6.4.5 Design Flood

A frequency analysis was carried out using flow discharge and water level data, then estimation was made of the design flood and high water level (being necessary for the bridge scale analysis - horizontal and vertical clearance, position of pier, and bridge side space).

The design flood water and high water level was calculated by two methods; Log-normal Distribution Method and the Hazen Plot Method. The volume of the design flood water was then decided in conjunction with the results of the pre F/S analysis. (see Table 6.6)

Table 6.6 Design Flood of Can Tho Station

Return Year / P % / Factor	100 / 1	50 / 2	20 / 5	10 / 10	5 / 20	2 / 50	Max.-Actual Record / Year
H-Water E.L. (cm)							
Log-normal Distribution	212.40	210.87	208.60	206.60	204.20	199.69	209
Hazen Plot	211.67	209.67	207.68	205.68	203.68	199.69	*1989*
Pre F/S	211.55	210.28	208.34	206.57	204.36	199.95	
Discharge (m^3/s)							
Log-normal Distribution	30,999	29,849	28,204	26,819	25,232	22,453	27,900
Hazen Plot	31,435	30,312	28,740	27,393	25,597	22,453	*1991*
Pre F/S	30,345	29,414	28,030	26,813	25,356	22,622	

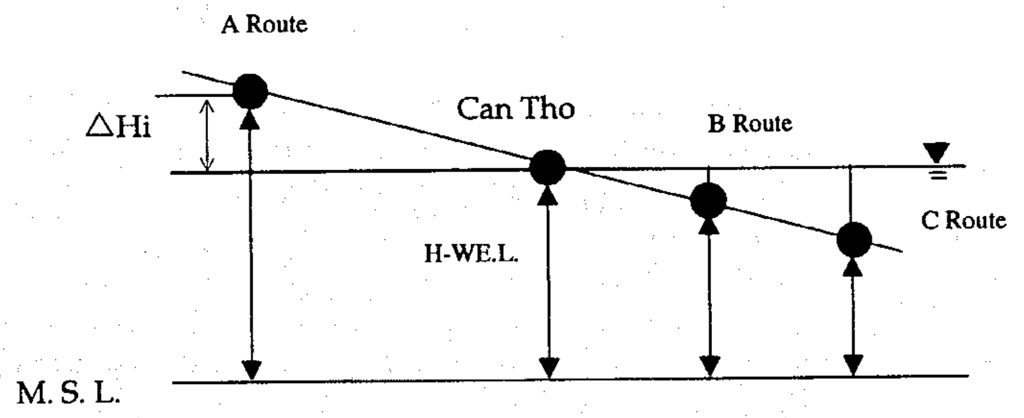
Remark: Zero of Gauge elevation 0.00cm

The above shows that the H-Water E.L. and discharge are nearly the same value when calculated by both methods. Therefore, in this study, these observations can be summarized as below;

- The result of the Hazen Plot Method is a temporary value.
- In the Log-normal Distribution method, both the H-Water E.L. and Discharge are bigger than that calculated from the Pre F/S during the 10 years to 100 years return period.

Due to these reasons, the Log-normal Distribution method was used to estimate the design flood water and high water level.

Further, values corresponding to route A, B and C were calculated for defined H-Water E.L's. The procedure of analysis and equation is given in Fig. 6.15 and the calculated design flood in Table 6.7.



$$\triangle Hi = 0.000055 \times \text{Dist. from Can Tho Station}$$

$$\text{H-Water E.L.}_{i} = \text{H-Water E.L.}_{\text{Can Tho Stataion}} + \triangle Hi$$

Fig. 6.15 Procedure of Analysis

Table 6.7 Design Flood of Each Route

Return Year		100	50	20	10	5	2	Max.- Actual Record
Factor	P %	1	2	5	10	20	50	209cm (1989)
H-Water E. L. (cm)	△Hi (cm)							
A Route	17.16	229.56	228.03	225.76	223.76	221.36	216.85	226.16
B Route	-6.16	206.24	204.71	202.44	200.44	198.04	193.53	202.84
C Route	-16.94	195.46	193.93	191.66	189.66	187.26	182.75	192.06

6.4.6 Hydrological and Hydraulic Conditions of Each Route

(1) Riverbed Changes/Velocity and Substructure

The scouring and deposition of riverbanks and riverbeds must be investigated in order to aid reliable substructure planning. Historical river cross-sections and the river flow patterns were investigated at the Can Tho bridge site using all available data, in order to clarify the actual condition of the riverbed changes.

Fig. 6.6 shows the water depth at the planned site of the Can Tho bridge and the river flow velocity overlaid over the cross-section of the proposed bridge, from which the following can be inferred.

- The flow velocity increases in routes A, B and C in descending order respectively. In particular the velocity in the C-route was high at 1.975 m/s at the 100 m point from the left bank and 2.033 m/s at the 500 m point from left bank.

- In route A, the right bank's velocity was high, and the area was showing erosion and scouring. Because the area was shifted to out corner according to the historical changes of the riverbed between 1963 to 1975, there will be a necessity to locate the pier at an area where it will not be under the influence of erosion and scouring.

- In route B, the left bank's velocity was high, and the area was showing scour due to a water depth of 25 m and a narrow riverbed shape. There is, therefore, also a necessity to locate the pier at an area where it will not be under the influence of scouring.

- In route C, the flow has branched off at the upper stream about 800 m from the C route. The velocity was higher because the main channel's discharge is frequently more than that of the branch river. The C route riverbed was stable between 1963 to 1975.

(2) Whirlpool Effects

Fig. 6.16 shows the distribution map of the occurrence of the whirlpool, which were made from the results of the velocity survey in September

1997. As shown in the figure, a whirlpool was observed around the left side of the river in the B route.

It seems that the whirlpool is caused by turbulence flow of the river water generated by structures, at the ferry port, confluence point about 300m from the ferry port, and 100m upstream from the ferry port. In the B route, piers have to be located in a safe position far from the effects of scour.

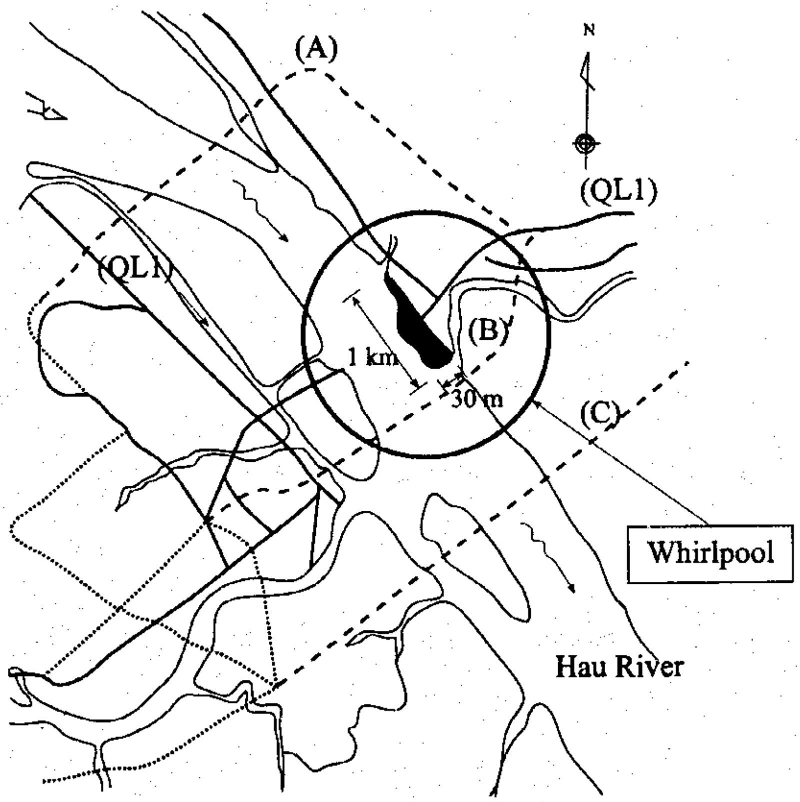


Fig. 6.16 Location of Whirlpool in 1997.09

(3) Bridge Length and Side Space

Fig. 6.10 shows route A, B and C and distribution of the 1992 flood, which was prepared using the JERS-1 SAR images at the Can Tho Bridge site.

The following can be inferred from this figure.

- In routes A, B and C, there is no flooding in the right bank of the Hau River at the Can Tho City site. However, we can see the flood area of the Can Tho City site was excluded, and there is a necessity to consider the influence of inundation at the section of approach road embankment.

- The flooded areas can be distributed in left banks of routes A, B and C. There is a necessity to consider the influence of inundation at the part of the approach road embankment, which is located several hundred meters from the riverbank or will be constructed using piers.

- In the sand bar of route C, the flooded area can be estimated at about 30% of the total sand bar area. Therefore, there is a high probability of inundation during a big flood.

- The merit in considering flood characteristics is that the bridge lengths of routes A and B can make shorter than that for route C.

(4) Embankment and Bridge Center Span

Fig. 6.12 shows the planform change of the Can Tho bridge site between January 1973 to February 1993. In this figure, alternative(A), (B) and (C) indicate the proposed route of bridge construction. The following can be inferred from this figure.

- On the right bank around route A, a planform change (riverbank erosion) has occurred and is spreading at the rate of about 3.0 m/year. Specifically, an embankment has to be constructed, in order to protect the riverbank. It was confirmed that the riverbed was shifting towards the right bank according to the river cross section of route A. There is a necessity to consider the influence of this phenomenon for the discussion of the bridge center span.

- Around route B, there are no planform changes. This shows that the bank is stable but deep and narrow on the left bank side.

However, there is a necessity to consider the influence of this of planform change for the discussion of the bridge center span, because it was confirmed that the riverbed was shifted to left bank according to the river cross section of route B.

- The sand bar on route C changed from river to land from January 1973 to February 1993. There is a necessity to consider the influence of this phenomenon of planform change for the discussion of the bridge center span, because it will be inundated in a big flood.

(5) Condition of Each Route

Based on the above investigation, hydrology and hydraulic characteristics of each route can be discussed as below.

Route A

- The piers must be arranged at such locations so that they are not influenced by the riverbed scoring.
- There is a necessity to consider the influence of inundation at the part of the approach road embankment on the left bank and the Can Tho city area on the right bank.
- On the right bank, planform changes have occurred, therefore embankment has to be constructed, in order to protect the riverbank.
- There is a necessity to consider the influence of the riverbed and riverbank shifting tendency to the right bank in consideration of the location and length of the bridge center span.

Route B

- In the right and left banks, there are no planform changes, and it can be assumed that the bank is stable at this location.
- There is a necessity to consider the influence of inundation at the section of the approach road on the left bank.

- It is necessary to arrange piers in safe locations so that no influence from the riverbed changes by scoring occurs.

- There is a necessity to consider the influence of the riverbed and riverbank tendency to shift towards the left bank in considering the location of the bridge center span.

Route C

- In the riverbank, there are no planform changes and it can be considered that the bank is stable. The influence of scouring on the Route C condition is much smaller than that for route A & B.

- The construction cost is high, as the bridge length is the longest due to there being a high probability of inundation in a big flood.

- There is a necessity to consider the influence of inundation at the part of the approach road at the left bank and in the Can Tho city area of the right bank.

- There is also a necessity to consider the influence from the sandbar being inundated in a big flood.

6.4.7 Summary of Hydrological and Hydraulic Conditions for the Bridge Planning

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

(1) Flood Water Conditions at Can Tho Station

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

(2) Design Flood Water Level of Each Route

Flood Water Level (cm)	100 years	20 years	Referred to Max Act-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 Mean Sea Water Level (MSL).

(3) Hydrological and Hydraulic Conditions

The hydrological and hydraulic conditions of each route for bridge planning, especially for the main bridge are presented in following table. (see Table 6.8)

Table 6.8 Hydrological and Hydraulic conditions for Each Route

	Route A	Route B	Route C
a) Riverbed (water depth)	- Deep toward the left bank side (18 m) - Shallow part near the rightbank 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 the main channel discharge
c) Planform Change	- Shift of riverbank to outer corner (left) according to the historical change to the riverbed between 1973 to 1993	- Stable for planform change, however a tendency of shift to the left bank	- Sandbar occurrence from 1973 to 1993, with possible inundation in a large flood of the sandbar
d) Special Observation	- Erosion at right bank	- Whirl pool toward the left bank side, immediately upstream of the confluence point	- Low level of sand bar, and 30% of the total sandbar area will be inundated 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 and subject to further hydro-dynamic study
f) Bridge Opening of Main Bridge	- Due to riverbank shift, not less than 600 m opening	- Due to riverbank shift, not less than 600 m opening	- Not less than 500 m opening

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

CHAPTER 7

INITIAL ENVIRONMENTAL EXAMINATION (IEE)

CHAPTER 7 INITIAL ENVIRONMENTAL EXAMINATION (IEE)

7.1 General

7.1.1 Background of the Study

The Mekong Delta is the biggest rice paddy area in Viet Nam. Its agricultural production accounts for some 40% of the total agricultural production in Viet Nam, including 50% of the rice production.

However, the growing economy of the Mekong Delta necessitates the rehabilitation of the southern part of National Highway No.1 in order to facilitate the traffic flow between the delta and other export zones or cities to the north. Bottlenecks in the existing road system are likely to occur near Ho Chi Minh City and at the crossings of National Highway No.1 with the Tien Giang and Hau Giang Rivers.

The My Thuan Bridge is a large scale infrastructure currently under construction to solve one of these bottlenecks as a land crossing over the Tien Giang branch of the Mekong River. The proposed Can Tho Bridge on the Hau Giang branch is another major infrastructure project that after being constructed will eliminate the second biggest bottleneck of the existing road system, and will trigger the development of the Mekong Delta.

The construction of the proposed Can Tho Bridge will also raise various impacts on the regional natural and socio-economic environment. Assessment of these impacts is considerably important and the measures for mitigating any adverse impacts, the environmental monitoring programs must be implemented to ensure that the existing environmental values can be protected, and the sustainable development of the Mekong Delta can be realized.

7.1.2 Project Objective

An environmental impact assessment (EIA) study has been conducted as part of the Feasibility Study on the Can Tho Bridge construction, to assess the impacts on natural (biophysical) environment and socio-economic environment caused by the construction of the bridge, by considering whether they outweigh the benefits of the proposed bridge, and to propose methods which would mitigate the adverse impacts identified.

The major objectives of the EIA Study are described as follows:

a) Identify and assess all environmental impacts of the Can Tho Bridge in the adjacent areas during construction and when in service,
b) Set up the recommended measures for mitigating and managing adverse impacts on the environment, and
c) Set up the recommended programs for environmental monitoring

In advance of the EIA study, an Initial Environmental Examination (IEE) was carried out in order to: (1) identify the key environmental factors for the EIA study; (2) determine of the EIA study methodology; and (3) establish environmental criteria for the selection of the optimum alternative route.

7.1.3 Study Approach

The EIA for the Can Tho Bridge Project has been conducted in compliance with the guidelines issued by the Vietnamese Ministry of Science, Technology and the Environment, and generally in accordance with the requirements of the OECF Environmental Guidelines and the JICA Environmental Guidelines.

The basic flowchart of the study is shown in Fig.7.1 and the main items of the study are:

a) Collection and analysis of data and information
b) Confirmation of various laws, regulations, and guidelines relevant to the environment
c) Field reconnaissance survey
d) Environmental impact analysis
e) Setting up of environmental conservation goals
f) Forecasting the future environmental situation
g) Environmental evaluation
h) Recommendation of the mitigatory measures
i) Recommendation of the monitoring system
j) Estimation of the environmental costs
k) Setting up of comprehensive evaluation on environmental issues

However, to fully understand the environmental issues of the Can Tho Bridge Construction Project, the existing environment and the socio-economic features of the Mekong Delta as a whole, as well as at the areas adjacent to Can Tho ferry crossing and the proposed bridge site have been studied.

For convenience, the natural environment sector and the socio-economic environment sector were separately assessed but have been partially integrated in the EIA reports.

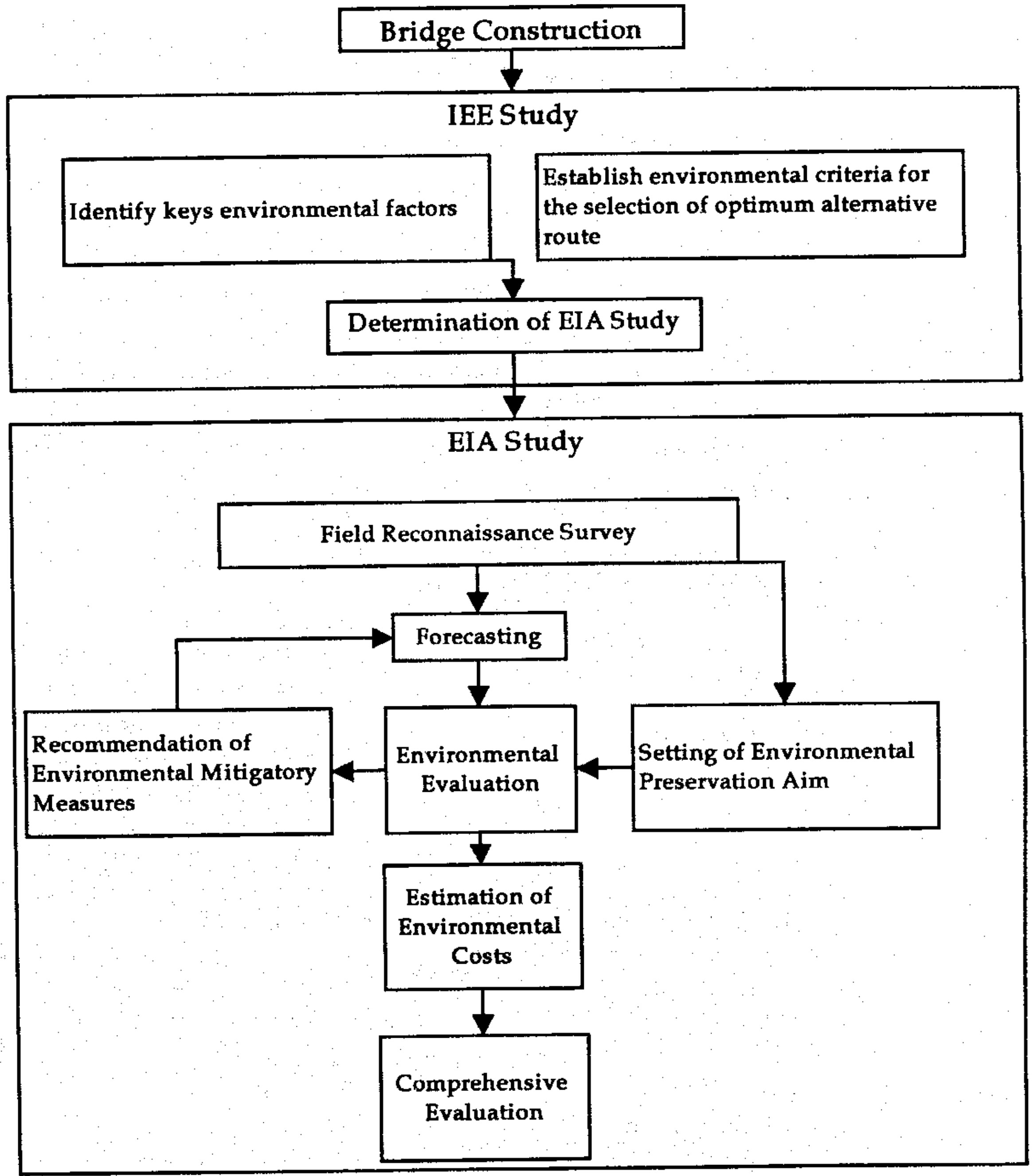


Fig. 7.1 Basic Flow-Chart of the IEE Study and EIA Study

7.2 Administrative Framework

7.2.1 Study Team

The IEE study was completed by the JICA Study Team in the first stage of the Feasibility Study.

A Vietnamese Consultant Agency, the Research Institute For Transportation Science And Technology (RITST), was entrusted to carry out the EIA study during 2 months starting from the latter part of January 1998.

7.2.2 Method of Collecting Data and Information

The IEE study was based mainly on existing documents, maps, etc. collected in Japan and Viet Nam, and data, reports, etc. provided by the Can Tho Province's People Committee and the Vinh Long Province's People Committee. An additional field reconnaissance survey was carried out to determine major factors relating to the environmental issues of the Project.

For the EIA study, RITST conducted the following works to collect the necessary data and information:

1) Collection of existing data

- from relevant agencies
- from relevant organizations

2) Socio-economic surveys

- Project-affected people,
- local community leaders,
- Can Tho Ferry Company,
- business communities adjacent to the Can Tho Ferry,
- cultural and archaeological significances

3) Natural environment surveys

- water quality,
- air quality,
- noise,
- vibration,
- river sediment,
- aquatic ecosystem,
- terrestrial ecosystem

7.3 Legal Framework on Environmental Impact Assessment

7.3.1 Legal Provisions for the Environmental Impact Assessment in Viet Nam

(1) Laws and Regulations on Environmental Protection

As a starting point for the environmental considerations for national sustainable development in Viet Nam, an action plan titled "Viet Nam National Plan for Environment & Sustainable Development, 1991-2000, Framework for Action" (NPESD) was prepared by the Viet Nam State Committee for Science in August 1991. In line with this action plan, the Ministry of Science, Technology and Environment (MOSTE) was established in September 1992, and in parallel with the establishment of the MOSTE, Viet Nam's "Environmental Protection Law" (LEP) was prepared and put into force in January 10, 1994. LEP constitutes the national basic policy, philosophy, and requirements for environmental protection and for achieving sustainable development of the country.

MOSTE had gathered, readjusted, and systemized a number of existing and available criteria relating to the environmental protection, and summarized them into a handbook called "Provisional Environmental Criteria", which was published in 1993.

The Council of Ministers issued a decree in January 1992 that stipulated protected rare and precious forest plants and animals. A list of special forest areas was also prepared, which can be considered as environmentally preserved areas (Annexure 5.1).

Table 7.1 lists major environmental laws and regulations already issued by the central government.

Table 7.1 Major laws and regulations on environmental protection

Regulation	Title
Decision No.545-QD/TCCB (Oct. 7,1993)	Organizing and activities of the National Environmental Agency (NEA)
Environmental Protection Law (Dec. 27, 1993)	National policy, philosophy and requirements for environmental protection
Decree No.175/CP (Oct. 18, 1994)	Guidelines on the implementation of the Environmental Protection Law
Decision No.1806-QD/MTg (Dec. 31,1994)	Organizing and activities of the EIA Report Evaluating Committee
Decision No.229-QD/TDC (Mar. 25, 1995)	Issue of Vietnam Environmental Standards
Directive No.715-Mtg (Apr. 3, 1995)	Guidance on the establishment and evaluating of EIA Report for projects with foreign investment
Directive No.714-MTg (Apr. 3,1995)	Issue of EIA Report Evaluating Results
Decree No.845-TTg (Dec. 22, 1995)	Approval of "Active Plan on Protection of Biodiversity in Vietnam"
Decision No. 2920-QD/MTg (Dec. 21, 1996)	Application of Vietnam Environmental Standards
Circular No.1100/TT-MTg (Aug. 20,1997)	Guidance on the establishment and evaluation of EIA Reports of (all) investment projects.

(2) Identification of Development Project

Environmental consideration has become a key factor in licensing a development project in Viet Nam. Depending on the financial source of the project, the process of establishing and evaluating the EIA report is different.

Projects with *domestic investments* can be classified into two categories depending on whether they are funded from the state budget or from private sources. In both cases, the pattern is very similar. The only significant difference between the two processes is that no financial allocation from the State Bank is required for privately funded investments.

Projects with *foreign investment* can take three legal forms: business co-operation on the basis of a contract, joint ventures, or enterprises with 100% foreign capital. In the first two cases, it is the Vietnamese partner who presents the project concept and feasibility study to the concerned authorities. Applications are first vetted by a Ministry or Provincial People's Committee and then forwarded to the Ministry of Planning and Investment (MPI).

(3) Requirement of EIA on Investment Project Appraisal Procedures

The EIA was incorporated as a legal requirement for a large number of projects through Articles 17 and 18 of LEP (see Box 1).

Box 1 EIA Requirements in Law on Environmental Protection

Article 17

Organizations and individuals in charge of the management of economic, scientific, technical, health, cultural, social, security and defense establishments that have begun operation prior to the promulgation of this law must submit an EIA report on their respective establishments for appraisal by the State management agency for environmental protection.

In case of failure to meet environmental standards, the organizations or individuals concerned must take remedial measures within a given period of time as stipulated by the State management agency for environmental protection. Upon expiry of the stipulated time limit, if they still fail to meet the requirements of the State management agency for environmental protection , the latter shall report to the higher State authority at the next level to consider and decide on the suspension of operation or other penalizing measures.

Article 18

Organizations, individuals when constructing, renovating production areas, population centers or economic, scientific, technical, health, cultural, social, security and defense facilities; owners of foreign investment or joint venture projects, and owners of other socio-economic development projects, must submit EIA reports to the State management agency for environmental protection for appraisal.

The result of the appraisal of EIA reports shall constitute one of the bases for competent authorities to approve the projects or authorize their implementation.

The Government shall stipulate in detail the formats for the preparation and appraisal of EIA reports and shall issue specific regulations with regard to special security and defense establishments mentioned in Article 17 and in the article.

The National Assembly shall consider and make decision on projects with major environmental impacts. A schedule of such types of projects shall be determined by the Standing Committee of the National Assembly.

The exact modalities to be followed for the EIA study of investment projects are not precisely indicated in Decree No.175/CP. To clarify this point, MOSTE issued Circular No.1100/TT-MTg (on August 20, 1997, as a revised version of Circular No.715/MT on April 3, 1995) providing guidance on the selection of projects for EIA, the establishment and appraising of EIA reports, and the organization in charge of appraising the EIA reports.

According to this circular, in order to smoothly and efficiently integrate environmental assessment into investment appraisal, and to take into account existing human resource limitation, all projects including domestic investment projects and foreign direct investment projects, are classified into three categories:

Category 1 - Projects which do not require the preparation of an EIA

Category 2 - Projects which require detailed report on the EIA

Category 3 - Projects which require reports on the EIA to be made in two steps

For project category 1, there is no requirement to prepare the report on the EIA. However, investors will have to include information in their investment license application on possible environmental impacts of the project and commit to protecting the environment during construction and implementation of their project.

For project category 2, when applying for an investment license, the project owner must submit the report that contains a separate part or chapter briefly defining the factors of the project that may impact on the environment.

For project category 3, the project owner must prepare the reports on the EIA in two steps: (1) a preliminary report on the EIA together with the pre-feasibility study report and the dossier of application for investment license; and (2) a detailed report on the EIA.

The required contents of a detailed report on the EIA as prescribed in an annex to Decree 175/CP is provided in Annexure 5.3.

(4) National Environmental Guidelines, Standards and Criteria .

A research project to develop Viet Nam's environmental quality standards was carried out by the National Research Program on Environment (NRPE). Project findings were presented to MOSTE in January 1994 with recommended standards based on the practical experiences in Viet Nam and neighboring Southeast Asian countries as well as the recommendations of UNEP, WHO and other international agencies.

After reviewing these standards, on December 21, 1996, MOSTE issued Decision No. 2920-QD/MTg on the application of the 97 environmental standards. All projects implemented on Vietnamese territory must apply these standards, or the standards published by local authorities if necessary, provided that these standards are not lower than those published by MOSTE.

7.3.2 Factors to be Considered for the EIA for the Can Tho Bridge Construction Project

The Can Tho Bridge Construction Project is supposed to be a part of the Highway Construction Project (Duong Cao Toc), and according to Circular 1100/TT-MTg it should be categorized as a project in category 3. Consequently, the preparation of the report on the Environmental Impact Assessment (EIA) for the Can Tho Bridge Construction Project should be undertaken in two steps:

Step 1: establish a preliminary EIA report for the investment appraisal;

Step 2: after being granted an investment license, establish and submit a detailed EIA report (hereinafter referred to as "EIA Report"), and grant the construction license before starting construction.

The agency in charge of evaluating the EIA Report is the Ministry of Science, Technology and Environment (MOSTE).

7.4 Key Environmental Issues

In advance of the EIA study, there were three studies on the environment relating to the construction plan of the Can Tho Bridge: the first was conducted by the Ministry of Transport as part of the pre-feasibility study, the second was conducted by a preparatory study team (dispatched by JICA in March 1997), and the third was the IEE study conducted at the early stage of the feasibility study in September and November 1997.

Based on the results of these studies, the key environmental issues which are supposed to be considered in relating to the construction of the Can Tho Bridge can be summarized as shown in Table 7.2.

In this report, all expected impacts caused by the Can Tho Bridge Construction Project are discussed briefly, and emphasis is placed on the key environmental issues mentioned in Table 7.2.

Table 7.2 Key Environmental Issues on the Can Tho Bridge Construction Project

Factor	Evaluation	Note
Resettlement	A	A number of residents may have to be relocated so as to acquire lands for the Project implementation.
Economic activities	A	A number of residents have means of livelihood depending on the business activities at the Can Tho Ferry crossing.
Traffic and social facilities	A	The reduction of the Can Tho Ferry may cause difficulties in accessibility to residents living near the ferry crossing.
Split of communities	B	Depending on the selection of the alternative route, some communities may be split by the new approach roads.
Waste	B	A volume of construction waste may be generated from the bridge construction site.
Soil erosion	C	Exposure of topsoil by land reclamation may cause the water turbidity and affect the growth of plants, animals, etc.
Hydrological situation	B	The hydrological regime may be changed by the construction of piers, etc. and by the changes of inflows.
Fauna and flora	B	Exhaust gas and noise, and new approach roads may cause change to the habitat of animals
Landscape	B	A large scale bridge will create changes to the existing landscape and raise various impacts to tourism and the local people's life.
Air pollution	B	Dust, exhaust gas and toxic gas from earthwork, construction machines and running vehicles may affect the health of residents, plants and animals along the road areas.
Water pollution	B	Disturbance of sediments by the construction of piers, eroded soil from the road embankment, dust and oil on the road surface, etc. may cause polluted, turbid water and affect the aquatic ecosystem.
Soil contamination	C	Dispersion of paving materials, exhaust gas and dust, etc., may cause contamination of the soil.
Noise and vibration	C	Some residents may be affected by the noise and vibration generated by construction machines.
Ground subsidence	A	Newly constructed embankments on the soft soils of the Mekong Delta may cause subsidence of land along the approach roads.

Note 1) A: serious impact is expected

B: some impact is expected

C: extent of impact is unknown

7.4.1 Natural Environment Impact Issues

The proposed Can Tho Bridge site is located in the central part of the Mekong Delta, on the Hau Giang River (one of two large distributors of Mekong River). The proposed location of the bridge is about 2.9 km downstream from the existing Can Tho Ferry, which is the main river crossing linking Can Tho City (Can Tho Province) and Binh Minh District (Vinh Long Province) on National Highway No.1.

The construction of a large scale infrastructure such as the Can Tho Bridge may raise numerous impacts on the natural environment of this region as described in Table 7.3.

Table 7.3 Expected Natural Environment Impacts

Impacts	Construction Phase	Service Phase
1. Impacts on land and soil (including ground subsidence)	O	O
2. Impacts on water resources and the hydrological system	O	O
3. Impacts on water quality	O	O
4. Impacts on terrestrial and aquatic ecology	O	O
5. Impacts of noise	O	O
6. Impacts of vibration	O	
7. Impacts on air quality	O	O
8. Impacts of excavation and transportation of construction materials	O	
9. Impacts of wastes	O	O
10. Impacts on environmental health and safety	O	O
11. Impacts on regional traffic and road network		O
12. Impacts on regional land use pattern and regional planning		O
13. Impacts on fauna and flora environment		O

7.4.2 Socio-Economic Impact Issues

Table 7.4 shows the major impacts on the socio-economic environment of the study area that may occur by the construction of the proposed Can Tho Bridge.

Table 7.4 Expected Socio-Economic Environment Impacts

Impacts	Construction Phase	Service Phase
1. Impacts of land acquisition and resettlement	O	
2. Impacts on economic activities of regional residents	O	O
3. Impacts on existing traffic and public facilities	O	O
4. Impacts on cultural heritage	O	
5. Impacts on public health	O	O
6. Hazards and risk	O	O
7. Impacts on energy use	O	O

7.5 Consideration of Alternatives

7.5.1 Consideration of Ferry Options

At the Can Tho ferry crossing, there are four to seven ferries usually operating simultaneously. For the passengers using these ferries, the total transport time is about 29 minutes (including 15.1 minutes of waiting time, and 12.2 minutes of travel time). In 1996, these ferries served about 18,000 passengers/day, and transported about 2,000 four-wheel vehicles/day.

In the future, the waiting time and traffic congestion will increase dramatically with the increasing traffic demand at the ferry crossing. Eventually, the total river-crossing traffic demand within the Mekong Delta will exceed the total capacity of the three main ferry points crossing the Hau Giang River (Can Tho, Vam Cong, and An Hoa). To avoid an unrealistic increase in waiting times, it is needed to improve the service ability of all three ferry crossings.

The improvement of the ferry service ability would require the construction of other landing positions so as to allow the simultaneous operation of more ferries. The construction of more landing positions would necessitate the installation of river bank stabilization structures upstream of the ferry crossings, and would necessitate the construction of more access roads and loading facilities. In such a case, in addition to the considerable construction cost, the traffic congestion, traffic accident risks (both on land and on the river), the degradation of the water and air quality environment in a large area adjacent to the ferry terminals would be unavoidably increased.

The option of upgrading the existing ferry services to meet the traffic demand in the future is, therefore, unrealistic, both from an economic and environmental point of view.

7.5.2 Consideration of the Bridge Option and Its Alternative Routes

While the ferry option is dismissed due to its disadvantage in necessitating large improvement costs and raising significant environmental problems, the bridge option is preferred from an economic and environmental viewpoint. The proposed bridge on being constructed will provide for free flow of traffic, avoidance of waiting time, and will lower the level of air pollution caused by vehicles and ferries at present.

The construction of a bridge as a substitute for the existing ferry crossing, however, may raise significant impacts on the socio-economic environment of the region. Accompanying the positive impacts such as the regional economic development, the relocation of a number of residents and loss of cultivated lands will be two of several major negative impacts caused by the Project.

For the bridge option, three alternative routes have been recommended and discussed (Fig.5.3).

7.5.3 Comparison of Alternative Routes by Environmental Criteria

Table 7.5 shows the environmental characteristics of each of the three alternative routes.

Fig. 7.2 shows the approximate number of houses, schools, churches, temples etc. which exist along the approach roads of each alternative route, and which are assumed to be affected by the Project.

For each alternative route, the proposed compensation costs for land acquisition were also estimated and concerned in the process for selection of the optimum alternative route.

Since all three alternative routes are planned to pass through an area with the same geomorphological characteristics, there is little difference in the impact on the natural environment (e.g. air quality, water environment, ecological environment, etc.) among the different sites of the alternative routes. 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, possibility of regional development, etc., vary significantly.

Table 7.5 Summary of Environmental Issues of Alternative Routes

Items	Alternative Route A	Alternative Route B	Alternative Route C
General features			
- Length of approach road	~ 5.2 km	~ 4.4 km	~ 16 km
- Soil characteristic	Partly strong support	Partly strong support	Weak support, requires substantial foundation
- Required number of other medium- scale bridges	2 bridges	1 bridges	5 bridges
- Accessibility to/from City/Town	fairly good	good	Requires 1 new inter-section at the Can Tho City side
- Deviation of traffic	available	unavailable	available
- Appropriate land for service area, construction site, workforce encampment, etc.	Only 1 side is possible	Only 1 side is possible	2 sides are possible
Resumption land			
- Rice field, annual crop land	70%	30%	70%
- Perennial crop land	5%	5%	20%
- Other land	25%	65%	10%
Households, school, churches/temple, etc. to be relocated			
- Permanent house (A-type)	~ 1800 houses	~ 70 houses	~ 10 houses
- Semi-permanent house (B-type)	~ 300 houses	~ 4 houses	~ 30 houses
- Other house (C-type)	~ 300 houses	~ 25 houses	~ 170 houses
- Elementary school	0	0	2 (1 avoidable)
- Temple / churches	0	2~3 (0 avoidable)	3 (3 avoidable)
- Lake	0	1 (0 avoidable)	0
- Grave, tomb	~ 5	~ 5	~ 10
- Medium/large factory	1 (0 avoidable)	0	0

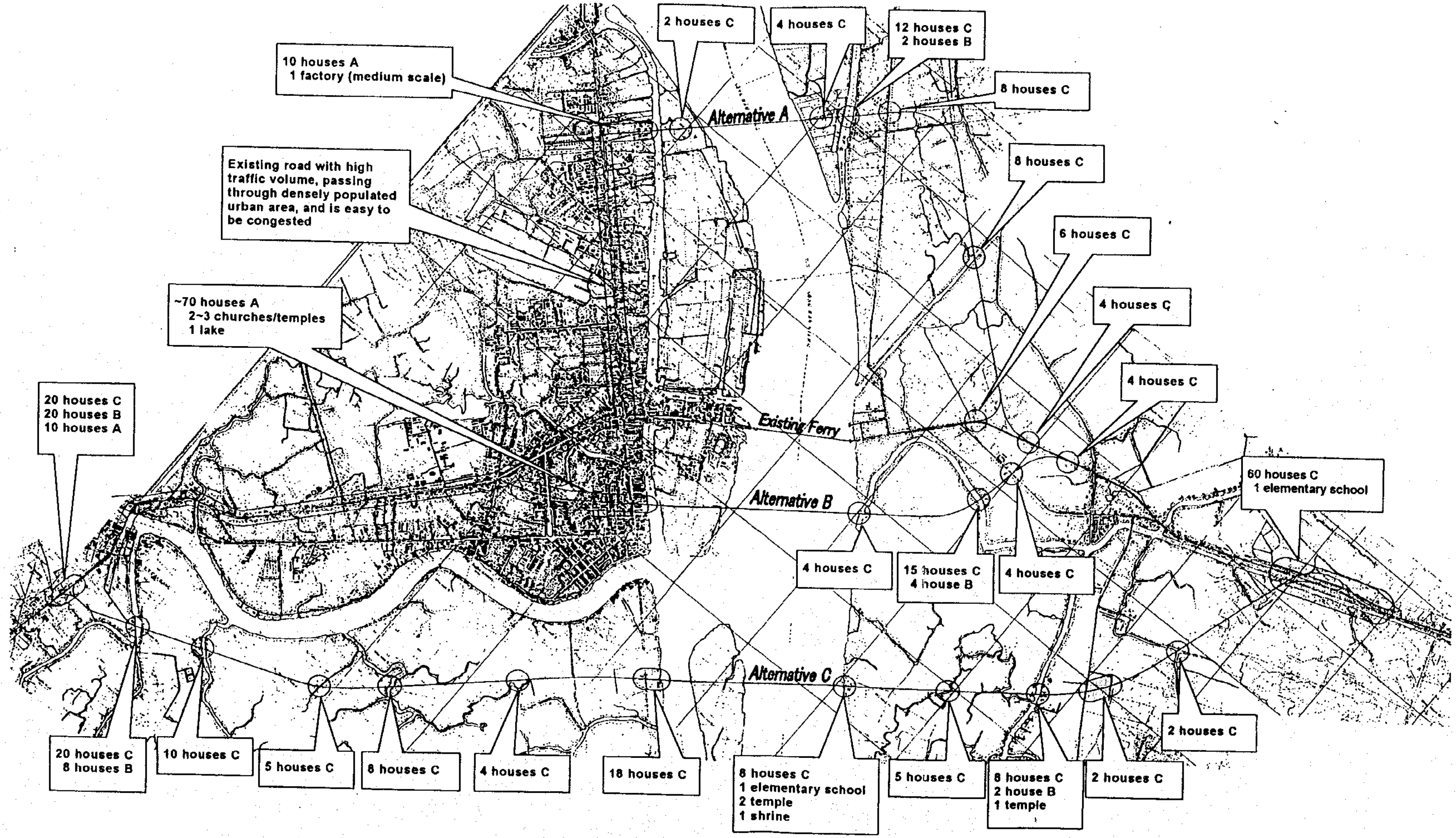


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Fig.7.2 Alternative Routes and Environmental Issues

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Table 7.6 summarized the result of the comparison of the environmental impacts caused by different approach roads of the alternative routes. As shown by this table, the positive impact on regional development of Alternative Route C is significant. This route is recommended by both the People Committees of Vinh Long Province and 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 garden-tourism areas.

In terms of the socio-economic impact, Route A and B are not seen as appropriate alternatives, as 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 will be extremely high compared to the case of Alternative Route C.

Furthermore, since the areas where the Alternative Route C is planned to pass 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 natural environment. Compared to Alternative Routes A and B, the number of residents who may be affected by the degradation of air quality, noise, traffic accidents, and other negative impacts caused by the future increase of traffic volumes is the least and these fewer adverse impacts can be controlled by appropriate environmental measures.

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

Table 7.6 Comparison of Alternative Routes by Environmental Criteria

Items	Alternative Route A	Alternative Route B	Alternative Route C
Positive Impacts			
- Regional development	●	●	●●● Consistent with regional development plans
- Travel time savings For thru-traffic For inter city/town traffic	 ● ●●	 ●● ●●●	 ●●● ●
- Energy saving	●	●●	●●●
Natural Environmental Impacts			
- Number of people to be affected by increasing air pollution, noise, vibration due to the increase in traffic volumes	××× A great number of residents in Cai Von Town, and in Can Tho City will be affected	××× A great number of residents in Cai Von Town, and in Can Tho City will be affected.	× Only a small number of residents living close to the existing highway will be affected
- Accident risk	×××	×××	×
- Heritage loss	×	××	×
- Energy consumption	×××	××	×
Socio-Economic Environmental Impacts			
- Households to be relocated	×××	×××	×
- Businesses to be displaced	×	×	×
- Health risks	×××	×××	×
- Schools to be relocated	× No need to relocate any school	× No need to relocate any school	×× Two elementary schools may need to be relocated
- Temple/Shrine to be relocated	×	××× 2~3 old and valuable temples may need to be relocated	×× 2 small temple /shrine may need to be relocated
Others			
- Construction cost	High cost is needed for the improvement of foundations	High cost is not needed for the improvement of foundations	High cost is needed for the improvement of foundations and the construction of other medium-scale bridges
- Available land for resettlement housing, service area, construction site, workforce encampment, etc.	small available land	Almost no available land	Large available land

Note: ● Positive impact × Negative impact

7.5.4 Initial Estimation of Environmental Costs for the Alternative Routes

The calculation of compensation costs for land is based on the following simplified equation:

*[compensation cost] = [affected length * affected width] *[unit price of land]*

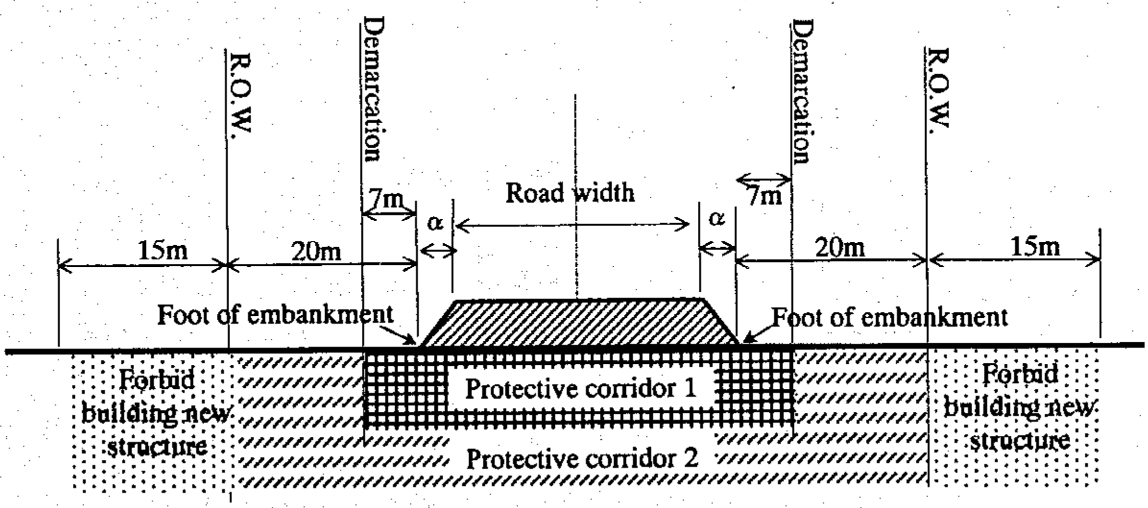
In common cases, the affected width is calculated as the sum of the road width and the protective corridor (20m) following the Vietnamese regulations on ROW (see Fig.7.3).

In the case that the proposed road passes through a densely populated urban area, the affected width is calculated to be the sum of road width and the demarcation width (7m) (see Fig.7.3).

The calculation of compensation costs for dwellings is based on the following equation:

*[compensation cost] = [number of affected dwellings] * [unit price of dwelling]*

Results of the calculation of compensation costs for each alternative route are shown in Table 7.7 and Table 7.8.



Note:
(1) road width = 22.6m (approach road's typical cross-section)
(2) α = embankment width = embankment height $\times$ 2 = 10m
(3) Protective corridor 1 = road width + 2(α +7) = 56.6m
(4) Protective corridor 2 = road width + 2(α +20) = 82.6m
(5) Zone of 'forbid building new structure' = 15m from ROW (according to Decree No.203/HDBT)

Fig. 7.3 Determination of the Protective Corridor

Table 7.7 Quantities of Land and Dwellings Acquisition

		Alternative A		Alternative B		Alternative C		
		A1	A2	B1	B2	C1	C2	C3
Rural residential land								
	City	200	200	1,000	1,000	600	1,900	1,900
	District	600	600	300	300	1,300	1,300	900
Urban land								
	Street type 1	0	3,000	80	400	0	0	0
	Street type 2	500	500	100	800	450	0	0
	Street type 3	0	0	0	400	600	0	0
Annual crop land and aquacultural land								
	City	300	300	400	400	2,000	2,950	2,950
	District	2,400	2,400	50	50	3,100	3,700	5,900
Perennial crop land, forest land								
	City	1,200	1,200	1,100	1,100	2,050	3,100	3,600
	District	0	0	0	0	0	0	0
Total length of acquisition lands		5,200	8,200	3,030	4,450	10,100	12,950	15,250
Dwellings								
	House category 1	10	1,800	10	70	30	10	10
	House category 2	2	300	4	4	90	30	30
	House category 3	45	300	25	25	170	140	170
	House category 4	0	0	0	0	0	0	0
Total number of acquisition dwellings		67	2,400	39	99	290	180	210

Street type 1: the first class street (2,600,000 ~ 6,500,000 VND/m2) as defined by Decree 87/CP
Street type 2: the second class street (1,950,000 ~ 4,875,000 VND/m2) as defined by Decree 87/CP
Street type 3: the third class street (1,440,000 ~ 4,500,000 VND/m2) as defined by Decree 87/CP
(See Section 17.3.4 for detailed explanation)

House Category 1 ~ 4: As defined by Circular 05/BXD/TT (See Annexure 5, 5.2)

Table 7.8 Initial Compensation Cost for Acquisition of Land and Dwellings

(Unit: 1000 VND)

	Price Unit	Alternative A		Alternative B		Alternative C		
		A1	A2	B1	B2	C1	C2	C3
Rural residential land								
City	38,000 VND/m^2	621,680	621,680	3,108,400	3,108,400	1,865,040	5,905,960	5,905,960
District	19,000 VND/ m^2	932,520	932,520	466,260	466,260	2,020,460	2,020,460	1,398,780
Urban land								
Street type 1	3,500,000 VND/m^2	0	585,900,000	15,624,000	78,120,000	0	0	0
Street type 2	2,000,000 VND/m^2	81,800,000	81,800,000	11,160,000	89,280,000	50,220,000	0	0
Street type 3	800,000 VND/m^2	0	0	0	17,856,000	26,784,000	0	0
Annual crop land and aquacultural land								
City	19,000 VND/m^2	466,260	466,260	621,680	621,680	3,108,400	4,584,890	4,584,890
District	5,500 VND/m^2	1,079,760	1,079,760	22,495	22,495	1,394,690	1,664,630	2,654,410
Perennial crop land, forest land								
City	14,000 VND/m^2	1,374,240	1,374,240	1,259,720	1,259,720	2,347,660	3,550,120	4,122,720
District	4,200 VND/m^2	0	0	0	0	0	0	0
Total cost for acquisition lands		86,274,460	672,174,460	32,262,555	190,734,555	87,740,250	17,726,060	18,666,760
Dwellings								
House category 1	1,000,000 VND/m^2	1,000,000	180,000,000	1,000,000	7,000,000	3,000,000	1,000,000	1,000,000
House category 2	900,000 VND/m2	108,000	16,200,000	216,000	2,160,000	4,860,000	1,620,000	1,620,000
House category 3	450,000 VND/m2	810,000	5,400,000	450,000	450,000	3,060,000	2,520,000	3,060,000
House category 4	300,000 VND/m2	0	0	0	0	0	0	0
Total cost of acquisition dwellings		1,918,000	201,600,000	1,666,000	9,610,000	10,920,000	5,140,000	5,680,000
		88,192,460	873,774,460	33,928,555	200,344,555	98,660,250	22,866,060	24,346,760

Note Road width = 41.8m; Right of Way (R.O.W) = 20 m; Road width +R.O.W = 81.8m; Demarcation = 7m; Road width + Demarcation = 55.8m

At urban areas of Can Tho City (A9, B7, B8, C20, C21): affected land area = [road length] * [road width + demarcation] = [road length] *55.8m

At other areas: affected land area = [road length] * [road width + R.O.W] = [road length] * 81.8m

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CHAPTER 8

DESIGN CRITERIA AND STANDARDS

CHAPTER 8 DESIGN CRITERIA AND STANDARDS

In order to select the route alignment and bridge structures, and to conduct the preliminary design, the design criteria were set up, by referring to the detailed design of the My Thuan Bridge (which is also located on N.H. No.1 and near the proposed Can Tho Bridge).

8.1 Standards and Specifications

The AASHTO Specifications were the primary standards for the design, and the Vietnamese and Japanese standards were 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

8.2 Design Loads

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

(1) Dead Load

Dead loads were calculated using the following density of each material

Reinforced concrete;	2.5 tf/m^3
Plain concrete;	2.3 tf/m^3
Asphalt;	2.3 tf/m^3
Steel;	7.85 tf/m^3

(2) Live Load

- Loading Classification

The bridges were designed based on the 125% live load of HS-20 specified by AASHTO. The design traffic loads H30 and XB80 in the Vietnamese Standard or B-loading in the Japanese Standard were used for the proof check.

(3) Wind Load

The wind load of the AASHTO Specifications was considered for a base wind velocity of 100 miles per hour (45 m/sec).

(4) Brake and Traction

Longitudinal forces stipulated in the AASHTO standards (5% of the live load) were considered. For the purpose of proof check, the following Vietnamese code was used.

From Article 2.20 of the Vietnamese bridge design code 2057-QD-KT4-1979, provision will be made for the effect of a longitudinal force without impact as determined from Table 2.2.6.1 of the standard.

Length of the portion of the loaded span	Longitudinal force
L = 25 m	0.3W
25m < L < 50m	0.6W
L > 50m	0.9W

In the above table: W = Total weight of truck = 30 ton for all lanes carrying traffic heading in the same direction. All lanes were considered as loaded in case the bridges become one way in the future. The longitudinal force was assumed to be located at the road surface level.

(5) Shake Force

From article 2.19 of the Vietnamese bridge design code, provision was made for the effect of a transverse force of 0.4 T/m from truck loading without impact. The transverse force was assumed to be located at the road surface level or top of curb level.

(6) Friction Force for Bearings

From article 2.28 of the Vietnamese bridge design code bridge bearings and piers supported on stone foundations shall be designed to resist a friction effect in the longitudinal direction. The friction force will be assumed to be applied through the bridge bearings.

The friction force was derived from the following formula:

$$Ff = f \cdot N$$

Where:

Ff	=	Friction force in ton
N	=	Breaking reaction force due to dead load and live load (without impact)
f	=	Friction coefficient

- For free bridge bearings of the roller, sliding, or sector type, f = 0.05
- For other types, f = 0.5

(7) Collision Load

1) River Bridges

In accordance with the AASHTO LRFD Bridge Design Specifications, the following head-on ship collision impact force on a pier was calculated.

$$Ps = 8.15\,(DWT)^{1/2}\,V$$

Where:

Ps = equivalent static vessel impact (KIP)

DWT = deadweight tonnage of vessel (TONNE)

V = vessel impact velocity (FT/SEC)

As for the proof check, collision force specified by Vietnamese Bridge Design Code was adopted. From article 2.26 of code 2057/QD-KT4-1979, values of collision loads are given in Table 8.1.

Table 8.1 Collision Force due to Navigational Collision

Total Weight of Ship (ton)	Loads in ton			
	Longitudinal Forces for the case of		Transverse Force from the direction of	
	Span Within Navigation Width	Span Outside Navigational Width	Up Stream	Down Stream, but for stagnant Water Force applied from the direction of Up Stream
12,000	100	50	125	100
8,000	70	40	90	70
4,000	65	35	80	65
2,000	55	30	70	55
500	25	15	30	25
250	15	10	20	15
100	10	5	15	10

Notes:
- When piers are within a protective barrier system, a collision force is not considered.
- Total weight of ship relative to the river class is given in table of the temporary criteria on the classification of Vietnamese rivers.

2) Grade Separated Bridges and Viaducts

Piers supporting grade separated bridges over other roads or railways shall be designed to resist accidental collision loads. Alternately, a protective barrier system shall be designed and installed.

a) Collisions of Vehicles and Other Equipment

Where the piers supporting an overpass are not located behind traffic barriers, they were designed to resist a static load of 100 tons applied at an angle of 10° from the direction of the centerline of the road that passes under the bridge. The load was applied 1.8 m above ground level.

b) Train Collisions.

Since no railway exists in the project area, the train collision force was not considered.

(8) Thermal Effects

Differential temperatures also cause both secondary longitudinal and transverse load effects. Variations in the average bridge temperature shall be based on the locality in which the structure is to be constructed. Due consideration shall be given to the difference between the air temperature and the interior temperature of massive concrete members or structures.

The range of average temperature shall generally be as follows:

Concrete Structures	Temperature Max.	Temperature Min.
Southern Viet Nam	40°C	15°C
Northern Viet Nam	30°C	10°C

The effects of the temperature differential applied shall satisfy article 2.27 and Annexure 6 of the Vietnam bridge design code 2057-QD-KT4 1979.

(9) Force Induced by Debris/Logs

Piers supporting bridges that may come under the influence of impact from debris or logs shall be analyzed accordingly. They were designed to resist the force due to debris, calculated by the formula:

$F = 0.05\ Cd\ V^2\ Ad$

Where:

F	=	Design force due to debris (ton)
Cd	=	1.04 (the drag coefficient)
Ad	=	The projected area of debris (m^2) acting on the piers shall be calculated assuming the depth of debris is 1.2 m below flood level, the length of the debris mat shall be taken as one half the sum of the adjacent spans or 20 m, whichever is the smaller.
V	=	Mean velocity of water flow for design flood level (m/s)

(10) Buoyancy

Buoyancy was considered where it affects the design of the substructure and piles.

(11) Other Design Loads

For other design loads the relevant specifications of the Vietnamese Standard were applied. For those aspects of loading details not covered by the specifications of the Vietnamese standard, the following specifications were referred to:

- Specifications for Highway Bridge, Japan.
- Standard Specifications for Highway Bridges adopted by the American Association of State Highway and Transportation Officials (AASHTO).
- General

  In the past, provision for seismic forces has not been a significant design factor in Vietnam. However, geological conditions have indicated certain areas require the consideration of seismic effects. These areas are predominantly in the northern part of Vietnam.

- Earthquake Coefficients in the Study Area

  The Study Area is covered by Region VI or Region VII in accordance with the Seismic Map of Viet Nam and the adoption of the following acceleration coefficients are suggested.

- Seismic Design

  The following table shows the relationship between the seismic intensity scale, acceleration coefficient and seismic performance category. (see Table 8.2)

Table 8.2 Relation of Seismic Condition

Seismic Intensity Scale Shown in the Map	VI	VII	VIII
Acceleration Coefficient	0.04	0.07	0.17
Seismic Performance Category	A	A	B

In the region which falls in the Seismic Performance Category A, no detailed analysis will be required for any bridge structures, except that the longitudinal connection of girders must be designed for specified forces. The seismic performance categories are defined in AASHTO Section 3.4 (Table I, P.341)

(12) Flood and Navigation Clearances

- Frequency of Design Flood

  The frequencies of the design flood were determined in accordance with Article 1.29 of the Viet Nam Bridge Design Code 2057/QD-KT4-1979 and Article 4.6 of the Design Criteria of Highway TCVN-4054-85. Table 7.14 gives the frequencies of the design flood by size of bridge and by class of highway. (see Table 8.3)

Table 8.3 Frequency of Design Flood

Size of Bridge	Class of Highway	Design frequency
All sizes of Bridges	I, II, and Town Road	1%
Length of Bridge > 25 m	All classes	1%
Small Bridges III	III	2%
L < 25m	IV to VI	4%

- Flood Clearance

The clearances for the design of bridges in the case the river is not utilized for navigation are given as shown in Table 8.4 (Article 1.27 of Vet Nam Bridge Design Code 2057/QD-KT4-1979).

Table 8.4 Minimum Clearance above Design Flood Level

Structure			Minimum clearance above Design flood level (m) for Highway Bridges
Girder	Water level rising by influence of piers	less than 1 m	0.50
		over 1 m	0.50
	Drifted	Wooden logs and debris	1.00
		Rolling stones	1.00
Bearing plate			0.25

Notes: Water level rising by piers is taken into account in the flood level of the area. Where there is water stagnating or a reservoir, the minimum clearance is > 3/4 of water depth.

(13) Shrinkage of concrete

Generally a thermal effect of - 15°C was considered for shrinkage. However, half of the effect can be neglected in the case where there is a stock of precast segments.

(14) Allowable stress of materials

- Prestressed concrete (see Table 8.5)

  Prestressed concrete will be constructed using the precast segmental method, and the allowable stress is based on the location of the joint between segments.

Table 8.5 Allowable Stress of Concrete

Strength of Concrete			
Fc′		400 (kgf/cm^2)	500 (kgf/cm^2)
Flexural tensile stress	During Erection	0	0
	Serviceability condition	0	0
	Over loading condition	25	30
	After prestressing	0.55 fc′	30
Flexural compressive stress	Serviceability condition	220	275
		0.4 fc′	275
		160	275

- Mild reinforcement steel SD 345 & SD 295 B

Table 8.6 Tensile stress of Mild Reinforcement Bar

Specified Stress	Tensile Stress	
Specified tensile stress	SD295 B	SD 345
Yield point stress	295~390 N/mm^2	345~440 N/mm^2
Breaking stress	> 440 N/mm^2	> 490 N/mm^2

- Prestressing Tendons

  a) Inner cable

  SWPR7B (12 S 12.7, 12 S 15.2)

  Stress at transfer : 0.7 *f*puk or 0.85 *f*pyk
  Stress during prestressing : 0.8 *f*puk or 0.9 *f*pyk
  Stress under serviceability : 0.7 *f*puk
  *f*pyk: yield point stress of prestressing cable
  *f*puk: ultimate stress of prestressing cable

b) Extra-dosed cable.

The extra-dosed cable is one of the outer cables with a large eccentricity. The change in the stress range is less than that of a stay cable and consequently the stress reduction due to fatigue is less. The allowable stress in this cable is 0.6 *f*puk.

c) Stay cable (H system)

The change in the stress range is bigger than the inner cable of a PC girder, and therefore the reduction of stress due to fatigue is larger. The allowable stress of a stay cable is, therefore, limited to 0.4 *f*puk.

Where, *f*puk: ultimate stress of prestressing cable

(15) Thickness of concrete covers

Location	Cover (mm)
Retaining walls and abutments	55
Pile caps	65
Deck Slab	45
Piers and Towers	45
Bearing plinths	45
Precast Girders	35
Precast parapets, NJ barriers, Kerbs, etc.	35
Tolerance on cover	±5

8.3 Geometric Design Standard

The Geometric Design Standard to be applied for the National Highway No.1 Bridge Rehabilitation Project was based on the Vietnam Design Standards (TCVN 4054-85). AASHTO Specification and Japanese Standards were referred to for items not covered by the Vietnamese standard.

For the new alignment design, the following conditions were carefully considered:

a) Minimize the number of houses for resettlement.

b) Minimize the land acquisition for additional R.O.W. and demarcation.

c) Avoid the unnecessary relocation of utilities such as telephone-cables, power poles and lines, water mains etc.

d) Avoid disturbance to public facilities such as the church, school, commercial area (market), temple and cemetery.

e) Minimize the construction costs and shorten the construction period of the temporary detour bridge which will be subject to width control and the flood level of the river canal.

f) Protect environmental degradation due to the new bridge construction.

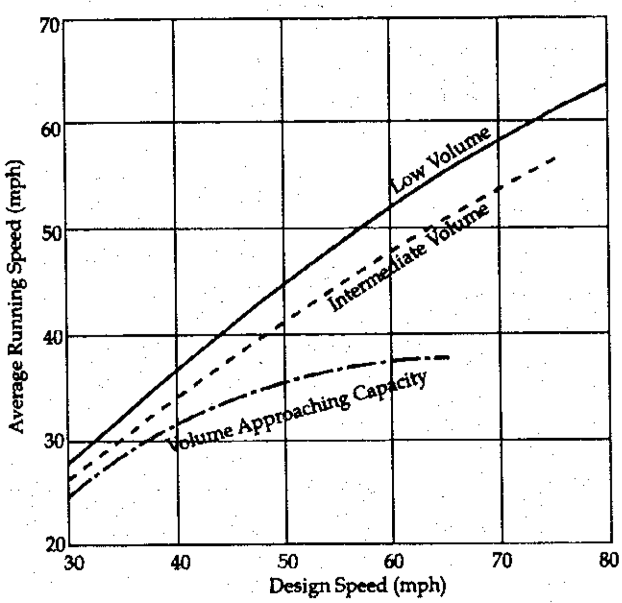
According to the traffic survey conducted by the Study Team, the traffic volume forecast (Average Daily Traffic) in the year 2010 varies from 17,890 to 18,236 with the construction of the Can Tho Bridge. Also, the Can Tho Bridge is to be situated on the road section of National highway No. 1 and therefore, from these traffic densities, the road section of the Can Tho Bridge shall be categorized as a Class-I road. However, the general relationship between the design and running speeds shows the possibility of reducing the design speed in the cases of house-resettlement and site topographical conditions. The reduction of the design speed from 80 km/hr to 60 km/hr should be considered from an economical and practical point of view.

(1) Design Speed

The design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are favorable and conform to the design requirements.

(2) Running Speed

The general relation between the design speed and the running speed is shown in Fig. 8.1. The upper curve represents the conditions for low traffic volume. If traffic volume increases on a highway, the actual running speed decreases because of interference among the vehicles. The curve labeled as intermediate volume represents the relationship between the design speed and the actual running speed when the traffic volume approximates the design service volume for rural highways. If the volume exceeds the intermediate level, the actual running speed would be further lowered where the volume is approaching the capacity of the highway. The speed of traffic is influenced more by congestion than by the design speed, especially where the design speed is above 50 miles/hr (80 km/hr) (see Fig. 8.1).



Source: A Policy on Geometric Design of Highways and Streets (AASHTO)

Fig. 8.1 Relation of average running speed and volume conditions.

In such cases that the new alignment would disturb many dwellings and require significant compensation, the reduction of the design speed should be considered. The reduction of the speed is technically justifiable as the actual running speeds are observed to be 80% to 90% of the design speed, and this will reduce the resettlement problems which may often occur at the site. Therefore, although the Can Tho bridge is situated on the road section of Highway No. 1, it is advisable to adopt a design speed of 80 km/hr, except the cases reducing the design speed as previously described.

(3) Design Speed and Design Standards of Geometrical Items

The table below shows the basic requirements of geometrical items for sections corresponding to traffic volume and design speed.

Items	Class of Road			
	I	II	III	IV
- Traffic Volume (ADT)	more than 6,000	3,000 to 6,000	1,000 to 3,000	300 to 1,000
- Design of Lane (km/hr)	120	100	80	60
- Number of Lane	4	2	2	2
- Width of Lane (m)	3.75	3.75	3.50	3.00
- Width of shoulder	2 x 3.00	2 x 3.00	2 x 2.50	2 x 1.50
- Safety Band (m)	4 x 0.50	2 x 0.50	2 x 0.50	-
- Soft Shoulder	0.50 to 1.00	0.50 to 1.00	0.50 to 1.00	0.50

Table 8.7 shows the detailed standards for design speeds of 80 km/hr and 60 km/hr.

Table 8.7 Geometric Design Standard

Item	Unit	Design Standard	
Design speed	km/hr	80	60
Horizontal Alignment			
- Min radius	m	250	130
- Min radius without super elevation	m	3,500	2,000
- Min curve length	m	140	100
- Min transition curve length	m	80 (70)*	60 (50)*
- Min radius without transition curve	m	2,000 (1,000)*	1,000 (500)*
- Super elevation runoff		1/200*	1/175
- Min stopping sight distance	m	200 (100)*	150 (75)
Vertical Alignment			
- Max grade**	%	6	7
- Min vertical curve radius			
Crest	m	5,000 (3,000)*	2,500 (1,400)*
Sag	m	2,000 (1,000)*	1,500 (1,000)*
- Min vertical curve length	m	70*	50*
Cross Section			
- Lane width	m	3.5	3.5
- Cross fall	%	2	2
- Max super elevation	%	6	6

Note: * In the particular case (modified standard from Japanese design standards)

** 5% is to be considered as the max grade.

(4) Grades

A highway should be designed to allow uniform operation throughout its section, however, vehicle-operating characteristics on grades are different and depend on the type (weight/horsepower) of vehicles. Ideally vehicles can run at the design speed, however, from the economical point of view, lowering of the speed for vehicles such as trucks should be accepted to a certain degree. For this to be acceptable, it is necessary to consider the critical slope length of the maximum gradient which would avoid reducing vehicle speeds.

For the control of the design of highway gradient, the following values give a guide for maximum grades (%).

Table 8.8 Design Speed and Maximum Gradients by Specifications

Design Speed (km/hr)	80	60
AASHTO Specification	6.1 - 6.8	6.7 - 7.6
Vietnamese Standards	6	7
* Japanese Standards	5, 6, 7	6, 7, 8

* Max. grades (%) which are allowed under the special conditions of topography and other particular circumstances of the highway section

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

CHAPTER 9

APPROPRIATE BRIDGE TYPES

CHAPTER 9 APPROPRIATE BRIDGE TYPES

9.1 Possible Bridge Types and Span Lengths

From the technical (applicable span length) and economic (cost minimum) reasons, the following six bridge types corresponding to the applicable span length were recommended for selecting the appropriate bridge type for the Can Tho Bridge (see Tables 9.1, 9.2 and Fig. 9.1)

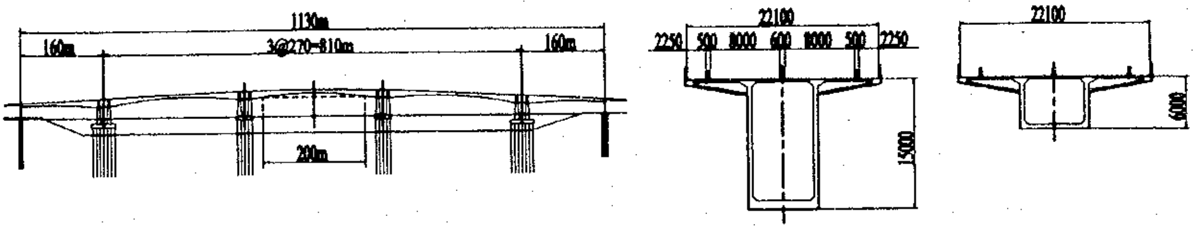
Table 9.1 Bridge Type and Span Length

Type	Suitable Span Length
1. PC Box Girder	270 m
2. Hybrid (PC) Extra-dosed	350 m
3. PC Cable-Stayed	350 m
4. Hybrid Cable-Stayed	500 m
5. Steel Cable-Stayed	550 m
6. Suspension Bridge	600-700 m

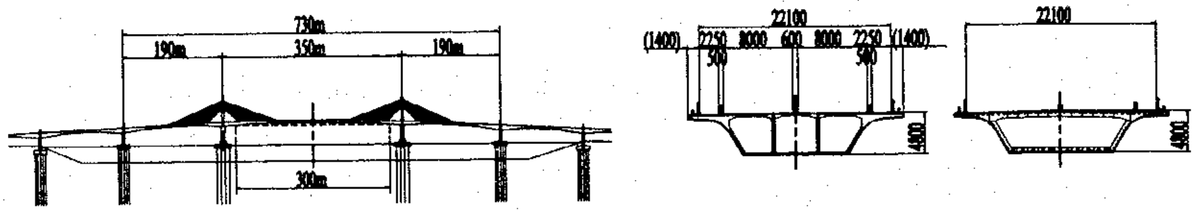
For the selection of the bridge type, the following conditions were examined and evaluated.

- Economy (Construction Cost)
- Structural features
- Construction Method
- Maintenance
- Aesthetic Aspect

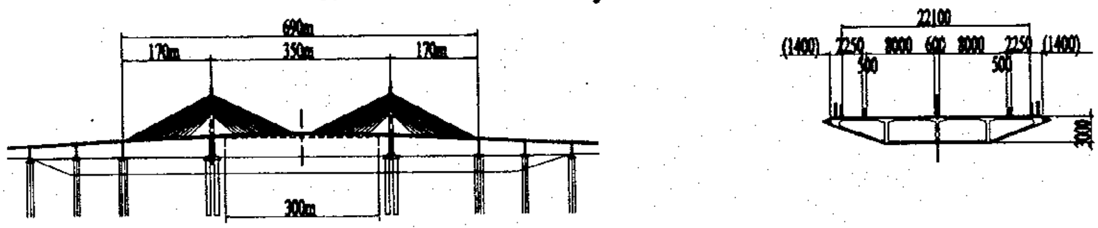
CASE-1 PC Box Girder



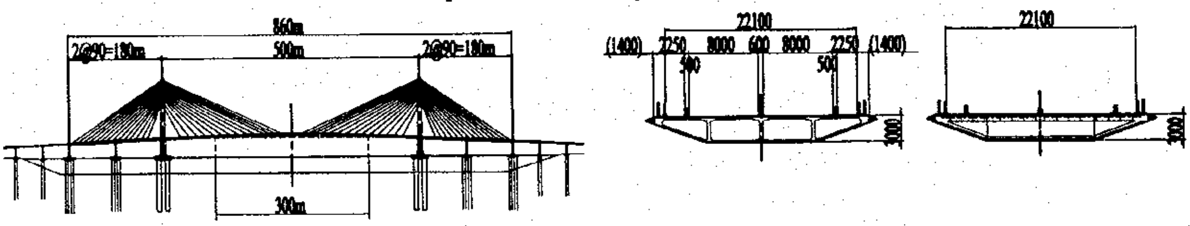
CASE-2 Hybrid Extra-dosed



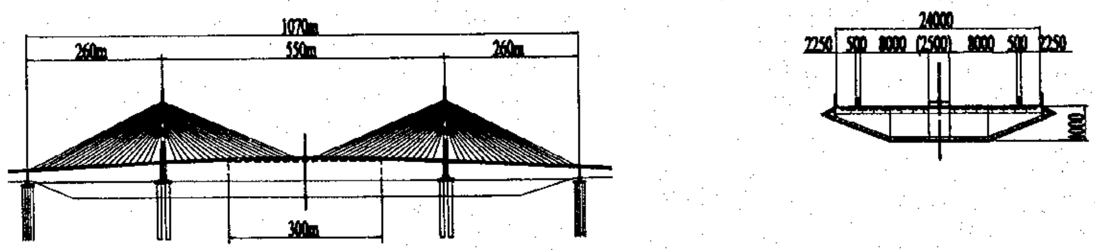
CASE-3 PC Cable Stayed



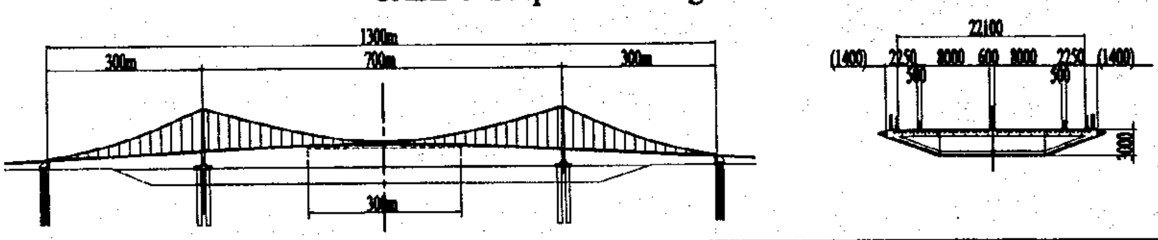
CASE-4 Hybrid Cable Stayed



CASE-5 Steel Cable Stayed



CASE-6 Suspension Bridge



THE FEASIBILITY STUDY ON THE CAN THO BRIDGE CONSTRUCTION IN SOCIALIST REPUBLIC OF VIET NAM	Fig.9.1 Applicable Bridge Types of Main Bridge JAPAN INTERNATIONAL COOPERATION AGENCY

Table 9.2 Comparative Table by Bridge Types for the Main Bridge

Main Bridge	(1) PC-Box Girder	(2) Hybrid (PC) Extra-dosed Bridge	(3) PC Cable-Stayed Bridge	(4) Hybrid (PC) Cable-Stayed Bridge	(5) Steel Cable-Stayed Bridge	(6) Suspension Bridge
a) Economy	- Comparatively economical structure.	- Economical span is 120 m to 200 m. - This type is rather economical, however slightly more expensive than the PC rigid frame type.	- Applicable to longer spans than a rigid frame bridge. However, the cost is rather higher for the superstructure.	- Cost is higher than PC cable-stayed. - Applicable longer span than PC cable-stayed bridge because of light weight of steel girder or center span.	- Girder is steel structure and applicable to longer span. - Cost is higher than PC hybrid cable-stayed type.	- The most expensive bridge type - This type is used only in the case that it is necessary to cross the complete width of the allover.
b) Structural Features	- More stable structure against earthquake and wind force vibration. - Disadvantage to vertical clearance due to deep section of girder at the piers.	- Center span is rather longer and must be a steel structure and the side span is PC for counter span. - Allowable stress of cable stay (60% of ultimate strength of cable) is higher than that cable for stayed bridge (40%).	- Applicable to span length 250 m to 350 m. - Structure system is flexible and can accommodate the movement of the substructure.	- Flexible structural system and ductile system. - Dead weight of central girder is light or steel structure and side span is prestressed concrete to be counter span with heavy weight.	- Flexible structural system leads difficulty to induce transfered stress and adjust stay cable. - Light dead weight of girder can be applied to long center span.	- Anchorage will be a huge structure due to the soft subsoil and deep bearing strata. This is the disadvantage of a suspension bridge.
c) Construction	- Easier construction with balanced cantilever method and concrete segmental method by using hoist and pontoon.	- More simple than cable-stayed to adjust cable stress during erection. - Anchorage of stay cable is more simple than for cable stayed bridge as there is less changeable stress range.	- Adjustment of stress of stay cable is easy because of fixed - rigid girder of the side span portion comparing all steel girder.	- Erection is done by free cantilever method. - Girder elements are prefabricated as precast segments and assembled by the erection truss. Transportation of segments is done by barge. Approach viaducts are erected from one-way with gantry crane and launching girder.	- Erection is done by free cantilever method. - Girders can be prefabricated. - Adjusting stress of cable stay is not so easy during cantilevering due to no fixed point.	- Main piers are located in the land area, this means easier construction can be expected.
d) Maintenance	- Maintenance free because of concrete and simple structure.	- Less maintenance (only anticorrosion of out cable). - Steel box girder portion is required to be repainted.	- Stay cable should be maintained and be replaced for corrosion of anchor portion.	- Girder made from prestressed concrete are maintenance free, however center span is necessary to be maintained for prevention from corrosion.	- For maintenance or prevention of corrosion of girder and stay cable, it is necessary to repaint steel girders.	- Cable and hangers should be maintained and the steel girder will need to be repainted periodically.
e) Aesthetic Aspect	- Less structurally aesthetic due to the large size of girder at the pier.	- Symbolic and landmark.	- This type is aesthetic and symbolic.	- This type of bridge is symbolic and landmark.	- This type of bridge is symbolic and landmark.	- This type bridge will be symbolic and landmark.

PC: Prestressed Concrete

Hybrid: The bridge deck is a combination of steel and concrete structures,
i.e. steel structure for center span and concrete structure for side spans

Extra-dosed: A type of prestressed concrete bridge with external cable (vertical exterior arch shaped) system

Rating Marks

- ⊙ Excellent
- O Good
- Δ Fare
- × Bad

Evaluation by Marks

Main Bridge	(1)	(2)	(3)	(4)	(5)	(6)
a)	O	O	Δ	Δ	×	×
b)	Δ	O	×	⊙	Δ	O
c)	O	O	O	O	Δ	Δ
d)	O	Δ	Δ	Δ	×	×
e)	×	Δ	Δ	O	O	⊙
Result				O	O	O

9.2 Alternative Bridge Types for Each Route (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 for each route were listed for initial evaluation.

1) Alternative Route (A) (see Fig. 9.2)

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

2) Alternative Route (B) (see Fig. 9.3)

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

3) Alternative Route (C) (see Fig. 9.4)

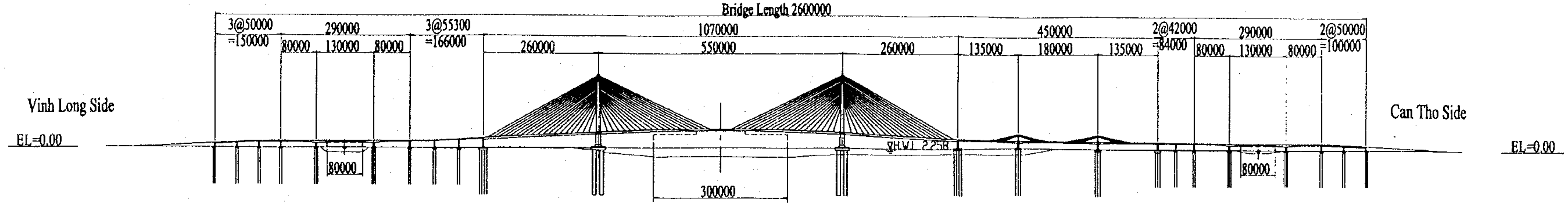
- Required center span length approx. 500m
  - a) Hybrid Cable-Stayed 500 m
  - b) Steel Cable-Stayed 500 m
  - c) Steel Cable-Stayed 550 m

Table 9.3 Cost Ratio of Alternative Bridge Type or Each Route

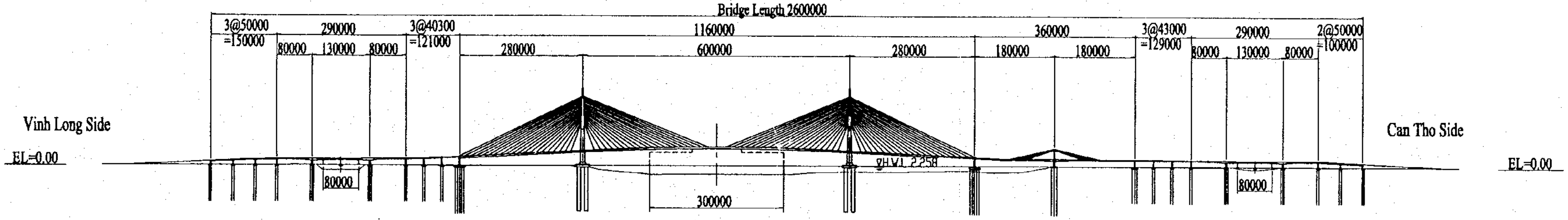
	Alternative Route (A)			Alternative Route (B)			Alternative Route (C)		
Options	a)	b)	c)	a)	b)	c)	a)	b)	c)
Construction Cost Ratio	1.17	1.20	1.79	1.29	1.35	1.76	1.00	1.23	1.15

Construction cost ratios for the superstructure are shown in Table 9.3 based on 1.00 for Hybrid Cable-stayed including main bridge and approach bridge portions.

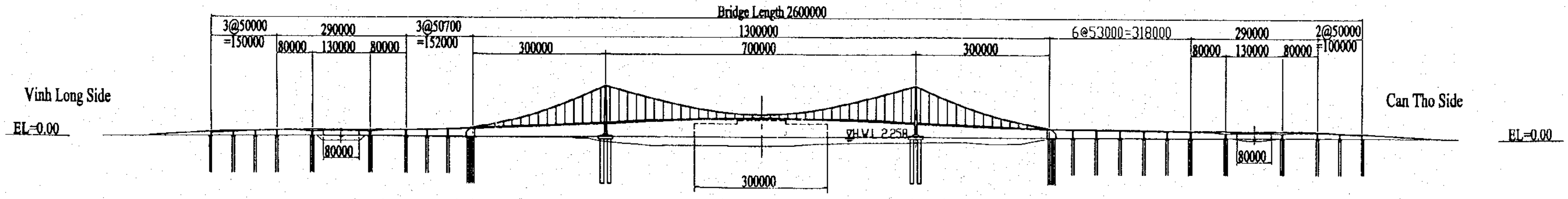
CASE A-1 Steel Cable Stayed

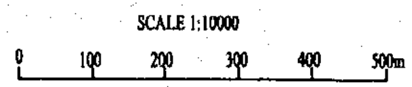


CASE A-2 Steel Cable Stayed



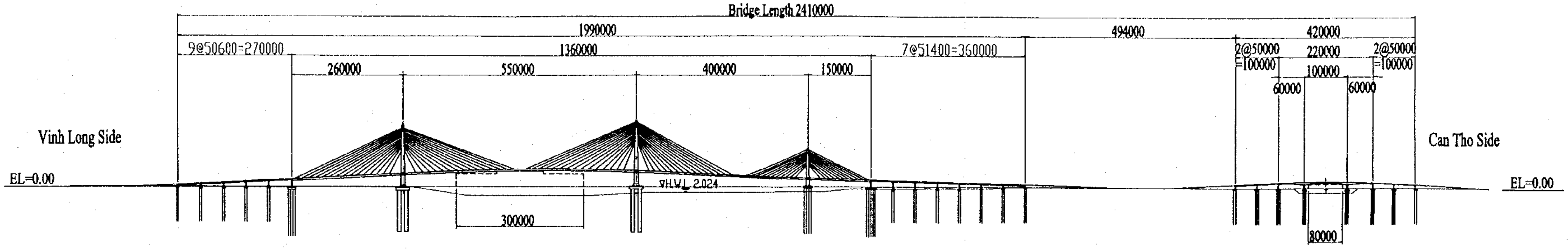
CASE A-3 Suspension Bridge



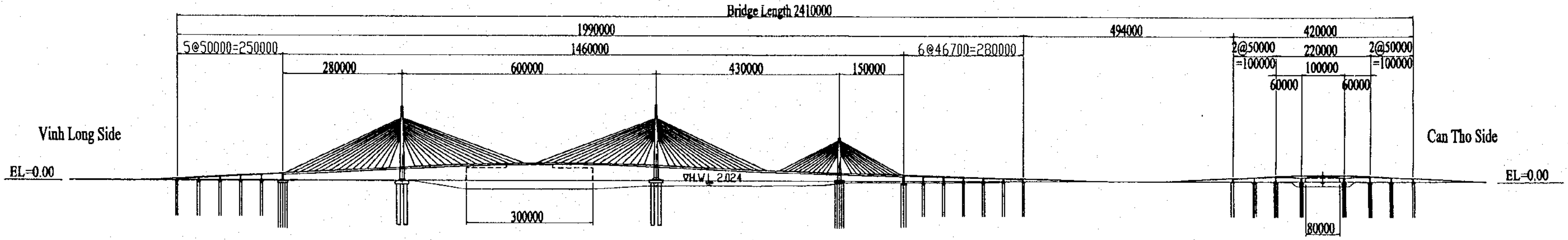


TEH FEASIBILITY STUDY ON THE CAN THO BRIDGE CONSTRUCTION IN SOCIALIST REPUBLIC OF VIET NAM	Fig. 9.2 Alternative Bridge Types for Route (A)
	JAPAN INTERNATIONAL COOPERATION AGENCY

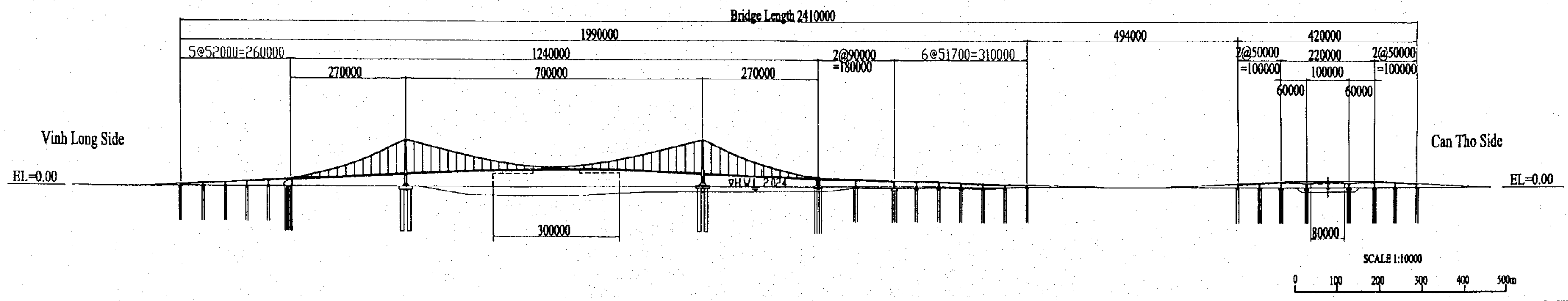
CASE B-1 Steel Cable Stayed



CASE B-2 Steel Cable Stayed



CASE B-3 Suspention Bridge



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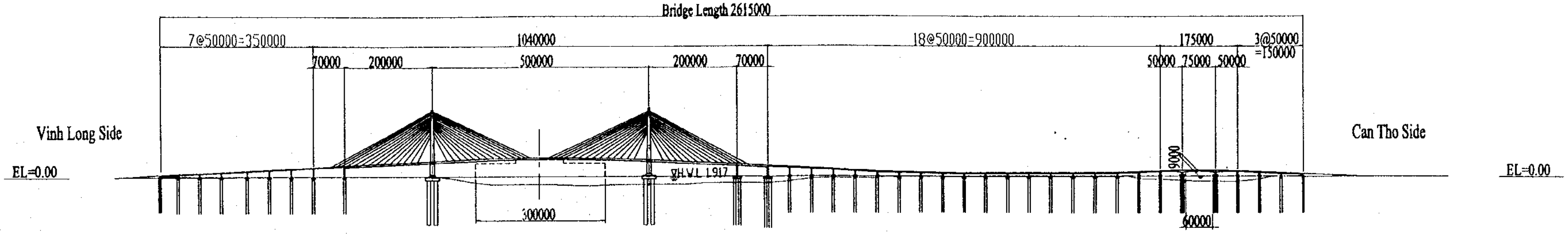
THE CAN THO BRIDGE CONSTRUCTION
IN SOCIALIST REPUBLIC OF VIET NAM

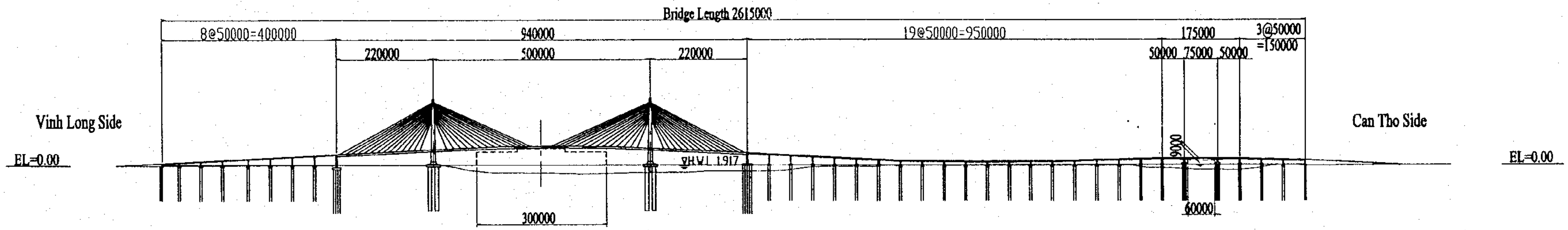
Fig. 9.3 Alternative Bridge Types for Route (B)

JAPAN INTERNATIONAL COOPERATION AGENCY

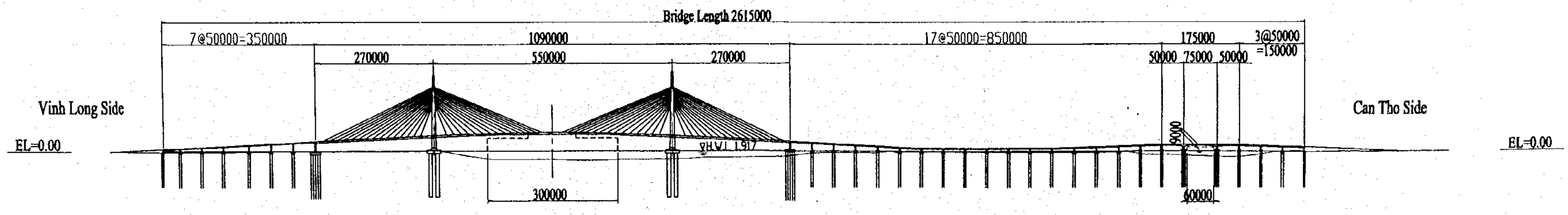
CASE C-1 Hybrid Cable Stayed



CASE C-2 Steel Cable Stayed



CASE C-3 Steel Cable Stayed



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0 100 200 300 400 500m

TEH FEASIBILITY STUDY ON THE CAN THO BRIDGE CONSTRUCTION IN SOCIALIST REPUBLIC OF VIET NAM	Fig. 9.4 Alternative Bridge Types for Route (C)
	JAPAN INTERNATIONAL COOPERATION AGENCY