13.2 Preliminary Design

13.2.1 Preliminary Design of Superstructure

1) Superstructure Design

Major loads to be considered for the checking of the stresses are as follows:

- - Dead load
- - Superimposed dead load
- - Live load (Vietnamese standard including XB80, Australian Standard and AASHTO)
- - Impact
- - Thermal effect
- - Shrinkage
- - Wind load
- - Prestress
-

Under serviceability loads, allowable stresses of materials must be ascertained, and deformation of members especially girders must be limited.

2) Model for Main Bridge Analysis

A frame analysis was done for sectional forces including deformation due to loading: Members of girder and towers have A (area) and I (moment inertia), and members of stay have area A (truss member) as shown as the following figure.

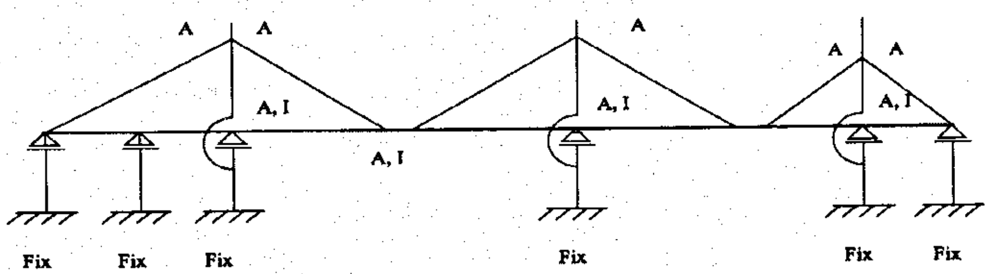


Fig. 13.10 Model for the Main Bridge Analysis

For moving live loads, influence lines were used to obtain the maximum influence of sectional force.

There was approximated 400 nodes.

Section forces at the fixed end of piers were used for calculation of the foundations (N, S, M).

Where
N : Normal Force
S : Shear
M : Bending Moment
A : Sectional area
I : Moment inertia

13.2.2 Effect of Wind Forces

(1) Wind Velocity

In order to construct a wind-resistant superstructure, the historical wind speed and direction data of Can Tho was analyzed using frequency charts. The following figures summarize the results of this analysis, and the following inferences can be made using the results and from the wind characteristics.

- From the monthly summary of the wind data, the average wind speed was 2.5~3.5m/sec. During the months of January ~ April, the wind direction was east to southeast. Between May and September, the wind directions were south/south-west to west. Between October and December, the directions were west to north, north to north-east, north-east to east. The directions are related to the seasons of the region.
- The actual recorded maximum wind velocity was 31m/sec which was recorded in July and August 1979 and in July 1982, and the wind direction during these times was southwest. Also, in the month of June 1970 and 1981, the wind speed was considerable reaching speeds of 30m/sec.

(2) Aerodynamic Stability of Bridge Structure

The problem of aerodynamic stability is crucial for suspension bridges and cable stayed bridges. The deck of a bridge with a long span such as in the cases of suspension and cable stayed bridges, tends to be subjected to flexural and torsional oscillations. For a critical wind velocity, the oscillations are not dampened, but lead to resonance excitation and failure of the structure. As an example of this phenomenon (flutter), the Tacoma Bridge (steel suspension bridge) in U.S.A., collapsed in 1940, under a wind velocity of 19 m/sec. (68 km/hr). The risk of flutter is higher for steel structure bridges, which have a deck lighter than that of concrete bridges. Similarly, wide bridges are less sensitive to flutter than narrow bridges.

Decks of suspension and cable-stayed bridges are subject to Karman vortices, which can lead the structure to resonance excitation. The following illustration shows that vortices are formed at the points where the air flow separates from the surface of a structure. They may break away into the wake at regular intervals causing a periodic variation of force on the structure. Excitation due to periodic formation of vortices in the air-flow in the wake of the structure is primarily dependent on details of the shape of the cross-section of bridge (Fig. 13.11).

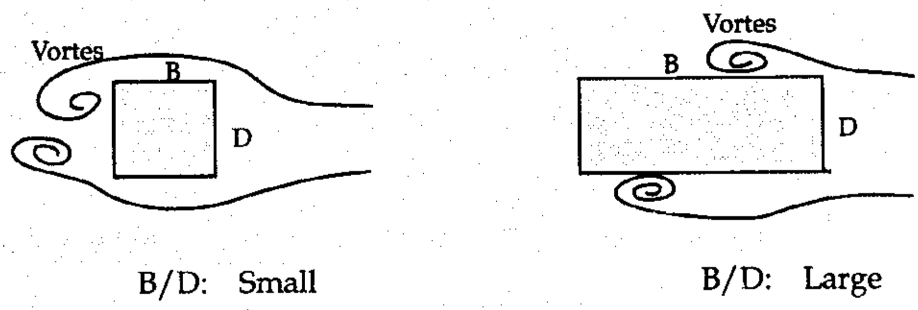


Fig. 13.11 Karman Vortices due to Cross Section

The following concepts regarding the aerodynamic stability for long span bridges are to be considered, however, it is advisable to make tests in wind tunnels in the case of large structures which have a risk of aerodynamic in stability.

- No significant aerodynamic problems may be induced under the condition that the ratio between span length and bridge width is less than 30.
- Complete separation of vortices (vortex shedding), for a rectangular bridge section will be induced, specifically, when the rectangular ratio (B/D) ranges from 0.7 to 2.5, and this situation may be responsible for an unstable phenomenon. This means a wider bridge section is desirable in terms of reducing instability.

- Vertical line load dominates the stresses produced in girders and cables if a bridge span length is less than 200 m, while the stresses in the girders and cables due to the live loads are equivalent to the stresses due to wind blowing if the span length becomes 400 m.
- The critical wind speed which may induce instability on bridge structures ranges from 20 m/s to 50 m/s.
- In the case of the multi-cable bridge, relatively low speed wind-blows will be responsible for cable-vibration during rain, this is called rain-vibration. Some treatment with parallel protrusions on the cable surface may reduce this kind of vibration.

13.2.3 Preliminary Design of Foundation

(1) Foundation Types

For the main bridge (towers), so as to support the large reactions from the superstructure and also considering the deep location of the bearing stratum (approx. 70 to 95 m deep), a multi open caisson type is recommended as shown in Fig. 13.12.

For the approach span bridge, the cast-in-place RC pile foundations are recommended. The comparative table is shown in Fig. 13.13.

(2) Major Elements of Main Bridge Foundation

Each tower foundation of the main bridge consists of six 10.0 m diameter open caissons and a footing (so-called well cap).

As the P9 tower is located in the riverbank on the Vinh Long side, normal practice that the footing is embedded in the ground has been adopted. On the other hand, the P10 foundation projects its footing from the river surface for the safety purpose of navigation. Accordingly, the elevation at the conjunction between caissons and footing for each tower is determined as follows:

Footing Elevation

Tower No.	Bottom Face Elevation of Footing
P9	EL - 7.00 m
P10	EL + 2.00 m

The tip elevation of caissons has been determined on the basis of the rooting depth into the bearing stratum S1. As a result of the preliminary calculation, each foundation has 27.0 m rooting depth as shown in Fig. 13.12. The tip elevations of caissons by the respective towers are summarized below.

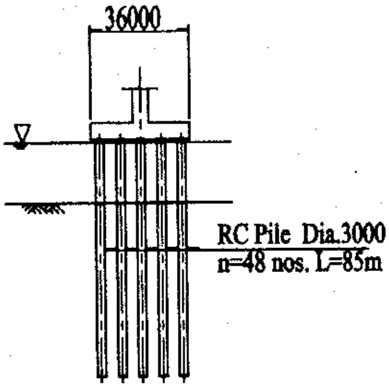
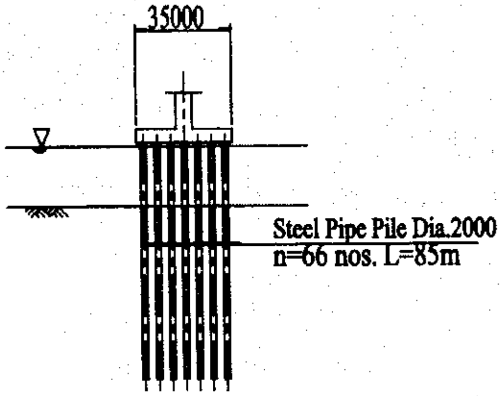
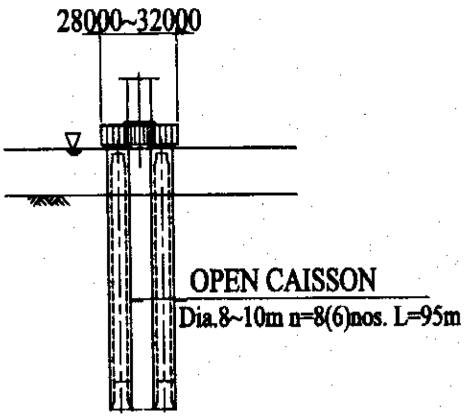
Caisson Tip Elevation

Tower No.	Tip Elevation of Caissons
P9	EL - 97.00 m
P10	EL - 93.00 m

(3) Major Elements of Approach Span Bridge Foundation

The 1.5-m diameter cast-in-place RC piles have been selected as the foundations for the piers in the viewpoints of the cost, construction practice and future maintenance. On the other hand, the 1.5-m and 0.8m diameter steel pipe piles have been selected for the piers in the river where the cast-in-place RC piles require special offshore construction devices. The comparative table is shown in Fig. 13.13. For these steel pipe piles, any protection against corrosion will be required.

As with the footings of the main bridge, pile caps (footings) on the riverbank are embedded in the ground while those in the river are placed above the water surface.

Arrangement of Foundation	Comparative Item		Evaluation	Remarks
Case-1. Cast in Place Concrete Pile (Pile by Reverse Circulation with Steel Casing Pipes) 	Soil Adaptation	Middle Hard Stratum	○	
		Bearing Capacity	△	
	Reliability of Quality Control	Quality of Pile Body	△	
		Construction Joint	○	
	Construction Workability	Particular Equipment	△	
		Construction Period	○	
	Hydrodynamics Problem	Local Scouring	△	
		Flood Hindrance	△	
	Construction cost (Cost Ratio)	18.5million USD (1.135)	△	
	Total Evaluation		△	
Case-2. Steel Pipe Pile (Pile Installation by Inner Excavation and Driving under Bearing Stratum) 	Soil Adaptation	Middle Hard Stratum	○	
		Bearing Capacity	△	
	Reliability of Quality Control	Quality of Pile Body	○	
		Construction Joint	△	
	Construction Workability	Particular Equipment	△	
		Construction Period	○	
	Hydrodynamics Problem	Local Scouring	△	
		Flood Hindrance	△	
	Construction cost (Cost Ratio)	16.8million USD (1.031)	○	
	Total Evaluation		○	
Case-3. Multi Column Piles (Open Caisson with Jack down method) 	Soil Adaptation	Middle Hard Stratum	○	
		Bearing Capacity	○	
	Reliability of Quality Control	Quality of Pile Body	○	
		Construction Joint	○	
	Construction Workability	Particular Equipment	△	
		Construction Period	△	
	Hydrodynamics Problem	Local Scouring	○	
		Flood Hindrance	○	
	Construction cost (Cost Ratio)	16.3million USD (1.000)	○	
	Total Evaluation		◎	to be recommended

TEH FEASIBILITY STUDY ON
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Fig.13.12 Comparative Table of Foundation Types for Main Bridge

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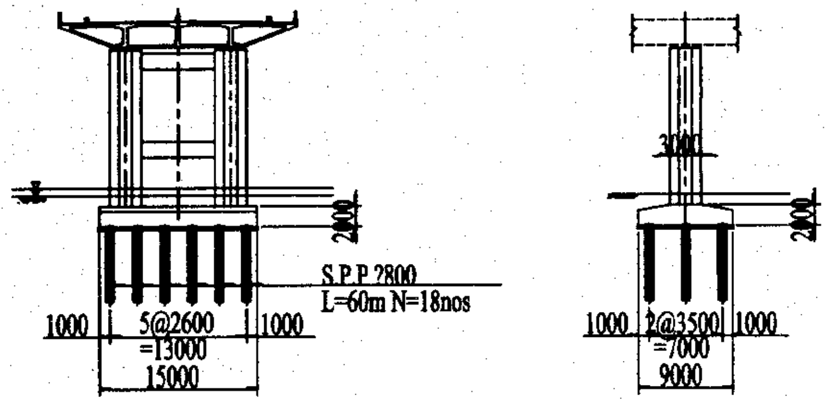
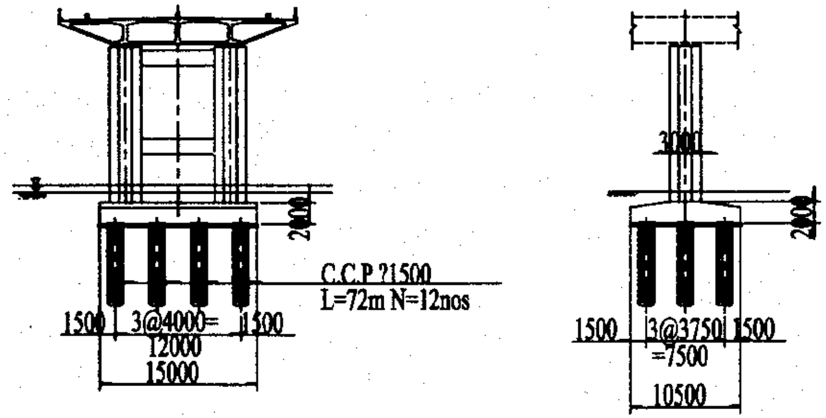
	Arrangement of Foundation	Comparative Item		Evaluation	Remarks
Case-1	Steel Pipe Pile (Pile Installation by Inner Excavation and Driving under Bearing Stratum) 	Soil Adaptation	Bearing Capacity	⊙	
		Reliability of Quality Control	Quality of Pile Body	○	
			Construction Joint	○	
		Construction Workability	Particular Equipment	○	
			Construction Period	○	
		Construction cost (thousand US$)	273 (1.050)	△	
		Total Evaluation		△	
Case-2	Cast in Place Concrete Pile (Pile by Reverse Circulation Method) 	Soil Adaptation	Bearing Capacity	○	
		Riliability of Quality Control	Quality of Pile Body	○	
			Construction Joint	○	
		Construction Workability	Particular Equipment	○	
			Construction Period	○	
		Construction cost (thousand US$)	260 (1.000)	○	
		Total Evaluation		⊙	to be recommended

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Fig.13.13 Comparative Table of Foundation Types for Approach Bridge

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

CHAPTER 14

CONSTRUCTION PLANNING

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14.1 General

The following concepts are fundamental in consideration of the construction planning for this project.

- Maximum utilization of the materials, which can be procured locally (in Vietnam) for reducing the construction cost.
- Minimization of the construction period by applying the prefabricated (segmental) construction method.
- Utilization of local waterways and the Hau River for transporting the construction materials and equipment to site.
- Applying advanced technology for cost saving, shortening the construction period, and maintaining work safety.

14.2 Project Outline

a) Bridge Width : 22.1 m 4- lane carriageway
b) Total Bridge Length : 2,615 m
c) Main Span Bridge:
  - Type: Hybrid Cable-Stayed (Steel and Prestressed Concrete)
  - Span Arrangement : 70+200+500+200+70 = 1,040 m

d) Approach Span Bridges : Total 1,575 m
e) Approach Roads
  - Road Length : Vinh Long Side: 4,990 m; Can Tho Side: 6,917 m; Total 11,907 m
  - Road Width : 23.10 m

f) Intersections
  - Vinh Long Side : Double-Y type intersection
  - Can Tho Side : T-shaped at-grade intersection

14.3 Major Construction Items

Major construction items and their quantities are categorized into main bridge, approach bridges, and approach roads, and they are summarized in Tables 14.1, 14.2, and 14.3.

Table 14.1 Major Construction Items and Quantities (Main Bridge)

Major Construction Item		Unit	Quantity
1. Superstructure			
Towers	Concrete (Design Strength = 500kgf/cm2)	m^3	19,800
	Plain Steel	tf	140
	Steel Bar Reinforcement (SD345) (D51)	tf	1,584
	(Equal or less than D32)	tf	396
Stay Cable		tf	1,366
PC Box Girder	Concrete (Design Strength = 500kgf/cm2)	m^3	12,177
	PC Cable (12T12.7)	tf	365.3
	(1T15.2)	tf	153.5
	Steel Bar Reinforcement (SD345)	tf	1,664
Metal Girder	Atomospheric Corrosion Resisting Steel	tf	2,464
2. Substructure			
Concrete (Design Strength = 240kgf/cm2)		m^3	28,820.6
Steel Bar Reinforcement (SD345)		tf	2,979.7
3. Foundation			
Open Caisson (D = 10.0m) (for Towers)	Concrete(Design Strength = 240kgf/cm2)	m^3	46,758.6
	(Design Strength = 180kgf/cm2)	m^3	3,793.2
	Steel Bar Reinforcement (SD345)	tf	4,675.9
	Excavation	m^3	88,593.1
Steel Pipe Pile (D = 1.5m, L = 70.0m, for P11 & P12)		pile	28
Cast-in-Place RC Pile (D = 1.5m, L = 72.0m, for P7&P8)		pile	24

Table 14.2 Major Construction Items and Quantities (Approach Bridges)

Major Construction Item			Unit	Quantity
(Vinh Long Side)				
1. Superstructure				
PC Box Girder	Concrete (Design Strength = 500kgf/cm2)		m^3	12,177
	PC Cable	(12T12.7)	tf	85.1
		(19T15.2)	tf	113.5
		(1T15.2)	tf	53.5
	Steel Bar Reinforcement (SD345)		tf	873.6
2. Substructure				
Concrete (Design Strength = 240kgf/cm2)			m^3	3,225.7
Steel Bar Reinforcement (SD345)			tf	323.8
3. Foundation				
Cast-in-Place RC Pile (D = 1.5m, L = 72.0m, A1~P6)			pile	80
(Can Tho Side)				
1. Superstructure				
PC Box Girder	Concrete (Design Strength = 500kgf/cm2)		m^3	21,114
	PC Cable	(12T12.7)	tf	325.4
		(19T15.2)	tf	434.0
		(1T15.2)		204.2
	Steel Bar Reinforcement (SD345)		tf	3,166.8
2. Substructure				
Concrete (Design Strength = 240kgf/cm2)			m^3	9,738.2
Steel Bar Reinforcement (SD345)			tf	923.2
3. Foundation				
Steel Pipe Pile (D = 1.5m, L = 70.0m, P13, P31&P32)			pile	36
Steel Pipe Pile (D = 0.8m, L = 65.0m, P29, P30, P33, P34)			pile	72
Cast-in-Place RC Pile (D = 1.5m, L = 72.0m, P14~P28, P34, A2)			pile	160

Table 14.3 Major Construction Items and Quantities (Approach Roads)

Major Construction Item		Unit	Quantity
(Vinh Long Side)			
Road	Earthwork	m^3	543,723
	Subgrade	m^2	90,432
	Pavement (t = 5cm+15cm)	m^2	84,780
	Concrete Block for Slope (300x300x50)	m^2	16,516
	Concrete Kerb	m	8,334
	Concrete Median Barrier	m	4,207
Soft Ground Treatment	Sand mat	m^3	97,951
	Surcharge	m^3	102,496
	Geotextile Drainage	m	40,505
Structures	Minor Bridges	bridge	10
	Culvert Pipe (D = 1,500)	Point	9
	Retaining Wall	m	330
(Can Tho Side)			
Road	Earthwork	m^3	587,515
	Subgrade	m^2	127,853
	Pavement (t = mm)	m^2	119,862
	Concrete Block for Slope (300x300x50)	m^2	24,570
	Concrete Kerb for Roadway surface drainage	m	12,360
	Concrete Median Barrier	m	6,200
Soft Ground Treatment	Sand mat	m^3	121,375
	Surcharge	m^3	118,292
	Geotextile Drainage	m	20,950
Structures	Minor Bridges	bridge	7
	Culvert Pipe (D = 1,500)	Point	6
	Retaining Wall	m	330

14.4 Construction of Superstructure

(1) Main Bridge (Hybrid Cable-Stayed Bridge)

The free cantilever erection method is applied for construction of the superstructure. PC box girders are prefabricated against each other in the yard, i.e., using the steam-cured casting system and stocked. The weight of girder elements is limited to 80 tons due to transportation restrictions and lifting machine capacity. Fabricated elements are then assembled using the stay cable and inner cable.

The layout of stay cables is radial. Anchorages are provided with anti-fatigue devices. The tensioning jack has the capacity to transfer a 1,000tf~2,000tf tensioning force to the cables which are composed of multi-strands. Several cables can be stressed at the same time.

The construction yard has to have space to provide for form work, a short line and bed, stockyard, reinforcement fabricating yard, concrete mixing plant, and space for stockpiling all materials. Transverse prestressing is done by pretensioning.

a) Construction of Tower (lower portion of Tower) (Fig. 14.1)

Concrete is cast by prefabricated staging method for cross beam and lower portion of tower.

b) Erection of Tower (upper portion of Tower) (Fig. 14.1)

Concrete is cast using self climbing form (travelling formwork).

c) Prefabrication of Precast Segment of girder (Fig. 14.3)

d) Cantilever erection from each pier using temporary stay and inner cable. (Fig. 14.2)

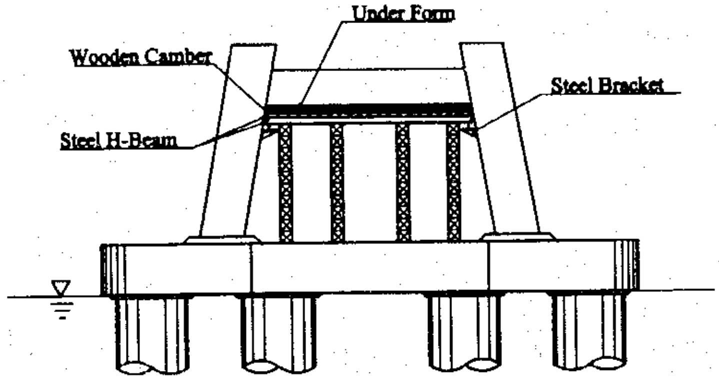
e) Installation and stressing of prefabricated cable stays is done by jack.

f) Closure of Center Span (Fig. 14.2)

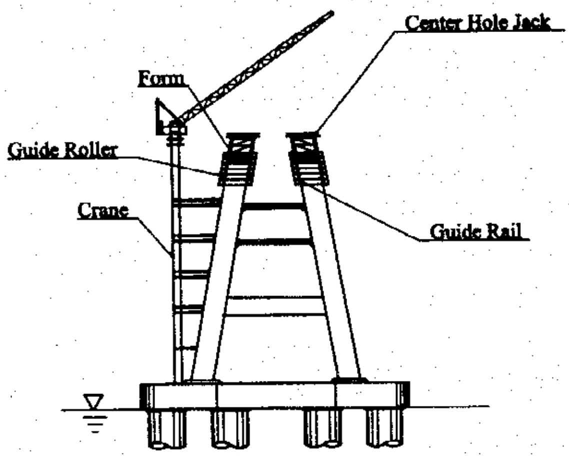
Each segment is transported by truck to the river side and then, transported by barge. Segments are lifted by using a jib crane and joined using PC cables and epoxy resin.

Fig.14.1 Launching Procedure of the Main Bridge

1 Main Tower Works (by Prefabricated Staging)



2 Main Tower Works (2) (by Self Climbing Form)



3 Lift Up of Main Cable (PE-Pipe)

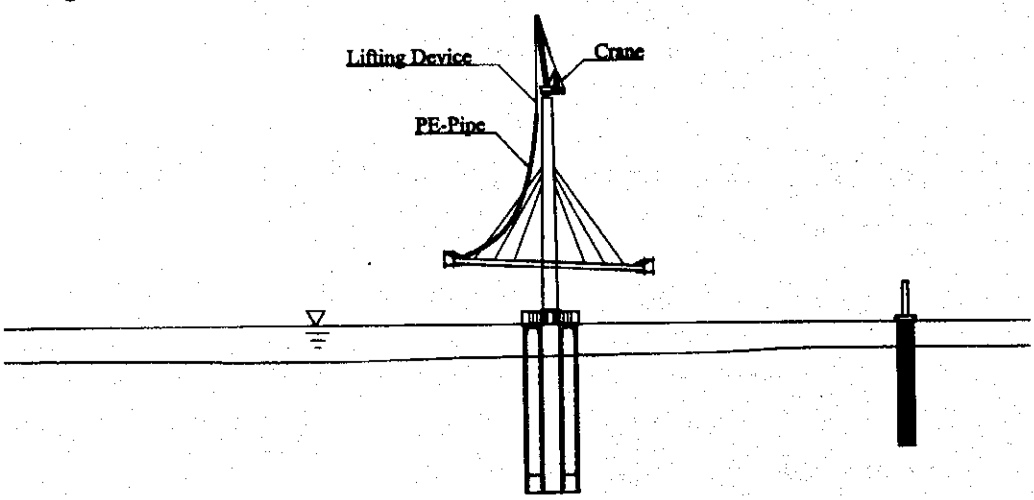
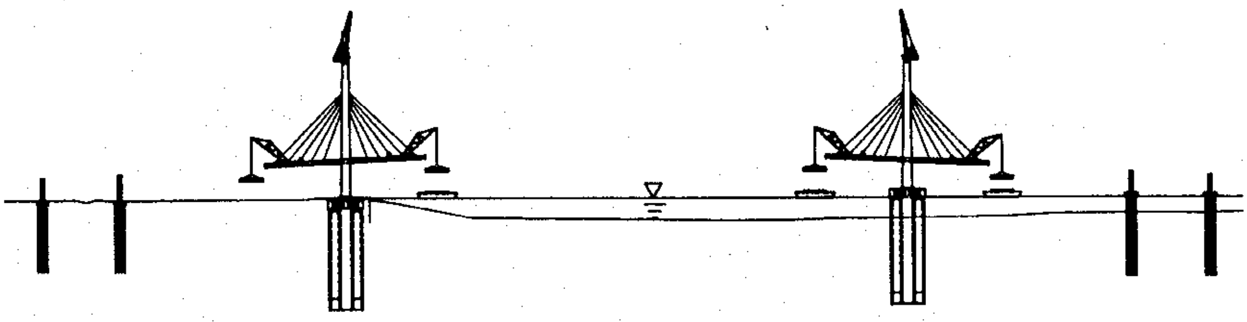
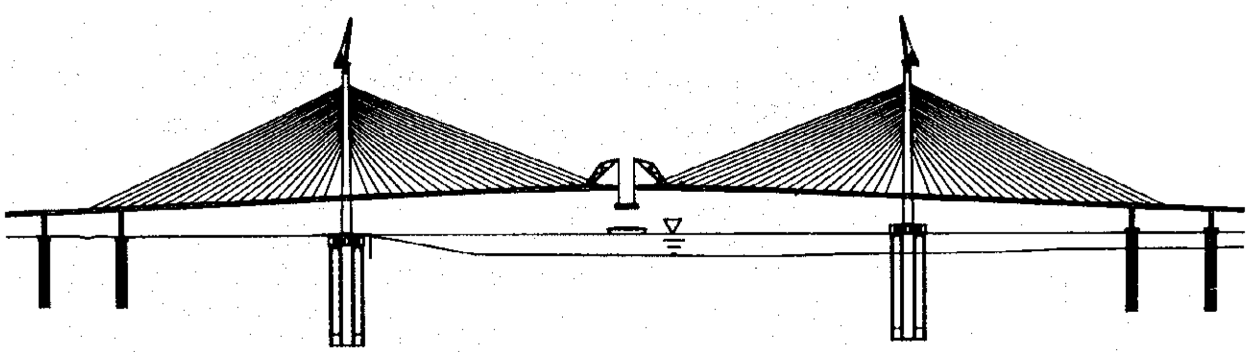


Fig.14.2 Launching Procedure of the Main Bridge

4 Erection of Girder Segment (Cantilever System)



5 Joint of Centr Span (Steel Girder)



A portion of the steel girder is also prefabricated using segmental elements in the factory. For minimizing site work, large scale segmental elements will be transported by sea. The prefabricated segmental block method will contribute to shortening the construction period and also in cost savings.

(2) Construction method of Approach Bridges

Span-by-span construction methods

a) Prefabrication of precast segment in the yard (Fig. 14.3)

- Precast segments are fabricated using the short-line system in the yard and steam cured.
- The precast segment weight is limited to 80 ton. A 2.5 m long segmental precast block is used.

b) Erection using erection truss (Fig. 14.4)

- Precast segments are assembled and prestressed using the outer cable on the erection truss span by span.
- The cross anchorage method is used for continuity of spans and continuous inner cables are installed for later tensioning.
- The erection truss can be shifted and reused span by span.

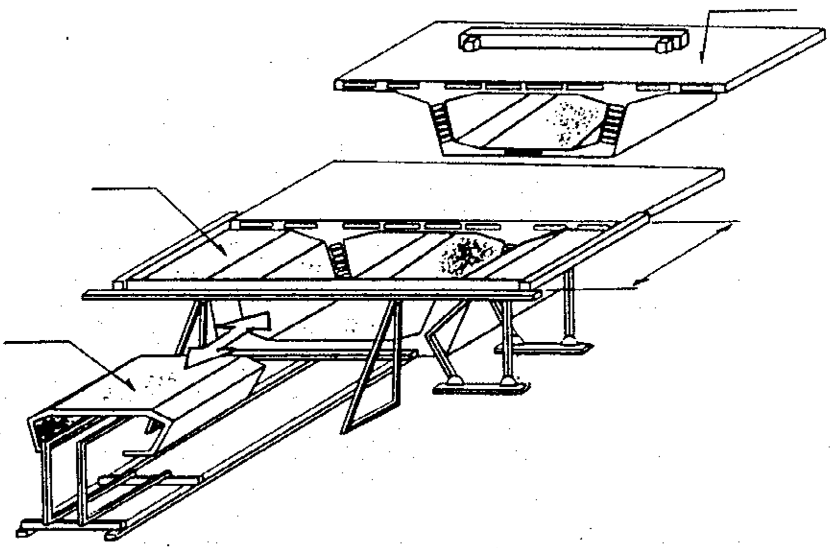
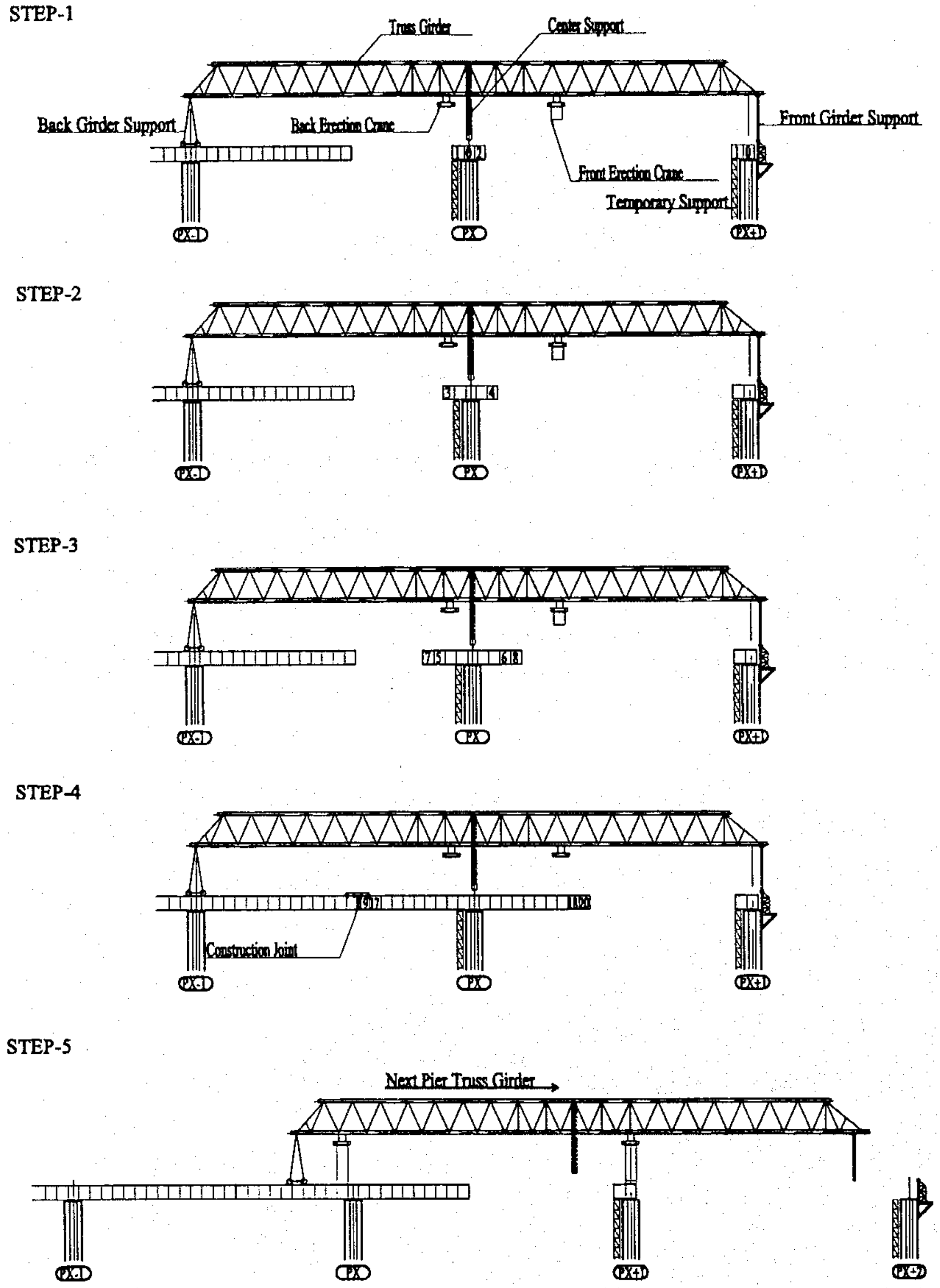


Fig. 14.3 Prefabrication of Precast Segment in the Yard (Shortline System)

Fig.14.4 Launching Girder Procedure (Approach Viaduct)



14.5 Construction of Substructures and Foundations

(1) General

The construction condition of the individual substructures is summarized below.

Table 14.4 Types of Substructure and Foundation (1 of 2)

Sequence No. of Substructure	Type and Height of Substructures		Type of Foundation
A1	Inverted T type	9.5m	C.P.P. D = 1,500 N = 10 L = 72.0m
P1	Twin Column type	9.6m	C.P.P. D = 1,500 N = 10 L = 72.0m
P2	Twin Column type	11.8m	C.P.P. D = 1,500 N = 12 L = 72.0m
P3	Twin Column type	14.1m	C.P.P. D = 1,500 N = 12 L = 72.0m
P4	Twin Column type	16.3m	C.P.P. D = 1,500 N = 12 L = 72.0m
P5	Twin Column type	18.6m	C.P.P. D = 1,500 N = 12 L = 72.0m
P6	Twin Column type	20.8m	C.P.P. D = 1,500 N = 12 L = 72.0m
P7	Twin Column type	23.1m	C.P.P. D = 1,500 N = 12 L = 72.0m
P8	Twin Column type	26.0m	C.P.P. D = 1,500 N = 12 L = 72.0m
P9	Main Tower	149.6m	Open Caisson D = 10,000 N = 6 L = 90.0m
P10	Main Tower	140.6m	Open Caisson D = 10,000 N = 6 L = 95.0m
P11	Twin Column type	22.3m	S.P.P. D = 1,500 N = 16 L = 70.0m
P12	Twin Column type	19.6m	S.P.P. D = 1,500 N = 12 L = 70.0m
P13	Twin Column type	17.4m	S.P.P. D = 1,500 N = 12 L = 70.0m
P14	Twin Column type	22.4m	C.P.P. D = 1,500 N = 12 L = 72.0m
P15	Twin Column type	20.2m	C.P.P. D = 1,500 N = 12 L = 72.0m

Note: S.P.P.: Steel Pipe Pile
C.P.P.: Cast-in-Place RC Pile

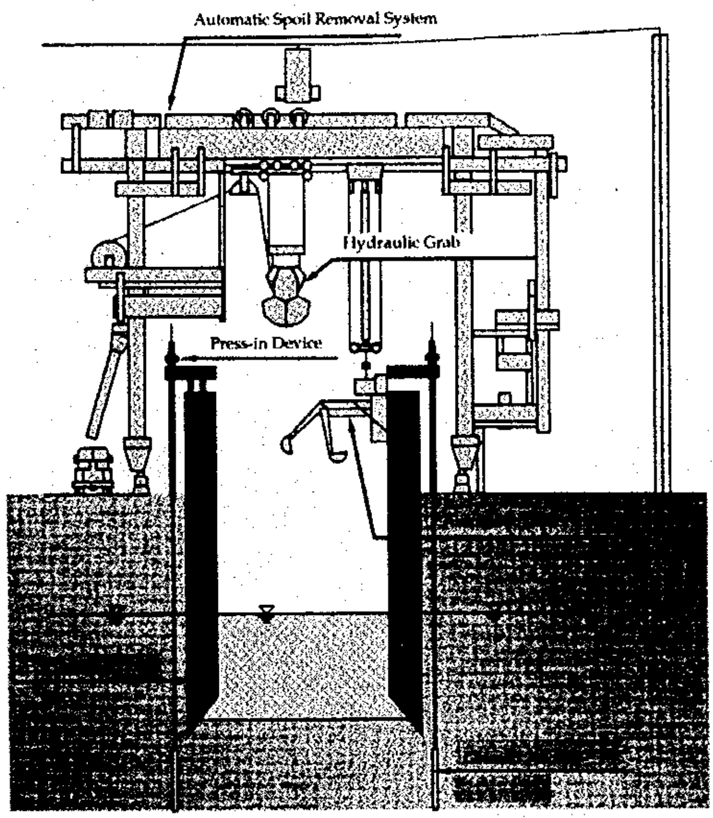
Table 14.4 Types of Substructure and Foundation (2 of 2)

Sequence No. of Substructure	Type and Height of Substructures		Type of Foundation
P16	Twin Column type	16.9m	C.P.P. D = 1,500 N = 12 L = 72.0m
P17	Twin Column type	14.7m	C.P.P. D = 1,500 N = 12 L = 72.0m
P18	Twin Column type	11.0m	C.P.P. D = 1,500 N = 12 L = 72.0m
P19	Twin Column type	9.0m	C.P.P. D = 1,500 N = 10 L = 72.0m
P20	Twin Column type	7.9m	C.P.P. D = 1,500 N = 10 L = 72.0m
P21	Twin Column type	7.6m	C.P.P. D = 1,500 N = 10 L = 72.0m
P22	Twin Column type	7.4m	C.P.P. D = 1,500 N = 10 L = 72.0m
P23	Twin Column type	7.3m	C.P.P. D = 1,500 N = 10 L = 72.0m
P24	Twin Column type	7.3m	C.P.P. D = 1,500 N = 10 L = 72.0m
P25	Twin Column type	7.4m	C.P.P. D = 1,500 N = 10 L = 72.0m
P26	Twin Column type	7.6m	C.P.P. D = 1,500 N = 10 L = 72.0m
P27	Twin Column type	8.1m	C.P.P. D = 1,500 N = 10 L = 72.0m
P28	Twin Column type	9.9m	C.P.P. D = 1,500 N = 10 L = 72.0m
P29	Twin Column type	7.3m	S.P.P. D = 800 N = 18 L = 65.0m
P30	Wall type	9.2m	S.P.P. D = 800 N = 18 L = 65.0m
P31	Wall type	8.2m	S.P.P. D = 1,500 N = 12 L = 70.0m
P32	Wall type	8.2m	S.P.P. D = 1,500 N = 12 L = 70.0m
P33	Wall type	9.2m	S.P.P. D = 800 N = 18 L = 65.0m
P34	Twin Column type	7.3m	S.P.P. D = 800 N = 18 L = 65.0m
P35	Twin Column type	8.3m	C.P.P. D = 1,500 N = 10 L = 72.0m
A2	Inverted T type	8.2m	C.P.P. D = 1,500 N = 10 L = 72.0m

Note: S.P.P.: Steel Pipe Pile
C.P.P.: Cast-in-Place RC Pile

(2) Open Caisson Foundation

The construction method is the automatic open caisson system with a jacking system for sinking of the caisson. This method is applied considering the depth to be excavated and the construction schedule. The excavating machine has an automatic underwater excavator and a hydraulic grab, and the excavating work under water can be controlled at ground level. Excavated subsoil is discharged by the hydraulic grab. One type of automatic open caisson system and the work procedure is shown in Fig. 14.5 and 14.6.



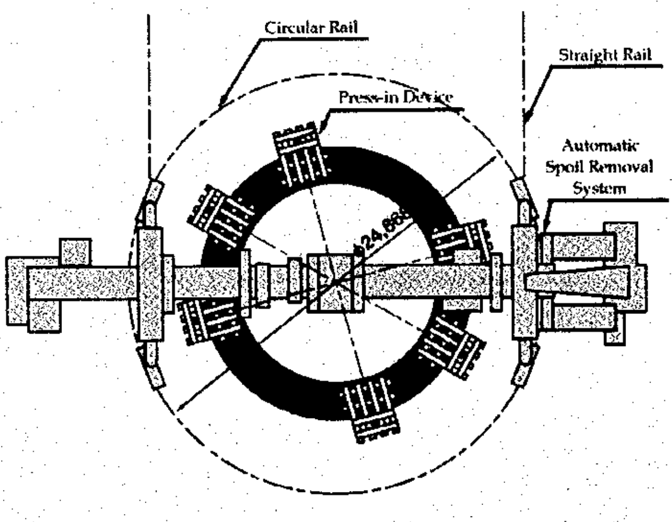


Fig. 14.5 Composition of the Automatic Open Caisson System

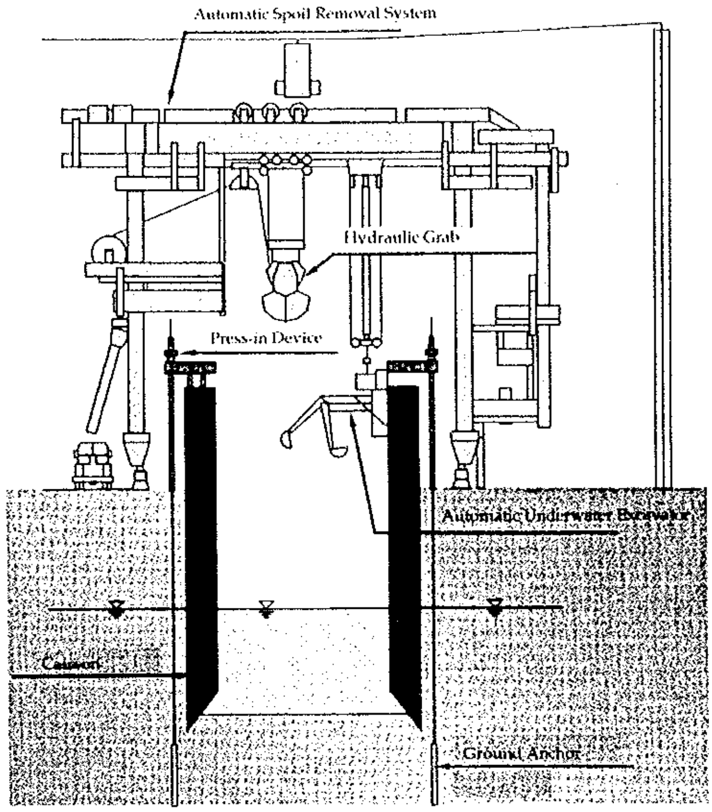
Table 14.4 Types of Substructure and Foundation (2 of 2)

Sequence No. of Substructure	Type and Height of Substructures		Type of Foundation
P16	Twin Column type	16.9m	C.P.P. D = 1,500 N = 12 L = 72.0m
P17	Twin Column type	14.7m	C.P.P. D = 1,500 N = 12 L = 72.0m
P18	Twin Column type	11.0m	C.P.P. D = 1,500 N = 12 L = 72.0m
P19	Twin Column type	9.0m	C.P.P. D = 1,500 N = 10 L = 72.0m
P20	Twin Column type	7.9m	C.P.P. D = 1,500 N = 10 L = 72.0m
P21	Twin Column type	7.6m	C.P.P. D = 1,500 N = 10 L = 72.0m
P22	Twin Column type	7.4m	C.P.P. D = 1,500 N = 10 L = 72.0m
P23	Twin Column type	7.3m	C.P.P. D = 1,500 N = 10 L = 72.0m
P24	Twin Column type	7.3m	C.P.P. D = 1,500 N = 10 L = 72.0m
P25	Twin Column type	7.4m	C.P.P. D = 1,500 N = 10 L = 72.0m
P26	Twin Column type	7.6m	C.P.P. D = 1,500 N = 10 L = 72.0m
P27	Twin Column type	8.1m	C.P.P. D = 1,500 N = 10 L = 72.0m
P28	Twin Column type	9.9m	C.P.P. D = 1,500 N = 10 L = 72.0m
P29	Twin Column type	7.3m	S.P.P. D = 800 N = 18 L = 65.0m
P30	Wall type	9.2m	S.P.P. D = 800 N = 18 L = 65.0m
P31	Wall type	8.2m	S.P.P. D = 1,500 N = 12 L = 70.0m
P32	Wall type	8.2m	S.P.P. D = 1,500 N = 12 L = 70.0m
P33	Wall type	9.2m	S.P.P. D = 800 N = 18 L = 65.0m
P34	Twin Column type	7.3m	S.P.P. D = 800 N = 18 L = 65.0m
P35	Twin Column type	8.3m	C.P.P. D = 1,500 N = 10 L = 72.0m
A2	Inverted T type	8.2m	C.P.P. D = 1,500 N = 10 L = 72.0m

Note: S.P.P.: Steel Pipe Pile
C.P.P.: Cast-in-Place RC Pile

(2) Open Caisson Foundation

The construction method is the automatic open caisson system with a jacking system for sinking of the caisson. This method is applied considering the depth to be excavated and the construction schedule. The excavating machine has an automatic underwater excavator and a hydraulic grab, and the excavating work under water can be controlled at ground level. Excavated subsoil is discharged by the hydraulic grab. One type of automatic open caisson system and the work procedure is shown in Fig. 14.5 and 14.6.



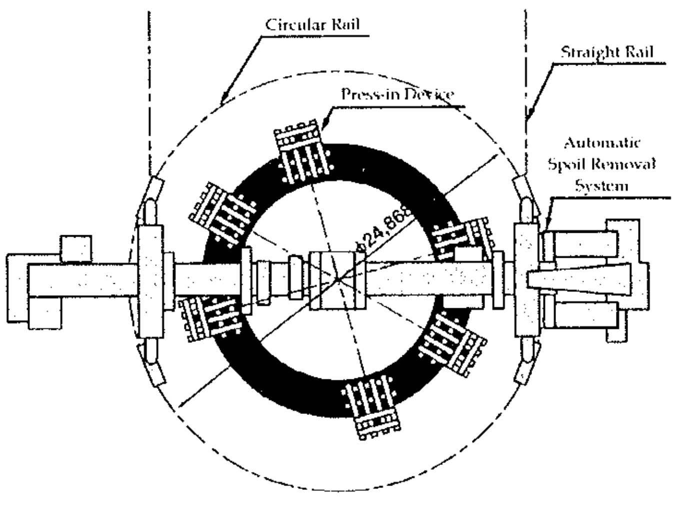
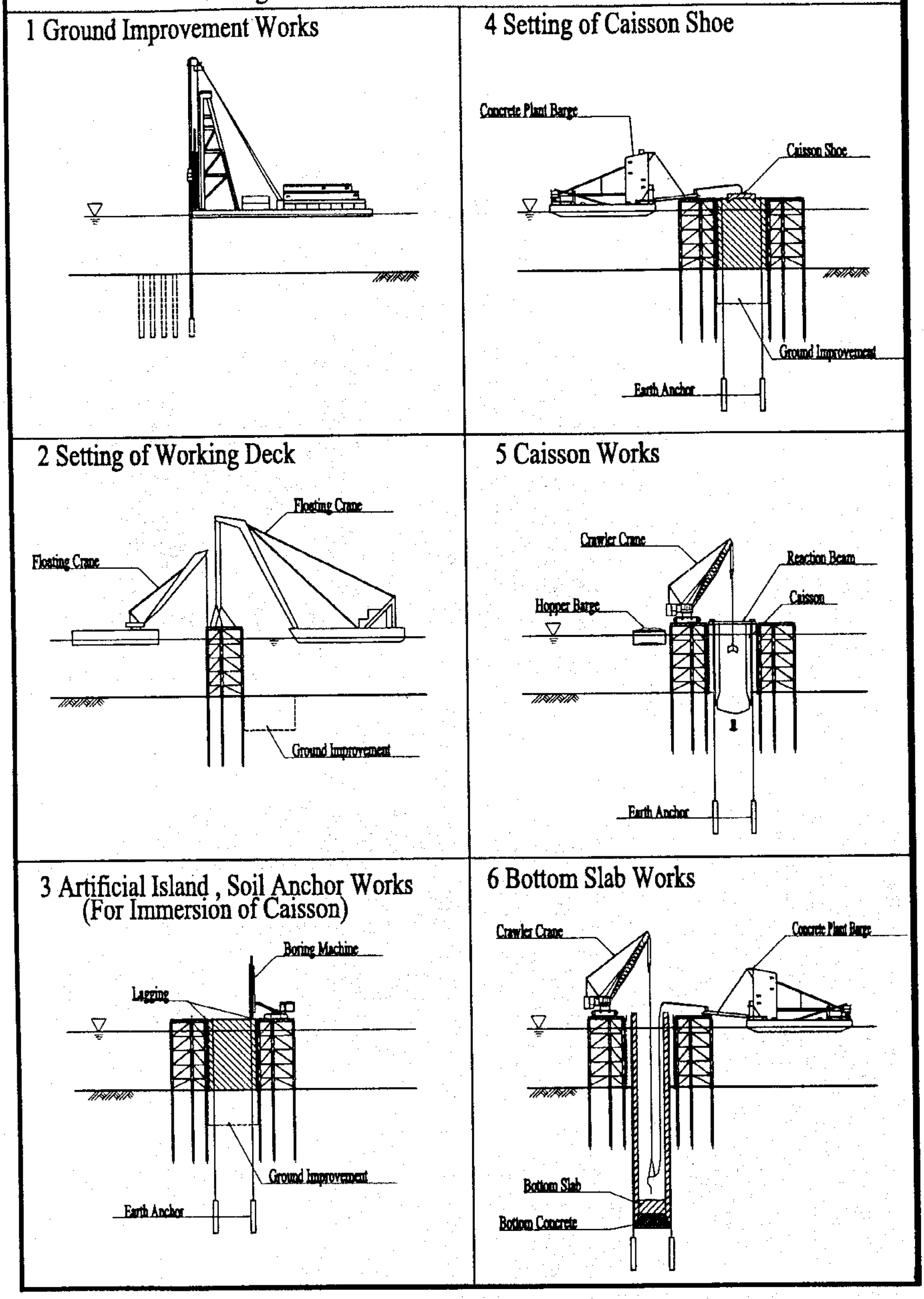


Fig. 14.5 Composition of the Automatic Open Caisson System

Fig.14-6 Caisson Work Procedure



14.6 Source and Procurement of Construction Materials

Major materials required for the Can Tho Bridge construction are summarized in Table 14.5.

Table 14.5 Major Required Materials

Major Construction Materials	Subject of Construction	Procurement (Local / Imported)
Cement	Structure	Local & Imported
Steel Bar Reinforcement	Structure	Local & Imported
PC tendon and anchor system	PC superstructure	Imported
Structural steel	Steel superstructure	Imported
Aggregate (Rock products)	Coarse aggregate of concrete and base coarse of road pavement	Local
Natural sand	Fine aggregate of concrete and embankment filling for approach road	Local
Steel Pipe Pile	Foundation	Imported

(1) Cement

Cement is locally manufactured in Viet Nam, however, the quality is not regarded as being suitable for the high strength concrete (Design Strength = 500kgf/cm^2) which will be used for the precast segmental blocks of the prestressed concrete girder, etc.

However, a new cement plant is now under construction at the Western Kien Giang town of Kien Luong, and a better quality product is likely to be available from this plant. The location of the new plant is shown in Fig. 14.7.

Cement from this new plant will be used for high strength concrete after inspection at the detailed design stage, if the quality and quantity are appropriate. In the case that the quality and quantity are not acceptable or adequate, imported cement will be used.

Admixtures for high strength concrete are to be imported.

For lower strength concrete which will be used in the substructures, foundations, and structures of the approach roads, locally produced cement will be used.

(2) Steel Bar Reinforcement

Similarly to cement, steel bar reinforcement of the required high strength will be imported, and locally produced steel bar reinforcement will be used for the bridge structures in which high strength is not normally required.

(3) PC tendon and anchor system

Because of its importance for the superstructure construction, all materials and equipment for the Project will be imported from outside Viet Nam.

(4) Structural steel

Structural steel is mainly used for the superstructure, and for the metal portion of girders where atomospheric corrosion resisting steel is to be used. Imported structural steel will be used because of short supply and sub-standard quality available locally.

(5) Aggregate (Rock products)

Aggregate is used for the coarse aggregate of concrete and also for the base coarse of road pavement. Based on the locations of potential source, some quarries were investigated. The location of these quarries is shown in Fig. 14.7, and a summary of the suitability survey is listed in Table 14.6.

For transport from source to site, barges, (which are generally used in Vietnamese waterway areas,) will be employed.

For the detail design, based on the conditions of the material sources mentioned above, a further study for the cost estimate will be made.

Subsoil survey program for the detail design is described in Chapter 6, section 6.3 "Earth and Rock materials".

Table 14.6 Summary of Source of Rock surveyed

Quarry	Distance from site	Type of Rock	Description
Bien Hoa	350km	Andesite	Suitable for coarse aggregate of concrete (Including High Strength Concrete) and base coarse of road pavement
Nui Sap	120km	Granite	Suitable for coarse aggregate of concrete (Including High Strength Concrete) and base coarse of road pavement
Vung Tau	220km	Granite	Suitable for base coarse of road pavement only
Ań Giang	140km	Granite	Suitable for base coarse of road pavement only

*Note; Distance is for barge transportation.

(6) Natural sand

Natural sand is used for the fine aggregate of the concrete and also the embankment filling of the approach road. Based on the locations of potential sources, some of these were investigated. All of the sources investigated are located at the riverside. Locations of these sources are shown in Fig. 14.7, and summary of the suitability survey is listed in Table 14.7.

As for aggregate, barges will be employed for transport, and a further study for the cost estimate will be made based on the suitability conditions of the sources mentioned below for the preliminary design.

Subsoil survey program for the detail design is described in Chapter 6, section 6.3 "Earth and Rock materials".

Table 14.7 Summary of Source of Sand surveyed

Source	Distance from site	Description
Dong Nai	400km	Fine sands suitable for fine aggregate of concrete and embankment filling of approach road.
Long Xuyen	120km	As above
Soc Trang	120km	As above

*Note; Distance is for barge transportation.

The sand from the Don Nai river will be the most suitable for the fine aggregate for concrete, because of its quality and available quantity.

This source also has enough sand for the embankment filling of the approach roads.

For other potential sources, the entrance/estuary of the Hau River will be considered. Dredging work at the estuary of the Hau River has been studied by the Belgium consultant from mid. 1995 to September 1998. This is the feasibility study for achieving and maintaining a safe navigation channel, and in 1990 and 1997, the river estuary was dredged (200,000m^3 of sand in each year).

In the likelihood that this dredging project will be carried out, a large quantity of sea sand will be dredged. Sea sand is not suitable for the fine aggregate of concrete; however, it is possible to use it for road embankment filling. Therefore, this dredging project will be considered as an alternative source for the embankment filling of approach roads.

(7) Steel Pipe Pile

Steel pipe piles which are used for the foundations of the main and approach bridges, will be procured as imported material because of the importance of their function.

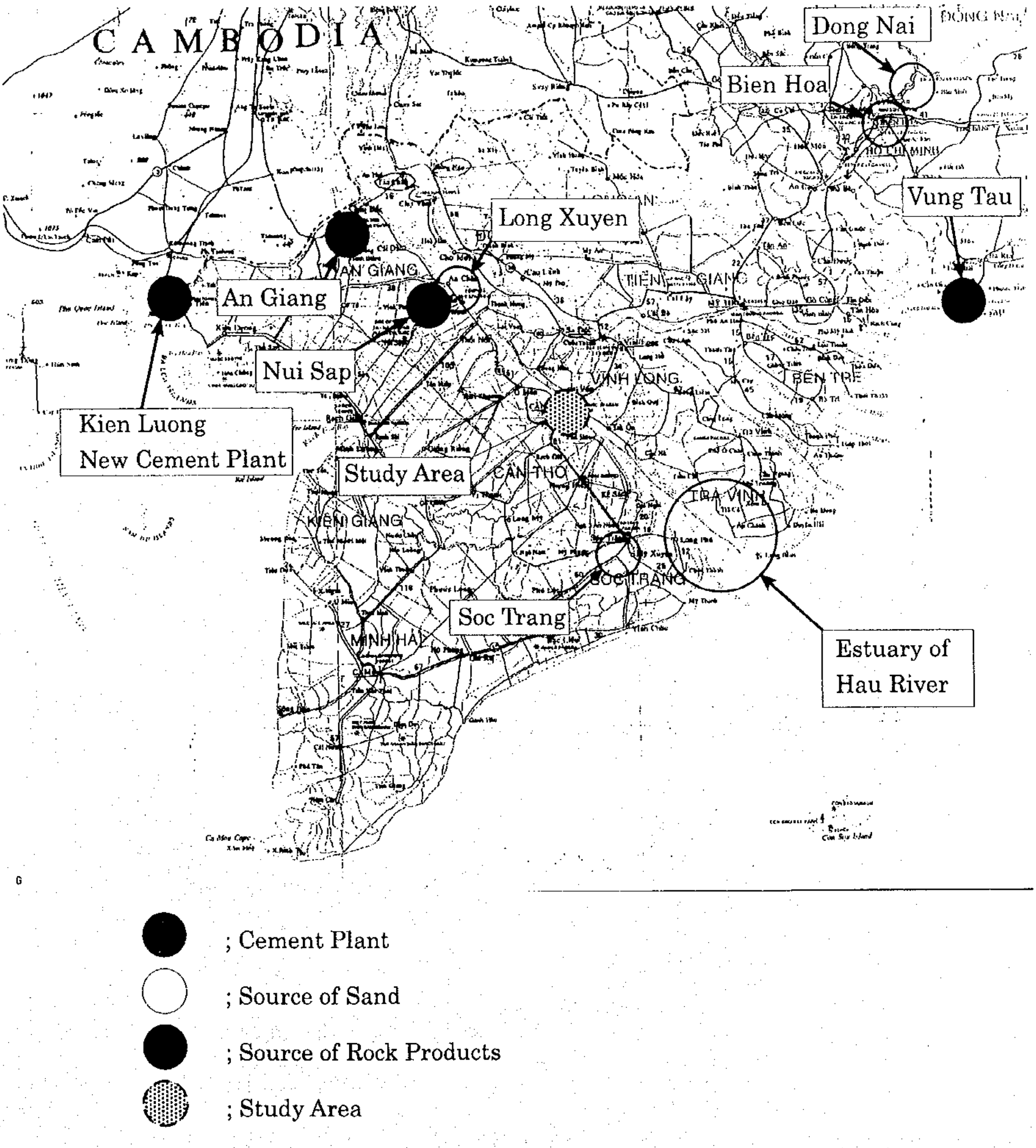


Figure 14.7 Location of Investigated Sources

14.7 Construction Packaging and Schedule

14.7.1 Construction Packaging

Considering total project condition, the construction for the Project has been divided into five packages as follows:

Package-1) Main Bridge
Package-2) Approach Bridge on Vinh Long side
Package-3) Approach Bridge on Can Tho side
Package-4) Approach Road on Vinh Long side
Package-5) Approach Road on Can Tho side

The interface between the construction packages would have to be coordinated appropriately with the responsibility of the administration by the PMU My Thuan and the construction supervision by the international consultant.

Project feature and major construction works of each package are described as below:

(1) Package-1 Main Bridge

Table 14.8 Project Outline of Package-1

<Object to be constructed> Hybrid Cable Stayed Bridge (Total Bridge Length = 1,040m)		
<Total Project Period>	November, 2000 ~ June, 2005	
- Pre Qualification:	November, 2000 ~ January, 2001	(3months)
- Tender:	June, 2001 ~ September, 2001	(4months)
- Construction:	October, 2001 ~ June, 2005	(45months)

<Major Construction Works>
1) Mobilization
2) Foundation and Substructure
- S.P.P. Construction in the waterway
- C.P.P. Construction on the ground
- Open Caisson Construction (in the waterway, on the ground)
- Construction of Caisson Caps (in the waterway, on the ground)
- Construction of Main Towers (in the waterway, on the ground)

3) Superstructure
- PC Precast Segmental Block Production
- PC Precast Segmental Block Erection
- Steel Segmental Block Production
- Steel Segmental Block Erection
- Stay Cable Installation
- Connection of Center Span and End Span
- Bridge Surface Works

4) Riverbank Protection
5) Demobilization

(2) Package-2 Approach Bridge on Vinh Long side

Table 14.9 Project Outline of Package-2

<Object to be constructed> PC Box Girder Bridge	(Total Bridge Length = 350m)	
<Total Project Period>	November, 2000 ~ November, 2004	
- Pre Qualification:	November, 2000 ~ January, 2001	(3months)
- Tender:	June, 2001 ~ September, 2001	(4months)
- Construction:	October, 2001 ~ November, 2004 (36months)	
<Major Construction Works> 1) Mobilization 2) Foundation and Substructure - C.P.P. Construction on the ground - Construction of Substructures on the ground 3) Superstructure - PC Precast Segmental Block Production - PC Precast Segmental Block Erection - Connection of Center Span and End Span - Bridge Surface Works 4) Demobilization		

(3) Package-3 Approach Bridge on Can Tho side

Table 14.10 Project Outline of Package-3

<Object to be constructed> PC Box Girder Bridge and PC Balanced Cantilever Bridge (Total Construction Length of Bridges = 1,225m)		
- PC Box Girder Bridge	Total Bridge Length = 900m	
- PC Balanced Cantilever Bridge	Total Bridge Length = 175m	
- PC Box Girder Bridge	Total Bridge Length = 150m	
<Total Project Period>	November, 2000 ~ December, 2004	
- Pre Qualification:	November, 2000 ~ January, 2001	(3months)
- Tender:	June, 2001 ~ September, 2001	(4months)
- Construction:	October, 2001 ~ December, 2004 (39months)	
<Major Construction Works> 1) Mobilization 2) Foundation and Substructure - C.P.P. Construction on the ground - S.P.P. Construction in the waterway - Construction of Substructures (in the waterway, on the ground) 3) Superstructure - PC Precast Segmental Block Production - PC Precast Segmental Block Erection - Balanced Cantilever erection works - Connection of Center Span and End Span - Bridge Surface Works 4) Demobilization		

(4) Package-4 Approach Road on Vinh Long side

Table 14.11 Project Outline of Package-4

<Object to be constructed>		
Total Construction Length of Approach Road = 4,990m		
- Earthwork	Total Length = 4,475m	
- Minor Bridges	Total Length = 515m	
- Service Area	Total Area = 15,000m^2 (Near the River bank, South side)	
<Total Project Period>	November, 2000 ~ November, 2004	
- Pre Qualification:	November, 2000 ~ January, 2001	(3months)
- Tender:	June, 2001 ~ September, 2001	(4months)
- Construction:	October, 2001 ~ November, 2004	(38months)
<Major Construction Works>		
1) Mobilization		
2) Road Works	- Earthwork	
	- Base Course and Subgrade	
	- Pavement & Road Surface works	
	- Slope Protection Work	
3) Structures	- Minor Bridges	
	- Culvert Pipe	
	- Retaining Walls	
4) Soft Ground Treatment		
5) Service Area		
6) Demobilization		

(5) Package-5 Approach Road on Can Tho side

Table 14.12 Project Outline of Package-5

<Object to be constructed>		
Total Construction Length of Approach Road = 6,917m		
- Earthwork	Total Length = 6,517m	
- Minor Bridges	Total Length = 400m	
- Service Area	Total Area = 15,000m^2 (Near the River bank, North side)	
- Toll Gate	(Near the Service Area)	
<Total Project Period>	November, 2000 ~ November, 2004	
- Pre Qualification:	November, 2000 ~ January, 2001	(3months)
- Tender:	June, 2001 ~ September, 2001	(4months)
- Construction	October, 2001 ~ November, 2004	(38months)
<Major Construction Works>		
1) Mobilization		
2) Road Works	- Earthwork	
	- Base Course and Subgrade	
	- Pavement & Road Surface works	
	- Slope Protection Work	
3) Structures	- Minor Bridges	
	- Culvert Pipe	
	- Retaining Walls	
4) Soft Ground Treatment		(Continued to next page)

5) Service Area and Toll Gate * As described in Chapter 17, 17.5.2 (4), the gardening-tourism areas are to be planned in the Con Au Island, and also access between this tourism areas and service area is to be planned in the future. 6) Demobilization

14.7.2 Construction Schedule

The construction schedule is established considering the individual package, total construction period, and the coordination of whole packages.

Recommended construction schedule is shown in Fig 14.8.

(1) General

a) Rainy Season

Generally, the rainy season of the project site is from June to October, and the difference of the highest flood level (HFL) between rainy season and non-rainy season is approximately, 1 m. It is a small enough difference that construction works of foundations and substructures in the waterway are available during the rainy season without any additional temporary works.

b) Pre-loading Work for Soft Ground Treatment

For the road section with the high embankment, pre-loading work is necessary as the countermeasure to the consolidation settlement. After pre-loading work is done, the treated ground has to leave to promote sinking, desirably 1.5~2years. This term can be critical pass for the construction of abutments where the embankment and bridge structures are to be connected. The packages which have the construction works of abutments are:

Table 14.13 Package including Abutment construction

Package		Abutments
- Package-4	Approach Road on Vinh Long side	- A1 abutment of Approach Bridge on Vinh Long side - Abutments of Minor Bridges
- Package-5	Approach Road on Can Tho side	- A2 abutment of Approach Bridge on Can Tho side - Abutments of Minor Bridges

This pre-loading work can be also critical for Package-2 and 3, so for packages 4 and 5, pre-loading works have to be done at the beginning of the construction phase.

Fig 14.8 Recommended Construction Schedule

Rainy Season: June~October

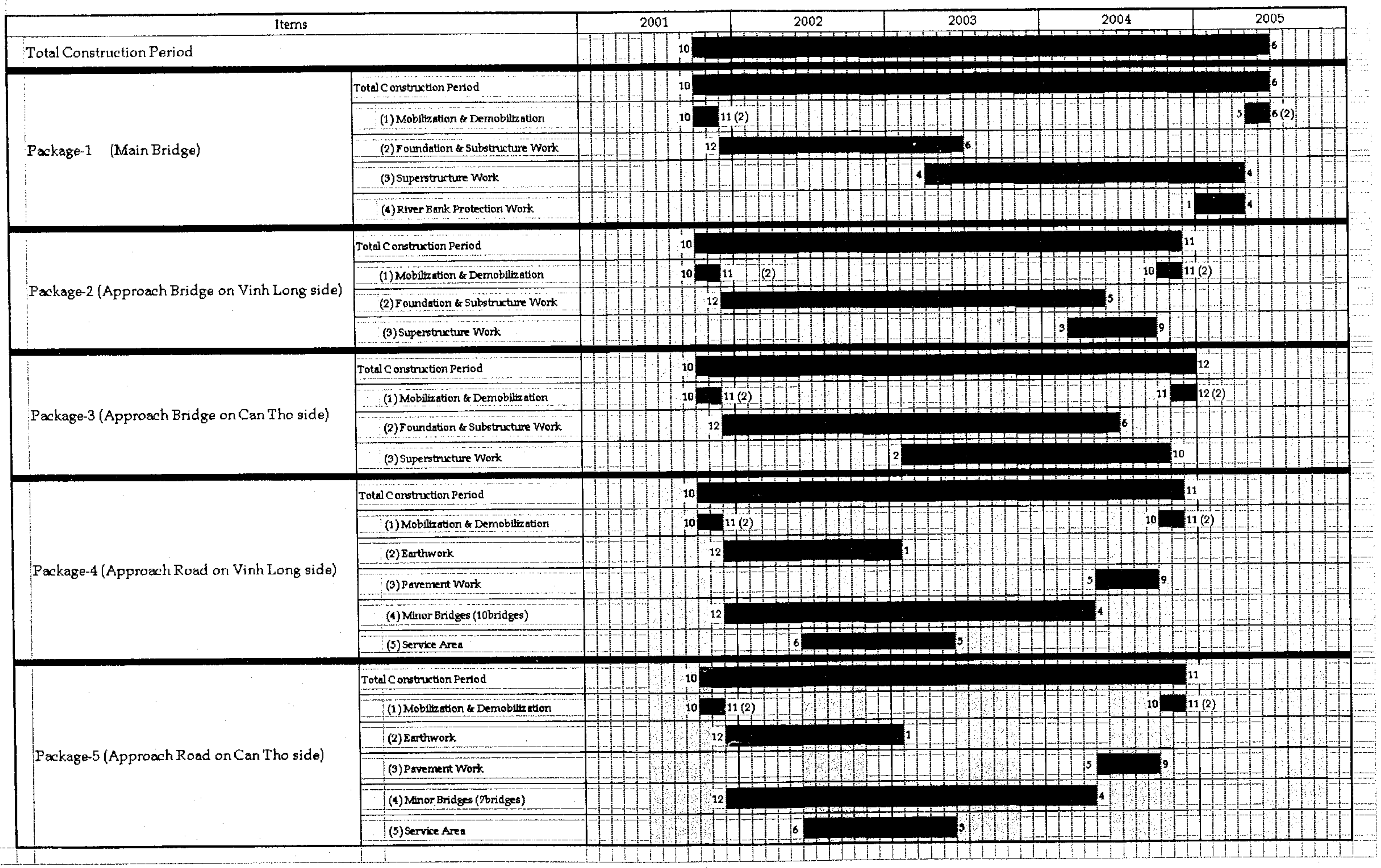


Fig. 11.8 Recommended Construction Schedule

Work	Item	Period
[illegible]		(45)
[illegible]	Total Construction Period	(45)
	1) Mobilization & Demobilization	
	2) Foundation & Substructure Work	(19)
	3) Superstructure Work	(25)
	4) River Bank Protection Work	(4)
[illegible]	Total Construction Period	(38)
	1) Mobilization & Demobilization	
	2) Foundation & Substructure Work	(30)
	3) Superstructure Work	(7)
[illegible]	Total Construction Period	(39)
	1) Mobilization & Demobilization	
	2) Foundation & Substructure Work	(31)
	3) Superstructure Work	(21)
[illegible]	Total Construction Period	(38)
	1) Mobilization & Demobilization	
	2) Earthwork	(14)
	3) Pavement Work	(5)
	4) Minor Bridges & Culverts	(29)
	5) Service Area	(12)
[illegible]	Total Construction Period	(38)
	1) Mobilization & Demobilization	
	2) Earthwork	(14)
	3) Pavement Work	(5)
	4) Minor Bridges & Culverts	(29)
	5) Service Area	(12)

(2) Package-1, Main Bridge

Critical construction works for construction schedule are, "Open Caisson construction for tower in the waterway", and "Construction of Main Towers (in the waterway, on the ground)", "PC and Steel segmental block erection", and "Stay Cable installation".

"PC and Steel segmental blocks production is to be done before and during "PC and Steel segmental blocks erection", and production is required to be done after enough training and under careful supervision.

(3) Package-2, Approach Bridge on Vinh Long side

Critical construction work is "C.P.P. construction on the ground", and the number of party for pile construction must be re-estimated considering actual construction progress.

"Production of PC segmental block" is required to be done under careful supervision as same as other Bridge packages.

The interface between Package-2 and Package-4 would have to be coordinated appropriately, considering the Pre-loading work for A1 abutment.

(4) Package-3, Approach Bridge on Can Tho side

This package has three individual bridges, in the following:

Table 14.14 The Bridge Outlines of Package-3

Superstructure	Substructure	Foundation
a) PC Box Girder Bridge 18 @ 50m= 900m	P13 (in the waterway) P14~P29 (on the ground)	S.P.P. (Dia. 1,500, L = 70m) C.P.P. (Dia. 1,500, L = 72m)
b) PC Balanced Cantilever Bridge 50 + 75 + 50 = 175m	P30&P33 (in the waterway) P31&P32 (in the waterway)	S.P.P. (Dia. 800, L = 65m) S.P.P. (Dia. 1,500 L = 65m)
c) PC Box Girder Bridge 3 @ 50 = 150m	P34 (in the waterway) P35&A2 (on the ground)	S.P.P. (Dia 800 L = 65m) C.P.P. (Dia. 1,500 L = 72m)

Considering the connection with Package-1, "Main Bridge", the construction work should be started from a) PC Box Girder Bridge (18 @ 50m = 900m), and the interface between this Package-3 and

Package-1 would have to be coordinated appropriately. "PC segmental block erection" would have to be done under careful supervision as same as other bridge packages.

The interface between this Package-3 and Package-5 is also to be coordinated, considering the Pre-loading work for A2 abutment.

(5) Package-4, Approach Road on Vinh Long side

Pre-loading work for abutments of minor bridges and A1 abutment of Package-2 can be the critical for construction period of this package. Pre-loading for A1 abutment has to be done carefully and certainly because of the coordination with Package-2, Approach Bridge on Vinh Long side.

(6) Package-5, Approach Road on Can Tho side

As for Package-4, pre-loading work for abutments of minor bridges and A2 abutment of Package-3 can be the critical for construction period of this package. Pre-loading for A2 abutment has to be done carefully and certainly because of the coordination with Package-3, Approach Bridge on Can Tho side.

14.8 Arrangement of Construction Yard

Considering both the construction items required and the construction schedule, five construction yards are planned close to the proposed alignment. The general arrangement is shown in the Drawing, No.40, "CONSTRUCTION YARD".

In Vinh Long side, three construction yards are established for Package-1, 2, and 4, and two yards for Package-3 and 5 in Can Tho side.

Total area of Construction Yard is 57 ha, and outlines of individual construction yard are described in the following:

(1) Construction Yard for Package-1 (Main Bridge)

Location: Vinh Long Side,
near the Riverbank, north of proposed alignment

Total Width: 600m x 350m = 21ha

The major facilities to be provided in the construction yard are as follows:

- Consultant Office
- Contractor Office
- PC Segmental Block Construction Yard
  - Preparation Yard (Steel Bar Reinforcement & PC Cable)
  - Production Yard
  - Curing / Stock Yard
- Concrete Mixing Plant
- Aggregate Stock Yard
- Stock Yard for Special Materials and Equipment
- Mechanical Workshop
- Aggregate and Cement Testing Laboratory
- Access Roads
- Wharf

(2) Construction Yard for Package-2 (Approach Bridge on Vinh Long side)

Location: Vinh Long Side,
near the Riverbank, north of proposed alignment

Total Width: 250m x 200m = 5ha

The major facilities to be provided in the construction yard are as follows:

- Consultant Office
- Contractor Office
- PC Segmental Block Construction Yard
  - Preparation Yard (Steel Bar Reinforcement & PC Cable)
  - Production Yard
  - Curing / Stock Yard
- Concrete Mixing Plant
- Aggregate Stock Yard
- Stock Yard for Special Materials and Equipment
- Mechanical Workshop
- Aggregate and Cement Testing Laboratory
- Access Roads

(3) Construction Yard for Package-3 (Approach Bridge on Can Tho side)

Location: Can Tho Side,
near the Riverbank, north of proposed alignment

Total Width: 250m x 200m = 5ha

The major facilities to be provided in the construction yard are as follows:

- Consultant Office
- Contractor Office
- PC Segmental Block Construction Yard
  - Preparation Yard (Steel Bar Reinforcement & PC Cable)
  - Production Yard
  - Curing / Stock Yard
- Concrete Mixing Plant
- Aggregate Stock Yard
- Stock Yard for Special Materials and Equipment
- Mechanical Workshop
- Aggregate and Cement Testing Laboratory
- Access Roads
- Wharf

(4) Construction Yard for Package-4 (Approach Road on Vinh Long side)

Location: Vinh Long Side
north of proposed alignment

Total Width: 250m x 200m = 5ha

The major facilities to be provided in the construction yard are as follows:

- Consultant Office
- Contractor Office
- Concrete Mixing Plant
- Aggregate Stock Yard
- Stock Yard for Special Materials and Equipment
- Mechanical Workshop
- Aggregate and Cement Testing Laboratory
- Access Roads

(5) Construction Yard for Package-5 (Approach Road on Can Tho side)

Location: Can Tho Side

Total Width: 250m x 200m = 5ha

The major facilities to be provided in the construction yard are as follows:

- Consultant Office
- Contractor Office
- Concrete Mixing Plant
- Aggregate Stock Yard
- Stock Yard for Special Materials and Equipment
- Mechanical Workshop
- Aggregate and Cement Testing Laboratory
- Access Roads

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

CHAPTER 15

MAINTENANCE PROGRAMME

CHAPTER 15 MAINTENANCE PROGRAMME

15.1 Purposes of Maintenance

Maintaining a highway bridge and roads in such a condition so as to provide safe and uninterrupted traffic flow is the primary function of maintenance. Protection of the investment in the structure facility through well programmed repairs and preventive maintenance programmes are also crucial. To achieve the desired result, constant awareness and thorough inspection procedures are required.

15.2 Organization for Maintenance

A maintenance organization is necessary to create the conditions and logistical support for the effective implementation of all maintenance activities. The organization should be simple and meet with the specific requirements and resources of Viet Nam. The system should also accommodate with the existing Vietnamese organizations and budgetary systems for the maintenance of highways. Normally, this consists of three levels: (a) the central level which establishes national highway plans and budgets, (b) the regional level where maintenance requirements are defined, planning, execution and supervision of maintenance is carried out, and budget control and cost control are implemented, and (c) the district level where the maintenance activities, including monitoring, are done under the supervision of maintenance engineers.

15.3 Organization and Expenditure (Budget Procedures and Allocations)

- Viet Nam Roads Administration (VRA)

  The Planning Department of the VRA under the Ministry of Transport (MOT) has responsibility for both annual and long-term plans. The long-term plan is a strategic document, which provides the framework for the more formal five-year expenditure plan. The five-year plan in turn provides the basis of the capital component of the annual plans, but subject to modification as the five-year period proceeds. The approval mechanism for long-term plans is for VRA to pass proposals to MOT for incorporation in the overall transport plan, which is then submitted to the Government for approval. VRA long-term plan for the roads sector deals principally with the national roads but also includes aggregate targets for the provincial roads summarizing the provincial plans drawn up by the Provincial Transport Authorities (PTAs).

- Provincial Transport Authorities (PTA)

PTAs are responsible to MOT for implementing the national annual plan and applying MOT standards or road works and management of national transport assets at the provincial level. On maters of legal standards and the management of national transport assets delegated to the provinces, PTAs refer to MOT. With regard to daily operations of the provinces transport infrastructure and services, they are responsible to the Provincial People's Committees (PPCs). This provincial pattern is repeated at the district and sub-district level.

- Expenditure and the Annual Plan

For the national roads, proposals or current expenditure originate with the maintenance authorities, i.e. RRMUs (Regional Road Management Units) and PTAs. These proposals are reviewed by the Planning Department of VRA and assembled into the form of a budget request, which is passed up from VRA to MOT and then to the State Planning Committee (SPC).

SPC determines the allocation of funds for VRA - the total VRA budget. VRA translates this back into allocations for the various departments, enterprises and authorities involved, and specifically in regard to road maintenance this implies RRMUs and PTAs. The annual maintenance budget for roads covers both small and medium repairs (corresponding to routine and recurring maintenance), but not big repairs (approximating to periodic maintenance), which are classed as capital expenditure.

- Capital Expenditure

Road works are considered to be either small, medium or large. Procedures differ accordingly. Proposals for small and medium works originate with RRMUs and PTAs and are reviewed by the Planning Department of VRA. Small works may be approved by the chairman of VRA; medium works proposals must go up to MOT. Proposals for large projects are prepared by VRA and must be submitted through MOT to the government. Certain large projects, notably those for which foreign finance is sought, come directly under MOT. Execution is the responsibility of the Project Management Units (PMUs).

- Provincial Planning Committees (PPCs)

The majority of finance for Provincial Roads comes from provincial sources and is voted by the Provincial Planning Committees (PPCs). PTAs also have the option of submitting proposals to MOT for joint financing. This is done through the Local Transport and Communications Department of MOT. Central finance is most likely to be forthcoming for large projects (especially bridges) and Projects in marginal areas. In total, central finance for provincial roads does not exceed 10 - 20% of total expenditure. Meanwhile in theories the PTAs operate on both an annual and long-term planning basis. The long-term may be little more than conceptual if no finance is allocated for capital improvements. The annual plan is prepared by PTA and submitted to PPC for the allocation of finance. The plan covers all works up to and including reconstruction. As in the case of the national roads, the PTAs' requests tend to be cut substantially in the Committee's allocation. Meanwhile PTAs have a dual reporting function - to PPC and to MOT, but generally, however, they tend to see their primary responsibility as being to the province.

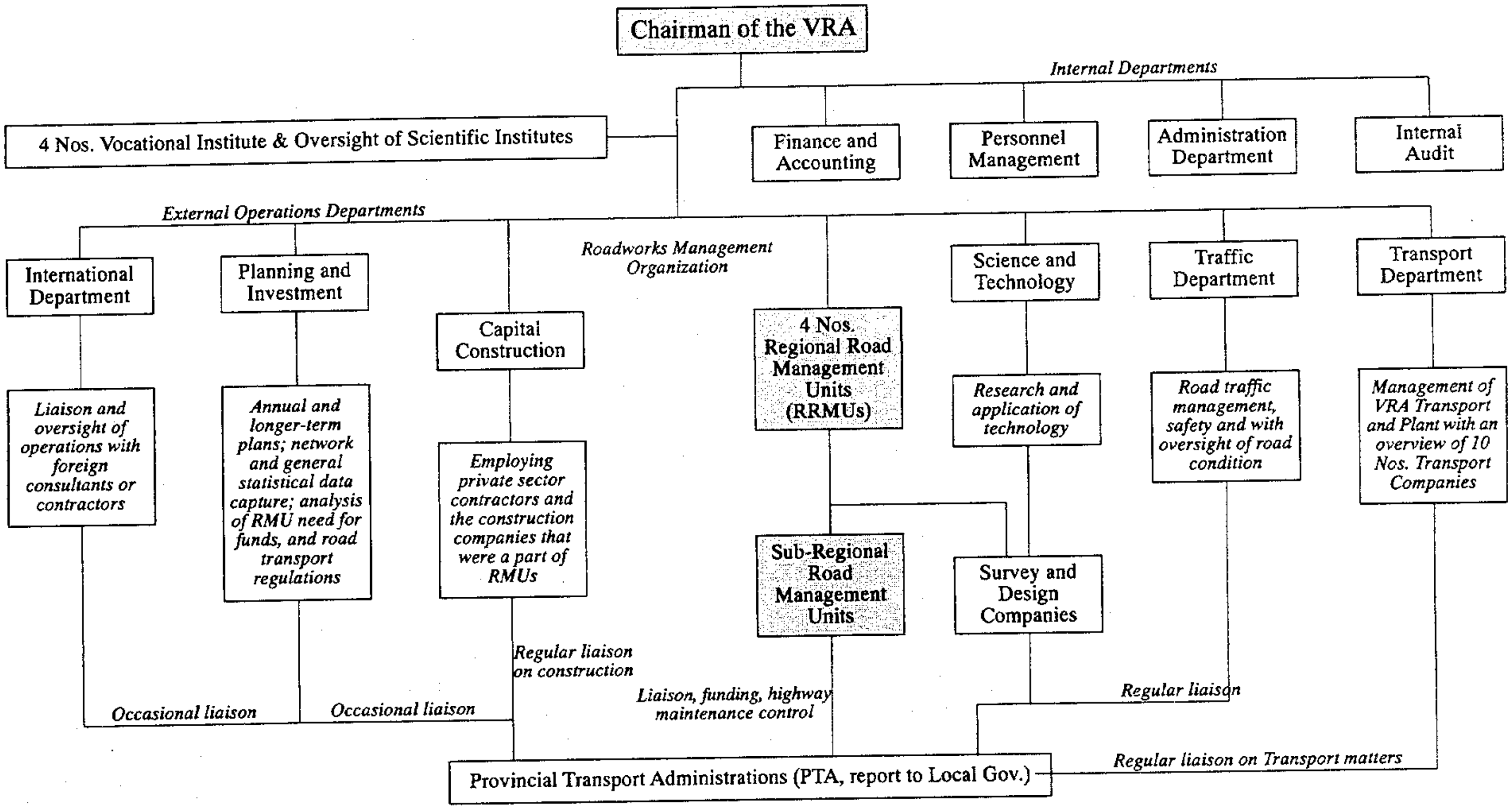


Figure Organization of the Vietnam Roads Administration (VRA) and the Interface with Provincial Transport Administrations

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Figure 15.1 Organization of the VRA

JAPAN INTERNATIONAL COOPERATION AGENCY

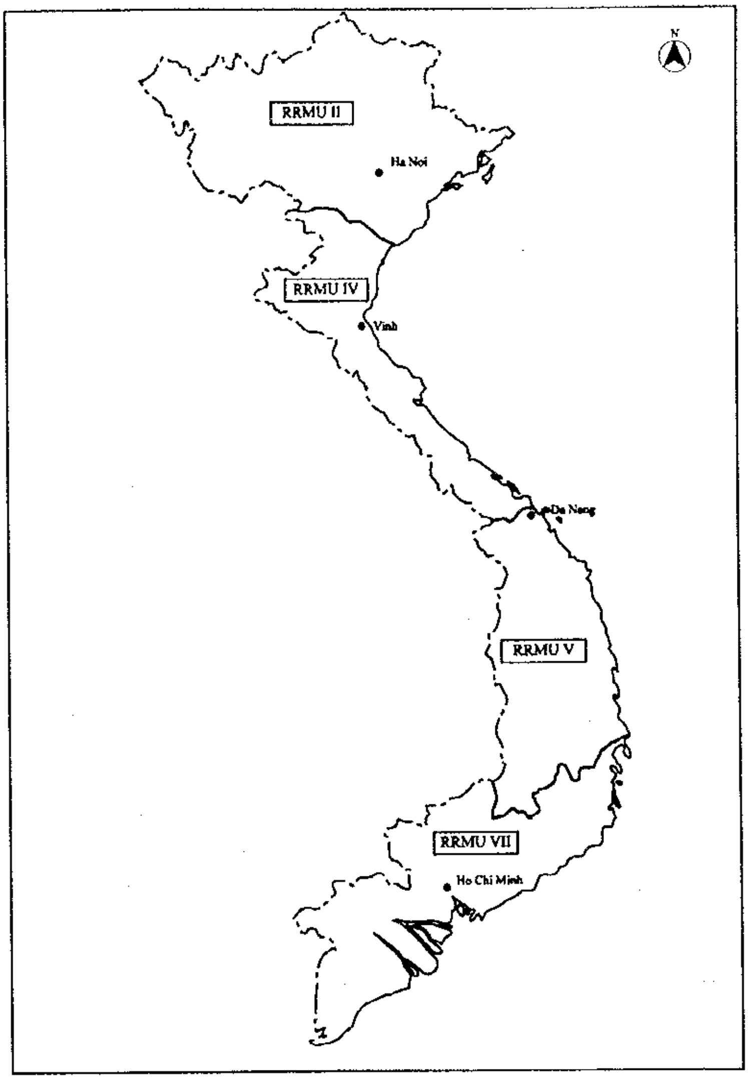

Fig. 15.2 Administrative Areas of the RRMUs

15.4 Inspections for Maintenance (Bridge Maintenance)

Inspection for bridge structures can be categorized as follows:

(1) Normal Inspection

The inspection to be performed visually in order to detect damage of a bridge at an early stage. It is performed at the same time as daily patrols of the road.

(2) Periodic Inspection

The inspection to be performed periodically in order to maintain the bridge. It is mainly done visually or by using simple inspection equipment.

(3) Special Inspection

The inspection to be performed in order to assure the safety of the bridge after the occurrence of a disaster, such as earthquake, typhoon, localized torrential downpour, or when any abnormal condition has been detected. It shall be done mainly in order to ensure the safety of the bridge.

(4) Follow-up Inspection

The inspection to be performed repeatedly of a damaged part whose condition of deterioration needs to be known. It shall be performed visually or by using simple inspection equipment and tools.

(5) Detailed Inspection

The inspection to be performed in order to determine necessity of any repair or reinforcement. It shall be performed by using inspection equipment and tools.

Damage can be graded into five ranks, each of which shows the steps to be taken considering the condition. Based on the ranking and grade of damage, the necessary maintenance work shall be carried out. (see Table 15.1)

Table 15.1 Criteria for Grade of Damage

Grade	General Conditions
I	Being heavily damaged, affecting or possibly affecting the safety of traffic, or causing or possibly causing trouble to third parties, it is necessary to carry out an emergency repair.
II	Being damaged in a large part, it is necessary to carry out a detailed inspection for studying whether or not any repairs are required.
III	Damaged being found, it is necessary to carry out follow-up inspection.
IV	Damage being found, it is necessary to record the conditions thereof.
V(O.K.)	No damage found as the result of inspection.

15.5 Inspection of Cable-Stayed Bridge

A cable-stayed bridge is a bridge in which the superstructure is supported by cables, or stays, passing over or attached directly to towers located at the main piers. The superstructure generally consists of an orthotropic deck and continuous girders.

(1) Special Elements

There are several special elements that are unique to cable-stayed bridges, and the bridge inspector should be familiar with those listed below.

a) Cable System

The inspection of the cable system should include:

- Exterior of the cables (cable wrapping)
- Cable anchorages
- Anchor pipe clearances
- Flange joints
- Sheathing pipe welds (polyethylene or steel)
- Sheathing expansion joints
- Wrap ends near the tower and deck
- Reading the load cells and recording the forces in the cables, noting the loads on the deck at the time of the readings
- Type and amplitude of cable vibrations, noting the direction and speed of wind

b) Cable Pipes

Inspect the cable pipes for:

- Corrosion
- Splitting
- Cracking
- Excessive bulging

Cable pipes should be inspected carefully. Special concern should be given to the connections with the cable dampers, the tower exists, and anywhere pipes are welded together.

c) Cable Damper System

The most commonly used cable damper system is a shock absorber type. Inspect this cable damper system for:

- Corrosion
- Tightness in the connection to the cable pipe
- Oil leakage in the shock absorbers
- Deformations in the bushings
- Torque in the bolts

d) Cable Anchorages

Inspect the cable anchorages for:

- Water tightness of neoprene boots at the upper ends of the guide pipes
- Drainage between the guide pipe and transition pipe
- Corrosion of the anchor system
- Defects, such as splits and tears, in the neoprene boots
- Sufficient clearance between the anchor pipe and cable, noting rub marks and kinks
- Cracks and nut rotation at the socket and bearing plate
- Seepage of grease from the protective hood

(2) Advanced Inspection Techniques

Since visual inspection is often insufficient to detect corrosion and fracture of individual cable wires, advanced inspection techniques may be used. In bridge cables, the greatest problems generally occur due to the corrosion and fracture of individual wires. Visual inspection of unwrapped cables is limited to the outer wires, while visual inspection of wrapped cables is limited to the protective sheathing. Therefore, advanced inspection techniques should be used to achieve a more rigorous and thorough inspection of the cables, including.

- Magnetic induction
- Electrical resistively
- Dye penetration
- Ultrasonic testing
- Radiographic testing
- Acoustic emission
- Accelerometers
- Strain measurements
- Vibration measurements
- Magnetic flux leakage
- Measurement of loads
- Measurement of stress ranges

15.6 Level of Expenditure for Maintenance

An annual expenditure of at least equal to 0.1 percent of the replacement cost of the bridges is necessary to implement a rational policy of preventive maintenance.

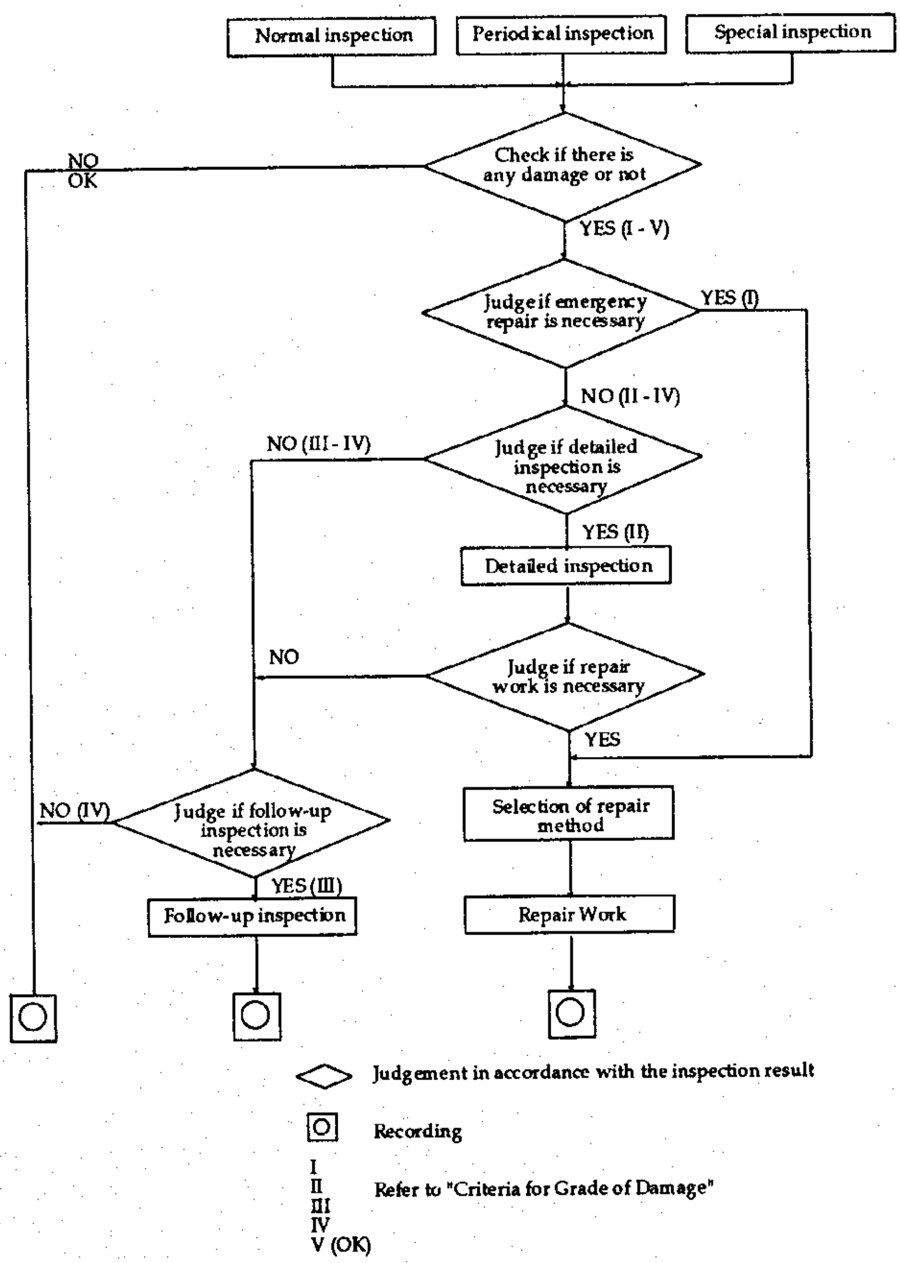

Fig. 15.3 Inspection Work Flow

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

CHAPTER 16

COST ESTIMATE

CHAPTER 16 COST ESTIMATE

16.1 General

The cost estimate consists of two stages, "the preliminary cost estimate", and "the general cost estimate". The preliminary cost estimate was carried out for the selection of the optimum route and bridge type. The general cost estimate was prepared based on the final proposed alternative route and bridge option. Fig. 16.1 shows procedures for the cost estimate.

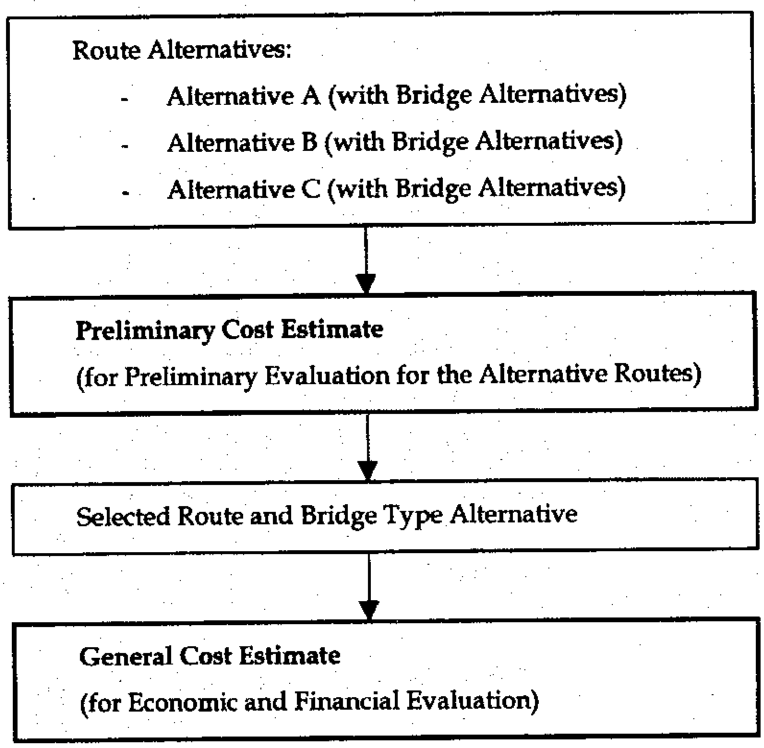

Fig. 16.1 Procedure and Objective of each Cost Estimate

For both cost estimates, some assumptions were applied when considering researched data about the source and procurement of construction materials, transportation of materials and equipment, taxes, decrees, circulars, etc:

The composition of the Project cost is shown in Fig. 16.2, and the individual components of the cost are summarized in Table 16.1.

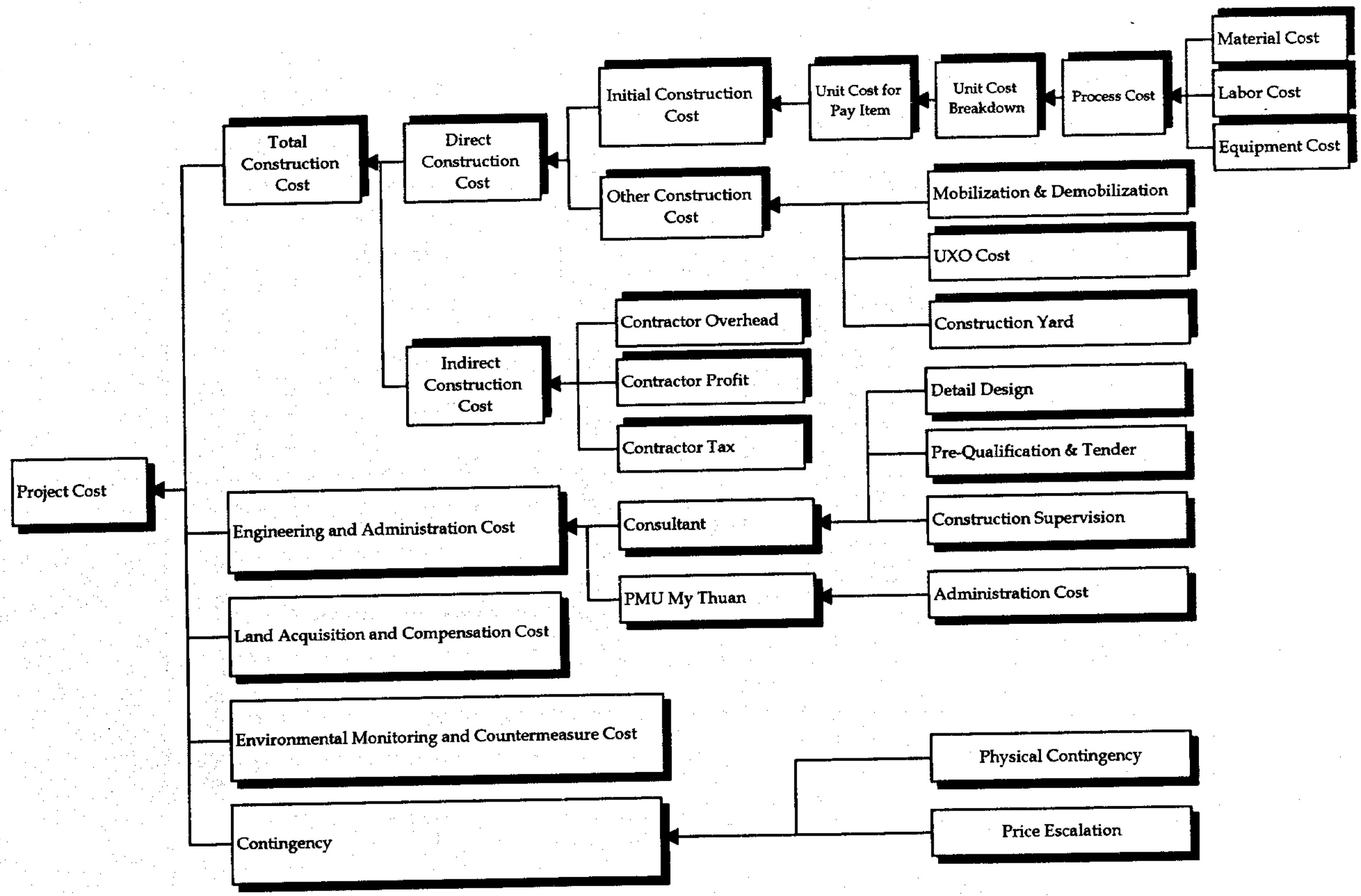

Fig. 16.2 Composition of Project Cost

Table 16.1 Summary of Cost Components

Component	Distribution

(1) Total Construction Cost	1) Direct Construction Cost
	- Initial Construction Cost
	  - Main Bridge
	  - Approach Bridge (Vinh Long & Can Tho)
	  - Approach Roads (Vinh Long & Can Tho)
	- Other Construction Cost
	  - Mobilization & Demobilization
	  - UXO Cost
	  - Construction Yard
	2) Indirect Construction Cost
	- Contractor Overhead
	- Contractor Profit
	- Contractor Tax

2) Engineering and Administration Cost	1) Engineering Cost (Consultant) - Pre-Qualification and Tender Assistance - Construction Supervision 2) Administration Cost (PMU My Thuan) - Administration Cost
3) Land Acquisition and Compensation	1) Cost of land 2) Cost of dwelling
4) Environmental Monitoring and Countermeasure	1) Environmental Monitoring 2) Environmental Countermeasure (During & After Construction)
5) Contingency	1) Physical Contingency 2) Price Escalation
6) Maintenance Cost	Maintenance Cost for the Main Bridge

In the following sections, the condition or method of cost estimation at each stage is explained.

Chapter 16.2 described the conditions for the preliminary cost estimate, and section 16.3 is describes the general cost estimate.

16.2 Conditions of Preliminary Cost Estimate

16.2.1 General

For preliminary cost estimate, major and important components of Project cost were estimated. These major and important components are described in the followings. Cost was initially estimated under the conditions explained below, and the references used for this estimate are also summarized at the end of this section.

Result of preliminary cost estimate was utilized for Chapter 10, "Preliminary Economic Evaluation".

16.2.2 Total Construction Cost

(1) Direct Construction Cost

a) Initial Construction Cost

The cost of the main and approach bridges, and approach roads were estimated by conventional methods and with reference to those items listed below.

< Reference of cost estimate >

- Results of the Review of the previous Feasibility Study of the Can Tho Bridge construction	1996
- Feasibility Study of the My Thuan Bridge Project	October, 1995
- Final Report of National Highway No.1 Bridge Rehabilitation Project	March, 1996
- Material sales prices of the existing markets of Can Tho, and Ho Chi Minh Cities	September, 1997
- Japanese Standard of the Cost Estimate (Ministry of Construction, GOJ)	1997

b) Other Construction Cost

Other construction costs include mobilization and demobilization. The percentage used in calculating these costs was determined from the actual condition of individual equipment's requirement for each bridge. Temporary calculations with a percentage of 5% of labor cost, material cost and equipment cost, has been used.

(2) Indirect Construction Cost

Indirect construction cost is basically categorized into contractor overhead, contractor profit, and tax. The percentage for these items was according to circular 23 BXD-VKT dated 15/12/1995.

16.2.3 Engineering and Administration Cost

(1) General

The composition and breakdown of the engineering and administration cost were defined with reference to the relevant Vietnamese circulars and decrees.

< References of cost estimate >

Circular	177/BXD-VKT	dated 17/7/1995	For Engineering Cost
Circular	179/BXD-VKT	dated 17/7/1995	For Engineering Cost
Circular	501/BXD-VKT	dated 18/9/1996	For Administration Cost
Circular	18/BXD-VKT	dated 10/6/1995	For Administration Cost
The official dispatch 158/MK-95			For Administration Cost
Circular	48TC/DTPT	dated 30/6/1995	For Administration Cost

(2) Engineering Cost (Consultant)

The surveying, boring and design fee has been based on the actual quantity of square meter of bridge construction following circular 177/BXD-VKT and 179/BXD-VKT dated 17/7/1995, and similar types of projects in Vietnam under foreign investment.

(3) Administration Cost (PMU My Thuan)

The percentage was based on circular 501/BXD-VKT dated 18/9/1996 concerning constructional spending.

The fee for the Project Management Unit was based on circular 18/BXD-VKT dated 10/6/1995 a guide for the implementation of organization types and management of invested & construction projects.

The insurance of the employer's workers was according to the official dispatch 158/MK-95 of the Vietnamese Insurance General Corporation.

The fee for supervision and approval of constructional balance and accounts was according to circular 48TC/DTPT of Finance Ministry dated 30/6/1995. This is a guide for management and the using of supervision and approval spending for invested fund's balance and accounts of finished invested projects.

16.2.4 Land Acquisition and Compensation

The estimate of compensation costs was based on the type of land use and the relocation involved. The compensation costs of houses, the transfer of rights to use land and the cost for compensation of arable land was estimated based on the following circulars and decisions;

- Principle: Land on Law (Promulgated on 15 October 1993
- Land valuation and compensation:
  Decree No.87 & No.90/CP dated 17/8/1994
- Unit cost of land: Decision No.2504/QD.UBT.97 dated 2/10/1997 (by People Committee of Can Tho Province)
- House valuation and compensation:
  Circular No.5 - BXD/DT dated 9/2/1993
- Right of Way: Decree No.203/HDBT of the Council of Ministers, dated 21/12/1982

Detail of the method and results of the calculation are shown in Chapter 7. Moreover, for general cost estimate, unit cost of land and dwellings were defined as the 20% of increase with unit cost in Chapter 7, with considering the contingency in the future.

16.2.5 Contingency

The Contingency for unexpected disaster was estimated at 5% of ["Total Construction Cost" + "Engineering and Administration Cost" + "Land Acquisition and Compensation Cost"], according to circular 23/BXD-VKT dated 15/12/1994.

16.3 Method and Composition of General Cost Estimate Procedures

16.3.1 General

For the general cost estimate, cost estimate condition and definition were reviewed with considering the discussion and comments with PMU My

Thuan and Steering Committee. Whole of the components shown in Fig.16.2 was estimated.

16.3.2 Composition of Project Cost

As shown in Fig. 16.2 "Composition of Project Cost", the components of the cost consists of the followings:

- Total Construction Cost
- Engineering and Administration Cost
- Land Acquisition and Compensation Cost
- Environmental Monitoring and Countermeasure Cost
- Contingency

16.3.3 Total Construction Cost

(1) Composition of Direct Construction Cost

The direct construction cost is the sum of the cost for the various work items required in the construction. These individual costs are the product of a calculated quantity of an item of work multiplied by an estimated unit cost for that item.

Direct construction cost is mainly distributed in "Initial Construction Cost" and "Other Construction Cost".

The initial construction cost includes the categories shown below, such as main structure (bridges & approach roads), and other construction items.

- The category of main structure (bridges & approach roads) includes;

  Bridges;

  - Superstructure
  - Substructure
  - Foundation
  - Riverbank Protection Work
  - Miscellaneous Items

  Approach Roads;

  - Earthwork
  - Pavement
  - Minor Structures
  - Soft Ground Treatment
  - Miscellaneous Items

- The category of other construction includes temporary bridges, and roads for construction traffic, coffer dam islands for the construction of the foundations and substructures, and dredging work of the branch river etc.

The other construction cost includes the categories shown below,

- Mobilization and Demobilization:

  The category of general includes preparation and reclamation work for the site; and removing debris of whatever nature.

- UXO Cost

  This UXO cost is required for the site clean up of unexploded bombs.

- Construction Yard Fee

  As shown in Chapter 14, five construction yards are necessary for each construction package. Construction yard fee was estimated for whole of them.

(2) Initial Construction Cost

a) Unit Cost and Process Cost

Unit costs are derived from direct and indirect costs. Costs attributed directly to a particular function of work are direct costs. Indirect costs are those which may be appropriately spread to the various items of work.

To establish unit costs, a process cost was applied.

Process cost is the unit cost for a standard quantity of individual work items, and is composed of material, labor, and equipment costs multiplied by the designed quanuties. For individual work items, the process cost was established, and the unit cost of each pay item obtained by accumulating the process costs.

b) Material Cost

As described in the Chapter 14, "Construction Planning", materials are classified into two groups namely, local materials which are available in the local markets and imported materials which are obtained from overseas.

The material prices were estimated based on domestic material price data such as the "Market and Price" of September 1997 for each province within the Project area. Costs include of procured material, processing, stockpiling, loading, haul roads required, transportation, handling, storage, allowance for losses and miscellaneous costs, and the calculation was made referring to both the Japanese and Vietnamese standards.

The cost of imported material such as prestressing tendons, steel etc, were based on the price list information of Japan and other countries.

c) Labor Cost

Labor costs were calculated based on "Vietnamese Standard". The calculation includes wage, allowance facilities, bonus, socio-insurance, health insurance, fund of trade union, and other facilities etc. For the labor skills required and experience, the standard price of foreign countries (Japan, etc.) was applied.

d) Equipment Cost

Equipment costs vary on a case by case basis depending on several factors such as the depreciation accounting of equipment and machinery, condition of equipment, location of the Project and the construction duration.

Equipment costs of imported machinery were considered on a hourly basis using new construction equipment and machinery (per one hour or per one day) and was based on the "Japanese Standard" which is a compilation of the Ministry of Construction of Japan (calculation lists of depreciable value for construction equipment). The operation costs for expendables such as fuel, lubricants, and other expenses were based on the local market price in Vietnam.

For the equipment costs of domestic machinery, "Common Regulations and applying guidelines (Promulgated in connection with Decision No.57/BXD-VKT dated 30th March, 1994 by the Construction Minister)" was applied. Equipment costs indicated in above circular include annual expenditure, depreciation expenditure, fuel consumption, and the labor cost of the equipment operator. The labor cost of the equipment operator was made using a 1.5 multiplier in consideration of an increase of salary.

e) Foreign and Local Currency

The cost is split into local and foreign currency portions, being indicated in U.S. Dollar, as follows.

- Foreign Currency Component
  - Imported equipment, material and supplies
  - Salaries and wages of foreign personnel
  - Overhead and profit of foreign firms(Contractors)

- Local Currency Component
  - Domestic material and supplies
  - Wages of local personnel
  - Overhead and profit of local firms(Contractors)

f) Construction Quantities

The quantities for all work items were calculated based on the prepared engineering drawings for each bridge.

(3) Other Construction Cost

Other construction cost is composed with "Mobilization and Demobilization", "UXO Cost", and "Construction Yard".

Mobilization and demobilization were estimated with same method with "Preliminary Cost Estimate", namely 5% of initial construction cost.

UXO Cost was estimated with the total area to be observed (Total proposed alignment multiplied by 50m width for both sides from proposed alignment) multiplied by the unit price indicated by the PMU My Thuan.

Construction Yard Fee was estimated with the total construction yard area that is indicated in Chapter 14 multiplied by the unit price.

(4) Indirect Construction Cost

Indirect construction cost, which is derived into "Contractor Overhead", "Contractor Profit", and "Contractor Tax" was estimated with same method with "Preliminary Cost Estimate".

16.3.4 Engineering and Administration Cost

(1) Engineering Cost

Engineering cost is composed with the following components;

- Detail Design
- Pre-Qualification and Tender Assistance
- Construction Supervision

These components were estimated with conventional method. The estimated engineering cost was compared with the 10% of the total construction cost indicated by PMU My Thuan, and MOT. As a result, the estimated Engineering Cost was lower, so this cost was adopted.

(2) Administration Cost

The percentage indicated by PMU My Thuan and MOT is 1% of total construction cost, and this value was applied.

16.3.5 Land Acquisition and Compensation Cost

This cost was estimated with the same method with "Preliminary Cost Estimate".

16.3.6 Environmental Monitoring and Countermeasure

The distribution of this component are shown in the following:

(During Construction Phase)

- Water quality monitoring
- Air quality monitoring
- Noise monitoring
- Monitoring on aquatic ecosystem
- Monitoring on socio-economic conditions

(During operation phase after the construction)

- Water quality monitoring
- Air quality monitoring
- Noise monitoring
- Monitoring on aquatic ecosystem
- Monitoring on socio-economic conditions

Detail of the method and results of the calculation are shown in Chapter 17.

16.3.7 Contingency

(1) Physical Contingency

Physical contingency was estimated 10% of project cost (not including contingency) indicated by MOT.

(2) Price Escalation

2~3% of project cost was proposed by MOT, and was applied. As described in Chapter 14, project cost was allocated to each year in the implementation schedule, based on the escalation rates of 2% and 3% for the foreign and local currency portions. Base year of escalation was 1997, in which the Feasibility Study and cost estimate were studied.

16.3.8 Maintenance Cost

Maintenance cost for the main bridge, which would require regular maintenance, was to be estimated.

0.1% of the construction cost for the main bridge, which percentage was referred to the guidelines set by OECD, was applied as the appropriate yearly maintenance cost.

16.4 Summary of General Cost Estimate

Summary of the General Cost Estimate is shown in Table 16.2.

Table 16.2 Summary of General Cost Estimate

Unit : thousand USD

Component		Foreign Currency Portion	Local Currency Portion	Total
1. Construction Cost	Mobilization & Demobilization	6,838.24	4,111.93	10,950.17
	Main Bridge	84,636.21	19,723.36	104,359.57
	Approach Bridge (Vinh Long)	8,734.35	3,428.45	12,162.80
	Approach Bridge (Can Tho)	33,763.77	10,071.57	43,835.34
	Approach Road (Vinh Long)	5,157.11	9,333.34	14,490.45
	Approach Road (Can Tho)	4,473.20	9,756.92	14,230.12
(Sub Total)		(143,602.88)	(56,425.57)	(200,028.45)
2. Engineering Cost	Detail Design & Tender Assistance	4,087.50	3,240.00	7,327.50
	Construction Supervision	3,506.25	2,384.20	5,890.45
(Sub Total)		(7,593.75)	(5,624.20)	(13,217.95)
3. Administration Cost		0.00	2,000.28	2,000.28
4. Environmental Monitoring & Countermeasures		0.00	235.90	235.90
5. Land Acquisition		0.00	1,944.45	1,944.45
6. Compensation		0.00	591.67	591.67
7. Sub Total of Project Cost without Contingency (1. + 2. + 3. + 4. + 5. + 6.)		(151,246.63)	(66,772.07)	(218,018.70)
8. Physical Contingency		15,124.66	6,677.21	21,801.87
9. Price Escalation (Base year 1997)		17,647.76	10,747.22	28,394.98
Total	(7. + 8.)	166,371.29	73,449.28	239,820.57
	(7. + 8. + 9.)	184,019.05	84,196.50	268,215.55

* Price Escalation: 2% for Foreign Currency Portion

3% for Local Currency Portion

*Yearly maintenance cost: Foreign Currency Portion: 89.09 thousand USD

Local Currency Portion: 20.92 thousand USD

Total: 110.01 thousand USD