1 Flood Water Conditions at Can Tho Station

Flood Water	100 years	20 years	Max Actual-Record
High Water Level (cm)	212.40	208.60	209.00 (1989)
Discharge (m^3/sec)	30,999	28,204	27,900 (1991)

Table 4.2 Design Flood Water Level of Each Route

	Flood Water Level (cm)		
	100 years	20 years	Max Actual-Record
Route A	229.56	225.76	226.16
Route B	206.24	202.44	202.84
Route C	195.46	191.66	192.06

For all Figures, the basic level is the Mean Seawater Level (MSL).

The hydrological and hydraulic characteristics for each alternative route and their implications for bridge planning, especially for the main bridge, are presented below:

Route A:

The riverbed (max. 16 ~ 18 m deep) is shifting to the left bank, while the right bank has been eroding over the last 20 years (1973 to 1993). Due to the river's shifting, a bridge opening for the main span should not be less than 600 m.

Route B:

The riverbed (max. 18 ~ 25 m deep) tends to shift to the left bank similar to Route A. One special observation is the occurrence of the whirlpool on the left bank side, which is near the confluence point. Due to the riverbed shifting with deep water, a bridge opening for the main span should not be less than 600 m.

Route C:

The riverbed is comparatively shallow (max. 14 ~ 16 m deep), stable, and straight with a fast stream. Since the riverbed has been stable during the last 20 years according to Land-sat images, a bridge opening for the main span should be a minimum of 500 m.

Table 4.3 Hydrological and Hydraulic Conditions on Each Route

	Route A	Route B	Route C
a) Riverbed (water depth)	- Deep toward the left bank side (18 m) - Shallow part near the right bank side	- Deep toward the left bank side (25 m) - Shallow riverbed toward the right bank	- Comparatively shallow (15 m) - Wider riverbed with depth (15 m)
b) Water Flow Velocity	- Right bank side (0.724 m/s)	- Left bank side (1.181 m/s)	- Faster velocity (2.033 m/s) due to main channel discharge
c) Planform Change	- Shift of river bank to out corner (left) according to historical change of riverbed between 1973 to 1993	- Stable for planform change, however tendency of shift to left bank	- Sandbar occurrence from 1973 to 1993, possible inundation in a large flood on the sandbar
d) Special Observation	- Erosion at right bank	- Whirl pool toward the left bank side, immediately upstream of confluence point	- Low level of sandbar, 30% of total sandbar area of inundation in a large flood
e) Center Span Location of Main Bridge	- Left side and straddling deep water area	- Left side and straddling deep water area	- Comparatively left side subject to further hydrodynamic study
f) Bridge Opening of Main Bridge	- Due to river bank shift, not less than 600 m opening	- Due to river bank shift, not less than 600 m opening	- Not less than 500 m opening

4.2 Topographic Survey

The topographic survey was conducted covering the range from the connecting point with the N.H. No.1 on both sides of the Hau River (i.e. Vinh Long and Can Tho) for each of the Alternative Routes. The horizontal coordinates (X and Y) are based on GPS (Global Positioning System) from the satellite, while the elevations were obtained from the National Bench Mark System in Viet Nam. The survey consists mainly of the topographic survey, river cross-sectioned survey, and hydrological/ hydraulic surveys.

The following Vietnamese Standards were applied to the basic datums needed for the topographic surveys:

- Projection: Gauss-Kruiger Grid System
- Scale Factor: 1,000 for the central Meridian
- Ellipsoid: Krasopskian
- Vertical datum: Mean sea level at Hon Dau Island (National Bench Mark System)
- Horizontal datum: HN-1972 (National Bench Mark System)
- Central Meridian: The selected Central Meridian 105°00′00″

4.3 Geotechnical Survey

Twelve bore holes, 1150 meters long in total, have been drilled with standard penetration test (S.P.T). Actual boring locations and results are shown in the Annexure.

CHAPTER 5 FUTURE TRAFFIC DEMAND

The transport capacity of the existing river-crossing ferry is only designed to accommodate the present traffic volume; therefore, it is highly likely that future traffic demand at the ferry points will exceed the ferry capacity during peak periods. If additional ferry improvement projects are not carried out, traffic diversion from ferry points to other river-crossing ferries or a bridge will be needed. Future traffic volumes using a bridge were assumed to be influenced to some extent by the capacities of ferries at the other ferry terminals. For the estimates of ferry waiting times in the without bridge case, a simulation program was developed expressly for this study.

The conceptual forecast procedures are as follows:

- Development scenarios of economic growth in the Mekong Delta and the North East South Region are prepared for the initial base case;
- Normal and development traffic demand in the form of origin-destination (OD) matrices based on the estimated growth rates by zone and vehicle type are forecast for passenger traffic and freight traffic;
- Diverted traffic from other modes are then forecast for passenger traffic and freight traffic;
- Basic traffic matrices are forecast by summing the normal and development traffic OD matrices and the diverted traffic OD matrices;
- The reduction of travel time between cases with and without a Hau Giang Bridge are estimated, and induced traffic in the future is forecast by applying elasticities with respect to 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 volumes at bridge and ferry points are then forecast by assigning the traffic OD matrices by vehicle type to the various networks (without bridge, and with bridge Alternative Routes A, B, and C).

This method enabled the accurate tracking and reporting of traffic assignments and related statistics (e.g., vehicle-minutes, vehicle-kilometers) by vehicle type.

The assignment results for Route C for 2006, 2010, and 2020 are summarized in Table 5.1. The assignment results for the other "with Bridge" Alternatives Route A and Route B revealed that forecast traffic volumes of those alternatives would be slightly higher than that of Alternative C. All three alternatives attract 29-34% more traffic than the "No Bridge" scenario.

Table 5.1 Traffic Assignment Results at the Hau River Crossing near Can Tho

Description	2006		2010		2020	
	No Bridge	Alternative C Bridge	No Bridge	Alternative C Bridge	No Bridge	Alternative C Bridge
Total Traffic in Vehicles / Day						
Motorcycle	9,585	15,165	14,125	22,281	31,877	49,612
Passenger Car	2,083	2,777	3,846	5,139	10,471	13,965
Light Bus	1,038	1,267	1,676	2,051	3,612	4,420
Heavy Bus	475	566	750	898	1,532	1,834
Light Truck	738	918	1,332	1,721	3,835	4,958
Medium Truck	1,853	2,201	3,484	4,175	10,006	11,978
Heavy Truck	74	185	138	397	396	1,053
PCU/Day	13,015	17,134	22,359	29,629	57,213	75,262

Note: PCU = Passenger Car Unit

A two-lane bridge for all three alternatives will reach capacity in year 2011 (5 years after opening in 2006). This assumes that the capacity for a two-lane facility can be approximated at 20,000 pcu/day (according to common accepted practice). The capacity for a four-lane facility (two lanes in each direction) is approximated at 60,000 pcu/day. Therefore, construction of a four-lane bridge would be more appropriate.

CHAPTER 6 INITIAL ENVIRONMENTAL EXAMINATION (IEE)

One of main purposes of the Initial Environmental Examination (IEE) was to establish environmental criteria for selection of the optimum alternative route. Each environmental characteristic of the three alternative routes was examined based on existing data, maps, and additional reconnaissance field surveys. For each alternative route, the proposed compensation costs for land acquisition were also estimated, and considered in the process for selection of the optimum alternative route.

Since all three alternative routes pass through an area with the same geomorphological characteristics, there is little difference in the impacts on the natural environment (such as air quality, water environment, ecological environment, etc.) among the three. However, depending on whether the proposed route passes through a densely populated area, the impacts on the socio-economic environment, such as the number of affected population and possibility of regional development, vary significantly.

Based on a comparison of environmental impacts among the three routes, alternative Route C is associated with the greatest positive impact on regional development. In fact, this Route was recommended by the People's Committee of Vinh Long Province and the People's Committee of Can Tho Province due to the fact that it is consistent with these two provinces' economic development plans which aim to develop Binh Minh District and Con Au Island as gardening-tourism areas.

In terms of their socio-economic impact, Routes A and B are not seen as appropriate alternatives because the construction of approach roads for these routes may adversely affect a great number of residents in the urban area of Can Tho City. The required cost for compensation of dwellings in these two cases would be significantly higher than for Alternative Route C.

Furthermore, since the area where Alternative Route C passes through contains mainly rice fields or fruit tree crop lands, this route is seen as the most favorable alternative in terms of impact on the socio-economic environment. Compared to Alternative Routes A and B, Alternative Route C involves the fewest number of residents who may be affected by degrading air quality, noise, traffic accidents, and other negative impacts caused by the forecast traffic volumes, and these adverse impacts can be better controlled for Alternative Route C by appropriate environmental impact mitigation plans.

In addition, Alternative Route C is seen to be the most appropriate route with respect to available land for construction sites, encampments for construction workers, houses for resettled residents, markets service areas for shopkeepers or peddlers and other residents who may lose their main sources of income from business activities at the existing ferry crossing.

CHAPTER 7 PRELIMINARY ECONOMIC EVALUATION

(1) Conditions for Preliminary Economic Evaluation

The main objective of the preliminary economic evaluation is to ascertain information on the viability of alternatives and to provide information on the relative supremacy of alternatives from an economic viewpoint. The basic conditions for the preliminary economic evaluation are:

a) Base year

The beginning year of the project, 1999, was set as the base year for the economic evaluation.

b) Evaluation period

Because of the severe budgetary constraints in Viet Nam, it is not likely that many large bridges project will be implemented in Viet Nam. Therefore, the project life in the economic evaluation should be long; a 50-year period after opening was assumed as the evaluation period.

c) Evaluation indicator

As evaluation indicators, the economic internal rates of return (EIRRs) were calculated for the evaluation period.

(2) Preliminary Calculation of the Economic and Project Costs

For the purpose of the preliminary economic evaluation, the Economic cost and Project Cost were preliminarily calculated. The composition of each is summarized in the following table:

Table 7.1 Composition of the Preliminary Economic Cost and Project Cost

Component	Economic Cost	Project Cost
1) Construction Cost (Direct / Indirect Cost) for: - Mobilization & Demobilization - Approach Roads, - Main & Approach Span Bridges	E(= 80% of P)	P
2) Engineering & Administration Cost	E(= 100% of P)	P
3) Land Acquisition	-	P
4) Compensation	-	P
5) Contingency	E*	P
6) Maintenance Cost	0.1% of 1) / year	-

E: Figures for Economic Cost
P: Figures for Project Cost
*: E = { 1) of P x 80% + 2) of P x 100% } x 5%

(3) Evaluation Results

The economic internal rates of return (EIRRs) of the alternatives are between 9.3 - 10.5%. Alternative C-1 shows the highest EIRR, followed by C-2, A-2, C-3, and A-1. Comparing the EIRRs of the alternatives routes, Alternative C-1 with the lower project cost has a relative advantage and shows the highest EIRR. Similarly alternatives with lower project costs at each river crossing point show relatively higher EIRRs. Of these alternatives, only C-1 and C-2 had positive Net Present Values and Benefit Cost Ratios over 1.0 at a discount rate of 8 percent (Table 7.2).

Table 7.2 Results of Preliminary Economic Evaluation for Alternative Routes

	A-1	A-2	B-1	B-2	C-1	C-2	C-3	C-2/3
EIRR	9.7%	9.8%	9.3%	9.4%	10.5%	10.4%	9.8%	9.9%

CHAPTER 8 SELECTION OF SUITABLE ALTERNATIVE ROUTE

The most desirable alternative route for the Can Tho Bridge construction should be selected considering the engineering, economic and environmental aspects of the Project. Table 8.1 summarizes the evaluation of the alternative routes including their options.

Route C is recommended as the most suitable route for the following reasons:

- Economically advantageous, i.e. the economic indicator (EIRR) is 9.8 ~ 10.5%.
- Less problems with the hydrological and hydraulic conditions of the river
- Less compensation for resettlement of houses and land acquisition
- Less influence on the stability of the ecosystems

Option C-1 is economically advantageous because the economic indicator (EIRR) is the highest (10.5%) among the group of options for Route C. However, the alignment is not smooth, compared with other options.

In terms of less compensation on land acquisition and resettlement of houses, and considering of traffic congestion and alignment, C-2/3 is recommended as a most suitable route with only a small difference of economic indicators compared with that of Route C-1.

Table 8.1 Evaluation by Alternative Route and Option

Description		Alternative Routes and Option							
		A-1	A-2	B-1	B-2	C-1	C-2	C-3	C-2/3
Outline of Each Route	Location	From N.H. No.1 connects to N.H. No.91	From N.H. No.1 joins N.H. No.91 and then connects to N.H.No.1	From N.H. No.1 to Can Tho city Street	From N.H. No.1 to Can Tho city street and then onto N.H. No.1	From N.H. No.1 to N.H. No.1 crossing Can Tho River with the shortest distance of Route C	From N.H. No.1 to N.H. No.1 after across the existing Can Tho River bridge	From N.H. No.1 to N.H. No.1 with longest distance of approach road of Route C	From N.H. No.1 to N.H. No.1 with same route with C-3 on the Vinh Long side, with C-2 on the Can Tho side
	Approach Road Length: Vinh Long	4,900	4,900	2,000	2,000	3,280	3,280	5,580	5,580
	Approach Road Length: Can Tho	3,000	2,500	1,970	894	4,110	6,260	7,260	6,260
	Bridge Length (m)	2,600	2,600	2,410	2,410	2,660	2,660	2,660	2,660
	Total Length (m)	10,500	7,500	6,380	5,304	10,050	12,200	15,500	14,500
	Bridge Type of Main span	- Hybrid Cable Stayed - Steel Cable Stayed - Suspension Bridge		- Hybrid Cable Stayed - Steel Cable Stayed - Suspension Bridge		- Hybrid Cable Stayed - Steel Cable Stayed - Suspension Bridge			
Evaluation	a) Hydrological Aspect (River Flow)	- Due to simuosity, shift to out side and deep left side - Erosion of river bank		- Comparatively stable but deep left side - Occurrence of whirlpool		- Comparatively shallow but high velocity - Possible inundation on the sand bar			
	b) Degree of Function of Route	- Advantage to the north direction	- Long distance diversion from / to N.H.. No.1	- Disadvantage to pass Can Tho city area	- Advantage to access to the Can Tho city area	- Advantage to access to the Can Tho city area	- Advantage without construction of bridge	- Advantage for connecting N.H. No.1 with better alignment	- Both advantage of C-2 and C-3
	c) Traffic Congestion of city Area	- Traffic congestion due to passing city area of Can Tho along N.H. No.91	- Traffic congestion to the central part of Can Tho city	- Very traffic congestion in Can Tho city	- Very traffic congestion in Can Tho city	- Comparatively traffic congestion in Can Tho city	- Less traffic congestion of the city area	- Less traffic congestion of the city area	- Less traffic congestion of the city area
	d) Consistency to Future Plans	- Fair	- Good	- Good	- Good	- Good	- Fair	- Fair	- Fair
	e) Impact on Ecology	- Serious	- Serious	- Comparatively less	- Comparatively less	- Comparatively less	- Comparatively less	- Serious	- Comparatively less
	f) Land Acquisition and Compensation	- Comparatively less	- Serious	- Serious	- Serious	- Comparatively less	- Comparatively less	- Serious	- Comparatively less
	g) Bridge Engineering Aspect	- Longer center span length for main bridge (more than 600m) due to river condition		- Longer center span length for main bridge (more than 600m) due to river condition		- Comparatively shorter span length for main bridge (approximately 500m)			
	h) Preliminary EIRR	9.7%	9.8%	9.3%	9.4%	10.5%	10.4%	9.8%	9.9%
	i) Overall Evaluation	-	-	-	-				To be recommended

EIRR: Economic Internal Rate of Return

Mark by Rating for Evaluation	
-	Excellent
O	Good
Δ	Fair
×	Bad

	A-1	A-2	B-1	B-2	C-1	C-2	C-3	C-2/3
a) Hydrological	×	×	×	×	O	O	O	O
b) Degree of function	Δ	×	×	O	O	O	O	O
c) Traffic congestion	×	Δ	×	×	Δ	O	O	O
d) Future plan	Δ	O	O	O	O	Δ	Δ	O
e) Impact to ecology	×	×	Δ	Δ	Δ	Δ	×	Δ
f) Land acquisition	Δ	×	×	×	Δ	Δ	×	Δ
g) Bridge engineering	Δ	Δ	Δ	Δ	O	O	O	O
h) Preliminary EIRR	Δ	Δ	Δ	Δ	O	O	O	O
Evaluation	Δ	×	×	Δ	O	O	O	-

CHAPTER 9 SELECTION OF APPROPRIATE BRIDGE TYPES

9.1 Appropriate Bridge Type for Main Bridge

Based on the river characteristics for each route, such as river bank erosion, river bed change, deep scouring, etc, the following bridge types were considered for an initial evaluation.

1) Alternative Route (A)
   - Required center span length approx. 600m
     a) Steel Cable-Stayed 550m
     b) Steel Cable-Stayed 600m
     c) Suspension Bridge 700m

2) Alternative Route (B)
   - Required center span length approx. 600m
     a) Steel Cable-Stayed 550m
     b) Steel Cable-Stayed 600m
     c) Suspension Bridge 700m

3) Alternative Route (C)
   - Required center span length approx. 500m
     a) Hybrid Cable-Stayed 500m
     b) Steel Cable-Stayed 500m
     c) Steel Cable-Stayed 550m

Table 9.1 Cost Ratio of Alternative Bridge Type for Each Route

	Alternative (A)			Alternative (B)			Alternative (C)		
Options	a)	b)	c)	a)	b)	c)	a)	b)	c)
Construction Cost Ratio	1.17	1.20	1.79	1.29	1.35	1.76	1.00	1.15	1.23

Construction cost ratios for the superstructure are shown in Table 9.1 based on 1.00 for Hybrid Cable-Stayed including main bridge and approach bridge portions.

A Hybrid Cable-stayed bridge for the main span is recommended for the following reasons:

- The Hybrid (steel and concrete) bridge types can maximize the use of construction materials locally procured, which in turn can economize the bridge construction cost compared with an all steel bridge type.
- The longer span of the Hybrid Cable-stayed bridge type can minimize the number of piers (which may increase the cost of foundations which have to penetrate into the bearing stratum of 90 m to 95 m deep).
- The Hybrid Cable-stayed bridge type can be applicable to longer spans, that means, it is able to be free from the hydrological and hydraulic problems such as river bank erosion, local scouring around piers, required horizontal navigational clearance, and can minimize the girder depth for the higher vertical navigational clearance (39.0 m).
- The cable-stayed bridge with a partial concrete structure (hybrid system) can be advantageous in the case of aerodynamic stability.
- The towers and cables can provide symbolic, landmark and rhythmic views, which is excellent from the aesthetic aspect.

9.2 Appropriate Bridge Type for Approach Span Bridges

Balanced-cantilever PC Box type and PC-Box Girder types are recommended for the approach span bridges.

Balanced-cantilever PC Box type is appropriate and economic bridge type for the river branch, considering the required navigational clearance.

PC-Box Girder types are recommendable for the other approach span bridges as it is economic, conventional, and locally familiar type of superstructure.

9.3 Appropriate Foundation Type

The following five foundation types are applicable for the foundations of the main and approach bridges for the Can Tho Bridge Construction from both the technical and economic viewpoints.

1) Cast-in-place Concrete Pile
2) Steel Pipe Pile
3) Open Caisson

4) Pneumatic Caisson
5) Cast-in-situ Diaphragm Wall

From the subsoil conditions and easier methods of construction, the following types of foundations were proposed:

Main Bridge		
- Tower for Hybrid Cable Stayed Bridge:	- Open Caisson	(ϕ10.0m)
	(Using a jack down force method)	
- Piers for Side Span:	- Cast in place concrete piles	(ϕ2.0m)
	- Driven steel pipe pile	(ϕ2.0~2.5m)
Approach Span Bridge:	- Cast in place concrete piles	(ϕ2.0m)
	- Driven steel pipe pile	(ϕ2.0~2.5m)

CHAPTER 10 PRELIMINARY DESIGN

10.1 Navigational Clearance

To establish the navigational clearance, the following items were reviewed and assessed:

- Existing Data and Previous Surveys
- Navigational Condition of the Hau (Bassac) River
- Assessment on the vertical navigational clearance for several cases

(1) 1st Stage

During the first stage of works, it was decided that the navigational (vertical) clearance to be considered for the Feasibility Study on the Can Tho Bridge Construction should be the same as that for the My Thuan Bridge (37.5 m corresponding to a vessel size of 10,000 DWT).

(2) 2nd Stage

In accordance with the Steering Committee Meeting held on 27 March 1998 in Ho Chi Minh City, a vertical navigational clearance of 39.0 m for a vessel size of 15,000 DWT above the flood water level at 5% frequency was adopted for the preliminary design. For the horizontal navigational clearance, 300m was adopted.

This clearance satisfied the comments on the document sent by the Mekong River Commission of Viet Nam on 8 April 1998, and was identified as the final design condition for the Feasibility Study in the Steering Committee Meeting held on 9 July 1998 in Hanoi.

10.2 Design Criteria and Standards

In order to select the route alignment and bridge structures, and to conduct preliminary design, the design criteria was set up, referring to the detailed design of the My Thuan Bridge which is also located on National Highway No.1 and next to the Can Tho Bridge, of which design has been recently accomplished.

(1) Standards and Specifications

AASHTO Specifications are to be the primary standards for the design, and the Vietnamese and Japanese standards are to be used for the proof check.

- Standard Specifications for Highway Bridges, Sixteen Edition 1996 adopted and published by AASHTO (American Association of State Highway and Transportation Officials)
- AASHTO LRFD Bridge Design Specifications, First Edition 1994 published by AASHTO
- Highway design standards (TCVN-4054-85), Viet Nam
- Japanese Highway and Bridge Standards
- Other related standards and specifications

(2) Design Loads

The Vietnamese Bridge Design Code (Specifications 2057/QD-KT4-1979) was used together with AASHTO specifications.

(3) Design Speed

The Can Tho Bridge is situated on the road section of N.H. No. 1 that is a Class-I road; it was advised to adopt the design speed of 80 km/hr.

10.3 Gradient for Approach Portion

Considering the vehicle operating condition and the construction cost, comparison of the gradient in conjunction with the critical length of gradient was studied between 4.5% and 5%. As a consequence, a maximum grade of 5% was adopted throughout the alignment, and a 4.5% grade was adopted as a maximum for the main bridge portion.

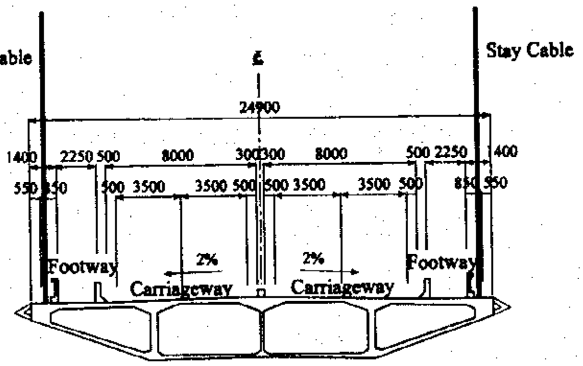
10.4 Typical Cross Section

(1) Geometrical Design Condition

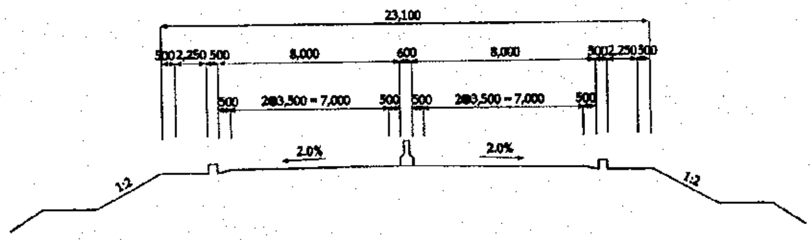
At present, there are two standards available for designing a national highway in Viet Nam:

a) Geometric Design Standard, issued in October 1995
b) Highway Design Standard (TCVN 4054-85), translation, issued in July 1990

The typical transverse cross-section was determined based on the Vietnamese Standard in consideration of the future traffic demand, traffic system, structural requirements, and economic viewpoint. The following transverse cross-sections for bridge and road (Fig. 10.1) was adopted for the Can Tho Bridge Construction.



(Bridge)



(Approach Road)

Fig. 10.1 Typical Cross-section

10.5 Embankment Height

The limitation, i.e., location of the abutment (approach bridge end) or the beginning of the embankment (highest point of approach road embankment), is at the point where the height of approach road embankment from the ground becomes 7.0m for economical optimization.

10.6 Type of Intersection

The following intersection types were recommended considering the future traffic demand, site topography, and the road network arrangement in future master plans.

- At-grade Intersection

  At-grade intersection (channelized Y-shaped) at the beginning point of Vinh Long side

- Rotary Intersection

  At the intersection point between the approach road and the future road relating to the Can Tho Master Plan

- At-grade Intersection

  At grade intersection (channelized Y-shaped) at the end point of Can Tho side

10.7 Preliminary Design

The project location and the general view of the Can Tho Bridge are shown in Fig. 10.2 and Fig. 10.3.

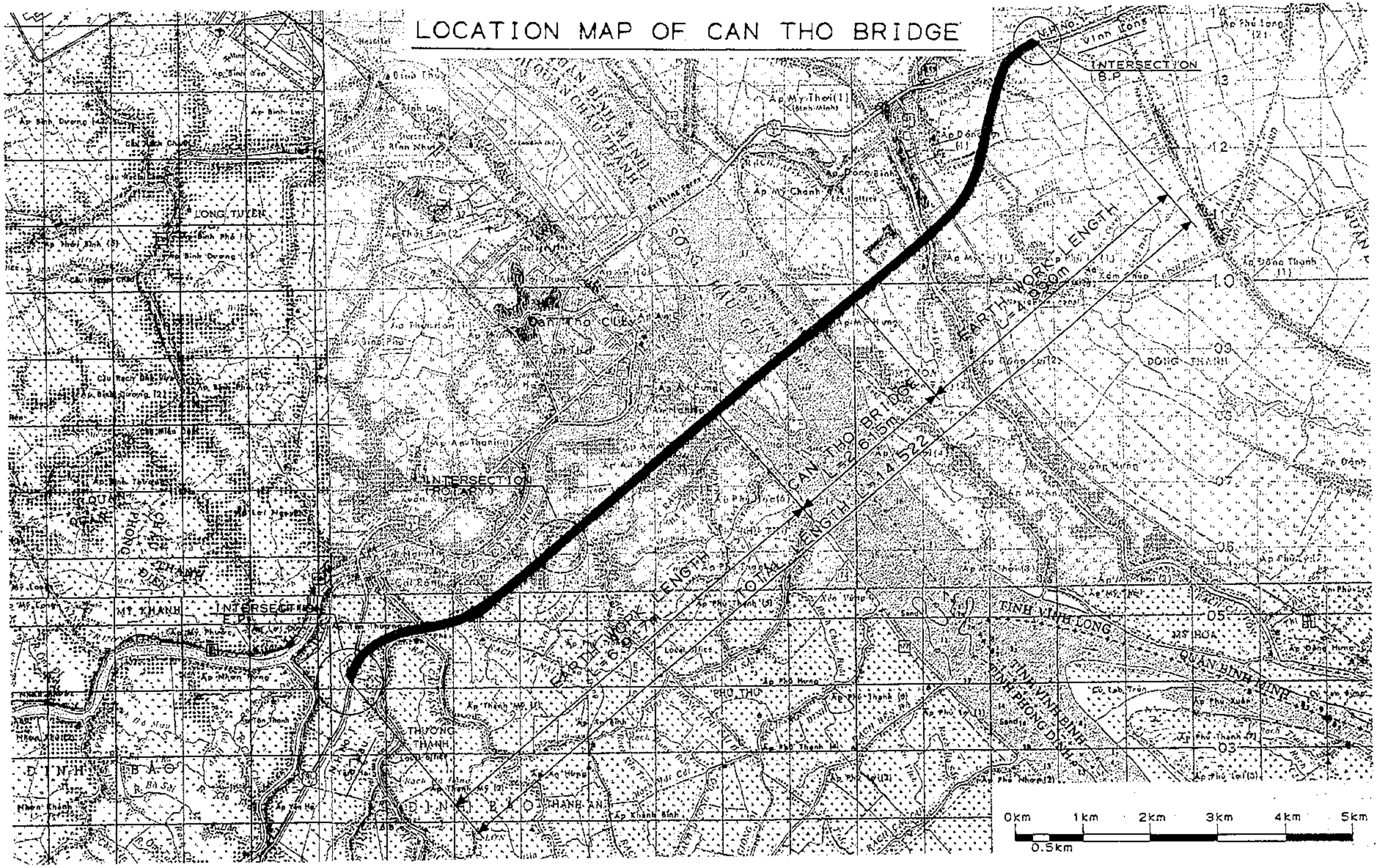


Fig. 10.2 Location Map of Can Tho Bridge

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THE FEASIBILITY STUDY ON
THE CAN THO BRIDGE CONSTRUCTION
IN SOCIALIST REPUBLIC OF VIET NAM