5.8. Alternative Plans for Port Development

5.8.1 Layout plan of basic port facilities

In Chapter 3, the container cargo volume at Sihanoukville Port in 2030 has been estimated as shown in Table 3.2-11, while other cargoes, which are dry bulk and break bulk cargoes, are shown in Table 3.2-11. Table 5.8-1 is the summary table of the cargo volumes estimated to be handled at Sihanoukville Port in 2030.

Table 5.8-1 In required wharf cargo handling equipment and handling capacity

Type of Cargo/Commodity	Unit	2010	2030	Reference
Container	TEU	222,928	1,190,000	Table 3.2-11
Drybulk				
Wood Chop	ton	71,000	1,921,000	
Whaest		0	255,000	
Steam Coal		12,300	240,000	
Break bulk				Table 3.2-13
Milled Rice		0	933,000	
Cement	ton	46,000	0	
Vehicle		17,000	194,000	
Sugar		0	10,000	
Others		58,000	571,000	

Prepared by Project Team

The volume and number of units of imported vehicles brought by RoRo (Roll-on/Roll-off) ships has also been estimated as shown in Table 3.2-14. The number of port calls by passenger cruise ship has been estimated in Table 3.3-4. The expansion plan of the port shall be prepared such a manner that the proposed plan should have enough capacity to cope with the demands.

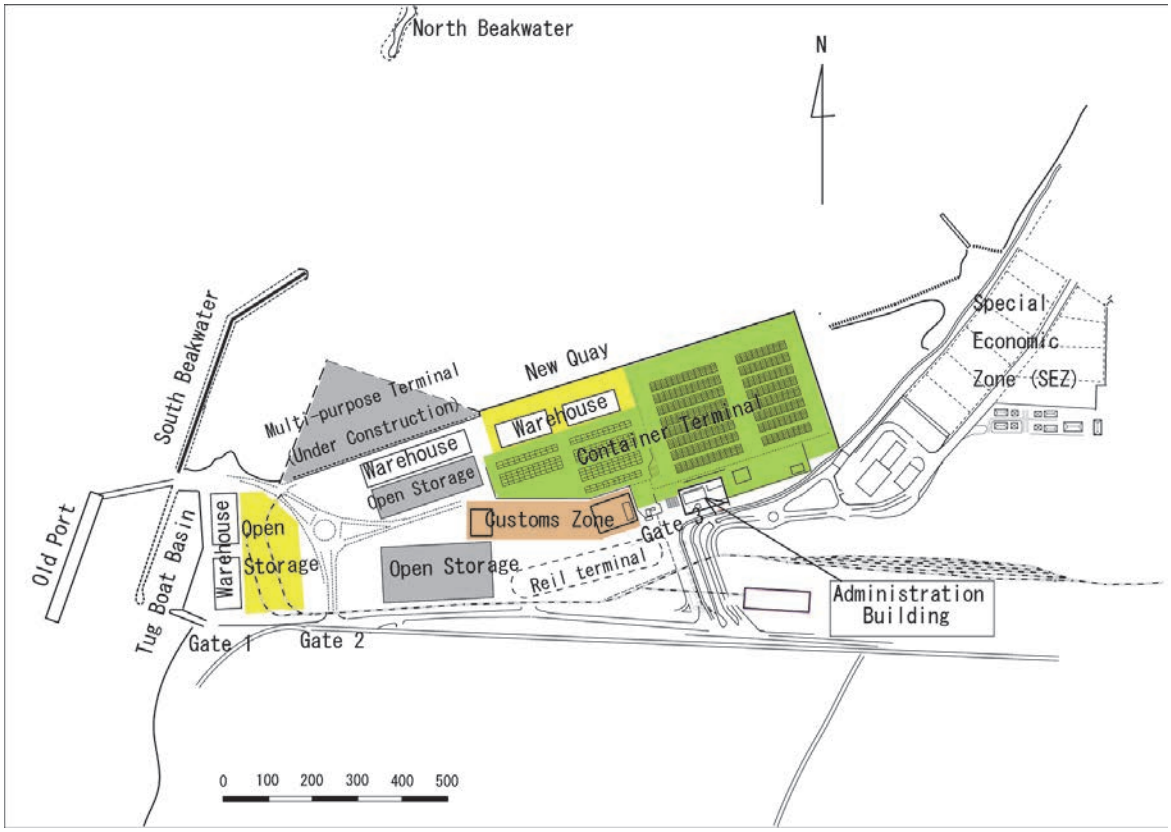
1) A cargo handling capacity of existing facilities)

a) Container Terminal

The existing container terminal has a 400m long quay and a 10ha large container yard having a capacity of 6,050 TEU's. (see Figure 5.8-1). The terminal is equipped with two (2) QGC's, seven (7) RTG's, nine (9) reach stackers and 22 yard chassis. At present, container ships are calling on Sihanoukville port during weekends, especially Friday and Saturday, 350m long New Quay, which is adjacent to the container berths, is also used weekends for container loading and unloading utilizing ship gears during weekends.

Due to such schedule of container ship arrival at Sihanoukville port, the container terminal should be operated in such a manner that, during weekends, container volume handled in a day cannot exceed the stacking capacity (6,050 TEU's). Thus, as the peak factor, which is the ratio of the maximum and the average container volume handled in a day, becomes larger, the capacity of the container yard, which is the annual total of container volume handled at the terminal reduces. The capacity of the existing container yard is estimated at 368,875 TEU (see Figure 4.1-5) when Peak Facto is 2.0. If container ships call on weekdays as well as weekends, the peak factor tends to reduce. The yard capacity is estimated at 492.000 TEU's for the case of Peak Factor is 1.5.

The container handling capacity at the berths is estimated at 350,000 TEU's with two (2) units of QGC. The capacity can be expanded up to 450,000 with three QGC's and to 500,000 TEU's with four (4) QGC's. The capacity of a container terminal as a whole is determined by the smaller of the capacity of berth or the capacity of the yard. Since, the capacity of the container yard is estimated to be 492,000 TEU's, the capacity of the existing container terminal is assessed at 492,000 TEU's.



Prepared by Project Team

Figure 5.8-1 Existing facilities and facilities under construction in Sihanoukville Port

The service lives of container handling machines are 25 years for QGC's and 15 years for other yard equipment such as RTG's and chassis. Table 5.8-2 shows the types and units of equipment required for the enhancement of the container handling capacity of the existing container terminal and for the renewal of the units which age reach to their life. The following number of units of equipment should be procured for the enhancement and the renewal of equipment by around in 2019 when the container cargo volumes reaches 450,000 TEU/per year:

QGC: 2 units, RTG：5 units, Top Lifter: 3 units, Chassis; 8 units

Table 5.8-2 Types and units to be installed as additional unit of QGC is introduced

Throughput (TEU)	Required Units			
	QGC	RTG	Top Lifter	chassis
150,000-350,000	2	7	3	10
350,000 - 450,000	3	9	4	13
450,000 - 500,000	4	11	5	16

Prepared by Project Team

b) Capacity of Dry Bulk and Break Bulk Cargo Terminal

The capacities of New Quay and Multi-purpose Terminal, where dry bulk and break bulk cargoes are handled, are estimated after commodities are allocated to respective terminals, because the cargo handling productivities varies depending on types of cargoes, commodities and ship size. Thus, the capacity of these terminals shall be determined in next section with commodity allocation on the basis of the results of the cargo forecast.

It should be noted that New Quay is also used for container ships during peak days, and the total days available for the general cargo ships carrying cargo handling of dry bulk are limited. The

available days of New Quay for dry bulk and break bulk handling is estimated in the following manner by utilizing the peak factor (PF) of container handling volume per day. The peak factor is calculated as shown in Table 5.8-3 for various hypothetical arrival schedules of container ships over a week under the condition that four container ships can dock at a time since it is possible for both the existing container berth and New Quay to accommodate two ships simultaneously. It is also assumed that the ship-in-port time is less than 24 hours and container loading and unloading work for a ship should be completed in 24 hours.

New Quay is available for bulk and break bulk ships only when the number of container ships is three or less. As observed in Table 5.8-4, seven (7) berth-days are available for bulk and break bulk ships when PF is 1.3 and eight (8) berth-days are available when PF is 1.5 and 2.0. Thus, a total of 416 Berth-days（= 8 Birth-day × 52week）are available in a year.

Table 5.8-3 Calculation of Peak Factor for various patterns of container ship arrival

Case	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Ship calls/Week	PF
1	4	4	4	4	4	4	4	28	1.0
2	4	2	3	3	3	4	4	23	1.2
3	4	2	2	2	3	4	4	21	1.3
4	4	1	2	2	2	4	4	19	1.5
5	4	0	0	0	2	4	4	14	2.0

Prepared by Project Team

Table 5.8-4 Available Berth-days of New Quay for dry bulk and break bulk ships

Case	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Abvailable Berth-day/Week	PF
1	0	0	0	0	0	0	0	0	1.0
2	0	2	1	1	1	0	0	5	1.2
3	0	2	2	2	1	0	0	7	1.3
4	0	2	2	2	2	0	0	8	1.5
5	0	2	2	2	2	0	0	8	2.0

Prepared by Project Team

2) Cargo allocation ton to respective terminals and assessment of facility requirement

a) Container Terminal

The capacity of the existing container terminal can be expanded up to 492,000 TEU's by installing additional units of container handling equipment. The container traffic at Sihanoukville Port is forecasted to grow up to 1,190,000 TEU in 2030, and the capacity will be short by 698,000 TEU's. Thus, two more container berths will be required, for the maximum capacity of a berth is estimated at 500,000* TEU's par year provided that the terminal has large enough container yard.

* Note: The capacity of a container terminal widely varies depending on size of container ship, number of containers brought by a ship, the capacity of cargo handling equipment and the number of units, number of workable days in a year without influence of weather, working hours per day and the peak factor as well as the capacity of the container marshaling yard.

The conditions for a container berth to handle 500,000 TEU in a year are as follows:

Container volume per ship:	Average 1,000 TEU
Units of QGC:	3 Units
Capacity of QGC:	25 boxes per hour
Ration of 20'and 40'containers：	1：1.5 (TEU/Box=1.6)
Workable days in a year:	360days
Working hours per day:	21 時間
Operation rate of QGC:	50%
Capacity of container yard:	12,000 TEU

b) New Quay and Multi-purpose terminal

New Quay

Since NEW Quay is used for container cargo handling over the weekends, the quay is available for 417 Birth-days for the purpose of the handling of dry bulk and break bulk cargoes provided that the 350m long New Quay can accommodate two ships at a time. With the assumption that the quay is used for the handling of coal and break bulk cargoes as currently observed and vehicles that are imported by RoRo ships. New Quay can handle a total of 594,000 tons (see Table 5.8-5 参照)。

Table 5.8-5 Commodities handled at New Quay

Commodity	Cargo ton	t/hr/gang	Gang	Work hr/day	t/day/ship	Berth-day	Berth Occupancy
Steam Coal	240,000	70	2	12.5	1,750	137.1	417 Berth-day
Other cargo	160,000	48	2	12.5	1,200	133.3	is available
RoRo	194,000					21.7	
Total	594,000				Total Berth-d	292.1	70.1%

Prepared by Project Team

The berth occupancy rate shown at the right end column of Table 5.8-5 is 75.3%, which seems to be considerably high. It is possible for the quay, however, to reduce by extending working hours per day beyond 12.5 hours when the quay is congested. The berth-day required for RoRo ships is estimated as described in the section "Car carrier" below.

Multi-purpose Terminal

Taking into considerations of the advantage of having a -14m deep berth, Multi-purpose Terminal should be used for large ships carrying wood chip and wheat. In addition, it is assumed that heavy and large size cargoes such as machines and materials of plants are handled at the terminal as well as other dry bulk and break bulk cargoes.

For those dry bulk cargoes that are imported and exported in large volumes, it is assumed that cargo handling equipment having large capacity should be introduced. The total cargo volume handled at Multi-purpose Terminal is estimated at 2,430,000 tons (see Table5.8-6)。Incidentally, the berth occupancy rate is larger than 70 %, which implies the berth is quite congested and that some ships have to wait until the berth becomes available. The extending working hours for cargoes other than wood chip beyond 12.5 hours, the congestion of the berth can be eased.

Table 5.8-6 Cargoes handled at Multi-purpose Terminal

Commodity	Cargo Volume	Shipsize	Ship Calls	Handling Productivity	Gang	t/ship/hr	Work hr/day	Berth-day	Berth occupancy
	ton	DWT	Ships	t/hr			hr		
Wood Chip	1,921,000	50,000	38.42	280	4	1,120	20	85.8	Workable
Wheat	255,200	20,000	12.76	112	4	448	12.5	45.6	days
Sugar	10,000	5,000	2.00	48	2	96	12.5	8.3	340
Other	250,000	8,000	31.25	100	2	200	12.5	100.0	Berth-day
Total	2,436,200						Total B-D	239.7	70.5%

Prepared by Project Team

Other cargoes

It is forecasted that, in 2030, 933,000 tons of rice will be exported at Sihanoukville Port in a form of break bulk (see Table 3.2-13 in Chapter 3). The volume of other cargoes handled at the port will reach 571,000 tons. It is assumed that, of 571,000 tons, 180,000 tons should be handled at New Quay while 150,000 tons can be handled at Multi-purpose Terminal. Thus, the port needs additional berths to handle the rest of 150,000 tons of other cargoes. The port also needs additional berth capacity to accommodate cruise ships: the number of calls is forecasted to reach 31 in 2030.

To cope with these requirements, it is estimated that two additional berths should be newly constructed as calculated in Table 5.8-7.

Table 5.8-7 Requirement for additional berths for break bulk cargoes and cruise ship

Commodity	Cargo Volume	Shipsize	Ship Calls	Handling Productivity	Gang	t/ship/hr	Work hr/d	Berth-day	Berth Occupancy	
	ton	DWT	Ships	t/hr			hr		No. of Berths	
Rice	933,000	150,000	6.2	48	3	144	20	324.0		
Other	150,000	7,000	21.4	48	2	96	12.5	125.0	1	2
Cruise Ship								31.0		
							Total	480.0	141%	70.6%

Prepared by Project Team

Car Carriers

Vehicles are currently imported either as container cargoes or break bulk cargoes. It is expected that, in 2030, vehicles will be brought to Sihanoukville Port by pure car carriers, which are RoRo vessels), as the volume of import vehicles will increase.

With an assumption that car carriers will call on the port regularly, average numbers of vehicle units unloaded per call are estimated as shown in Table 5.8-8 for various frequencies of ship calls: monthly, bi-weekly, weekly or semi-weekly. The total berth-days required for the mooring of car carriers are also estimated (see rightmost column) with an assumption that a car carrier stay five (5) hours per call and spend three (3) hours for unloading vehicles. A total of 10.8 berth-days are required for weekly service, while 21.7 berth-days are needed for bi-weekly service. Car carriers stay at the berth for short period of time, they should be give priority use of New Quay.

Table 5.8-8 Estimation of the berth occupancy of car carriers (RoRoships)

Vehicle	89,067 unit/yr*		Units/hr	Berth-h	Required
	Calls	Unit/Call	Stay 3 hr	5hr/ship	Berth-day
RoRo Calls	12	7,422	2,474	60	2.5
	24	3,711	1,237	120	5.0
	52	**1,713**	**571**	**260**	**10.8**
	104	**856**	**285**	**520**	**21.7**

* Note: See Table -3.2-14

Prepared by Project Team

The required area of storage yard for the imported vehicles are estimated as the product of the sum of the lengths of all the unloaded vehicles and 2.5 m. With the considerations of peak factor of 1.5, 4 ha are needed for the case of weekly call while 2 ha are needed for bi-weekly call. Table 5.8-9 is the calculation of the required yard area for the case of weekly call.

Table 5.8-9 Calculation of required yard space for imported vehicles (weekly call)

Car Type	Units/yr	Share	Unit/ship	Length(m)	Total L(m)	Total Length	m	12,286
Bus	9,998	11%	192	11	2,115	Lane width	m	2.5
Passenger	56,264	63%	1,082	6	6,493	Peak Factor		1.3
Truck	19,032	21%	366	8	2,928	Required Area	m2	39,931
Semi-traler	1,273	1%	24	11	269			
Special Purpose	2,501	3%	48	10	481			
Total	89,068	100%	1,713		12,286			

Prepared by Project Team

3) Summary of facility requirement

Summing up above discussion, the allocation of cargoes to the terminals and the requirement of new facilities are listed in Table 5.8-10.

Table 5.8-10 Allocations of cargoes and facility requirement

Commodity	Unit	2030 Forecast	Container Terminal	New Quay	Multi-Purpose	Required Capacity	Required Facilities
Container	TEU	1,190,000	492,400			**697,600**	New Container Terminal (2 Berth)
Vehicle	t	194,000				**194,000**	
Wood Chip	t	1,921,000			1,921,000	0	
Wheat	t	255,200			255,200	0	
Steam Coal	t	240,000		240,000		0	
Sugar	t	10,000			10,000	0	
Milled Rice	t	933,000				**933,000**	New General Cargo berths (2 berths)
Other	t	571,000		130,000	285,500	**155,500**	
Cruise Ship							

Prepared by Project Team

A new container terminal having two (2) berths and a cruise ship and general cargo terminal having two berths is needed.

New facilities should be operational before the cargo volumes exceed the capacity of the existing facilities. The annual variation of container cargo volume is shown in Figure 5.8-2, which is drawn with an assumption that the container cargo volume should increase at the same annual growth rate.

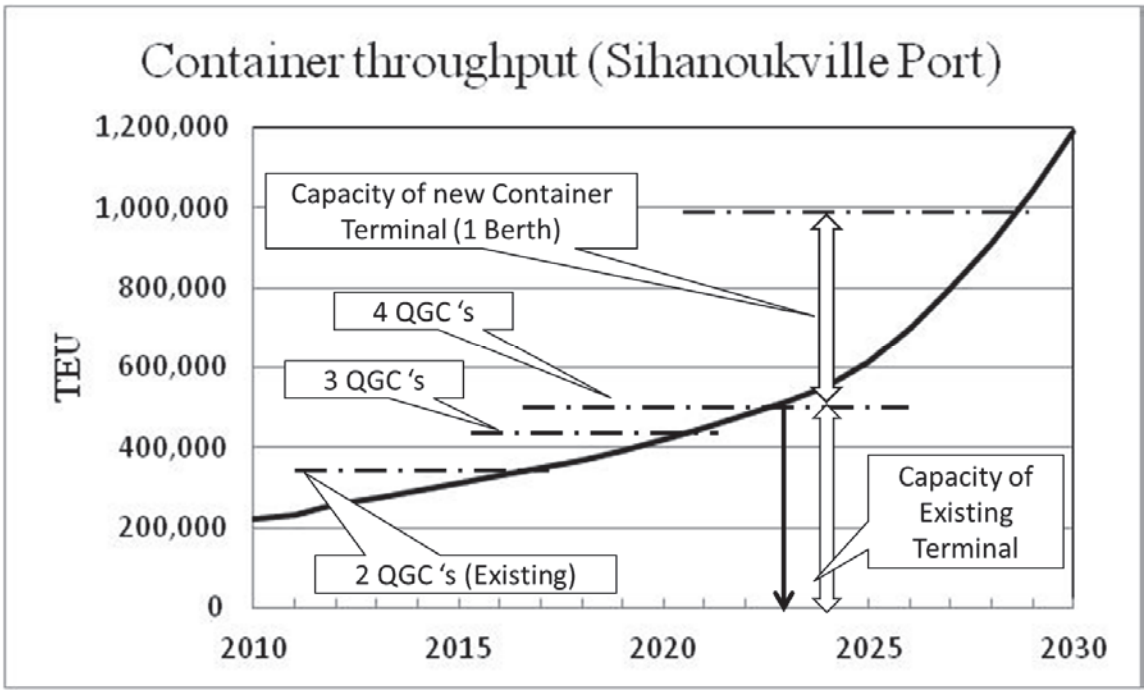


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Figure 5.8-2 Container cargo volume and the capacity of container terminals

Figure 5.8-2 also shows the capacities of the existing container terminal with the enhancement by additional QGC's and other yard equipment as well as the capacity of a new container berth. The capacity enhancement and the construction of the new container terminal should be completed before the container cargo volume will exceed the capacity of the existing facilities. Provided that the container cargo volume increases as estimated, it is observed in Figure 5.8-2 that the existing container terminal should install an additional QGC and other yard equipment by 2017. By around 2023, a new container terminal should start operation.

Figure 5.8-3 is drawn to exhibit the annual growth of the volumes of dry bulk and break bulk cargoes on the basis of 2010 statistics, the estimate for the year 2020 given in the final report of "Kingdom of Cambodia Special Assistance for Project Formation (SAPROF) for Sihanoukville Port

Urgent Development for Oil Supply Base and Multipurpose Terminal, JICA, 2008" and the estimation given in Table 3.2-13 in this report with the assumption that the volume should increase linearly from 2010 to 2020 and from 2020 to 2030 .

Provided that the cargo volume increases as forecasted, It is foreseen that New quay, where currently dry bulk and break bulk cargoes are handled, will overflow in few years and that ship waiting may occur until Multi-purpose Terminal starts operation. It is also foreseen that the cargo volume will exceed the total capacity of New Quay and Multi-purpose Terminal sometime in around 2022 or 2023.

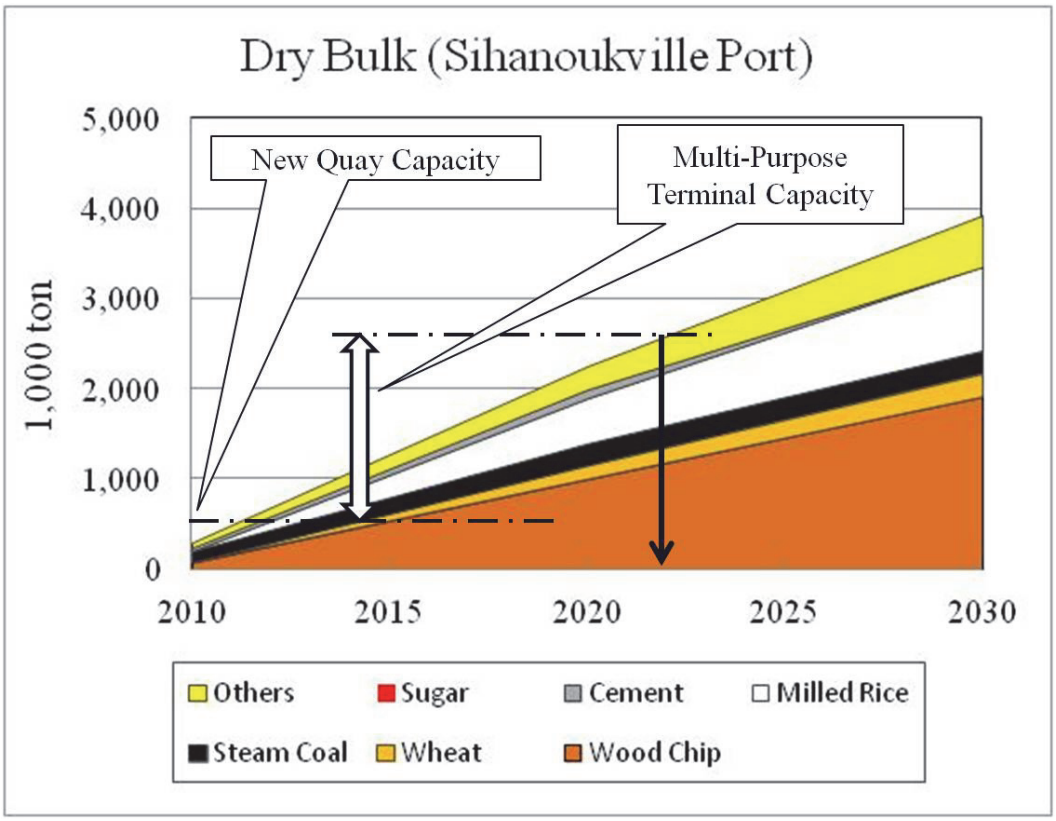

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Figure 5.8-3 Dry Bulk and break bulk cargo volume and the capacity of New Quay and Multi-purpose Terminal

(2) Guideline for the enhancement of port facilities

The first step of the development of Sihanoukville Port toward 2030 is the capacity enhancement of the existing facilities. Since it is foreseen that the volumes of dry bulk ad break bulk cargoes exceeds the capacity of New Quay in few years, efforts should be made to reduce the occupancy of New Quay by container ships. To this end, the productivity of the existing container terminal by introducing additional equipment such as two units of QGC's and necessary yard equipment at the earliest opportunity. The upgrading of the productivity of the existing container terminal by the enhancement of equipment is the highest priority project.

The development plan of a new container terminal and cruise ship and general cargo terminal is prepared under the premises that the priority project, i.e., the capacity enhancement of the existing container terminal will be completed including the improvement in the operational efficiency of the terminal.

(3) Assessment of the project site

This study aims at the strengthening of the competitiveness of PAS, and the development plan aiming at 2030 should also be elaborated from the viewpoint of strengthening the competitiveness of

PAS. Therefore, it is assumed that the new facilities to be operational in 2030 shall be operated under the administration of PAS, and, therefore, the water and land area adjacent to the existing port is chosen as the potential project site.

In Section 5.4, the Project Team identified the water area enclosed by North Breakwater is the highest potential area for the development of Port SEZ, which is a conglomerate of port and EPZ. In this section, the alternative development plans of those facilities required to start operation by 2030 shall be discussed. It is In the process of the preparation of the alternative plans, location and space for EPZ is also duly taken into consideration.

(4) Pre-screening of conceptual layout plans for the development of basic port facilities

In general, the port development is done step by step over a long period of time. Though the target of the facility development in this project is set at the year 2030, it is a relevant that the plan is drawn as one of the steps toward further expansions. Therefore, prior to the preparation of the plans aiming at 2030, firstly, conceptual development plans were drawn at the ultimate stage when the water area within North Breakwater is fully utilized. Then the alternative development plans aiming at the year 2030 shall be drawn in within the frame of the conceptual plan for a long-range development.

The main cargo at Sihanoukville Port is containers, and it will become more important for PAS to provide efficient service for container cargoes as the container traffic increases in accordance with the economic growth of Cambodia. The size of container ships tends to become larger. It is expected that, in 2030, container ships having a DWT of 50,000 tons will call on Sihanoukville Port as well as those container ships having DWTs of 20,000 tons, which is the size of the container ships currently call on the port. Therefore, the new container terminal should have deep draft berth having a depth of -14 m and the length of 350 m. The container marshaling yard should have an area of 350 m wide and 550m long from front to back.

1) Premises for the preparation of conceptual layout plans

The conceptual layout plans presented hereunder have been drawn on the following premises:

a) Port area should be clearly defined

The port area that includes port facilities and EPZ and that authority is given by law to PAS to administrate the port area.

b) Separation of navigation zones

The navigation zones in the enclosed water area clearly separated between those vessels calling Sihanoukville Port and other vessels and fishing boats and agreed by the agencies concerned.

c) Project of the construction of the industrial road will be realized

A project of the constructing of the industrial road has been proposed in the final report of "The Study on National Integrated Strategy of Coastal Area and Master Plan of Sihanouk-ville for Sustainable Development, Book I : National Integrated Development Strategy for Coastal Area, JICA, November 2010" will be realized. The possible route of the Industrial Road near Sihanoukville Port is shown in Figure 4.1-12 in Chapter 4).

d) Social and environmental considerations during and after the port development

The following social and environmental considerations should be duly taken during the project implementation and the port operation after the completion of the project

- To minimize risks of the occurrence of traffic accidents in the sea and on land
- To minimize the involuntary relocation of residents
- To minimize negative impacts on the livelihood of local community
- To minimize the division of local communities
- To minimize impacts on the social infrastructure
- To minimize water quality degradation, air pollution and traffic noise

e) Review of the scale and schedule of the project

The cargo forecast should be updated regularly, e.g., every three years, and the operational efficiency should be monitored. The scale and the schedule of the project should be reviewed on the basis of the updated forecast and the operational efficiency.

2) Alternative Conceptual Plans

Three conceptual plans can be drawn within the water area enclosed by North Breakwater. These three plans exhibit the concept and the scale of the development, and are not intended to propose specific locations, face line orientations of the berths or the configuration of the facilities.

a) Conceptual Plan -1 (Extension toward the north)

This concept of the development is to expand the port to the north of the existing container terminal. Container terminal facilities and EPZ are constructed on the reclaimed island (see Figure 5.8-4). A cruise ship and general cargo terminal is constructed outside of South Breakwater. An opening is made at the north part of North Breakwater for the passage of fishing boats and small cargo ships calling on the local port. A breakwater is constructed to block waves coming from the north.

There are two alternative routes for the access to the island: along the North Breakwater (Access Route-1) and a bridge connecting the island and the coastal road (Access Route-2).

Access Route-1

An access road is constructed outside of the North Breakwater. A bridge is also constructed over the opening of the breakwater for the passage of fishing boats and small cargo vessels. The access road crosses the existing coastal road by flyover and is extended up to the proposed Industrial Road (see Figure 4.1-12).

Access Route-2

Access route-2 connects the Industrial Road and the new container terminal crossing the existing SEZ by a flyover and a bridge

This plan has such shortcomings that the dredging volume of basin is comparatively large and the difficulty in dredging northern part of basin due to the hard bed rock. Therefore, the water depth of the northernmost berth must be limited to -12m or shallower.

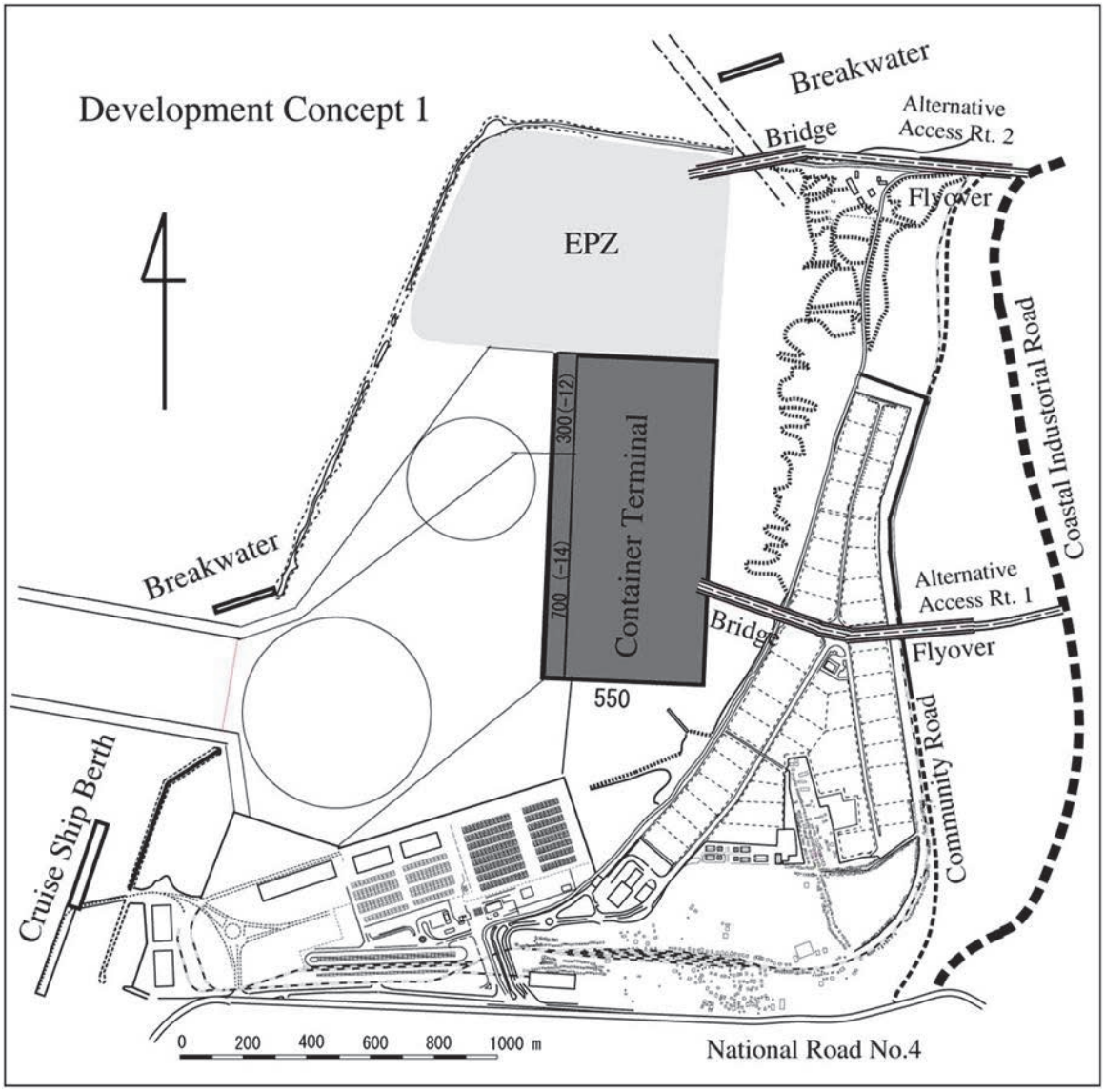

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Figure 5.8-4 Conceptual Plan -1 (Extension toward the north)

Since it is difficult to dredge the basin up to -14m in the northern area due to the hard bed rock, the container berths may be constructed in two sections: a 700m long berth and a 350 m long berth (see Figure 5.8-5). The access routes are the same as Conceptual Plan -1. The locations of the cruise ship and general cargo terminal and the opening of North Breakwater are also the same as Conceptual Plan -1.

This plan has such shortcomings that the yard space for the 350 m long berth is not large enough and that the dredging volume is large because the area of the basin is larger than Conceptual Plan-3. In addition, separation of berths may cause some inconvenience in the terminal operation.

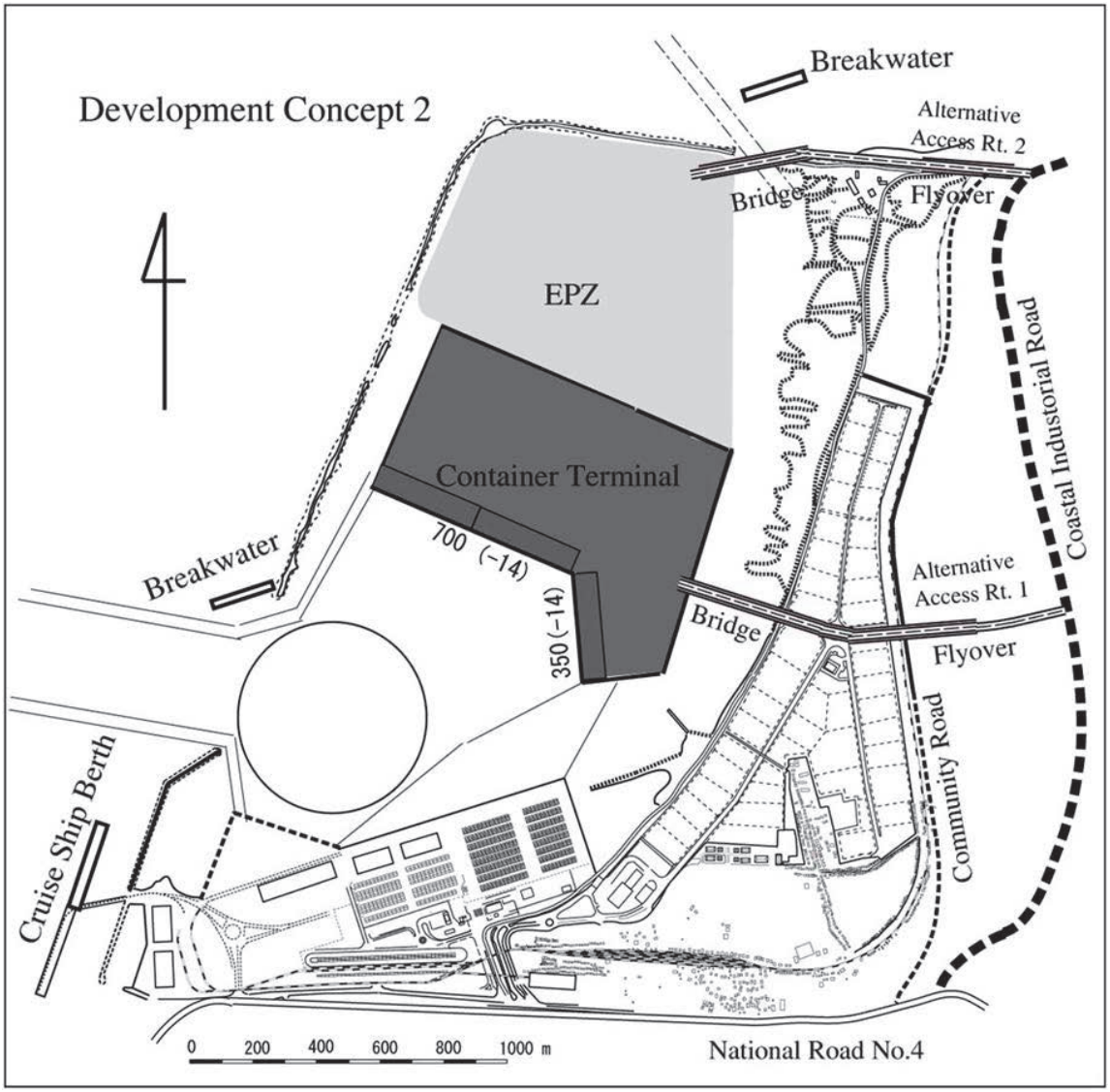

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Figure 5.8-5 Conceptual Plan-2（L-shape terminal）

b) Conceptual Plan -3 (Expansion toward the west)

This conceptual plan aims at the construction of a 1,000m long continuous container berth across the water area within the North Breakwater. (see Figure 5.8-6). Location and layout of the access routes and the cruise ship and general cargo terminal are the same as Conceptual Plans -1 and -2.

This plan has such advantage that the dredging volume is smaller than other conceptual plans because the location of the container berths is closer to the entrance and that large space is available behind the container terminal for EPZ.

The plan proposes to construct 1,000 long berth, which is 50 m shorter than the total berth length of Conceptual Plan-2. However, since such probability is very low that three large container ships call on the port at the same time, the terminal can accept three container ships with 1,000 m long berth. In addition, A continuous berth allows efficient utilization of QGC by sharing QGC's among the berths.

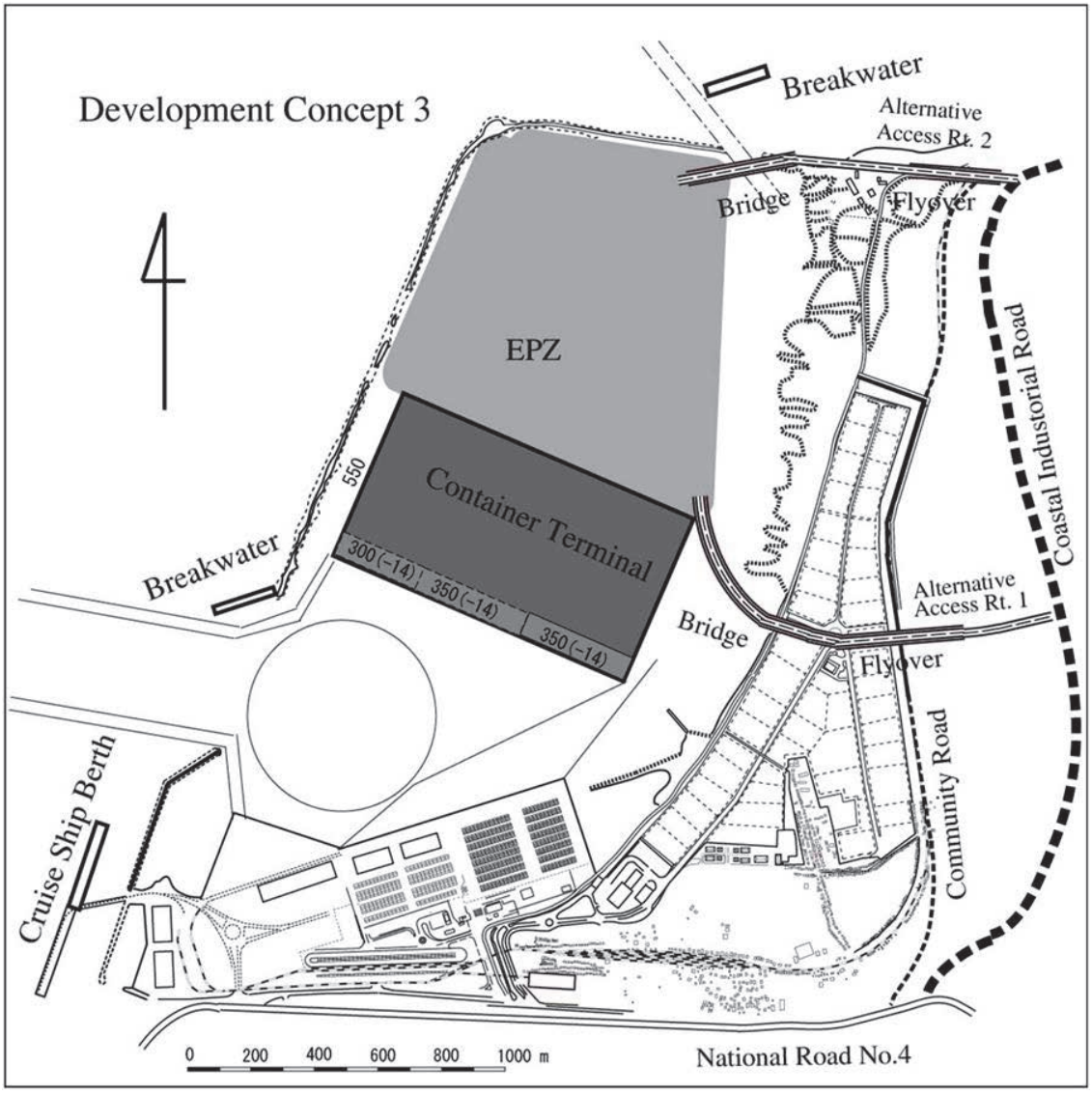

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Figure 5.8-6 Conceptual Plan-3（Expansion toward the west）

3) Selection of the best conceptual development plan

On the basis of the comparison of the three conceptual development plans, Conceptual Plan-3 is chosen as the best plan for the following advantages:

- Three berths having a water depth of -14 m can be constructed,
- The dredging volume of basin is small,
- A 1000 m long continuous berth can be constructed, and
- Large space is available for EPZ at the back of the container terminal.

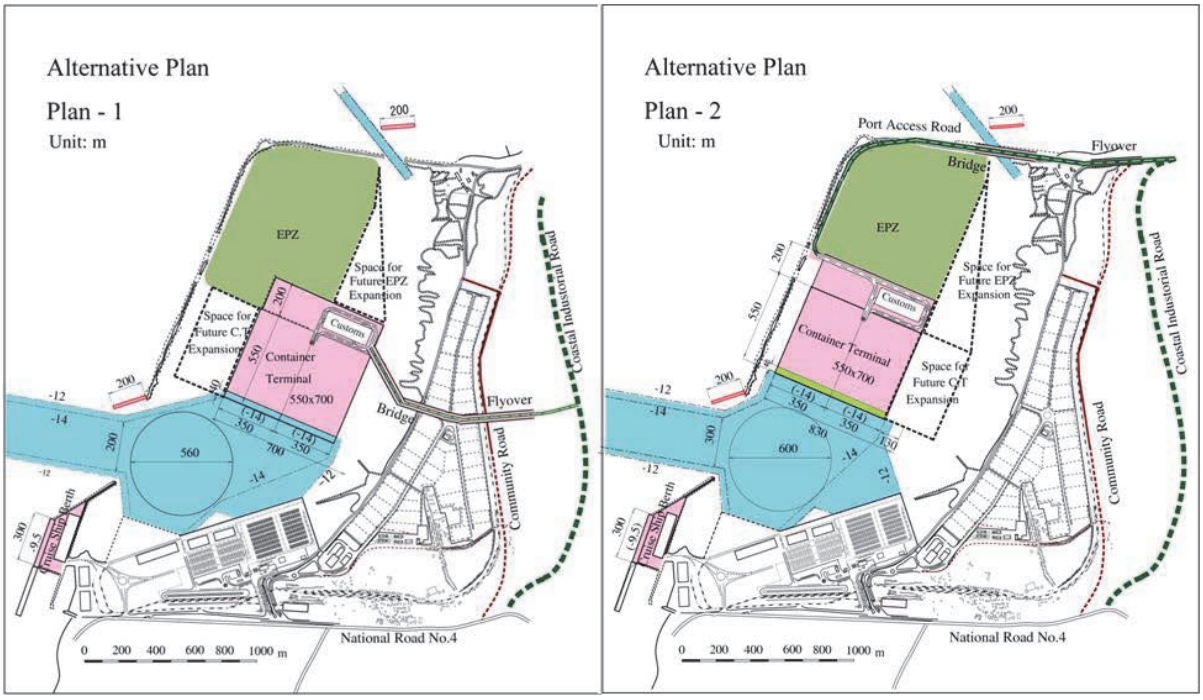
(5) Alternative development plans of basic port facilities

1) Preparation of alternative facility development plans

Alternative facility layout plans for the development toward 2030 have been prepared as the first phase to realize Conceptual Plan-3. Alternative facility layout plan should include a new container terminal having two berths and a cruise ship and general cargo terminal having two berths.

Of the three container berths drawn in Conceptual Plan-3, two berths should be constructed by 2030, and, thus, there are two alternative approaches: to construct two container berths either from land side (Alternative Plan-1) or from sea side (Alternative Plan-2). Figure 5.8-7 shows the facility

layout of Alternative Plan -1 and Alternative Plan-2.

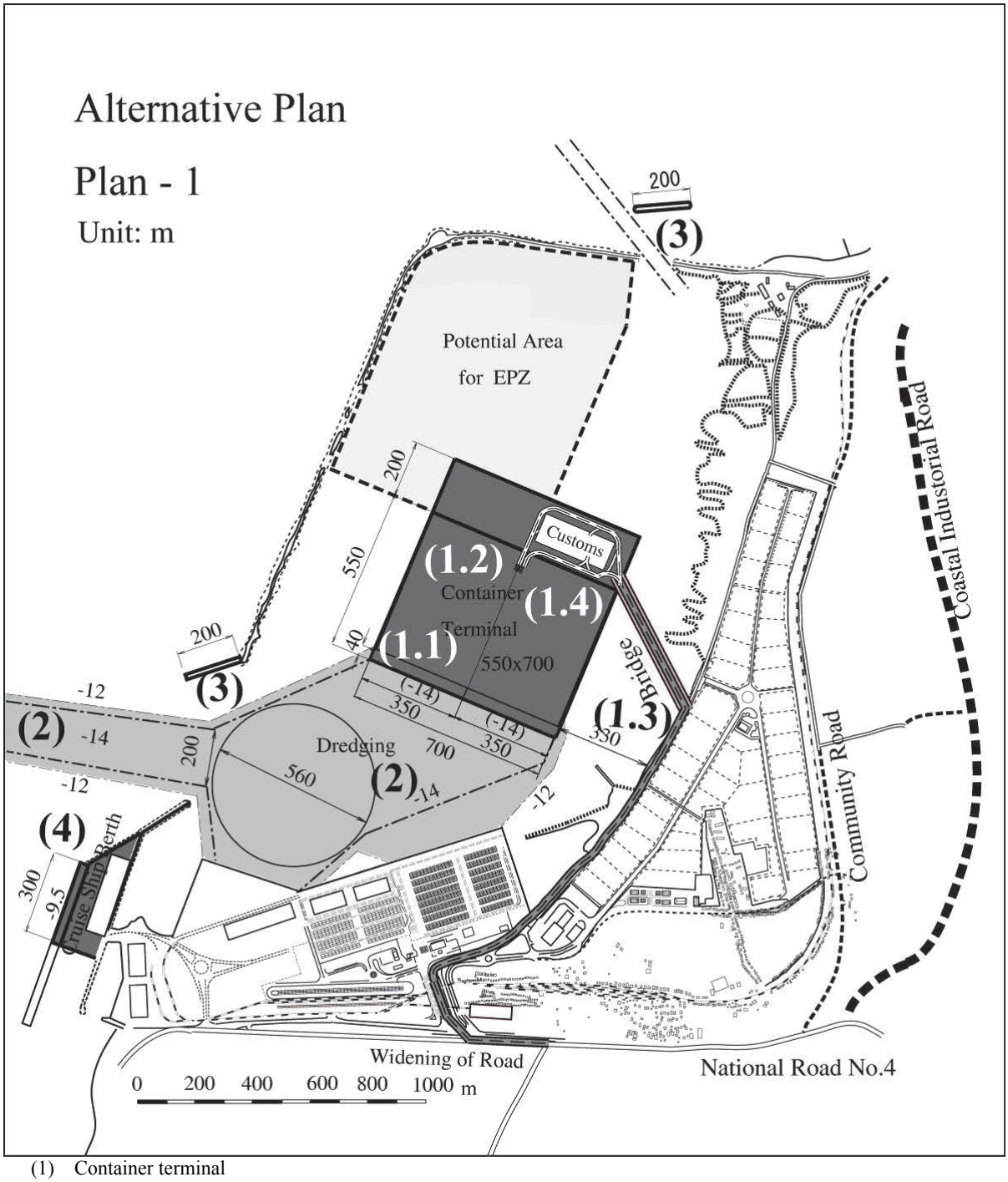


Prepared by Project Team

Figure 5.8-7 Alternative facility development plans toward 2030 on the basis of Conceptual Plan-3

Since Industrial Road is still at the stage of proposal and it is uncertain when the road will be completed, the Project Team proposes that the port access roads should be connected to National Road via the existing coastal road until Industrial Road is completed.

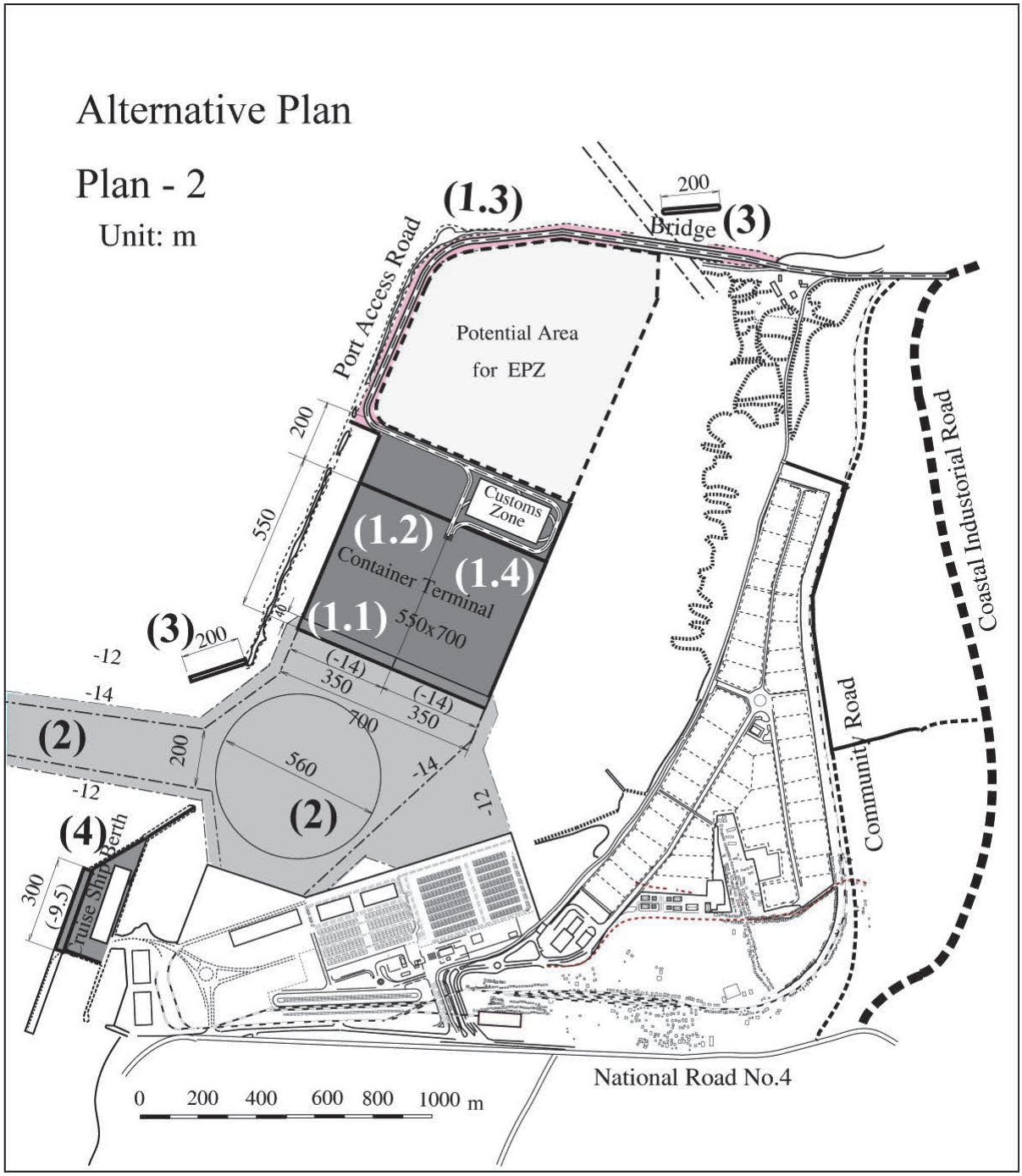
Alternative Plan -1 and Alternative Plan-2 are shown in Figures 5.8-8 and 5.8-9, respectively. The difference between the two alternative plans is the location of the container terminal and the routes of the port access road. The configurations of other facilities are the same for the two alternative plans. The project components are summarized in Table 5.8-11.



(1) Container terminal
  (1.1) Container berths, (1.2) Buildings, (1.3) Access road, (1.4) Cargo handling equipment
(2) Dredging
(3) breakwaters

Prepared by Project Team

Figure 5.8-8 Alterative Plan-1 for the basic facility development



(1) Container terminal
(1.1) Container berths, (1.2) Buildings, (1.3) Access road, (1.4) Cargo handling equipment
(2) Dredging
(3) breakwaters
Prepared by Project Team

Figure 5.8-9 Alterative Plan-2 for the basic facility development

Table 5.8-11 Project components

1. Container Terminal			
1.1 Container Berths			
Length 350m, Berth Depth -14m, Apron width 35m	Berth		2
Container Yard (700mx515m), Custom, Storage, etc.	ha		48
1.2 Building			
Administration Building, Power station, Maintenance shop, Fuel Station			4,300m^2
Terminal Gate (Export 3 Lanes, Import 2 Lanes)			5 Lanes
1.3 Access Road/Bridge/Fly Over	ls		
Plan 1	Access bridge, widening of coastal road		
Plan 2	Acces bridge, Access road		
1.4 Equipment			
Quay Gantry Crane	Unit	30.5 ton Post Panamax	6
RTG	Unit	35.6 ton, 5 stacks	18
Top Lifter/Reach Stacker	Unit	7.5 ton, Empty Container	9
Tracktor & chassis	Unit	40'	26
Light tower,	Unit		18
Operation System, Security Equipment			
2. Dredging of basin and access channel			
Dredging of Access Channel	1,000m^3		1,700
Dredging of Basin	1,000m^3		2,330
3. Breakwaters			
Main Entrance Breakwater	m		200
North Opening	m	Removal of Stones	100
	m	Breakwater	200
4. Cruise Shop Terminal			
Berth	Berth	400m(L)x30m(W)x-9.5m(D)	2
Recramation	ha		5
Warehouse (Rice)	m^2	50mx150m	7,500

Prepared by Project Team

The location of the opening of North Breakwater proposed in the two alternative plans for the passage of fishing boats and small cargo vessels is one of the possible locations. Three alternative locations, i.e., Location (a), (b) and (c), for the opening can be designed as shown in Figure 5.8-10.

Alternative Plan -1 and Plan -2 include the proposal of potential area for EPZ adjacent to the container terminal. Therefore Location (c) has been chosen because Locations (a) and (b) are not possible.

The facility development plan proposed in this study as well as the Conceptual development Plan should be authorized by relevant authorities prior to the implementation of the project. In the process of authorization, the plan may be further elaborated and modified so that a consensus on the plan is built among all those who are concerned with development and utilization of the water area enclosed breakwater.

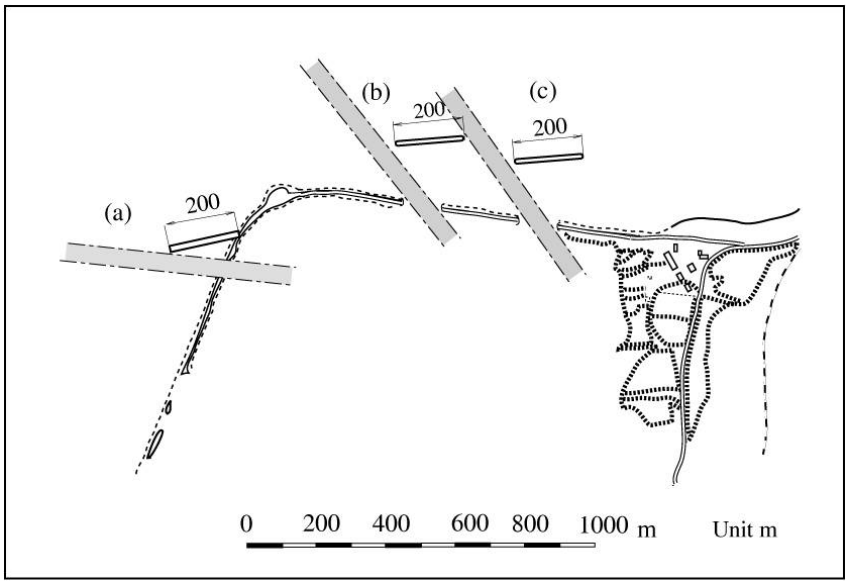


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Figure 5.8-10 Alternative locations for the opening of North Breakwater

5.8.2 Calmness of the basin

The calmness of the water area enclosed by the breakwaters is analyzed by a numerical model. The conditions of analysis and the results are described in detail in Appendix-2.

(1) Objective of the analysis of the calmness in the water area

The analysis has been done with the following objectives:

- Impact assessment of the existence of the new container terminal on the adjacent water area,
- Evaluation of the effects of the extension of North Breakwater,
- The effects of use of the wave absorbing structure at the container berths, and
- Impact of the opening of North Breakwater on the calmness inside north water area.

(2) Conditions of calculation

1) Direction of incoming wave

West (W) and northwest (NW) waves were chosen for the analysis because of the frequency of occurrence is high and the port is open in the directions of W and NW.

2) Dimensions of incident waves

The wave period of 4 second is chosen since the longer the wave period, the larger the impact on the calmness of the water area. The directional spreading parameter that characterizes directional randomness is set at Smax=10, with the considerations that waves are generated within the bay and has wide range of directional spreading.

3) Water depth of the basin

It is assumed that the water depth of the water area within the breakwaters to be -14 m. It should be noted that the actual water depth is larger except dredged basin and that the numerical tends to yield larger wave height in the shallow water area such.

4) Configurations of the structures in the numerical model

The configurations of the structure and boundary of the calculation in the numerical model are Alternative Plan -1 and -2 as shown in Figure 5.8-11. Since the port opens to the east, the calmness, which is indicated by the ratio of the wave heights at the point of interest and at the opening of the breakwater, and the net working rate of the berths, which is the rate of the workable days in a year, are

calculated for the waves coming from the west and northwest. The calmness is evaluated at the four areas, i.e., Area 1 through Area 4 as indicated in Figure 5.8-10, while the net working rate of the berths is evaluated at Berth-1 and Berth-2 of the new container terminal.

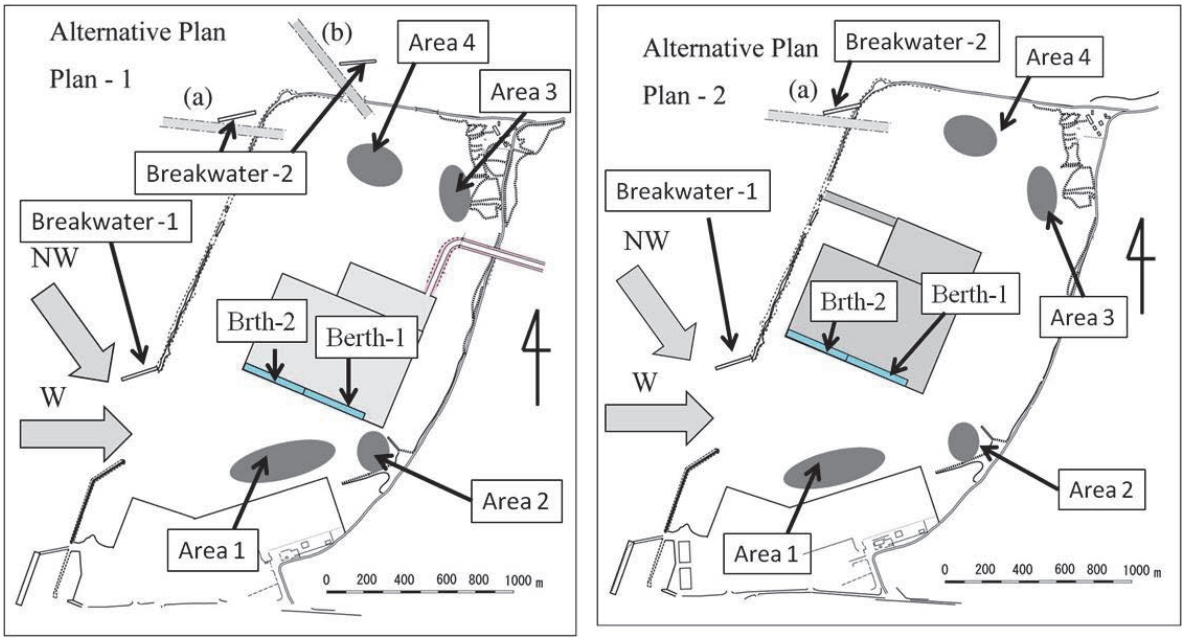

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Figure 5.8-11 Configurations of numerical model and locations for evaluation of calmness

The calculation has been done for Alternative Plan -1 and Plan -2 under the conditions with and without breakwater-1 (see Figure 5.8-11) and two different types of berth structures, i.e., wave absorbing type and reflective type. The calculation cases are listed below.

Case 1: Without Breakwater -1 and reflective type of container berths

Case 2: With Breakwater -1 and reflective type of container berths

Case 3: Without Breakwater-1 and wave absorbing type of container berths

Cade 4: With Breakwater-1 and wave absorbing type of container berths

In addition, the impact of the opening at the north part of North Breakwater on the calmness of the basin behind the opening was examined for the locations of the opening: facing to the west (Case (a)) and facing to the north (Case (b)). It was also examined with and without Breakwater -2, which is constructed in front of the opening.

(3) Results of the calculation

1) Net working rate of the container berths

The container handling operation at berths may be suspended when the wave height at the berth exceeds 50 cm. Thus, the net working rates of the berths have been estimated on the basis of the probability of occurrence of wave height of less than 50 cm at the container berths. It is said that for large ships having DWT of 50,000 tons, the container handling operation is not influenced unless the wave height exceeds 1.0 m. However, the new container berths are also used by smaller size container ships having DWT of about 20,000 tons, which are currently calling on the port as well as large container ships. Thus, the net working rate is calculated as the probability of occurrence of wave heights less than 50 cm.

The results are exhibited in Figure 5.8-12. The net working rates shown in the Figure are the average of Berth -1 and Berth-2. It is observed that the net working rate is a little higher for Plan-2. This is because the berths of Plan-1 are exposed to the waves from the west without shelter of North

Breakwater, while Berth -2 of Plan -2 is situated within the sheltered zone of the breakwater -1. As observed in the Figure, the net working rate at the container berths is 95.5 % for Case 1 (Without Breakwater-1 and reflective type of berth structure). The rate is improved to 97% either by employing wave absorbing type berth structure (Case 2) or by construction Breakwater-1 (Case 3). The rate can be improved to 98 % by Breakwater-1 and wave absorbing type of berths (Case 4).

It is concluded that, even without breakwater-1 and reflective type of berth structure, the net working rate is higher than 95%.

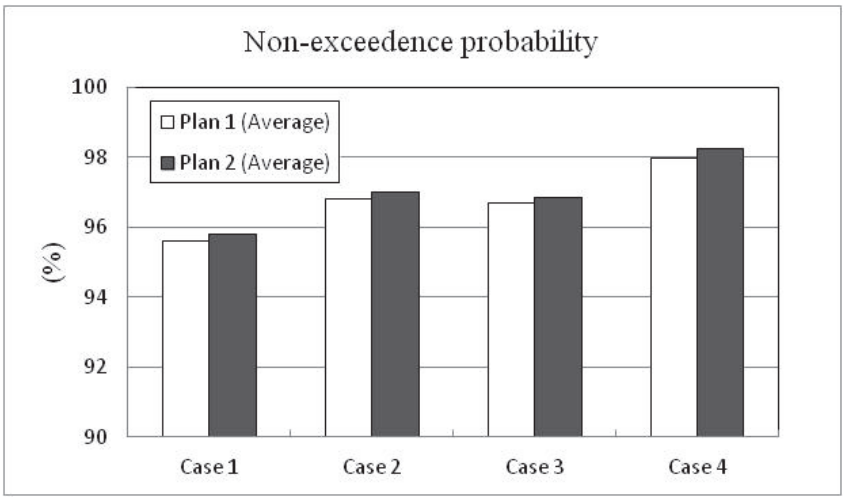

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Figure 5.8-12 Net working rate of the new container berths (Marginal wave height is 50 cm)

Calmness at the existing container berths and New Quay (Area 1）

The breakwaters of the port open to the west, and he waves coming from the west directly intrude inside the basin. When the new container terminal is completed the waves are reflected by the berth structures and propagate toward the existing container terminal and New Quay and disturb the water area (Area 1). Figure 5.8-13 shows the wave height attenuation rate, which is the ratio of the wave height at the location of interest and that at outside of the breakwater and which is 1.0 at the entrance, for the four cases and without new container terminal case, which is indicated in the Figure by “No CT”.

Except Case 4 that has breakwater -1 and wave absorbing type berth structure, the wave attenuation rates are higher and the calmness is worse than without project.

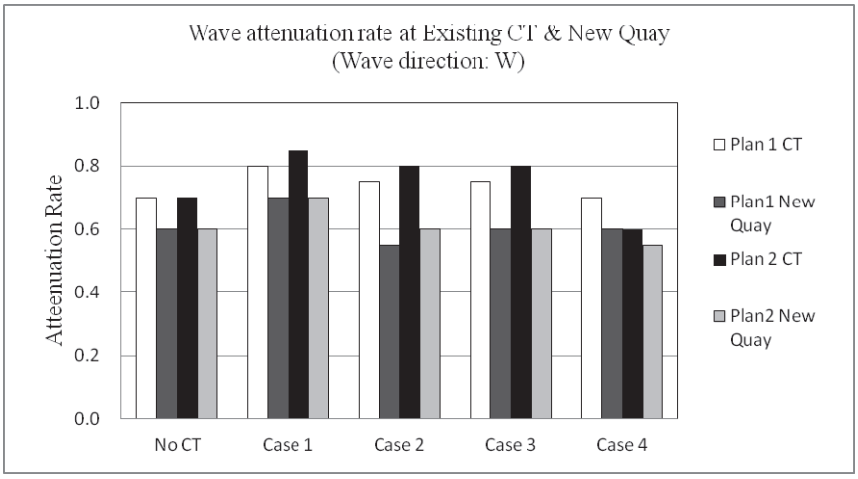

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Figure 5.8-13 Calmness in front of the of existing container berth and New Quay (Area 1）

Figure 5.8-14 shows the wave attenuation rate when waves come from the northwest. Since the existing breakwaters do not shelter New Quay and the existing container berths, the wave attenuation rate is 0.8 for the existing container berths and 1.0 for New Quay for Case 1 and Case 3, which have no Breakwater-1. In Case 2 and Case 4, the wave attenuation rates are decreased to 0.6 (the existing container terminal) and 0.8 (New Quay), and, thus, the effect of Breakwater-1 is quite obvious. No impact of the new container terminal is observed because the wave attenuation rates remain the same regardless of the types of the berth structure of the new container terminal.

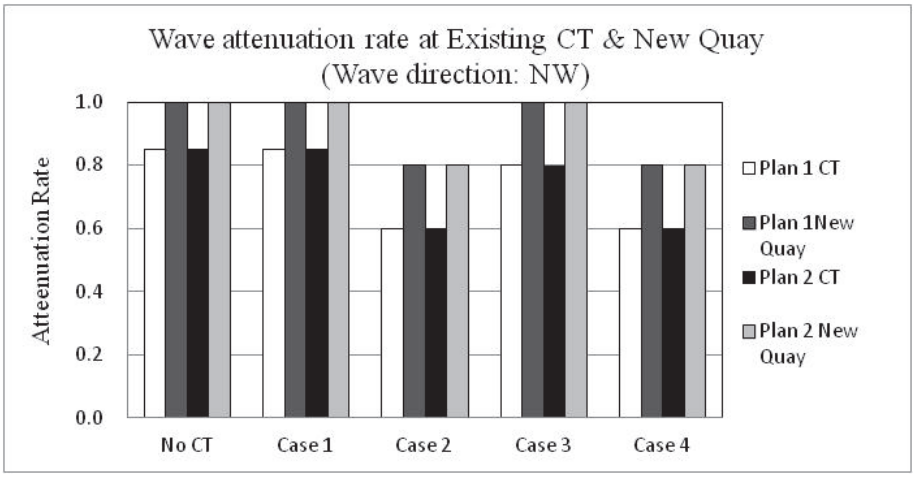

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Figure 5.8-14 Calmness at the existing container berth and New Quay (Area 1)

2) Calmness at the fish port (Area 2)

The wave attenuation rates in the water area in front of the fishing port adjacent to the existing container terminal is estimated as shown in Figure 5.8-15. When waves come from the west, the calmness at the fish port becomes worse without Breakwater-1 of wave absorbing berth structure at the new container berths. When waves come from the northwest, the calmness in Area 2 remains the same or is improved by Breakwater-1 by 10 %.

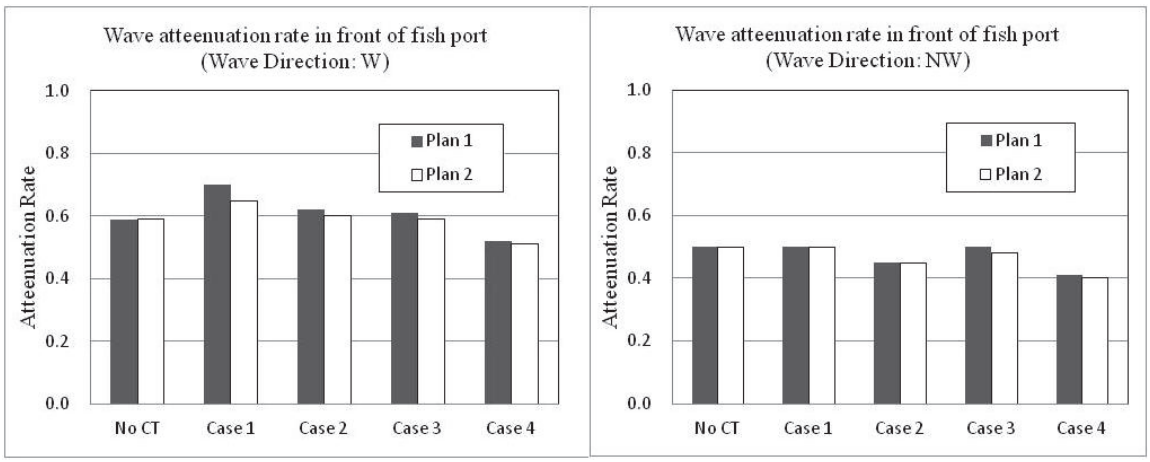

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Figure 5.8-15 Wave attenuation rate in front of fish port (Area 2)

3) Calmness in the north basin

The results of the wave attenuation in the north basin (Area 3 and 4) are shown in Table 5.8-12. Even without project case, the wave attenuation rates in Area 3 and 4 are 0.27 or higher. The results show the fact that, when waves come from the west or northwest, the waves propagate deep into the north basin. This fact indicates that the opening of the existing breakwaters, i.e., the entrance of the

port, is too wide and that the waves are reflected by the existing berths and then propagate toward the north basin.

The new container terminal blocks the wave propagation toward the north basin, and the calmness in the north basin will be improved (see Table 5.8-12 Option (a)).

Table 5.8-12 Wave attenuation rate in north basin (Area3 and 4)

North Corner (Area 3)			Location of North opening of Breakwater			
			Option (a)		Option (b)	
Wave Direction	Plan	No Project	With Breakwater-2	Without Breakwater-2	With Breakwater-2	Without Breakwater-2
W	Plan 1	0.36	0.18	0.27		
	Plan 2		0.28			
NW	Plan 1	0.27	0.09	0.16	0.21	0.21
	Plan 2		0.23			

North Water Area (Area 4)			Location of North opening of Breakwater			
			Option (a)		Option (b)	
Wave Direction	Plan	No Project	With Breakwater-2	Without Breakwater-2	With Breakwater-2	Without Breakwater-2
W	Plan 1	0.36	0.24	0.28		
	Plan 2		0.28			
NW	Plan 1	0.30	0.13	0.27	0.35	0.35
	Plan 2		0.13			

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Table 5.8-12 also shows that, if the location of the opening of breakwater is Option (b) and when waves come from the northwest, the wave attenuation rate in Area 4 is higher than without project case. This implies that the location of Breakwater-2 is not appropriate and it does not shelter the opening effectively. It is possible necessary to examine carefully the locations and configurations of Breakwater -2 when the detail dimensions such as location of the opening, the width and the orientation of navigation channel are determined.

(4) Conclusions on the calmness of the basin

1) The net working rate of the new container berths

The net working rate of the new container berths is higher than 95% without extension of North Breakwater and the wave absorbing berth structure for both Alternative Plan-1 and Plan -2. However, for small size container ships having DWT of about 20,000 tons, there is a probability that container handling operation at the berths may be suspended about 20 days per year. The extension of North Breakwater and the employment of wave absorbing type of berth structure for the new container berths increase net working rate, and the net working days become no less than 350 days.

2) Impact on the existing container berth and New Quay

Due to the reflected waves from the new container berths, the wave height in front of the existing container berths and New Quay become larger when waves come from the west. By The extending North Breakwater and employing wave absorbing type structure for the new container berths, the impact of the reflection can be reduced to the level as low as without project case.

For the waves come from the northwest, the waves propagate to the existing container berths and New Quay without attenuation. This situation will remain the same regardless of the existence of the new container terminal. However, by extending North Breakwater, the calmness at the existing berths is improved.

3) Impact on fish port (Area 2)

When waves come from the west, the wave heights in the water area (Area 2) in front of the fish

port adjacent to the existing container terminal tend to increase due to the wave reflection at the new container berths. By extending North Breakwater and by the employment of wave absorbing berth for the new terminal, the calmness scan be reduces as low as present level. The extension of Breakwater reduces the wave height in Area 2 by 10% for the waves coming from the northwest.

4) Impact on north basin (Area 3 and 4)

The new container terminal blocks wave propagation toward the north basin and reduces the wave height in Area 3 and 4 by 30%. On the other hand, the opening for the passage of small vessels of the north part of breakwater allows northwest waves to intrude into the north basin and cause disturbance in the basin. By constructing a breakwater to shelter the opening, the calmness in the north basin can be improved to the extent as calm as the present level.

5) Conclusions

Summing up the results of the analysis, it is recommended that the North Breakwater should be extended and the berth structure of the new container terminal should be wave absorbing type.

5.8.3 Planning of lands for industrial use

The conceptual development Plan has been prepared to integrate port and EPZ. It proposes the construction of EPZ adjacent to the container terminal for the pursuance of the effectiveness of logistics functions and the promotion of the export processing industries in Sihanoukville port area. While the proposed EPZ has advantages of the proximity to the port, it has also disadvantage of the cost of the reclamation in deep water area.

Once the proposed industrial road that connects Sihanoukville Port and Stung Hav is completed, the land area along the road can be the potential area for EPZ. Therefore, prior to the development of EPZ by reclamation adjacent to the container terminal, a careful assessment should be done on the advantage and disadvantage of having the EPZ just next to the port including the comparison of the development costs, demand for EPZ and the type of business suitable for EPZ next to the port. The scale of development of EPZ should be determined on the basis of the result of the assessment.

5.8.4 Planning port access

The alternative facility development plan -1 (Figure 5.8-8) and -2 (Figure 5.8-9) proposed the construction of port access road up to the existing coastal road, because the industrial road, which is shown in these figures in thick broken line, is just planning stage and it is unknown when the road is operational.

However, once the new container terminal stats fully operation and handles a million of containers, about a half million of trailers will be going in and out of the terminal. It is, thus, indispensable that the port access is directly connected with the industrial road and that the intersection of the port access and the existing coastal road is grade separation to avoid the congestion.

Although Alternative Plan-1 proposes the widening the coastal road up to the intersection with National Road No. 4 for the alleviation of traffic congestion, it is indispensable to construct by-pass access that is directly connected to the industrial road via flyover across the existing SEZ (see Figure 5.8-11) . It is also recommended that a road behind SEZ, which is called the community, should be improved so that the local traffic currently using the coastal road should be by-passed.

To this end, PAS should take proactive approach for the realization of the industrial road and the community road at the earliest opportunity.

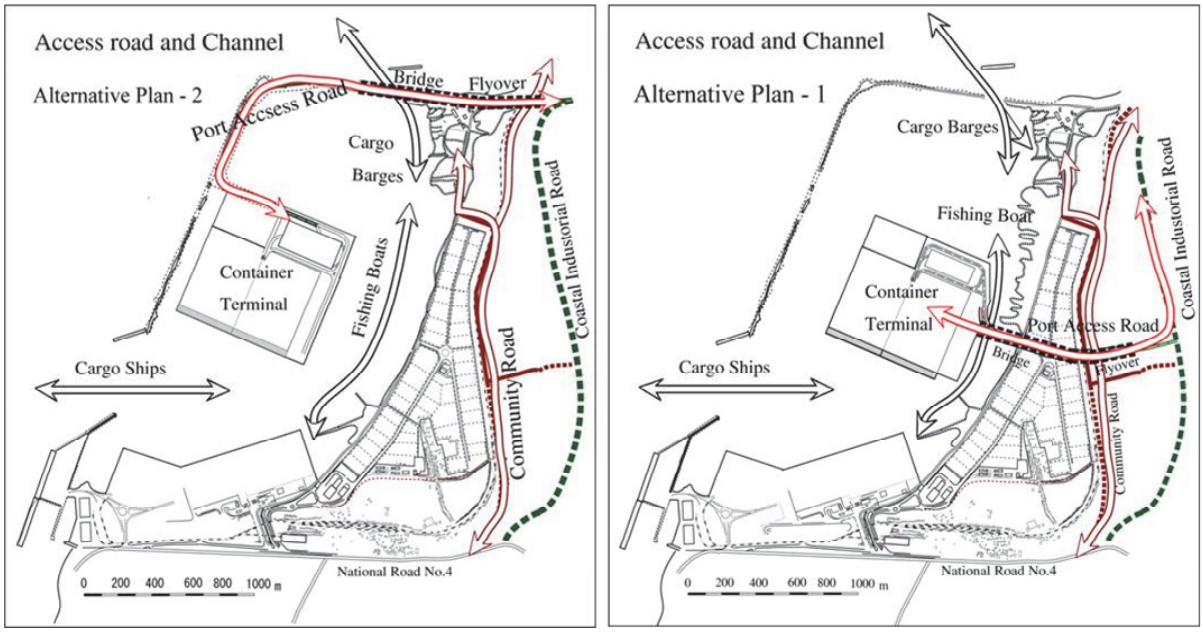

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Figure 5.8-16 Access road and navigation routes.

5.8.5 Environmental and social consideration in the process of formulating the alternative development plans

Through the JICA Advisory Committee, a total of eleven environmental impact factors were identified as particularly important for consideration in the process of formulating the alternative development plans. However, since the area available for development was limited, occurrence of certain impacts was unavoidable. Table 5.8-1 shows the environmental and social considerations made for each alternative development plan.

Table 5.8-13 Environmental and social considerations made for each alternative development plan

		Impact factor	Plan 1	Plan 2
Social environment	1	Involuntary resettlement	Facilities are planned to be situated no to cause the result of involuntary resettlement.	Facilities are planned to be situated no to cause the result of involuntary resettlement.
	2	Local economy such as employment and livelihood, etc	New opening for fishery boats going through has been planned at the pier to avoid to put much problems on fishery people's living condition an activities in the pier as possible.	New opening for fishery boats going through has been planned at the pier to avoid to put much problems on fishery people's living condition an activities in the pier as possible.

	3	Land use and utilization of local resources	Facilities are planned to be situated not to change present land use as much as possible.	Facilities are planned to be situated not to change present land use as much as possible. Regarding to the access road, the detail root selection study has not been done yet, because the route of the new industrial road has not been decided yet. In the next Project the route should be selected based on the study of land use condition around the alternative routes.
	4	Social institutions such as social infrastructure and local decision - making institutions	Facilities are planned to be situated not to divide community as much as possible.	Same as Plan 1
	5	Existing social infrastructures and services	Present coastal road will be used as an access road for the future plan. Because the first plan to construct a new route exclusively for vehicles and trucks related to the port to separate ordinary vehicles (with a bridge over SEZ) was not feasible in terms of cost.	In the plan new access road will cross the present coastal road. Because the first plan to construct a new route exclusively for vehicles and trucks related to the port to separate ordinary vehicles (with a bridge over the base of the pier) was not feasible in terms of cost.
	6	Misdistribution of benefit and damage	All plan are supposed to be set to avoid any negative effect as much as possible. However, due to limited developable area, adjustment of misdistribution of benefit and damage could not work at some extent.	Same as Plan 1
Natural environment	7	Topography and geographical features	No specific consideration was necessary as all new marine structures will be constructed inside or close to the existing breakwater.	Same as Plan 1
	8	Flora, fauna and biodiversity	No consideration on terrestrial flora/fauna was necessary as the new access road was routed along the existing coastal road.	The entire route of the new access road could not be planned as the route of the connecting new industrial road is unfixed. The precise route of the new access road should be determined in the ensuing F/S stage by taking into account important habitats of terrestrial flora/fauna.

Pollution	9	Air pollution	To avoid exhaust gas impacts from construction and cargo vehicles, the route of the access road was initially routed through a non-residential area by constructing a flyover over the SEZ. However, this option was not financially feasible. Apart from the above option, there was no route that could avoid residential area.	The new access road could not be routed through a non-residential area as the entrance area of the existing breakwater is fully occupied by residential houses.
	10	Water pollution	Due to the general lack of water depth inside the breakwater area, the potential location for the new container berth was limited to the deep water area adjacent to the current breakwater opening. Plan 1 is the case when the new container terminal is built as close to the shore as possible.	Due to the general lack of water depth inside the breakwater area, the potential location for the new container berth was limited to the deep water area adjacent to the current breakwater opening. Plan 2 is the case when the new container terminal is built from the existing breakwater area.
	11	Noise/vibration	To avoid noise/vibration impacts from construction and cargo vehicles, the route of the access road was initially routed through a non-residential area by constructing a flyover over the SEZ. However, this option was not financially feasible. Apart from the above option, there was no route that could avoid residential area.	The new access road could not be routed through a non-residential area as the entrance area of the existing breakwater is fully occupied by residential houses.

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5.8.6 Plans for utilization and management of basin which will become calm by the port development

1) Utilization of calm water area

As described in section **5.8.1**, Alternative Plan -1 and -2 are the first step to realize the conceptual development plan -3. When the container traffic increases further, a 1,000 m long container terminal will be constructed across the water area enclosed by the breakwaters. Even after the container terminal is fully developed, a large water area still remains behind the container terminal. The project team has proposed the development of EPZ for the realization of a Port SEZ that integrates the logistics and the production in the water area as one of the effective use of the available space.

This concept is intended to utilize the calm water area in the north basin the most productively and to ensure the navigation safety and the preservation of the environment by separating the port area from the area for other socioeconomic activities such as local port, piers for tourist boats, fish port, aquiculture site, shipbuilding and residential area.

Prior to the implementation of the project, the jurisdiction PAS including the proposed project site, the existing port area, basin, navigation channel, access road, SEZ and EPZ, etc. should be delineated, and the port area should be clearly separated from the areas for other activities. To this end, it is most desirable to elaborate the best plan through the discussions among all those concerned with

the utilization of the water area enclosed breakwaters. There is enough time for the discussion before the project starts. It is the responsibility of PAS to proactively promote forums among relevant agencies and to draft consensus zoning plan of the water area enclosed by breakwaters.

2) Management plan

In accordance with the consensus zoning plan, PAS should administrate the utilization and development of the port area and the port related area, while the provincial government should administrate other activities outside of the port and the port related areas, Other use with specific purpose should be administrated by respective agencies responsible for the activities.

However, maintenance of those facilities for navigation and calmness of the basin such as navigation channel, basin, and breakwater should be done by PAS.

5.8.7 Preliminary design

(1) General

The preliminary design was conducted for alternative plans 1 and 2, which were conceptually established in port planning of the master plan in 2030.

(2) Design criteria

1) Natural conditions

a) Tide

The following tides, which are the same as those used for the existing container terminal design and construction and multi-purpose terminal design were applied in this preliminary design:

Highest Water Level (HWL) : +1.43 m
Mean Sea Level (MSL) : +0.60 m
Lowest Water Level (LWL) : ±0.00 m
Chart Datum Level (CDL) : ±0.00 m

b) Waves

The following design waves of port facilities outside the harbor such as a breakwater were adapted in this design, and were sourced from 1996-1997 JICA M/S and F/S study report:

Significant wave height (H1/3) : 2.4 m
Significant wave period : 5.6 sec
Dominant wave direction : West

The following design waves of port facilities inside the harbor such as slope protection were adapted in this design, which considered waves deflected and reflected by existing and new port facilities:

Significant wave height (H1/3) : 1.0 m
Significant wave period : 4.0 sec

c) Subsoil conditions

Design parameters of subsoil for the new container and cruise ship terminals were determined based on the soil investigation results carried out in this Project as well as in the 1996-1997 JICA M/S and F/S study. Table 5.8-14 presents the subsoil conditions and design parameters applied for both terminals.

Table 5.8-14 Design Subsoil Conditions

Location	Layer	Depth	Soil Property			
			Nav-Value	Unit Weight		Strength
		(CDL)		γ (kN/m3)	γ' (kN/m3)	
New Container Terminal (-14m)	Loose Sand	-4.0 to -14.6	5	18	10	Kh=8 N/m3
	Lean Clay	-14.6 to -19.5	5	18	10	C=30 kN//m2 Kh=8 N/m3
	Dense Sand	-19.5 to -22.0	20	18	10	Kh=30 N/m3
	Dense Sand	-22.0 <	>50	18	10	
Cruise Ship Terminal (-10m)	Sand Stone	-10.8 to -15.2	>50	18	10	

Prepared by Project Team

2) Applicable codes and standards

The following design codes and standards were applied in this design:

- Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009)
- Port Development, UNCTAD
- Approach Channels, A Guideline for Design, PIANC
- Technical Standards and Explications of Shore Protective Facilities in Japan (1987)
- Shore Protection Manual, US Army Corps of Engineers
- Road Structure Ordinance in Japan (2003)
- A policy on Geometric Design of Highways and Streets, ASSHTO (2011)
- Guideline for Asphalt Concrete Pavement in Japan
- Guideline for Concrete Pavement in Japan
- Guideline for Interlocking Concrete Block Pavement

3) Service life

All the facilities planned were designed for a service life of 50 years.

4) Target vessels

Table 5.8-15 shows the design target vessels of new container and cruise ship terminals.

Table 5.8-15 Design Target Vessels

Description	Target Vessel					
	Vessel Type	Weight	LOA (m)	Beam (m)	Draft (m)	Loading Capacity
Container Terminal	Container	45,000 DWT	260	32.3	12.6	4,500 TEU
Cruise Ship Terminal	Cargo	15,000 DWT	148	23.1	9.2	
	Cruise Ship	80,000 GT	299	32.3	8.1	

Prepared by Project Team

5) Basic quay dimensions

Table 5.8-16 shows the basic quay dimensions of the new container and cruise ship terminals.

Table 5.8-16 Basic Quay Dimensions

Description	Berth		Planned Depth (CDL)	Design Depth (CDL)	Apron Width (m)
	Length (m)	Number			
Container Terminal	350	2	-14.0	-14.6	35
Cruise Ship Terminal	300	1	-10.0	-11.0	15

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6) Loading conditions

a) Quay

Table 5.8-17 shows the loading conditions at the quay of the new container terminal, and Table 5.8-18 and Figure 5.8-1 respectively present loading conditions of the quayside gantry crane and its assumed crane wheel arrangement at the new container terminal.

Table 5.8-17 Quay Loading Conditions (New Container Terminal)

Description	Surcharge		Berthing Condition			Tractive Force on Mooring Bollard (kN)
	Normal (kN/m2)	Normal (kN/m2)	Vessel Size	Contact Velocity (m/sec)	Contact Angle (degree)	
Container Terminal	30	15	45,000 DWT	0.10	10	1,000

Prepared by Project Team

Table 5.8-18 Quayside Gantry Crane Loading Conditions (New Container Terminal)

Size	Loading Condition				
	Condition	Direction		Seaside (kN/wheel)	Landside (kN/wheel)
Post-Panamax	Operation	Vertical		600	540
		Horizontal	⇔	-	60
			⇕	48	36
	Storm/Seismic	Vertical		780	780
		Horizontal	⇔	-	120
			⇕	72	72

Prepared by Project Team

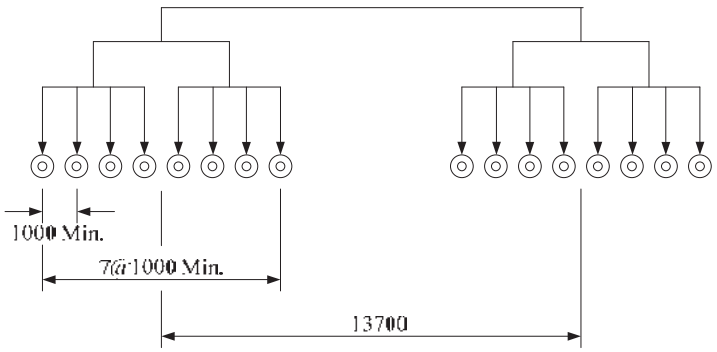

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Figure 5.8-17 Assumed Wheel Arrangement of Quayside Gantry Crane

Table 5.8-19 shows the loading conditions at the quay of the cruise ship terminal.

Table 5.8-19 Quay Loading Conditions (Cruise Ship Terminal)

Description	Surcharge		Berthing Condition			Tractive Force on Mooring Bollard (kN)
	Normal (kN/m2)	Normal (kN/m2)	Vessel Size (DWT)	Contact Velocity (m/sec)	Contact Angle (degree)	
Cruise Ship Terminal	30	15	15,000 DWT 80,000 GT	0.15	10	1,000

Prepared by Project Team

b) Terminal yards, relevant roads and bridges

Table 5.8-20 and 5.8-21 respectively show design vehicles and cargo handling equipment, and their wheel loads. Also, Table 5.8-22 and Figure 5.8-18 respectively show wheel loads of rubber tired

gantry crane (RTG) and container loads of four layers stocked.

Table 5.8-20 Design Vehicles and Cargo Handling Equipment

Facility		Design Vehicle / Equipment	Frequency
Container Terminal	Apron	Trailer	
		Container	
		Top Lifter	Occasional
		Reachstacker (boom not extended)	Occasional
	Maintenance Yard Van Pool	Trailer	Occasional
		Forklift	Occasional
		Toplifter, Reachstacker, RTG, etc (not loaded)	Occasional
		Empty Container (4 high)	
		Toplifter, Reachstacker (loaded)	
	Office Area	Regular Vehicle	
	Yard Circulation Road, Main Gate, Container Terminal Access Road, Container Related Building Area	Regular Vehicle	
		Trailer	
		Toplifter, Reachstacker, Forklift (not loaded)	Occasional
Cruise Ship Terminal	Apron	Mobile Crane (100t capacity)	
		Mobile Crane (235t capacity)	
		Forklift Trucks (15 ton type)	
		Truck	
	Truck Loading/Unloading Area	Forklift Trucks (15 ton type)	
		Truck	
	Parking Area	Truck	
	Main Access and circulation road	Truck	
Access Road & Bridge		Regular Vehicle	
		Trailer	
		Truck	

Prepared by Project Team

Table 5.8-21 Wheel Loads of Major Vehicles and Cargo Handling Equipment

Equipment	Description	Conditions	Front Wheels	Rear Wheels
Chassis for Container Transport	2 x 20 ft or 1 x 40/45 ft	with load	(15 t King Pin on 5th wheel)	3.8 t x 8 wheels
		without load	(0.9 t King Pin on 5th wheel)	0.4 t x 8 wheels
Tractor Head for Container Transport	40.5t, Container Chassis Towing	with load on 5th wheel	3.2 t x 2 wheels	2.5 t x 8 wheels
		without load on 5th wheel	2.0 t x 2 wheels	0.6 t x 8 wheels
Top Lifter for Empty Containers	5 Tiers, 4.5 t under preader	with load	8.6 t x 4 wheels	3.1 t x 2 wheels
		without load	5.4 t x 4 wheels	7.2 t x 2 wheels
Top Lifter for Loaded Containers	4 Tiers, 30.5 t under Spreader	with load	21.2 t x 4 wheels	7.5 t x 2 wheels
		without load	9.7 t x 4 wheels	12.9 t x 2 wheels
Reach Stacker for Empty Containers	5 Tiers, 4.5 t under Spreader	with load	8.6 tx 4 wheels	3.1 t x 2 wheels
		without load	5.4 t x 4 wheels	7.2 t x 2 wheels
Reach Stacker for Loaded Containers	4 Tiers, 30.5 t under Spreader	with load	21.2 t x 4 wheels	7.5 t x 2 wheels
		without load	9.7 t x 4 wheels	12.9 tx 2 wheels
Forklift Truck for heavy cargo	15 ton capacity	With load	14.5t tire pressure 7.6 kg/cm2	
Fork Lift Truck for General Use	2.5 ton capacity	with load	2.9 t x 2 wheels	0.6 tx 2 wheels
Mobile Crane	100t capacity	with load	Per outrigger 70t	

Prepared by Project Team

Table 5.8-22 Assumed Wheel Loads of Rubber Tired Gantry Crane (RTG)

Conditions		Wheel Loads (P)
With Rated Load	Static*	Pv max = 266 kN
(On runway Foundation)	During Acceleration	Pva max = 319 kN
With No Load	Static*	Pv max = 176 kN
(On Lane Shifting Foundation)	During Acceleration	Pva max = 212 kN

*: Dynamic coefficient ϕ = 1.2 must be multiplied to the static loads.

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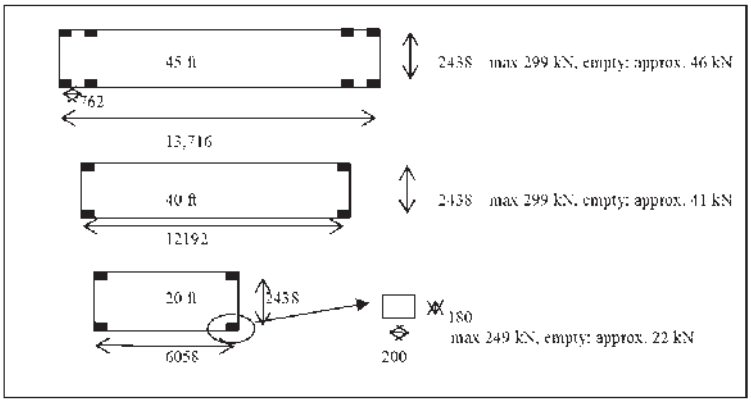

Source: PIANC Guideline (1987)

Figure 5.8-18 Container Loads (Four Layers Stacking)

7) Material properties

a) Structural steels

Table 5.8-23 shows the allowable stresses of structural steels.

Table 5.8-23 Allowable Stresses of Structural Steels

Structural steel (steel pipe)	SM490/SKK490/SKY490 (N/mm^2)
Axial tensile stress	185
Axial compressive stress	185 : l/r<16, 185-1.2x(l/r-16):16<l/r<79, 1,200,000/(5,000+(l/r)^2):79<l/r
Bending tensile and compressive stress	185
Examination of members simultaneouslysubject to axial compressive and bending compressive stress	$\sigma_c/\sigma_{ca}+\sigma_b/\sigma_{ba}< 1.0$

Where

l: effective buckling length of member (cm)

r: radius of gyration of area for the gross cross-sectional area of the member (cm)

σc: compressive stress due to axial compressive force acting on the section (N/mm2)

σb :maximum compressive stress due to bending moment acting on the section (N/mm2)

σca: allowable axial compressive stress relating to smallest moment of inertia (N/mm2)

σba: allowable bending compressive stress (N/mm2)

Source: Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009)

b) Stone, quarry run, sand and backfill materials

Considering the availability of local materials and their properties, the following properties were adapted in this design as shown in Table 5.8-24.

Table 5.8-24 Adapted Materials Properties of Stone, Quarry Run, Sand and Backfill Materials

Discreption	Unit Weight		Angle of Shearing Resistance
	γ (kN/m3)	γ' (kN/m3)	ϕ (degree)
Fill Material, Sand	18	10	30-35
Rubble Backing, Stone, Rock	18	10	35
Rubble Base Stone	18	10	40

Prepared by Project Team

8) Corrosion rates of steel materials

Table 5.8-25 shows the corrosion rates of steel materials.

Table 5.8-25 Allowable Stresses of Steel Materials

Corrosive environment		Corrosion Rate (mm/year)
Sea Side	Above HWL	0.3
	From HWL to LWL-1.0m	0.1 ~ 0.3
	From LWL-1.0m to the sea bottom	0.1 ~ 0.2
	Below the sea bottom	0.03
Land Side	In marine atmosphere	0.1
	In soil (above the residual water level)	0.03
	In soil (below the residual water level)	0.02

Source: Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009)

9) Factor of safety

Table 5.8-26 shows the factors of safety in structural computation in this design.

Table 5.8-26 Factors of Safety in Structural Computation

Structure	Condition	Factor of Safety
Gravity Type	Sliding	1.20
	Over-Turning	1.20
	Tolerable Rubble Base Reaction	500 kN/m2
	Circular Arc Slip	1.30
	Bishop Method	1.00
Deck on Pile Type	Bearing Capacity	2.50
	Pullout	3.00
	Circular Arc Slip	1.30

Source: Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009)

10) Increase of allowable stresses

The increase of allowable stresses was 50% for seismic conditions as referenced from Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009).

11) Coefficients of friction

Coefficients of friction for design of gravity type structures were applied as 0.5 for between concrete and concrete, and 0.6 for between concrete and rubble base stone as referenced from Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009).

12) Others

The vertical inclination of access roads and bridges was set as less than 3% suitable for a speed of 40 km/h for 40’ tractor-trailers, based on the relevant codes and standards.

(3) Summary of preliminary design

Based on the preliminary design for each alternative plan, five major facilities including the channel and basin, breakwaters, new container terminal, cruise ship terminal, access roads, bridges, and cargo handling equipment and other port equipment were consequently required. Each component is generally explicated as follows:

1) Channel and basin

a) Channel

The target vessel for the new container terminal is of 45,000 DWT with 12.6 m draft. The vessel will be the biggest at Sihanoukville Port and the existing approach channel should accommodate the vessel dimensions. This study applied three approaches using different standards and guidelines as listed below to determine suitable dimensions of the channel:

- Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2007/2009)
- Port Development, UNCTAD
- Approach Channels, A Guideline for Design, PIANC

Table 5.8-27 shows the computation results of channel dimensions for 40,000 and 50,000 DWT container carriers.

Table 5.8-27 Computation Results of Required Channel Dimensions

Ship Dimension Container Carrier				Channel Depth (m)				Channel WIdth (m)					
DWT	LOA (L)	Beam (B)	Draught (T)	PIANC	JPN P&H Standard		UNCTAD	PIANC		Japan Port & Harbor Standard		UNCTAD	
(ton)	(m)	(m)	(m)					1-way	2-way	1-way	2-way	1-way	2-way
40,000	237	32.3	12.0	15.6	13.8	13.5	13.8	126.0	271.3	118.5	237.0	161.5	256.1
50,000	274	32.3	12.7	16.5	14.6	14.2	14.6	126.0	271.3	135.0	270.0	161.5	256.1

Prepared by Project Team

This study applied waves and the tidal current nearby the channel sourced from the 1996-1997 JICA study report. In the study, the required dimensions for the case of one-way traffic were respectively -14 to -15 m deep and 120 to 160 m wide. On the other hand, those for the case of two-way traffic were respectively -14 to -15 m deep and 250 to 270 m wide. The multi-purpose terminal development project is planning to expand existing channel dimensions (-10 m deep and 125 m wide) to accommodate a 50,000 DWT bulk carrier so the dimensions will become -12 m and 150 m wide in the near future. Based on the above computation results and the planning status of the multi-purpose terminal development project, the future channel dimensions were consequently determined as follows:

- In case of one-way traffic : -14 m in depth and 150 m in width
- In case of two-way traffic : -14 m in depth and 300 m in width

The dredging slope was applied entirely as 1:2 due to no sufficient subsoil information. Both channel plans for one-way and two-way traffic are shown in Figures 5.8-3 and 5.8-4.

b) Basin

The basin must accommodate the turning radius of the target vessel. A basin -14 m deep with a 300 m turning radius was therefore secured in this study.

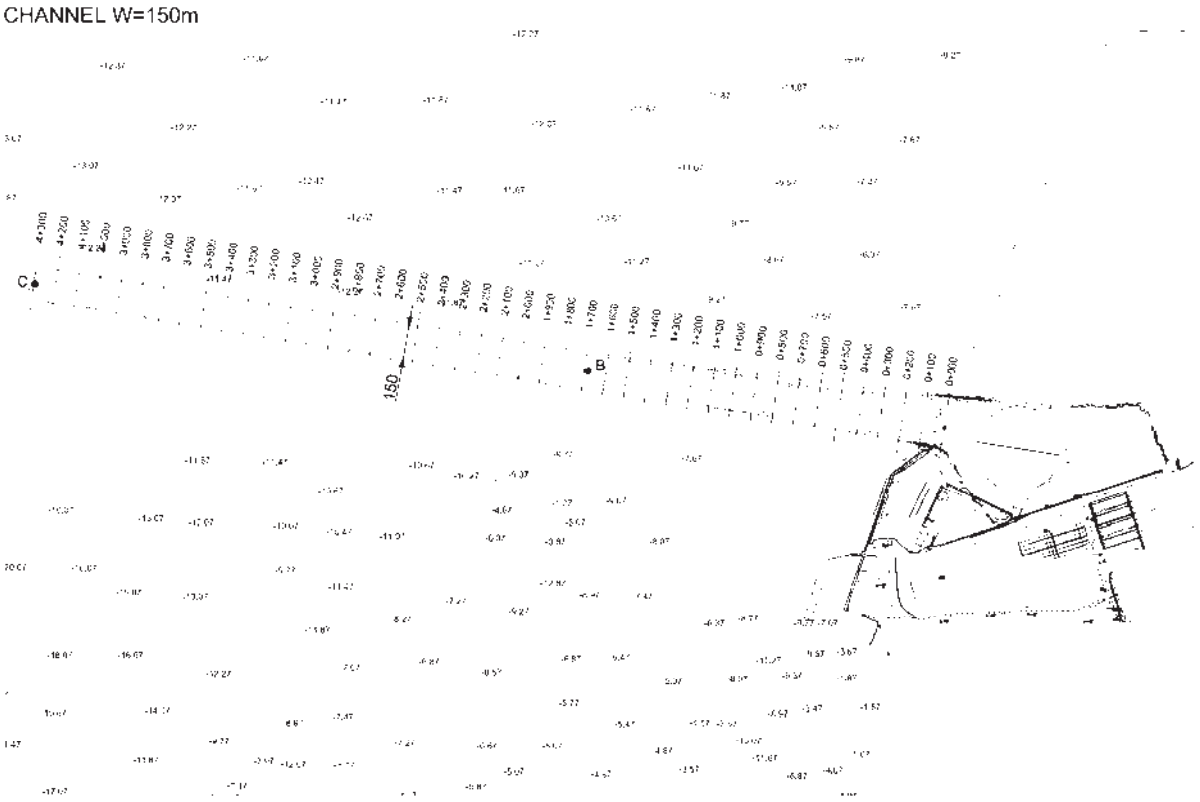

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Figure 5.8-19 Approach Channel Plan (W=150 m)

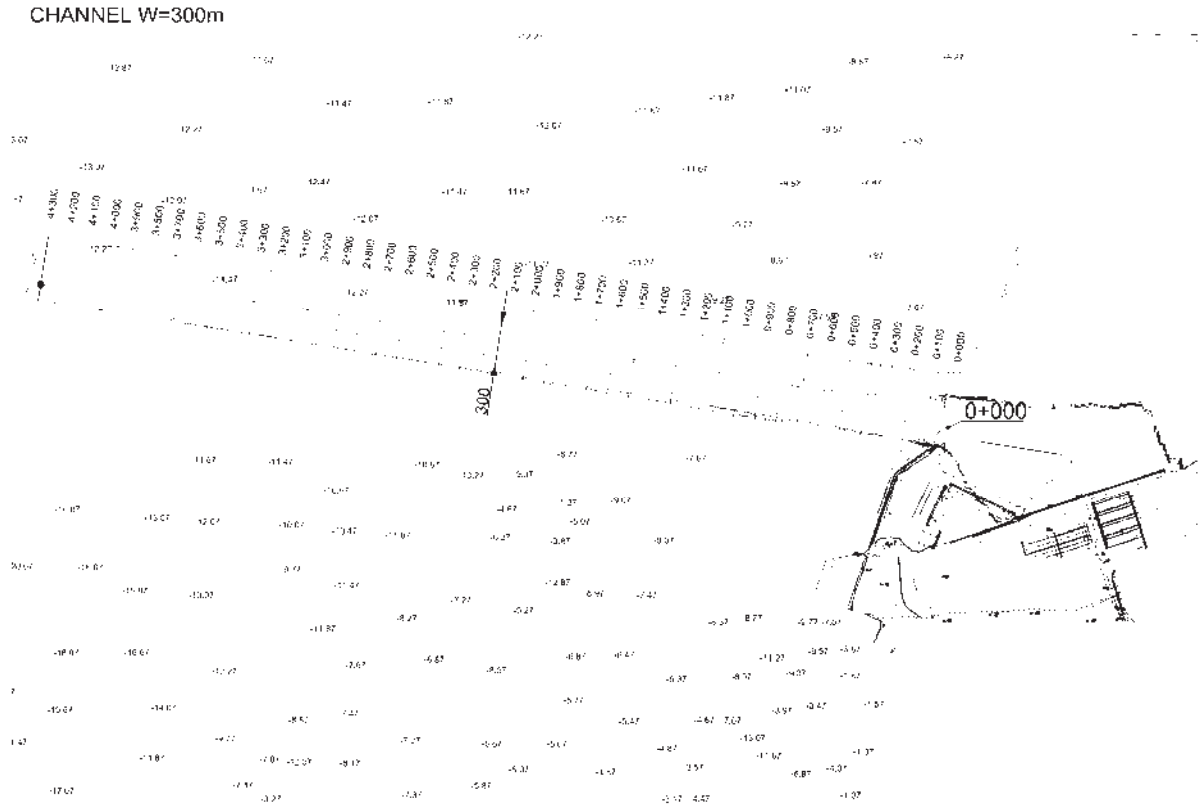

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Figure 5.8-20 Channel Plan (W=300 m)

2) Breakwaters

a) Removal and elevation of existing breakwaters

The new container terminal development might hamper the current small boat traffic; thus, removal of about a 200 m length of the existing north breakwater is required. In addition, if the future plan on the container terminal is along the north breakwater like the alternative plan 2, the existing breakwater is also to be elevated as a protective measure because the terminal and access road are to be located beside the breakwater. Armor rock weight for the elevation was calculated by formula (1) as below. Elevating the existing breakwater resultantly provided +5.5 crest level (0.6 x significant wave height H1/3 +HWL), 6 m wide crest (more than three times of armor rock thickness), and 1:2 slope inclination. Table 5.8-28 shows the computation results of armor rock weight by formula (1) and Figure 5.8-21 describes a typical section of the elevated existing breakwater.

$$M = \frac{\rho_r H^3}{N_s{}^3 (S_r - 1)^3} \qquad \text{……formula (1)}$$

Where,

M : Required rock weight (ton)
H : Design significant wave height (m)
ρ_r : Density of rock or stone (t/m³)
ρ_w : Density of seawater (t/m³)
Sr : Ratio of rock and seawater densities ($=\rho_r/\rho_w$)
Ns : Parameter mainly determined by rock shape, slope and damage ratio ($=K_D$ x cot α)

Table 5.8-28 Calculation Result of Armor Rock Weight (Elevation of Existing Breakwater)

Wave Height	Density		Damage Ratio	Slope Angle	Stone Weight	
	Stone	Seawater				
H (m)	ρr(t/m3)	ρw(t/m3)	KD	cot α	M (t)	
2.4	2.3	1.03	3.2	2	2.65	2-3

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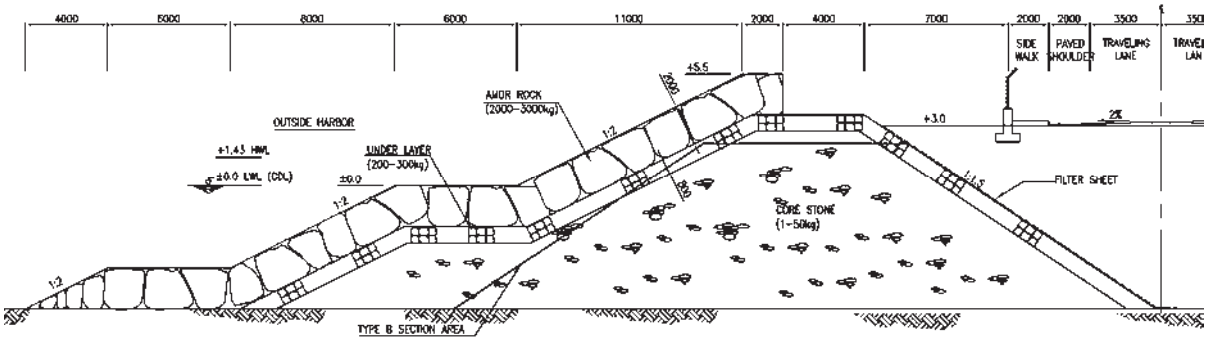

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Figure 5.8-21 Typical Section (Elevated Existing Breakwater)

b) New breakwaters

Because of a reduction in the wave calmness inside the harbor by the new container terminal arrangement and direct waves entering the opened existing breakwater, two new breakwaters are required to mitigate the anticipated situations. One breakwater, "Breakwater A," arranged at the south

tip of the existing breakwater, required a 200 m length at an average -8 m depth. Another "Breakwater B," arranged at the offshore side in front of the opened existing north breakwater, also required a 200 m length at an average -6 m depth. The armor rock weights calculated by formula (1) were the same as referred to Table 5.8-28. The weights of the armor rock at the middle and core layers were determined respectively at 1/10 and 1/200 of the weight of the first rock layer. Both breakwaters resultantly provided +5.5 crest level (0.6 x significant wave height H1/3 +HWL), 6 m wide crest (more than three times of armor rock thickness), and 1:2 (outside port) and 1:1.5 (inside port) slope inclinations. Figures 5.8-22 and 5.8-23 describe typical sections of both breakwaters.

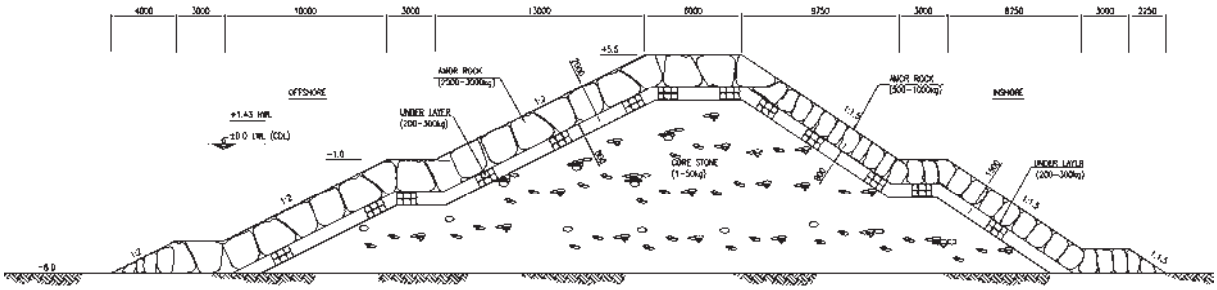

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Figure 5.8-22 Typical Section (Breakwater A)

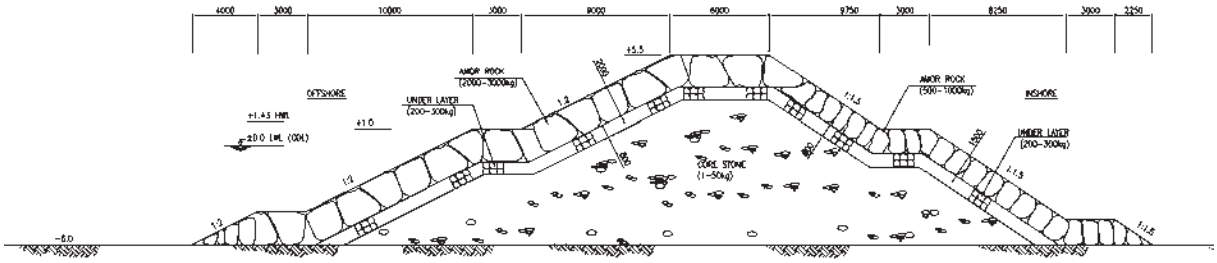

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Figure 5.8-23 Typical Section (Breakwater B)

c) Small breakwater inside harbor

Because of aqua-cultural facilities transferred from the locations of the alternative plans and direct waves coming to the facilities through the opened breakwater, a small breakwater arranged after the opened breakwater as necessary required a 50 or 100 m length at an average -4.5 m depth. The armor rock weight calculated by formula (1) is shown in Table 5.8-29. The weights of the armor rock at the middle and core layers were determined respectively at 1/10 and 1/200 of the weight of the first rock layer. The breakwater resultantly provided +3.0 crest level (+0.5 of existing breakwater crest level), 3 m wide crest (more than three times of armor rock thickness), and 1:1.5 slope inclinations. Figure 5.8-24 describes typical sections of the breakwater.

Table 5.8-29 Calculation Result of Armor Rock Weight (Small Breakwater)

Wave Height	Density		Damage Ratio	Slope Angle	Stone Weight	
	Stone	Seawater				
H (m)	ρr(t/m3)	ρw(t/m3)	KD	cot α	M (t)	
1.0	2.3	1.03	3.2	1.5	0.26	0.2-0.5

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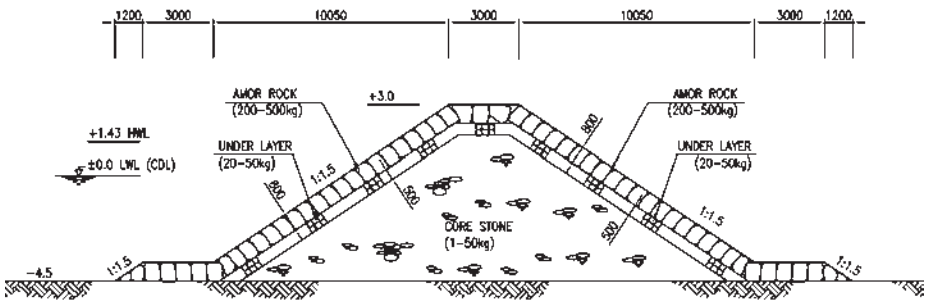

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Figure 5.8-24 Typical Section (Small Breakwater)

3) New container terminal

a) Reclamation area

Based on the soil investigation conducted in this Project, a compressive sandy-silt soft layer exists around 5 m from the seabed like the existing container terminal and the multi-purpose terminal areas. It is presumed that settlement at the new terminal locations would be almost the same 1.6-1.8 m at final settlement and would require 4.5 years to finish the settlement. It is experientially understood that settlement at U=80% about 250 days appears by filling of reclamation materials and the rest of U=20% comes up after commencement of terminal facilities. Therefore, the settlement would continue even after completion of construction works of the terminal and should be considered into the plan and design of the reclamation area. Considering the above, the final planned elevation of the reclamation area was determined as +3.0, the same as the quay elevation.

b) Slope protection

The seawall of the reclamation area applied slope protection formed of core stone, an under-layer and armor rocks. The armor rock weight calculated by formula (1) was the same as that referred to in Table 5.8-29. The weights of the armor rock at the middle and core layers were determined respectively at 1/10 and 1/200 of the weight of the first rock layer (armor rock layer). The slope protection resultantly provided +3.5 crest level (+0.5 of the reclamation level), 3 m wide crest (more than three times of armor rock thickness), and 1:2 (seaside) and 1:1.5 (reclamation side) slope inclinations. Figure 5.8-25 describes a typical section of the slope protection.

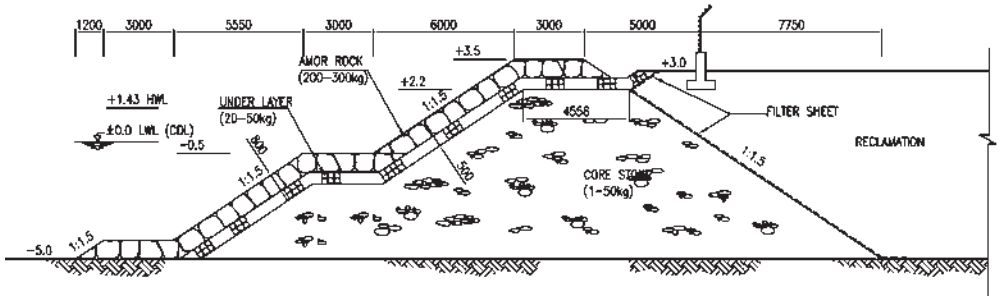

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Figure 5.8-25 Typical Section: Slope Protection (New Container Terminal)

c) Quay

The quay of the new container terminal requires an optimized structural type considering structural adaptability, suitability to subsoil conditions, wave calmness, durability, workability on construction, environmental impact and cost. Based on subsoil investigation results around the locations of the new container terminal, gravity type and deck on pile type were preliminarily suitable among other structural types of quay. So this study initially selected caisson type, block type, block type with wave dissipating block (WDB) and deck on pile type (raked pile) and carried out a

comparative study for the structural types based on the said seven elements. Table 5.8-30 shows the results of the comparative study and Figures 5.8-26, 5.8-27, 5.8-28 and 5.8-29 present typical sections of each type.

Structural adaptability: Deck on pile type is advantageous for adaptation to a deeper quay and because of the unified superstructure as a foundation for quayside gantry cranes. On the other hand, caisson type, block type and block type with WDB are disadvantageous due to the necessity to replace the existing soft subsoil layer with rubble base stone up to the hard stratum in order to secure the required bearing capacity, and for having to place quayside gantry cranes on different structures.

Suitability of subsoil conditions: Deck on pile and all the gravity types are basically suitable for the existing subsoil conditions. However, the deck on pile type might be disadvantageous in suitability for cases of uniformity of subsoil layers and their thicknesses appearing along the quay line.

Wave calmness: Deck on pile type and block type with WDB are regarded as having a lower ratio of wave reflection. On the other hand, caisson and block types have a higher wave reflection ratio due to the vertical wall structure.

Durability: Caisson, block, block with WDB types are made of concrete without exposure of any steel materials and are therefore durable. Deck on pile type composed of pile foundations and concrete superstructures require certain corrosion protection initially and continuously afterward and are comparatively disadvantageous due to the measures required.

Workability on construction: Caisson type requires large-scaled preparatory works such as provision of floating dock for fabrication but its construction period is comparatively shorter. Block type and block type with WDB needs to prepare certain yard space for fabrication and temporary storage of concrete blocks and the associated equipment and materials, and requires a longer construction period for such preparation. Deck on pile type requires the provision of a piling barge and could have a shorter construction period, unless suspension of piling works due to subsoil conditions is anticipated.

Environmental impact: Caisson type may have a detrimental effect on the marine environment because of many marine and underwater works required during its construction. Block type and block type with WDB require middle-scaled marine and underwater works, and some environmental concerns are certainly expected upon their construction. Among the structural sections, deck on pile type has relatively less impact on the environment because this type has fewer marine works than other structural types.

Overall cost: In terms of cost per linear meter, caisson type is the most expensive among the structural types due to the preparation of the floating dock, fabrication and installation of caissons, and placing rubble base stone. There is a remarkable difference in the costs between block type and block type with WDB, with the costs being cheaper than the caisson type but more expensive than the deck on pile type. Depending on the market price fluctuation of steel materials, deck on pile type is the cheapest among the structural types because of the lower volumes of dredging and rubble base stone.

Evaluation: Although the deck on pile type requires a further detailed subsoil investigation and needs to consider and analyze the fluctuant market price of steel materials, it has been concluded so far that the deck on pile type is most recommendable.

Table 5.8-30 Comparative Study of Quay Structural Type (New Container Terminal)

Structure Type / Evaluation Item	Concrete Caisson		Block		Block with WDB		Raked Pile	
Structural Adaptability	7 m rubble base installation required for securing bearing capacity. Two different structures required for supporting Quayside Gantry Crane rail foundations.	B	Same as left	B	Same as left	B	Commonly applicable for deeper water. United structure for supporting Quayside Gantry Crane rail foundations.	A
Suitability to Sub-soil Conditions	Stable due to replacement of existing soft layers under quay structure.	A	Stable due to replacement of existing soft layers under quay structure.	A	Stable due to replacement of existing soft layers under quay structure.	A	Basically stable but stiffness of sub-soil layers absolutely required. Possibly unstable in case of uneven sub-soil layers and lacking of resistance of sub-soil layers.	B
Wave Calmness	Higher reflected wave height generated without wave dissipating function.	C	Same as left	C	Smaller reflected wave height generated with wave dissipating function.	A	Same as left	A
Durability	No exposure of steel materials and generally maintenance free.	A	Comparatively costly	A	Same as left	A	Possibly corroded especially at splash zone area. Adequate corrosion protection measure required.	B
Construction	Floating dock or temporary submarine mound required for fabrication. Construction period moderately shorter.	B	Certain temporary yard required for fabrication of concrete block. Construction period comparatively longer.	C	Same as left	C	Pile driving barge required. Raked pile driving difficult in case of appearance of hard stone etc. Constriction Period shortest.	B
Environmental Impact	Many underwater works and dredging works required.	C	Comparatively minor underwater and dredging works required.	B	Same as left	B	Minimum underwater and dredging works required.	A
Overall Cost	Costly	C	Comparatively costly	B	Same as left	B	Comparatively cheaper	A
Evaluation	Not recommendable	C	Recommendable	B	Recommendable	B	Most recommendable	A

Note: WDB means wave dissipating block. A: Excellent/Appropriate, B: Fair, C: Poor

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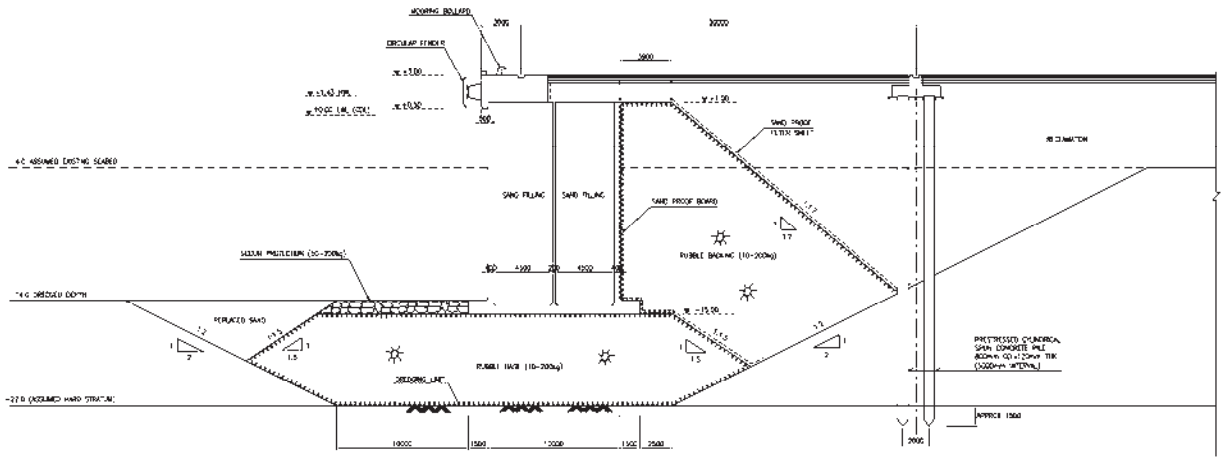

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Figure 5.8-26 Typical Section: Caisson Type (-14 m)

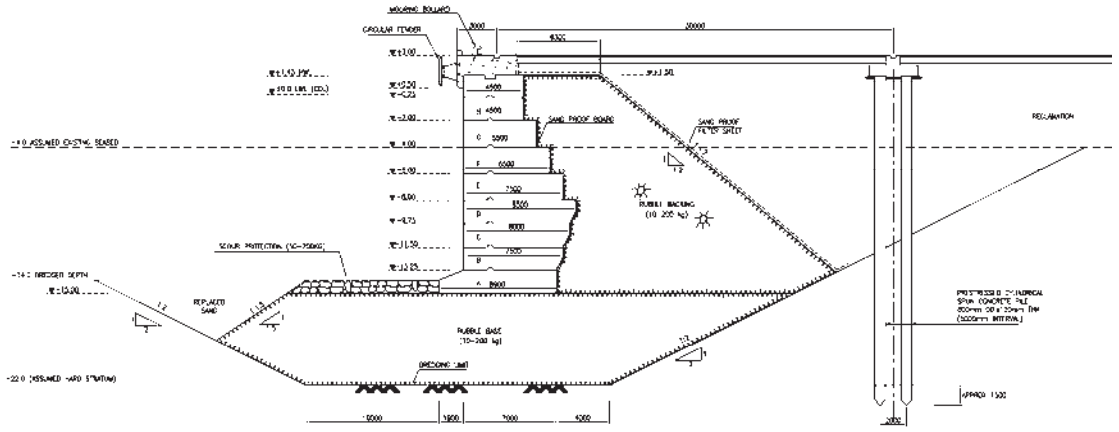

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Figure 5.8-27 Typical Section: Block Type (-14 m)

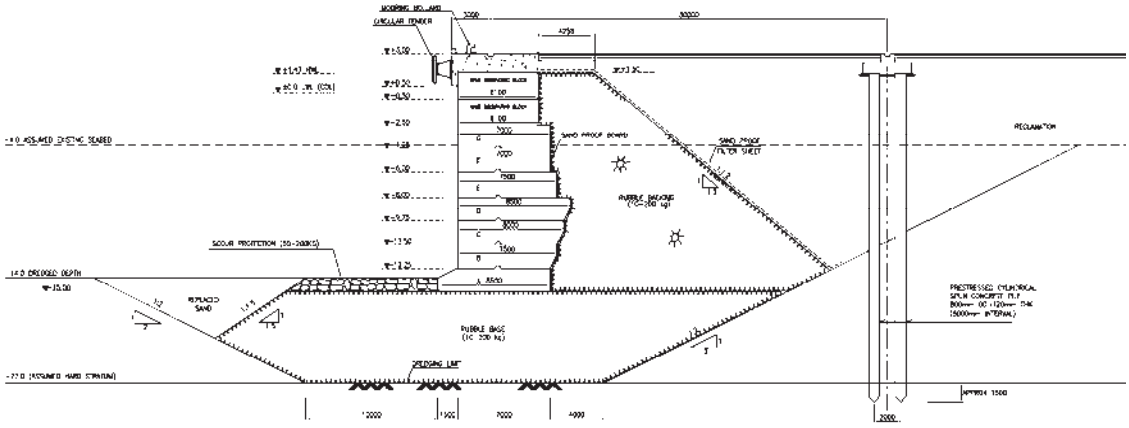

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Figure 5.8-28 Typical Section: Block Type with Wave Dissipating Block (-14 m)

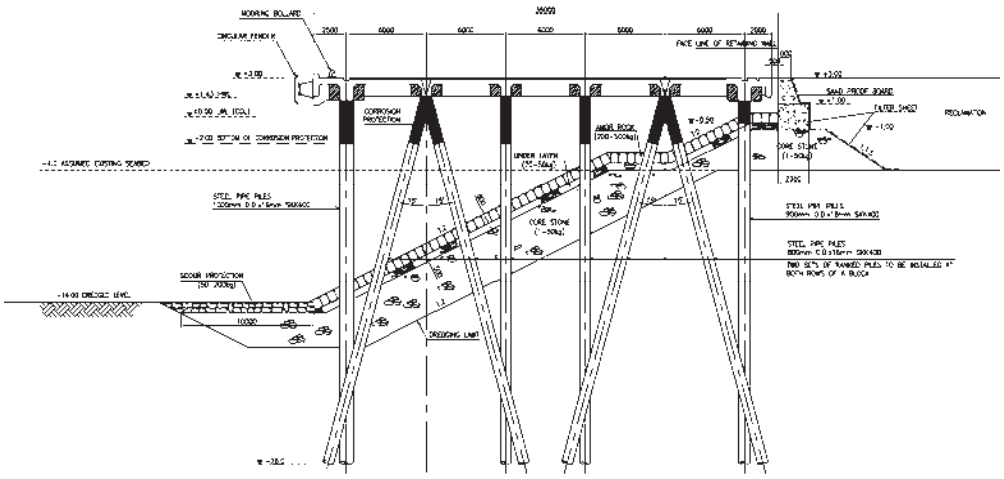

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Figure 5.8-29 Typical Section: Deck on Pile Type (-14 m)

d) Container yard

The container yard provided five major civil structures: pavement, RTG travelling concrete slab, container stacking slab, drainage system, and perimeter fence.

Based on design vehicles and cargo handling equipment, each pavement composition inside the yard was determined as shown in Table 5.8-31.

Table 5.8-31 Pavement Compositions (New Container Yard Area)

Pavement Type	Pavement Section		Applied to
	Composition	Thickness (mm)	
Interlocking Concrete Block (Type 1)	Interlocking Co. Block	120	Service Road Yard Internal Road Imported Car Storage Area Custom Zone Area
	CTB	150	
	Base Course	250	
	Sub Base	400	
Interlocking Concrete Block (Type 2)	Interlocking Co. Block	120	Portions between Container Stacking Foundations
	Sand Layer	50	
	Base Course	150	
	Sub Base	400	
Concrete Pavement (Type 1)	Concrete with Wire mesh	250	Portions around Terminal Buildings
	Base Course	150	
	Sub Base	300	
Concrete Pavement (Type 2)	Concrete with Wire mesh	350	RTG Repair Area
	Base Course	150	
	Sub Base	300	

Prepared by Project Team

Based on design loading conditions of RTG and four layered containers stocked, basic dimensions of the concrete foundation slabs were determined as summarized in Table 5.8-32.

Table 5.8-32 Dimensions of RTG and Container Stacking Slabs (New Container Yard Area)

Item	Structure Type	Foundation Slab Dimension			Base Section under Slab	
		Length (m)	Width (m)	Thickness (m)	Composition	Thickness (mm)
RTG crane foundation Slab	Prestressed Concrete	4 to 40	1.5	0.25	Course Sand	40
					Base Course	200
					Sub Base	300
Container Stacking Foundation Slab	Prestressed Concrete	6 to 9	1.0/1.4	0.25/0.35	Course Sand	40
					Base Course	200
					Sub Base	300

Prepared by Project Team

The drainage system provided surface drainage, underground pipelines and open ditches for the entire yard, imported car storage and custom areas. Also, perimeter fences were considered for all terminal boundaries except for the quay line in consideration of the case of separated operational management.

e) Mechanical and electrical facilities

Mechanical facilities provided a water supply system for berthing vessels, fire hydrants, relevant terminal buildings, custom building, etc., and a sewerage system for the said buildings. Electrical facilities composed of the following items based on an assumption of outer power source availability:

- External power cable installation and connection 1 ls x 2 terminals
- Emergency generator (for QGC) 1 unit x 2 terminals
- Transformer 3 units x 2 terminals
- Power supply system for QGC 3 units x 2 terminals
- Power supply system for relevant buildings 9 bldgs x 2 terminals
- Power supply system for custom building 1 bldg
- Yard lighting system 9 units x 2 terminals
- Reefer container power supply system 1 ls x 2 terminals
- Power supply system for weighing bridge 1 ls x 2 terminals
- Power supply system for CCTV system 1 ls x 2 terminals
- Others (provisional) 1 ls x 2 terminals

f) Buildings

Based on preliminary terminal planning of the new container terminal, the following buildings were basically required:

- Administration building (4,000 m²) 1 bldg x 2 terminals
- Entrance gate (4 in&out+1through, 800 m2) 1 bldg x 2 terminals
- Maintenance shop (600 m²) 1 bldg x 2 terminals
- Substation (64 m²) 1 bldg x 2 terminals
- Generator house (100 m²) 1 bldg x 2 terminals
- Fuel station (50 m²) 1 bldg x 2 terminals
- Worker station (150 m²) 1 bldg x 2 terminals
- Water reservoir and pump house (150 m²) 1 bldg x 2 terminals
- Sewerage treatment plant (150 m²) 1 bldg x 2 terminals
- Weighing bridge control house (10 m²) 1 bldg x 2 terminals

4) Cruise ship terminal

a) Reclamation area

Based on the soil investigation conducted in this Project, the seabed at the location of the cruise ship terminal is already a rock layer unlike the one at the locations of the new container terminal, and no settlement is therefore considered at this location. The final planned elevation of the reclamation area for the terminal was determined as +5.2 matching the elevation of the existing old jetty.

b) Slope protection

Like the new container terminal, the seawall of the reclamation area applied slope protection was formed of core stone, and under-layer and armor rocks. The armor rock weight calculated by formula (1) was the same as that referred to in Table 5.8-14. The weights of the armor rock at the middle and core layers were determined respectively at 1/10 and 1/200 of the weight of the first rock layer (armor rock layer). The slope protection resultantly provided +5.5 crest level (0.6 x significant wave height H1/3 +HWL), 6 m wide crest (more than three times of armor rock thickness), and 1:2 (outside port) and 1:1.5 (inside port) slope inclinations. Figure 5.8-30 describes a typical section of the slope protection.

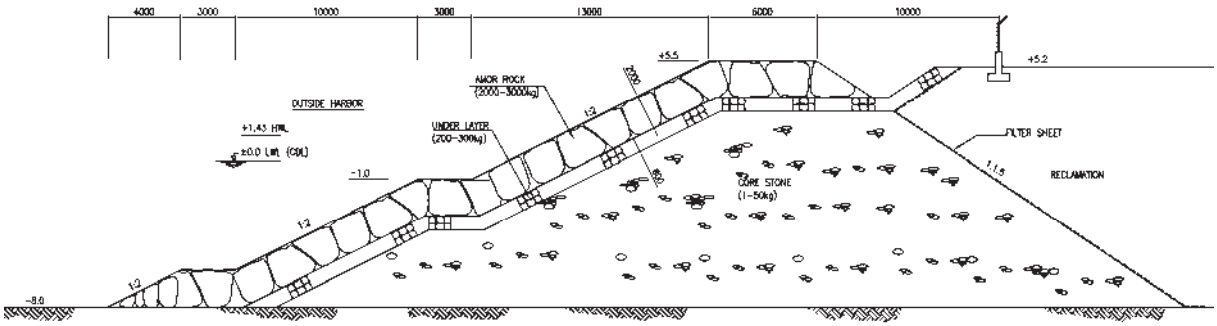

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Figure 5.8-30 Typical Section: Slope Protection (Cruise Ship Terminal)

c) Quay

The quay of the cruise ship terminal requires an optimized structural type considering structural adaptability, suitability to subsoil conditions, durability, workability on construction, environmental impact and cost. Based on subsoil investigation results at the location of the terminal, gravity type was the only applicable type among structural types of quay. So this study initially selected caisson type, block type, cellular block type and carried out a comparative study for the structural types based on the said six elements. Table 5.8-33 shows the results of the comparative study and Figures 5.8-31, 5.8-32 and 5.8-33 present typical sections of each type.

Structural adaptability: All the types are structurally adaptable even though they require rock dredging and installation of rubble stone under the quay bodies.

Suitability of subsoil conditions: Likewise, all types are suitable for the existing subsoil conditions.

Durability: All types are made of concrete without exposure of any steel materials and are therefore durable. However, cellular block type is disadvantageous due to the possible outflow of infilling materials inside the blocks.

Workability on construction: Caisson type requires large-scaled preparatory works such as provision of a floating dock for fabrication but its construction period is comparatively shorter. Block type requires a certain yard space for fabrication and temporary storage of concrete blocks and the associated equipment and materials, and thus needs a longer construction period for such preparation. Cellular block type additionally requires infill sand or other equivalent materials after installation of the cellular blocks and will have a longer construction period than the block type.

Environmental impact: Caisson type may have a detrimental effect on the marine environment because of many marine and underwater works required during its construction. Block type and cellular block type have small to middle-scaled marine and underwater works, and some environmental concerns are certainly expected upon their construction.

Overall cost: In terms of cost per linear meter, cellular block type is the most expensive among the structural types due to fabrication and installation of the blocks, infilling of sand or equivalent materials and its longer construction period. Caisson type is cheaper than the cellular block even with the preparation of a floating dock, but fabrication and installation of caissons are required and is thus more expensive than block type. The block type is the cheapest among the three structural types because of less preparation and difficulty in construction compared to the other types.

Evaluation: Generally, it has been concluded so far that the block type is most recommendable.

Table 5.8-33 Comparative Study of Quay Structural Type (Cruise Ship Terminal)

Structure Type / Evaluation Item	Concrete Caisson		Block		Cellular Block	
Structural Adaptability	Rock layer dredging required from existing seabed below 3 m. Other structural type unable to be adapted due to sub-soil conditions	A	Same as left	A	Same as left	A
Suitability to Sub-soil Conditions	Stable due to placing structure on existing rock layer.	A	Same as left	A	Same as left	A
Durability	No exposure of steel materials and generally maintenance free.	A	Comparatively costly	A	No exposure of steel materials and generally maintenance free. Possible effluence of infill sand.	B
Construction	Floating dock or temporary submarine mound required for fabrication. Construction period moderately shorter.	B	Certain temporary yard required for fabrication of concrete block. Construction period comparatively longer.	C	Certain temporary yard required for fabrication of concrete block. Construction period comparatively longer.	C
Environmental Impact	Certain underwater works and dredging works required.	C	Comparatively minor underwater and dredging works required.	B	Same as left	B
Overall Cost	Comparatively costly	B	Economical	A	Costly	C
Evaluation	Recommendable	B	Most Recommendable	A	Not recommendable	C

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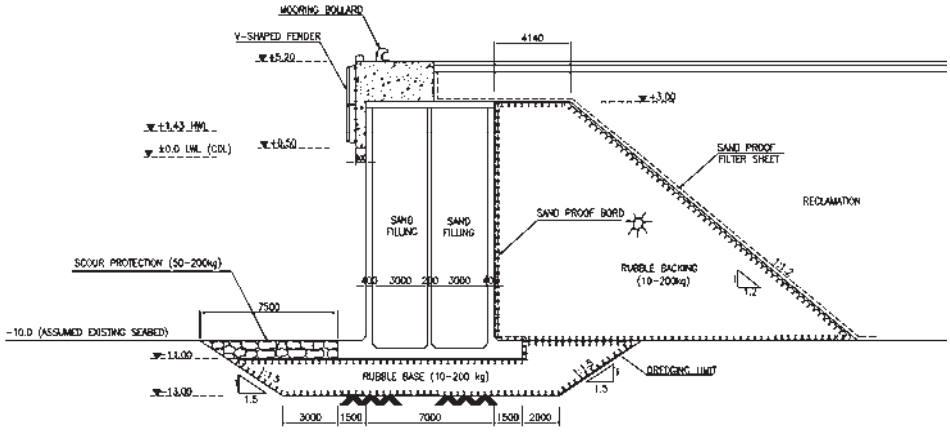

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Figure 5.8-31 Typical Section: Caisson Type (-10 m)

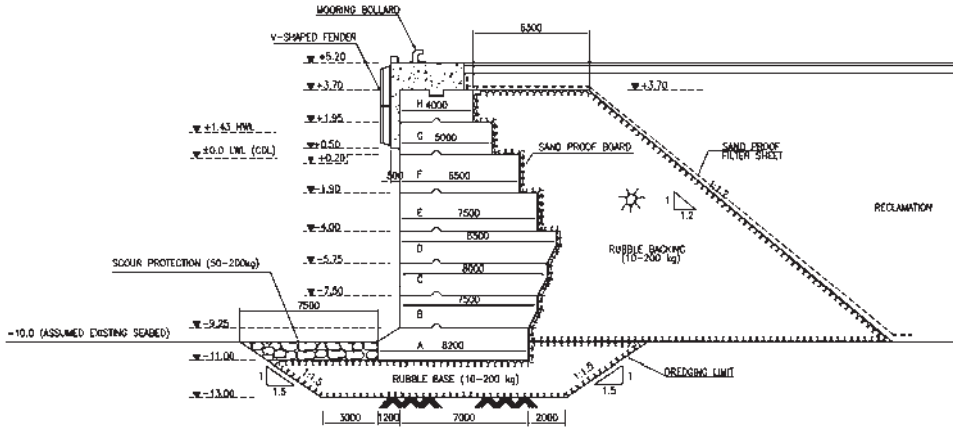

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Figure 5.8-32 Typical Section: Block Type (-10 m)

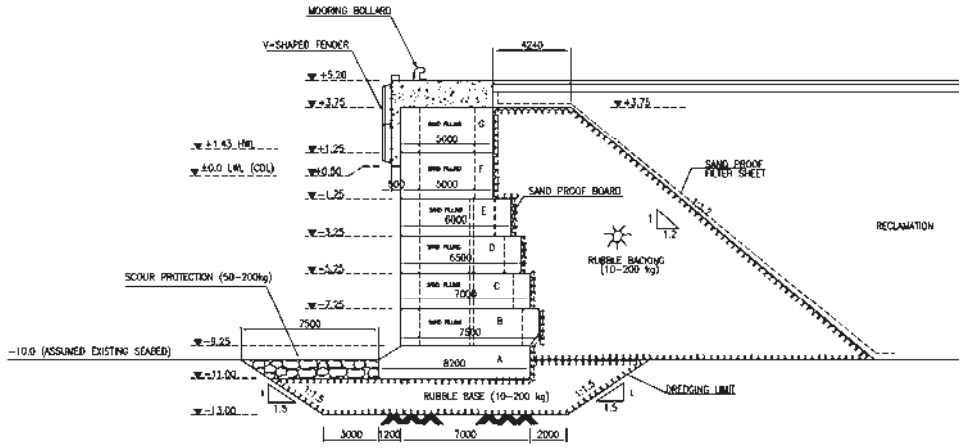

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Figure 5.8-33 Typical Section: Cellular Block Type (-10 m)

d) Common yard

The common yard provided three major civil structures: pavement, drainage system and perimeter fence.

Based on design vehicles and cargo handling equipment, pavement composition at the yard was determined as shown in Table 5.8-34.

Table 5.8-34 Pavement Composition (Cruise Ship Terminal)

Pavement Type	Pavement Section		Applied to
	Composition	Thickness (mm)	
Concrete Pavement (Type 1)	Concrete with Wire mesh	250	Apron, Terminal Yard, Inner Rood etc.
	Base Course	150	
	Sub Base	300	

Prepared by Project Team

The drainage system provided surface drainage, underground pipelines and open ditches for the entire yard area. Also, perimeter fences were considered for all terminal boundaries except the quay line.

e) Mechanical and electrical facilities

Mechanical facilities provided a water supply system for berthing vessels, fire hydrants, relevant terminal buildings, etc., and a sewerage system for the said buildings. Electrical facilities composed of the following items based on outer power source availability:

- Power supply system for relevant buildings 3 bldgs
- Yard lighting system 6 units
- Small power supply system 1 ls
- Power supply system for CCTV system 1 ls
- Others (provisional) 1 ls

f) Buildings

Based on preliminary terminal planning of the new cruise ship terminal, the following buildings were basically required:

- Warehouse (7,500 m²) 1 bldg
- Security guard house (25 m²) 1 bldg
- Water reservoir and pump house (150 m²) 1 bldg

5) Access roads and bridges

a) Access roads

Access roads were required as an import access connection between the new container terminal and main truck roads, e.g. new coastal road conceptually planned. Required travelling lanes of relevant roads were estimated from dividing the passenger car unit (PCU) per hour of the total vehicle traffic by 1,800 PCU per hour as an assumed one lane capacity of the roads as shown in Table 5.8-35. According to the computation results, 2-lane two-way roads were minimally required for the access roads. However, access for the portion near the new container terminal required 4-lane two-way roads in consideration of future possible expansion and queuing area for container tractor-trailers. In addition, the roads provided two paved shoulders at the edge of both travelling lanes and two sidewalks at both ends of the paved shoulders. 4 m wide center medians were required on the 4-lane two-way roads for U-turns of 40’ tractor-trailers.

Table 5.8-35 Calculation Result of Required Travelling Lanes

Category	Item	Vehicle Type		Unit/day		PCU	
				1 way	2 ways	PCU/day	PCU/hr
Traffic Volume	Container	Large Vehicle	Tractor Trailer (with container)	1,852	8,148	-	-
			Tractor Trailer (without container)	2,222			
	Imported Vehicle	Large Vehicle		91	91	-	-
		Small Vehicle		156	156		
	Others	Large Vehicle		100	200	-	-
		Small Vehicle		200	400		
	Total	Large Vehicle		-	8,439	25,318	-
		Small Vehicle			556	556	
		Total				25,874	3,450
Lane Capacity (PCU/hr)							1,800
Required Lane (nr)							1.92

Prepared by Project Team

Based on design vehicles and other possible traffic, pavement composition of the access road was determined as shown in Table 5.8-36.

Table 5.8-36 Pavement Composition (Cruise Ship Terminal)

Pavement Type	Pavement Section		Applied to
	Composition	Thickness (mm)	
Concrete Pavement (Type 1)	Concrete with Wire mesh	250	Access Road
	Base Course	150	
	Sub Base	300	

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In each alternative plan, several access roads were required at different locations. Each specific segment of the roads was categorized and named below as also shown in Figures 5.8-34, 5.8-35, 5.8-36 and 5.8-37.

- Access road A (4-lane, 2 way) : nearby the new container terminal
- Access road B (2-lane, 2 way) : reclaimed area inside port along existing north breakwater
- Access road C (2-lane, 2 way) : reclaimed area outside port along existing north breakwater
- Access road D (2-lane, 2 way) : connection to main truck roads

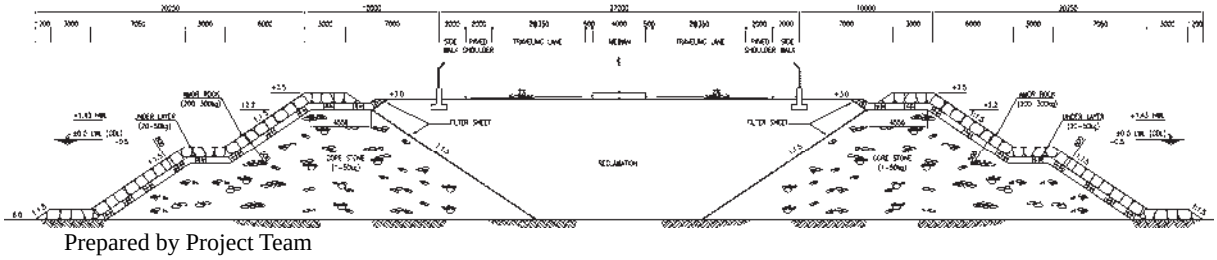

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Figure 5.8-34 Typical Section: Access Road A

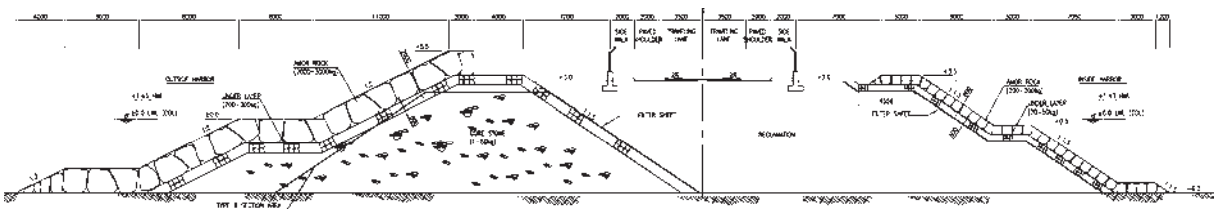

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Figure 5.8-35 Typical Section: Access Road B

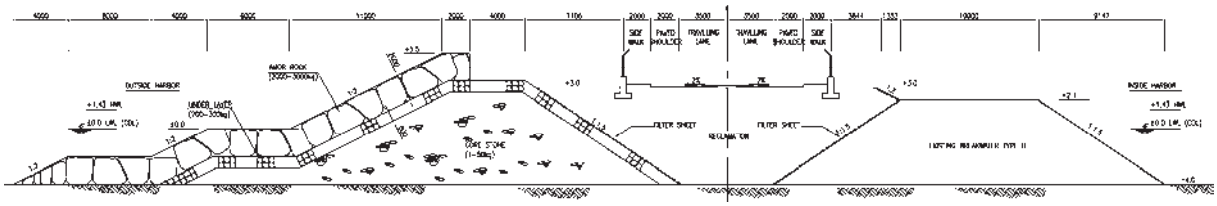

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Figure 5.8-36 Typical Section: Access Road C

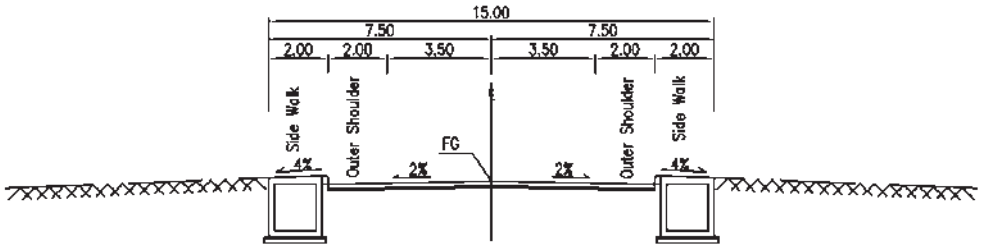

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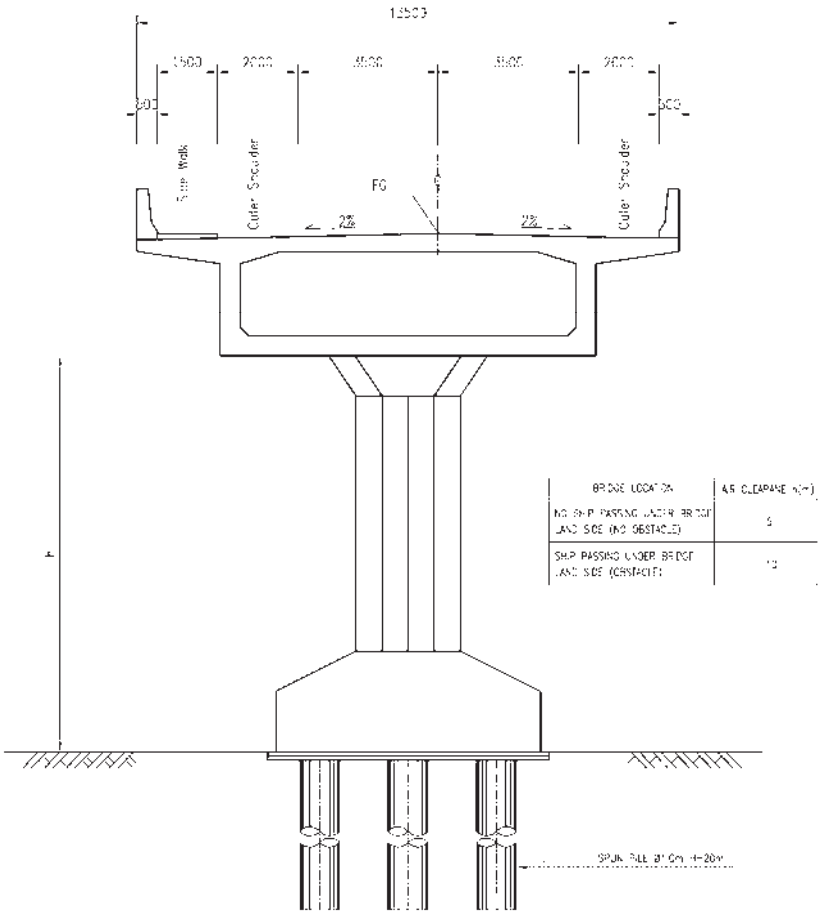
Figure 5.8-37 Typical Section: Access Road D

b) Bridges

Bridges were required for road connection at the opened existing breakwater and to avoid disturbing existing structures and/or residences. Required travelling lanes were same as the access roads (2-lane two ways). Paved shoulders secured 2 m at both ends of each travelling lane and 1.5 m wide sidewalks provided at the edge of the paved shoulder (one side only). Basic air clearance of the bridges was set as 10 m for securing navigational access of existing boats and vessels. Typical section of the bridge was shown in Figure 5.8-38.



Prepared by Project Team

Figure 5.8-38 Typical Section (Bridges)

6) Cargo handling equipment and port equipment

a) Cargo handling equipment

Based on preliminary terminal planning of the new container terminal, the following cargo handling equipment was basically required:

- Quayside gantry crane (Post-Panamax, 14 rows) 2 units x 2 terminals
- RTG (6 rows, 4+1) 9 units x 2 terminals
- Top Lifter (10 tons) 3 units x 2 terminals
- Tractor & Chassis (40’ container) 16 units x 2 terminals

b) Port equipment

Based on preliminary terminal planning of the new container terminal, the following port equipment was basically required:

- CCTV system 1 ls x 2 terminals
- Container Yard Management System 1 ls x 2 terminals

Based on preliminary terminal planning of the cruise ship terminal, the following port equipment was basically required:

- CCTV system 1 ls

5.8.8 Construction planning and implementation schedule

(1) Construction planning

1) Estimated work quantities

Each alternative plan was established considering the basic development policy of port planning, container cargo demand forecast, natural conditions such as wave calmness inside harbor, socioeconomic conditions, environmental impacts, etc. Based on the preliminary design as mentioned in 5.8.7, a summary of estimated work quantities for each alternative plan is presented in Table 5.8-37.

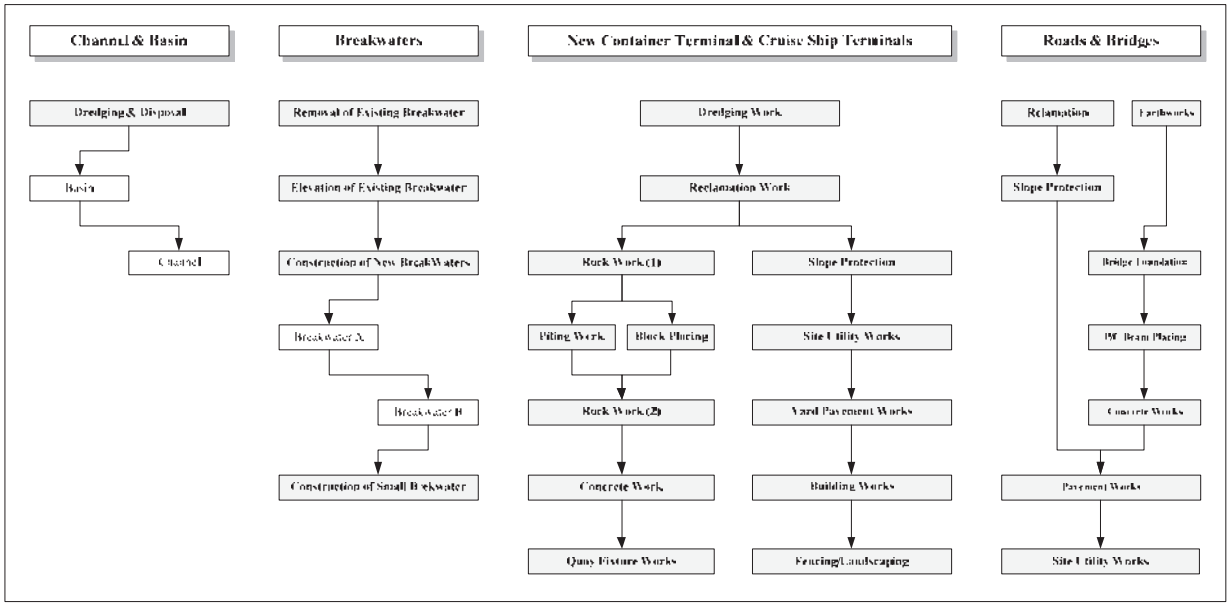
Table 5.8-37 Estimated Work Quantities for Each Alternative Plan

Bill No.	DESCRIPTION	Unit	Alternative-1		Alternative-2	
			Q'ty		Q'ty	
			W=150	W=300	W=150	W=300
I.	**CONSTRUCTION**					
2.0	**CHANNEL AND BASIN**					
2.1	Dredging (-14m channel)	m3	1,699,220	3,236,140	1,699,220	3,236,140
2.2	Dredging (-14m basin)	m3	2,327,700	2,004,400	2,327,700	2,004,400
3.0	**BREAKWATERS**					
3.1	Existing Breakwater					
3.1.1	Removal of Existing Breakwater	lm	200	200	200	200
3.1.2	Elevation of Existing Breakwaters					
3.1.2.1	Type A section	lm			410	410
3.1.2.2	Type B section	lm			1,210	1,210
3.2	New Breakwaters					
3.2.1	New Breakwater A	lm	200	200	200	200
3.2.2	New Breakwater B	lm	200	200	200	200
4.0	**NEW CONTAINER TERMINAL**					
4.1	Dredging (quay)	m3	270,370	270,370	270,370	270,370
4.2	Reclamation	m3	4,063,400	4,063,400	4,515,300	4,515,300
4.3	Slope Protection	lm	2,200	2,200	2,200	2,200
4.4	Quay (-14m)	lm	700	700	700	700
4.5	Yard Pavements and Dranage System	m2	459,000	459,000	459,000	459,000
4.6	Mechanical Works	ls	1	1	1	1
4.7	Electrical Works	ls	1	1	1	1
4.8	Buildings					
4.8.1	Administration Building	m2	8,000	8,000	8,000	8,000
4.8.2	Entrance Gate and Security Booth	m2	1,600	1,600	1,600	1,600
4.8.3	Maintenace Shop	m2	2,400	2,400	2,400	2,400
4.8.4	Substation	m2	128	128	128	128
4.8.5	Generator House	m2	600	600	600	600
4.8.6	Pump House and Water Resovoir	ls	300	300	300	300
4.8.7	Fuel Station	ls	100	100	100	100
4.8.8	Labor Station	ls	300	300	300	300
4.8.9	Sewerage Treatment Plant	ls	100	100	100	100
4.8.10	Weighing Bredge	nr	2	2	2	2
5.0	**CRUISE SHIP TERMINAL**					
5.1	Dredging (quay)	m3	21,240	21,240	21,240	21,240
5.2	Reclamation	m3	690,810	690,810	690,810	690,810
5.3	Slope Protection	lm	380	380	380	380
5.4	Quay (-10m)	lm	300	300	300	300
5.5	Yard Pavements and Drainage System	m2	68,400	68,400	68,400	68,400
5.6	Mechanical Works	ls	1	1	1	1
5.7	Electrical Works	ls	1	1	1	1
5.8	Buildings					
5.8.1	Warehouse	m2	7,500	7,500	7,500	7,500
5.8.2	Gurd House	m2	25	25	25	25
5.8.3	Pump House and Water Resovoir	m2	150	150	150	150
6.0	**ACCESS ROADS AND BREDGES**					
6.1	Access Roads					
6.1.1	Access Road 1A (2 ways, 4 lanes)	lm				
6.1.2	Access Road 2A (2 ways, 4 lanes)	lm			400	400
6.1.2'	Access Road 1B (2 ways, 2 lanes)	lm	330	330		
6.1.3	Access Road 2B (2 ways, 2 lanes)	lm			978	978
6.1.4	Access Road 2C (2 ways, 2 lanes)	lm			645	645
6.1.5	Access Road 1D (2 ways, 2 lanes)	lm	1,900	1,900		
6.1.6	Access Road 2D (2 ways, 2 lanes)	lm			820	820
6.2	Bridges					
6.2.1	Connecting Bridge (2 ways, 2 lanes)	lm	265	265	265	265
II.	**PROCUREMENT**					
1.0	**SPECIAL EQUIPMENT**					
1.1	Cargo Handling Equipment					
1.1.1	Quayside gantry crane (Post Panamax)	unit	4	4	4	4
1.1.2	RTG	unit	18	18	18	18
1.1.3	Top lifter	unit	6	6	6	6
1.1.4	Tranctor and chassis	unit	26	26	26	26
1.2	Port Security Equipment					
1.2.1	CCTV System	ls	2	2	2	2
1.2.2	Terminal Management Ssytem	ls	2	2	2	2

Prepared by Project Team

2) Work flow

Scoped construction work items are composed of the approach channel and basin, breakwaters, new container terminal, cruise ship terminal, access roads and bridges. The general work flow of these items to enable carrying out each work independently is shown in Figure 5.8-39.



Prepared by Project Team

Figure 5.8-39 General Work Flow

3) General methodologies of major work items

a) Dredging work

Dredging work is commonly required at the approach channel, basin and quay as described in Figure 5.8-40. Before the dredging work, silt protector sheets should be installed around dredging barges and a patrol boat should be provided near the working barges in order to pay due attention to environmental impacts and marine safety. Dredged materials are basically planned to be dumped at the permitted offshore disposal area and to be possibly utilized as reclamation materials depending on the suitability of the material properties.

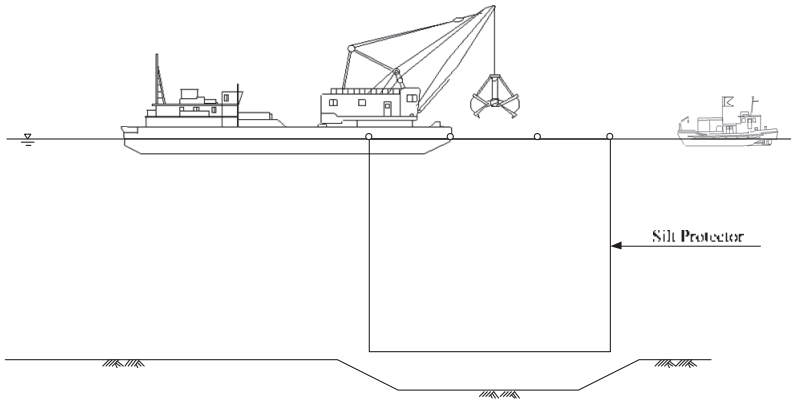


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Figure 5.8-40 Dredging Work

b) Reclamation work

Reclamation work is required at the new container terminal, cruise ship terminal and access

roads. As illustrated in Figure 5.8-41, reclamation materials are basically planned to be transported by dump trucks and to be temporarily stockpiled. The stockpiled materials are to be pushed out to the sea by pay-loader and to be formed by excavator. Because of the possibility of inclusion of fine silt materials inside the stockpiled materials, a silt protector should be placed at the edge of the slope made by the reclamation materials. Spread materials should be compacted afterward by a roller at a certain layer to be determined.

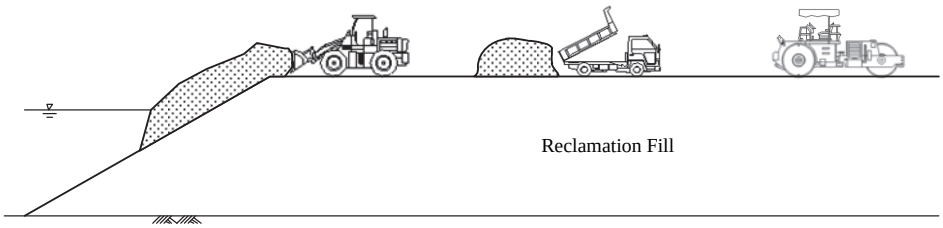

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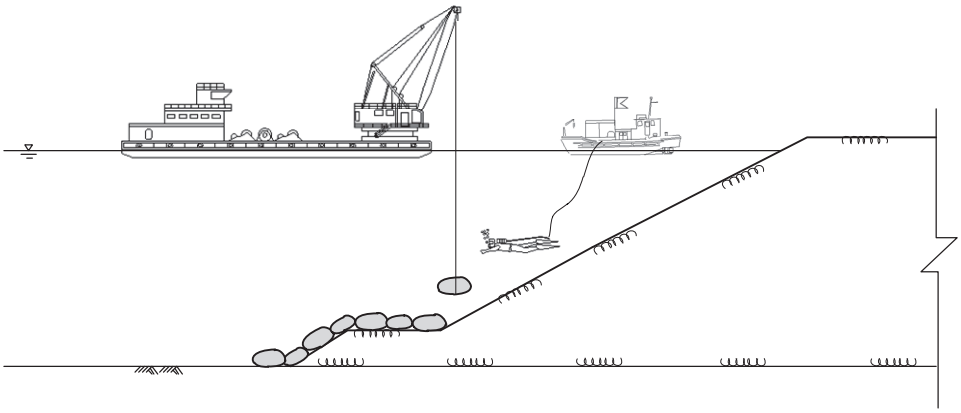
Figure 5.8-41 Reclamation Work

c) Slope protection work

Slope protection work is required for construction of breakwaters and forming shore slopes of earth retaining at the new container terminal, cruise ship terminal and access roads. Core stone material is to be dumped by split barge from the seaside and is to be spread out and formed by excavator from the landside. In addition, armor rocks suspended by crane barge are to be installed with guidance of divers as illustrated in Figure 5.8-42.



Prepared by Project Team

Figure 5.8-42 Slope Protection Work

d) Piling driving work

Piling work is required for construction of the quay at the new container terminal. Before driving piles, a core stone layer should be placed on the dredged slope. Piles are to be driven with penetration of the layer. As seen in Figure 5.8-43, piles kept on the storing barge are to be set on pile guides and guide wires are to be installed on the piling barge. After setting the piles, driving of the piles is carried out concurrently with survey monitoring from at least two points landside.

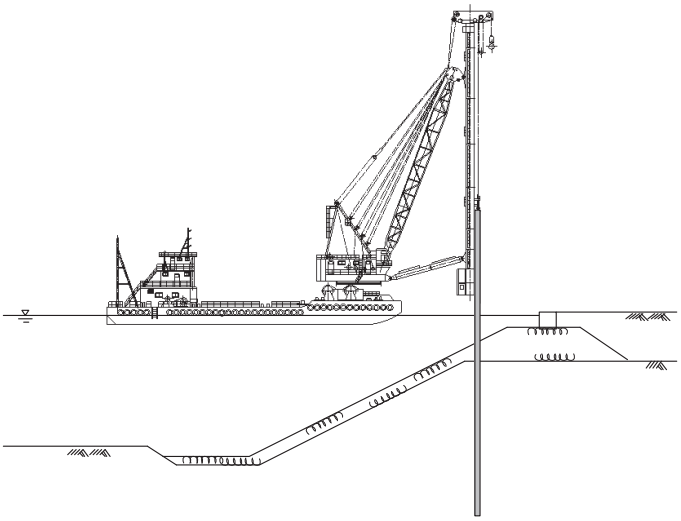


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Figure 5.8-43 Piling Driving Work

e) Quay block installation work

Quay block installation work is required for construction of the quay at the cruise ship terminal. As presented in Figure 5.8-44, quay blocks are to be installed from the bottom layer on rubble base filled at the dredged seabed. During the installation, the blocks should be carried by supporting frame to maintain flatness of the blocks with guidance of divers under the water.

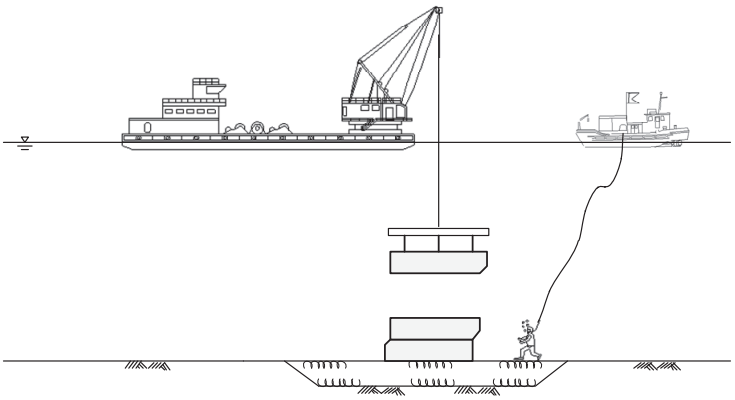

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Figure 5.8-44 Quay Block Installation Work

(2) Implementation schedule

1) Establishment of project packages

The project of the master plan 2030 requires efficient investment with consideration of cargo demand and its actual growth. Therefore, the Project has been divided into the following three packages.

a) Package 1

Package 1 was planned to implement the following construction and procurement items in order to maximize the cargo handling capacity of the existing container terminal without drastic improvement of the infrastructures:

- External power cable installation and connection 1 ls
- Quayside gantry crane (Panamax) 2 units

- RTG (6 rows, 4+1) 2 units
- Top Lifter (10 tons) 3 units
- Tractor & Chassis (40' container) 8 units

Matching the container cargo growth forecast, this package was divided into two phases on its investment. Phase 1 consists of external power source installation and connection, and 50% of the cargo handling equipment as mentioned above, and the milestone was set to be the end of 2016. Phase 2 consists of the other 50% of the equipment and the milestone of the completion is set to be the end of 2020.

b) Package 2

Package 2 was planned to implement all the construction works and procurement in Table 5.8-38 except for cruise ship terminal construction in order to execute container cargo handling to be not accommodated in the existing container terminal. Furthermore, like Package 1, this package was also divided into two phases considering the container cargo growth forecast and required certain periods of construction and procurement. Phase 1 consists of dredging work of the channel and basin, construction of breakwaters, new container terminal (1 berth 350 m only) including 50% of procurement of cargo handling and port equipment, access roads and bridges, and the milestone of the completion is set to be 2022. Phase 2 consists of construction of the other 50% of the new container terminal (1 berth 350 m only) including the other 50% of procurement of cargo handling and port equipment.

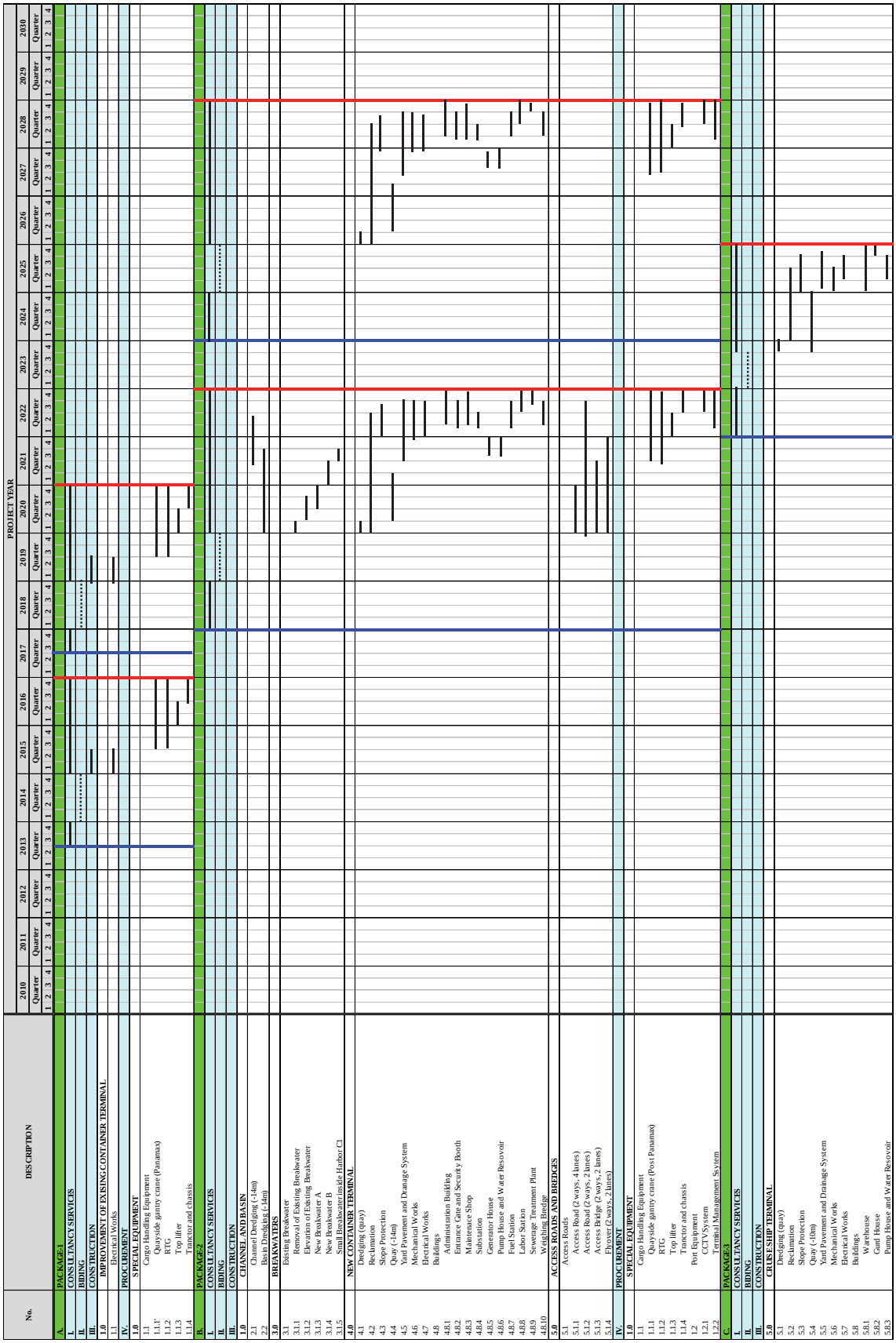
c) Package 3

Package 3 was planned to implement construction of the cruise ship terminal in order to prepare a full-scaled cruise ship terminal and general cargo terminal as an alternative berth of the multi-purpose terminal. The milestone of the completion is set to be 2025.

2) Implementation schedule

The implementation schedule was developed in consideration of work quantities of each alternative plan, the work flow and package as presented in Table 5.8-38. As seen in the table, Package 1 needs 7 years in total, which consists of 3.5 years as phase 1 from the middle of 2013 to 2016 and 3.5 years as phase 2 from the middle of 2017 to 2020. Package 2 accumulatively requires 10 years, which consists of 5 years as phase 1 from 2018 to 2022 and 5 years as phase 2 from 2024 to 2028. Also, Package 3 was expected to schedule a total of 4 years from 2022 to 2025.

Table 5.8-38 Implementation Schedule (Packages 1, 2 &3)



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5.8.9 Capital cost estimation

(1) General

The capital cost estimation consists of construction and procurement costs for the work items as mentioned in 5.8.8. The construction cost considered general administrative costs for construction including common preparatory expenses, site office expenses and general expenses, direct construction cost, consultancy service fees and contingency. The procurement cost consisted of equipment costs including purchase and installation expenses, consultancy service fees and contingency.

(2) Construction and procurement situation

1) Construction materials

a) Cement

Cement is mainly imported from Thailand, Vietnam, China, etc. but is now possibly supplied in Cambodia. The quality has improved to the same levels as imported cement and there is no significant difference in price these days.

b) Concrete

There are at present three concrete batching plants around Sihanoukville Port within a 15 km area. It is possible to procure common reinforced concrete products such as U-ditch, concrete pipes, lighting poles, etc. in Cambodia. However, supply of pre-stressing concrete products must rely on imports from Thailand, Vietnam and China.

c) Steel materials

No steel mills exist in Cambodia to date. All the steel materials are imported mainly from Thailand, Vietnam, China and the like.

d) Reclamation and backfill materials

Suitable reclamation materials are commonly obtained at some quarry sites located within 20 km of Sihanoukville Port. It may be also possible to procure some sea sand materials near the Port. Also, laterite materials are available for reclamation of temporary work and backfilling at land civil works.

e) Rock, stone and quarry run

Certain sand rocks can be supplied around Sihanoukville Port. Other rocks such as granite could be produced at some quarry sites located within 180 km of the Port.

2) Construction equipment

Generally, construction equipment such as under 100-ton capacity cranes, excavators, bulldozers, pay-loaders, rollers, etc., which are commonly used for common land civil and architectural construction, are available to be leased from Cambodian construction companies. Full-scaled and special construction equipment for land and marine construction works can be only provided from other countries through foreign construction companies.

(3) Capability of local construction companies

There are around 20 local construction companies that have less than 100 employees. Depending on the scale of work, they are generally able to carry out common civil and architectural works independently. However, it is somehow difficult to implement large-scaled and special land and/or marine construction works by themselves because the works require advanced technologies and general management capability. Therefore the works depend on foreign construction companies at present.

(4) Basic unit prices

Basic unit prices are summarized in Tables 5.8-39, 5.8-40 and 5.8-41, based on information gathered from local market prices through local construction companies and suppliers as well as on-going projects at Sihanoukville Port such as SEZ and multi-purpose terminal development projects.

Table 5.8-39 Unit Costs (Major Construction Materials)

No.	Description	Unit	Unit Price (USD)
1	Concrete (Type I, 300kg/cm2)	m3	81
2	Concrete (Type I, 280kg/cm2)	m3	79
3	Concrete (Type I, 210kg/cm2)	m3	72
4	Concrete (Type I, 120kg/cm2)	m3	70
5	Concrete (Type I, 350kg/cm2)	m3	89
6	Cement	ton	89.4
7	Deformed Bar12~20 (SD40)	ton	795
8	Deformed Bar 20~35(SD40)	ton	795
9	Structural Steel	ton	1000
10	Granite Rocks	ton	25
11	Granite Stone (5kg ~100kg)	ton	23
12	Granite Stone (0 ~40mm)	m3	21
13	Sand Stone	m3	18
14	Reclamation Sandy Soil	m3	8.5
15	Laterite (Soil Aggregate)	m3	8.5
16	Sand Aggregate	m3	26
17	Light Diesel Oil	litter	1.2
18	A-Heavy Diesel Oil	litter	1.1
19	Gasoline	litter	1.28

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Table 5.8-40 Unit Costs (Major Workers and Laborers)

No.	Description	Unit	Unit Price (USD)
1	Foreman	day	24
2	Skilled Labor	day	19
2	Un-skilled Labor	day	14
3	Heavy Equipment Operator	day	29
4	Equipment Operator	day	24
5	Re-bar Bender	day	19
6	Carpenter	day	19
7	Truck Driver	day	19
1	Captain of Dredger	day	345
2	Operator of Dredger	day	235
2	Crew of Dredger	day	95
3	Captain of Tugboat	day	175
4	Crew of Tugboat	day	95
5	Operator of Crane Barge	day	135
6	Crew of Crane Barge	day	95
7	Captain of Boat	day	115
8	Captain of Floating Dock	day	345
9	Operator of Floating Dock	day	235
10	Crew of Floating Dock	day	95
11	Diver	day	125
12	Diving helper	day	65

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Table 5.8-41 Unit Costs (Major Construction Equipment Lease)

No.	Description	Unit	Unit Price (USD)
1	Bulldozer (21ton)	day	233
2	Pay-loader (2.5m3)	day	233
3	Excavator (1m3)	day	200
4	Excavator (0.4m3)	day	167
5	Tier roller	day	250
6	Motor Grader	day	250
7	Track Crane 25ton	day	500
8	Crawler Crane 150 ton	day	1,120
9	Crawler Crane 100 ton	day	831
10	Crawler Crane 50ton	day	1000
11	Dump truck (20ton)	day	167
12	Concrete pumping truck	day	450
13	Welding machine	day	80
14	Bar Bender	day	80
15	Concrete vibrator	day	96
16	Generator 200 KVA	day	150
17	Generator 100 KVA	day	80
18	Generator 50KVA	day	60
19	Truck 4ton	day	100
20	Trailer Truck (40 ton)	day	400
21	Floating Dock (2500 ton Class)	day	5,234
22	Grab Dredger (20 m3 including heavy Bucket)	day	14,953
23	Piling Barge (D-80)	day	13,707
24	1000 ton barge crane 150ton Spud type	day	2,181
25	1000 ton Flat barge	day	1,059
26	Hopper barge (1300 m3)	day	3,502
27	Tugboat / Pusher 1600 PS	day	1,421
28	Tugboat 500 PS	day	467
29	Anchor boat 250 PS	day	430
30	Flat barge 500 ton	day	586
31	Diving pontoon	day	60
32	Diving Equipment (Decompression Chamber)	day	200
33	Survey Boat	day	80

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(5) Exchange rate

In cost estimation, local and foreign currency portions were applied respectively as US dollar and Japanese yen. Because the US dollar is commonly used at current markets all over Cambodia, the US dollar was used for the local currency portion. The basic exchange rate in cost estimation was applied as 1USD = 80.25 Japanese Yen which was sourced from the closing price of the Tokyo foreign exchange market on 22 February 2012.

(6) Components of local and foreign currencies

Each currency has different compositions in the unit prices and requires careful application and/or treatment in transaction. The following are the components of each currency:

- Local currency component includes:
  - Cost of construction materials locally supplied
  - Local currency portion of depreciation and maintenance costs of construction equipment
  - Expenses of salary and others related for local employees
  - Import duties of construction materials
  - Inland taxes in Cambodia
- Foreign currency component includes:
  - Costs of construction materials imported from foreign countries
  - Foreign currency portion of depreciation and maintenance costs of construction equipment
  - Foreign currency portion of costs of construction materials locally supplied
  - Expenses of salary and others related for foreign employees

(7) Application of constant ratios on cost estimation

In cost estimation, constant ratios were applied to general administrative costs for construction including common preparatory expenses, site office expenses and general expenses, consultancy service fees and contingency as shown in Table 5.8-42.

Table 5.8-42 Summary of Applied Constant Ratios on Cost Estimation

Description		Applied Rate	
Construction	General Expenses	15	% of Direct Construction Cost
	Consultancy Services	8	% of (General Expenses + Direct Construction Cost)
	Contingency	10	% of (General Expenses + Direct Construction Cost + Consultancy Services)
Procurement	Consultancy Services	4	% of (Equipment Procurement Cost)
	Contingency	10	% of (Equipment Procurement Cost + Consultancy Services)

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(8) Results of capital cost estimation

1) Package 1

Table 5.8-43 shows a breakdown of the cost estimation of Package 1. As seen in the table, the total cost was 34.4 million US dollars.

Table 5.8-43 Total Project Cost (Package 1)

PACKAGE-1 1USD=Yen 80.25

No.	DESCRIPTION	Unit	Q'ty	Amount		
				Local Portion	Foreign Portion	Combined
				('000 USD)	('000 YEN)	('000 USD)
I.	**CONSTRUCTION (1+2+3+4)**			**593**	**10,110**	**719**
1.0	**GENERAL EXPENCES (15% of 6')**	ls		65	1,110	78
2.0	**IMPROVEMENT OF EXISING CONTAINER TERMINAL**			434	7,400	526
2.1'	Electrical Works for connection to external power source	ls	1	434	7,400	526
3.0	**ENGINEERING SERVICES (8% of 1+2)**			40	681	48
4.0	**CONTINGENCIES (10% of 1+2+3)**			54	919	65
II.	**PROCUREMENT (1+2+3)**			**128**	**2,694,120**	**33,699**
1.0	**SPECIAL EQUIPMENT**			112	2,355,000	29,458
1.1	Cargo Handling Equipment					
1.1.1	Quayside gantry crane (Panamax Size)	unit	2	40	1,340,000	16,738
1.1.2	RTG (6 rows, 4+1)	unit	5	50	750,000	9,396
1.1.3	Top lifter (10 ton)	unit	3	6	105,000	1,314
1.1.4	Tranctor and chassis (40')	unit	8	16	160,000	2,010
2.0	**ENGINEERING SERVICES (4% of 1)**			4	94,200	1,178
3.0	**CONTINGENCIES (10% of 1+2)**			12	244,920	3,063
III.	**TOTAL PROJECT COST (I.+II.)**			**721**	**2,704,230**	**34,418**

Prepared by Project Team

2) Package 2

Tables 5.8-44 and 5.8-45 respectively show breakdowns of the cost estimations of the two alternative plans for 150 m and 300 m channel widths. In the case of 150 m channel width, the cost of Alternative Plan 1 was estimated at 376 million US dollars, while that of Alternative Plan 2 was estimated at 421 million US dollars. In case of 300 m channel width, all the cost trends were the same as the case of 150 m channel width with 15 million US dollars added to each case of 150 m channel width due to increasing dredging volumes.

3) Package 3

Table 5.8-46 shows a breakdown of the cost estimation of Package 3. As seen in the table, the total cost was 44 million US dollars.

Table 5.8-44 Total Project Costs (Package 2: Channel Width=150m)

Package 2 (Channel W=150m) 1USD=Yen 80.25

Bill No.	DESCRIPTION	Unit	Alternative 1				Alternative 2			
			Q'ty	Cost Component		Combined Amount	Q'ty	Cost Component		Combined Amount
				Local ('000 USD)	Foreign ('000 Yen)	('000 USD)		Local ('000 USD)	Foreign ('000 Yen)	('000 USD)
				Amount	Amount	Amount		Amount	Amount	Amount
I.	**CONSTRUCTION**			**172,378**	**8,892,031**	**283,182**		**205,823**	**9,830,739**	**328,325**
1.0	**GENERAL EXPENCES (15% of 2+3+4+5+6)**	ls		**18,926**	**976,288**	**31,092**		**22,598**	**1,079,352**	**36,048**
2.0	**CHANNEL AND BASIN**			**8,632**	**1,849,962**	**31,685**		**8,632**	**1,849,962**	**31,685**
2.1	Channel Dredging (-14m)	m3	1,699,220	3,838	810,315	13,935	1,699,220	3,838	810,315	13,935
2.2	Basin Dredging (-14m)	m3	2,327,700	4,794	1,039,647	17,749	2,327,700	4,794	1,039,647	17,749
3.0	**BREAKWATERS**			**4,547**	**166,567**	**6,623**		**11,070**	**388,218**	**15,907**
3.1	Existing Breakwater									
3.1.1	Removal of Existing Breakwater	lm	200	195	937	207	200	195	937	207
3.1.2	Elevation of Existing Breakwaters									
3.1.2.1	Type A section	lm					410	1,791	61,825	2,562
3.1.2.2	Type B section	lm					1,210	4,731	159,825	6,722
3.2	New Breakwaters									
3.2.1	New Breakwater A	lm	200	2,404	92,204	3,553	200	2,404	92,204	3,553
3.2.2	New Breakwater B	lm	200	1,948	73,427	2,863	200	1,948	73,427	2,863
3.2.3	Small Breakwater inside Harbor C1	lm								
3.2.4	Small Breakwater inside Harbor C2	lm								
4.0	**NEW CONTAINER TERMINAL**			**101,367**	**3,764,577**	**148,277**		**106,455**	**3,822,008**	**154,081**
4.1	Dredging (quay)	m3	270,370	523	115,286	1,960	270,370	523	115,286	1,960
4.2	Reclamation	m3	4,063,400	37,578	172,288	39,725	4,515,300	41,757	191,449	44,143
4.3	Slope Protection	lm	2,200	6,455	241,397	9,463	2,200	7,363	279,668	10,848
4.4	Quay (-14m)	lm	700	15,933	1,460,820	34,136	700	15,933	1,460,820	34,136
4.5	Yard Pavement and Dranage System	m2	459,000	36,543	1,323,653	53,037	459,000	36,543	1,323,653	53,037
4.6	Mechanical Works	ls	1	275	49,440	891	1	275	49,440	891
4.7	Electrical Works	ls	1	731	194,757	3,157	1	731	194,757	3,157
4.8	Buildings									
4.8.1	Administration Building	m2	8,000	2,240	128,000	3,835	8,000	2,240	128,000	3,835
4.8.2	Entrance Gate and Security Booth	m2	1,600	288	13,363	455	1,600	288	13,363	455
4.8.3	Maintenace Shop	m2	2,400	432	37,584	900	2,400	432	37,584	900
4.8.4	Substation	m2	128	25	935	37	128	25	935	37
4.8.5	Generator House	m2	600	118	9,396	235	600	118	9,396	235
4.8.6	Pump House and Water Resovoir	m2	300	20	1,566	39	300	20	1,566	39
4.8.7	Fuel Station	m2	100	67	2,506	98	100	67	2,506	98
4.8.8	Labor Station	m2	300	84	2,506	115	300	84	2,506	115
4.8.9	Sewerage Treatment Plant	m2	100	12	2,440	42	100	12	2,440	42
4.8.10	Weighing Bredge	unit	2	43	8,640	151	2	43	8,640	151
6.0	**ACCESS ROADS AND BREDGES**			**11,627**	**727,481**	**20,692**		**24,497**	**1,135,492**	**38,647**
6.1	Access Roads					-				
6.1.1	Access Road 1A (2 ways, 4 lanes)	lm				-				
6.1.2	Access Road 2A (2 ways, 4 lanes)	lm				-	400	4,398	133,931	6,067
6.1.2'	Access Road 1B (2 ways, 2 lanes)	lm	330	2,618	92,661	3,772				
6.1.3	Access Road 2B (2 ways, 2 lanes)	lm				-	978	6,325	181,674	8,589
6.1.4	Access Road 2C (2 ways, 2 lanes)	lm				-	645	6,042	232,733	8,942
6.1.5	Access Road 1D (2 ways, 2 lanes)	lm	1,900	2,121	84,151	3,169				
6.1.6	Access Road 2D (2 ways, 2 lanes)	lm				-	820	844	36,485	1,299
6.2	Bridges					-				
6.2.1	Connecting Bridge (2 ways, 2 lanes)	lm	265	6,888	550,669	13,750	265	6,888	550,669	13,750
7.0	**ENGINEERING SERVICES (8% of 1+2+3+4+5+6)**			**11,608**	**598,790**	**19,069**		**13,860**	**662,003**	**22,109**
8.0	**CONTINGENCIES (10% of 1+2+3+4+5+6+7)**			**15,671**	**808,366**	**25,744**		**18,711**	**893,704**	**29,848**
II.	**PROCUREMENT (1.0.+2.0+3.0)**			**372**	**7,439,432**	**93,075**		**372**	**7,439,432**	**93,075**
1.0	**SPECIAL EQUIPMENT**			**325**	**6,503,000**	**81,359**		**325**	**6,503,000**	**81,359**
1.1	Cargo Handling Equipment									
1.1.1	Quayside gantry crane (Post Panamax)	unit	4	80	3,000,000	37,463	4	80	3,000,000	37,463
1.1.2	RTG	unit	18	153	2,295,000	28,751	18	153	2,295,000	28,751
1.1.3	Top lifter	unit	6	12	210,000	2,629	6	12	210,000	2,629
1.1.4	Tranctor and chassis	unit	26	52	520,000	6,532	26	52	520,000	6,532
1.2	Port Security Equipment									
1.2.1	CCTV System	ls	2	10	60,000	758	2	10	60,000	758
1.2.2	Terminal Management Ssytem	ls	2	18	418,000	5,227	2	18	418,000	5,227
2.0	**ENGINEERING SERVICES (4% of 1)**			**13**	**260,120**	**3,254**		**13**	**260,120**	**3,254**
3.0	**CONTINGENCIES (10% of 1+2)**			**34**	**676,312**	**8,461**		**34**	**676,312**	**8,461**
III.	**TOTAL PROJECT COST (I.+II.)**			**172,749**	**16,331,463**	**376,257**		**206,195**	**17,270,171**	**421,400**

Prepared by Project Team

Table 5.8-45 Total Project Costs (Package 2: Channel Width=300 m)

Package 2 (Channel W=300m) 1USD=Yen 80.25

Bill No.	DESCRIPTION	Unit	Alternative 1				Alternative 2			
			Q'ty	Cost Component		Combined Amount	Q'ty	Cost Component		Combined Amount
				Local ('000 USD) Amount	Foreign ('000 Yen) Amount	('000 USD) Amount		Local ('000 USD) Amount	Foreign ('000 Yen) Amount	('000 USD) Amount
I.	**CONSTRUCTION**			**176,606**	**9,749,126**	**298,091**		**210,052**	**10,687,833**	**343,234**
1.0	**GENERAL EXPENCES (15% of 2+3+4+5+6)**	ls		**19,390**	**1,070,392**	**32,728**		**23,062**	**1,173,456**	**37,685**
2.0	**CHANNEL AND BASIN**			**11,728**	**2,477,319**	**42,598**		**11,728**	**2,477,319**	**42,598**
2.1	Channel Dredging (-14m)	m3	3,236,140	7,553	1,574,393	27,171	3,236,140	7,553	1,574,393	27,171
2.2	Basin Dredging (-14m)	m3	2,004,400	4,175	902,926	15,426	2,004,400	4,175	902,926	15,426
3.0	**BREAKWATERS**			**4,547**	**166,567**	**6,623**		**11,070**	**388,218**	**15,907**
3.1	Existing Breakwater									
3.1.1	Removal of Existing Breakwater	lm	200	195	937	207	200	195	937	207
3.1.2	Elevation of Existing Breakwaters									
3.1.2.1	Type A section	lm					410	1,791	61,825	2,562
3.1.2.2	Type B section	lm					1,210	4,731	159,825	6,722
3.2	New Breakwaters									
3.2.1	New Breakwater A	lm	200	2,404	92,204	3,553	200	2,404	92,204	3,553
3.2.2	New Breakwater B	lm	200	1,948	73,427	2,863	200	1,948	73,427	2,863
3.2.3	Small Breakwater inside Harbor C1	lm								
3.2.4	Small Breakwater inside Harbor C2	lm								
4.0	**NEW CONTAINER TERMINAL**			**101,367**	**3,764,577**	**148,277**		**106,455**	**3,822,008**	**154,081**
4.1	Dredging (quay)	m3	270,370	523	115,286	1,960	270,370	523	115,286	1,960
4.2	Reclamation	m3	4,063,400	37,578	172,288	39,725	4,515,300	41,757	191,449	44,143
4.3	Slope Protection	lm	2,200	6,455	241,397	9,463	2,200	7,363	279,668	10,848
4.4	Quay (-14m)	lm	700	15,933	1,460,820	34,136	700	15,933	1,460,820	34,136
4.5	Yard Pavement and Dranage System	m2	459,000	36,543	1,323,653	53,037	459,000	36,543	1,323,653	53,037
4.6	Mechanical Works	ls	1	275	49,440	891	1	275	49,440	891
4.7	Electrical Works	ls	1	731	194,757	3,157	1	731	194,757	3,157
4.8	Buildings									
4.8.1	Administration Building	m2	8,000	2,240	128,000	3,835	8,000	2,240	128,000	3,835
4.8.2	Entrance Gate and Security Booth	m2	1,600	288	13,363	455	1,600	288	13,363	455
4.8.3	Maintenace Shop	m2	2,400	432	37,584	900	2,400	432	37,584	900
4.8.4	Substation	m2	128	25	935	37	128	25	935	37
4.8.5	Generator House	m2	600	118	9,396	235	600	118	9,396	235
4.8.6	Pump House and Water Resovoir	m2	300	20	1,566	39	300	20	1,566	39
4.8.7	Fuel Station	m2	100	67	2,506	98	100	67	2,506	98
4.8.8	Labor Station	m2	300	84	2,506	115	300	84	2,506	115
4.8.9	Sewerage Treatment Plant	m2	100	12	2,440	42	100	12	2,440	42
4.8.10	Weighing Bredge	unit	2	43	8,640	151	2	43	8,640	151
6.0	**ACCESS ROADS AND BREDGES**			**11,627**	**727,481**	**20,692**		**24,497**	**1,135,492**	**38,647**
6.1	Access Roads					-				
6.1.1	Access Road 1A (2 ways, 4 lanes)	lm				-				
6.1.2	Access Road 2A (2 ways, 4 lanes)	lm				-	400	4,398	133,931	6,067
6.1.2'	Access Road 1B (2 ways, 2 lanes)	lm	330	2,618	92,661	3,772				
6.1.3	Access Road 2B (2 ways, 2 lanes)	lm				-	978	6,325	181,674	8,589
6.1.4	Access Road 2C (2 ways, 2 lanes)	lm				-	645	6,042	232,733	8,942
6.1.5	Access Road 1D (2 ways, 2 lanes)	lm	1,900	2,121	84,151	3,169				
6.1.6	Access Road 2D (2 ways, 2 lanes)	lm				-	820	844	36,485	1,299
6.2	Bridges					-				
6.2.1	Connecting Bridge (2 ways, 2 lanes)	lm	265	6,888	550,669	13,750	265	6,888	550,669	13,750
7.0	**ENGINEERING SERVICES (8% of 1+2+3+4+5+6)**			**11,893**	**656,507**	**20,073**		**14,145**	**719,719**	**23,113**
8.0	**CONTINGENCIES (10% of 1+2+3+4+5+6+7)**			**16,055**	**886,284**	**27,099**		**19,096**	**971,621**	**31,203**
II.	**PROCUREMENT (1.0.+2.0+3.0)**			**372**	**7,439,432**	**93,075**		**372**	**7,439,432**	**93,075**
1.0	**SPECIAL EQUIPMENT**			**325**	**6,503,000**	**81,359**		**325**	**6,503,000**	**81,359**
1.1	Cargo Handling Equipment									
1.1.1	Quayside gantry crane (Post Panamax)	unit	4	80	3,000,000	37,463	4	80	3,000,000	37,463
1.1.2	RTG	unit	18	153	2,295,000	28,751	18	153	2,295,000	28,751
1.1.3	Top lifter	unit	6	12	210,000	2,629	6	12	210,000	2,629
1.1.4	Tranctor and chassis	unit	26	52	520,000	6,532	26	52	520,000	6,532
1.2	Port Security Equipment									
1.2.1	CCTV System	ls	2	10	60,000	758	2	10	60,000	758
1.2.2	Terminal Management Ssytem	ls	2	18	418,000	5,227	2	18	418,000	5,227
2.0	**ENGINEERING SERVICES (4% of 1)**			**13**	**260,120**	**3,254**		**13**	**260,120**	**3,254**
3.0	**CONTINGENCIES (10% of 1+2)**			**34**	**676,312**	**8,461**		**34**	**676,312**	**8,461**
III.	**TOTAL PROJECT COST (I.+II.)**			**176,978**	**17,188,558**	**391,166**		**210,424**	**18,127,265**	**436,309**

Prepared by Project Team

Table 5.8-46 Total Project Costs (Package 3)

PACKAGE-3 1USD=Yen 80.25

No.	DESCRIPTION	Unit	Q'ty	Amount		
				Local Portion	Foreign Portion	Combined
				('000 USD)	('000 YEN)	('000 USD)
I.	**CONSTRUCTION**			**32,911**	**894,282**	**44,055**
1.0	**GENERAL EXPENCES (15% of 2)**	**ls**		**3,613**	**98,186**	**4,837**
2.0	**CRUISE SHIP TERMINAL**			**24,090**	**654,576**	**32,246**
2.1	Dredging (quay)	m3	21,240	331	49,787	952
2.2	Reclamation	m3	690,810	6,389	29,290	6,754
2.3	Slope Protection	lm	380	3,218	117,867	4,687
2.4	Quay (-10m)	lm	300	8,621	223,732	11,409
2.5	Yard Pavement and Drainage System	m2	68,400	4,029	111,939	5,424
2.6	Mechanical Works	ls	1	65	13,680	235
2.7	Electrical Works	ls	1	41	12,305	194
2.8	Buildings					
2.8.1	Warehouse	m2	7,500	1,350	94,542	2,528
2.8.2	Gurd House	m2	25	5	183	7
2.8.3	Pump House and Water Resovoir	m2	150	42	1,253	58
3.0	**ENGINEERING SERVICES (8% of 1+2)**			**2,216**	**60,221**	**2,967**
4.0	**CONTINGENCIES (10% of 1+2+3)**			**2,992**	**81,298**	**4,005**
II.	**TOTAL PROJECT COST**			**32,911**	**894,282**	**44,055**

Prepared by Project Team

5.8.10 Economic analysis and financial analysis

(1) Economic analysis

1) Economic cost

The economic cost of a project indicates the cost necessary for the national economy. Import duties and VAT are therefore excluded from economic costs. Since the capital cost estimated in section 5.8.9 excludes import duties but includes VAT in local cost, economic analysis is made based on cost estimates without VAT.

2) Economic benefit

Economic benefit of the development of the new terminal at Sihanoukville Port is to offset future port congestion which may happen if the new terminal is not developed, to reduce maritime transportation cost by deploying larger container ships, to promote the establishment of manufacturers in the hinterland of the port, and to generate other indirect positive effects on regional economy. Resulting from the new terminal development, port related service companies will increase sales and employ more staff and workers. Investment in port development will encourage economic activities in the hinterland. Economic benefit of the new terminal is assessed as follows:

a) To offset port congestion at Sihanoukville Port in the future;
b) To reduce maritime transportation cost by deploying larger ships;
c) To cancel possible increases of transportation cost which may happen by using other transportation routes and means;
d) To increase passenger ship calls;
e) To increase employment at the port and encourage the establishment of manufacturers in the hinterland,
f) To promote port related business activities; and
g) To increase job opportunities of service industries around the port.

Considering the possible effects of the new terminal, the abovementioned benefit items are assessed as follows:

a) In the case that the new container terminal is not developed, container handling capacity of Sihanoukville Port is assessed at 500,000 TEUs subject to installing two more quay gantry cranes. When container handling volume reaches capacity, port congestion will take place and ship waiting queue will become longer. Overflowed cargo will shift to Phnom Penh Port and will be carried to Cai Mep Port by barge, or will be carried to HCM directly by land transportation.

If such a situation occurs, shipping companies will impose congestion surcharges on shippers. While congestion surcharges sometime reach over USD 700 per 20' container at congested African ports, the minimum surcharge is supposed to be USD 50 per 20' container (USD 100 per 40' container, cf. Bangkok Port in 2011). In the case of Sydney Port, congestion surcharges of USD 100 per 20' container and USD 200 per 40' container were imposed in 2011, and in the case of Chennai, USD 180 per 20' container and USD 360 per 40' container were imposed in 2011. As congestion surcharges are increased in connection with the extent of ship congestion, this economic analysis is made on the assumption that congestion surcharges will be imposed at a rate of USD 90 per 20' container and USD 180 per 40' container if the demand for container throughput exceeds 500,000 TEUs at Sihanoukville Port, and those will be increased by 15% if the demand exceeds 1,000,000 TEUs.

Supposing that no congestion will take place and no congestion surcharge is imposed in the "with case", the total amount of congestion surcharges to be imposed on import containers is estimated as the benefit of "with case".

In the case of export containers, such congestion surcharges will be imposed on foreign consignees as part of CIF price, so the savings of congestion surcharges may not be of economic benefit to the Cambodian economy. However, such surcharges will be transferred to Cambodian shippers as lower FOB prices, and may cause loss of shippers. Taking into account that congestion surcharges on export containers will be finally settled by Cambodian shippers, congestion surcharges to be imposed on export containers is also estimated as the benefit of "with case".

b) In the case that larger container vessels will be deployed for services at Sihanoukville Port resulting from the development of the new deep water container terminal, ocean freight rates to/from Sihanoukville Port may be lowered due to economy of scale. Importers' savings of maritime transportation cost are estimated as the benefit of "with case". Reduction of maritime transportation cost of export containers may reduce CIF price at foreign ports and not directly contribute to shippers income. However, it may finally promote the production of Cambodian manufactures and contribute to the national economy. Reduction of maritime transportation cost for export containers is also estimated as the benefit of "with case".

Assuming a case of typical maritime transportation, unit cost for transportation of a 20'/40' container on 2,000 TEU ship and 4,000 TEU ship is estimated in "Manual of Cost Benefit Analysis for Port Development, 2004, MLIT, Japan" as follows:

Table 5.8-47 Maritime transportation cost per container

(Case of two days voyage) (USD)

	20' Box	40' Box
2,000 TEU Vessel	153.2	229.8
4,000 TEU Vessel	119.9	179.8
Difference	33.3	50.0

Source: Manual of Cost Benefit Analysis for Port Development, 2004, MLIT, Japan

c) In the case that container throughput at Sihanoukville Port will reach its capacity of 500,000 TEUs and overflowed containers will be transported through Phnom Penh Port or Cai Mep Port, transportation cost of overflowed containers will be higher than if they were transported through Sihanoukville Port. Savings of transportation cost and time for overflowed containers are deemed as a benefit to the national economy.

Transportation cost and time for containers to/from USA and South East Asia have no

significant difference between cases through Phnom Penh Port or Sihanoukville Port. Containers to/from Europe and East Asia have to pay higher freight rates if they are transported through Phnom Penh Port or Cai Mep Port. Savings of transportation cost and time for containers to/from Europe and East Asia are estimated as the benefit of "with case". While savings of transportation cost and time for export containers are not of direct benefit to Cambodian shippers, those savings are supposed to be finally transferred to Cambodian economy. Ocean freight rates used for economic analysis are indicated in Tables 2.7-15 and 2.7-16 in this report.

d) In the case that the new cruise terminal will not be developed, the number of passenger shipcalls will be limited. Additional income from passenger shipcalls is estimated as the benefit of "with case".

e)、f)、g) In case that the development of new terminals will be realized, the development will bring the abovementioned economic impacts in the hinterland of the port. This report points out such items as the benefit of "with case", however quantitative analysis of those benefits is omitted due to the fact that those are indirect effects.

3) Economic internal rate of return (EIRR)

Assuming the benefit and economic cost mentioned in the previous section, EIRR is estimated as shown in Table 5.8-48 and details are shown in Appendix-7 Economic and Financial Analysis.

Project life is deemed as 30 years after commencing construction work. Construction period for package 1 is assumed from 2013 to 2020, the first half of package 2 from 2018 to 2022 and the second half of package 2 from 2024 to 2028, and package 3 from 2022 to 2025. Therefore, economic analysis covers a period until 2054, when all long-term loans will be repaid and cleared.

Economic analysis shows that Alternatives No.1 and No.2 are worth implementing from the viewpoint of economic cost and benefit, and Alternative No.1 has higher EIRR than Alternative No.2.

Table 5.8-48 EIRR

Case	Base Case	Cost 10% up	Benefit 10% down	Cost 10% up and Benefit 10% down
Alt. No.1	9.19%	7.07%	6.84%	4.61%
Alt. No.2	7.43%	5.42%	5.20%	3.04%

(1) Financial analysis

Financial feasibility of the project is preliminarily assessed by analyzing the Financial Internal Rate of Return, Cash Flow, Working Ratio, Operating Ratio, Rate of Return on Net Fixed Assets, and Debt Service Coverage Ratio. Table 5.8-49 shows FIRR of the base case and cases of sensitivity analysis. Details of financial analysis are shown in Appendix-7 Economic and Financial Analysis.

Table 5.8-49 FIRR

Case	Base Case	Cost 10% up	Revenue 10% down	Cost 10% up and Revenue 10% down
Alt. No.1	4.27%	2.93%	1.53%	0.25%
Alt. No.2	2.97%	1.79%	0.36%	-0.81%
Alt. No.1'	7.42%	5.47%	4.26%	2.75%

Alternative No.1' is a case that development of the container berth and superstructure of package 2 will be carried out by private investors and the new container terminal will be operated by a private terminal operator. Private investors may be the same as the private terminal operator. In the case of Alternative No.1', PAS will invest in land reclamation from the sea and channel dredging, and receive concession fees from the private terminal operator. Alternative No.1' shows higher FIRR than Alternative No.1. While Alternatives No.1 and No.1' assume the same construction cost for

infrastructure and superstructure, the difference of FIRR, which is the rate of return on PAS's investment, is caused by the difference of operating cost. If PAS can reduce operating cost to the level of a private operator, FIRR may increase to a level of Alternative No.1'.

Cash Flow, Profit and Loss, and Balance of the project implementation are estimated as shown in Appendix-7. In order to realize package 2 and 3, it is indispensable to use low interest long-term loans, specifically loans less than 2.0% interest in the case of Alternative No.1. It shall be less than 1.0% in case of Alternative No.2. In the case of Alternative No.1', in which a private operator will invest in development of the container berth and superstructure, it will be feasible for PAS if long-term loans with interest of less than 3.0% are available.

Sensitivity analysis of financial feasibility shows that the second half of package 2 and/or package 3 must be postponed or suspended if cost increases by 10% or revenue decreases by 10% or if both take place simultaneously in the cases of Alternative No.1 and No.2. In the case of Alternative No.1', the project will be feasible even if cost increases by 10% and revenue decreases by 10% due to the use of low interest long-term loans.

In order to improve financial feasibility, it is also effective to reduce the interest rate of MEF sub-loans as indicated in section 4.2.4.

5.8.11 Scheme for new investment and operation

Investment in the new container terminal is estimated at about USD 4.5 million, which is a heavy burden for PAS. In order to reduce PAS's investment, it will be an effective and adequate means to invite a private investor(s) for the development and operation of the container terminal.

Demarcation between the investment of PAS and private investor/terminal operator is assumed as shown in Table 5.8-50 "Public and private investment in new container terminal", where private investor/terminal operator is expected to construct a container wharf and paved container yard, install quay gantry cranes and RTGs, procure cargo handling equipment, build entrance gates, and operate the container terminal.

As indicated in section 4.2.3 (Public and private partnership), there are several patterns for private investment. It may be a possible option that PAS constructs the container wharf and paves the container yard, and the private investor/terminal operator installs quay gantry cranes and other superstructure. A detailed survey on possible demarcation between PAS and a private investor/operator shall be made before deciding the investment of PAS in the new container terminal. Concession fees for private investment and operation shall also be carefully studied in connection with the investment of PAS.

Table 5.8-50 Public and private investment in new container terminal

Development by public sector	USD 190 million
Channel dredging (-14m)	
Basin dredging (-14m)	
Breakwaters	
New container terminal reclamation	
Slope Protection	
Access roads and bridges	
Development by private sector	USD 186 million
Construction of pier (-14m)	
Yard pavement and drainage system	
Quayside gantry crane (Post Panamax)	
Cargo handling equipment	
Entrance gate and security booth	
Buildings	
Maintenance shop	
Others	

The above demarcation plan is made on the assumption that PAS will dredge the navigation channel, reclaim land from the sea for the container yard, and build an access road and bridge. The private investor/ terminal operator will construct a pier for the container terminal. In the case that the private operator is already authorized before completion of land reclamation, it may be adequate that PAS and the private terminal operator carry out the slope protection, land reclamation, construction of pier and foundation of quay gantry cranes simultaneously in order to reduce construction cost and time.

In this situation, F/S on private participation in the development of the new container terminal shall be made at an early stage and a private investor/terminal operator shall be selected following the F/S. A detailed demarcation plan shall be agreed upon before the completion of land reclamation.

In addition, careful study shall be made on the amount of concession fees, incentives for good performance, and financial analysis on private investment, maintenance and operation. If the new container terminal is expected to enter into operation in 2023, its development plan and financial resources shall be authorized before 2018. In view of this schedule the development scheme and private participation shall be studied and decided before committing to the development of a new container terminal.

Possible options for the development of a new container terminal are as follows:

a) PAS develops all infrastructure and superstructure, and operates the container terminal;

b) PAS develops all infrastructure and large scale superstructure, and a private terminal operator prepares cargo handling equipment and operates the container terminal;

c) PAS carries out land reclamation and dredging work, and a private investor/terminal operator constructs the container wharf and yard, installs quay gantry cranes and RTGs, prepares cargo handling equipment, and operates the container terminal (Case of Table 5.8-3);

d) PAS and private investor(s) establish a joint stock company and the company implements container terminal development including land reclamation, and operates the terminal. PAS carries out channel dredging and access road development as a landlord port authority.

Decision on the method for development of the new container terminal shall be made from the viewpoint of commercialization (privatization) of PAS, the future increase of container cargo throughput, and government policy for port administration and management.

5.8.12 Social consideration on the fisherman's settlement in the Port area

(1) Fundamental Principle

Fundamental principle of social consideration on the fisherman's settlement in the Port area in this Project is stated below;

- EIA should be conducted with recognition of the fisherman's settlement area as "a community and town" and be one of guiding principles in this Port development project plan

To ensure this fundamental principle, the following four (4) concepts have been taken into considerations in the course of the preparation of alternative development Plan.

1) No massive resettlement

The fisherman's settlement in the Port area has a long history to be stated as "poverty area" and secluded from other community in a city since development project of Sihanoukville Port had started in 1950's. However nowadays estimated 2,200 people and 11,000 families live in this area as "a community and town".

The reasons why this point was chosen as a concept are as follows:

a) The cargo traffic demand should be updated and it results may result in revision of the scale and the implementation schedule of the project. The required scale of development drawn on the basis of the traffic demand in 2030 done in this report does not require a massive resettlement.

b) The water area and coastal land area enclosed by the breakwater are the space for various socioeconomic activities such as Sihanoukville Port, fish port, shipbuilding, mooring of excursion boats, local port and aquaculture. Therefore, piecewise resettlement of fish port from the viewpoint of the development of Sihanoukville Port only may deprive of the most productive and harmonious development of the potential space as a whole.

c) The development plans of the Port has been without zoning and land use plan of the Sihanoukville port area, which should delineate the port development sites. Prior to the implementation of the project, the land and water area use plan including the resettlement should be authorized by the government of Cambodia through participation of relevant agencies and local people in the preparation process.

d) For the realization of the project, it is vital that PAS takes steps of proactively approach relevant agencies and local people and coordinates them. In this process, there are various occasions that the port development plan is made public. The inclusion of the resettlement of the local people, which is a sensitive issue and not necessary, in the port development plan up to 2030 may mislead the discussion among those who are concerned.

2) Minimization of segmentalization of community

Along with progress of Port development project and SEZ Project living environment in the area has changed in a decade to be more clean and safe as a community and town not only for residents but also for visitor from outside of the area. This change creates better alteration that some tourists can be seen in the area in recent years, who had never stepped in the area in the past due to safety issues. Small tourist boat carries backpackers to islands from the small boatslip at a jetty in the area, which creates other job opportunity for fisherman. Some shops constructed with concrete can be seen in recent, which were rare in the area due to poverty, dealing with commodity which is not illegal with open atmosphere. This area should be treated as a community with social relationship, not just as a poverty area for people who cannot have anywhere to go.

3) Project compatible with fishery as livelihood

Fishery has become "an industry" in this area from a family work for poverty people to live a

single day. It is assumed that 73% and more of fishery boats with 33 horse power (HP) and more in Preah Sihanouk Province is in the Port area. Technical assistant project for shipbuilding by FAO started since in November 2011 in this area. In this context EIA should be conducted with recognition of the fisherman's settlement area as "a community and town" and be one of guiding principles in this Port development project plan

4) Mutual understanding about future plan for the fisherman's settlement among related organizations and guiding assistance

Considering the future of the fisherman's settlement the area in the Port has become incapacious already. Moreover it is expected that fish boats are growing in size and fishermen's living standard is improving day by day. The issue of new fishery port and fishery town is getting to be inevitable. However, it is beyond PAS's authority and mutual understanding and cooperation among related organizations and authorities are indispensable. In this context this Project will put guiding and creation of relationship among related organizations into view for future perspective.

5.9. Comparison of environmental impacts of alternative plans

5.9.1 No-development option

The no-development option will not involve any new terminal construction, but will include the installation of new cargo-handling equipment required for strengthening the capacity of the existing container terminal as proposed by this project. If the capacity of the existing container terminal is strengthened as planned, the cargo handling capacity of the existing container terminal will increase to 490 thousand TEU. However, if the cargo volume exceeds 490 thousand TEU, the port will experience difficulties in handling efficiently the growing cargo volume, which may raise various problems such as follows:

- Ship-waiting time will increase as the existing container terminal will not have sufficient capacity to handle efficiently the increasing number of ship calls. This may disrupt the time schedule of the container ships, and result in financial losses for shipping companies and cargo owners. To avoid such risks, port users may shift to Phnom Penh Port or other ports in Thai or Vietnam. In such case, Phnom Penh Port will experience major congestion, as well as more traffic congestion inside the city.
- If the efficiency of port operation is disrupted by congestion, transport cost and time will increase. This will be disadvantageous to the promotion of SEZ in Preah Sihanoukville Province, and consequently may hinder the economic development of Cambodia.
- Since the port will not be able to accommodate larger ships, the opportunity for shippers to save transport cost will be lost.
- Cruise ships currently berth at the ageing old jetty, but may be forced to berth at other berths if the jetty becomes unusable. This will have adverse affects on other cargo ships by increasing their waiting time and transport cost; which consequently may lower the export competitiveness of Cambodian agricultural products.
- All types of ships including fishing and tourist boats will continue to use the same opening. This will significantly raise the risk of maritime accidents as ship traffic will be more congested in the future.

5.9.2 IEE of alternative development plans

Environmental impacts of each development plan were assessed by conducting IEE, covering the pre-construction, construction and operation phases. The IEE was conducted for 30 impact factors, based on the requirements of JICA's Guideline for Environmental and Social Consideration. The degree of impacts was rated with a numerical score (between -2 and +2). The score was multiplied by 1.5 for impact factors that were considered to be particularly important by the JICA Advisory Committee. Table 5.9-1 shows the results of the IEE.

Table 5.9-1 Results of IEE

		Impact factor		Plan 1	Score	Plan 2	Score
Social environment	1	**Involuntary resettlement**	P	No need of involuntary resettlement.	0	Due to construction of access roads and bridges, it is assumed that residents living at the base of the pier need to be resettled.	-1.5
			C		0	No need for Involuntary resettlement.	0
			O		0		0
	2	**Local economy such as employment**	P	A large scale effect is not assumed.	0	Residents need to be resettled may have negative impacts such as change of livelihood and income reduction.	-1.5

		Impact factor		Plan 1	Score	Plan 2	Score
			C	Due to dredging of channel, there is possibilities to put negative effect on water quality It may cause fish farmers along the pier to move their preserves during construction. Also after construction the water area for fish farm will be narrowed so that it is assumed that the water quality becomes not suitable for aquaculture. After all there is a strong probability that fish farmers need to move their preserves on a permanent basis.	-3	Due to construction of the new container conterminal along the present pier, fish farmers (21 families) need to move their reserves to other placed.	-3
			O	For some fisherman living in the pier it takes more time to get their fish ground through the new opening of the pier. It may cause them more cost for fuel and other items for extension of working time.	-1.5	Same as Plan1.	-1.5
	3	**Land use and utilization of local resources**	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	A part of coastal road will be utilized for construction traffic as well.	-1.5		-1.5
			O	A part of coastal road will be utilized as a access road for the Port as well.	-1.5		-1.5
	4	**Social institutions such as social infrastructure and local decision - making institutions**	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C		0		0
			O		0		0
	5	**Existing social infrastructures and services**	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	A part of coastal road will be utilized for construction traffic as well.	-1.5		-1.5
			O	A part of coastal road will be utilized as a access road for the Port as well.	-1.5		-1.5
	6	The poor, indigenous and ethnic people	P	No poor, indigenous and ethnic people in the Project area.	0	Same as Plan1.	0
			C		0		0
			O		0		0
	7	**Misdistribution of benefit**	P	A large scale effect is not assumed.	0	Some residents must be resettled.	-1.5

		Impact factor		Plan 1	Score	Plan 2	Score
			C	The Port Project will cause the benefit such as increase of employment opportunity. On the other hand, resident nearby construction site may receive various negative impacts caused by construction. (refer to items 2, 13, 24, 28.)	-1.5	Same as Plan1.	-1.5
			O	The Port Project will cause various benefit. On the other hand, fishing people in the pier may receive various negative impacts caused by construction, such as; • For some fishing people it takes more time to get their fishi grounds, • Due to access road running next to resident area of fishing people, convenient and safety access to social service will not be guaranteed any more. • Access road running next to resident area of fishing people may give them negative impact such as effluent gas and noise pollution. • Deterioration of water quality of water area in front of resident area of fishing people may cause deterioration of sanitary condition.	-3	Same as Plan1.	-3
	8	Cultural heritage	P	No cultural heritage in the Project area.	0	Same as Plan1.	0
			C		0		0
			O		0		0
	9	Local conflicts of interest	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	Specifically local conflicts of	0		0
			O	interest is not expected.	0		0
	10	Water usage or water rights and communal rights	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	Due to construction work in the pier the water area which fishing people can use will be reduced and narrowed as well as the area in front of residents of fishing people.	-2	Due to construction work in the pier the water area which fishing people can use will be reduced and narrowed, however, the area in front of residents of fishing people will be broader tha the Plan 1.	-1

		Impact factor		Plan 1	Score	Plan 2	Score
			O	Bridge, container terminal and EPZ will narrow the water area in front of residents of fishing people and the area which they can use broadly. There is no regal rights such as water use right, and common right.	-2	Container terminal and EPZ will narrow the water area which fishing people can use, however, the area in front of residents of fishing people will be broader tha the Plan 1. There is no regal rights such as water use right, and common right.	-1
	11	Sanitation	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	There is possibility that construction workers coming in the area give negative impact to sanitation.	-1		-1
			O	A large scale effect is not assumed.	-1		-1
	12	Hazards (risk), infectious diseases such as HIV/AIDS	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	Due to construction workers coming in the risk of infectious diseases may increase..	-1		-1
			O	A large scale effect is not assumed.	0		0
	13	Accidents	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	The risk of traffic accident may increase due to mix use of ordinary cards and construction vehicles and trucks.	-1	The risk of traffic accident may increase because the coastal road crosses the access road.	-1
			O	• Though separation of course of fishing boats and cargo ships will reduce the risk of crush between them, the risk of crush among fish boats will be higher because the navigation area for fish boat will be narrowed. • Because part of coastal road is utilized for construction traffic as well as ordinary cards the risk of traffic accidents increase.	-2	• Separation of course of fishing boats and cargo ships will reduce the risk of crush between them. Also the risk of crush among fish boats will be lower because the area for fish boat in the pier will be set wide enough to navigate in safe. • The risk of traffic accident may increase because the coastal road crosses the access road.	-1
	14	Landscape	P	A large scale effect is not assumed.	0	Same as Plan1.	0
			C	Residents in the pier will lose restful. and airy landscape due to construction.	-1		-1

		Impact factor		Plan 1	Score	Plan 2	Score
			O	Residents in the pier will lose restful. and airy landscape due to port activity.	-1		-1
Natural environment	15	**Topography and geographical features**	P	No impacts expected.	0	No impacts expected.	0
			C	• Although the seabed of the approach channel will be deepened approximately -2 m through dredging, it is not expected to have any significant impact on natural and social environment. • Although the new cruise terminal and breakwater may alter the seabed topography, its alteration will be of local scale and is not expected to have any significant impact on the surrounding natural and social environment.	0	• Although the seabed of the approach channel will be deepened approximately -2 m through dredging, it is not expected to have any significant impact on natural and social environment. • Although the new cruise terminal and breakwater may alter the seabed topography, its alteration will be of local scale and is not expected to have any significant impact on the surrounding natural and social environment.	0
			O	No significant impacts are expected for reasons similar to the construction phase.	0	No significant impacts are expected for reasons similar to the construction phase.	0
	16	Soil erosion	P	No impacts expected.	0	No impacts expected.	0
			C	No impacts expected.	0	Although the new access road may cause local-scale soil erosion, it's impact on the surrounding natural and social environment is likely to be insignificant.	0
			O	No impacts expected.	0	There are no additional factors that may cause soil erosion.	0
	17	Groundwater	P C O	No impacts are expected as there will be no usage of groundwater.	0	No impacts are expected as there will be no usage of groundwater.	0
	18	Hydrological situation	P C O	There are no lakes/rivers in the development area.	0	There are no lakes/rivers in the development area.	0
	19	Coastal zone	P C O	No impacts are expected as development will be limited within the existing port area.	0	No impacts are expected as development will be limited within the existing port area.	0
	20	**Flora, fauna**	P	No impacts expected.	0	No impacts expected.	0

		Impact factor		Plan 1	Score	Plan 2	Score
			C	Dredging and dumping activities may have significant impacts on marine life, especially on marine life that are vulnerable to high turbidity such as corals.	-3	• Dredging and dumping activities may have significant impacts on marine life, especially on marine life that are vulnerable to high turbidity such as corals. • Although the new access road may have certain impacts on terrestrial flora/fauna, its impact are likely to be negligible as the area of the potential route is already quite developed.	-3
			O	Although maintenance dredging and dumping activities may have impacts on marine life, the level of impact should be less than the construction phase due to the smaller dredging volume.	-1.5	Although maintenance dredging and dumping activities may have impacts on marine life, the level of impact should be less than the construction phase due to the smaller dredging volume.	-1.5
	21	Meteorology	P C O	No impacts expected.	0	No impacts expected.	0
	22	Ground subsidence	P C O	There are no factors that may cause ground subsidence.	0	There are no factors that may cause ground subsidence.	0
	23	**Global warming**	P C O	Port development will have limited impact on global warming.	0	Port development will have limited impact on global warming.	0
Pollution	24	**Air pollution**	P	No impacts expected.	0	No impacts expected.	0
			C	Dust and exhaust gas emission from the following construction activities are likely to have major impacts on the residents of the fishing community. • Construction of new access road • Dump truck movement along the new access road	-3	Dust and exhaust gas emission from the following construction activities are likely to have major impacts on the residents of the fishing community. • Construction of new access road • Dump truck movement along the new access road	-3
			O	Since the new access road will be located adjacent to the fishing community area, dust and exhaust gas emission from cargo vehicles may have major impacts on the residents.	-3	Since the new access road will be located adjacent to the fishing community area, dust and exhaust gas emission from cargo vehicles may have major impacts on the residents.	-3
	25	**Water pollution**	P	No impacts expected.	0	No impacts expected.	0
			C	Dredging and dumping activities will temporary deteriorate the surrounding water quality.	-1.5	Dredging and dumping activities will temporary deteriorate the surrounding water quality.	-1.5

	Impact factor		Plan 1	Score	Plan 2	Score
		O	The water quality inside the breakwater, especially the fishing community area, will likely further deteriorate as the new container terminal and EPZ will drastically reduce the existing water area. Also, due to population increase, pollution load into the breakwater area will likely be higher in the future, further increasing the risk of water pollution. While a new opening (50-100 m) will be created in the north side of the breakwater, its water quality improvement effect is likely to be spatially limited.	-3	For similar reasons as Plan 1, the water quality inside the breakwater will likely deteriorate.	-3
26	Soil contamination	P C O	There are no factors that may cause soil contamination.	0	There are no factors that may cause soil contamination.	0
27	**Waste**	P	No impacts expected.	0	No impacts expected.	0
		C	Dredging of the approach channel will generate between 1.7-3.6 million m^3 of dredged spoil. Ocean disposal at the existing dumping ground is the planned disposal method.	-1.5	Dredging of the approach channel will generate between 1.7-3.6 million m^3 of dredged spoil. Ocean disposal at the existing dumping ground is the planned disposal method.	-1.5
		O	No impacts are expected as the type of waste will be similar to the present.	0	No impacts are expected as the type of waste will be similar to the present.	0
28	**Noise/vibration**	P	No impacts expected.	0	No impacts expected.	0
		C	Noise/vibration from the following construction activities are likely to have major impacts on the residents of the fishing community. • Construction of new access road • Construction of new access bridge (e.g. pile driving) • Dump truck movement along the new access road	-3	Noise/vibration from the following construction activities are likely to have major impacts on the residents of the fishing community. • Construction of new access road • Construction of new access bridge (e.g. pile driving) • Dump truck movement along the new access road	-3
		O	Since the new access road will be located adjacent to the fishing community area, noise/vibration from cargo vehicles may have major impacts on the residents.	-3	Since the new access road will be located adjacent to the fishing community area, noise/vibration from cargo vehicles may have major impacts on the residents.	-3
29	Offensive	P	No impacts expected.	0	No impacts expected.	0

		Impact factor		Plan 1	Score	Plan 2	Score
		odor	C	Dredging activities may release offensive odor (e.g. hydrogen sulfide smell) as the bottom sediments inside the breakwater is in an anaerobic state.	-1	Dredging activities may release offensive odor (e.g. hydrogen sulfide smell) as the bottom sediments inside the breakwater is in an anaerobic state.	-1
			O	Offensive odor (e.g. hydrogen sulfide smell) may occur in concurrence with water and sediment quality deterioration inside the breakwater area.	-2	Offensive odor (e.g. hydrogen sulfide smell) may occur in concurrence with water and sediment quality deterioration inside the breakwater area.	-2
	30	Bottom sediment	P	No impacts expected.	0	No impacts expected.	0
			C	No impacts expected.	0	No impacts expected.	0
			O	For reasons stated in "25 Water pollution", the bottom sediment quality will likely further deteriorate especially in the fishing community area.	-2	For reasons stated in "25 Water pollution", the bottom sediment quality will likely further deteriorate especially in the fishing community area.	-2
				Social environment total	-27	Social environment total	-28.5
				Natural environment total	-4.5	Natural environment total	-4.5
				Pollution total	-23	Pollution total	-23
				Grand total	-54.5	Grand total	-56

P: pre-construction phase, C: construction phase, O: operation phase
Note: Impact factors in bold are factors that were identified in the JICA Advisory Committee as particularly important to consider in the process of formulating the development plan.
-2: Potential major adverse impact
-1: Potential moderate adverse impact
0: Minor or no impacts expected
+2: Major project benefit or environmental improvement
+1: Moderate project benefit or environmental improvement
Prepared by Project Team

Conclusion:

In regards to social environment, both plans are likely to have major adverse impacts such as: hindrance to fishing/aquaculture activities and degradation of living conditions through pollution. However, for the fishermen based inside the breakwater, Plan 2 may have less impact as the usable water area inside the breakwater is wider than Plan 1 (e.g. less risk of maritime accidents). Overall, Plan 2 (-28.5) was rated lower than Plan 1 (-27), primarily due to the requirement of resettlement at the access road.

In regards to natural environment, impacts from dredging/dumping activities are the main concern for both plans. However, the degree of impacts of both plans were similar, as there are no major differences in the dredging/dumping location between both plans. Hence both plans had the same score (-4.5).

In regards to pollution, impacts from air pollution, water pollution and noise/vibration are the main concern for both plans. Impacts from air pollution and noise/vibration are likely to be significant for both plans as the new access road will be located adjacent to residential area. Water quality inside the breakwater is likely to deteriorate for both plans, as the new container terminal will increase semi-enclosed water areas. Overall, both plans were considered to have similar level of impacts, hence the rating was -23 for both plans.

In conclusion, there was no significant difference in natural environment and pollution impacts. However, in terms of social impacts, Plan 1 was in overall assessed to have slightly less impacts than Plan 2, due to the requirement of resettlement.

5.10. Priority projects

The study team recommends that the facility development plan up to 2030 should be implemented in three packages.

Package 1: Capacity expansion of the existing container terminal

Installation of additional equipment and related works

Package 2: Construction of the new container terminal

Package 3: Construction of cruise ship and general cargo terminal

The volume of container cargoes is estimated to exceed the capacity of the existing container terminal, and Package 1 is the first priority project. The alternative plans that have been discussed in the previous sections consist of Package 2 and Package 3. Since Package 3 is the same for Alternative Plan -1 and Alternative Plan-2. The difference between the two alternative plans is the contents of Package 2. Therefore, the evaluation of the alternative plans shall focus on the Package 2 proposed in the two alternative plans with the assumption that Package 1 will have implemented before the implementation of Package 2.

5.10.1 Evaluation of alternative plans for port development

(1) Methodology

The evaluation of the alternative plans shall be cone from the following three viewpoints:

Viewpoint 1: Those quantitative criteria that should be fulfilled by the alternative plans such as the cargo handling capacity, economic and financial feasibilities and scale of the project.

Viewpoint 2: Qualitative evaluation regarding the construction and the operation of the facilities such as technical difficulties in the construction, difficulties in the maintenance, the convenience of the utilization, expandability of the facilities, the flexibility to the change of the plan due to the change of traffic demand and construction schedule. The evaluation from the viewpoint 2 shall be done comparatively between the alternative plans.

Viewpoint 3: The magnitude of the impact on the national and provincial economy and on the social and natural environment. The evaluation from this viewpoint shall be done either quantitatively or qualitatively. If the quantitative criteria are prescribed in laws and regulations such as environmental law, evaluation should be done quantitatively.

(2) Evaluation items

Evaluation items of each viewpoint are chosen as follows:

Evaluation items from Viewpoint 1

1) Cargo handling capacity
2) Scale of the project
3) Cost vs. Benefit (economic and financial feasibility of the plans)

Evaluation items from Viewpoint 2

1) Technical difficulties in the construction
2) Effectiveness of operation and Convenience of the users
3) Difficulties in the operation of the facilities (maintenance, navigation safety, port security and safety, etc.)
4) Flexibility to the change of the plan in accordance with the change of traffic demand
    a) Expandability for the future
    b) Availability of water and land spaces for the development of EPZ

Evaluation items from Viewpoint 3

1) Impact on natural environment

2) Pollution
3) Impact on social environment

(3) Evaluation and Weight of evaluation for each item

The evaluation results are listed in Table 5.10-1. The evaluation has been made in 5 grades. The weights of each evaluation item are equal because these items are so chosen that the weights are the same.

1) Evaluation criteria for Viewpoint 1

5: The requirement is fulfilled without any additional refinement.
4: The requirement is fulfilled with miner refinement work.
3: The requirement is barely fulfilled. Considerable refinement work is required
2: The requirement is not fulfilled. The implementation of the project involves some problems
1: The requirement is not fulfilled. The project is not implementable.

2) Evaluation criteria for Viewpoint 2

5: The requirement is fulfilled completely.
4: The requirement is fulfilled, but some minor inconvenience may occur.
3: The requirement is barely fulfilled. Considerable inconvenience or shortcoming may occur.
2: The requirement is not fulfilled. Some problems are foreseen to occur.
1: The requirement is not fulfilled. Serious problems are expected to occur.

3) Evaluation criteria for Viewpoint 3

5: No impacts expected
4: Possible moderate impact
3: The risk of major impact is moderate
2: The risk of major impact is high
1: Major impact is certain and not environmentally feasible

Table 5.10-1 Evaluation Table for Alternative Plans

Evaluation item	Zero option		Alternative Plan-1		Alternative Plan-2	
	Description	Evaluation	Description	Evaluation	Description	Evaluation
Viewpoint 1 Evaluation items (Requirements that Projects should				**15**		**13**
1) Capacituy of cargo handling	＜Cargo volume in 2030		＞Cargo volume in 2030		＞Cargo volume in 2030	
Capacity of contianer terminal	500,000TEU	**1**	1,500,000TEU	5	1,500,000TEU	5
Capacity of othr terminals	3,030,000 t		4,120,000 t		4,120,000 t	
2) Scale of the project	US $ 34 million		US $ 455 million	4	US $500 milliin	3
3) Economic feasibility (EIRR)			9.14%	3	7.37%	3
4) Financial feasibility (FIRR)			4.27%	3	2.97%	2
Viewpoint 2 Evaluation Items				**18**		**16**
1) Technical difficulties and construction period			Intermediate Period 3 years	4	Intermediate Period 3 years	4
2) Efficiency of operation and Convenience for users			Productivities are improved for the large size container ships No congestion at contiane rterminal Existing SEZ is close to the port	5	Productivities are improved for the large size container ships No congestion at contiane rterminal Distance between Existing SEZ and new	4
3) Operational difficulties of the facil;ities (including maintenance, Navigation safety and security)			Cruise ships are docked safely With large powered tug boat, the safe Separation between cammercial vessels and fishing boats	5	Cruise ships are docked safely With large powered tug boat, the safe Separation between cammercial vessels and fishing boats	5
4) Flexibility to the change of traffic demend a) Flexibility for further expansion or b) Difficulties in the development of EPZ (Unit cost of the land area, availability of water area to recraim			Two-phase implementation is possible for slow growth of cargo volume Site of an additional berh is reserved construction cost is relatively small, for the reclamation area is shallow The water area for EPZ is relatively small	4	Due to the large cost for the access, slower growth of cargo volume may influence the finansial soundness Site of an additional berh is reserved Construction cost of reclamation is large, for the water depth is large The water area for EPZ is relatively large	3
Viewpoint 3 Evaluation items				**7**		**7**
1) Impact on natural environment			Dredging and dumping activities may have adverse impacts on marine life, especially on marine life that are vulnerable to high turbidity such as corals.	3	Dredging and dumping activities may have adverse impacts on marine life, especially on marine life that are vulnerable to high turbidity such as corals.	3
2) Polution			Air pollution and noise/vibration impacts may become of major concern as the access road/bridge will be located adjacent to the fishing community area. Water pollution is also a major concern due to the narrowing of the water area in front of the fishing community.	2	Air pollution and noise/vibration impacts may become of major concern as the access road/bridge will be located adjacent to the fishing community area. Water pollution is also a major concern due to the narrowing of the water area in front of the fishing community.	2
3) Impact on social environment			The fishermen based inside the breakwater may be adversely affected such as from decrease of available water usage area and water pollution.	2	For similar reasons as Plan 1, the fishermen based inside the breakwater may be adversely affected. The main difference from Plan 1 is the requirement of resettlement. However, oveall the level of impact is similar to Plan 1.	2
Overall Evaluation		**Fail**		**40**		**36**

Prepared by Project Team

4) Multi-criteria evaluation

a) Evaluation from Viewpoint 1

Zero option, which is intended to expand the capacity of the existing container terminal up to 490,000 TEU's by installing additional equipment, is abandoned because the option cannot fulfill the capacity requirement. Both Alternative Plan-1 and Alternative Plan 2 have enough capacity to cope with the cargo volume forecasted in 2030. The scale of the project is few times larger than the projects that PAS has implemented in the past. The construction cost of Alternative Plan-2 is 20% higher than Alternative Plan-1. and, thus, both EIRR and FIRR are lower than Alternative Plan-1. Thus Alternative Plan -1 is advantageous than Alternative Plan -2

b) Evaluation from Viewpoint 2

Utilization of the facilities and the expandability of facilities of Alternative Plan-1 are

more advantageous than those of Alternative Plan-2: the interconnection between the new container terminal and the existing SEZ, and the flexibility for the change of the implementation to adjust slower increase of cargo traffic demand.

c) Evaluation from Viewpoint 3

There was no significant difference in natural environment and pollution impacts. However, in terms of social impacts, Plan 1 was in overall assessed to have slightly less impacts than Plan 2, due to the requirement of resettlement.

d) Conclusions of multi-criteria evaluation

As the result of the evaluation from three viewpoints, the Project Team recommends Alternative Plan -1 for the facility development toward 2030. The reasons are:

- Plan-1 is financially advantageous as the development plan up to 2030 (Viewpoint 1)

- the convenience of connection of container terminal and SEZ and the flexibility in the project implementation (Viewpoint 2), and

- the social and environmental impact (Viewpoint 3) of the both plans are assessed almost b the same.

5) Recommendation

a) For the purpose of the realization of the project, PAS should take proactive approach to the following items:

- To prepare zoning plan of the water and land area in the neighborhood of Sihanoukville Port including the project site of the new container terminal and EPZ and to build consensus on the zoning plan among relevant agencies and the local public.
- On the basis of above mentioned zoning plan, to make the jurisdiction of PAS universally known by relevant agencies and local people.
- To build consensus on the separation of the navigational water area for the ships calling on Sihanoukville Port and for other ships.
- To realize the industrial road
- To update the cargo demand forecast about every three years and to re-evaluate the performance of the port for the purpose of reviewing the scale and schedule of the project.

b) Prevention of environmental impact on the fishing port and residential area

Along the coast line of the basin enclosed by the breakwaters, many houses exist. Without proper sewage treatment system, sewage from these houses directly flows into the basin. This situation is the main cause of water pollution of the basin. It is urgently needed for the national and the provincial governments to take actions to settle this situation regardless of the project.

The new container terminal, which is a large island, constructed in the middle of the basin blocks the water circulation in the basin and may make the water pollution in the basin worse.

The port access roads proposed in the alternative plans will be constructed across or near the residential areas. This may impact the livelihood of the local residents: risks of air pollution, noise, vibration and traffic accidents.

This is particularly true for the residents in the fishing village adjacent to the existing container terminal. Even though the project does not require any relocation of the residents in the village, the impact of the project is assessed to be considerable. In order to avoid the risks, it is desirable for both the port and all those who reside and run business in the fishing village to start discussion to prepare a draft plan of the relocation of the whole village to a more suitable place. It is vital for the national and provincial governments to play a responsible role in the process of the preparation of the relocation plan. PAS should proactively approach the relevant agencies and the local public and play as the

coordinator among those who are concerned with and influenced by the expansion of Sihanoukville Port.

5.10.2 Draft TOR of EIA

(1) Institutional and legal framework for social and environmental consideration in Cambodia

1) Related laws and regulations

The history of institutional and legal framework related to social and environmental consideration in Cambodia is summarized in Table below.

Table 5.10-2 Related laws and regulations to EIA/IEIA

Year	Movoment	Function and Explanation
1996	Law on Environmental Protection and Natural Resource Management	It is the fundamental law of environment in Cambodia in which chapter III stipulates Environmental Impact Assessment (EIA). Article 6 in this chapter stipulates that EIA shall be conducted on every project and activity of the private or public, and shall be approved by the Ministry of Environment (MOE) before being submitted to the Royal Government of Cambodia (RGC) for decision. It also stipulates that this assessment shall also be conducted for existing activities that have not yet been assessed for environmental impact.
1997	Establishment of Department of Environmental Impact Assessment (Dept. of EIA) in MOE.	The Department of Environmental Impact Assessment (DEIA) is a structure of the MOE Its main role and responsibility is focused on reviewing the EIA/IEIA report and monitoring the environmental management plan of both public[1] and private development projects.
1999	Sub-Decree on Environmental Impact Assessment Process	This sub-decree stipulates the definition of "EIA", obligation of submission of EIA Report, target project types and public participation. Sub-Decree stipulates the criterion of necessity of EIA in Cambodia as type of project and their size and capacity.
2000	Prakas (Declaration) on Guideline for Conducting Environmental Impact Assessment Reports	This Declaration stipulated first that Department of Environmental Impact Assessment (DEIA) in MOE is the unit in charge of EIA.
2009	Prakas (Declaration) on General Guideline for Conducting Initial and Full Environmental Impact Assessment Reports	This Declaration stipulates the approval procedure of IEIA/EIA of project each on national level and municipality/provincial level (Figure 17.1.1) and detail instruction of application form and documents which should be attached. Also Declaration allows the project owner to hire consultant company, which must be registered in Ministry of Commerce (MOC) and be recognized by MOE beforehand, to prepare IEIA/EIA report with.

Source: Dept. of EIA, MOE, Dept. of Resettlement, MEF, "Preparatory Survey for National Road No.5 Rehabilitation

[1] Definition of "public" by MOE is;
-Line ministries, the Council for Development of Cambodia (CDC), etc.;
-Provincial Environmental Departments;
-Local government authorities: Provincial, district, commune and village authorities;
-NGOs
-The Project Proponents (Government, Private Sectors, Joint-Ventures, Consultant Companies);
-Local communities and local people in and surrounding the project site.

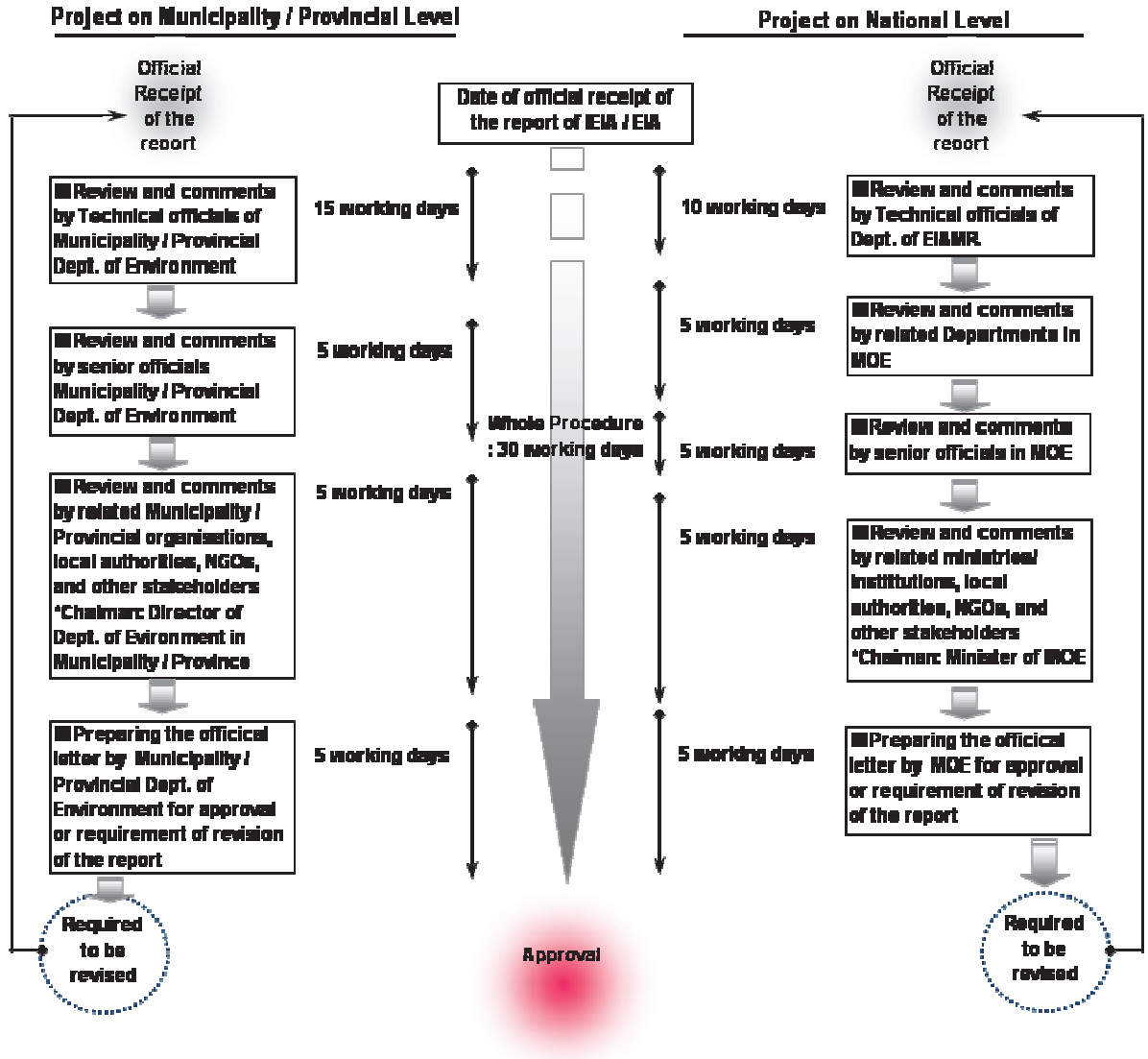
Project" (2011-2012, JICA), Project Team

2) EIA system in Cambodia

EIA shall be conducted on every project and activity of the private or public (projects are categorized in Sub-Decree on Environmental Impact Assessment Process, 1999), and shall be approved by the Ministry of Environment (MOE) before being submitted to the Royal Government of Cambodia (RGC) for decision. Regarding the Port Project, all project with construction activity need EIA/ IEIA. It also stipulates that this assessment shall also be conducted for existing activities that have not yet been assessed for environmental impact.

3) IEIA/EIA Approval Procedure in Cambodia

"PRAKAS on General Guideline for Conducting Initial and Full Environmental Impact Assessment Report, 02 September, 2009" stipulates the approval procedure of IEIA or EIA report. The approval procedure of IEIA or EIA report (Figure 17.2.1) should be within 30 (thirty) working days from the date of official receipt of the report by the DEIA or Municipality/ Provincial DE.



Source: PRAKAS on General Guideline for Conducting Initial and Full Environmental Impact Assessment Report, 02 September, 2009, "Preparatory Survey for National Road No.5 Rehabilitation Project" (2011-2012, JICA), Project Team

Figure 5.10-1 IEIA/EIA Approval Procedure in Cambodia

4) Institutional Setup and Legal and Policy Framework for Resettlement and Land Acquisition in Cambodia

In Cambodia the fundamental system for "resettlement", which are i) land management system, ii) policy and system for land acquisition, illegal occupation, and resettlement, and iii) methodology to fill up the gap between development partners' (DPs) policy on resettlement and the Cambodian laws and regulations related to resettlement, are still improving, and therefore the compromise between them is necessary in terms of dealing with resettlement issues caused by development projects. In prepresent situation the fundamental legal base of resettlement is the Constitution (1993), Land Law (2001) and Expropriation Law (2010. As enforcement order for those fundamental laws, there are Anukret/Sub-Decree, Prakas/Declaration, and Sarachor/Circular under control of Ministry of Economy and Finance (MEF), Ministry of Land Management, Urban Planning and Construction (MLMUPC) and other related ministries and institutions.

Legal and Policy Framework for Resettlement and Land Acquisition in Cambodia is stated in Table below.

Table 5.10-3 Related laws and regulations to EIA/IEIA

Function	Laws and Regulations	Institution in charge
Constitution (1993)	The September 1993 Constitution of the Kingdom of Cambodia includes provisions that are relevant to involuntary resettlement. Based on the right to ownership of all persons, individually or collectively, the right to confiscate (land) possession from any person shall be exercised only in the public interest as provided for under law with fair and just compensation in advance (Article 44). Though there are no further supporting procedures or regulatory frame works that have been developed.	
Civil Code (2007)	Civil Code : General principle. (drafted with cooperation of JICA)	Ministry of Justice (MOJ)
Land management / land legislation	: Land Law (2001)	MLMUPC
Land acquisition	Expropriation Law (2010)	MEF
Concession	Sub-Decree on Social Land Concessions (2003) Sub-Decree on Economic Land Concession (2003)	MLMUPC Ministry of Agriculture, Forestry and Fisheries (MAFF)
Resettlement	Sub-Decree on Addressing Socio-Economic Impacts caused by Development Projects (Draft) Compensation Price List of Affected Property (2000)	MEF MEF
Illegal occupation	Sechkdey Prakas No.6 : Measures to Crack Down on Anarchic land Grabbing and Encroachment (1999) Regarding the Implementation of ROW(Right of Way) policy on National Roads, Provincial Roads, Communal Roads, and Railways in Cambodia, No.961 (2000) Circular in Settlement of the illegal construction on the state land in cities and urban areas (2010)	Office of the Deputy Prime Minister (OPM) MEF MLMUPC
Right of Way (ROW)	Sub-Decree on Right of Way of National road channels and Railroads of the Kingdom of Cambodia (2009)	MPWT

Source: MPWT, OPM, MEF, MLMUPC, MAFF, "Preparatory Survey for National Road No.5 Rehabilitation Project" (2011-2012, JICA), Project Team,

Regarding land legislation the unified system for the certificates issued by old governments in deferent level (Municipality, Commune, etc.) and issued after Land Law (2001) is urgent matter in Cambodia. In this context "Sub-Decree on Addressing Socio-Economic Impacts caused by Development Projects" has been drafted with assistance of international organizations. However, because this Sub-decree gives large burden and task to Government of Cambodia, it has not pass Congress yet.

Even in this situation compensation for land, house and other building, and trees in the project will be admitted for people who can prove land ownership. However, several issue s has remained, which stated below;

- No compensation for people who cannot prove its land ownership, except occupation with intent of occupation (with bad faith) for 10 years or occupation with intent of ownership (with good faith) for 5 years (these people have the right of application for ownership).
- Land without certificate or other materials to prove clear ownership is treated as "deemed public land" and people who actually occupy lose its land.
- Rights are not guaranteed and compensated are not for people living in "retrospective public land" after declaration of "Right of Way (ROW)".

Therefore in projects by international organizations and donors the policy has been taken and implemented which stated below;

- If people who is identified that she (he) has been lived in the land,
- compensation should be paid before resettlement project starts,
- with reacquisition price in a market.

5) Comparison and Verification of between Cambodian System and JICA New Guideline

Comparison and verification of between Cambodian system and JICA New Guidelines are stated in Table below.

Table 5.10-4 Comparison and Verification of between Cambodian System and JICA New Guideline

	Item	JICA New Guideline Policy	Regulation in Cambodia (officially promulgated)	Actual Operation
1	Establishment of support system for socially vulnerable groups	Socially vulnerable groups tend to be exposed to environmental and social impacts. In addition, they have limited access to a process of decision making. Thus, it is necessary to give appropriate consideration to them.	The 1993 Constitution and the 2001 Land Law do not address socially vulnerable groups.	The guideline of donors in development projects by donors is followed.
2	Provide assistance to restore and improve living standards	Living standards and, income opportunities, and production levels of project affected people should be improved or at least restored to their pre-project levels.	The Government has no clear policy or procedure to restore the livelihoods of Aps.	The guideline of donors in development projects by donors is followed.

3	Enhancement of public participation in planning and implementation of resettlement plans	Appropriate participation by the affected people and their communities should be promoted in planning, implementation and monitoring of involuntary resettlement plans and measures taken against the loss of their means of livelihood.	It is clearly declared in Social Land Concession.	Concession land provided to people is smaller or of no value and far away from the town or urban center. Past experience shows that most of the families abandon the land and move to places where there are job opportunities. With this reason MEF follows the guideline of donors in development projects by donors mostly.
4	Compensation for land acquisition with replacement cost	Compensation will be done with replacement cost according to OP4.12 of the World Bank on Involuntary Resettlement, which means that compensation for lost assets must be made in full amount at replacement cost and at current market price.	- "No person shall be deprived of their ownership unless this action is for the public interest consistent with formalities and procedures provided by law and after just and fair compensation." Therefore compensation is not provided for other types of losses. - Compensation should be fair and just in advance.	The guideline of donors in development projects by donors is followed.
5	Providing support for illegal occupants	People to be resettled involuntarily and people whose means of livelihood will be hindered or lost should be sufficiently compensated and supported by the project proponents in appropriate time.	Those who have occupied a ROW or public properties are not entitled to any compensation or social support, regardless of their being an AP or from a vulnerable group.	The guideline of donors in development projects by donors is followed.
6	Grievance redress system	Grievance redress system must be formulated and functions appropriately.	Grievance redress system is stipulated in the Law on Expropriation, however, with provisions to exclude the public infrastructure project.	The guideline of donors in development projects by donors is followed.

Source: "Preparatory Survey for National Road No.5 Rehabilitation Project" (2011-2012, JICA), Project Team

(2) Analysis of alternatives

The following alternatives should be analyzed in the EIA.

- The water quality inside and around the existing breakwater is likely to deteriorate through

construction of the new container terminal and EPZ. Therefore, several water quality improvement options should be considered and their effectiveness analyzed through for example conducting water quality simulation.

- Since the route of the access road/bridge will be located adjacent to residential area, air pollution and noise/vibration impacts from construction activities and port-related vehicles will be a major concern. Therefore, several air pollution and noise/vibration mitigation measures should be considered and their effectiveness analyzed through for example conducting simulation.

(3) Scoping

The IEE identified the various adverse impacts that may occur through this project. Table 5.10-6 shows the impact factors that require detailed assessment in the EIA (i.e. impact factors that had a negative score in the IEE).

Table 5.10-5 Impact factors that require detailed assessment in the EIA

Natural environment	Pollution	Social environment
Flora, fauna and biodiversity	Air pollution, water pollution, waste, noise/vibration, offensive odor, bottom sediment	"Local economy such as employment and livelihood, etc", "Land use and utilization of local resources", "Existing social infrastructures and services", "Misdistribution of benefit and damage", "Water usage or water rights and communal rights", "Sanitation", "Hazards (risk), infectious diseases such as HIV/AIDS Accidents", "Landscape"

Prepared by Project Team

(4) Baseline environmental survey

1) Natural environment

Dredging and dumping activities are likely to have adverse impacts on the surrounding marine life as it will disperse turbidity over a wide range, possibly even towards Ream National Park. Therefore, the survey area of marine fauna should be determined by estimating the potential turbidity dispersion range, which may be determined by referring to the dredging monitoring results of the "Multi-purpose Terminal Project" and other similar projects. Table 5.10-7 shows the recommended baseline survey method for marine fauna.

Table 5.10-6 Recommended baseline survey method for marine fauna

	Survey method/item	Survey area	Survey period/frequency
Coral reef	Line-transect method (main coral species, coral coverage, bleaching rate, main fish/invertebrate species, presence of threatened species)	Coral reefs within the potential turbidity dispersion range, including the coastal area of Sihanoukville	Once (preferably in dry season)
Fish	Interview survey of fishermen, experts, fishery department (main species and commercial species, main spawning and	Within the potential turbidity dispersion range	Once

	nursery grounds, presence of threatened species)		
Benthos	Trawling survey (abundance and wet-weight of collected species)	• Dredging area • Around the dumping area • Within the potential turbidity dispersion range	Once each in rainy and dry seasons
Marine mammal	Literature survey, interview survey of fishermen, experts, fishery department and boat survey (habitat range, species)	Within the potential turbidity dispersion range	Once each in rainy and dry seasons for boat survey

Prepared by Project Team

2) Pollution

Table 5.10-8 shows the recommended baseline survey method for pollution indicators.

Table 5.10-7 Recommended baseline survey method for pollution indicators

	Survey item	Survey area	Survey period/frequency
Water quality	Water temp., pH, salinity, DO, turbidity, SS, COD, T-N, T-P, Oil content, Coliform bacteria	• Inside/outside of breakwater • Upper/middle/bottom layers • Adjacent waters of natural (e.g. coral reef) and social (e.g. tourist beach) environment sensitive to turbidity	Once each in rainy and dry seasons (ebb and flood tide)
Sediment quality	Specific gravity, water content, particle size distribution, Total organic carbon, Total nitrogen, Total phosphorus, Total sulfur, heavy metals (Ar, Cd, Pb, Hg, Cu, Ni, Zn), PCBs, dioxins, TBT	• Dredging area (surface and -0.5 m from surface) • Inside/outside of breakwater (surface only)	Once
Air quality	CO, NO_2, SO_2, TSP, PM_{10}	Sensitive areas (e.g residential area) that may be affected from the traffic of new access road and port activities	Once each in rainy and dry seasons (continuously for 1 week)
Noise/vibration	Equivalent sound level (L_{Aeq}), max/min sound level	Sensitive areas (e.g residential area) that may be affected from the traffic of new access road and port activities	Once (continuously for 1 week)
Current	Current speed/direction	• Inside/outside of breakwater and approach channel (i.e. points required for conducting SS and	Once each in rainy and dry seasons (at least continuously for 15 days)

		water quality simulation) • All layers	

Prepared by Project Team

3) Social environment

This Project will be implemented without resettlement. However, a certain scale of impact is expected on employment and livelihood during construction of port facility and after implementation of new port facility. To avoid to dismiss opinions and claims of the minority under benefit of the majority and public welfare, thoughtful consideration should be paid from on the survey stage in the next stage of the Project. Therefore socio economic survey (public awareness survey, population census, inventory of estate and land, housing and livelihood, regional economic activity, status survey of fishery) should be conducted in a baseline survey in the next stage to clarify details of expected impacts.

The contents of baseline survey are drafted in Table below.

Table 5.10-8 Recommended baseline survey method for social environment

Survey	Items	Survey period
Public awareness survey, population census,	-Target: all residents in the Project area -Purpose: to grasp statistically and spatially number and situation of people who would need the livelihood reestablishment assistance	After draft of specification and placement of facilities have been set generally in the fist half of the Project.
Inventory of estate and land, housing and livelihood	-Target: at least 20% of residents -Purpose: to grasp family structure, estate and livelihood, vulnerable groups and other fundamental data	
Regional economic activity	-Target: non-residents who have economic activity in the Project area. -Purpose: to grasp actual situation and regional relationship of economic activity.	
Status survey of fishery	-Target: residents and non-residents related to fishing industry in the Project area.	

Prepared by Project Team

(5) Impact prediction and assessment

1) Natural environment

According to the results of the IEE, dredging/dumping activities and access road construction may have adverse impacts on “flora/fauna and biodiversity”. Hence, a detailed impact prediction and assessment should be conducted on “flora/fauna and biodiversity”. Table 5.10-10 shows the recommended impact prediction and assessment method.

Table 5.10-9 Recommended impact prediction and assessment method (natural environment)

Potential impact	Prediction and assessment method
Impact on marine life through turbidity dispersion from dredging and dumping activities	• Predict the turbidity dispersion through SS dispersion simulation. Include Ream National Park in the simulation area if it is included in the potential turbidity dispersion range. • Predict for wet and dry seasons • Assess impacts based on tolerance of marine life on SS elevation • Refer also to the dredging monitoring results of the “Multi-purpose Terminal Project”

Prepared by Project Team

2) Pollution

According to the results of the IEE, adverse impacts are expected for "air pollution", "water pollution", "waste", "noise/vibration", "offensive odor" and "bottom sediment". Hence, a detailed impact prediction and assessment should be conducted for these impact factors. Table 5.10-11 shows the recommended impact prediction and assessment method.

Table 5.10-10 Recommended impact prediction and assessment method (pollution)

	Potential impact	Prediction and assessment method
Air pollution	Impact of exhaust gas emitted from construction and cargo trucks that pass through the new access road	• Based on the traffic volume forecast of construction and cargo trucks, simulate the dispersion range of air pollutants from the new access road for both the construction and operation phase. • Predict for wet and dry seasons • Compare the simulation results with Cambodian and other air quality standards.
Water pollution	Deterioration of water quality inside/outside of the breakwater through construction of new container terminal	• Estimate the pollution load (e.g. T-N) into the breakwater, and predict the water quality through water quality simulation. • Include fishing village and SEZ as pollution source. • Predict for wet and dry seasons • Compare the simulation results with Cambodian and other water quality standards.
Waste	Around 1.7-3.6 million m^3 of dredged spoil will be generated from dredging.	• Since the dredged spoil is planned to be dumped in the existing offshore dumping ground, predict its natural and social impacts through SS dispersion simulation. • If the sediment quality at the dredging sites exceeds the standards for safe ocean disposal, consider alternative disposal methods. • Other wastes: Estimate the amount of construction waste, and predict impacts on the disposal ground.
Noise/ vibration	Noise impacts from construction activities and cargo trucks	[Construction period] • Predict the noise/vibration impact range of pile driving and construction trucks through noise/vibration simulation. • Compare the simulation results with Cambodian and other noise standards. [Operation period] • Predict the noise/vibration impact range of cargo trucks through noise/vibration simulation.
Offensive odor	Offensive odor may be emitted through water quality deterioration	To the extent possible, quantitatively predict the occurrence of offensive odor by referring to weather conditions and the results of the water quality simulation. Use hydrogen sulfide as indicator.
Bottom sediment	Bottom sediment quality may worsen through water quality deterioration	To the extent possible, quantitatively predict the extent of sediment pollution by conducting sediment pollution simulation. Use eutrophication indicators.

Prepared by Project Team

3) Social environment

According to the result of IEE, negative impacts are expected on items which are "Local economy such as employment and livelihood, etc", "Land use and utilization of local resources", "Existing social infrastructures and services", "Misdistribution of benefit and damage", "Water usage or water rights and communal rights", "Sanitation", "Hazards (risk), infectious diseases such as HIV/AIDS Accidents", and "Landscape" (items evaluated as "-1" and below). These items need detailed evaluation and prediction.

Table 5.10-11 Recommended impact prediction and assessment method (social environment)

Items	Potential impact	Prediction and assessment method
Local economy such as employment and livelihood, etc	-After construction the water area for fish farm will be narrowed so that it is assumed that the water quality becomes not suitable for aquaculture. After all there is a strong probability that fish farmers need to move their preserves on a permanent basis. -For some fisherman living in the pier it takes more time to get their fish ground through the new opening of the pier. It may cause them more cost for fuel and other items for extension of working time.	• Estimate from the result of water quality simulation and the technical stand point of aqua culture. • Study actual time and fuel fee and compare to the result of inventory of estate and land, housing and livelihood.
Land use and utilization of local resources, Existing social infrastructures and service	Traffic jam and bad access because a part of coastal road will be utilized for construction traffic and access road as well.	• Estimate the traffic volume of construction vehicles and cargo trucks based on the estimated construction scale. • Study actual access route and transportation method for residents to major public facilities and estimate impact.
Misdistribution of benefit and damage	The Port Project will cause the benefit such as increase of employment opportunity. On the other hand, resident nearby construction site may receive various negative impacts caused by construction such as worse living environment and access.	• Grasp statistically and spatially number and situation of people who would need the livelihood reestablishment assistance
Water usage or water rights and communal rights	Due to construction work in the pier the water area which fishing people can use will be reduced and narrowed as well as the area in front of residents of fishing people.	• Visualize usable water area and interview the expected accidents and activities in the public awareness survey.
Sanitation	There is possibility that construction workers coming in the area give negative impact to sanitation.	• Estimate an devaluate the level of degradation of water quality by population increase based on the result of water quality simulation from the estimated amount of construction workers, and estimate the impact on residents.
Hazards (risk), infectious diseases such as HIV/AIDS	Due to construction workers coming in the risk of infectious diseases may increase.	• Estimate from the estimated amount of construction workers with assistance of Dept. of Health in Province.

Accidents		
Landscape	Residents in the pier will lose restful and airy landscape due to construction.	• Interview opinion on the future plan drawing by 3D using photos and other medias based on estimated scale and shape of facilities.

Prepared by Project Team

(6) Mitigation measures

Mitigation measures should be determined based on the results of the environmental impact assessment. The ensuing section provides a brief description of mitigation measures that should be considered in the EIA.

1) Natural environment

Table 5.10-13 shows the mitigation measures that should be considered for natural environment.

Table 5.10-12 Mitigation measures for natural environment

Potential impact	Mitigation measures
Impact on marine life through turbidity dispersion from dredging and dumping activities	If adverse impacts are predicted through the SS dispersion simulation, consider alternative dredging methods and turbidity reduction measures (e.g. silt curtain, adaptive monitoring)

Prepared by Project Team

2) Pollution

Table 5.10-14 shows the mitigation measures that should be considered for pollution.

Table 5.10-13 Mitigation measures for pollution

	Potential impact	Mitigation measures
Air pollution	Impact of exhaust gas emitted from construction and cargo trucks that pass through the new access road	[Construction period] ・Exhaust gas reduction measures of construction trucks (e.g. usage of low-emission trucks) [Operation period] ・Exhaust gas reduction measures of cargo trucks (e.g. prevention of traffic congestion)
Water pollution	Deterioration of water quality inside/outside of the breakwater through construction of new container terminal	Consider water quality improvement measures (e.g. installation of culverts, creation of new openings) if adverse impacts are predicted through the water quality simulation. Predict their effectiveness with water quality simulation.
Waste	Around 1.7-3.6 million m^3 of dredged spoil will be generated from dredging.	If the sediment quality at the dredging sites exceeds the standards for safe ocean disposal, consider alternative disposal methods (e.g. confined disposal, capping).
Noise/ vibration	Noise impacts from construction activities and cargo trucks	[Construction period] ・Noise/vibration reduction measures of pile driving (e.g. use of low-noise pile driver, installation of noise barrier) ・Noise/vibration reduction measures of new access road (e.g. installation of noise barrier) [Operation period] ・Noise/vibration reduction measures of cargo trucks

Prepared by Project Team

3) Social environment

Table 5.10-15 shows the mitigation measures that should be considered for social environment.

Table 5.10-14 Mitigation measures for social environment

Item	Potential impact	Mitigation measures
Local economy such as employment and livelihood, etc	-After construction the water area for fish farm will be narrowed so that it is assumed that the water quality becomes not suitable for aquaculture. After all there is a strong probability that fish farmers need to move their preserves on a permanent basis. -For some fisherman living in the pier it takes more time to get their fish ground through the new opening of the pier. It may cause them more cost for fuel and other items for extension of working time.	・Survey the actual alternative site for fish farming both for temporally base and permanent base. ・Study possibility of fishery assistance and compensation for the increase of expense from the result of survey.
Land use and utilization of local resources, Existing social infrastructures and service	Traffic jam and bad access because a part of coastal road will be utilized for construction traffic and access road as well.	・Propose actual plan of community road and industrial road.
Misdistribution of benefit and damage	The Port Project will cause the benefit such as increase of employment opportunity. On the other hand, resident nearby construction site may receive various negative impacts caused by construction such as worse living environment and access.	・Public information disclosure about project contents, construction scheme, schedule and so on to give feeling of participation to residents and community.
Water usage or water rights and communal rights	Due to construction work in the pier the water area which fishing people can use will be reduced and narrowed as well as the area in front of residents of fishing people.	・Visualize estimated usable water area and disclose information to set mutual understanding.
Sanitation, Hazards (risk), infectious diseases such as HIV/AIDS Accidents”	-There is possibility that construction workers coming in the area give negative impact to sanitation. -Due to construction workers coming in the risk of infectious diseases may increase.	・Let project owner make the labor management plan including living environment of workers, labor environment, labor condition, and so on with assistance of Dept. of Health in Province. ・Study mitigation plan for water quality, if negative impact is estimated from the result of water quality simulation and also survey for the effect of the plan.
Landscape	Residents in the pier will lose restful and airy landscape due to construction.	・From interview of opinion on the future plan drawing by 3D using photos and other medias based on estimated scale and shape of facilities, put feasible ideas into the Project and share the information.

Prepared by Project Team

(7) Monitoring plan

A detailed monitoring plan should be prepared based on the results of the environmental impact assessment. Table 5.10-16 provides a brief description of the monitoring activities that are likely to be required during the construction and operation phases.

Table 5.10-15 Monitoring activities likely to be required during the construction and operation phases

	Item	Monitoring activity
Natural environment	Marine life	[Construction period] Monitoring of coral reefs that may be affected from dredging and dumping activities
Pollution	Air quality	[Construction period] Air quality monitoring at sensitive areas near the construction site and new access road [Operation period] Air quality monitoring at sensitive areas near the new access road
	Water quality	[Construction period] Continuous monitoring of SS levels around the dredging area and sensitive sites. [Operation period] Water quality monitoring inside and outside of the breakwater
	Sediment quality	[Operation period] Sediment quality monitoring inside and outside of the breakwater
Social environment	Local economy such as employment and livelihood, etc	[Construction period] Monitoring of fish farmers who resettled temporally about living environment and, living condition such as income, mental distress and so on. [Operation period] Monitoring of fish farmers who resettled temporally about living environment and, living condition such as income, mental distress and so on.
	Land use and utilization of local resources, Existing social infrastructures and service	[Construction period] Monitoring condition of traffic jams and route change of residents in daily life. [Operation period] Monitoring condition of traffic jams and route change of residents in daily life.
	Misdistribution of benefit and damage	[Construction period/ Operation period]] Monitoring of methodology of information disclosure, times and occasion, and resident's awareness of Project.
	Water usage or water rights and communal rights	[Construction period/ Operation period]] Monitoring of public awareness about change of living condition and environment
	Sanitation, Hazards (risk), infectious diseases such as HIV/AIDS Accidents"	[Construction period] Monitoring of labor management system by Project owner.
	Landscape	[[Construction period/ Operation period]] Monitoring of public awareness.

Prepared by Project Team

(8) Stakeholder meeting

The stakeholder meeting should be held by inviting the fishermen and aquaculture operators that are based inside the breakwater. Topics such as the status of pollution, pollution mitigation measures and water use should be discussed in the meeting.

(9) Other considerations

1) Ballast water management

Ballast water of ships is known to transport invasive species, which may cause significant harm to the local ecosystem and human activities. For example, in the U.S., the zebra mussel (*Dreissena polymorpha*) transported through ballast water has infested numerous inland waterways; causing significant damage such by clogging intakes of factories. Since the risk of ballast water impacts will increase through port development (i.e. increase in ships), appropriate ballast water management should be considered.

2) Procurement of construction material

Environmental impacts should be evaluated if development of a new procurement site is required for landfill and other construction materials (e.g. rocks, rubbles, sand).

3) Impacts on fisheries

If port construction and operation activities are predicted to have significant impacts on fish spawning grounds and consequently affect fisheries, mitigation measures should be considered such as creation of artificial reefs.

5.11. Improvement of port environment

5.11.1 Issues and improvement measures

(1) Air pollution

Air quality around Sihanoukville Port is generally under good condition, as port and industrial activities are still relatively limited. However, as mentioned in Section 5.7.3, the following local-scale air pollution may occur under certain weather and traffic conditions:

- Dust emission from bulk commodities
- Exhaust emission from cargo trucks

While the main bulk commodities are coal and woodchip, dust emission from coal are of particular concern as it contains minute particles that are readily dispersible. To counter coal-dust problems, the port currently has a wind fence installed around the stockyard and conducts water spraying. However, there are numerous holes and gaps in the wind fence, hence should be repaired as soon as possible. Note also that the port's dust control measures will be improved after the completion of the "Multi-purpose terminal project (to be completed in 2016)", as a new wind fence (6 m height) and sprinkler system will be installed in the expanded coal stockyard.

After the completion of the "Multi-purpose terminal project", the new woodchip stockyard will be located behind the multi-purpose terminal. To maintain the quality of the woodchip, it will be important to prevent dispersion of coal dust towards the woodchip stockyard. Hence, coal unloading should not be conducted at berths near the woodchip stockyard. If that is unavoidable, a mobile wind fence (e.g. 5 m x 30 m) should be purchased and installed around the unloading site.

Air pollution from cargo truck exhausts will be most significant during traffic congestion at the access road. Hence, alleviation of traffic congestion will be one of the effective solutions, which is expected to materialize through gradual improvement of port operation efficiency. Another way is to reduce exhaust gas emission from cargo trucks. Following are recommended measures:

- In principal, all cargo trucks that enter the port should satisfy the national vehicle emission standard. However, it is near impossible to inspect all trucks. As an alternative and simpler method, the port may conduct visual inspection for trucks that are emitting black soot, and warn applicable trucks for improvement (e.g. repair, retrofit, renewal). Penalties (e.g. entrance prohibition) or fines should be applied to non-compliant trucks.
- Prohibition of unnecessary idling near the port

(2) Water pollution

According to the water quality survey, the waters around the port area is polluted by oil and coliform bacteria, and could worsen through port expansion, SEZ operation (2012) and population increase. Following are examples of water pollution impacts that have occurred in Japan:

- Uncontrolled discharge of pollutants may cause human diseases such as Minamata disease, which is a neurological syndrome caused by severe mercury poisoning. It was caused by the release of methylmercury in the industrial wastewater of a chemical factory. The highly toxic chemical bioaccumulated in shellfish and fish in Minamata Bay, which when eaten by the local populace resulted in mercury poisoning.
- Discharge of nutrient rich effluents from human settlements may cause eutrophication, and result in red tides and hypoxic waters. This may then cause mass mortality of marine organisms. For example in Japan, red tides are a common phenomena in semi-enclosed waters such as Seto Inland Sea, resulting in mass mortality of aquaculture fish and consequent economic loss.

To prevent such incidents, it is therefore necessary to implement appropriate pollution control measures. Table 5.11-1 shows the main water pollution sources and recommended improvement measures.

Table 5.11-1 Main water pollution sources and recommended improvement measures

Pollution source		Recommended improvement measures
Discharge of bilge water	The port's tug boat fleet (5 boats) currently discharges their bilge water into the sea without treatment. Although one tug boat is equipped with oil-treatment system it is often not used due to difficulty in handling. Discharge of untreated bilge water is against the port's PSHE policy and MARPOL regulations, and should be stopped immediately.	• Prevention of bilge water discharge unless it is discharged at levels below MARPOL Annex I discharge standard*. • Tug boats without oil-treatment system should unload bilge water at the port, and dispose it through private contractor.
Effluent discharge from SEZ	While the SEZ will be equipped with a wastewater treatment plant, it cannot treat hazardous substances such as heavy metals, which will be the responsibility of each factory. Although PAS will conduct regular wastewater monitoring, there is no staff inside PAS that is capable of assessing adequately the monitoring results and implement appropriate actions.	Allocation of environmental management department and staff.
Sewage discharge from adjacent fishing community	Untreated sewage water from the adjacent fishing community (approx. 10,000 residents) is discharged into the breakwater area.	Since the fishing community area is outside PAS jurisdiction, PAS should request the local government to consider and implement measures against sewage water.

*: Oil content inside the effluent should be under 15 ppm
Prepared by Project Team

(3) Oil spill response

Any large-scale oil spill that occur in Cambodian waters are countered through the National Oil Spill Contingency Plan, under the order of the Prime Minister. For example, if a large-scale oil spill occurs in Sihanoukville, relevant organizations such as port, navy and oil terminal (located approximately 6 km north from the port) will be ordered to collaborate and take appropriate actions. Therefore, it is not vital to equip an entire range of oil spill response equipments as it can be supplied from other organizations in case of emergency.

The port currently is equipped with one 25 m oil fence and one skimmer, which is applicable only for small-scale spills. According to the Harbor Master Department, the current skimmer is heavy and difficult to handle, hence procurement of a more light and compact skimmer is recommended.

(4) Organizational structure

Currently there is no department or staff inside PAS that is specifically responsible for environment management. However, the importance and demand for environment management is expected to grow through the implementation of "Multi-purpose terminal project", operation of SEZ and intensification of port activities. Hence, establishment of an environment management department is highly recommended, which will be assigned to manage all environmental matters that arise inside the port. Table 5.11-2 shows some examples of the tasks of the environment management department.

Table 5.11-2 Tasks of the environment management department

Category	Tasks
Sihanoukville Port SEZ	• Monitoring of effluent from wastewater treatment plant and factory • Reporting of monitoring results to the Ministry of Environment • Environmental inspection of SEZ factories • Instruction to SEZ factories that do not satisfy environmental standards • Maintenance of wastewater treatment plant • Response to complaints from local people
Multi-purpose terminal project	• Environmental management of construction activities • Reporting of monitoring results to the Ministry of Environment • Maintenance of environmental facilities (e.g. sprinkler system, wind fence, settling tank) • Response to complaints from local people
Others	• Management of waste (e.g. waste oil) • Inspection of cargo-truck exhaust gas • Safety inspection (e.g. labor safety, fire hazard)

Prepared by Project Team

Since the above mentioned tasks will require a broad range of environmental knowledge, ideally an experienced environmental engineer should be recruited. However, since these tasks may not require full-time commitment, for the time being, an existing staff of PAS could be assigned as an alternative option. In such case, PAS should establish a back-up system to support the assigned staff on technical issues, for example by establishing an ad-hoc advisory committee that consists of in-house and outside experts (e.g. Department of Environment, professors) of various fields.

5.11.2 Port environment improvement plan

Table 5.11-3 summarizes the recommended environmental improvement measures as identified in Section 5.11.1, their implementation period and rough cost estimate.

Table 5.11-3 Port environment improvement plan

	Issue	Improvement measure	Implementation period	Cost
Air pollution	Dust dispersion from coal handling	Installation of mobile wind fence (e.g. 5 m x 30 m)	Before operation of multi-purpose terminal	US$10,000 (to be purchased by the terminal operator)
	Dust dispersion from coal stockyard	Repair of existing wind fence	As soon as possible	Negligible
Water pollution	Bilge water discharge from tug boat	• Prevention of discharge of untreated bilge water • Land disposal of bilge water through private contractor	As soon as possible	Collection and disposal fee
	Effluent discharge from SEZ	• Allocation of environmental management	As soon as possible	New recruit: US$6,000/year/staff

		department and staff • Establishment of technical assistance system		
	Sewage discharge from fishing community	Request local government to consider and implement measures against sewage water	As soon as possible	—
Oil spill response	Difficulty in handling of existing oil skimmer	Purchase of light and compact oil skimmer	As soon as possible	To be updated in F/R
Organizational structure	No environmental management department and staff	• Allocation of environmental management department and staff • Establishment of technical assistance system	As soon as possible	New recruit: US$6,000/year/staff

Prepared by Project Team

5.12. Intensification of port security

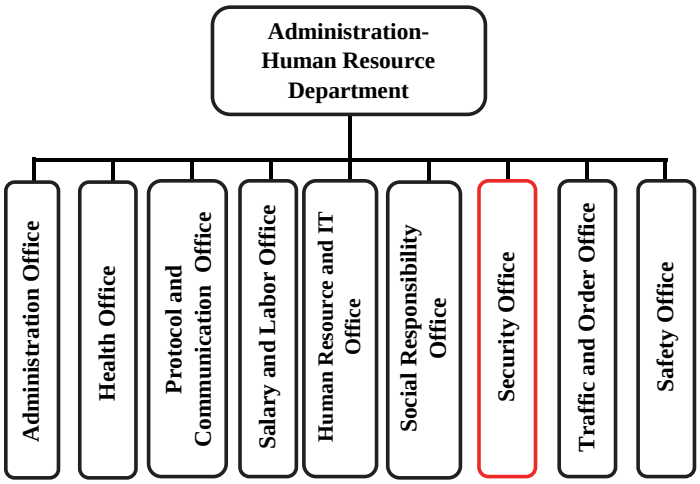
5.12.1 Current situation and issues of port security

(1) Tasks of security division

i) Organization and tasks

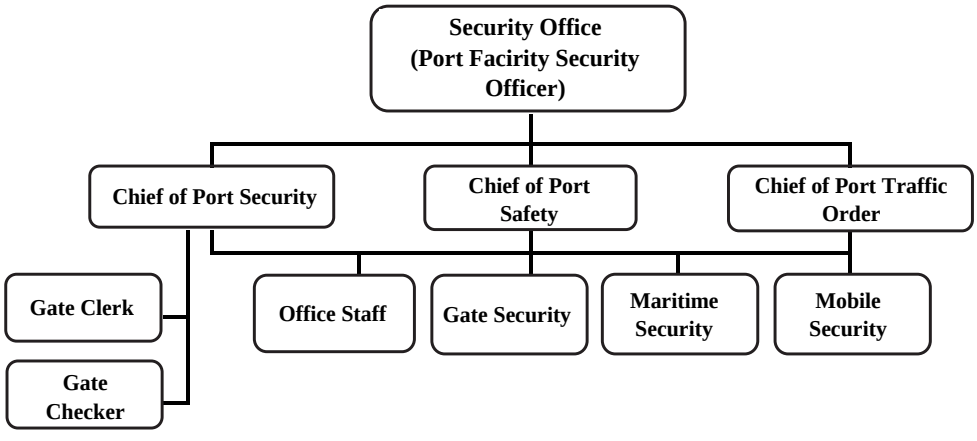
PAS applied the ISPS code and port security has been carried out according to the PFSP (Port Facility Security Plan) drawn up mainly by the PFSO (Port Facility Security Officer) of the security office. MPWT (Ministry of Public Works and Transport) approved the PFSP of PAS in 2006 and it went into effect. First edition is planned to be released by 2012.

The Security Office, which is a part of the Administration-Human Resource Department and has a staff of 77, performs the gate control tasks at four gates and the security tasks for the restricted area at all times.



Source: PAS

Figure 5.12-1 Organizational Structure of Administration-Human Resources Department



Source: PAS

Figure 5.12-2 Organizational structure of Security Office

The Security Office is headed by one Port Facility Security Officer (PFSO) under which three Chiefs are in charge of six security tasks. Each of the tasks is outlined with the number of members on the staff in parentheses. The budget for the activities of the Office is managed by the Administration-Human Resource Department on a consolidated basis, and thus the Office has no budget at its discretion.

- Gate clerk (8)

  Gate clerk examines the export declaration brought by the driver. If the document is in order, truck goes to the booth where the custom officers, camcontrol and immigration police follow the prescribed procedure. After the driver pays container handling charge of PAS, the truck enters the container yard through the gate. Gate clerk inputs the data of container number and related information in a computer at the gate booth.
- Gate checker (6)

  Gate checker inspects external container condition by visual inspection. He enters comments on EIO when damages of container are detected such as tiny holes, dents and so on.
- Gate security (36)

  Gate control is conducted at Gate No.1, No.2, No.3 and the administration building. In particular, Gate No. 3 is for container cargo, and there is traffic congestion extending from the gate and driveway onto National Road No. 4 from Friday night to Saturday evening. Many members of the Security Office, as well as traffic police, take care of this line.
- Office staff (4)

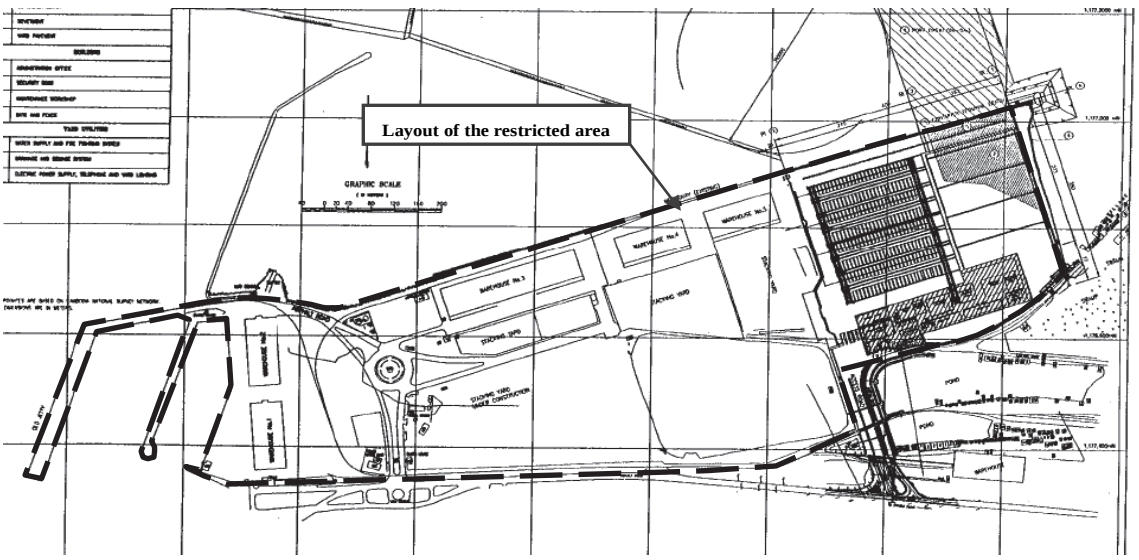
  The office staff monitors the port activities, and watch for possible port security threats on surveillance monitors. They also conduct general ID pass control, and education/training.
- Maritime security (4)

  The Security Office patrols the sea area of the port by boat.
- Mobile security (15)

  The Security Office also patrols the land area of the port, and maintains and manage the traffic signs in the area.

ii) Restricted area

The restricted area of the PAS extends from the New Container Berth in the west to the Old Jetty in the east, covering the entire port area, as shown in Figure 5.12-3.



Source: PAS

Figure 5.12-3 Restricted area of PAS

(2) Assessment

We conducted a port facility security assessment to evaluate the vulnerability of the port with respect to the physical structures, surveillance systems and processes, and so on. We analyzed the assessment results to find the issues rerated to equipment and arrangements of the port to be addressed.

1) General matters and the current status of use of the port

For the specifications of the wharf and terminal and the current situation of use of the port, refer to 5.2.1.

An international passenger service ship enters the port and comes alongside the cargo wharf in some cases. In those cases, buses are chartered to transport the passengers out of the port so that they cannot walk around the terminal.

2) Physical security

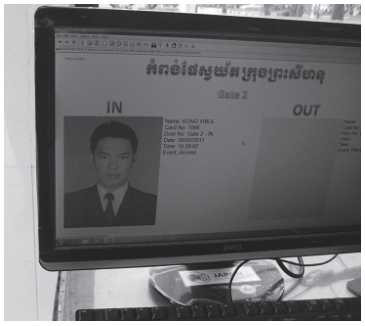
i) Gate control

At present, some cables that comprise the security system in the port have breaks, and the gate control with CCTV cameras is partially inoperable. It is already known who is responsible for these matters, therefore, the system should be restored to fully operable condition as soon as possible.

Gate control is a task of the Security Office. A photo ID card was issued to each member of the PAS (including the crews of tug boats and pilot boats), and once used for gate control. If gate control is to be resumed, ID cards need to be reissued, partially because the issued ID cards expired.

The gates for cargo trucks are separate from those for persons. Taxis are not allowed to enter the port premises.

Cargoes are checked at Gates 2 and 3. Bulk cargoes and general goods are at Gate 2, and container cargoes are at Gate 3.



Prepared by Project

Figure 5.12-4 A card reader and monitor used at Gate 2

ii) Security facility equipment and management

The port has six gates, and gate control is placed at five of them excluding the old railway gate. When the gates are closed, they are locked and the keys are kept under the control of Security Office staff.

The restricted area is enclosed with fences 2.4 m high. No sensors are installed on the fences. Some of the fences are movable. Lighting equipment and surveillance CCTV cameras are installed on the yard, wharf, gates, storehouses, office building and fences. The port is monitored through the surveillance cameras, and the CCTV images are retained for 15 days. No warning system is installed. Instead, VHF radio and mobile phones are used for emergency communication.

iii) Guards and patrols

The Security Office conducts no regular patrols in the port, nor posts any guards on the wharf. It has patrol boats in case of emergency.

i) Identification of ships that enter the port, and surveillance of the port sea area

Necessary information on a ship to enter the port is obtained and checked in advance of its entry. The PAS has a Vessel Traffic Management System (VTMS) and conducts traffic control with that system. When a ship in the port, the security office monitors the wharf through surveillance cameras.

3) Structural integrity

The PAS has a power generation station and a substation. They are not fenced at some points. They are locked. No refueling equipment for ships is installed in the port. The bunkering place is not fenced. We did not make a visual check of the warehouses in the port for aging deterioration. They are not equipped with a device to measure the illuminance inside or surveillance cameras.

The port has service boats which are used as tug boats or mooring rope- service boats.

4) Personnel protection system

There are emergency evacuation routes and emergency exits in the facilities, but no signs to indicate the emergency exits.

5) Policies for procedures

The Port Facility Security Plan (PFSP) has been established in accordance with the ISPS Code. Procedures have also been established accordingly. The PSA has a means of emergency communication and communication chains are in place.

6) Radio and telephone communication systems including computer systems and a network

Wired telephones and mobile phones can be used in the terminal. Computers are connected to a network and used for purposes of port security, cargo control and communication. Anti-virus measures have been taken for communication systems. The cables are protected with covers.

7) Connected transportation infrastructures

There is no railway sideline into the port, but there is a railway station at the back of the port. A railway sideline into the port is planned to be constructed soon. National Road No. 4 passes at the back of the port.

8) Public utilities

The port facilities are provided with town gas, underground power cable line, or water supply extended from an urban area. Drains are open concrete-block structures, and drain water is discharged into the sea. The discharge holes have gratings on them.

9) Others

The anchorage area and turning water area are patrolled by patrol boats. The use of contiguous land lots and management buildings was confirmed. The PSC (Port Security Committee) consists of the Security Office of the PAS, Customs, CAMCONTROL, Immigration Bureau and KAMSAB. They discuss, and carry out simulations of, port security matters. The PAS has a security organization and does not contract with a private security company for port security. The PFSO and SSO take training courses regularly.

(3) The current situation and issues of arrangements of the port

1) Organization and personnel education are important

The Security Office as it is works well, roughly speaking, except during the days/times container Gate No. 3 is congested with cargoes, when a considerable portion of the staff must be allocated to deal with them. Thus, the Security Office does not have an enough capacity. The PFSO considers that the Office needs ten more staff members.

About 60% of the personnel are middle-aged or older. Container cargoes are likely to increase in the port. Thus, it is now necessary to develop and implement measures to employ more and younger people. The tasks of the Security Office involve scenes where its staff members have to make others follow their orders/instructions. Therefore, it is necessary to select, and assign to the Office, employees on the basis of their aptitude for the tasks. Education/training for security work is necessary, not to mention OJT training, and it takes some time to train/educate newly employed members into full-fledged security workers.

2) Ensuring that other divisions/offices of the PAS have understanding of, and cooperate for, the security arrangements

Port security tasks involve coercive measures in some cases and may impose some restrictions on other members of the PAS. It is therefore likely that there may occur friction between the imposing side and the imposed side. Accordingly, it is absolutely necessary that other divisions/offices of the PSA have understanding of, and cooperate for, the security arrangements in order for the Security Office to implement gate control without frictions.

To resume the gate control, it is important to ensure that all the other members of the staff of the PAS have understanding of, and cooperate for, the security arrangements by explaining/enlightening them in advance.

3) Continual port security drills/exercises

There have been cases where port security was breached because the security work became lax over time. It is fortunate that the PAS has had no such experience so far. To prevent the security work from becoming lax, it is important to implement drills/exercises continually and regularly. The contents of drills/exercises should also be considered to incorporate up-to-date security drills/exercises of the world to raise the participants' consciousness of port security.

4) Need for budget

Currently, the Security Office does not have a budget at its discretion. However, the types of equipment and the numbers of units of items of equipment in use have increased. For many of them, a failure of such a unit may lead to a reduced efficiency/effectiveness of the operation of the PAS, not to mention the importance of maintenance of each unit.

Repairing a unit once it has failed cannot avoid compromising the function of the PAS. In view of likely increases in the volume of freight handled in the port, the maintenance and control of equipment implemented by the Security Office will be increasingly important. Therefore, the responsibilities and authorities of the Security Office should be clarified, and it should be authorized to develop a budget plan and use the budget according to the plan in an integrated system.

(4) Status and issues of the hardware

1) Gate control system

It is most urgent that the gate control system that is out of order be recovered, and that normal gate control be resumed.

For example, loose gate control allows shipping agents or other concerned people to freely enter container operation yard by motor bike to bring the documents required for import/export of container cargoes. It is necessary to improve this situation because the gate control procedure may be compromised. The Security Office should cooperate with the Container Operation Department to establish an appropriate system to cope with the situation. Some improvements it have already been made.

The current restricted area for port security of the PAS covers all the port area. The container operation area is restricted with simple partitions made of movable blocks; however, persons or vehicles can easily enter there, which may pose safety problems.

An important and essential problem, like safety problems, is that container vehicles cannot smoothly travel in the operation area and thus the container operation cannot efficiently be performed.

In particular, during the time periods of Saturdays and Sundays when containers are concentrated in the area, concerned people and vehicles come and go in complicated patterns, which is dangerous. If the gate is opened early at 4 o'clock in the morning, the congestion will be eased; however, the current situation in which there is no entry/exit control of people and vehicles will remain unless the gate control function is restored.

2) Surveillance system

Because some cables buried in the premises were broken, the surveillance through CCTV cameras cannot be implemented for some parts of the port now. It is not until the equipment operate

normally that the entire security operation is possible. Therefore, the surveillance equipment should be recovered as soon as possible.

5.12.2 Intensification plan of port security

(1) Intensification and enhancement of gate control

The gate control at Gate No. 3 is closely related to container operation; therefore, the Security Office should construct appropriate gate control there in cooperation with the division in charge of container operation.

The greatest issue to be addressed is that cargo containers are concentrated on Saturdays and Sundays. To solve this issue, it is important to talk with cargo owners. It is necessary to know the conditions that cause the concentration of cargoes on Saturdays and Sundays, and it is expected that some solution will be found by talking with the cargo owners. We heard that some experts in the Study Group, together with PAS staff, have already made a proposal to ease the peak concentration and are working forwards reaching a consensus on this matters.

The Security Office considered the traffic line for container vehicles, and a layout of a parking area for vehicles waiting for X-ray inspection or for loading/unloading, which would be an effective use of contiguous land. As a result, the Office proposed a two-stage gate system. It is an excellent idea for solving the congestion at the gate (see Figure 5.12-5).

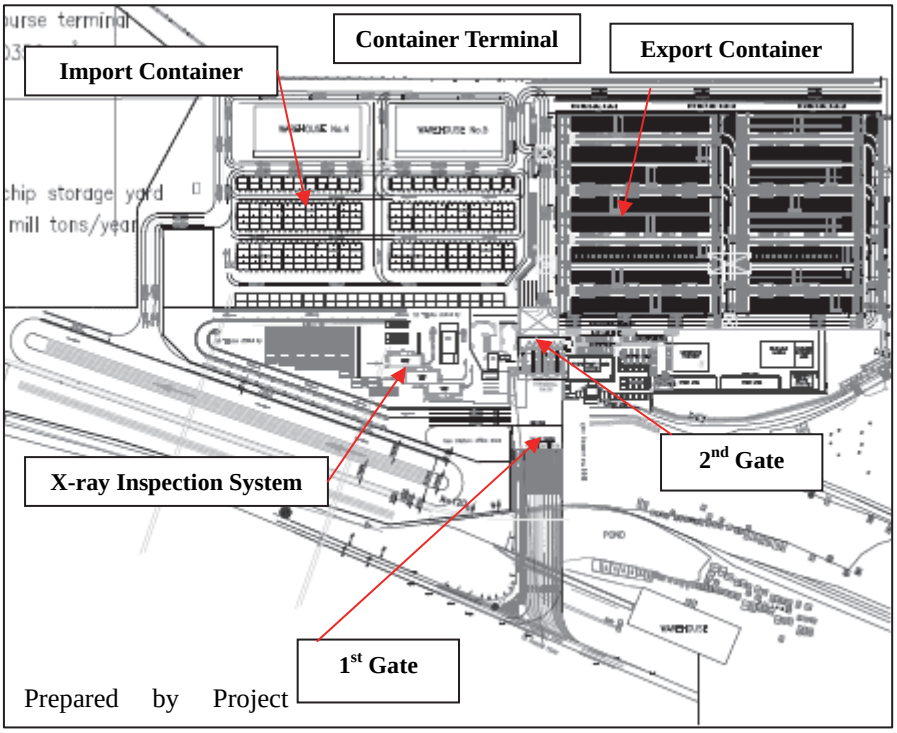


Figure 5.12-5 Expected layout of container yard and gate control

(2) No entry zone of container operation area

The container operation area is dedicated to freight vehicles that transport export/import cargoes. If vehicles that have no relation to the container operation were allowed to enter, the container operation would be hampered. The traffic lines for freight vehicles are indicated by arrow marks on white background color on the ground of the area. Such vehicles follow those lines to go to the places instructed at the gates. Currently, the container operation area is only demarcated by movable fences on the boundaries. Thus, it would be easy to enter the area from neighboring yards.

As gate control is improved, the container operation area should be completely enclosed by fences so that a vehicle that has no relation to container operation cannot enter to ensure smooth and safe container operation.

(3) Patrol by security staff

The restricted area is monitored through surveillance CCTV cameras. The cameras can be rotated, so that it is possible to cover all the restricted area with them. However, guards on patrol may be able to use their eye or other sense to detect something that cannot be seen through the cameras. Patrols may notice something small but unusual or some situation that persists, from which they may become aware of a danger. Thus, it is a simple but important and fundamental security activity for patrols to be conducted. Patrols should pay attention to the following.

○ Suspicious persons:

①A person or a vehicle that comes/goes by the same place many times
②A person who has stayed inside a parked vehicle for a long time
③A person who is taking notes, writing something on a map, or taking photos or video images
④A person using binoculars
⑤A person who activates the security system with the intention of testing the security arrangements

○ Suspicious objects:

① A container is left at some place. Is it an appropriate place for a container to be?
② A container is left at some place. Is there anything unnatural in that container being at that place?
③ If a suspicious object is found at some place, since when has it been there?
④ Has anyone moved the suspicious object?
⑤ Has any call or threat been received concerning the suspicious object?

5.12.3 Transfer of technologies to reinforce port security

In Japan, the government has assessed the security status of international port facilities, approved their security regulations, and conducted on-site inspection of those facilities according to the International Ship and Port Security Act, which was put in force in July 2004, and the Administrators of international port facilities have taken security measures under the government's authority and the Act.

The government's on-site inspection has revealed some vulnerability in the security arrangements for entry/exit control at terminal gates. In addition, in view of the improved security level in major overseas ports, the progress in the prevention of forgery of ID cards, and so on, Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism is now working in cooperation with the Administrators of the International Port Facilities to introduce/construct an entry/exit control information system for people (truck drivers, etc.) eateries and learning ports.

Here, we present the entry/exit control system that Japan is trying to introduce, and examples of such systems in overseas ports, for your reference.

(1) Entry/exit control information system

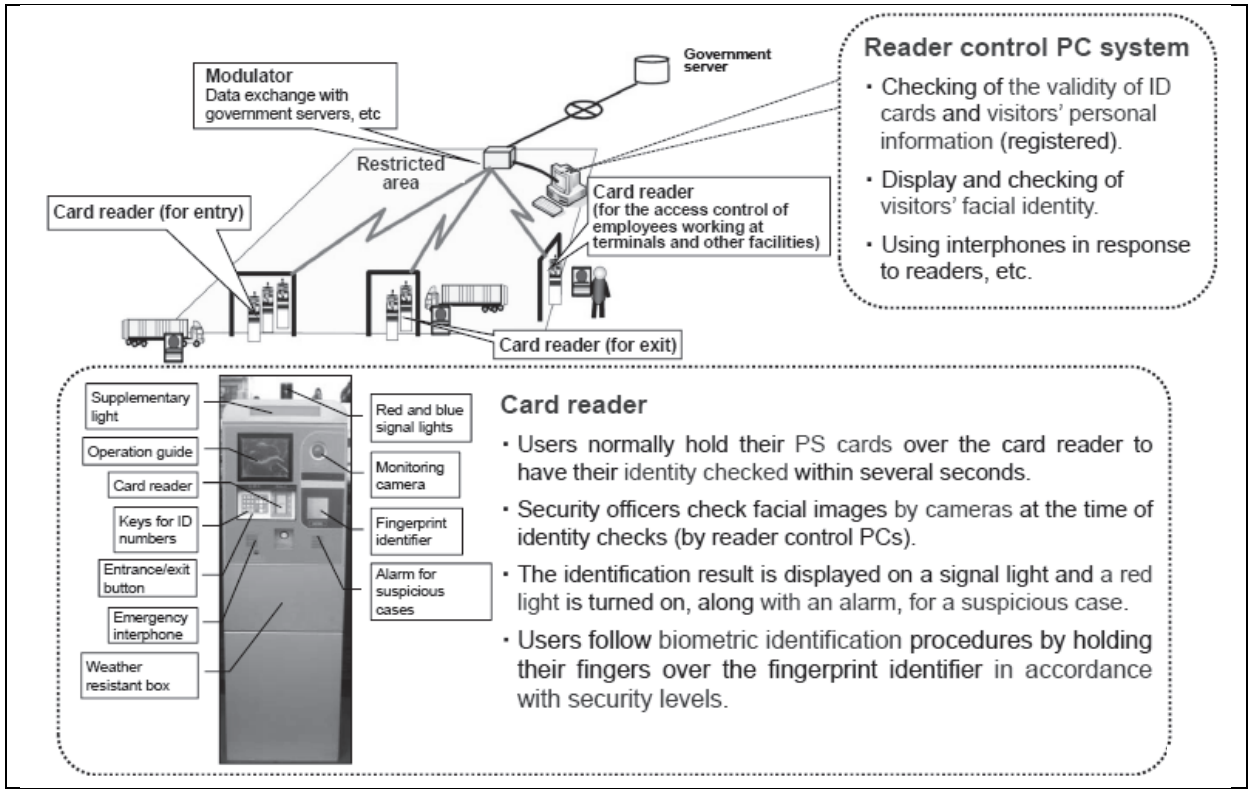
In this system, a card reader contained in an enclosure reads a PS (Port Security) card and determines whether the holder car access a restricted area. In this way, security is maintained and people can enter/exit the area smoothly.

The government issues PS cards that are IDs for principal ports across the country to truck drivers, etc., and installs card readers, a personal computer to control the card readers, etc., at the container terminals in principal ports. Figure 5.12-6 shows the concept of the system.

(2) PS card and identification process

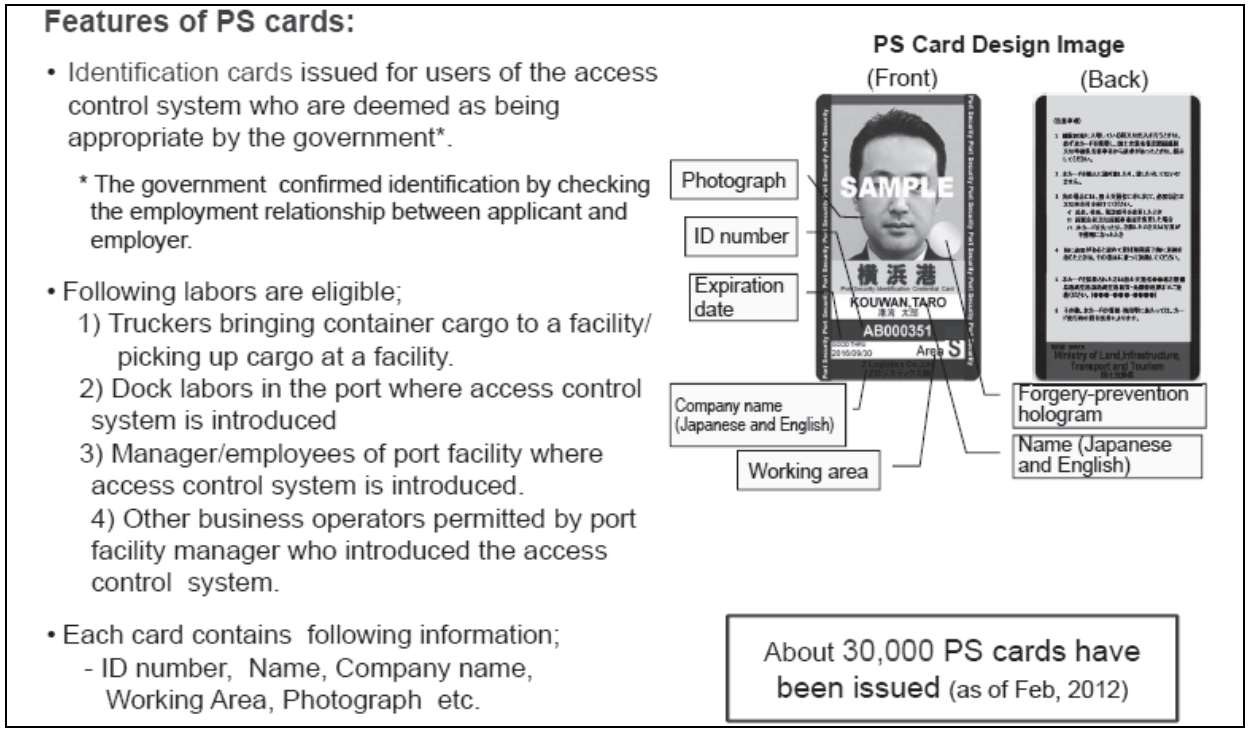
The PS card issued by the government is an ID that is effective in all the principal ports and indispensable for using the entry/exit control information system there.

This photo ID card incorporates enhanced anti-forgery technologies, and makes it easy to identify the card holder by containing an IC chip that stores his or her division/section, identification number, encryption key, etc. (See Figure 5.12-7)



Source: MLIT

Figure 5.12-6 Concept of entry/exit control



Source: MLIT

Figure 5.12-7 Entries into PS card

(3) Approaches to port security at international wharf/port terminal facilities

The Government of Japan and the Administrators of the international wharf/port terminal facilities in Japan implement the following port security measures according to their roles prescribed by laws and regulations to comply with the revised International Convention for the Safety of Life at Sea (SOLAS).

i) Port security measures implemented by the government

The government approves the security regulations on wharf/port terminal facilities (i.e., the regulations on security created by an Administrator of international wharf/port terminal facilities) and notifies the IMO of the facilities for which it has approved such regulations, and conducts an on-site inspection on the security measures that the Administrator of international wharf/terminal facilities implements (i.e., checks that appropriate security measures are performed appropriately) and issues an order for change, improvement or correction, if necessary, (an order to the Administrator in case of a problem found in security) to demand appropriate improvements, and provide security information (e.g., security information concerning ships), from ① an international perspective (i.e., international cooperation in accordance with the revised SOLAS convention, etc.), from ② a wide-range perspective (i.e., construction of a safe and efficient international marine transportation network), from ③ a perspective of uniformity (uniformity and compatibility across the country), and from ④ a perspective of urgency (i.e., visual check on site, and report to the Prime Minister's Office, if necessary).

ii) Port security measures implemented by the Administrator of international wharf/port terminal facilities

The Administrator of international wharf/port terminal facilities implements the following security measures.

1. Setting and controlling a restricted area, e.g., by constructing fences, gates, etc.
2. Surveillance in the restricted area, e.g., installing surveillance cameras and lights, and stationing guards to watch the inside and outside of wharf/port terminal facilities
3. Security drills/exercises (e.g., drill of communication with relevant parties and drills based on scenarios of danger)
4. Cargo control, e.g., by checking cargoes in the restricted area
5. Entry/exit control at the gates, e.g., checking each person's identification, his or her division/section, and the need for entry, and preventing illicit articles from being brought in

Figure 5.12-7 shows the above-mentioned measures.

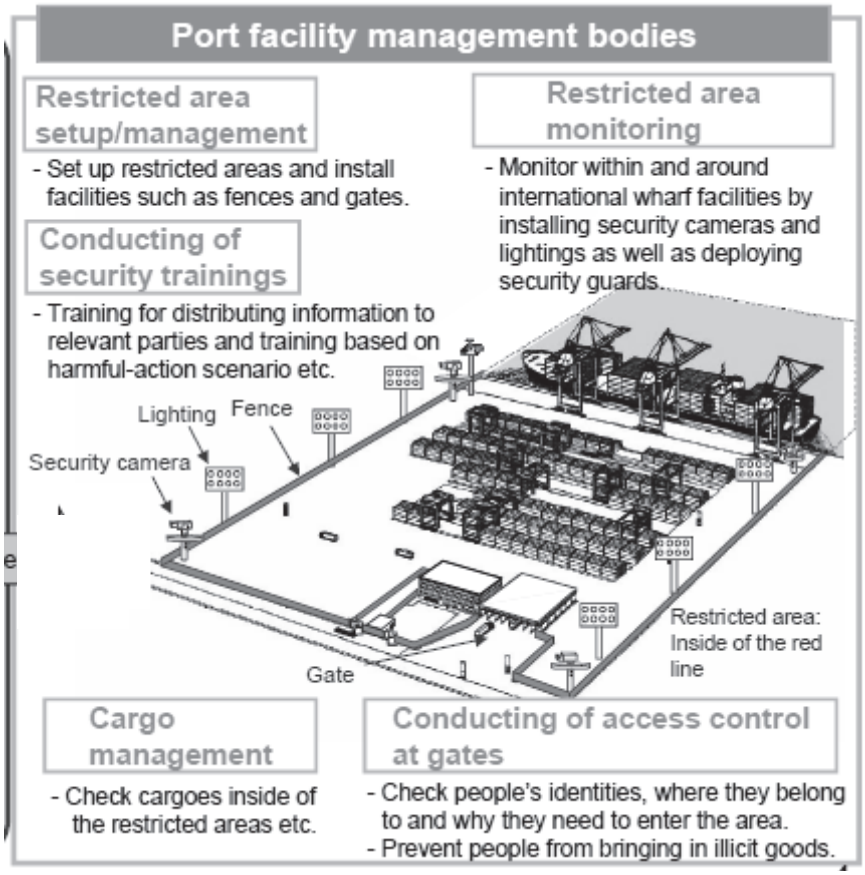


Figure 5.12-8 Port security measures implemented by Port Administrator

(4) Enhanced entry/exit control (examples of electronic ID cards introduced)

Table 5.12-1 compares entry/exit control systems in major ports.

The United States, has introduced excellent measures with respect to security than other countries, but it is pointed out that there are some inconveniences from the perspective of physical distribution management there. The entry/exit control system in the United Situations will be a good reference for your country.

TWIC (The Transportation Worker Identification Credential)

i) Outline

TWIC (The Transportation Worker Identification Credential) is an important measure implemented in the maritime transportation system to prevent persons who are likely to threaten security from entering the restricted areas without asking for permission.

TWIC has been established by the Congress in accordance with The Maritime Transportation Security Act (MTSA). The TWIC system is operated by TSA (Transportation Security Administration) and the U.S. Coast Guard. TWIC uses biometric ID cards that are tamper-proof. TWIC cards are issued to every worker and every ship crew member who has access to the restricted port areas or ships for access control. These include port workers, truck drivers, port employees, etc. To date, it is estimated that more than 1.2 million cards have been issued.

An applicant for a TWIC card is required to submit his or her career history, biometric data such as finger prints, and digital photo, and to pass the examination conducted by TSA. The examination includes cross-checking with these data bases.

① Crime history records

② Whether he or she has US citizenship or working visa

③ Terrorist list

The registration fee for the TWIC is US$ 132.5, and it is valid for five years.

ii) Progress of the implementation

The TWIC registration was first introduced at the Port of Wilmington, Delaware, in October 2007. This system was planned to be implemented on a full scale on April 15, 2009. Since then, no one has been allowed to enter the security areas by himself or herself without holding a TWIC card.

As of the end of 2008, approximately 800,000 people have registered with the TWIC system and approximately 600,000 people have already obtained TWIC cards issued.

As of November 2008, applications for the TWIC registration are accepted at 163 ports, and the TWIC system is implemented at half of all ports.

iii) Issues

The following issues concerning legal, technical, and operational aspects of TWIC have been pointed out.

① Legal aspect

The introduction of TWIC was decided in January 2007, and registration commenced in October 2007, as mentioned above. Nevertheless, legislative arrangements for card readers are yet to be made. Until now, it seems that 15 types of reader have been certified as TWIC readers. As the demand for them will increase when the system is implemented on a full scale, the manufacturers will develop more types of reader.

② Technical aspect

The compatibility of TWIC with the existing entry/exit control systems used in various facilities is pointed out as an issue. DHS is considering remodeling, or adding necessary functions to, existing equipment to accommodate TWIC, as well as introducing new equipment. However, it involves some technical improvements. Furthermore, if the TWIC system is made compatible with cargo control systems (e.g., container control system), it will make the port operation more efficient, e.g., making the time of trailer trucks passing through the gate shorter. Thus, it seems to be necessary that the compatibility of TWIC with the cargo control system of each port be further considered.

③ Operational aspect

There is a concern that the implementation of this system may adversely affect physical distribution, e.g., with respect to compatibility of cargo control systems, as mentioned in Technical aspect. There are issues of TWIC's compatibility with entry/exit control systems for trailer trucks and smooth control of concurrent entries/exits of a great many shift workers, which leads to questions of locations and number of access control gates to be placed. US authorities are operating the TWIC system on a trial basis in cooperation with the Ports of New York, New Jersey, Long Beach, Los Angeles and Baltimore to address these issues.

Table 5.12-1 Comparison of entry/exit control of various countries

	Japan: PS card	USA: TWIC	Belgium: Alfa Pass	Netherland: PorKey	UK: RHIDES
Covered ports	Yokohama, Kobe, Nagoya, Kitakyushu, Hakata (at present)	Sea ports in the United Situations	Antwerp, Zeebrugge	Rotterdam	Felixstowe, London, Thames
Issued by:	Ministry of Land, Infrastructure, Transport and Tourism	US DHS	Private company: a joint company of port businesses	Private company: owned by the Port Industry Association	Private company: supported by the government
Issued to:	Truck drivers, port carriers	Single visitors to restricted port areas or ships	Regular visitors to ports and their employers	Regular visitors to ports and their employers	Truck carriers and their drivers
Information on the card	Name, face photo, ID number, name of company, expiry date, biometric information	Name, face photo, ID number, expiry date, finger prints	Name, face photo, ID number, name of company, expiry after 5 years, finger prints	Name, face photo, ID number, name of company, (expiry date unclear), palm print	Name, face photo, ID number, nationality, name of company, expiry after 3 years, palm print
Issuance process	Via employing businesses	To individuals	Employing businesses make applications, and individuals' biometric information is registered	Employing businesses make applications, and individuals' biometric information is registered	Employing businesses make applications, and individuals' biometric information is registered

Prepared by Project Team from the materials of MLIT and International Association of Ports and Harbours

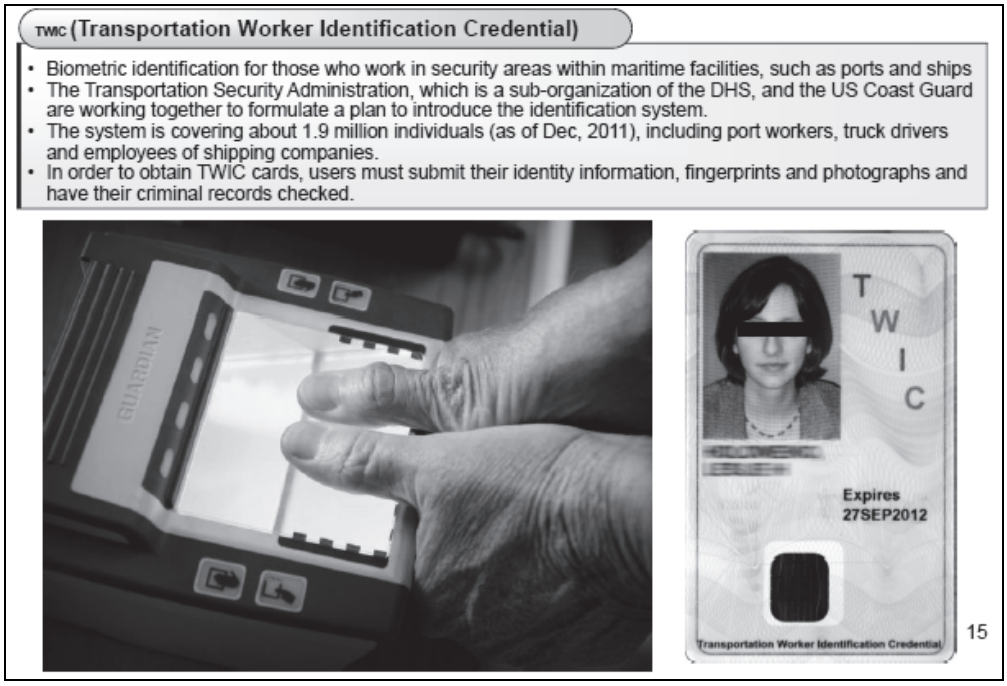


Figure 5.12-9 Example of PS card authentication in the United Situations

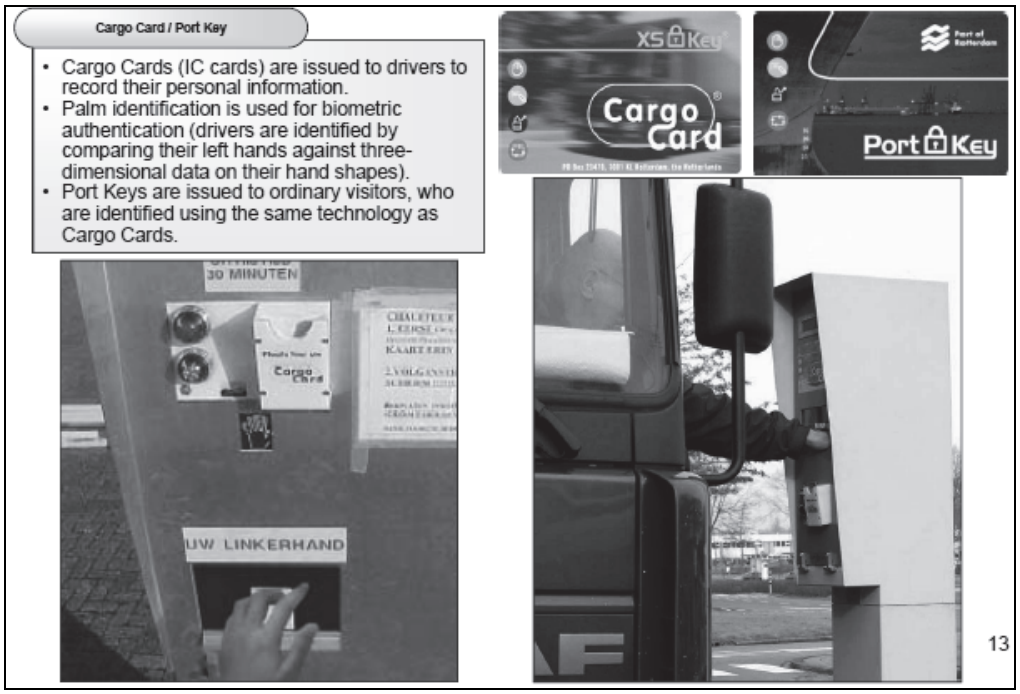


Figure 5.12-10 Example of authentication system in the Netherland

5.12.4 Navigation safety

(1) Tug boats

PAS owns tug boats of 1-100 HP, 2-800 HP, 1-800 HP and 1-900HP. They are very old and the eldest is 43 years.

Normally, container ships are attended by two tug boats for cargo ships. One tug boat is deployed on standby beside a passenger ship which has thrusters. Objective ships for tug boats attendance are container ships, general cargo ships, bulk cargo ships, passenger ships and tankers which berth at two oil terminals located outside the port. The maximum number of tug boats required in the port is estimated at 6 in case the following ships need tug boats simultaneously; two tug boats for one ship entering the port among such ship as container, cargo or passenger and two tug boats for each tanker.

Sometime tug boats are broken down due mainly to their age. Even the newest is 13 years old as shown in Table 1. The broken tug boats are repaired on the slip way in the port. The horse power of tug boats is reduced far below the nominal hose power due to the age of them though they are repaired. Shipping companies sometime claim the low horse power of the tug boats.

The port should be equipped with proper machinery in order to provide the safe and reliable port management and operation for customers. From this point of view, it is required to replace the tug boats with new one at appropriate time. PAS owns one tug boat with the age of 10s, two of 20s and two of 30s and over. On the other hand, one tug boat with horse power of 3,200 is expected to be purchased under the on-going multi-purpose terminal project.

In terms of the number of tug boats, the required 6 tug boats can be prepared including the brand new tug boat for multi-purpose terminal. However, it is still required to overcome insufficiency of the horse power by aging. It is recommended to replace tug boats of older than 30 years with new ones as soon as possible. Appropriate tug boats replacement program should be formulated taking into account the age of tug boats.

(2) Navigational aid

In accordance with the regulation, pilotage is compulsory for foreign vessels when entering and

leaving the port. An anchorage area cum pilot station is located about 2.3 km off the harbor entrance.

The port can provide 5 tug boats. Two tug boats attend a vessel without bow thruster for berthing and one tug boat for a vessel with thrusters.

In the past, ship collisions between cargo ships and fishing boats occasionally occurred but currently such accidents are very rare.

Before the completion of a bridge to Koh Pos Island over the South Channel, vessels navigated through both the North Channel (10.5 m deep, 125 m wide) and the South Channel (8.5 m deep). After the completion of the bridge in the year 2011, a vessel which is larger than 2,000 DWT and requires pilotage navigates the North Channel. The reasons why the South Channel is avoided are as follow;

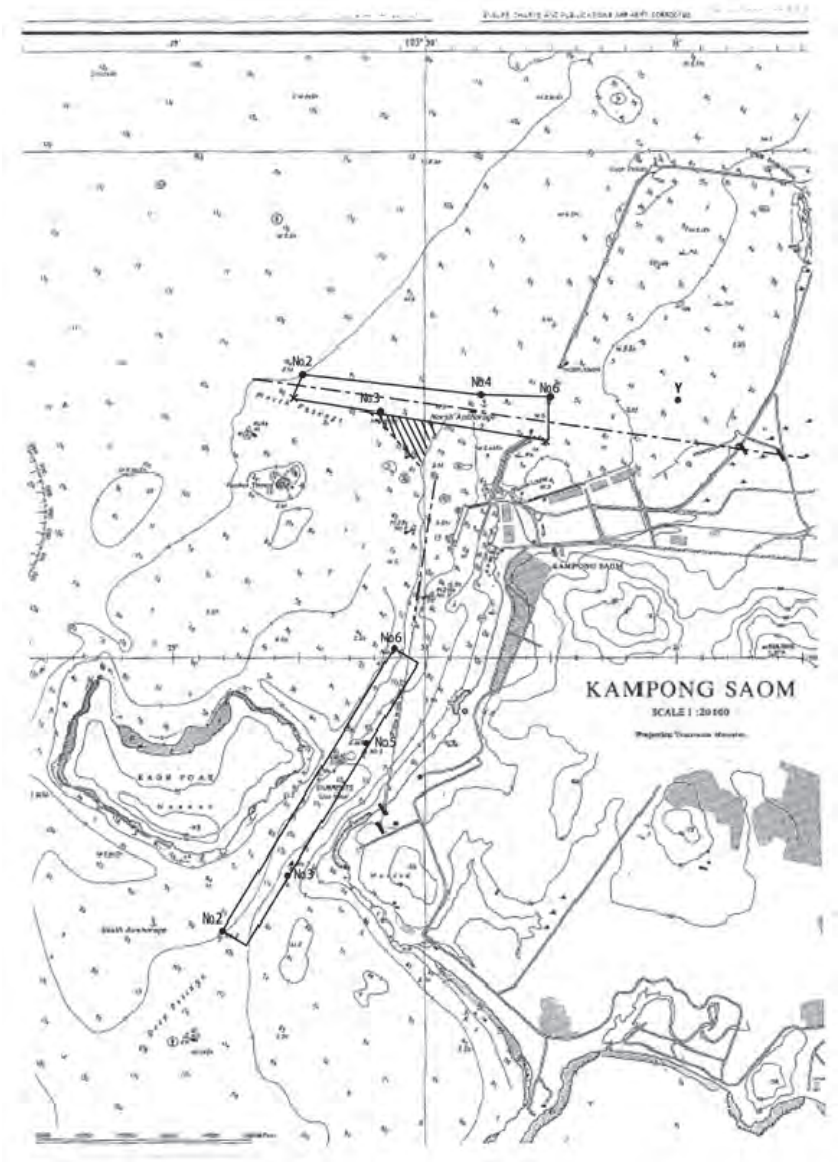
- The clearance underneath the bridge is estimated at only 28 m although the bridge was designed to maintain a clearance of 32m. Due to the curved configuration of the bottom of bridge beam, the minimum clearance is supposed to be smaller than claimed height of 28 m but it is not clearly known. This inexact clearance height causes anxiety for pilots navigating the South Channel.
- The alignment of the South Channel meanders due to the existence of shallow areas. Therefore it is hard to see navigation buoys ahead which makes navigation difficult.
- The South Channel is equipped with 5 buoys and the North Channel with 7 buoys. As explained above, the buoys in the South Channel which are no longer needed are planned to be reused in the North Channel as spares (see Figure 5.12-1).

The buoys are sometime replaced for maintenance. In that replacement work, the location of the buoy changes from the original position, however, it is hard to know the exact location of the replaced buoy. This could potentially jeopardize safe navigation.

In order to secure the safety of navigation, in particular during the evening, foggy days and heavy rain days, it is suggested to provide two leading lights on the land in the same direction as the alignment of the North Channel and the channel approaching to the old jetty from the North Channel. Installation of a lighthouse or a buoy at Dek Koul Island will be an effective measure for securing the safe navigation during severe meteorological conditions. Repair of the entrance light at the tip of the South breakwater is also needed to ensure safe navigation.

Dredging works for increasing depth in the triangular shaped area at the corner of the alignment of the North Channel and the alignment of the channel toward the old jetty will be recommended. This works will create a gentle bend in the channel toward the Old Jetty which will secure safe navigation, in particular for passenger ships, when entering. As indicated above, it is also required to install leading lights on the land in the same direction as the alignment of the channel toward the old jetty for the safety of navigation.

All requirements for safe navigation are illustrated in Figure 5.12-11.



Source: PAS (Harbor Master)

Figure 5.12-11 Layout of existing and proposed navigational aids