Chapter 27 Structural Design

27.1 Design Conditions

In order to carry out structural design of the port facilities of Lower Cai Mep International Container Terminal and Thi Vai International General Cargo Terminal for the feasibility study, additional bathymetric survey, topographic survey and soil investigation were conducted during May to June 2002 in the port sites. The design criteria for structural design of port facilities for the feasibility study are basically the same with the ones presented in the Master Plan study; however, minor modifications on the design criteria have been made based on the above additional survey results and new operational requirements. As defined in the port planning, the project for feasibility study consists of construction of two container terminals for 50,000 DWT vessels at lower Cai Mep site and two general cargo terminals for 50,000 DWT vessels at Thi Vai site. In addition, relevant essential facilities for both terminal operations will be also included in the Project. They are access roads to the terminals at Cai Mep and Thi Vai, and channel dredging and navigational aids for the safe maneuvering of calling vessels to the new terminals.

New design criteria to be applied to the structural designs of each project component are summarized in Table 27.1-1. Special considerations on the criteria are described below.

(1) Container Terminals

The container terminals for 50,000 DWT full loaded container vessels should be able to accept 80,000D WT container vessels loaded up to the draft of –12.5m. Other design conditions for the new container terminals should fully meet operational requirements for a modern international container terminal. Live loadings, such as surcharge and equipment loads on the apron, berthing and mooring forces of the design vessels, and appropriate seismic forces have been considered in the design criteria.

Three borings were conducted in Cai Mep site in May 2002. Considering these borings and laboratory test results, sub-soil conditions for the design of quay structure and on-land facilities at lower Cai Mep site have been established as shown in Figure 27.1-1. As seen in the figure, the soil conditions at Cai Mep site consists of upper very soft clay; (i.e., soil type classified as CH) up to around –30 m and lower clayey sand (of SC type) up to around –40 m on the bearing stratum of silty sand (of SM type).

(2) General Cargo Terminal

In the port planning of this study, the depth of access channel to this terminal is designed to be –12 m below CDL, which is shallower than the full loaded draft of 50,000 DWT cargo vessels. Therefore, vessels can navigate to/from the terminal during high tide and the berthed vessels can stay at berth even during the low tide. The water depth of this berth should be maintained to be more than –14 m and the quay of this general cargo terminal should be designed for 50,000 DWT full loaded cargo vessels.

Thi Vai general cargo terminals will be used as international terminals for non-container operation of cargoes (such as fertilizer, steel, coal, heavy equipment, construction materials, etc.) and probably used for container operation of semi-container vessel. For this, cargo handling equipment suitable to the operation, with surcharge on the apron the same as that for the container facilities, has been considered for this structural design, as well as sufficient capacity for transit sheds / warehouses.

Three borings were carried out in Thi Vai site in May to June 2002. Based on these borings and laboratory test results, sub-soil conditions for the design of quay structure and on-land facilities at Thi Vai site have been established as shown in Figure 27.1-2. As seen in the figure, the soil conditions at Thi Vai site seems to consist of upper very soft to soft clay (i.e., soil type classified as CH and CL) up to around –15 m and lower silty sand (of SM type) and clayey sand (of SC type) up to around –30 to –40 m on the bearing stratum of lean clay (of CL type).

+3.00	Existing Ground Surface	
	Clay, very soft	
	γ = 1.55 t/m^3	C_c= 0.997
	e_0= 1.842	C_v= 14~67 cm^2/day
	c = 1.95 t/ m^2	m_v= 0.094~0.063 cm^2/kgf
	w = 63%	N= 0~1
-31.00		
	Clay, soft to very stiff	
	γ = 1.62 t/m^3	C_c= 0.651
	e_0 = 1.606	C_v= 23~73 cm^2/day
	c = 2.00 t/ m^2	m_v= 0.095~0.043 cm^2/kgf
	w = 56%	N = 7~27
-36.60		
	Silty Sand, dense	
	γ = 2.00 t/m^3	LL=20.6%
		PL=14.5%
	w = 18%	N = 27~63

Figure 27.1-1 Sub-soil Conditions of Lower Cai Mep Site

+3.00 Existing Ground Surface

Clay, very soft

γ = 1.50 t/m^3 C_c= 0.791

e_0= 2.068 C_v= 13~15 cm^2/day

c = 0.30 t/ m^2 m_v= 0.043~0.459 cm^2/kgf

w = 71% N= 1~2

-11.30

Silty Sand

γ = 1.90 t/m^3 LL=18.8%

e_0 = 0.669 PL=15.0%

w = 21% N = 8~18

-36.00

Clay, very stiff

γ = 2.00 t/m^3 LL=33.2%

e_0 = 0.586 PL=17.5%

w = 18% N = 40~100

Figure 27.1-2 Sub-soil Conditions of Thi Vai Site

Table 27.1-1 Design Criteria for Structural Design for Feasibility Study

Particulars	Container Terminal	General Cargo Terminal
I. Operational Conditions		
1. Object Vessel and Water Depth		
1.1 Object Vessels		
(1) Type	Container Vessel	General Cargo Vessel
(2) Tonnage (ton)	50,000 (80,000) DWT	50,000 DWT
1.2 Water Depth (Draft) (m)	12.5 (12.5)	12.6
1.3 Mooring	100 tf/post	100 tf/post
1.4 Berthing	0.10m/s	0.1m/s
2. Surcharge and Live Load at Apron		
2.1 Surcharge (tf/m2)		
(1) Normal	4.0	4.0
(2) Seismic	2.0	2.0
2.2 Live Load		
(1) Quayside Crane (Self weight)	1,000 tf x 3 units/berth	700 tf x 3 units/berth
(2) Mobile Equipment	40 ft Container Truck	H-30 Truck, 100T Mobile Crane

II. Natural Conditions	
1. Meteorology	
1.1 Temperature	Max: 39.3, Min: 14.1, Mean: 27.5℃
1.2 Rainfall	Probability 1%: 126 mm/hr
1.3 Wind	Max: 36 m/s
2. Oceanography & Hydrograph	
2.1 Tide (Vung Tau Station)	CDL: 0.00, LWL: 0.58, MSL: 2.67, HWL: 3.97, HHWL: 4.43m
2.2 Current	Cai Mep: 2.50 m/s, Thi Vai: 1.33 m/s
2.3 Wave	Negligible
3. Geotechnical Conditions	See Figure 27.1-1 & 2
4. Seismic Condition	Design seismic coefficient: 0.05
III. Structural Conditions	
1. Materials	
1.1 Concrete	
(1) Grade and Strength (kPa)	A(for ICB): 42.0, B(for PC): 34.5, C(for marine RC): 27.5, D(for on-land RC): 24.0, E(for plain concrete): 18.0, F(for lean concrete): 10.0
(2) Re-Bars (Grade, Allowable Stress Mpa)	SR295: fa=157 (Round Bar), SD345: fa=196 (Deformed Bar)
(3) PC Strands (Yield Stress Mpa)	PC-250: fy=1725, PC-270: fy=1860
1.2 Structural Steel (Grade, Yield & Allowable Stress Mpa)	SS400, SM400, SMA400: fy=235, fa=140, SM490: fy=315, fa=185, SM490Y, SMA490: fy=355, fa=210
1.3 Steel Pipe Pile (Grade, Yield & Allowable Stress Mpa)	SKK400, SHK400, SKY400: fy=235, fa=140, SKK490, SHK490, SKY490: fy=315, fa=185
1.4 Steel Sheet Pile (Grade, Yield & Allowable Stress Mpa)	SY295: fy=295, fa=180, SY390: fy=390, fa=235
1.5 Corrosion Rate of Steel (mm/yr.)	Sea Side: above HWL: 0.3, HWL~LWL-1.0m: 0.2, LWL-1.0m ~seabed: 0.15 below seabed: 0.03 Land Side: above GL: 0.1, GL~GWL: 0.03, below GWL: 0.02
1.6 Unit Weight (kN/m^3)	PC, RC: 24.0, Asphalt: 22.6, Stone: 26.0, Sand: 18.0, Steel: 77.0
1.7 Fill Material	Sand, Unit weight 18 kN/m^3, Internal Friction Angle 30 deg.
2. Other Consideration	
2.1 Increase in Allowable Stress	Seismic condition: 50%, Temporary loading condition: 33%
2.2 Safety Factor (Factors in bracket: Seismic condition)	
(1) Slope	1.3 (1.0)
(2) Gravity Type Structures	Sliding: 1.2 (1.0), Over Turning: 1.2 (1.1), Bearing Capacity: 1.2 (1.0)
(3) Sheet Pile Wall	*Stability of Moment Balance: 1.5 (1.2), Anchor Block Stability: 1.5 (1.2)*
(4) Shallow Foundation	Bearing Capacity: 2.5 (1.5)
(5) Pile Foundation	Bearing Capacity: 2.5 (1.5), Pullout: 3.0 (2.5)
2.3 Service Period	50 years

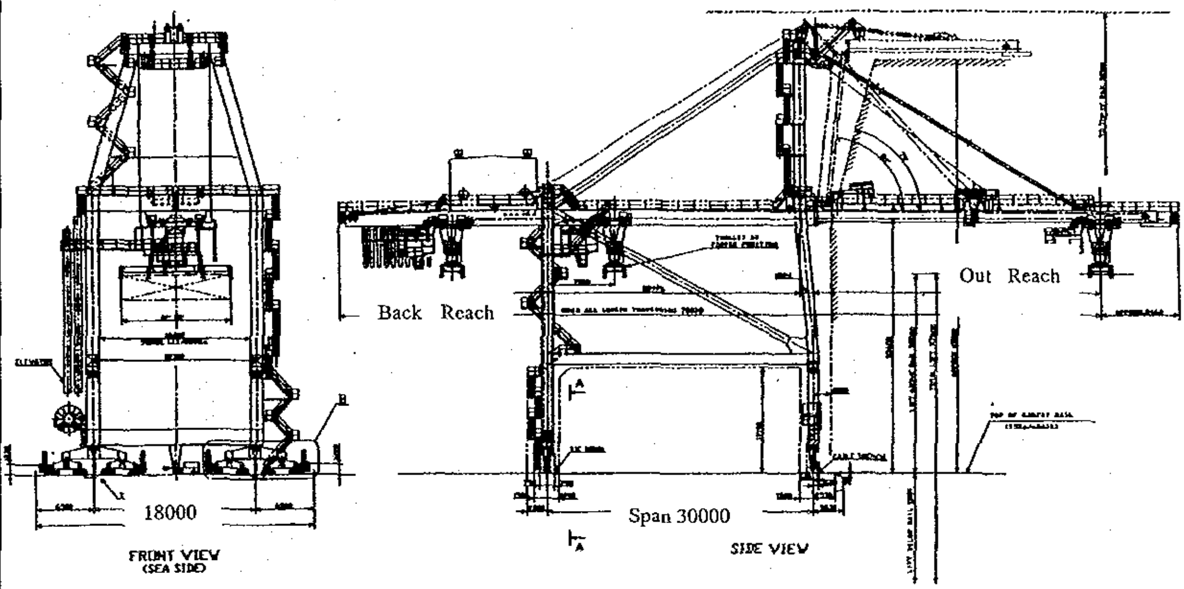
27.2 Design of Container Terminal at Lower Cai Mep

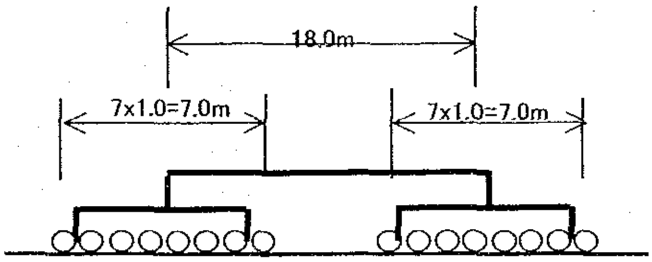
27.2.1 Quay Structure

(1) External Forces

a) Quayside Container Crane

Based on the size of full loaded 50,000DWT container vessels and partial loaded 80,000DWT container vessels, the following container crane is applied for the design of quay structure.





Maximum Wheel Load (tf/wheel)		
	Sea Side	Land Side
Operation Condition	47	33
Seismic Condition	28	22

Figure 27.2.1-1 Quayside Container Crane

b) Surcharge

For the container berth in the world, generally, 2 to 4 t/m^2 of surcharge is adopted for the design of apron. In this design, 4 t/m^2 of surcharge is applied considering the flexible operation of heavy cargo handling equipment on the any part of apron. apron.

c) Berthing Energy and Reaction Force of Rubber Fender

The ship berthing energies for full-loaded 50,000 DWT vessel and partial loaded 80,000 DWT vessel are calculated as follows:

$$Ef=(Ws*V^2/2g)*Ce*Cm*Cs*Cc$$

Table 27.2.1-1 Berthing Energy

Item	Description	50,000 DWT Full loaded	80,000 DWT Partial loaded
Ws	Water displacement of berthing ship (tf)	70,000	90,000
V	Approach velocity of ship against the fender (m/s)	0.1	0.1
G	Acceleration gravity (m/s^2)	9.8	9.8
Ce	Eccentricity factor	0.52	0.48
Cm	Virtual mass factor	1.92	1.80
Cs	Softness factor	1.0	1.0
Cc	Shape factor of berth	1.0	1.0
Ef	Ship's berthing energy (tf-m)	35.4	39.5

From above berthing energies, two units of rubber fender type 1000H/R0 are selected and installed as shown in Figure 27.2.1-2. The reaction force of this fender system will be 2 x 44.5 = 89.0 tf as known from the performance curve of rubber fender 1000H in Figure 27.2.1-3.

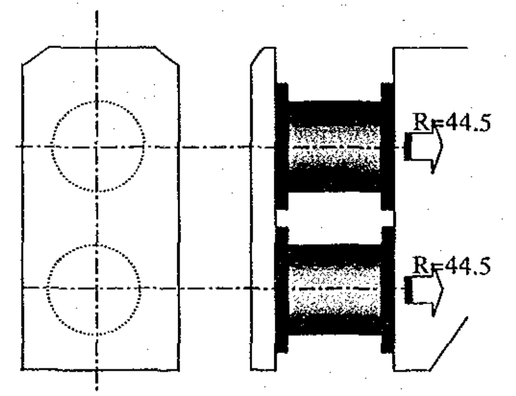


Figure 27.2.1-2 Fender System

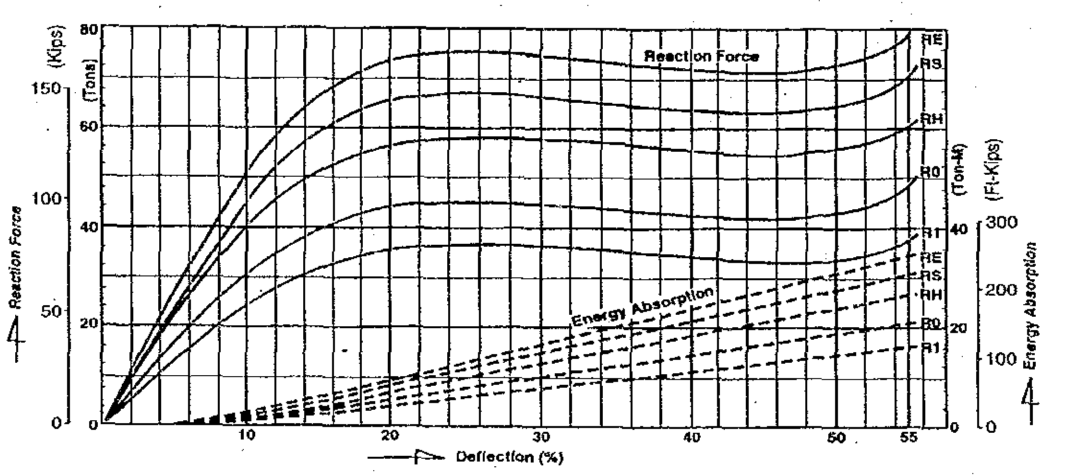


Figure 27.2.1-3 Performance Curve of Rubber Fender 1000H

d) Mooring Force

The mooring force consists of the pressures due to winds, currents and waves in general. However, both project sites are situated in the river and wave action is negligibly small and current pressure on shipside is also negligible. The wind pressure acting perpendicular on shipside (Y-direction) for full-loaded 50,000 DWT vessel and partial loaded 80,000 DWT vessel is calculated as follows:

$$Ry=1/2*\rho a*U^2*A_L*Cy$$

Table 27.2.1-2 Wind Force on Shipside (Y-direction)

Item	Description	50,000 DWT Full loaded	80,000 DWT Partial loaded
ρa	Density of air (tf/m^3)	1.23x10^{-3}	1.23x10^{-3}
U	Wind velocity (m/s)	15	15
A_L	Y-direction projection area of ship above water (m^2)	6,000	7,500
Cy	Shape factor of Y-direction	1.094	1.094
Ry	Wind force of Y-direction (kN)	910	1,140

The wind and current pressure acting on bow (X-direction) for full-loaded 50,000 DWT vessel and partial loaded 80,000 DWT vessel is calculated as follows:

Wind: $Rx=1/2*\rho a*U^2*A_T*Cx$ Current: $Rf=0.0014*S*V^2$

Table 27.2.1-3 Wind and Current Force on Bow (X-direction)

Item	Description	50,000 DWT Full loaded	80,000 DWT Partial loaded
ρa	Density of air (tf/m^3)	1.23x10^{-3}	1.23x10^{-3}
U	Wind velocity (m/s)	15	15
A_T	X-direction projection area of ship above water (m^2)	930	1,390
Cx	Shape factor of X-direction	0.653	0.653
Rx	Wind force of X-direction (kN)	84	126
S	X-direction projection area of ship under water (m^2)	375	560
V	Current velocity (m/s)	2.0	2.0
Rf	Current force of X-direction (kN)	2	3

Against the above forces, the vessel will be moored by 2 to 4 bowlines, 2 to 4 stern lines and 2 spring lines. Therefore, as recommended in the Technical Standards for Port and Harbour Facilities in Japan, bollards of 1000 kN (100 tf) capacity are provided along the face line of quay at an interval of 20 m.

e) Seismic Force

The horizontal seismic forces are considered for this structural design but the vertical seismic forces are not necessary to be considered. The coefficient of horizontal seismic force is Kh = 0.05g. In general, 50% of surcharge loads will be considered during seismic conditions. In this design, therefore, 2.0 tf/m^2 of surcharge load is considered.

(2) Alignment and Layout of Quay Structure

a) Alignment of Quay

Alignment of the face-line of quay was determined as shown on Figures 27.2.1-4. Based on the proposed alignment, the quay structure should be open type (Concrete deck super structure supported by foundation piles) in order not to disturb the flow of river. They will be constructed about 140 m off from the reclaimed terminal yard at riverbank. Therefore, approach roads between the quay and the terminal should be provided and it should also be an open type structure.

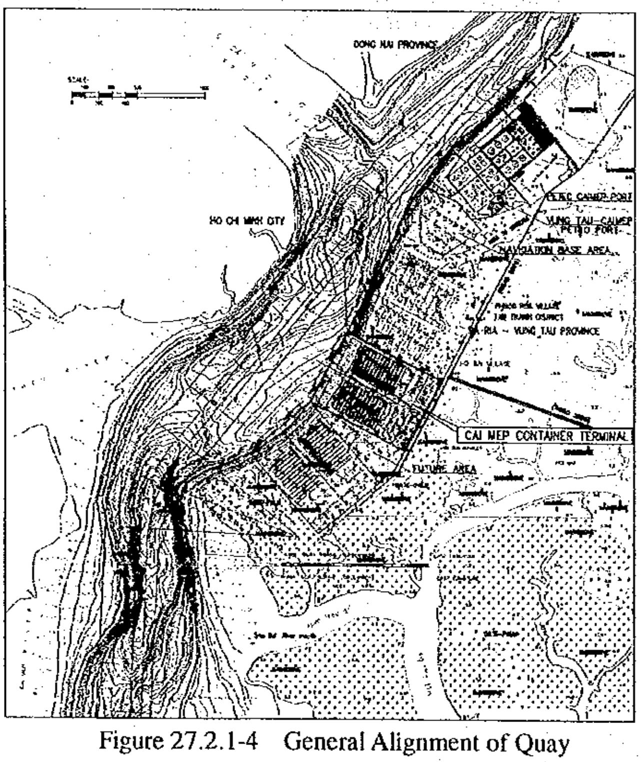


Figure 27.2.1-4 General Alignment of Quay

b) Plan and Elevation of Quay

The crown height of quay was determined at CDL+5.00 m based on the elevation of HWL and variation of tide levels. The water depth in front of quay was decided at CDL-14.0 m based on the maximum full loaded draft of 12.5 m of 50,000 DWT container vessels.

The width of quay apron was decided at 50 m based on the rail span of 30 m of quayside container crane and a space for hatch covers of container vessel of around 15 m. The quay length for one 50,000 DWT container vessel was determined at 300 m on account of its LOA of 267 m and that was divided into four blocks structurally considering the stability of structure and construction method.

Along the face-line of quay, the fender system shown in Figure 27.2.1-2 will be provided at an interval of 10 m and bollards of 100 tf each are installed at 20 m intervals.

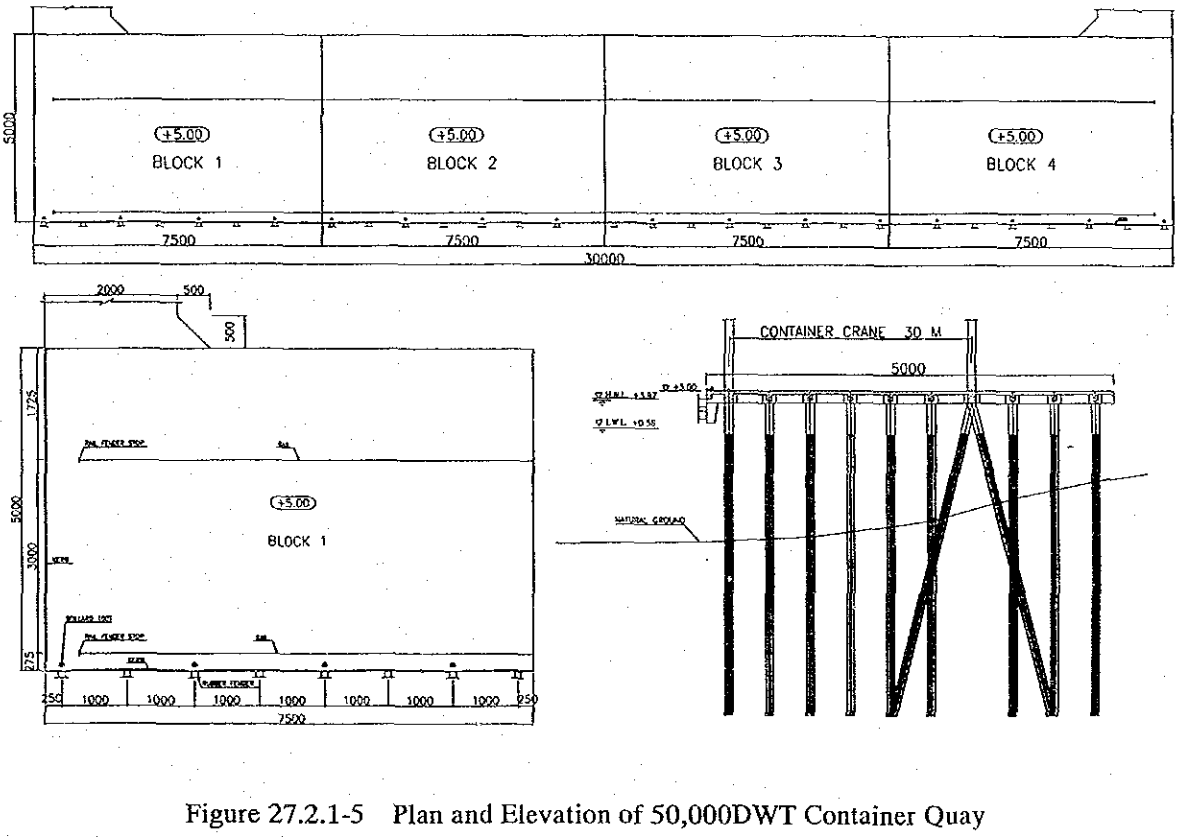


Figure 27.2.1-5 Plan and Elevation of 50,000DWT Container Quay

c) Critical Berthing Force for Quay Structure

When container vessel hits fender systems on the quay at berthing, the fender systems will absorb berthing energy and produce reaction forces against the quay structure. The quay structure should stand safely against the reaction forces of fender system. In the design of quay structure, it must be noted that generally, the critical condition against structure will occur under Case 1 berthing condition illustrated in the Figure 27.2.1-6. However, due to the special characteristics of rubber fender, its absorption energy is not in direct proportion to the reaction force (See Figure 27.2.1-3 Performance Curve of Rubber Fender 1000H). The critical condition for the structure occurs under

Case 2 berthing condition as shown below.

Berthing forces against the structural frame at end row (H11 and H21) are calculated as follows:

$$H11=k_1/\Sigma ki*R + (ki*Xi/\Sigma ki*Xi^2)*e*R = 1/8*R + 1225/6300*R = 0.319R=28.5 \text{ tf}$$

$$H21= k_1/\Sigma ki*2R + (ki*Xi/\Sigma ki*Xi^2)*(e_1+e_2)*R = 2/8*R + 2100/6300*R = 0.583R=52.1 \text{ tf}$$

Where; ki : Horizontal spring constant of the i-th pile (tf/m)

Xi : Distance from the symmetrical axis of a block to the i-th pile (m)

e : Distance between the symmetrical axis to horizontal force (m)

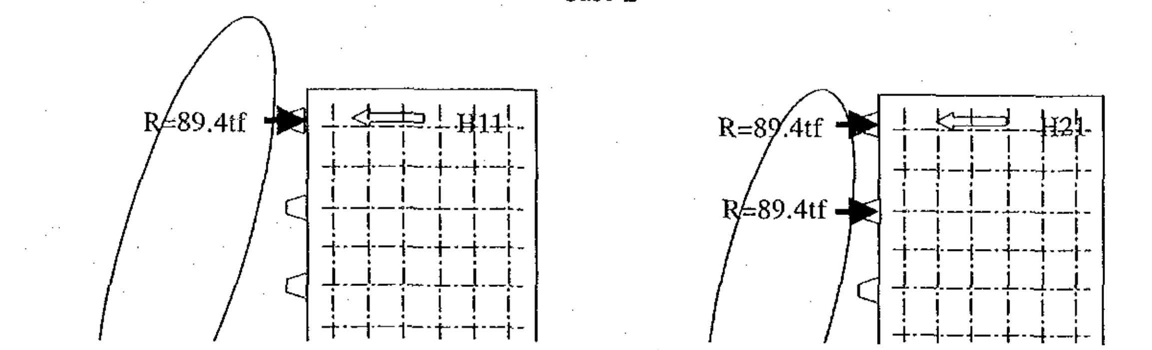


Figure 27.2.1-6 Critical Berthing Condition

d) Critical Loading Conditions for Quay Structure

The following combination of loads is considered for the structural design of quay and an increase ratio for the allowable stresses of structural materials is applied in case of seismic condition.

Table 27.2.1-4 Loading Combinations for Quay Structure

Case	Vertical Load			Horizontal Load					Increase Ratio (%)
	Dead Load	Live Load		X-Direction			Y-Direction		
		Crane	Surcharge	Berthing	Mooring	Seismic	Mooring	Seismic	
Case 1	○	○	○	○					100
Case 2	○			○					100
Case 3	○	○	○		○				100
Case 4	○				○				100
Case 5	○	○	○			○			150
Case 6	○					○			150
Case 7	○	○	○					○	150
Case 8	○							○	150
Case 9	○	○	○				○		100

(3) Quay Structure

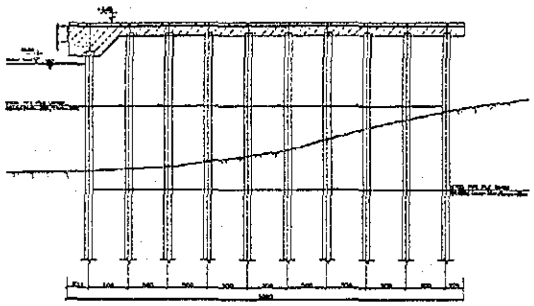
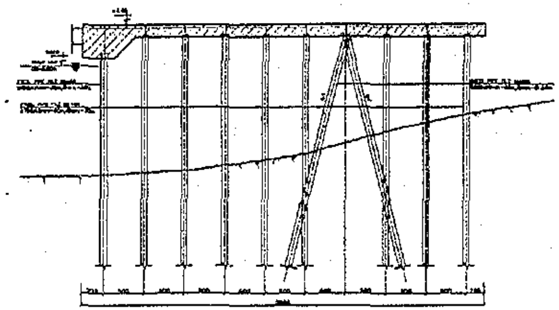
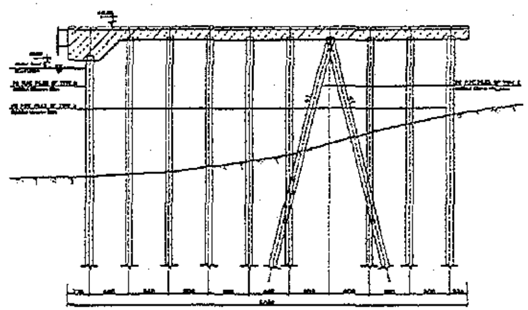
As explained, the quay structure of this terminal should be "Open Type" so as not to disturb the river flow and to eliminate unfavorable impact of erosion or sedimentation of riverbed. Three kinds of open type quay structures have been compared as summarized in Table 27.2.1-5. The coupled steel pipe piles type quay structure was selected as the most suitable to the site conditions. Typical section of the coupled steel pipe piles quay structure is shown in Figure 27.2.1-7 and design calculation is summarized in Table 27.2.1-6.

Table 27.2.1-6 Structural Calculation Results of Quay Foundation Piles

Case 1: Berthing Condition							
Pile	M (t-m)	S (t)	N (t)	Member Section Steel Pipe Pile SN490	σb (kg/cm2)	σc (kg/cm2)	σb/σba+ σc/σca ≦1.0
Sea side 1st row Vertical Pile	38.0	2.0	317.8	D=800mm t= 16mm	535	861	0.98
Sea side 2nd row Vertical Pile	18.2	1.0	159.8	D=700mm t= 12mm	454	673	0.85
Sea side Batter Pile	26.5	3.1	72.8	D=800mm t= 16mm	374	197	0.36
Land side Batter Pile	23.2	2.9	230.6	D=800mm t= 16mm	327	625	0.68
End row Vertical Pile	10.5	0.7	151.2	D=700mm t= 12mm	262	637	0.72
Case 5: Seismic Condition							
Pile	M (t-m)	S (t)	N (t)	Member Section Steel Pipe Pile SN490	σb (kg/cm2)	σc (kg/cm2)	σb/σba+ σc/σca ≦1.0
Sea side 1st row Vertical Pile	34.2	1.8	225.5	D=800mm t= 16mm	482	611	0.50
Sea side 2nd row Vertical Pile	18.3	1.1	107.0	D=700mm t= 12mm	456	451	0.43
Sea side Batter Pile*	28.3	3.2	12.3	D=800mm t= 16mm	798	67	0.32
Land side Batter Pile*	25.8	3.1	202.1	D=800mm t= 16mm	728	1095	0.84
End row Vertical Pile	4.9	0.3	102.6	D=700mm t= 12mm	311	432	0.37

Note: Coupled batter piles are arranged in every two structural frames.

Figure 27.2.1-5 Comparison of Quay Structure

	Vertical Steel Pile Type	Coupled Steel Pile Type	Coupled Pre-streessed Concrete Pile Type
Typical Cross Section			
Merit	• Pile driving equipment is low price • Pile driving work is the easiest • Construction period is the shortest	• Total construction cost is the lowest • Deflection by horizontal force is small • Deepening of the water depth is not much problem for structural stability	• Maintenance against corrosion is not necessary • Pile material can be available locally • Deflection by horizontal force is small • Deepening of the water depth is not much problem for structural stability
Demerit	• Pile material cost is the highest • Deflection by horizontal force is bigger • Counter-measure against corrosion is essential • Deepening the water depth will require the reinforcement of piles	• Pile driving equipment is high price • Pile driving work is difficult • Construction period is a little longer • Counter measure against corrosion is essential	• Pile weight is very heavy and careful handling is required • Pile driving equipment is the highest price • Pile driving work is the most difficult • Construction period is the longest
Cost	120%	100%	110%
Evaluation	**Good**	**Best**	**Better**

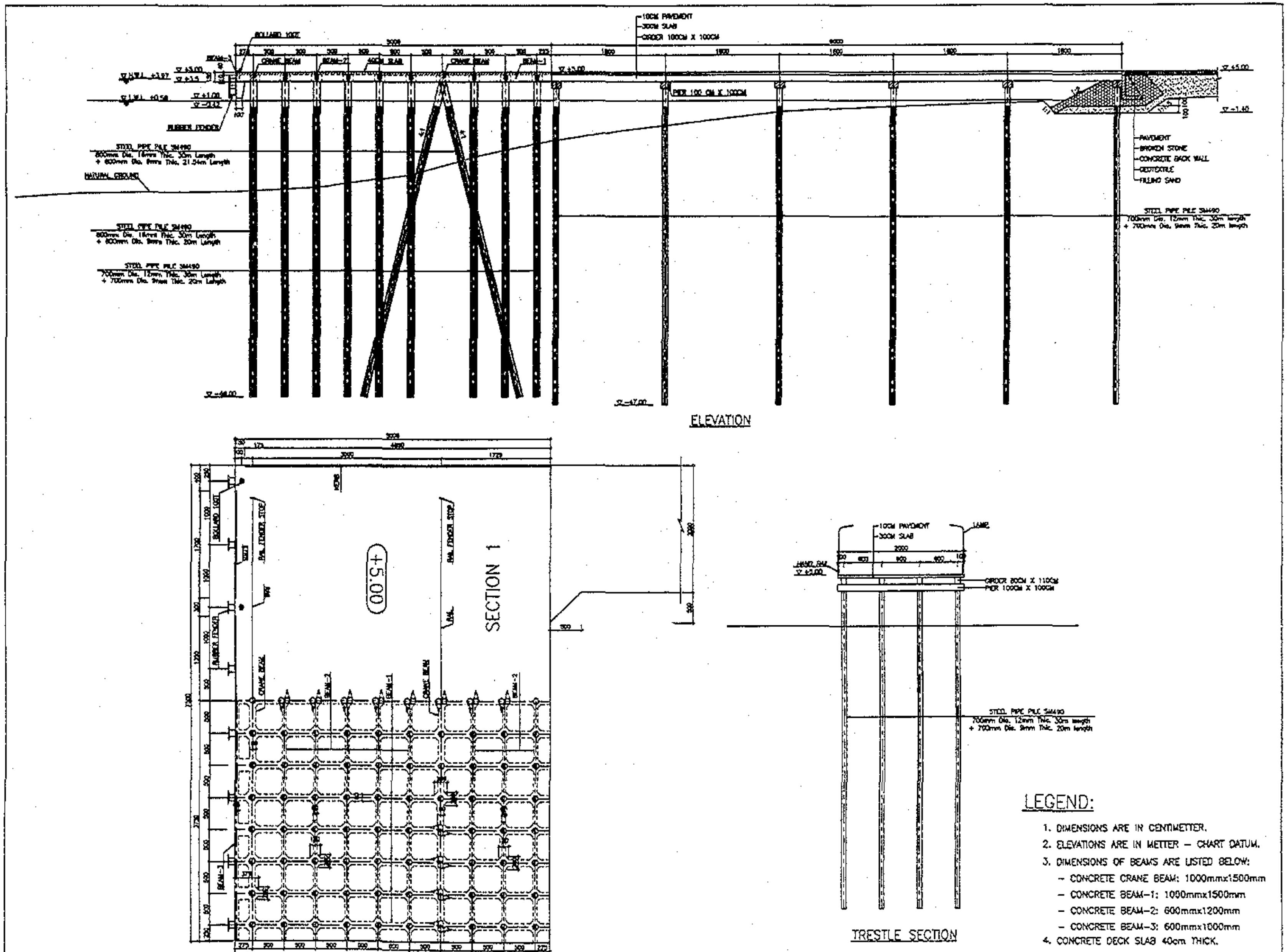
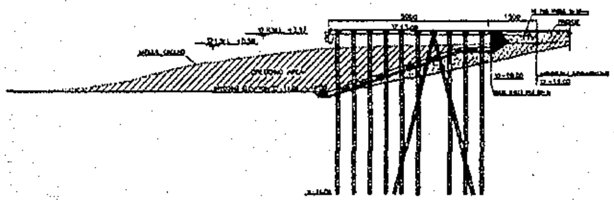
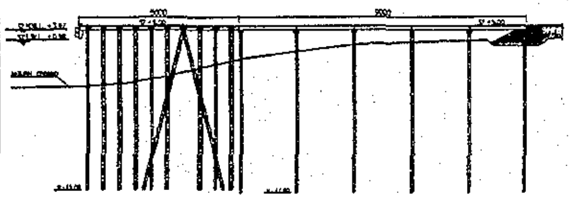
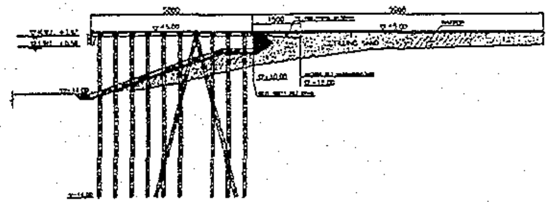


Figure 27.2.1-7 Typical Plan and Section of Quay Structure

Table 27.2.1-7 Comparison of Connection Way between Quay and Terminal Yard

	Quay at Riverbank	Quay connected by Trestle	Quay with Sheet Pile Revetment
Typical Cross Section			
Merit	• Cargo handling operation is most convenient	• River side revetment is simple and low cost, and total construction cost is the lowest • River flow is not disturbed • No maintenance dredging is required • No erosion and sedimentation troubles will occur • Impact on natural environment is minimum	• Cargo handling operation is convenient • No capital dredging is required • Minimum land acquisition is required
Demerit	• Capital dredging cost is highest • Maintenance dredging cost is highest • Total construction cost is high	• Cargo handling operation is ineffective	• Big erosion and/or sedimentation troubles will occur around the site • River flow is disturbed • Impact on natural environment is largest • Revetments for both sides are costly • Total construction cost is most expensive
Cost	200% + maintenance dredge	100%	300%
Evaluation	**Not recommendable**	**Recommendable**	**Not recommendable**

(4) Trestle (Access Bridge)

For the layout of terminal, the quay and terminal yard should be located as close as possible from the operational point of view. However, such layout cannot always be realized due to restrictions of site conditions, especially from the hydrographic conditions. In case of lower Cai Mep site, the width of river is wide enough. However, the slope of riverbed is gentle and direct connection of quay structure and terminal yard is difficult, because if the quay is arranged just in front of terminal yard at riverbank, capital dredging volume becomes large as well as maintenance dredging volume in the future.

On the other hand, if the quay is arranged apart from riverbank, there are two alternative plans: one is that the terminal yard is constructed behind the riverbank and connected to the quay by trestles (access bridges), and the other is that the sheet pile revetment is constructed just behind the quay structure and the area between the sheet pile revetment and riverbank is reclaimed and used for a part of terminal yard. The merits and demerits of each alternative are summarized in Table 27.2.1-7.

Considering the merits and demerits of above three alternatives, the trestle type plan has been selected. Only disadvantage of this plan is a less efficiency of container handling operation that is caused by increase in transport distance of 90 m between quay apron and container stacking yard.
In case of a container terminal, unlike a general cargo terminal, even if terminal yard is connected with quay apron directly, traffic routes can not be shortcut since tractor-trailers shall enter from the end of quay apron and exit from the other end of quay apron, then, shall enter into stacking yard from the end and exit from the other end. Therefore, the deference of efficiency between the direct connection case and access bridge case is about 0.5 minutes/cycle while one cycle time is estimated at 12.5 minutes. This efficiency loss can be recovered easily by increasing one tractor-trailer for each berth that is equivalent to 0.1% of total equipment cost.

As a conclusion, it can be said that the access bridge plan is most suitable for natural conditions at site and the operational disadvantage is practically negligible.

Only small horizontal forces act on the trestle structure. Hence, a reinforced concrete superstructure and steel pile piles foundation is adopted for the trestle structure as illustrated in Figure 27.2.1-7.

27.2.2 Land Reclamation

(1) Present Condition of Sub-soil and Operational Requirements of Land

Project site is low-lying swampy land covered by mangroves. Based on the natural condition survey conducted in May to June 2002, it was proved that the existing ground elevation is around CDL +3.00 m and the subsoil consists of very soft clay upper layer of 33 m thick, soft to very stiff clay middle layer of 6 m thick and dense sand bearing layer.
In order to construct a container terminal here, the site should be reclaimed up to CDL +5.00 m as explained in Chapter 18 and the reclaimed land will be mainly used for the container stacking and marshalling yard where full loaded containers are stacked 4 tiers high.
As known from the subsoil conditions presented in Figure 27.1-1, it is clear that if dead-load of fill sand and port operation load are charged on the existing ground, the upper very soft clay layer and soft to stiff clay middle layer of subsoil will be consolidated and considerable amount of settlement will occur on the surface of ground and structures on the ground.
A suitable countermeasure against the settlement, therefore, will be inevitable for the construction of container terminal at this site.

(2) Settlement and Soil Improvement

There are many construction methods to cope with soft subsoil material. When constructing an independent building on the soft subsoil, piling to bearing layer is the most popular method. However, the piling method is not suitable for the construction of a wide stable area like a container yard. To prepare evenly stable wide area, there are the following methods: pre-loading, sand replacement, vertical sand drain, vertical plastic board drain, vacuumed drain, cement stabilizing, etc. These methods are applied independently or in some combinations.

In this project, the combination of plastic board drain and pre-loading methods is recommended, since it is easy for work, low construction cost, no hazardous impact for natural and social environment, and already very popular in this region.
Considering the subsoil conditions and construction program, the design is to drive plastic boards up to –31 m at horizontal intervals of 1.5 m and fill sand up to +11.0m as pre-load. The results of consolidation analysis show that ultimate settlement amount will be 4.73 m at the center of reclaimed land. About 2-years period is required to obtain the 80% consolidation ratio which allows removal of pre-loading sand and commencing the construction works on the reclaimed land as shown in Figures 27.2.2-1 and 27.2.2-2.

(3) Revetment

The reclamation for the terminal should be secured by appropriate revetment along its edges. The revetment along the river will be permanent and made of rubble stone mound and concrete retaining wall. The revetment along the other edges may be temporary or a simple one (such as made of sand back mound) because both sides of the terminal will be continuously extended through successive implementation of Phase 2 and 3 terminal construction. Typical section of the riverside revetment is shown in Figure 27.2.1-7.

Soil Improvement at Lower Cai Mep International Container Terminal
Estimated Cross Section of Fill Sand (2000days)

Item	FillCenter	Fill Edge	140mOff
Fill Top El.	CDL 6.27	CDL 2.95	CDL 2.99
Settlement	4.73m	2.05m	0.01m

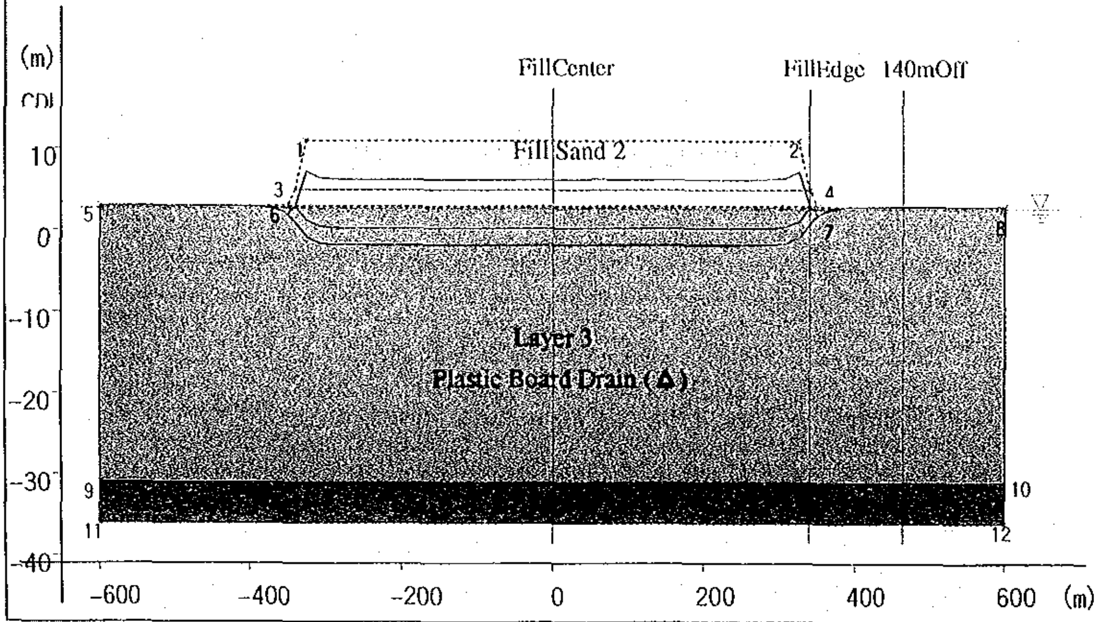


Figure 27.2.2-1 Cross Section of Reclaimed Land and Final Settlement at Lower Cai Mep

Soil Improvement at Lower Cai Mep International Container Terminal
Time – Consolidation Ratio (2000days)

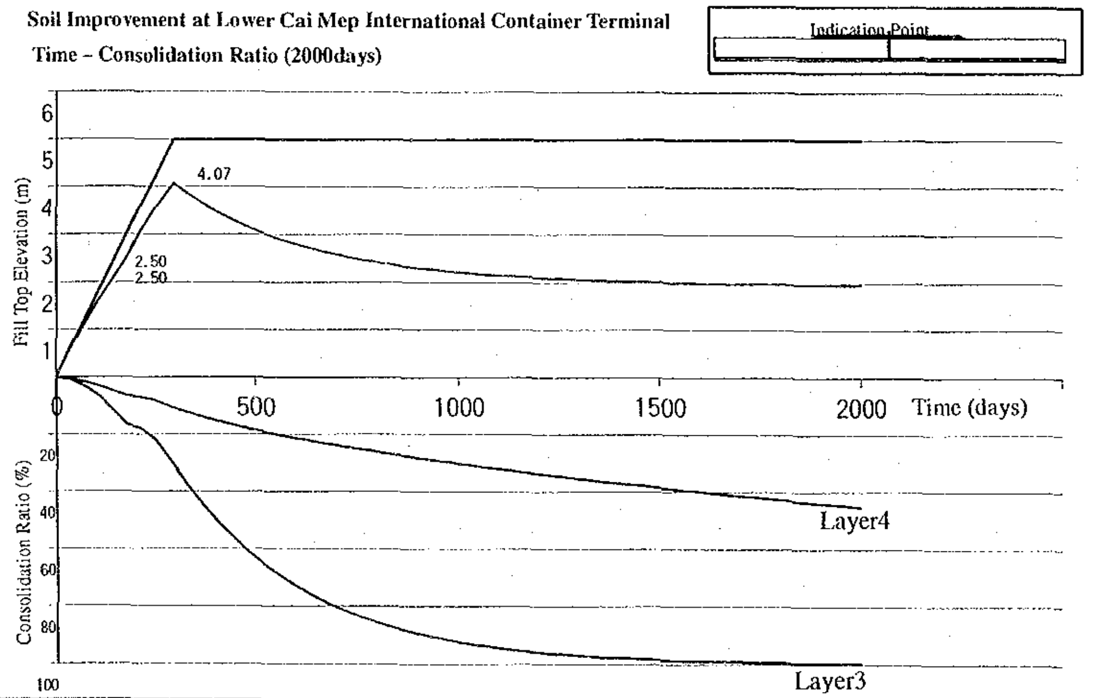
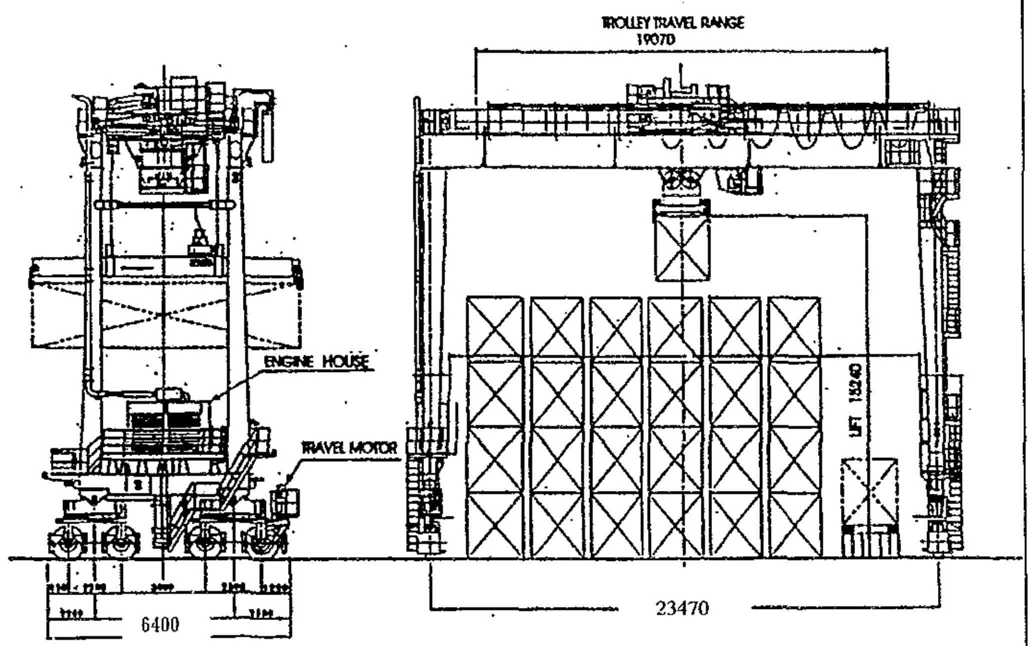


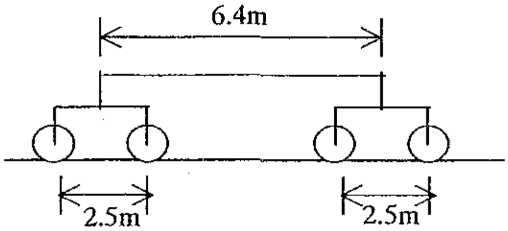
Figure 27.2.2-2 Tame-Consolidation Ratio Curve by Soil Improvement Work

27.2.3 Pavement of Terminal Yard

(1) Use Plan of Terminal Yard

Based on the terminal layout prepared in the Chapter 26, pavements inside the terminal area have been studied for its specific operational use. For the container stacking/unstacking operation, Rubber-tired Transfer Gantry cranes (RTG) are used in this terminal. Dimensions and wheel loads of RTG for the design of pavement are shown in Figure 27.2.3-1.





Self-Weight	130tf
Maximum Wheel Load	30tf

Figure 27.2.3-1 Rubber Tired Transfer Gantry Crane (RTG)

(2) Type of Pavement

As explained, the upper layer of subsoil at the site will be improved by using plastic board drains. However, consolidation of lower clay layer will continue for a long period and the settlement of the yard will be very slow and also continue for a long time. Therefore, a flexible type of pavement is preferable for this terminal yard. On the other hand, the hard surface of pavement is required for container handling operations. Based on these conditions, the interlocking concrete block (ICB) pavement is adopted for this terminal except some specific areas, such as container washing area, runways of RTG cranes, etc.

(3) Typical Section of Pavement

Depending on the critical loading for each area, suitable types and strengths of pavement were selected and determined as shown in Figure 27.2.3-2 and Table 27.2.3-1.

For this selection, the following remarks were considered in the design:

- Passageway inside the yard: Ideally only loaded trailer trucks and unloading handling equipment will pass on the pavement. Thus, it does not need to be designed for heavy wheel loads of equipment, such as forklifts, side loaders, and reach stackers for loaded containers.
- Container stock yard: Considering the site conditions, the yard will be provided in the reclamation on improved soft clay stratum and residual settlement is anticipated. Accordingly, concrete sleeper foundation and ICB pavement between sleepers are selected. The sleeper will bear container corner loads up to 4 tiers high.
- Runway of RTG: Rigid block pavement of pre-stressed concrete slab is adopted for heavy wheel loads.

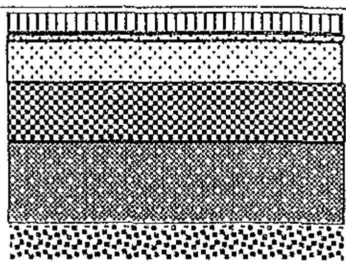
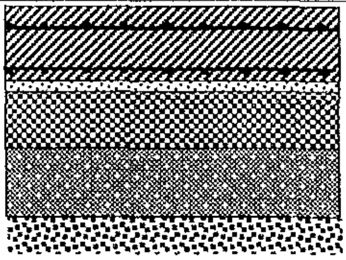
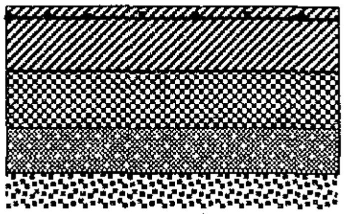
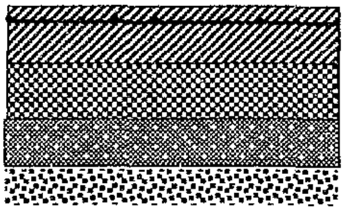
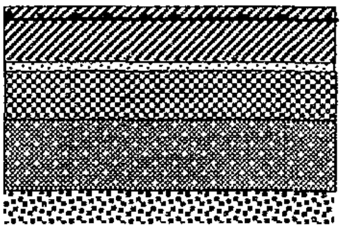
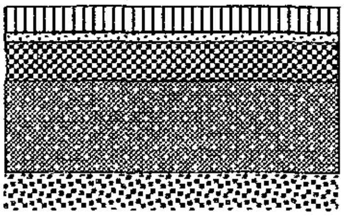
27.2.4 Gate, Gatehouse and Weigh Bridge

Main gate consists of a gate canopy which covers 6 traffic lanes (3 lanes for incoming traffic and 3 lanes for outgoing traffic) and has 4 check rooms (2 rooms for incoming traffic and 2 rooms for outgoing traffic) with an extra traffic lane (without either a canopy or check room) for emergency passage which allow large trucks, top loaders or cranes to pass. Sub-gate consists of a gate canopy which covers 4 lanes (2 lanes for incoming traffic and 2 lanes for out going traffic) and has 2 check rooms (1 room for incoming traffic and 1 room for outgoing traffic).

The canopy has clear height of 5.3 m from the road level and is made of reinforced concrete columns and flat slab. The checkroom has a space of 30 m^2 and is made of reinforced concrete. At the main gate, 4 weighbridges are installed (2 weighbridges for incoming traffic lanes and 2 weighbridges for outgoing traffic lane). At the sub-gate, 2 weighbridges are installed (1 weighbridge for incoming traffic lane and 1 weighbridge for outgoing traffic lane). The weighbridge can measure up to 50 tons. The weighbridges are mounted on the foundations supported by reinforced concrete piles.

The preliminary plan and elevation of main gate are presented in Figure 27.2.4-1

Table 27.2.3-1 Typical Cross Section of Pavement

Area	Type	Load	Section of Pavement
Terminal Service Road	Concrete Block	Container Trailer Truck	 12cm Inter Locking Block 4cm Compacted Sand 15cm Lean Concrete Base Course 10MPa 25cm Grain Adjusted Material Base Course CBR ≧ 80 40cm Subgrade CBR≧30 Compacted Fill CBR≧ 5
Runway of RTG (B=1.5m)	PC Slab	RTG	 25cm Pre-Stressed Concrete Slab 4cm Compacted Sand 20cm Grain Adjusted Material Base Course 30cm Subgrade CBR ≧ 30 Compacted Fill CBR≧ 5
Maintenance Shop, Container Washing Area	Concrete	Reach stacker, Forklift	 25cm Concrete Slab 20cm Grain Adjusted Material Base Course CBR ≧ 80 15cm Subgrade CBR≧ 30 Compacted Fill CBR≧ 5
Floor of CFS	Concrete	Forklift	 20cm Concrete Slab 20cm Grain Adjusted Material Base Course CBR ≧ 80 15cm Subgrade CBR ≧ 30 Compacted Fill CBR≧ 5
Container Stacking Foundation	Concrete	Loaded Containers 4 tiers high	 25cm Concrete Stacking Foundation 4cm Compacted Sand 20cm Grain Adjusted Material Base Course CBR ≧ 80 30cm Sub grade CBR≧ 30 Compacted Fill CBR≧ 5
Container Stacking Area, Other Terminal Area	Concrete Block	No Load Equipment	 12cm Inter Locking Block 4cm Compacted Sand 15cm Grain Adjusted Material Base Course CBR ≧ 80 40cm Sub grade CBR ≧ 30 Compacted Fill CBR ≧ 5

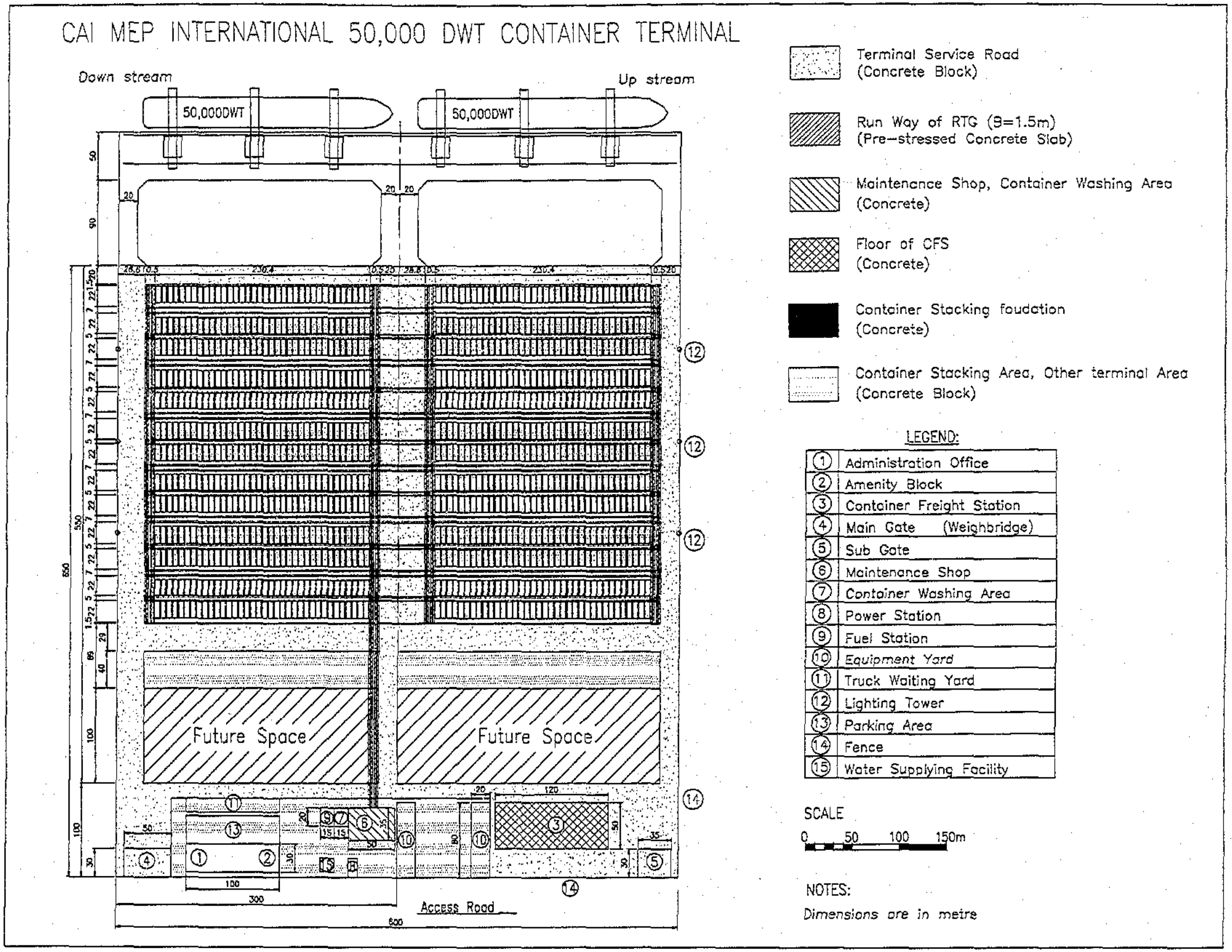
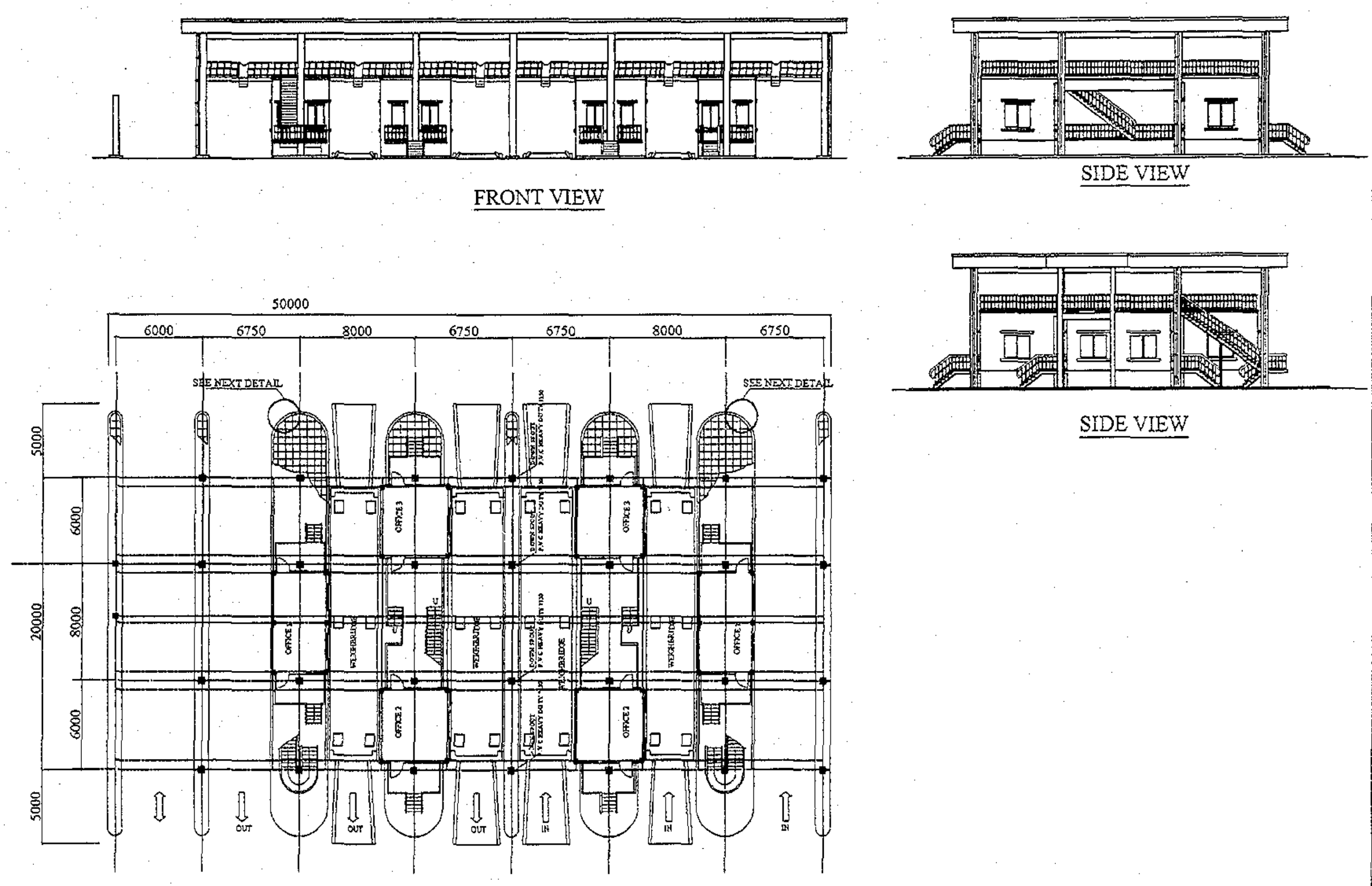


Figure 27.2.3-2 Terminal Use Plan and Typical Section of Pavement



PLAN VIEW

Figure 27.2.4-1 Plan and Elevation of Main Gate

27.2.5 Buildings

(1) CFS

As defined in the port planning, one CFS shed is required to be built. This shed has dimensions of 120 m in length and 50 m in width, with 6 m deep canopy on stripping side and 10 m deep canopy on delivery side. These canopy-covered area function as working space even under rainy weather. The shed has 16 doors on both sides and each door is 6 m wide and 6 m high and has a floor area of 6,000 m^2 for cargo store, including 450 m^2 of damaged and valuable cargo store and 150 m^2 of operators and customs office space. This office consists of two floors: the ground floor provides workers refreshment room and toilets, and the upper floor provides operators and customs office room. The floor level of this shed is 1.3 m above ground elevation in order to facilitate cargo handling from/to trucks and the minimum clearance height inside the shed is 6.5 m.

The shed will consist of steel columns and beams, concrete block wall with wire netting at the upper part, steel rolling shutter doors, aluminum box-rib sheet roof with transparent PVC panel and reinforced concrete floor slab.

The floor slab is designed to be able to store cargoes of 2ton/m^2. The columns of this shed are supported by the concrete piles, since residual settlement of subsoil will occur for long period in future. The tentative floor plan and elevations of this shed are shown in Figure 27.2.5-1.

(2) Maintenance Shop

The maintenance shop is planned mainly for the repairing of containers but also the minor repairing of forklift trucks, chassis, top loaders, etc. The maintenance shop has dimensions of 50 m length and 35 m width, and a ceiling crane, spare parts shelves, battery room and locker room for mechanics are provided. The doors of this shop should be more than 7 m height and 5 m width and the minimum clearance height inside the maintenance shop should also be more than 7 m.

This building will consist of steel columns and beams, concrete block wall with wire netting at the upper part, steel rolling doors, aluminum box-rib sheet roof with transparent PVC panel and reinforced concrete floor slab. The floor slab is designed to be able to support the equipment of 3 ton/m^2. The columns of this building are supported by the concrete piles for the same reason as for CFS building. The open area for maintenance work purpose is provided behind this maintenance shop and a special treatment facility for oil leakage will be provided around the shop.

The tentative floor plan and elevation of this maintenance shop is presented in Figure 27.2.5-2.

(3) Terminal Office Building (Administration Office and Amenity Block)

One terminal office building is planned to build near the main gate. This building is two or three storeys reinforced concrete structure having the floor space of 3,000 m^2 and a control tower is provided on the top. This building is comprised of terminal operators office rooms, customs office room, workers refreshment room, canteen and toilets, etc.

This building is supported by the reinforced concrete piles, since subsoil condition here is poor and settlement will occur gradually for long period in the future.

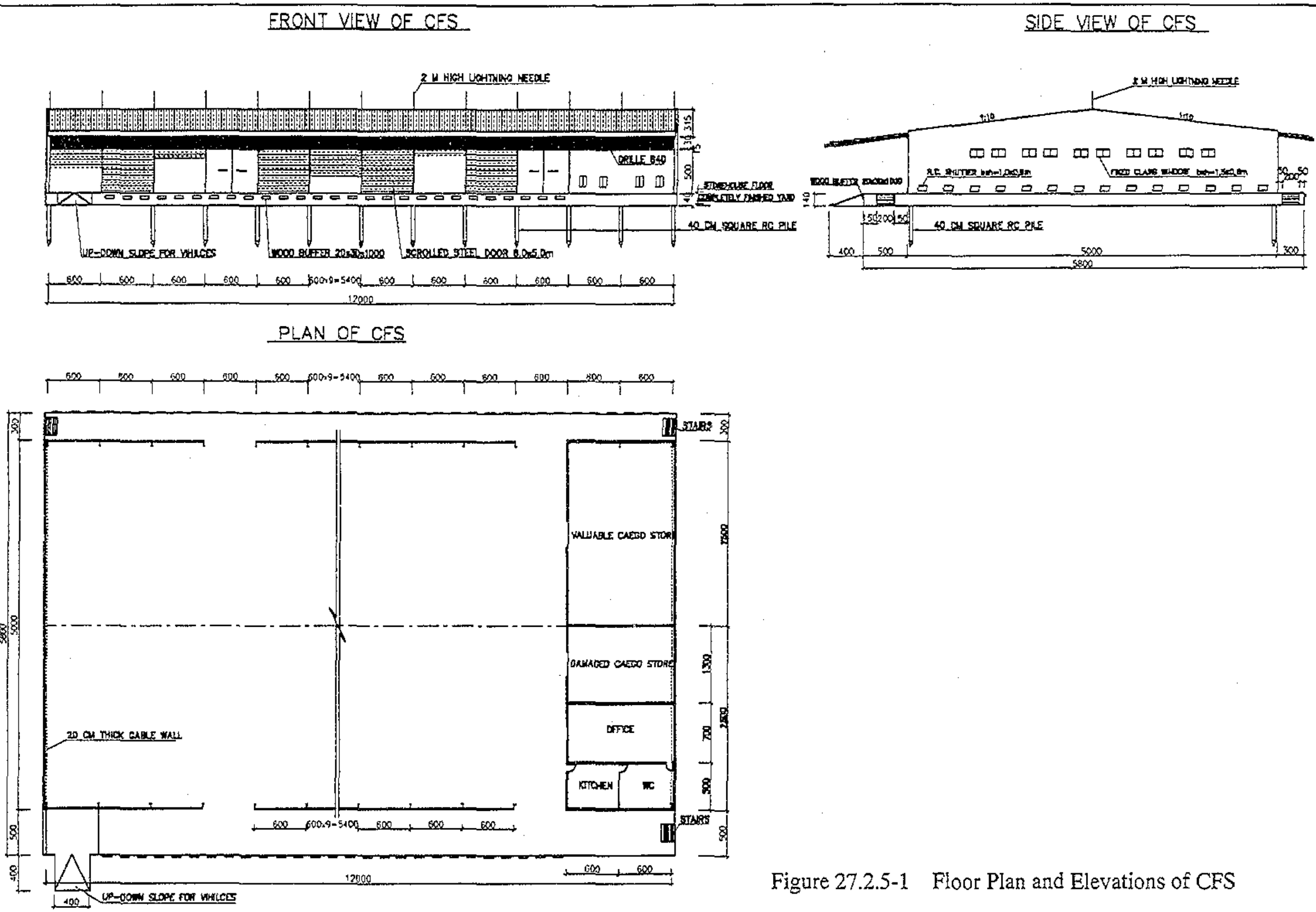


Figure 27.2.5-1 Floor Plan and Elevations of CFS

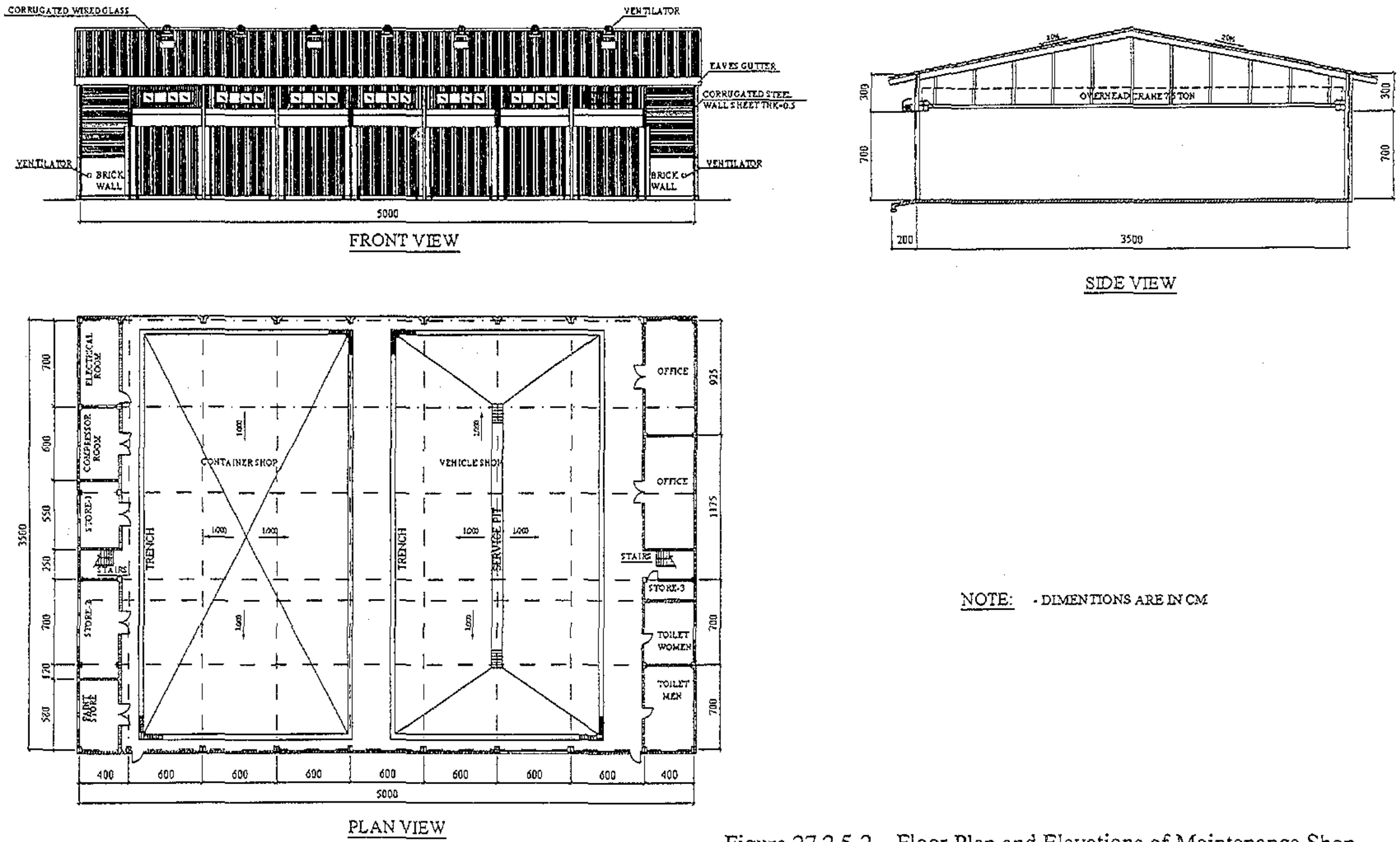


Figure 27.2.5-2 Floor Plan and Elevations of Maintenance Shop

27.2.6 Utilities

(1) Drainage

Inside the container yard, storm water will be collected by an appropriate gradient of the pavement to surface drainage, which will be of an open type, i.e. U-shaped ditch, V-shaped gutter, etc. The main drainage will be a buried concrete box culvert type, to which surface and domestic drains will be connected. Septic tanks for each building will be also installed, as well as spilled wastewater collector for the container washing area and maintenance shop.

(2) Water Supply

Fire fighting, ship's supply and other domestic consumption in the terminal have been considered and the water will be tapped at mains of IZ area. Relevant facilities, such as reservoirs, elevated tanks and pumps will be included, together with their network pipes.

(3) Power Supply

Substation and emergency generator for quay cranes will be provided, in addition to other demands of reefer receptacles, lighting and building supply.

27.2.7 Access Road

(1) Present Conditions of the site

The new project site has no access road to the existing road network in Cai Mep industrial development zone. Therefore, a new access road of about 3,000 m should be constructed. Based on the topographic survey and geotechnical investigation conducted in June 2002, the existing ground elevations along the route are around +3.0 m and there are many small creeks of less than –1.0 m deep. There is one creek about 150 m wide with –1.5 m depth, which is utilized by small barges for local transportation to be maintained even after construction of this access road. The subsoil along the access road is very soft clay of which N values are zero up to around –20 m, but it is expected that the clay below there will be stiff.

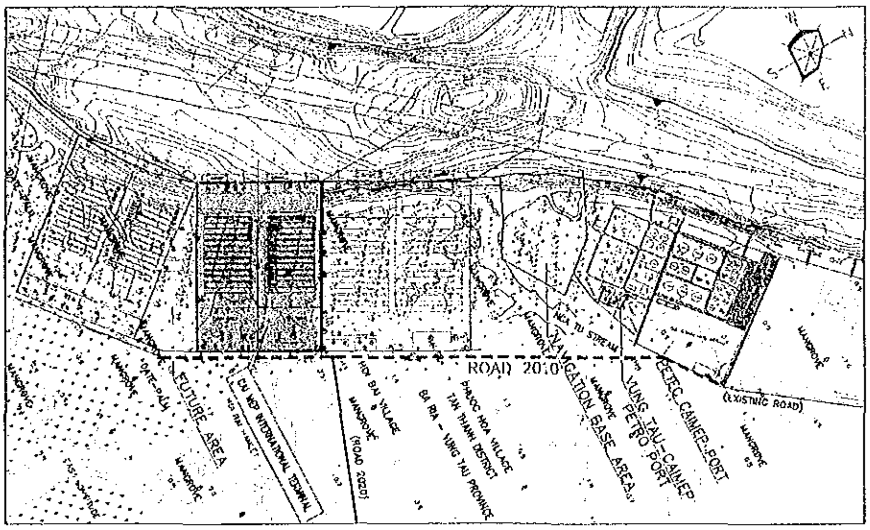


Figure 27.2.7-1 Layout of Access Road

(2) Layout of Access Road

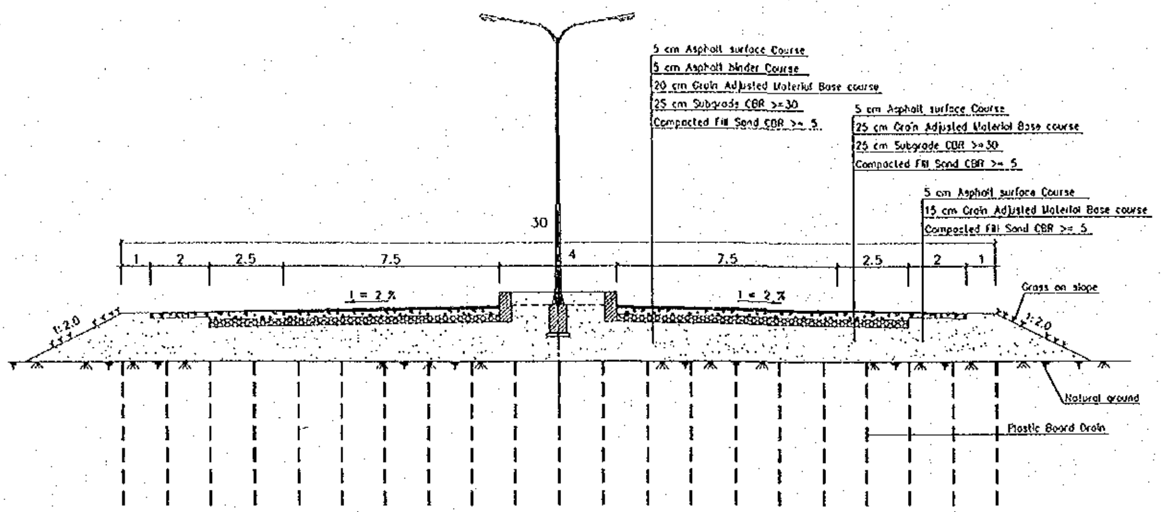
The access road originates at the Southeast corner of the Port site and terminates at the existing road near the PETEC Cai Mep Port. The proposed layout of access road is illustrated in Figure 27.2.7-1. The entire route passes through flood plain and the route is mostly free from any adjacent housing or agricultural and aquaculture activities.

(3) Typical Section of Road

The cross section adopted for the access road follow the Vietnam standard for national road. In order to ensure that the formation of the access road is sufficiently above HWL +3.97 m, the surface level of the pavement has been determined at 5.00 m.
Considering the expected traffic volume in 2010 and 2020, and the present situation of existing road to be connected, a crest width of 30.0 m and a paved width for vehicles of 15.0 m have been adopted.
As mentioned above, the bearing capacity of subsoil is insufficient for the construction of access road, thus subsoil improvement by the plastic board drains will be executed up to –20 m, and for the same reason, flexible pavement consisting of improved subgrade, base course and asphalt binder course and surface is adopted as shown in Figure 27.2.7-2.

(4) Bridges and Culverts

In order to keep water exchange between both sides of this access road, concrete culverts are planned to be constructed at around 10 points. To maintain barge transportation through the big creek, one bridge which length and width are 100m and 20 m respectively and above water clearance of 8.5 m for 500 DWT barges, is planned to construct.



NOTE:

Dimensions and elevations are in (m)

Figure 27.2.7-2 Typical Cross Section of Access Road to Cai Mep Site

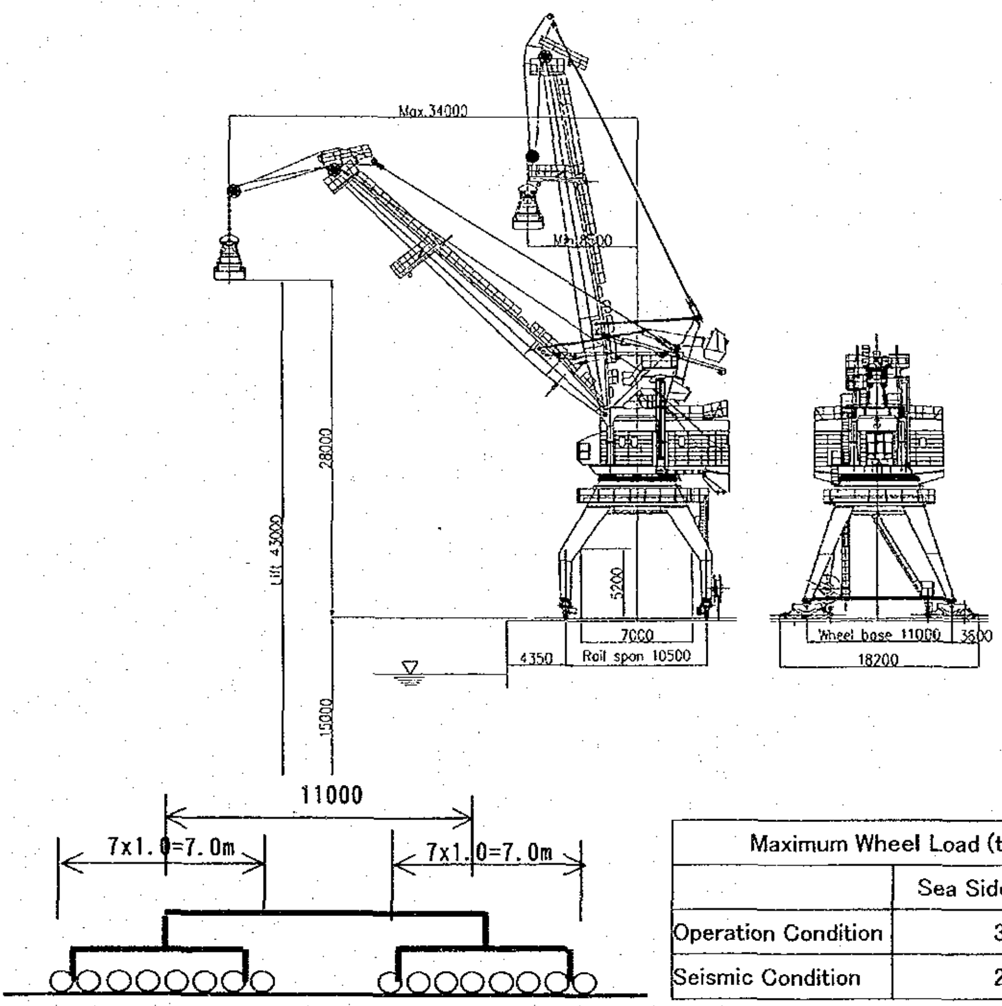
27.3 Design of General Cargo Terminal at Thi Vai

27.3.1 Quay Structure

(2) External Forces

f) Quayside Multipurpose Crane

In this terminal, many kinds and types of cargoes including containers will be handled. Therefore, the following multi-purpose crane is applied for the design of quay structure.



Maximum Wheel Load (tf/wheel)		
	Sea Side	Land Side
Operation Condition	35	28
Seismic Condition	20	15

Figure 27.3.1-1 Quayside Multi-purpose Crane

g) *Surcharge*

In the port planning of this study, this terminal will be used as a main international terminal for general cargoes, such as heavy equipment, steel materials and other bulk cargoes. Therefore, in this design, 4 ton/m^2 of surcharge is applied for the design of quay structure.

h) Berthing Energy and Reaction Force of Rubber Fender

The ship berthing energy for 50,000 DWT general cargo vessel is calculated as follows:

$Ef=(Ws*V^2/2g)*Ce*Cm*Cs*Cc$

Table 27.3.1-1 Berthing Energy

Item	Description	50,000 DWT G.C. Vessel
Ws	Water displacement of berthing ship (tf)	64,000
V	Approach velocity of ship against the fender (m/s)	0.1
g	Acceleration gravity (m/s^2)	9.8
Ce	Eccentricity factor	0.57
Cm	Virtual mass factor	1.82
Cs	Softness factor	1.0
Cc	Shape factor of berth	1.0
Ef	Ship's berthing energy (tf-m)	33.2

From the above berthing energy, the same fender system with the Lower Cai Mep container terminal is selected, i.e., two units of rubber fender type 1000H/R0 as shown in Figure 27.2.1-2. The reaction force of this fender system will be 2 x 44.5 = 89.0 tf/fender.

d) Mooring Force

The mooring force consists of the pressures due to winds, currents and waves in general. However, this site is situated in the river and wave action is negligibly small and current pressure on shipside is also negligible.

The wind pressure acting perpendicular on shipside (Y-direction) for 50,000 DWT general cargo vessel is calculated as follows:

$Ry=1/2*\rho a*U^2*A_L*Cy$

Table 27.3.1-2 Wind Force on Shipside (Y-direction)

Item	Description	50,000 DWT G.C. Vessel
ρ a	Density of air (tf/m^3)	1.23x10^{-3}
U	Wind velocity (m/s)	15
A_L	Y-direction projection area of ship above water (m^2)	6,000
Cy	Shape factor of Y-direction	1.016
Ry	Wind force of Y-direction (kN)	838

The wind and current pressure acting on the bow (X-direction) for 50,000 DWT general cargo vessel is calculated as follows:

Wind: $Rx=1/2*\rho a*U^2*A_T*Cx$ Current: $Rf=0.0014*S*V^2$

Table 27.3.1-3 Wind and Current Force on Bow (X-direction)

Item	Description	50,000 DWT G.C. Vessel
ρa	Density of air (tf/m^3)	1.23×10^{-3}
U	Wind velocity (m/s)	15
AT	X-direction projection area of ship above water (m^2)	930
Cx	Shape factor of X-direction	0.806
Rx	Wind force of X-direction (kN)	104
S	X-direction projection area of ship underwater (m^2)	375
V	Current velocity (m/s)	2.0
Rf	Current force of X-direction (kN)	2

Against above forces, the vessel will be moored by 2 to 4 bowlines, 2 to 4 stern lines and 2 spring lines. Therefore, as recommended in the Technical Standards for Port and Harbour Facilities in Japan, bollards of 1000 kN capacity are provided along the face line of quay at an interval of 20m.

i) Seismic Force

The coefficient of horizontal seismic force of Kh = 0.05 g and surcharge of 2.0 tf/m^2 are adopted in this design.

(2) Alignment and Layout of Quay Structure

a) Alignment of Quay

Alignment of the face-line of quay was determined as shown on Figures 27.3.1-2(1) and 27.3.1-2(2), considering the river flow, configuration of riverbed and riverbank, maneuverability of design vessels and initial and maintenance dredging cost.

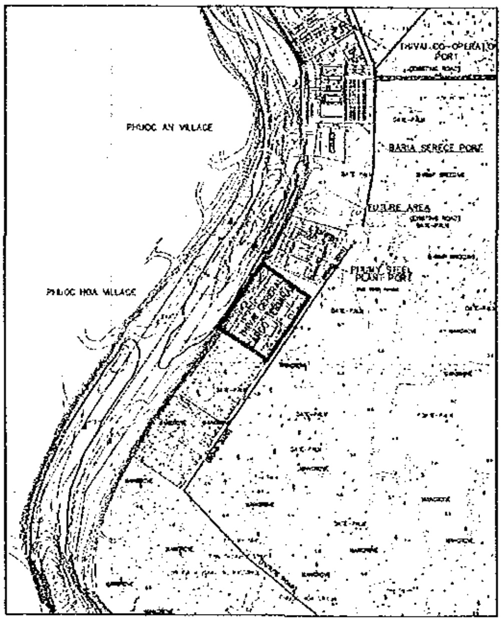


Figure 27.3.1-2 (1) General Alignment of Quay

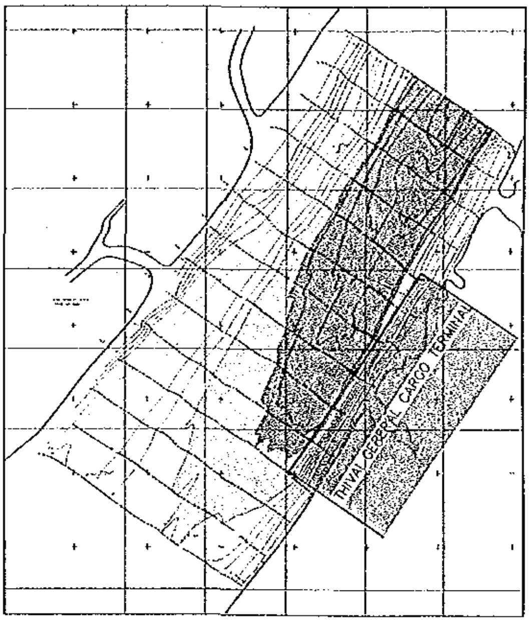


Figure 27.3.1-2 (2) Detailed Alignment of Quay

b) Plan and Elevation of Quay

The crown height of quay was determined at CDL+5.00 m based on the elevation of HWL and variation of tide levels. The water depth in front of quay was decided at CDL-14.0 m considering the maximum full loaded draft of 12.6 m of 50,000 DWT general cargo vessels.

The width of quay apron was decided at 40 m based on the rail span of 10 to 15 m of quayside multi-purpose crane and a space for traffics for trucks and forklifts. The quay length for one 50,000 DWT general cargo vessel was determined at 300 m on account of its LOA of 212 m and that was divided into four blocks structurally considering the stability of structure and construction works.

Along the face line of quay, the fender system will be provided at an interval of 10 m and bollards of 100 tf each are installed at 20 m intervals.

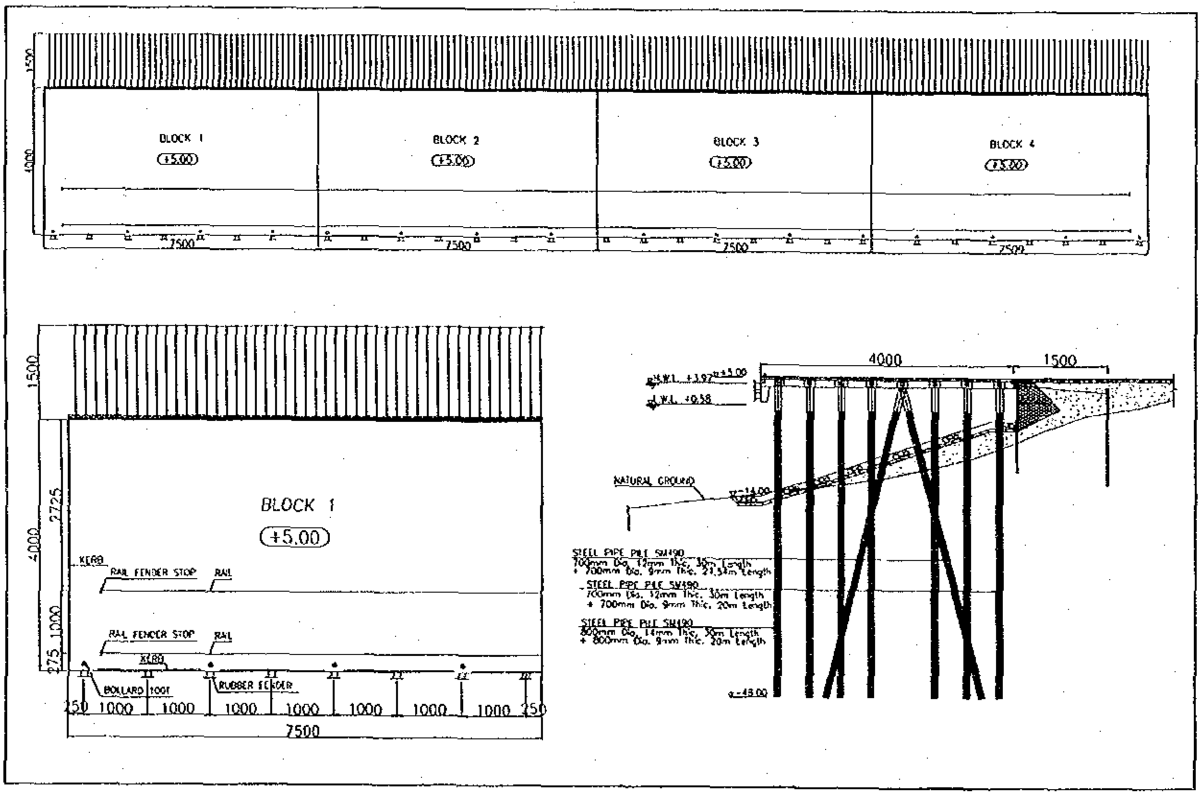


Figure 27.3.1-3 Plan and Elevation of 50,000DWT GC Quay

c) Critical Berthing Force for Quay Structure

As explained in 27.2.1.c) the berthing force at two point berthing condition should be considered for the design of quay structure.

d) Critical Loading Conditions for Quay Structure

The same combination of loads explained in 27.2.1.d) should be considered for the structural design of quay and an increase ratio for the allowable stresses of structural materials may be applied in case of seismic condition.

(3) Quay Structure

As explained in previous paragraph, the quay structure of this terminal should be "Open Type" not to disturb the river flow and to eliminate any unfavorable impact of erosion or sedimentation of riverbed. Among several kinds of open type quay structures, a coupled steel pipe piles type quay structure was selected as the most suitable to the site conditions based on the comparative study as summarized in Table 27.3.1-5.

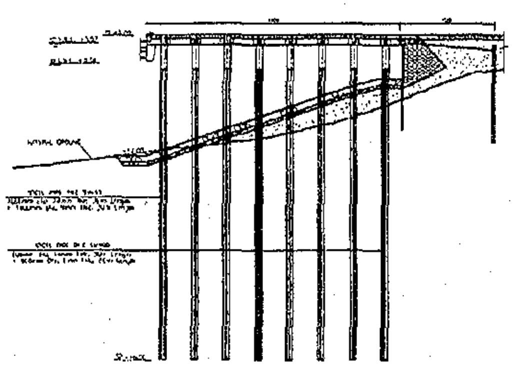
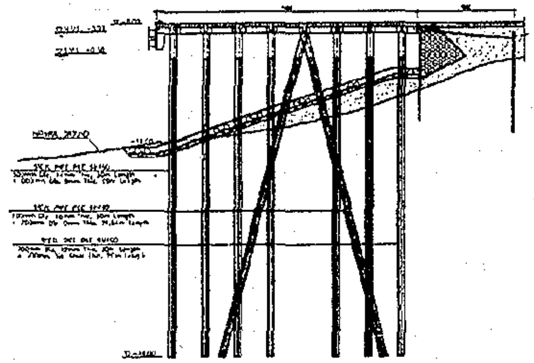
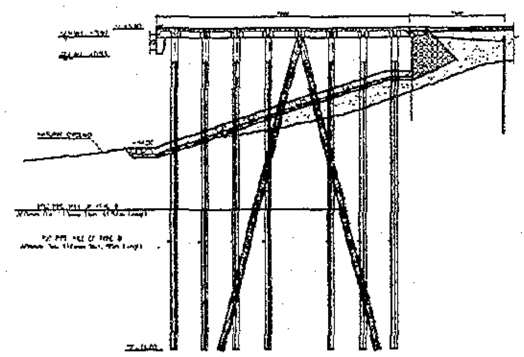
Typical section of the coupled steel pipe piles quay structure is shown in Figure 27.3.1-4 and design calculation is summarized in Table 27.3.1-4.

Table 27.3.1-4 Structural Calculation Results of Quay Foundation Piles

Pile	M (t-m)	S (t)	N (t)	Member Section Steel Pipe Pile SN490	σb (kg/cm2)	σc (kg/cm2)	σb/σba+ σc/σca ≦1.0
Case 1: Berthing Condition							
Sea side1st row Vertical Pile	16.4	1.0	285.3	D=800mm t= 14mm	271	890	0.87
Sea side 2nd row Vertical Pile	11.3	0.8	155.0	D=700mm t= 12mm	282	653	0.74
Sea side Batter Pile	10.9	1.5	36.9	D=700mm t= 12mm	272	155	0.28
Land side Batter Pile	9.8	1.4	204.6	D=700mm t= 12mm	244	862	0.91
End row Vertical Pile	16.1	2.3	137.3	D=700mm t= 12mm	401	578	0.74
Case 5: Seismic Condition							
Pile	M (t-m)	S (t)	N (t)	Member Section Steel Pipe Pile SN490	σb (kg/cm2)	σc (kg/cm2)	σb/σba+ σc/σca ≦1.0
Sea side1st row Vertical Pile	5.7	0.4	121.5	D=800mm t= 14mm	92	379	0.36
Sea side 2nd row Vertical Pile	2.8	0.3	95.3	D=700mm t= 12mm	70	401	0.27
Sea side Batter Pile*	5.8	1.0	34.5	D=700mm t= 12mm	579	581	0.56
Land side Batter Pile*	5.3	1.0	89.7	D=700mm t= 12mm	529	1511	1.00
End row Vertical Pile	6.0	0.8	90.3	D=700mm t= 12mm	150	380	0.28

Note: Coupled batter piles are arranged one set in every 4 structural frames.

Table 27.3.1-5 Comparison of Quay Structure

	Vertical Steel Pipe Pile Type	Coupled Steel Pipe Pile Type	Coupled Pre-stress Concrete Pile Type
Typical Cross Section			
Merit	• Pile driving equipment is low price • Pile driving work is the easiest • Construction period is the shortest	• Total construction cost is the lowest • Deflection by horizontal force is small • Deepening of the water depth is not much problem for structural stability	• Maintenance against corrosion is not necessary • Pile material can be available locally • Deflection by horizontal force is small • Deepening of the water depth is not much problem for structural stability
Demerit	• Pile material cost is the highest • Deflection by horizontal force is bigger • Counter measure against corrosion is essential • Deepening the water depth will require the reinforcement of piles	• Pile driving equipment is high price • Pile driving work is difficult • Construction period is a little longer • Counter measure against corrosion is essential	• Pile weight is very heavy and careful handling is required • Pile driving equipment is the highest price • Pile driving work is the most difficult • Construction period is the longest
Cost	120%	100%	110%
Evaluation	**Good**	**Best**	**Better**

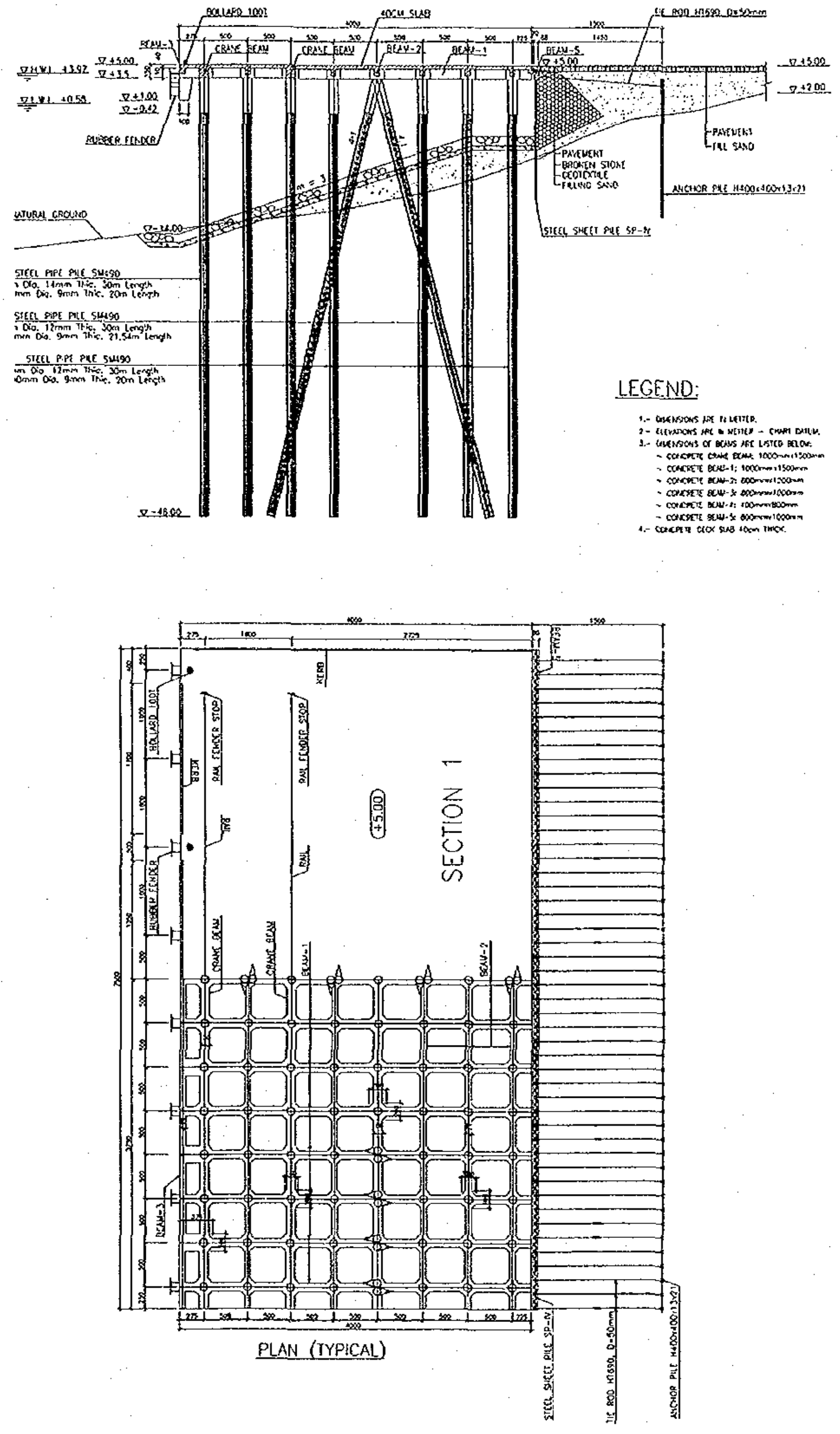


Figure 27.3.1-4 Typical Plan and Section of G.C. Quay Structure

27.3.2 Land Reclamation

(1) Present Condition of Sub-soil and Operational Requirements of Land

Project site is low-lying swampy land covered by mangroves. Based on the natural condition survey conducted in May to June 2002, it was proved that the existing ground elevation is around CDL +3.00 m and the subsoil consists of very soft clay upper layer of 13 m thick, silty sand middle layer of 30 m thick and very stiff clay bearing layer.

In order to construct a general cargo terminal here, the site should be reclaimed to CDL +5.00 m as explained in Chapter 18 and the reclaimed land will be mainly used for the stacking yard for bulk cargo, steel materials, construction equipment, etc. Therefore, the reclaimed land should have bearing capacity of more than 2.5 tf/m^2 in average.

As known from the subsoil conditions presented in Figure 27.1-1, it is clear that if dead-load of fill sand and port operation load are charged on the existing ground, the upper very soft clay layer and silty sand middle layer of subsoil will be consolidated and considerable amount of settlement will occur on the surface of ground and structures on the ground.

A suitable countermeasure against the settlement, therefore, will be inevitable for the construction of general cargo terminal at this site.

(2) Settlement and Soil Improvement

By the same reasons explained in Section 27.2.2.(2), the combination of plastic board drain and pre-loading methods is proposed for this project.

Considering the subsoil conditions and construction program, the design is to drive plastic boards up to –15 m in average at horizontal intervals of 1.5m and fill sand up to +8.00 m as pre-load. The results of consolidation analysis show that ultimate settlement amount will be 1.77 m at the center of reclaimed land. About 2-years period is required to obtain the 80% consolidation ratio which allows removal of pre-loading sand and commencing the construction works on the reclaimed land as shown in Figures 27.3.2-1 and 27.3.2-2.

(3) Revetment

The reclamation for the terminal should be secured by appropriate revetment along its edges. The revetment along the river will be permanent and made of steel sheet pile wall and H-shaped steel anchor piles. The revetment along the other edges may be simple slope protection such as made of sand back mound covered by thin layer of stones or concrete blocks. Typical section of the riverside revetment is shown in Figure 27.3.1-4.

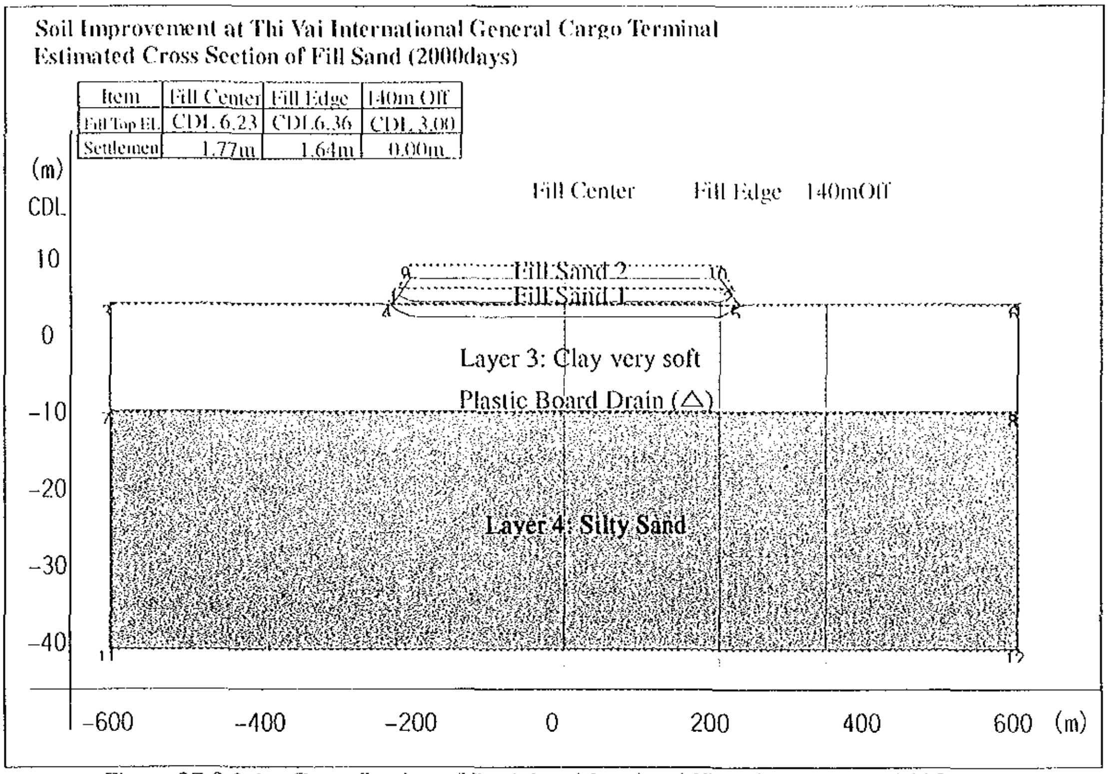


Figure 27.3.2-1 Cross Section of Reclaimed Land and Final Settlement at Thi Vai

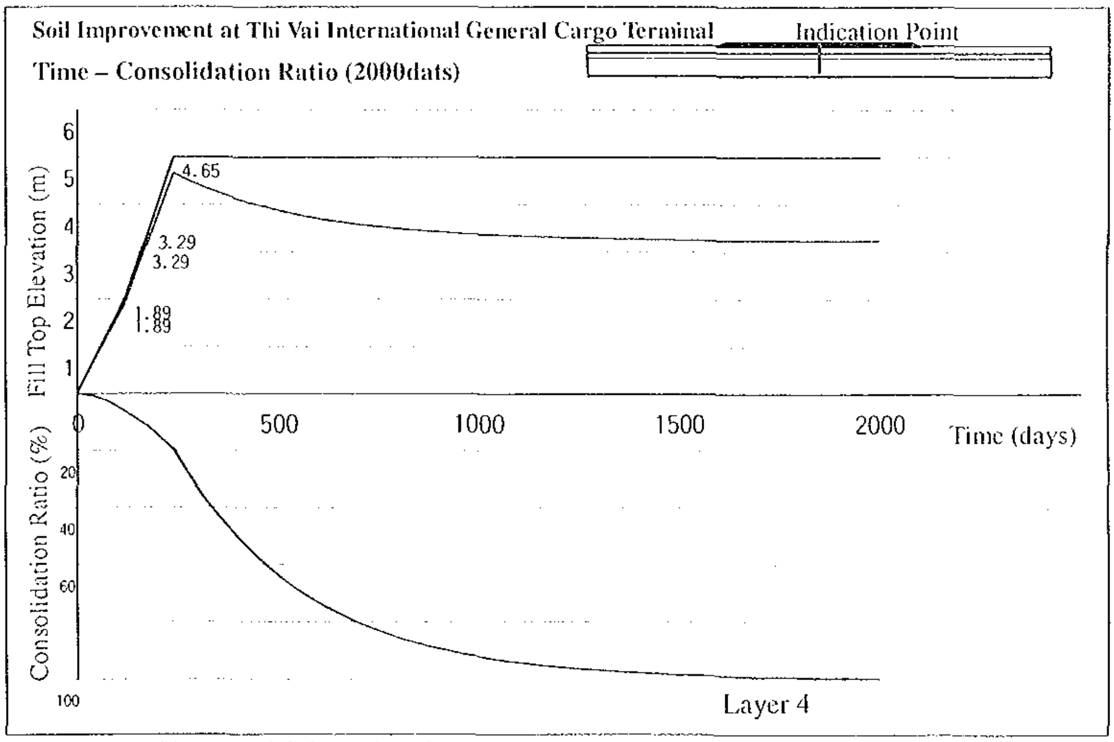


Figure 27.3.2-2 Time-Consolidation Ratio Curve by Soil Improvement

27.3.3 Pavement of Terminal Yard

Based on the terminal layout prepared in Chapter 26, pavements inside the terminal area have been studied in view of their specific operational use.

As explained in the previous section, the upper layer of subsoil at the site will be improved by using plastic board drains. However, residual consolidation of the clay layer will continue for long period and the settlement of the yard will be very slow and continue for a long time. Therefore, a flexible type of pavement is preferable for this terminal yard. Hence, asphalt concrete pavement is adopted for this terminal except some specific areas such as floor of maintenance shop.

Depending on the critical loading for each area, suitable types and strengths of pavement are selected and determined as shown in Figure 27.3.3-1.

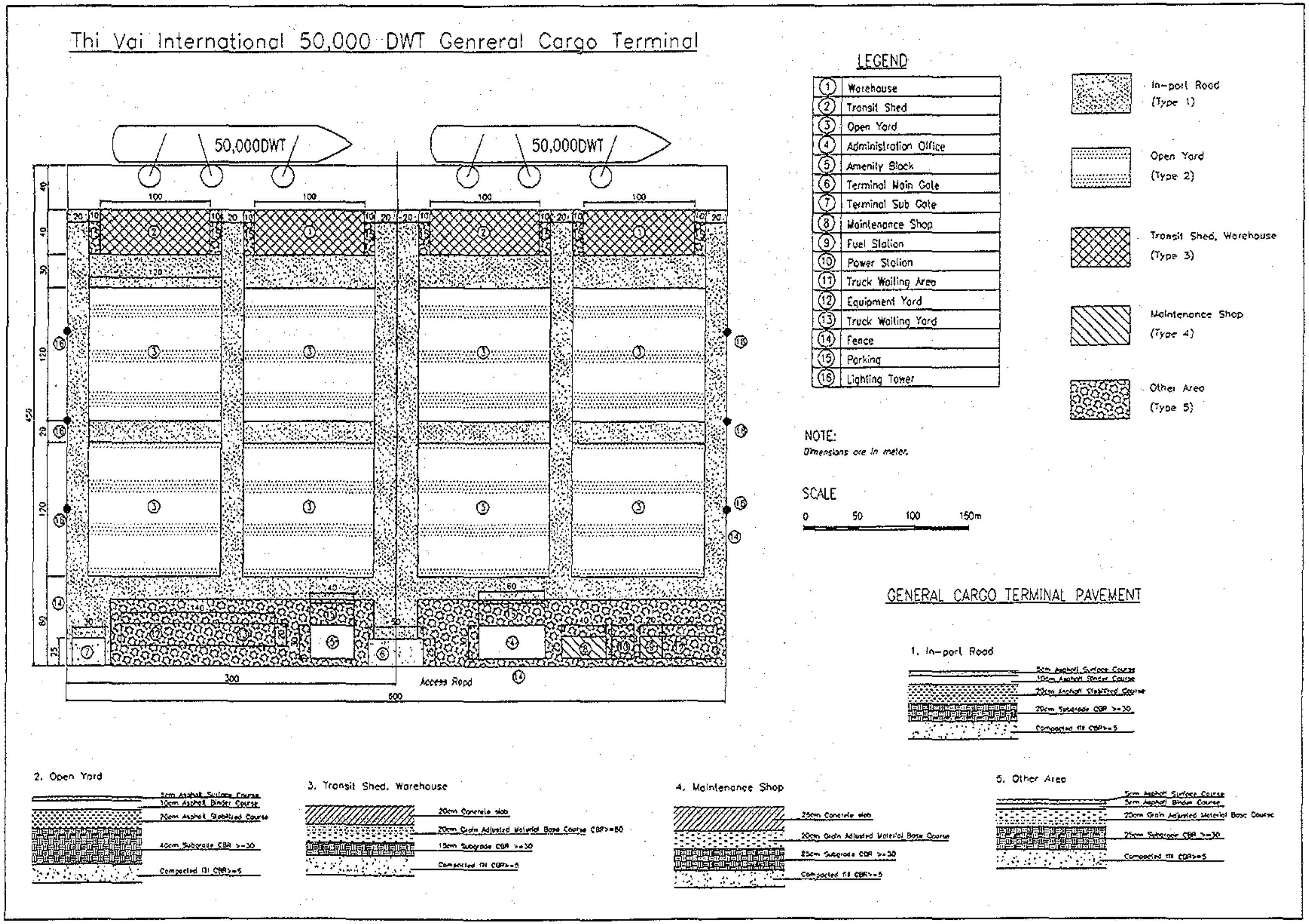


Figure 27.3.3-1 Terminal Use Plan and Typical Section of Pavement

27.3.4 Buildings

(4) Transit Sheds and Warehouses

As defined in the port planning, two transit sheds and two warehouses are required to be built. Transit sheds are used for relatively short-stay cargoes and warehouses are used for long-stay cargoes. Both transit sheds and warehouses have dimensions of 100 m length and 40 m width, with 6 m deep canopy on delivery side. This canopy-covered area functions as working space even in rainy weather. The shed has 4 doors on both sides and each door is 6 m wide and 6 m high and has a floor area of 4,000 m^2 for cargo storage, including 300 m^2 of damaged and valuable cargo storage and 100 m^2 of operators and customs office space. This office consists of two floors: the ground floor provides workers refreshment room and toilets, and the upper floor provides operators and customs office room. The floor has a slope of 3% from sea side exit on ground level to delivery side exit level of 1.2 m above ground; in order to facilitate cargo handling from/to trucks and the minimum clearance height inside the shed is 6.5 m.

The shed will consist of steel columns and beams, concrete block wall with wire netting at the upper part, steel rolling shutter doors, aluminum box-rib sheet roof with transparent PVC panel and reinforced concrete floor slab.

The floor slab is designed to be able to store the cargoes of 2 ton/m^2. The columns of this shed are supported by the concrete piles since residual settlement of subsoil will occur for long period into the future. The tentative floor plan and elevations of this shed are shown in Figure 27.3.4-1.

(5) Maintenance Shop

This maintenance shop is planned mainly for the repairing of forklift trucks, mobile crane, etc. The maintenance shop has dimensions of 40 m length and 20 m width, and a ceiling crane, spare parts shelves, battery room and locker room for mechanics are provided in this shop. The doors of this shop should be more than 6 m height and 5 m width and the minimum clearance height inside the maintenance shop is also more than 7 m.

This building will consist of steel columns and beams, concrete block wall with wire netting at the upper part, steel rolling doors, aluminum box-rib sheet roof with transparent PVC panel and reinforced concrete floor slab. The floor slab is designed to be able to support equipment of 3 ton/m^2. The columns of this building are supported by the concrete piles for the same reason as for Transit sheds/Warehouses. The open area for maintenance work is provided in front of this maintenance shop and a special treatment facility for oil leakage will be provided around the shop.

The tentative floor plan and elevation of this maintenance shop is presented in Figure 27.3.4-2.

(6) Terminal Office Building (Administration Office)

One terminal office building is planned to be build near the main gate. This building is a two or three story reinforced concrete structure having the floor space of 1,800 m^2. This building is consists of terminal operators office rooms, customs office room, workers refreshment room, canteen and toilets,

etc.
This building is supported by the reinforced concrete piles, since subsoil condition here is poor and if not, settlement will occur gradually for a long period into the future.

27.3.5 Utilities

(4) Drainage

Inside the general cargo terminal, storm water will be collected by an appropriate gradient of the pavement to the surface drainage, which will be of an open type (i.e. U-shaped ditch, V-shaped gutter, etc.). The main drainage will be a buried concrete box culvert type, to which surface and domestic drains will be connected. Septic tanks for each building will be also installed, as well as spilled wastewater collector for the maintenance shop.

(5) Water Supply

Fire fighting, ship's supply and other domestic consumption in the terminal have been considered and the water can be tapped at mains of IZ area. Relevant facilities, such as reservoirs, elevated tanks and pumps will be included, together with their network pipes.

(6) Power Supply

Substation and emergency generator for quay cranes will be provided, in addition to other demands of lighting and building supply.

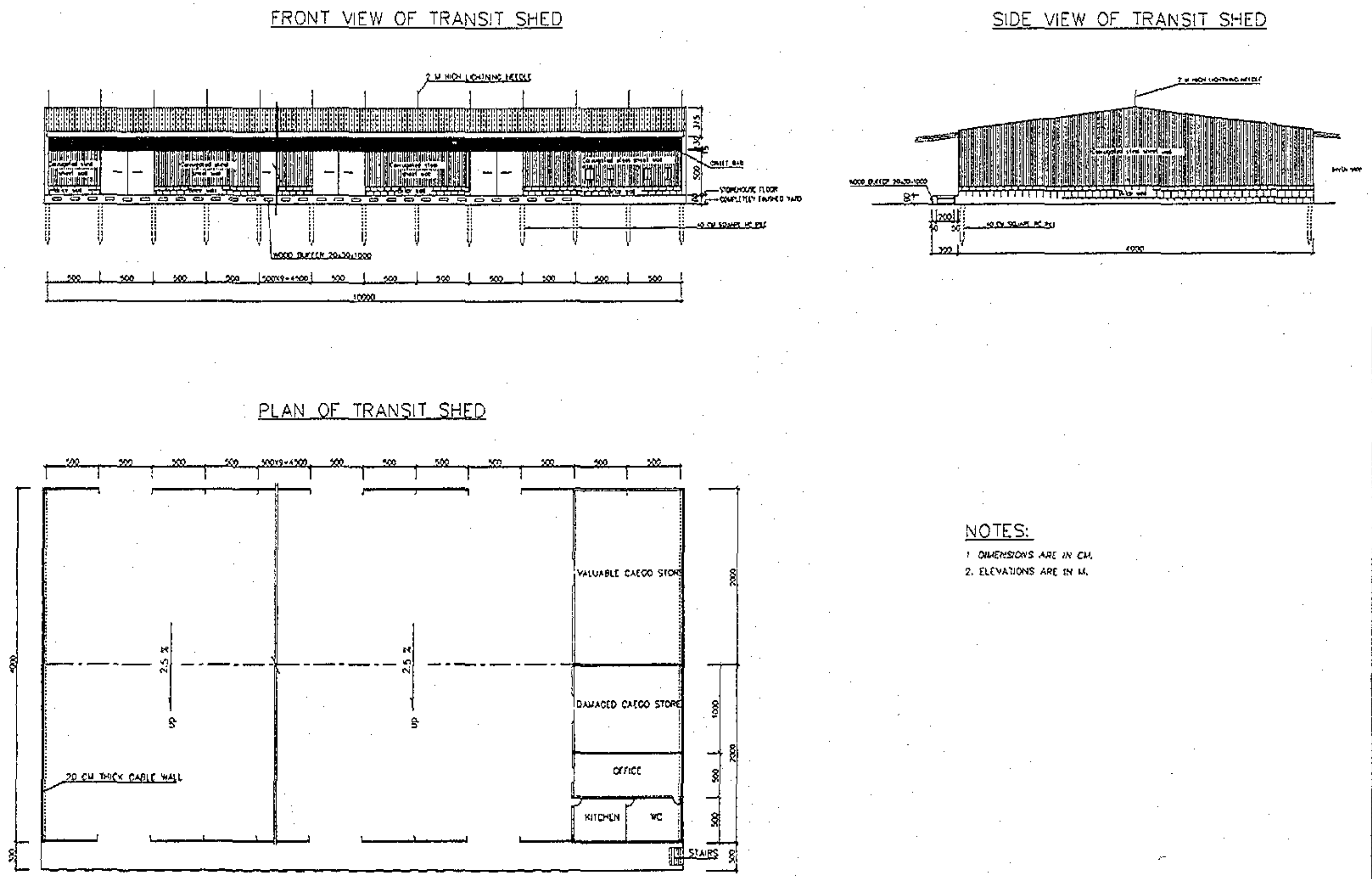


Figure 27.3.4-1 Floor Plan and Elevations of Shed

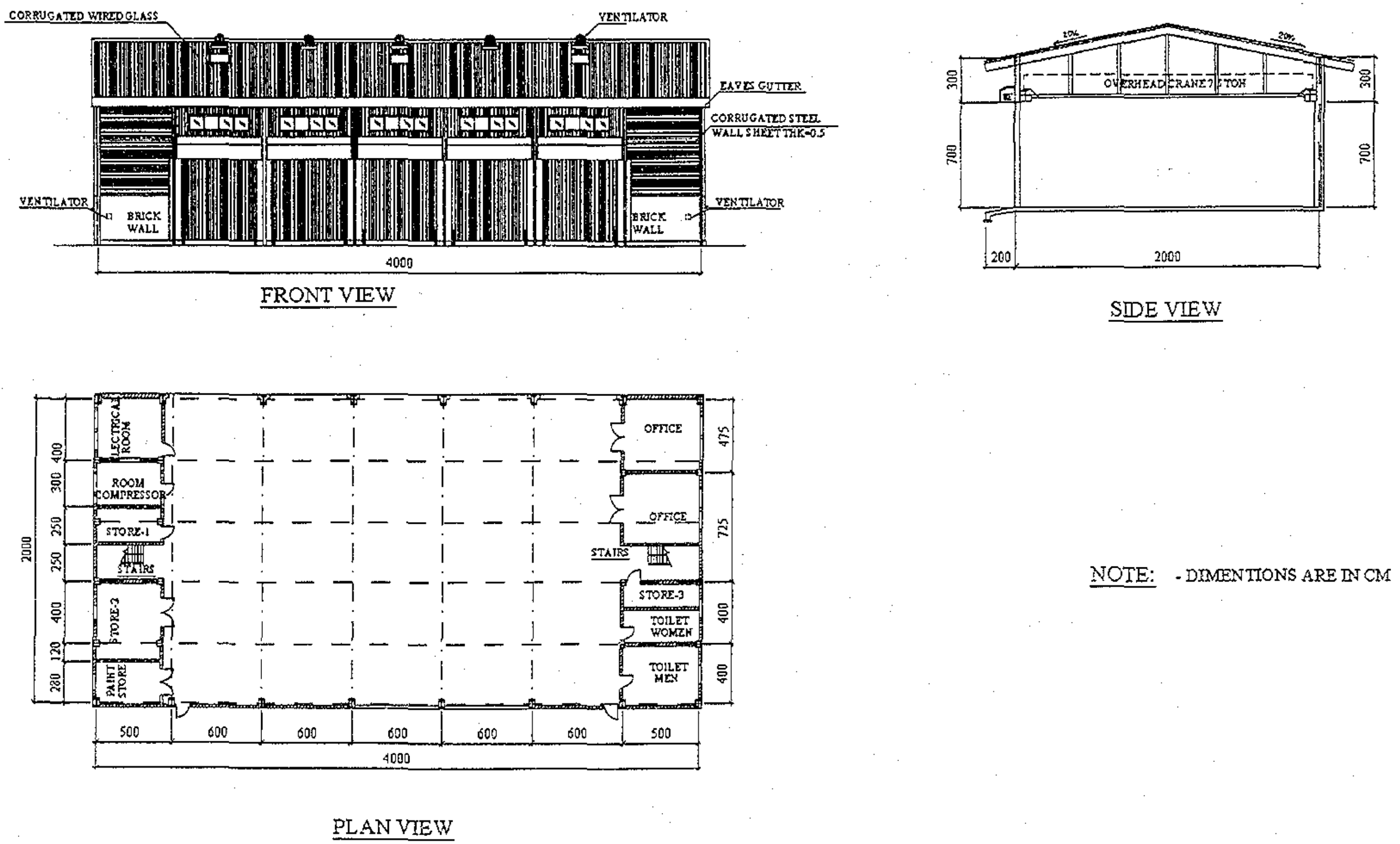


Figure 27.3.4-2 Floor Plan and Elevation of Maintenance Shop

27.3.6 Access Road

(5) Present Conditions of the site

The new project site has no access road to the existing road network in Phu My industrial development zone. Therefore, a new access road of about 2,000 m should be constructed. Based on the topographic survey and geotechnical investigation conducted in June 2002, the existing ground elevations along the route are around +3.0 m. The subsoil along the access road is soft clay of which N values are 2 to 3 up to -5 to -10 m, but the silty sand below it is much better stratum having N values of 8 to 12.

(6) Layout of Access Road

The access road originates at the Southeast corner of the Port Site and terminates at the existing road near the Phu My steel plant port, which is under construction. The proposed layout of access road is illustrated in Figure 27.3.6-1.
The entire route passes through flood plain and the route is mostly free from any adjacent village or housing, etc.

(7) Typical Section of Road

The cross section adopted for the access road follow the Vietnam standard for national road. In order to ensure that the formation of the access road is sufficiently above HWL +3.97 m, the surface level of the pavement has been determined at 5.00 m.
Considering the expected traffic volume in 2010 and 2020, and the present situation of the existing road to be connected, a crest width of 30.0 m and a paved width for vehicles of 15.0 m have been adopted.
As mentioned above, the bearing capacity of subsoil of surface layer is not sufficient for the construction of access roads, but its thickness is small and hence subsoil improvement by the plastic board drains is eliminated and pre-loading will be executed. Flexible pavement consisting of improved sub-grade, base course and asphalt binder course and surface is adopted as shown in Figure 27.3.6-2.

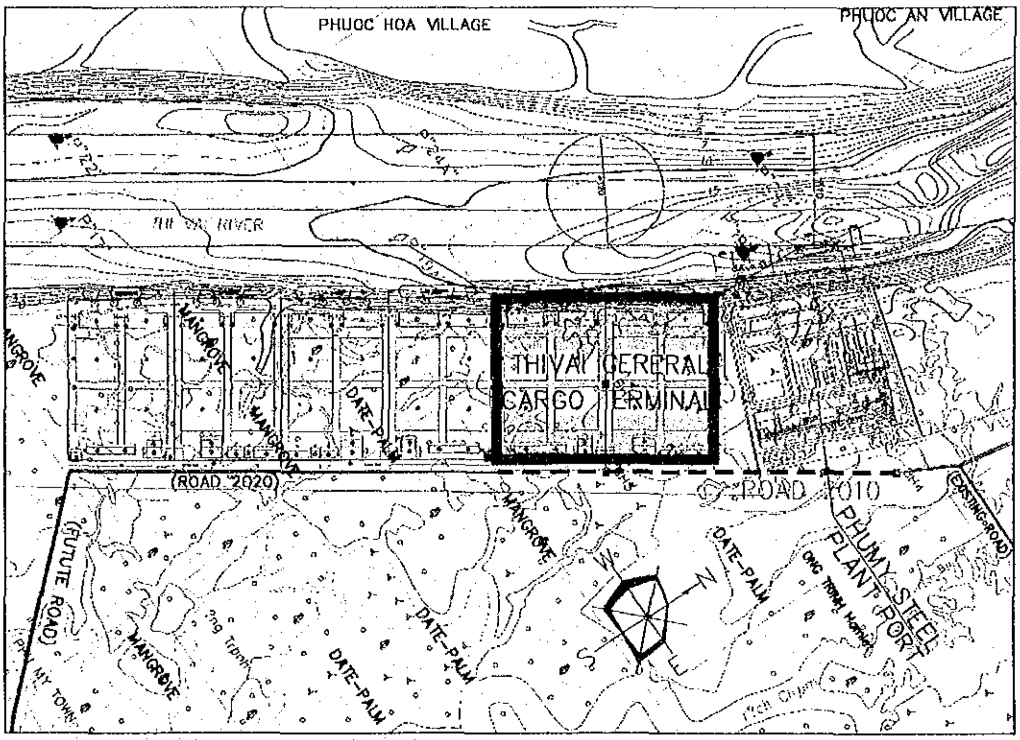
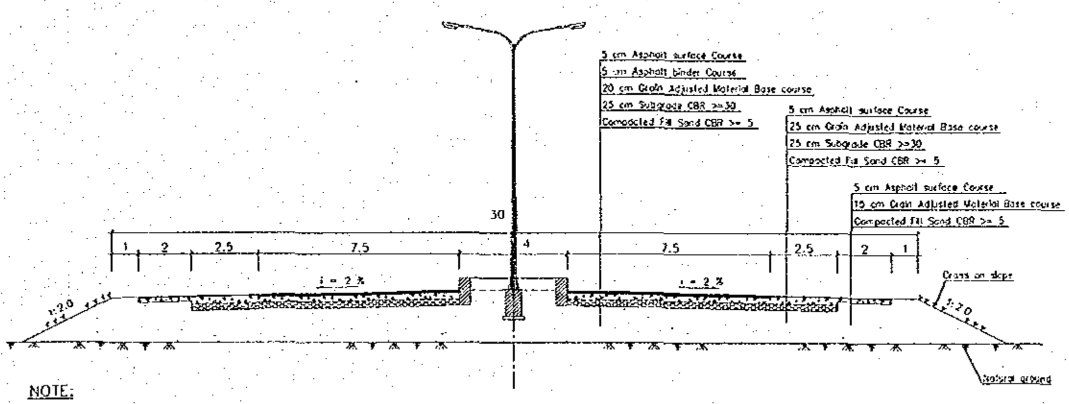


Figure 27.3.6-1 Layout of Access Road



NOTE:

Dimensions and elevations are in [m]

Figure 27.3.6-2 Typical Cross Section of Access Road to Thi Vai Site