4.8.4 Berth Allocation Plan for Domestic Containers and Conventional Cargoes at Tanjung Priok Terminal

(1) Petroleum Products to be Allocated off North Kalibaru

The volumes of petroleum products to be transferred to a new petroleum terminal and the respective cargo-handling productivities (CHC) in 2030 have been estimated as 4.4 million MT. Its breakdown is shown as follows:

	Volume		CHC	
- International Petroleum products (mostly import):	2,217,000	MT	700	MT/hr
- Domestic petroleum products (mostly unload):	1,918,000	MT	500	MT/hr
- Lubricant oil:	177,000	MT	100	MT/hr
Total:	4,351,000	MT		

To handle the above volume for PERTAMINA, two berths are sufficient. It is said that petroleum dealers other than PERTAMINA are requesting to set up their terminals. Taking account of the request, four berths have been planned as follows:

- Total berth length: 270 m/berth x 4 berths =1,080m
- Water depth: -15.5m

(2) Dry Bulk Cargoes Allocated off Kalibaru

The volumes of dusty dry bulk cargoes to be transferred to a new dry bulk terminal and the respective cargo-handling productivities (CHC) in 2030 have been estimated as 18.4 million MT. Its breakdown is shown as follows:

	Volume		CHC	
- Clinker (mostly export):	3,217,000	MT	1,100	MT/hr
- Gypsum (mostly import) :	1,448,000	MT	700	MT/hr
- Unloaded Coal (mostly Intra-Indonesia):	7,611,000	MT	600	MT/hr
- Unloaded Sand (Intra-Indonesia):	7,279,000	MT	300	MT/hr
Total:	18,395,000	MT		

To handle the above volume, one berth for ocean-going bulkers and six barge berths have been planned as follows:

One berth for Panamax-type bulkers:
- Berth length: 275 m
- Water depth: -15 m

Two berths for coal barges:
- Total berth length: 240 m
- Water depth: -6 m

Four berths for sand barges:
- Total berth length: 400 m
- Water depth: -3 m

Thus, a total berth length has been estimated to be 915 m. To ensure flexible berthing, dry bulk berth has been planned as a continuous berth with the same water depth. In addition, petroleum terminal and container terminal have been planned to be located on the west and on the east of the bulk terminal respectively with the same water depth of 15.5m.

Thus, so as to facilitate possible maintenance dredging and ensure safe maneuvering operations of vessels, the same water depth of 15.5 m has been adopted in the bulk terminal planning throughout the berth line.

As to cargo-handling system on dockside, cargoes exported or imported including clinker and gypsum have been supposed to be loaded or unloaded by ship cranes equipped with ocean-going bulkers such as Handy-max bulkers. Some Handy-max bulkers are equipped with four units of deck cranes of 30 tons lifting capacity.

On the other hand, cargoes transported by barges such as coal and sand have been supposed to be unloaded by using crawler-crane typed tower-cranes equipped with grab bucket and outriggers. At least 30 tons lifting capacity seems to be required by taking account of weights of both cargo and grab, and beam length (around 15m).

(3) Domestic Containers Allocated within the Existing Conventional Wharves

The volume of domestic containers has been estimated to be 4.4 million TEUs in 2030.

To handle a large amount of domestic containers in 2030, the Third Wharf of Tanjung Priok Terminal has been redeveloped as a container terminal specializing in domestic containers except for MAL terminal in addition to converting MTI and JICT II to domestic container terminals.

Berth length for domestic containers is shown as follows

- The third Wharf:	1,800	m	(West: 750m, East: 1,050m)
- MTI:	410	m	
- JICT II:	520	m	
Total	2,730	m	

Total yard area and average width are 45 ha in total and 170 m, respectively. Around 800 ground slots in TEUS per berth could be placed on condition of using RTG system and 5 high stacking. Thus, stacking capacity is equivalent to loading and unloading container amount of 2 – 3 vessels. Taking account that domestic containers do not need customs clearance and weekly service allocation ratio mentioned below, the amount of GSLs is judged to be sufficient for receiving forecast volumes of domestic containers in 2030.

Representative vessel size has been assumed to be 170 m in LOA and 25 m in beam length and hence unit berth length has been estimated as 200 m. Berth number has been estimated as 14 berths.

To ensure efficient container handling, two units of container gantry cranes per berth have been planned to be introduced, totaling 18 units of quayside cranes. Container-handling conditions used to estimate container-handling capacity per berth are summarized as follows:

- Container-handling productivity per vessel:	52	boxes/hr
- TEU/box ratio:	1.2	
- Average lot (Unloading + Loading):	1,200	TEUs/vessel
- Average berthing hours:	19	hr
- Number of container gantry cranes per berth :	2	units
- Weekly service allocation ratio:	0.73	

Container-handling capacity per berth has been estimated as follows;

- 1,200 TEUs/vessel x 365 vessels x 0.73 vessels /year = 320,000 TEUs/year/berth

Thus, annual capacity of handling domestic containers has been estimated as follows:

- 320,000 TEUs/berth/year x 2,730 m/200 = 4.4 million TEUs /year

(4) Conventional Cargoes Allocated at the Existing Conventional Wharves

The total volume of conventional cargoes to be handled at the First Wharf, the Second Wharf and Island (Nusantara) Wharf excluding dusty cargoes to be transferred to a new berth off North Kalibaru has been estimated as 16.3 million MT. To ensure efficient cargo handling, sufficient units of mobile harbor cranes (tower cranes) have been planned to be introduced. Together with ship cranes, it is preferable to prepare 2 or 3 gangs per vessel in stevedoring operations.

For handling conventional general cargoes, the following berths are recognized to be available (Japat River Wharf has not been counted):

- Island Wharf: 14 berths,
- First Wharf: 13 berths (MTI berths are excluded)
- Second Wharf: 12 berths (JICT II berths are excluded)

Actual record of conventional cargo volumes in 2009 and forecast cargo volumes by conventional cargo item in 2030 are shown in Table 4.8-1 and Table 4.8-2, respectively.

(5) Cargoes handled at Berths for Exclusive Use for Specified Cargoes

The total volume of conventional cargoes to be handled at berths for exclusive use for specified cargoes has been estimated as 10.1 million MT. Main berths are as follows:

- Bogasari (Sarpindo) berths for wheat and wheat bran
- Pertamina berth for LPG
- Car Terminal berth
- Bulk cement berth at the West Side of the Second Wharf
- MEDCO berth for High Speed Oil
- DKP berth for Chemical Products

(6) Imported and Exported Vehicles

Imported and exported vehicles are currently handled at the Car Terminal at the east end of the existing terminal. To meet the future demand the following berths and car storage yards are required (see Section 4.2.1).

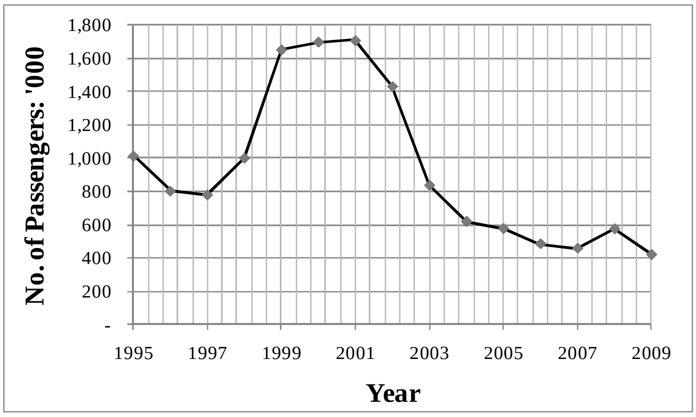
Two berths for vehicles:

- Total berth length:	460	m
- Water depth:	-12	m
- Required storage area:	128,000	sq. m

Currently one berth with a length of 220m and a yard of 156,000 sq. m are available. Thus one berth with a length of 240m and a yard with an area of 28,000 sq. m will be additionally required in the stage of 2030.

(7) Passengers

Currently, a passenger terminal is placed behind Berth No.106 at the east side of the First Wharf. The number of passengers passing through the passenger terminal at Tanjung Priok Terminal has sharply dropped in the past decade. In 2009, the number of passengers fell to 400,000, less than one fourth of that in 1999 (see Figure 4.8-4). The current passenger terminal is placed near the bus terminal and Jakarta Railway Station, which enables so-called one-ticket services. Parking lot is placed in front of the passenger terminal. Thus, there seems to be no need to have any improvement or transfer plan for the passenger terminal for the time being.



Source: The statistical data from Pelindo II

Figure 4.8-4 Historical Trend of the Number of Passengers through Passenger Terminal

4.8.5 Comprehensive Movements of Cargoes and Ships within Tanjung Priok Terminal in 2030

To reveal movements of cargoes and ship in 2030 containing international and domestic containers, conventional general cargoes, petroleum products, and dry bulk cargoes and to estimate a service level of the port, a computer simulation has been conducted. In the simulation, navigation channel traffic capacity and off-shore waiting conditions have also been checked.

The simulation has been conducted assuming that 48.1 million MT of conventional cargoes and containers of 10.3 million TEUs containing international containers of 5.9 million TEUs and domestic containers of 4.4 million TEUs will be handled at Tanjung Priok Terminal, whereas 7.5 million TEUs of containers will be handled at the new Cilamaya Terminal as proposed in this study. The entire volume of cargoes to be handled at Tanjung Priok Terminal in 2030 is summarized as follows (see Table 4.7-16 and Table 4.8-2):

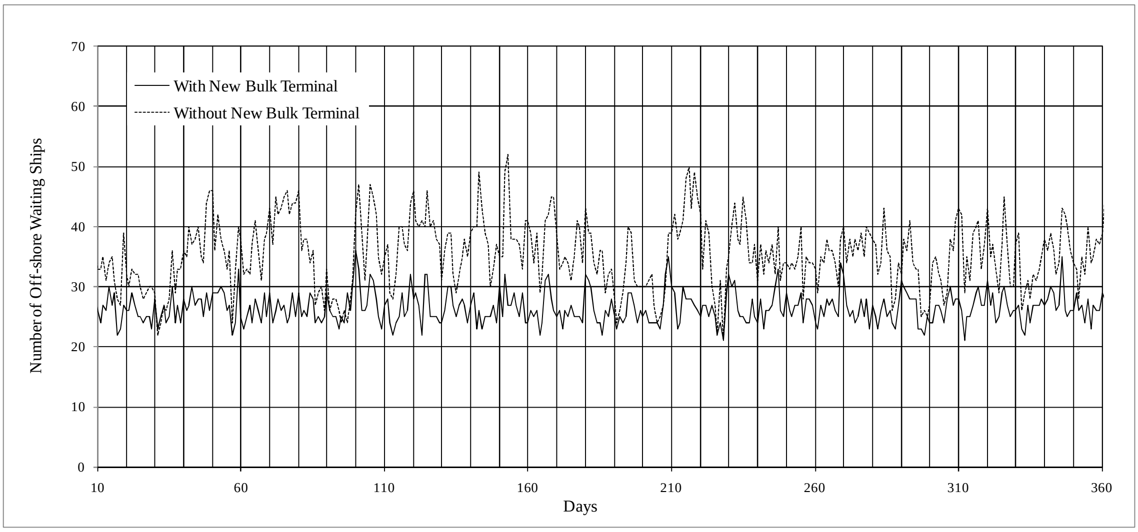
Containers:			
- International containers:		5.9	million TEUs
- Domestic containers:		4.4	million TEUs
	Sub-total	10.3	million TEUs
Conventional Cargoes:			
- Petroleum products to be transferred to the new terminal:		4.4	million MT
- Dry Bulk Cargoes to be transferred to the new terminal:		18.4	million MT
	Sub-total	22.8	million MT
Conventional Cargoes handled at Berths for Public Use:		16.3	million MT
- Cargoes handled at Berths for Exclusive Use:		10.1	million MT
	Sub-total	26.4	million MT
	Grand total:	49.2	million MT

The existing West Access Channel has also been assumed to be improved by deepening and widening to ensure two-way traffic as proposed in this study.

The resulting service level and average off-shore waiting time per vessel there have been revealed to be 14% and 3 hours, respectively, with total vessel calls of around 21,000 through the West Channel in 2030. The service level of 14% is considered to be satisfactory as mentioned in Section "4.4.3".

On the other hand, if only the new container terminal is developed and the new bulk terminal is not developed, in other words, all the conventional cargo is handled solely within the existing terminal area, the resulting service level and average off-shore waiting time per vessel in the West Area is calculated at 27% and 7 hours, respectively with total vessel calls of around 21,000 through the West Channel in 2030. The service level of 27% exceeds the appropriate level of around 10%. Thus, New Bulk Terminal is expected to contribute not only to the reduction of environmental burden on urban areas adjacent Tanjung Priok Terminal but also to upgrading the port service level in terms of less off-shore ship waiting.

Ship waiting conditions at the entrance of the West Access Channel throughout one year in 2030 in the above two cases are shown Figure 4.8-5.



Source: Made by the Study Team

Figure 4.8-5 Number of Off-Shore Waiting Ships in Tanjung Priok Terminal in 2030

4.8.6 Anchorage Layout Plan off Tanjung Priok Terminal in 2030

When making an anchorage layout plan, the following anchorage categories have been used by taking account of the current ones on the sea chart.

- Petroleum tanker
- Commercial vessels
- Vessel laden with hazardous cargoes
- Barges and tugboat (shallow draft)
- Quarantine

Required radius of anchorage circle space per vessel has been computed by the following formula in the condition of anchorage with a single anchor:

Radius (m) = Ship length (LOA) + 6 x Water depth (m)

Using the record of vessels calling at Tanjung Priok Terminal in 2009, average radiuses of anchorage for commercial vessels and barges have been estimated 250 m and 150 m, respectively.

On the other hand, the required anchorage numbers by ship category in terms of anchorage circle have been estimated by using the above-mentioned computer simulation. The resulting figures of the numbers of off-shore ship waiting by ship category in the condition of 95% of non-excess probability which is equivalent to the required anchorage numbers are as follows:

- Commercial vessels: 29
- Petroleum tankers: 1

- Barges: 5

The required anchorage space has been arranged in the waters area off Tanjung Priok Terminal along the planned access channel. When making the layout plan for anchorage, the installation conditions of submerged materials such as petroleum pipelines and telecommunication cables have been also considered. The waters area off Tanjung Priok Terminal has sufficient space for anchorage (see Figure 4.9.4).

4.9 Master Plan of Tanjung Priok Port

4.9.1 Requirements for the Master Plan by Law No. 17

Tanjung Priok Port as a public port is administrated by its port authority which was established in December of 2010 by Law of Republic of Indonesia No.17 Year 2008. Its jurisdictional area is located along the northern coast extending from Banten Province, DKI Jakarta and West Java Province.

Tanjung Priok Port must have its Port Master Plan stipulated by the Minister of Transport in compliance with the New Shipping Law No.17. The Master Plan of Tanjung Priok Port in compliance with the Law must fulfill the following requirements.

- National Territory Spatial Layout Plan,
- Provincial Spatial Layout Plan
- Regency Area Spatial Layout Plan
  Harmony and Balance with other related activities at the port
  Technical, economic and environmental feasibility
  Safe and secure ship traffic

From the above points of view, when drafting the Master Plan for the Port Development in this JICA Study, the requirements by the Law No. 17 have been taken into account.

4.9.2 Principal Port Development Plans

In this study, the two principal port development plans have been proposed at Tanjung Priok and at Cilamaya as shown in Sections 4.7 and 4.8 and as summarized below.

(1) Tanjung Priok Terminal

New International Container Terminal

Site: Off North Kalibaru

- Berth length:	1,200	m
- Water depth:	-15.5	m
- Terminal area:	77	ha
- Container-handling capacity:	1.9	million TEUs per annum

New Petroleum Terminal

Site: Off North Kalibaru

- Berth length:	1,080	m
- Water depth:	-15.5	m
- Terminal area:	109	ha

New Bulk Terminal

Site: Off North Kalibaru

- Berth length:	915	m
- Water depth:	-15.5	m
- Terminal area:	18	ha

New Access Bridge to off North Kalibaru

- Length:	1,100	m

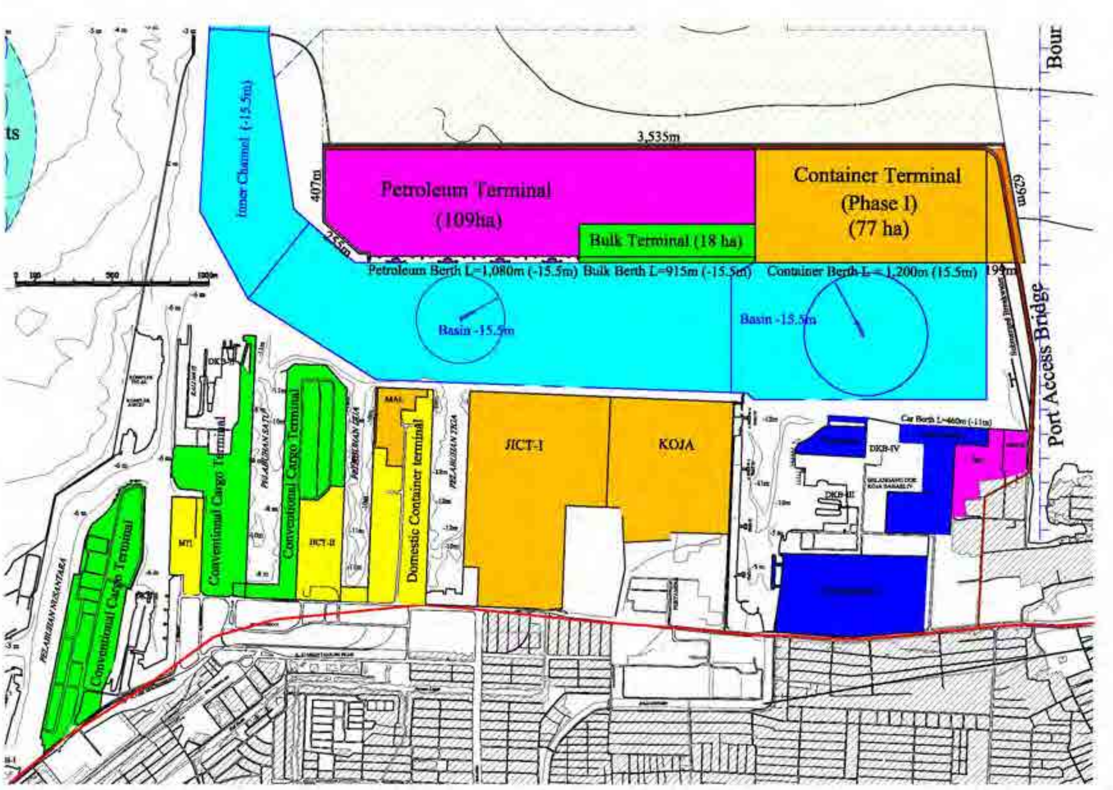
Conversion of the conventional wharves to terminals specialized for domestic containers

- The Third Wharf from usage in mixture with conventional cargo (except for MAL)
- JICT II Terminal from the international container terminal
- MTI Terminal from the international container terminal

Expansion of the Car Terminal

- Berth length:	240	m
- Water depth:	-12	m
- Terminal area:	3	ha

Facility layout plan of Tanjung Priok Terminal is shown in Figure 4.9-1. The figure includes the redevelopment plan for domestic containers and conventional cargoes within the existing Tanjung Priok Terminal and the development plan of the new petroleum and bulk terminals off North Kalibaru in the stage of the Master Plan. International container terminals comprising JCT and the new terminal off North Kalibaru are also shown in the figure.



Legend

- Domestic Containers
- Public Use for Conventional Cargoes (Existing Wharves and North Kalibaru
- Exclusive Use for Specified Cargoes (Bogasari Terminal and Car Terminal)
- Exclusive Use for Specified Cargoes (DKP, MEDCO, Petroleum Terminal at North Kalibaru)
- International Containers (JICT, KOJA, MAL, North Kalibaru)

Source: Made by the Study Team

Figure 4.9-1 Facility Layout Plan of Tanjung Priok Terminal in the Stage of Master Plan (2030)

(2) Cilamaya Terminal (see Figure 4.9-2)

New International Container Terminal

Site: Off Karawan Coast

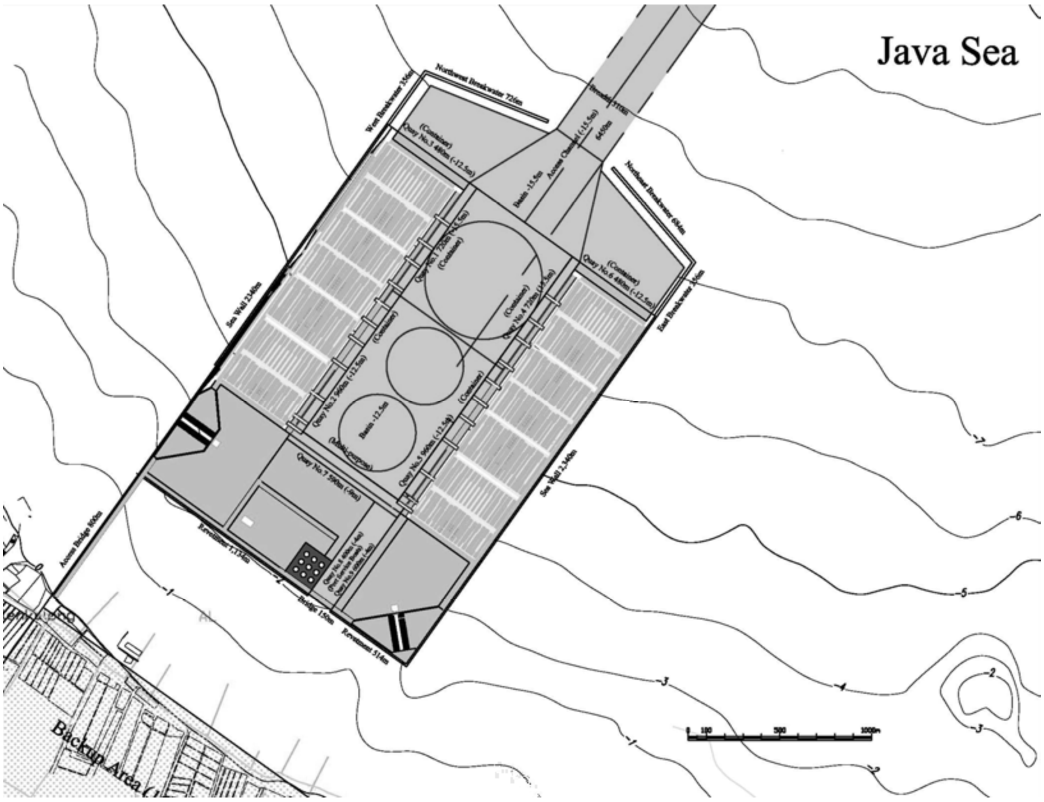
- Berth length: 4,920 m
- Water depth: -9 ～ -15.5 m
- Terminal area: 290 ha
- Container-handling capacity: 7.5 million TEUs per annum

New Access Bridge to the New Terminal

- Length: 800 m

New Access Road from Karawan to the New Terminal

- Length: 28.6 km



Source: Made by the Study Team

Figure 4.9-2 Facility Layout Plan of a New Container Terminal at Cilamaya in Master Plan (2030)

4.9.3 Development Directions of Marine Terminals under Tanjung Priok Port other than Tanjung Priok Terminal and Cilamaya Terminal

(1) The Existing and Potential Public Terminals other than Tanjung Priok Terminal and Cilamaya Terminal

In addition to Tanjung Priok Terminal and the newly proposed Cilamaya Terminal, the following public terminals are also under the umbrella of Tanjung Priok Port:

- Sunda Kelapa Terminal in DKI Jakarta
- Patimban Terminal in Kabupaten Indramayu (to be constructed)
- Bojonegara Terminal in Banten Province

In addition to the above three existing terminals, the following potential terminals might join as public terminals:

- Marunda in DKI Jakarta
- Marunda in Kabupaten Bekesi
- Tarumajaya in Kabupaten Bekesi

(2) Various Activities along the Coast of the Greater Jakarta Metropolitan Area

The coastal area along the Greater Jakarta Metropolitan Area is already densely used on both the land and sea sides.

On the land, within the JABODETABEK area there are densely-populated areas and the serious traffic congestion is getting worse year by year due to the lack of a mass transport system and a poor road network.

On the other hand, Jakarta Bay along the JABODETABEK area is densely used for marine terminals including Tanjung Priok Terminal, mooring buoys for discharging oil and gas towards land, navigational ways, submerged pipelines for petroleum, submerged cables for telecommunication. The sea is also used for fishery including net and rod fishing, and shell cultivation all over the waters. So as to sustain such fishery, fishing villages are found almost all over the coast. Some of the coast is designated as a protected mangrove forest so as to protect against coastal erosion and sea waves.

Outside the JABODETABEK area, fertile rice fields are spread all over. Along toll roads, a lot of industrial areas are placed. Even along coast lines fish ponds are found and thus it is almost impossible to find empty or idle space.

The waters outside the JABODETABEK area are also used for mooring buoys or platforms for exploiting oil and gas, navigational ways, submerged pipelines for petroleum, submerged cables for telecommunication. The sea is also used for fishery all over the waters. So as to sustain such fishery, fishing villages are placed mostly along the river mouths. To some extent, the coast is designated as a protected forest.

(3) Proposed Principle When Making Port Development Plan

From the standpoints mentioned in the above Paragraphs “(2)” and “(3), the following principles when making a port development plan have been proposed:

To make the most of spatial resources

The coastal area along the Greater Jakarta Metropolitan Area is already densely used and space is limited and valuable. Hence it is essential to make the most of such spatial resources.

To concentrate financial resources on a limited port development

It is essential to concentrate financial resources on limited port development so as to save financial resources and to avoid duplicated investment

To coordinate other activities to share limited spatial resources

It is essential to coordinate properly with other various activities to share limited space so as to make the most of spatial resources

To make adequate functional allotment among marine terminal under the umbrella of Tanjung Priok Port

It is essential to make adequate functional allotment among marine terminal under the umbrella of Tanjung Priok Port so as to avoid duplicated port investment and to ensure smooth coordination with non-port related activities as a whole in the port field.

(4) Development Directions of Marine Terminals under Tanjung Priok Port

The following development directions of marine terminals under Tanjung Priok Port have been proposed:

1) Sunda Kelapa Terminal in DKI Jakarta

Sunda Kelapa Terminal has a long history, and has undergone some significant changes. Currently, the terminal is enclosed by the urban area of Jakarta, and hence suffers from urban traffic congestion. In addition, the water depth of the terminal is too shallow for modern commercial vessels.

Thus, as already planned, it is recommendable to convert it to a recreation terminal with perhaps a marine museum to exhibit its history.

2) Bojonegara Terminal in Banten Province

Though Bojonegara Terminal was originally developed as an international container port, it is planned to be converted to a petroleum terminal for a refinery to be set up behind the terminal. The existing berth has only a length of 100m and currently used for unloading coal which is only port facility within its compound. Sand and coal are currently loaded and unloaded along the waterfront within its compound.

The conversion of the terminal to a petroleum terminal and the usage of the existing berth for multi-purpose terminal are considered to be adequate to serve the west of Banten Province rather than to serve for Jakarta Metropolis taking account of its geographical location.

3) Marunda in DKI Jakarta, Marunda and Tarumajaya in Kabupaten Bekesi

These three potential terminals will be suitable to be set up as shallow terminals rather than deep-sea terminals. They are expected to serve for barges in a sea-transport network involving Tanjung Priok Terminal.

As to dry bulk cargoes such as coal and sand, these potential terminals are expected to alleviate the current congestion in Tanjung Priok Terminal by receiving these cargoes. As to containers, it is considered that to transport containers by barge between Tanjung Priok Terminal and these potential shallow terminals could be viable by taking account of serious road congestion in the JABODETABEK area. Needless to say, it is essential to develop road network behind their hinterland as a precondition of these shallow terminal developments.

4.9.4 Port-Related Waters Area Use Plan of Tanjung Priok Port

Port-related waters use plan of Tanjung Priok Port has been drafted in Jakarta Bay and off Carawan Coast in the vicinity of the project site at Cilamaya.

(1) Waters Area Use Plan in Jakarta Bay

Port-related waters use plan in Jakarta Bay has been drafted based on the development plan of Tanjung Priok Terminal and taking account of the three potential public terminals along the coast of Marunda and Tarumajaya as shown in Figure 4.9-4.

When drafting the waters use plan, the harmonization with JABODETABEK spatial plan based on the Presidential Regulation No 54/2008 has been considered. According to the spatial plan, the categories of the waters extending from off the existing Tanjung Priok Terminal to the left bank of Caran River, are designated as P3 and P4.

According to its legend the aims of those zones are as follows:

- Zone P3: Zone with a characteristic functioning to support any zone with a high use intensity and high accessibility level, Utilization will aim at maintaining the functions of Zone B1
- Zone P4: Zone with a characteristic of low environmental support capacity, Utilization will aim at maintaining the functions of Zone B2 and Zone B4
- B1: a. Urban residential area,

b. Trade service area
c. Light industry without pollution

- B2:
  a. Rural residential area,
  b. Agriculture
  c. Labor-oriented industry
- B4:
  a. Low densely populated residential area,
  b. Wet and dry agriculture
  c. Plantation, fishery, agro-industry

On the other hand, the category of the waters extending from the right bank of Caran River to Muara Genbong is designated as P1 with the following aim:

- Zone P1: Zone P1: Zone with a characteristic functioning to prevent abrasion, seawater intrusion, sea pollution and deterioration, Utilization will aim at maintaining the functions of Zone N1
- N1: Protected forest

According to the above zone designation, Tanjung Priok Terminal and the potential terminal of DKI Marunda in DKI Jakarta belong to Zone P3.On the other hand, the potential terminals of off Marunda Center and Tarumajaya in Kabupaten Bekesi belong to Zone P4.

Source: Made by the Study Team

Figure 4.9-3 JABODETABEK Spatial Plan based on the Presidential Regulation No 54/2008

Source: Made by the Study Team

Figure 4.9-4 Port-Related Waters Area Use Plan in Jakarta Bay

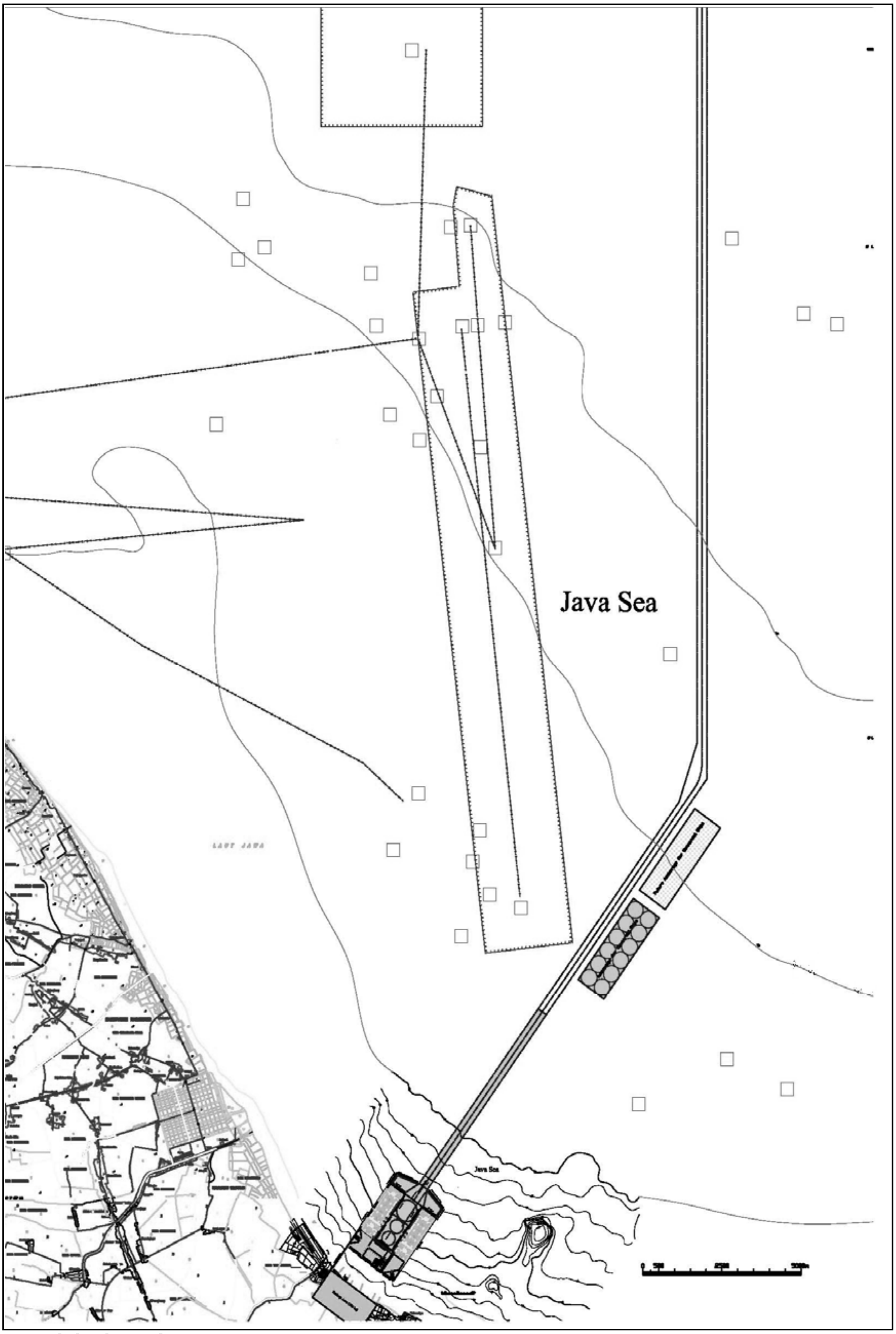
(2) Waters Area Use Plan off Karawan Coast

Port-related waters use plan off Karawan Coast in the vicinity of the planned new container terminal at Cilamaya is shown in Figure 4.9-5.

As to the harmonization with the spatial plans of local governments containing those of the West Java Province and Regency of Karawan, any waters use plans have not been made.

On the other hand, waters area in front of “Zone of Protected Forest” designated by the Ministry of Forestry corresponding to Zone N1 in case of JABODETABEK spatial plan mentioned in the former clause (1) in the range of several hundred meters, development activities are prohibited in principle. On the coast in the vicinity of Cilamaya Terminal “Zone of Protected Forest” is not designated.

According to the regulation stipulated by DGST, for port-related activities such as installation of access channel and anchorage, at least one km needs to be kept from submerged pipelines of oil and gas. The regulation has been taken into account when drafting the waters area use plan of off Cilamaya Terminal.



Source: Made by the Study Team

Figure 4.9-5 Port-Related Waters Area Use Plan in Karawan Coast

4.9.5 Compliance with the Requirements Stipulated in Law No. 17

Law No.17 stipulates that a Port Master Plan shall cover Land Area Allotment Plan and Water Area Allotment Plan based on requirement criteria for main facilities and supporting facilities (Article 74, (1) ~ (3)).

In addition, the law also stipulates that the Port Master Plan shall be accompanied with Work Environment Area and Interest Environment Area with geographical coordinates to ensure port activities (Article 75, (1) and (2)).

Work Environment Area consists of land area used for activities of main facilities and supporting facilities and water area used for activities of shipping lanes, anchorages, etc (Article 75 (3)).

On the other hand, Interest Environment Area is the port waters beyond the waters of Port Work Environment Area used for shipping lanes, long-term port development, etc (Article 75 (4)).

Figure 4.9-1 and Figure 4.9-2 showing the facility layout plans include Land Area Allotment Plan and Water Are Allotment Plan.

Figure 4.9-4 and Figure 4.9-5 showing the port-related waters area use plans include both Work Environment Area (colored) and Interest Environment Area (lighter shade).

CHAPTER 5 PRELIMINARY DESIGN, COST ESTIMATE AND DEVELOPMENT SCHEDULE

5.1 NEW CONTAINER TERMINAL DEVELOPMENT

5.1.1 Breakwater Construction for Candidate Terminal Sites

(1) Design Criteria for Breakwater

1) Harbour Calmness Analysis for Breakwater Layout Determination

Breakwater layouts are determined so that the probability of non-exceeding occurrence of the threshold wave height for cargo handling for basins in front of mooring facilities shall be achieved for 97.5% or more days of the year. The threshold wave height is determined as 0.5m considering reference values of threshold wave height for cargo handling works not affected by swell or long period waves [Technical Standards and Commentaries for Port and Harbour Facilities in Japan, 2002, PART III, Chapter 3, [3], Table 3.2.3]. For verification of the above mentioned conditions inside the harbour, calmness analysis was conducted using ordinary wave conditions.

2) Design Waves for Breakwater Design

For breakwater design of features such as estimation of required mass of armour and verifications of the structural stability against the wave forces acting on the structures, peak waves of appropriate return period are employed (defined as low-occurrence waves). Design deepwater waves (peak waves) are determined based on the return period of the wave and encounter probability to the breakwater facilities, and using the wave data for off Tanjung Priok which are estimated based on the yearly peak waves of 22 years data from 1980 to 2001. Wave transformation during the propagation of waves from deepwater off Tanjung Priok as they move toward the place where the breakwater construction is proposed is calculated by the Energy Balance Equation Model Method. Design waves are chosen by the extraction of the maximum waves near the breakwater to be designed.

On the other hand, for breakwater performance evaluations such as overtopping wave rate estimation and transmitted wave height calculations, short return period waves (defined as high-occurrence waves) are employed. High-occurrence waves for this purpose are chosen referring to the results of the JICA Study 2003.

3) Tides

Mean sea level at Tanjung Priok port is used to define Zero Level (MSL=0.0m) for planning and designing of roads and railways in this Project. However, for the port facilities, the lowest low water level (LLWL) at Tanjung Priok port is defined as the Datum Level as follows. To avoid confusion, both elevations are described in this report.

HHWL	(Highest high water level)	+ 1.05 m	(0.57 m +MSL)
MHWS	(Mean high water spring)	+0.91 m	(MSL + 0.43 m)
MSL	(Mean sea level)	+0.48 m	(0.00 m)
MLLWS	(Mean low water spring)	+0.09 m	(MSL - 0.39 m)
DL	(Datum level)	0.00 m	(MSL - 0.48 m)
	(Defined as DL = LLWL: Lowest low water level)		

(2) Estimation of the Design Deepwater Waves off Tanjung Priok

Base data

Wave data off Tanjung Priok are obtained by the SMB method based on the five (5) year wind information during 1997 to 2001 observed at Cengkareng Meteorological Station of BMKG (Badan Meteorologi Klimatologi dan Geofisika).

Yearly peak waves off Tanjung Priok

The extreme high deepwater waves off Tanjung Priok port are estimated based on the existing information of yearly peak waves for the 18 years from 1980 to 1997 (1980-1997; wave hindcast by ITB, July 2000) and hindcast data from 1997 to 2001 which was estimated in the Study for Development of the Greater Jakarta Metropolitan Ports, December 2003 (hereinafter called "the 2003 JICA Study"). The Yearly peak wave heights in these 22 years (from 1980 to 2001 are summarized in below.

Table 5.1.1-1 Yearly Peak Wave Height by Wave Hindcast

	Direction / Year	W	NW	N	NE	E	Max
Wave Hindcast by existing Report (June 2000) **	1980	1.71	2.28	1.80	1.17	1.95	2.28
	1981	1.66	1.76	2.64	1.00	2.04	2.64
	1982	1.15	1.00	2.78	1.42	1.48	2.78
	1983	2.02	1.66	1.90	2.49	3.77	3.77
	1984	2.02	2.78	2.34	1.27	2.93	2.93
	1985	2.00	1.66	2.17	0.92	0.83	2.17
	1986	2.02	2.53	1.29	1.49	1.93	2.53
	1987	2.00	1.99	1.09	1.15	1.53	2.00
	1988	1.73	1.91	1.73	2.09	1.68	2.09
	1989	1.35	2.17	1.65	0.97	1.55	2.17
	1990	2.02	2.35	1.38	1.30	1.49	2.35
	1991	1.65	2.13	2.17	1.48	1.00	2.17
	1992	2.49	2.33	1.48	1.53	2.24	2.49
	1993	1.84	2.98	1.42	1.53	1.68	2.98
	1994	1.87	2.33	1.42	1.15	2.04	2.33
	1995	2.00	1.20	1.00	2.04	1.49	2.04
	1996	2.15	1.13	1.24	1.09	2.30	2.30
	1997	1.65	1.53	2.49	1.55	1.66	2.49
Tanjung Priok *	1997	2.42	2.57	1.91	2.63	2.07	2.63
	1998	2.00	2.22	1.94	1.83	1.38	2.22
	1999	2.08	1.89	1.94	2.16	1.96	2.16
	2000	2.35	2.15	1.88	1.99	1.67	2.35
	2001	1.82	2.12	1.90	1.90	1.78	2.12

Source: * The Study for Development of the Greater Jakarta Metropolitan Ports (Dec. 2003), JICA
** Studi Kelayakan Rencana Pegembangan Terminal Curah dan Petikemas Pelabuhan Tanjung Priok, Final Report, June 2000, IPC2, ITB

Estimation of Probability of Wave Height by Return Period

Based on the above data, probability of wave height by return period per wave direction off Tanjung Priok port is estimated by the Weibull distribution function as follows.

Table 5.1.1-2 Estimated Deepwater Waves per Return Period

Design Deepwater Waves and Return Period (off Tg. Priok) Unit: m

Year \ Direction	W	NW	N	NE	E	Max
5	2.32	2.70	2.46	2.24	2.64	2.95
10	2.46	2.93	2.69	2.47	2.99	3.25
20	2.59	3.14	2.90	2.69	3.34	3.55
30	2.66	3.25	3.02	2.80	3.54	3.72
50	2.74	3.39	3.15	2.94	3.79	3.94
100	2.84	3.56	3.32	3.11	4.13	4.24

Wave Period of Design Deepwater Waves (off Tg. Priok) Unit: second

Year \ Direction	W	NW	N	NE	E	Max
5	6.19	7.41	7.26	6.00	7.76	8.12
10	6.27	7.76	7.65	6.12	8.40	8.79
20	6.34	8.08	8.00	6.24	9.03	9.47
30	6.38	8.25	8.20	6.29	9.40	9.85
50	6.42	8.47	8.42	6.37	9.85	10.34
100	6.48	8.73	8.70	6.46	10.47	11.01

Return Period of Design Wave

According to the Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2009), it is advised that design waves shall be determined with consideration of the encounter probability based on the return period and life time of the structures of the port facilities.

The British standard stated that marine structures such as quay walls and jetties are normally expected to have 50 years or more working life, and docks are expected to have a 100-year life.

Encounter probability can be estimated by the following formula (refer to Technical Standards of Japan 2009 [Part II, Chapter 1, 2, (1)] and BS 6349-1: 2000 [Section 4, Figure 4]).

$$E = 1 - (1 - 1/T)^{L}$$

Where E: Encounter Probability

L: Lifetime length (Year)

T: Return Period (Year)

Considering the 50 year lifetime, the encounter probabilities according to the return period are as follows.

Table 5.1.1-3 Relations between Encounter Probability and Wave Return Period

(50 year life time)

Return Period (T)	Encounter Probability (E) %
10	99.5
30	81.6
50	63.6
100	39.5
500	9.5
1000	4.9

If a 50 year return period is selected, the design will be more economical since wave height can be reduced. However, it is recommended that the encounter probability shall be small as possible and at least less than 50%. Therefore, a 100-year return period wave is selected as the design wave, considering about a 40% encounter probability during the 50 year life time.

Design Deepwater Waves off Tanjung Priok

1) Low-occurrence waves

If the return period is 100 years, wave height and period of deepwater waves off Tanjung Priok are as follows. These waves are chosen as the deepwater waves to estimate the design waves for breakwater design.

Table 5.1.1-4 Design Deepwater Waves off Tajung Priok

(100 year return period)

Wave \ Direction	W	NW	N	NE	E	Max
Height (m)	2.84	3.56	3.32	3.11	4.13	4.24
Period (s)	6.48	8.73	8.70	6.46	10.47	11.01

2) High-occurrence waves

Another aspect of the facility design, wave over-topping of the breakwater and revetments and transmitted waves through the breakwaters shall be discussed against the high waves that frequently occur. For this purpose, a 1 year return period wave is chosen as the high-occurrence design wave. Referring to the results of the JICA Study 2003, the following 1 year return period waves are given as the high occurrence design wave.

Table 5.1.1-5 Design Deepwater Waves off Tajung Priok

(High Occurrence, 1 year return period)

Wave \ Direction	W	NW	N	NE	E
Height (m)	1.78	1.98	1.68	1.45	1.70
Period (s)	5.92	6.30	5.96	5.59	6.04

(3) Harbour Calmness Analysis

1) Analysis method

Wave refractions and shoaling due to change of seabed topography are dominant during the wave propagations from the deepwater area as the waves move toward the shore. On the other hand, wave diffractions and reflections by the breakwater, revetment and other structures are dominant inside the harbour.

The Energy Balance Equation Model Method is suitable for wave refractions and shoaling calculations, but wave diffractions and reflections can not be calculated by this Model. Therefore, Takayama’s Method is employed for the harbour calmness analysis. Since water depth shall be assumed as uniform by Takayama’s model, therefore, wave refractions and shoring can not be calculated, however, this method is suitable for harbour calmness analysis because the Model can be applicable for wave diffraction and reflection calculations.

Considering the above mentioned reasons, wave transformation from off Tanjung Priok to the port entrance at each candidate site is calculated by the Energy Balance Equation Model Method, and calmness analysis inside the harbour is calculated by Takayama’s Method.

Calmness is evaluated in front of berths, turning and port basins, port entrances and access channels about 1km off from the port entrance.

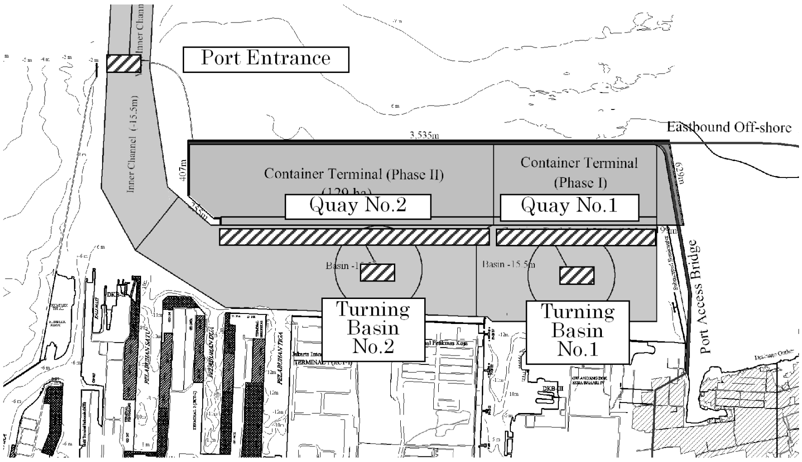
2) Harbor Calmness of North Kalibaru in Tanjung Priok

Alternative-1

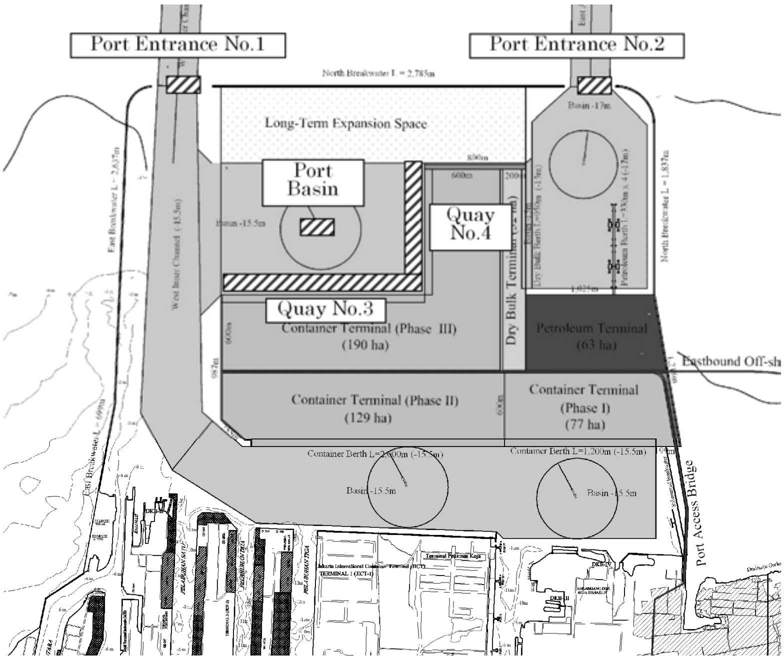
Calmness Analysis is conducted considering the implementation plan of the new terminal. For Alternative-1 development plan, two cases of analysis are considered as follows;

Case 1: after completion of Phase 1 and 2
Case 2: after completion of Phase 3

Evaluation locations of the calmness are as shown in Figure 5.1.1-1.



(1) Case 1: After completion of Phase 1 and 2



(2) Case 2: After completion of Phase 3

Figure 5.1.1-1 Calmness Evaluation Locations of North Kalibaru New Terminal (Alternative-1)

Analysis results of the calmness are as shown below. Based on the results, it can be said that the harbour area is sufficiently calm through the year. Therefore, the breakwater layout is sufficient.

Table 5.1.1-6 Summary of Non-exceeding Percentage of 0.5 m Height Waves

North Kalibaru New Terminal (Alternative-1)

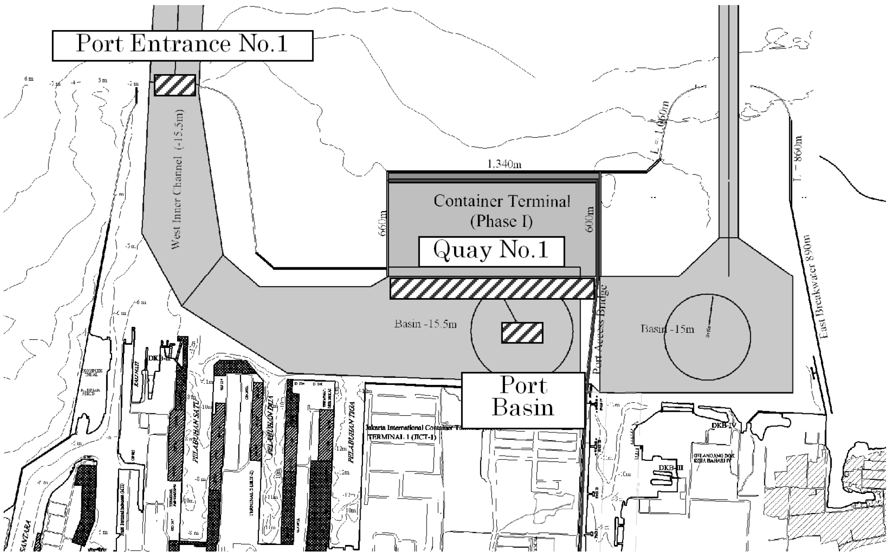
	Location	Non-exceeding Percentage		
Phase 1 & 2	Quay No.1	100%	≧	97.50%
	Quay No.2	100%	≧	97.50%
	Turning Basin No.1	100%	≧	97.50%
	Turning Basin No.2	100%	≧	97.50%
	Port Entrance	95.0%		
	Access channel 1km off	95.4%		
Phase 3	Quay No.3	98.5%	≧	97.50%
	Quay No.4	99.6%	≧	97.50%
	Port Basin	99.5%	≧	97.50%
	Port Entrance No.1	94.6%		
	Port Entrance No.2	93.7%		
	Access channel 1km off	94.8%		

Alternative-2

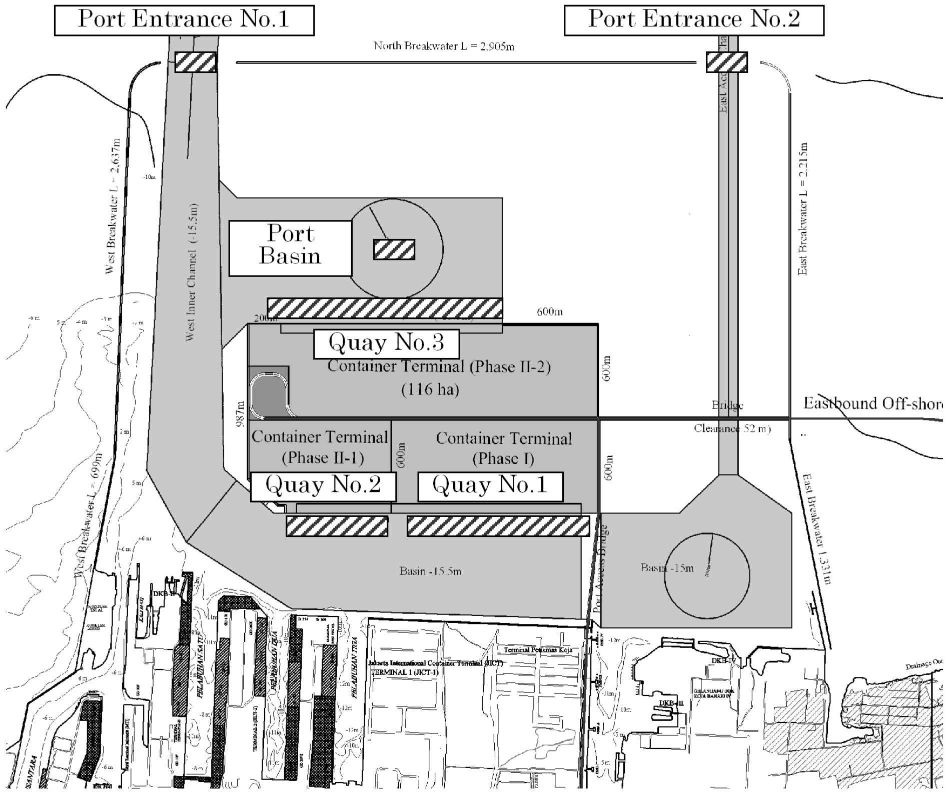
Calmness Analysis for Alternative-2 is conducted for the following three cases for each development phase.

Case 1: after completion of Phase 1
Case 2: after completion of Phase 2
Case 3: after completion of Phase 3

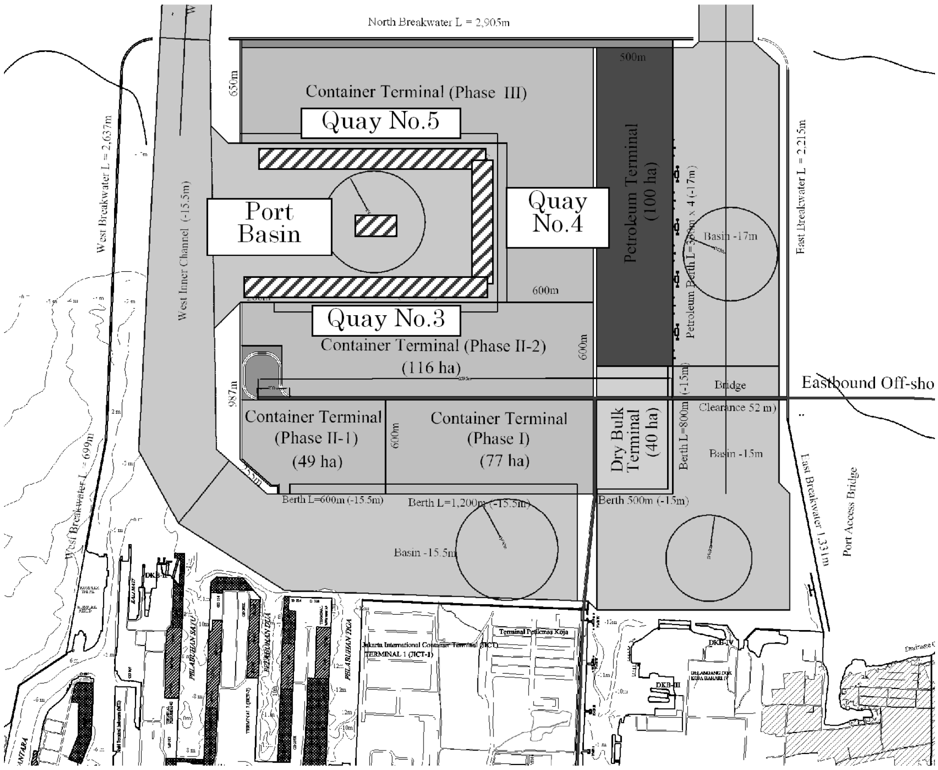
Evaluation locations of the calmness are as shown in Figure 5.1.1-2.



(1) After completion of Phase 1



(2) After completion of Phase 2



(3) After completion of Phase 3

Figure 5.1.1-2 Calmness Evaluation Locations of North Kalibaru New Terminal (Alternative-2)

Analysis results are as shown below. Harbour area is sufficiently calm through the year. Breakwater layout is sufficient.

Table 5.1.1-7 Summary of Non-exceeding Percentage of 0.5 m Height Waves
North Kalibaru New Terminal (Alternative-2)

	Location	Non-exceeding Percentage		
Phase 1	Quay No.1	100%	≧	97.50%
	Port Basin	100%	≧	97.50%
	Port Entrance No.1	94.0%		
Phase 2	Quay No.1	98.6%	≧	97.50%
	Quay No.2	98.6%	≧	97.50%
	Quay No.3	98.5%	≧	97.50%
	Port Basin	99.5%	≧	97.50%
	Port Entrance No.1	94.4%		
Phase 3	Quay No. 3	98.8%	≧	97.50%
	Quay No. 4	100%	≧	97.50%
	Quay No. 5	99.9%	≧	97.50%
	Port Basin	100%	≧	97.50%

Alternative-3

Calmness Analysis for Alternative-3 is represented by the results of Alternative-1 since the port layout is similar to Alternative-1.

3) Harbour Calmness of Cilamaya Terminal

Calmness analysis is conducted taking into account the new terminal layout plan. Calmness is evaluated in front of berths, turning and port basins, port entrance and the access channel about 1km off the port entrance. Evaluated locations of the calmness are as shown in the Figure below.

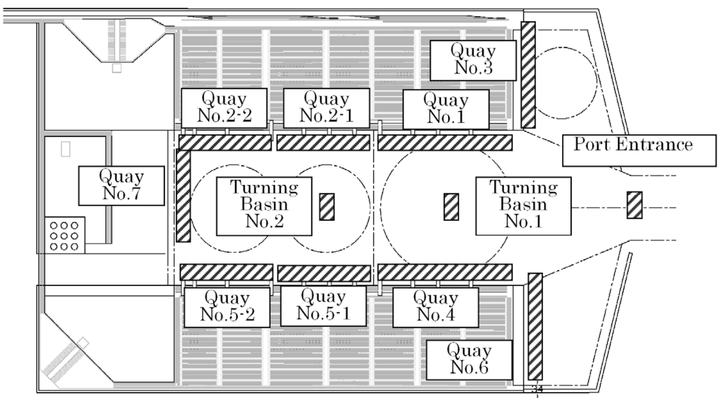


Figure 5.1.1-3 Calmness Evaluation Locations of Cilamaya New Terminal

Inside of harbour is sufficiently calm according to the results of calmness analysis as shown in Figure 5.1.1-8. Therefore breakwater layout is sufficient.

Table 5.1.1-8 Summary of Non-exceeding Percentage of 0.5 m Height Waves

Location	Non-exceeding Percentage		
Quay No.1	97.50%	≧	97.50%
Quay No.2-1	97.60%	≧	97.50%
Quay No.2-2	97.60%	≧	97.50%
Quay No.3	98.40%	≧	97.50%
Quay No.4	97.80%	≧	97.50%
Quay No.5-1	97.60%	≧	97.50%
Quay No.5-2	98.00%	≧	97.50%
Quay No.6	99.50%	≧	97.50%
Quay No.7	98.00%	≧	97.50%
Access channel 1km off	92.30%		
Port Entrance	93.10%		
Turning Basin No.1	97.40%		
Turning Basin No.2	98.20%		

4) Harbour Calmness of Tangerang Terminal

Similar to the Kalibaru and Cilamaya Terminal, calmness analysis is conducted taking into account the new terminal layout plan. Evaluated locations of the calmness are as shown in the Figure below.

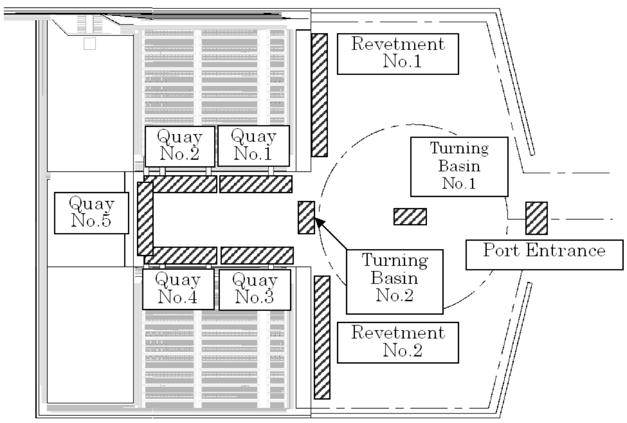


Figure 5.1.1-4 Calmness Evaluation Locations of Tangerang New Terminal

Inside of harbour is sufficiently calm according to the results of calmness analysis as shown in Table 5.1.1-9. Breakwater layout is sufficient.

Table 5.1.1-9 Summary of Non-exceeding Percentage of 0.5 m Height Waves

Location	Non-exceeding Percentage		
Quay No.1	97.60%	≧	97.50%
Quay No.2	98.40%	≧	97.50%
Quay No.3	97.80%	≧	97.50%
Quay No.4	98.60%	≧	97.50%
Quay No.5	98.10%	≧	97.50%
Revetment No.1	97.60%		
Revetment No.2	97.30%		
Access channel 1km off	94.70%		
Port Entrance	94.70%		
Turning Basin No.1	97.20%		
Turning Basin No.2	98.30%		

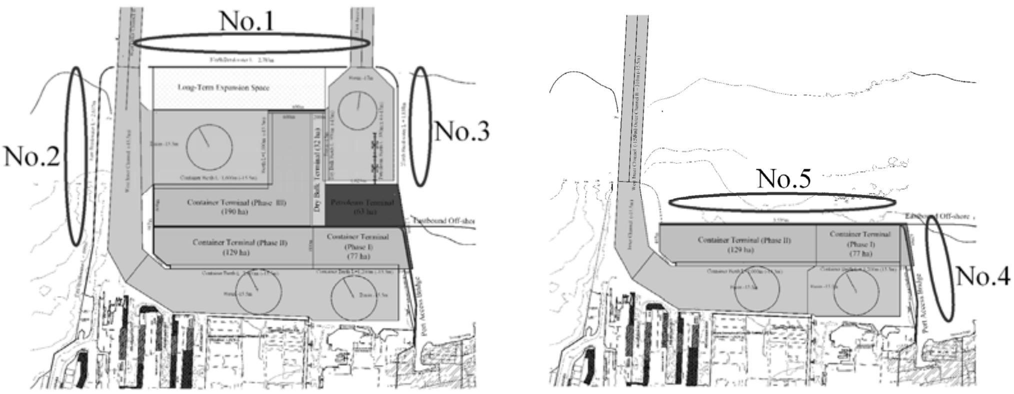
(4) Breakwater Design

1) Design Waves at Each Site

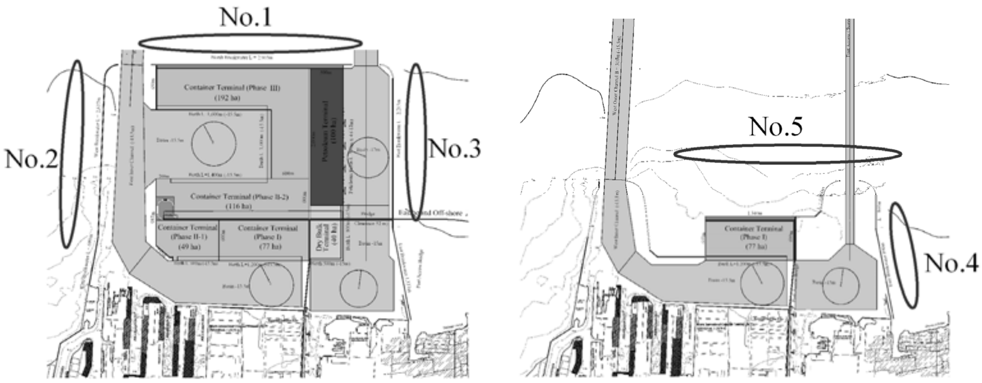
Extraction of Maximum Waves in front of the Breakwater

Equivalent deepwater waves at each site are estimated by the wave transformation of deepwater storm waves off Tanjung Priok as they move toward the shallow water area at the new terminal candidate site. Wave transformation by refraction and shoaling effect due to bathymetry is calculated by the Energy Balance Equation Model Method.

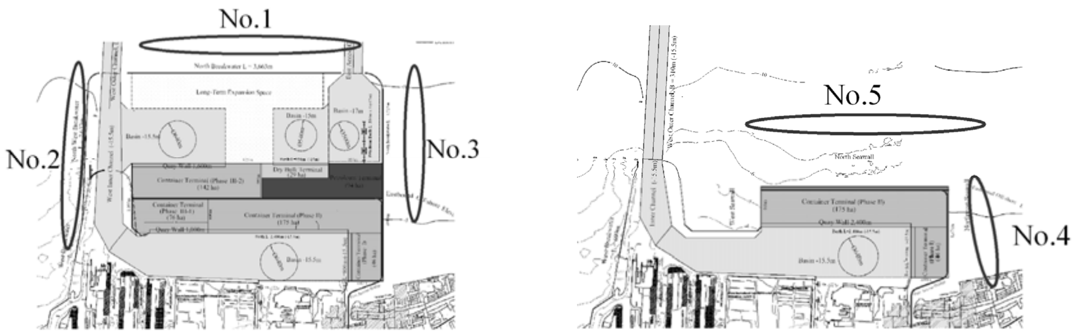
Design waves are determined by the extractions of maximum waves in front of the new terminal facilities to be designed at each site. Figure 5.1.1-5 to Figure 5.1.1-7 show the extraction locations at each new terminal.



(1) For Development Plan of North Kalibaru New Terminal, Alternative-1



(2) For Development Plan of North Kalibaru New Terminal, Alternative-2



(3) For Development Plan of Kalibaru Alternative-3

Figure 5.1.1-5 Wave extraction locations for North Kalibaru Development in Tanjung Priok

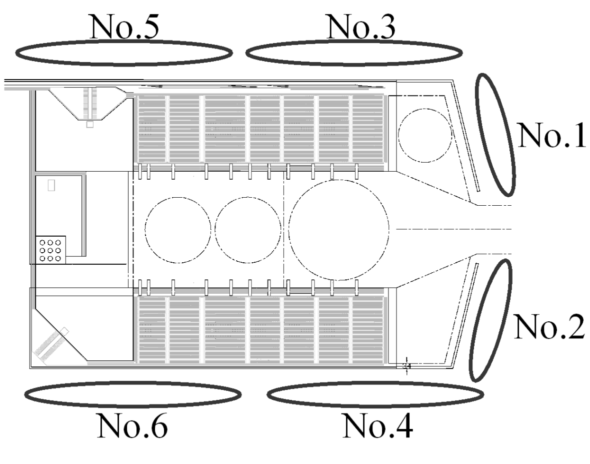


Figure 5.1.1-6 Wave extraction locations for Cilamaya New Terminal

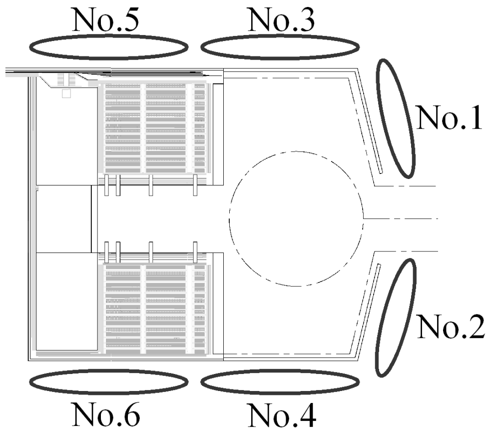


Figure 5.1.1-7 Wave extraction locations for Tangerang New Terminal

Design waves for the north seawall to be constructed in Phase 1 and 2 Development in North Kalibaru

In the Urgent Rehabilitation Project, design waves for Dam Tengah breakwater were chosen. Waves that act on the north seawalls can be considered to be almost the same as the waves that act on Dam Tengah breakwater, because the location of the north seawall is close to Dam Tengah breakwater. Therefore, it is decided that the design waves chosen for Dam Tenggah breakwater rehabilitation should be applied for the north seawall design.

Design waves for the east breakwater planned in Alternative-2

In addition to the above, in Alternative-2, the east breakwater is planned to be extended to the land side. Since the breakwater is the closest to the land among the breakwaters, the wave conditions may not be the same as for the other breakwaters at the north, east and west side. Especially for the design of this breakwater, the same design wave conditions (low occurrence higher wave) of the Dam Tengah breakwater rehabilitation under the Urgent Rehabilitation Project were chosen since the location of the break water is close to the Dam Tengah breakwater.

Summary of design waves for breakwater design

Following is the summary of the design wave conditions, determined by the above mentioned process.

Low-occurrence design waves are applied for verification of the stability of the breakwaters and deciding the design section of the breakwater.

Table 5.1.1-10 Low-occurrence Design Waves

Site	Wave Height (m)	Wave Period (Sec)
Tanjung Priok (other than north seawall)	3.7	8.8
Tanjung Priok (for west breakwater Alt.2)	2.5	7.5
Tanjung Priok (for north seawall)	1.5	6.0
Cilamaya	2.8	8.7
Tangerang (for N and E side breakwater)	2.1	8.8
Tangerang (for West side breakwater)	1.1	6.5

Performance evaluations such as estimation of over-topping wave amounts and calculation of transmitted wave height through breakwaters shall be considered against the waves that frequently occur. For this purpose, high-occurrence design waves are chosen as follows.

Table 5.1.1-11 High-occurrence Design Waves

Site	Wave Height (m)	Wave Period (Sec)
Tanjung Priok (other than north seawall)	2.0	6.3
Tanjung Priok (north seawall)	1.5	6.0
Cilamaya	2.0	6.3
Tangerang (for N and E side breakwater)	2.0	6.3
Tangerang (for West side breakwater)	1.0	6.3

2) Breakwater Design at North Kalibaru Area

Type of breakwater Structure

Considering the 2003 JICA Study and sections determined based on the comparison study on the Urgent Rehabilitation Project of Tanjung Priok Port, a rubble mound slope type breakwater is applied.

Crown height of breakwater

The crown height of the breakwater is set to an appropriate level with a height at least 0.6 times the significant wave height ($H_{1/3}$) to secure the required harbour calmness. Here, the height is assumed as DL +3.50 m (3.02 m + MSL) as follows.

MHWS + 0.6 x $H_{1/3}$ = 0.91+ 0.6 x 3.7 = 3.13 (say, DL +3.50 m (3.02 m + MSL)

Permissible rate of over-topping

According to the plan of the Project, it can be considered that there will be large ships calling and the water area behind the breakwater is very wide, therefore, wave overtopping is allowed to some extent. Therefore, crown height is assumed as 0.6 $H_{1/3}$ above the mean high water spring.

The permissible wave overtopping rate depends on factors such as the structural type of the seawall/breakwater, and the situation with regard to the usage and conditions behind the seawall/breakwater. There is no one standard value for the permissible wave over topping rate, however, in view of the degree of importance of the hinterland of the seawall/breakwater, the following permissible rates of wave over-topping are given.

Table 5.1.1-12 Permissible Wave Overtopping Rate in view of Degree of Importance of Hinterland (m^3/m/s)

Areas where there is a high concentration of houses, public facilities, etc. behind the seawall, and so it is anticipated that flooding due to over-topping or spray would cause particularly serious damages	about 0.01
Other important areas	about 0.02
Other areas	0.02 – 0.06

Source: Technical Standards and Commentaries for Port and Harbor Facilities in Japan, 2009

The wave overtopping rates are estimated by using the design diagram proposed by Goda, Y, Y. Kishira and Y. Kamiyama. [Technical Standards and Commentaries for Port and Harbour Facilities in Japan, 2009, PART II, Chapter 2, [3], Figure 4.3.20 to 4.3.23]. The wave over-topping shall be less than the values in Figure 5.1.1-13 against the high occurrence wave from the operational and economic point of view. According to the estimated results using the design diagram, the wave over-topping rate under the crown height DL +3.5 is smaller than the 0.01 m^3/m/s. Therefore, the DL +3.5 crown height is acceptable.

Breakwater structures

Required mass of armour materials are determined by Huddson's formula which is commonly used for estimation of the required stone or block weight. Wave height inside of the breakwater is smaller than outside, therefore, armour type and mass of harbour side is determined under the assumption that the refraction coefficient is Kr= 0.6.

Necessary armour weight is reduced considering that there is about 60 degrees of incident wave angle to the east and west breakwaters. Armour types of each breakwater are summarized in Table 5.1.1-13 below.

Table 5.1.1-13 Summary of Breakwater Armour Layers

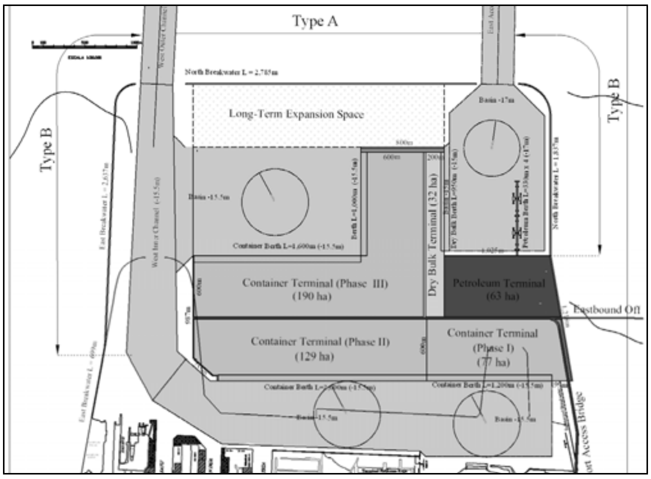
Type	Sea Side Armor	Harbor Side Armor	Location
A	Tetrapod 6.3t type	Concrete Cube 0.9m	North Breakwater
B	Tetrapod 3.2t type	Concrete Cube 0.7m	West & East Breakwaters
C	Tetrapod 2.0t type	Concrete Cube 0.7m	West Breakwater (Alt.2)

Rubble stones are used for the layer under the armour material. The mass of the rubble is determined to be approximately 1/10 to 1/15 that of the armor units or more. The stones used for these underlying layers are approximately 1/20 or more of the weight of the rubble stones under the armour material.

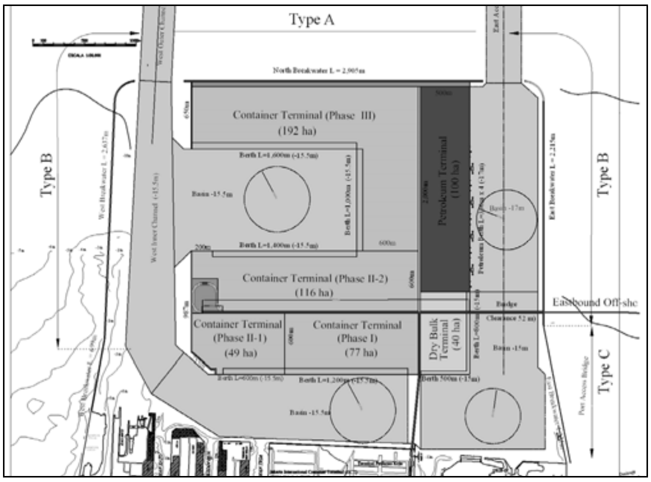
At the top of the breakwater between the sea and harbour side armour, coping concrete is provided to reduce the transmitted wave height behind the breakwater. Size of the concrete is determined by calculating the sliding and overturning forces on the coping concrete body due to the wave pressure that acts on the front face of the concrete. Estimated transmitted waves are smaller than 0.5m which is the threshold wave height for cargo handling operations.

According to the subsoil information, a layer of silt and clay (fine materials) is deposited about 8 to 10 m thickness under the seabed, therefore, it is designed so that these unsuitable materials are to be improved by PVD and the upper part of the drain is replaced by sand considering the settlement of the under layer of fine materials..

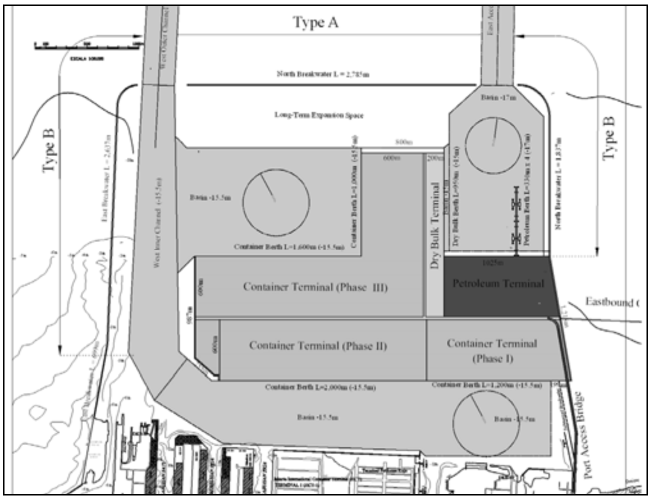
Breakwater layout and its types are as shown in Figure 5.1.1-8. Typical sections of breakwaters are as shown in Figure 5.1.1-9.



(1) North Kalibaru New Terminal Alternative-1

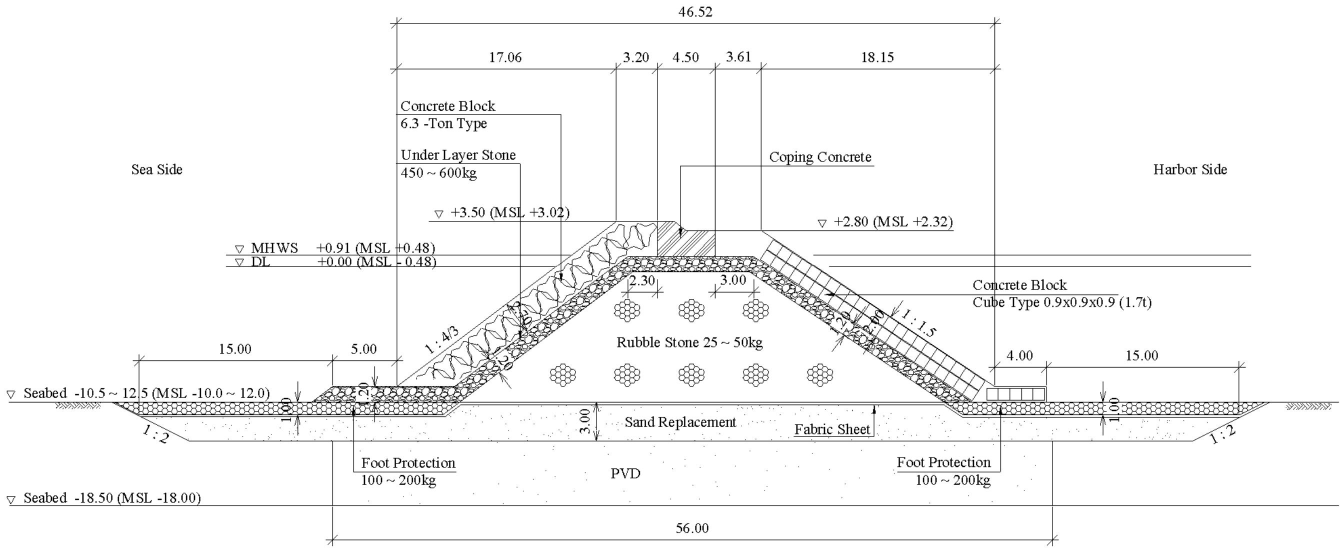


(2) North Kalibaru New Terminal Alternative-2

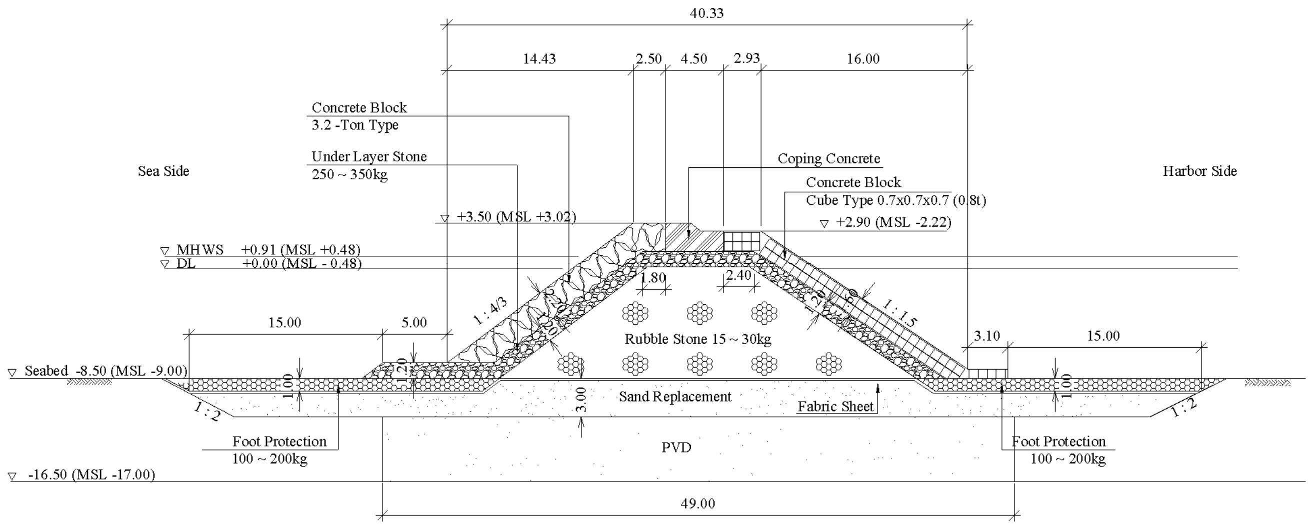


(3) North Kalibaru New Terminal Alternative-3

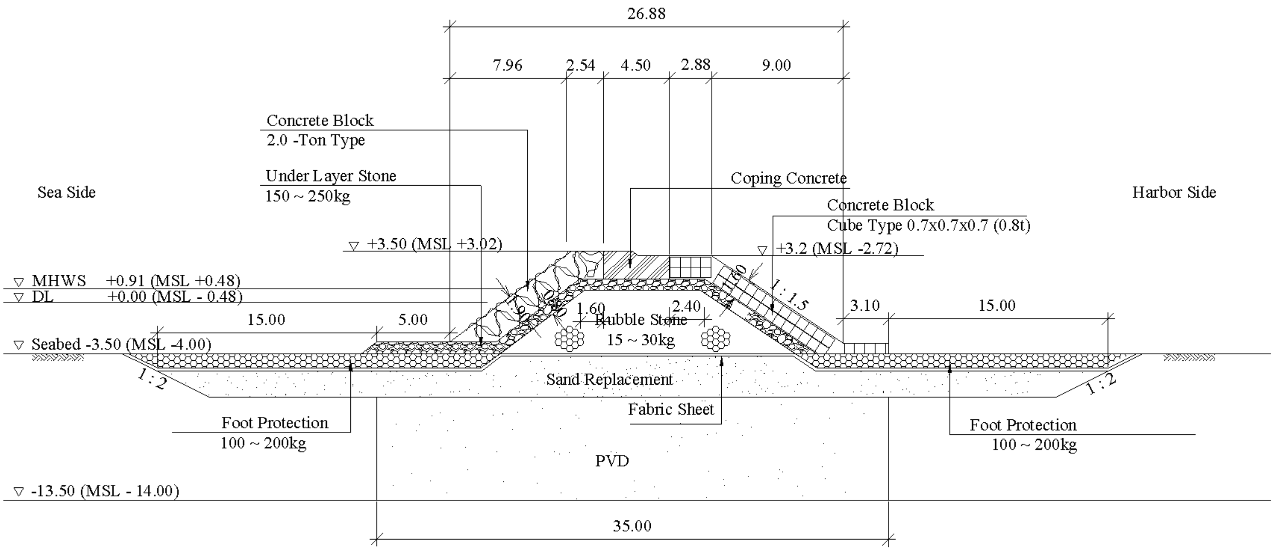
Figure 5.1.1-8   Breakwater Layout and Types at Tanjung Priok



(1) Typical Section of North Breakwater (Type A)



(2) Typical Section of West and East Breakwaters (Type B)



(3) Typical Section of West Breakwater (Landside Alt.2 only) (Type C)

Figure 5.1.1-9 Typical Section of Breakwater in North Kalibaru New Terminal

3) Breakwater Design at Cilamaya Area

Type of breakwater Structure

Rubble mound sloping type breakwaters are considered because of easy maintenance and they make it possible to follow the subsoil deformations.

Crown height of breakwater

The crown height is assumed as DL +3.00m (2.52 m + MSL) as 0.6 $H_{1/3}$ above the mean high water spring the same as the considerations for the North Kalibaru New Terminal.

Permissible rate of wave over-topping

Based on the same method as used for the North Kalibaru New Terminal, wave over-topping rate against the high-occurrence wave is less than 0.01 m3/m/s. Therefore the crown height of DL +3.0 m is acceptable.

Breakwater structures

Type and size of armour materials are as summarized in Table 5.1.1-14 below. Weight of armour materials and size of coping concrete are estimated using the same method as for North Kalibaru New Terminal. Loose material of about 5 m thickness under the seabed is to be improved by PVD. Breakwater layout and typical sections of the breakwaters are as shown in Figure 5.1.1-10 and Figure 5.1.1-11 respectively.

Table 5.1.1-14 Summary of Breakwater Armour Layers

Type	Sea Side Armour	Harbor Side Armour	Location
A	Tetrapod 3.2t type	Concrete Cube 0.7m	North Breakwater
B	Concrete Cube 0.9m	Concrete Cube 0.5m	West & East Breakwaters

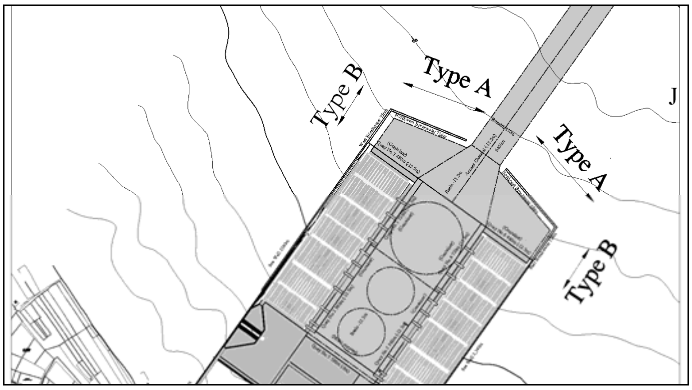
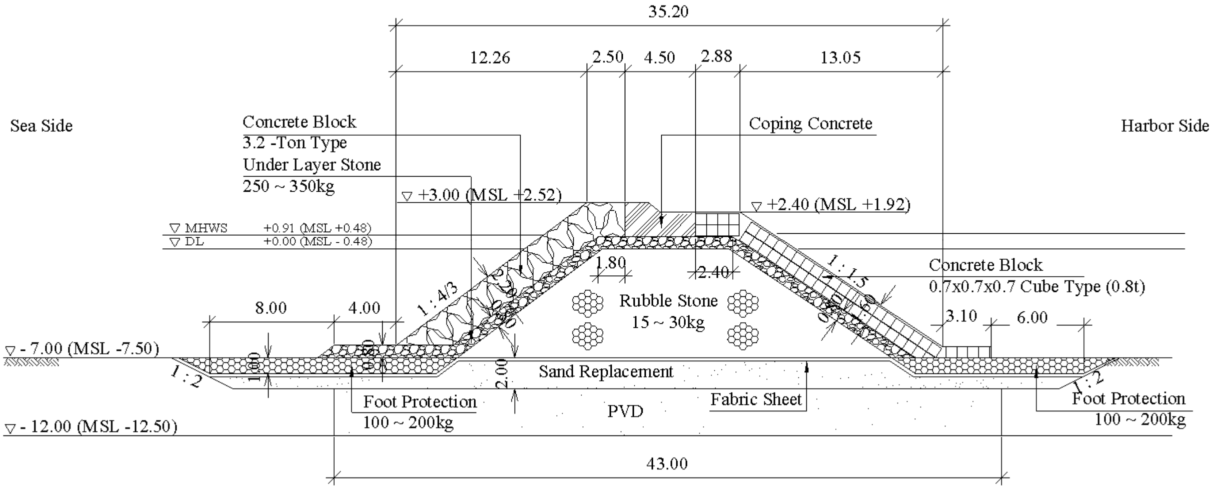
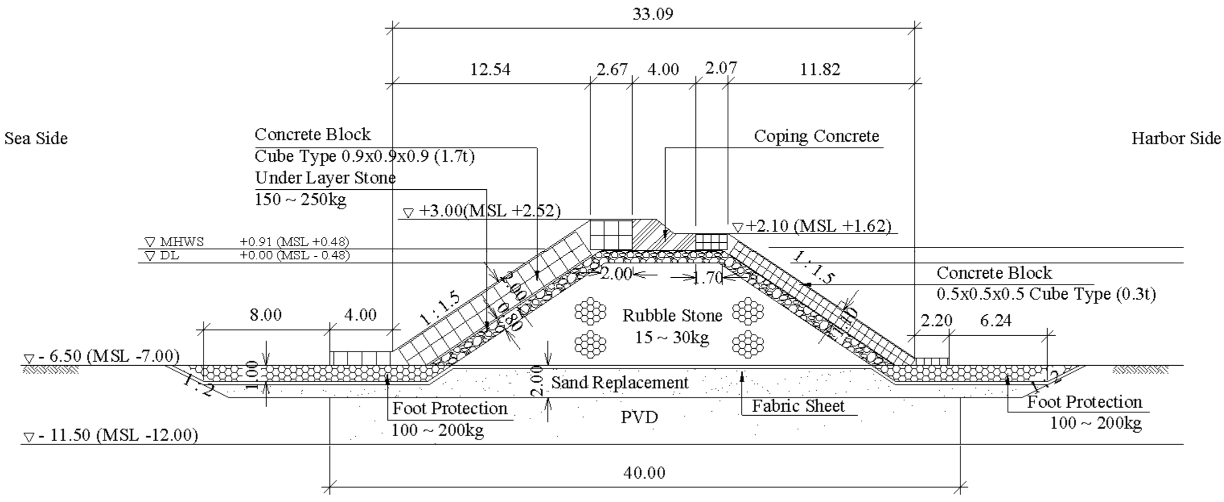


Figure 5.1.1-10 Breakwater Layout and Types at Cilamaya



(1) Typical Section of North Breakwater Type A



(2) Typical Section of West and East Breakwaters Type B

Figure 5.1.1-11 Typical Section of Breakwater in Cilamaya New Terminal

4) Breakwater Design at Tangerang Area

Structure type of breakwater

Rubble mound sloping type breakwaters are designed under the same considerations as for the Cilamaya new terminal.

Crown height of breakwater

The same as the North Kalibaru and Cilamaya new terminals, the crown height is assumed as DL +2.50m (2.52 m + MSL) which is 0.6 $H_{1/3}$ above mean high water spring.

Permissible rate of over-topping

Based on the estimations, overtopping rate under the crown height DL +2.5 is more than the 0.01 m^3/m/s. Therefore, the height is increased +0.5m. As shown in the following table, the crown height is set as DL +3.0m.

Table 5.1.1-15 Rate of Over-topping of Breakwater

Crown Height of Breakwater	DL +2.5 m	DL +3.0 m
Crown Height above MHWS	+1.59	+ 2.09
Rate of wave over-topping (m3/s/m)	0.01028	0.00376
Evaluation	Not acceptable	Acceptable

Breakwater structures

1) North-west, north-east and east breakwaters

Two ton type wave dissipation blocks and 0.7 m size concrete cube type concrete blocks are used for armor layers for the seaside and port side respectively. Coping concrete is provided at the top part of the breakwater between the sea side and port side blocks to reduce transmitted wave height behind the breakwater. Loose materials under the seabed are improved by PVD.

2) West breakwater

Design wave height is smaller than the design wave for the north and east breakwaters. Therefore, from an economical point of view, a different type of section is designed especially for the west breakwater. If natural stones are used for the armour layer, the required mass of stones is more than 2 tons, therefore, concrete cube type blocks are applied. Based on the estimation, a 0.5m size concrete cube is sufficient. Considering the uniformity of the breakwater section, the same blocks are applied for the sea and harbour sides. To reduce the number of blocks that must be fabricated and installed, the size of cube is increased from 0.5 m to 0.7 m size.

The breakwater layout and typical sections of breakwaters are as shown in Figure 5.1.1-12 and Figure 5.1.1-13 respectively.

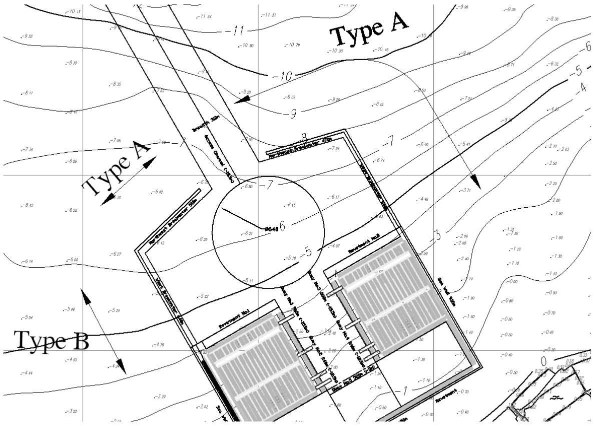
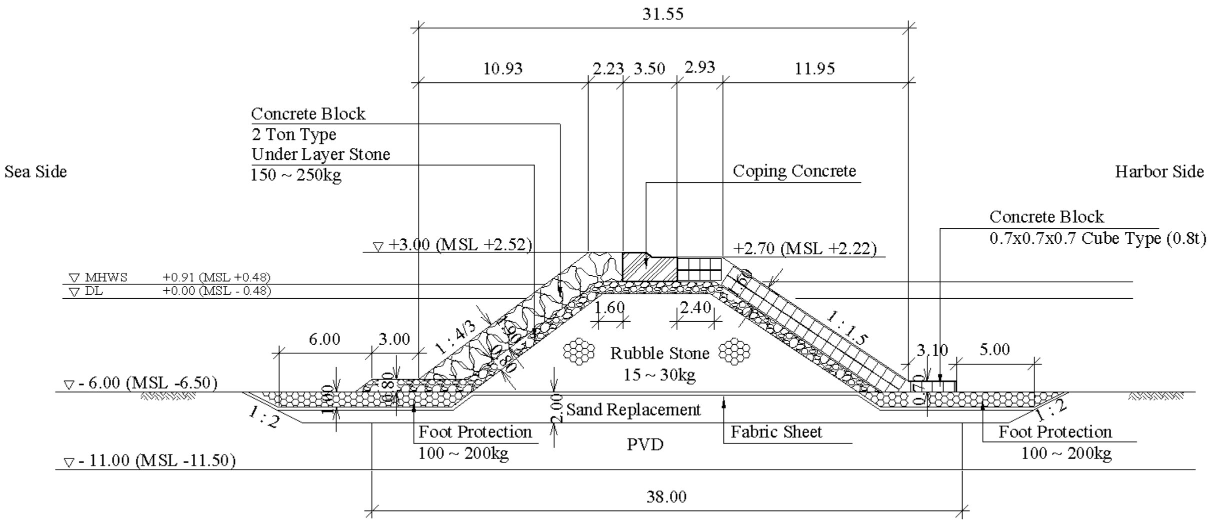
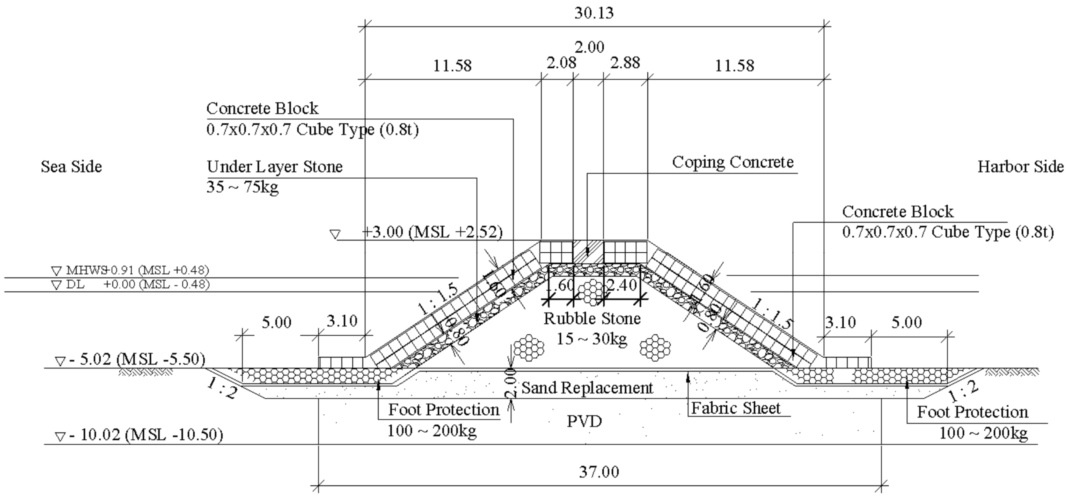


Figure 5.1.1-12 Breakwater Layout and Types at Tangerang



(1) Typical Section of North-west, North-east and East Breakwaters Type A



(2) Typical Section of West Breakwater Type B

Figure 5.1.1-13 Typical Section of Breakwater in Tangerang New Terminal

5.1.2 New Container Terminal Development at North Kalibaru

In this chapter the preliminary design of port facilities at North Kalibaru in Tanjung Priok is studied and described based on the alternative 1 out of three alternative plans.

(1) Channel Improvement and Turning Basin Development

1) Nautical and Operational Aspects of Existing Port

The near-shore waves off the Terminal at North Kalibaru in Tanjung Priok are comparatively mild throughout the year. The predominant directions of waves to the terminals are in the range of 310 degrees N to 30 degrees N.

The existing breakwaters protect the Terminals against those waves, except in its eastern part, where parts of the breakwater are almost submerged during high tides due to settlement/collapse of the structure. The currents in and around the Terminals entrance are rather weak, resulting in no significant maneuvering problem for incoming/outgoing ships.

The Terminals of Tanjung Priok have two entrances, a western entrance and an eastern entrance. The eastern entrance is heavily silted and very shallow (around -5 m) and only small ships like fishing boats and tug boats use it. The western entrance with a water depth of 14 m and a channel width of 150 m serves as a main entrance of the Terminals of Tanjung Priok. Through the western entrance two ways traffic is permitted to vessels shorter than 150 m in LOA equivalent to 15.000 DWT in size.

The maximum ship allowed to enter the Port is at present limited. In principle less than 300m in LOA is allowed to enter the International Container Terminals. In the meantime the maximum ship size ever recorded to call in the International Container Terminals was 325 m in LOA.

The present dimension of the outer and inner channels is planned to be improved by widening to 300m and deepening to -14.0m for allowing two way traffic of 50,000 DWT under the Urgent Rehabilitation Project of Tanjung Priok Port (URPT) by JICA finance (Ex-JBIC).

2) Planning Criteria for Channel/Basin Improvement.

Under URPT the depth of the outer channel and inner channel and area of turning basin inside the breakwater was determined by the maximum size of ships calling at the Terminals as the container ship of 50.000 GT, whose particulars are 280m in LOA (length of overall of vessel) 32 m in beam and 12.7 m in draft. To receive this size of vessel the basic space requirements of the navigation channel and basin were determined in accordance with international standards including PIANC.

However under this study the ship size trends since 2003 are reviewed and updated based on the records of the maximum container vessels calling to Tanjung Priok Terminals in 2009, in which the maximum size was 61,400 DWT, LOA 276 m and Draft 13.62 m. The expected maximum ship size is set the Post-Panamax (DWT; 87,545, LOA; 318m, Draft; 14.0m, Beam; 40.06m). The difference of depth and width of the channel and basin by objective ship size between 2003 and 2010 is shown in the Table below.

Table 5.1.2-1 Difference of Dimensions of Channel by Objective Ship between 2003 and 2010

Description	Study in 2003	Study in 2010
Objective Container Ship Size	50,000DWT, D=12.7m, LOA=280m, B=32.23m	87,545DWT, D=14.0m, LOA=318m, B=40.06m
Depth and Width of Channel	D=14.0 m, W=300m	D=15.5m, W=310m
Depth and Width of Turning Basin	D=14.0m, W=600m	D=15.5m, W=640m
Depth of Berth and Length	D=14.5m, W=320m	D=15.5m, W=360m

Source: JICA Study Team

To receive the objective ship size the basic space requirements of the navigation channel and basin are determined as follows.

To allow two-way traffic of 87,000 DWT vessels the new navigation channel is set at 310 m in width and 15.5 m in depth. The channel width meets international standards and the water depth requirements are reasonable considering local natural conditions. So that in this preliminary design, these key dimensions are adopted for planning the channel and turning basin and design of container berths at new terminals.

The alignment of the navigation channel in the bending portion was determined following the recommendations stipulated in "Technical Standards and Commentaries for Port and Harbor Facilities in Japan". It suggests that the intersection angle of channel centre lines at a bend should not exceed approximately 30 degrees.

When the angle exceeds 30 degrees, the centreline at the bend should be made as an arc having the radius of curvature larger than four times LOA. The turning circle with tug assistance is planned of a diameter of four times of LOA, 640 m and depth of -15.5m.

3) Improvement of Channel and Turning Basin

Outer Channel alignment by URPT

Under the URPT financed by JICA the centerline of the outer channel was planned by consultation with the Pilot Office of Tanjung Priok Terminal, which has determined that the navigation channel should be aligned in a straight line entirely from the outer channel to the inner channels with the orientation of due north (0-l80 degree). However, to minimize the dredging volume and interruptions of ongoing traffic as well as to ensure safety of sea traffic in to and out of the terminals, the center line of the outer channel will be shifted 3 degrees east from the originally used centerline.

In the master plan of future expansion of Tanjung Priok Terminals the alignment of the outer channel will be extended and follow this alignment as set.

A long term development plan of Tanjung Priok Terminal Alternative 1 (year 2030) is shown in Figure 5.1.2-1, in which the proposed navigation channel plan is indicated.

Inner Channel and Turning Basin by URPT

The alignment of the inner charnel and basin has been determined area by area starting from the offshore part of the inner channel that is directly linked to the outer channel followed by the turning basin areas located deep inside the port and the transition part linking the above two areas.

In front of the Jakarta International Container Terminal I (JICT-I), a turning basin of 560 m (280 m x 2) diameter is planned to be provided with a 40 m wide space left to clear the ships mooring along the quays. When no ship is berthed alongside the quay, a turning basin of 600 m diameter will be secured.

In this Study a 640 m diameter basin will be planned to provide with a 50 m wide space for berthing ships in front of the new terminal. This basin arrangement will allow simultaneous turning of two ships, one for the maximum of 50,000 GT and another for the maximum of 87,000DWT.

The southern and northern boundaries of the E-W waterway to access a proposed new container terminal at North Kalibaru area (NKB) will be set out for 640 m between the existing berths of KOJA and new proposed berth alignment of the new terminal, enveloping the proposed turning basins and linking it to the N-S axle of the inner channel.

It is proposed that the remaining portion of the existing breakwater “Dam CITRA” which is located about 330m away from the face line of JICT be removed. This represents an area of about 740m (Turning basin 640m + 50m of berthing area on both sides) between the berth of JICT/KOJA and the new terminal berth.

Anchorage Areas

URPT recommended to re-align the existing anchorage area located outside the breakwater with the improvement of the navigation channel. A part of such anchorage areas designation outside the Terminals should be modified, because the new outer channel will be aligned very close to the designated offshore anchorage areas.

The improvement of the navigation channel and basin by URPT is limited to the waterway of -14m depth. For the development of a new container terminal at NKB the depth of outer and inner channel as developed by URPT should be deepened to -15.5m and the waterway in front of the JICT/KOJA berths should be widened to 640 m plus 50 m for berthing area on both sides (total of 740m) to accommodate larger container ships (max. 87,000 DWT).

4) Proposed Scope of Channel Improvement

Dredging Requirements for Navigation Channel

The dredging requirement is calculated by superimposing the proposed channel/basin improvement plan on the bathymetric survey produced in 2010 by the JICA Study Team. The water depth for dredging has been set at -15.5 m at the channel and turning basin and side slope of the dredging section is assumed to be 1 to 5.

The net volume of dredging requirements for the long term plan is summarized in the Table below. The location of each area is shown in Figure 5.1.2-1.

Table 5.1.2-2 Dredging Volume Requirement in Long Term Plan

Location	Design Depth	Dredging Volume (m3)		
		Phase 1	Phase 2	Phase 3
WC-1; West Outer Channel	-15.5m	362,700	n.r	962,100
WC-2; West Turning Basin	-15.5m	1,800,000	n.r	n.r
WC-3;West Inner Channel	-15.5m	919,700	63,500	n.r
WD-4; Inner Channel west side	-15.5m	4,004,000	2,070,900	n.r
KB-1; Inner Channel for phase 1	-15.5m	1,396,800	n.r	5,867,400
KB-2; Turning Basin for oil berth	-17.0m	n.r	n.r	12,871,800
KB-3; East Outer Channel	-17.0m	7,701,200	n.r	n.r
Total Volume		16,184,400	2,134,400	19,701,300

Note; n.r means Not Required
Source: JICA Study Team

Removal of the remaining portion of the existing breakwater by URPT

The following existing breakwater is planned to be removed under URPT.

Table 5.1.2-3 Removal Plan of Existing Breakwater by URPT

Existing Breakwater to Remove	Existing Length (m)	Plans of Recycling by URPT
Dam Timur	228	The southern parts will be demolished and remaining offshore parts will be linked to the New Dam Tengah-1.
Dam Tengah	934	The existing breakwater will be removed to New Dam Tengah-1 breakwater covering a distance of 1,243m, which would overlap with existing Dam Citra for 160m.
Connection Part between existing Dam Tengah and Dam Citra	93	This part will be demolished.
Closure structure between New and Existing Dam CITRA	318.2	The gap between a new Dam Tengah and the existing Dam CITRA will be closed by temporary breakwater.

Source: JICA Study Team

The area of these removed breakwaters will be used for widening the turning basin and navigation channel and deepening from 12m to 14.0m. A new Dam Tengah breakwater will be constructed opposite of JICT 740 m away from the face line of their berth.

The temporary breakwater for closing the gap between the new Dam Tengah and existing Dam Citra is planned to extend vertically from the new Dam Tengah. The JICA Study recommends this temporary breakwater to extend to the east direction straight from the new Dam Tengah 1 alignment to obtain the clear water way along the berths of new container terminals.

Length of Breakwater and Revetment for New Terminal Phase I

Figure 5.1.2-2 shows the relocation plan of the existing breakwaters to be removed for development of Phase 1 and 2 new terminals at NKB. The parts of the planned breakwater will be constructed by recycling above demolishing material. The length of breakwater to protect the new terminal as Phase 1 project is worked out as follows.

Table 5.1.2-4 Planned length of New Breakwater, Seawall and Revetment by this Study

New Breakwater to be constructed	Location	Length
Revetment of reclamation	West and East sides of reclamation	600 m x 2 =1,200m
Seawall as breakwater	North side of reclamation land	1,320 m
New Breakwater as extension of New Dam Tengah	Dam Citra removed and named as New Dam CITRA breakwater	633 m
Total length of Breakwater, Seawall and Revetment to be constructed as Phase 1		3,609.8m

Source: JICA Study Team

Demolition of Existing Remaining Breakwater for New Terminal

The existing breakwater “Dam Citra” (about 1,548m long) and “Dam Pertamina East (713m) and West (1,507m)” are demolished. New breakwaters are planned to protect container yard of the new terminal by off shore land reclamation.

A 500m portion of the Dam Pertamina breakwater west between the oil products terminal and its unloading jetty located will be preserved to prevent sedimentation. Accordingly the length to be removed will be about 1,007 m.

The length of about 3,268 m, which is the remaining portion of the existing breakwater will be removed for widening and deepening the water way from JICT/KOJA terminals for the new terminal.

These breakwater materials are planned to be recycled for use in constructing a seawall/revetment of reclamation for the terminal yard development. The usage of material from each breakwater is planned to the following locations.

Table 5.1.2-5 Demolition and Recycling Plan of Existing Breakwater

Removal Breakwater	Present Location	Length of removal	Recycled place after demolition
Dam CITRA	In front of KOJA Terminal	1,548m	Material of 1,148m length will be recycled for construction of new breakwater “New DAM CITRA” extending on the same alignment from the newly constructed breakwater “New DAM Tengah” by URPT. 400m portion will be recycled for construction of retaining wall of 1,250m as revetment of reclamation works.
Dam PERTAMINA East	In front of Car Terminal	713m	Material of 713m will be recycled for construction of revetment of reclamation
Dam PERTAMINA West	In front of Products Terminal Berth	1,007m*	Material of 1,007 m will be recycled for construction of revetment of reclamation works.
Total length of Breakwater to Remove		3,268m	Total required length of revetment is estimated about 1,250 m + 600 m x 2=2,450 m.

Source: JICA Study Team

New Berth Alignment with co-existence of New Dam Tengah 1 Breakwater

The berth alignment of Phase 1& 2 of the new container terminal is planned about 50m from the edge of the concrete head of the breakwater in the water area in front of the new Dam Tengah 1 breakwater, so that in future the newly constructed breakwater by URPT will be utilized by forming parts of the reclaimed of the new container terminal.

The cross sectional relation with relocated breakwaters (New Dam Tengah 1) by URPT and new berthing facilities by Phase2 Project of North Kalibaru is shown in Figure 5.1.2-2.

Construction of breakwater for the long term development plan

As shown in Figure 5.1.2-1, long term development of Tg Priok Terminal under the Alternative 1 case is planned toward the off shore beyond the Phase I container terminal. In order to protect the Terminals facilities a new breakwater will be constructed for Phase 3 development at the depth of around 10 m and distance of about 3.6-4.0km away from the existing berthing facilities of JICT/KOJA. The detailed construction plan of the new breakwater is described in Chapter 5.1.1.

Construction of new breakwater for the urgent terminal development at North Kalibaru

As shown in Figure 5.1.2 2, the existing breakwater in front of the JICT/KOJA is planned to be demolished and new breakwater named New Dam Tengah under URPT will be constructed. In order to protect the existing port facilities and cargo handling operation along the berth of JICT/KOJA, it is planned to construct a new breakwater at the depth of around 4 m. The distance between the planned new off shore container terminal at North Kalibaru under the Phase 1 Project and New Dam Tengah breakwater to be constructed by URPT is about 640m.

The design wave for the breakwater has been determined assuming that the water depth at the construction sites of Dam Citra is about - 4.0 m as follows.

High-frequency wave height is applied as the designed wave height to decide the breakwater crest elevation, with consideration given to the permissible rate of wave overtopping for port operations. The high-frequency design wave was determined as follows

$H_{1/3}$ = 1.5 m, T = 6.0s, Direction of Incident Wave: North (1 year return)

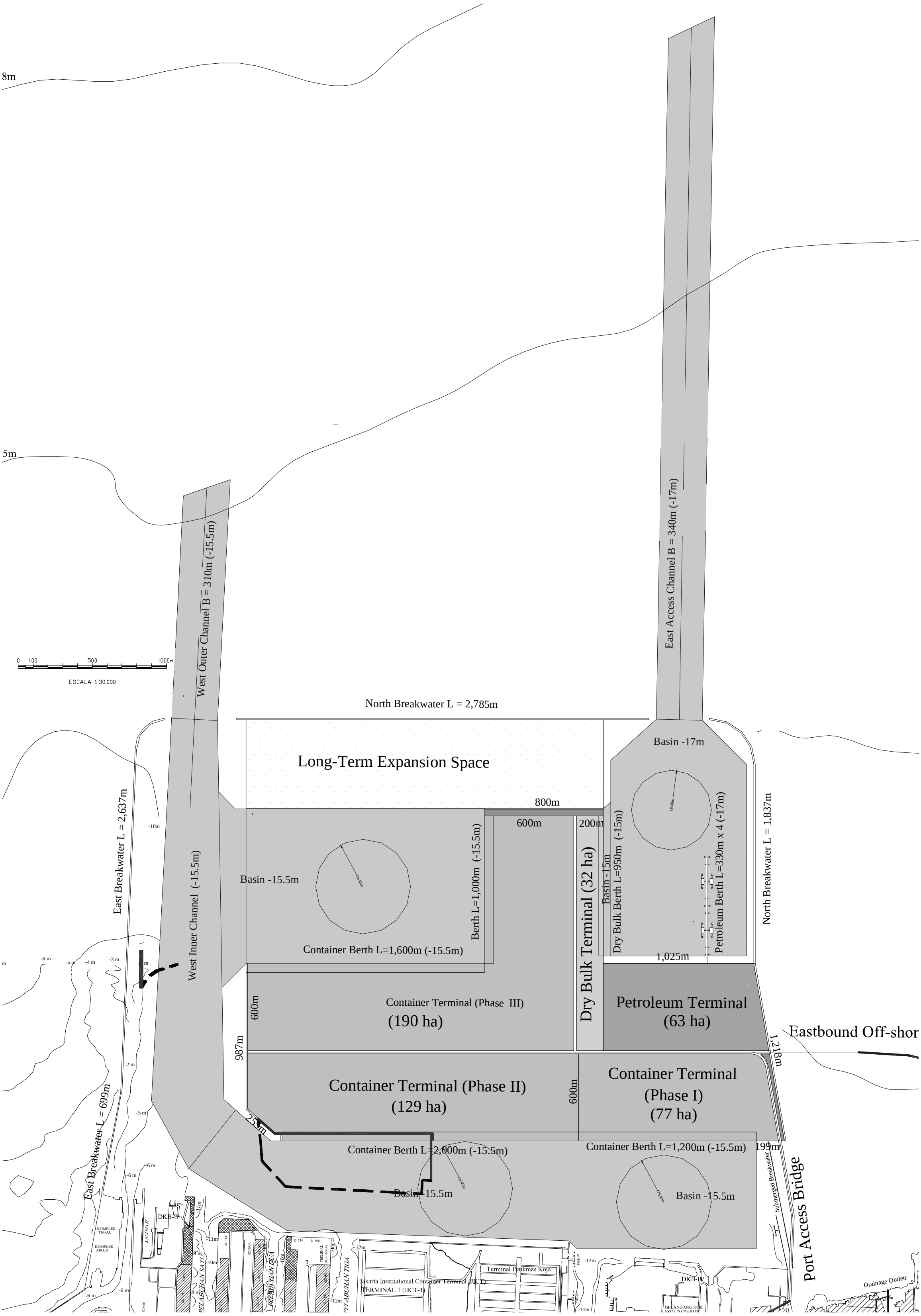
Low-frequency wave height is applied to examine the breakwater stability. The low frequency design wave was determined as follows:

$H_{1/3}$ =:2.5 m, T = 7.5s, Direction of Incident Wave: North (50 years return)

Considering the following soil conditions at North Kalibaru area and minimizing environmental impacts, and the existing soft soil, the soil improvement by PVD (Plastic Vertical drain) is applied for breakwater foundation.

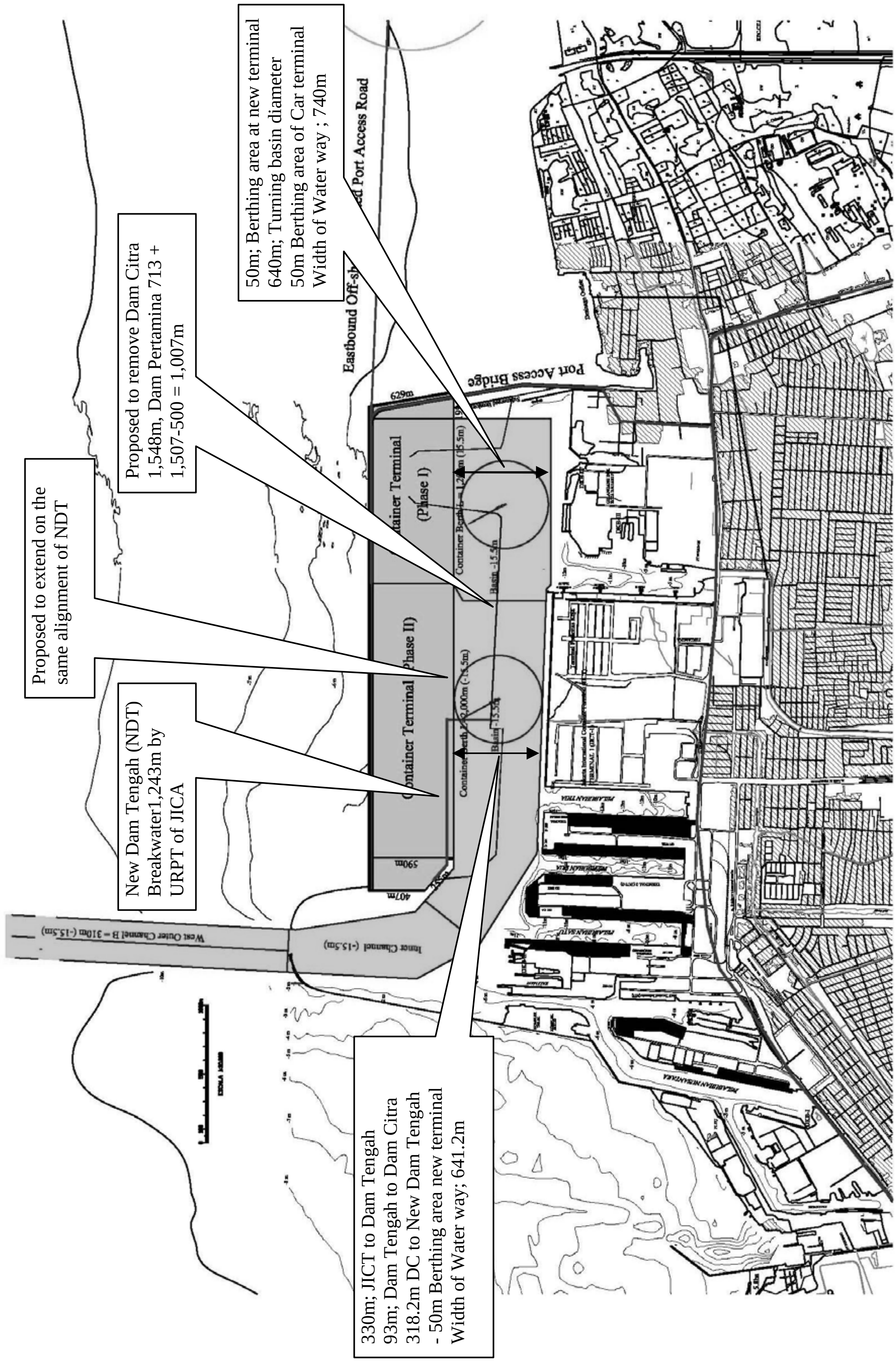
Elevation -4.0 m-
Silty 'Clay N=0, Ø =0° yt = 1.45 tf/m3 y'= 0.45 tf/m3 (in water) C = 1.0 tf/m2 Cc = 1.12 G, = 0.0028 cm2 / sec.
Elevation-15.00m
Silt-Cv lay N=12 @=0' 7t = 1.69 ttm3 y' : 0.69 ttim3 (in water) C= 12 tIlnA Cc = O.42 Cv = 0.03 cm2 / sec.

The rubble mound type with PVD for improvement of foundation soil is planned. The typical section of breakwater is shown in Figure 5.1.1-9.



Source: JICA Study Team

Figure 5.1.2-1 Long Term Development Plan of Tanjung Priok



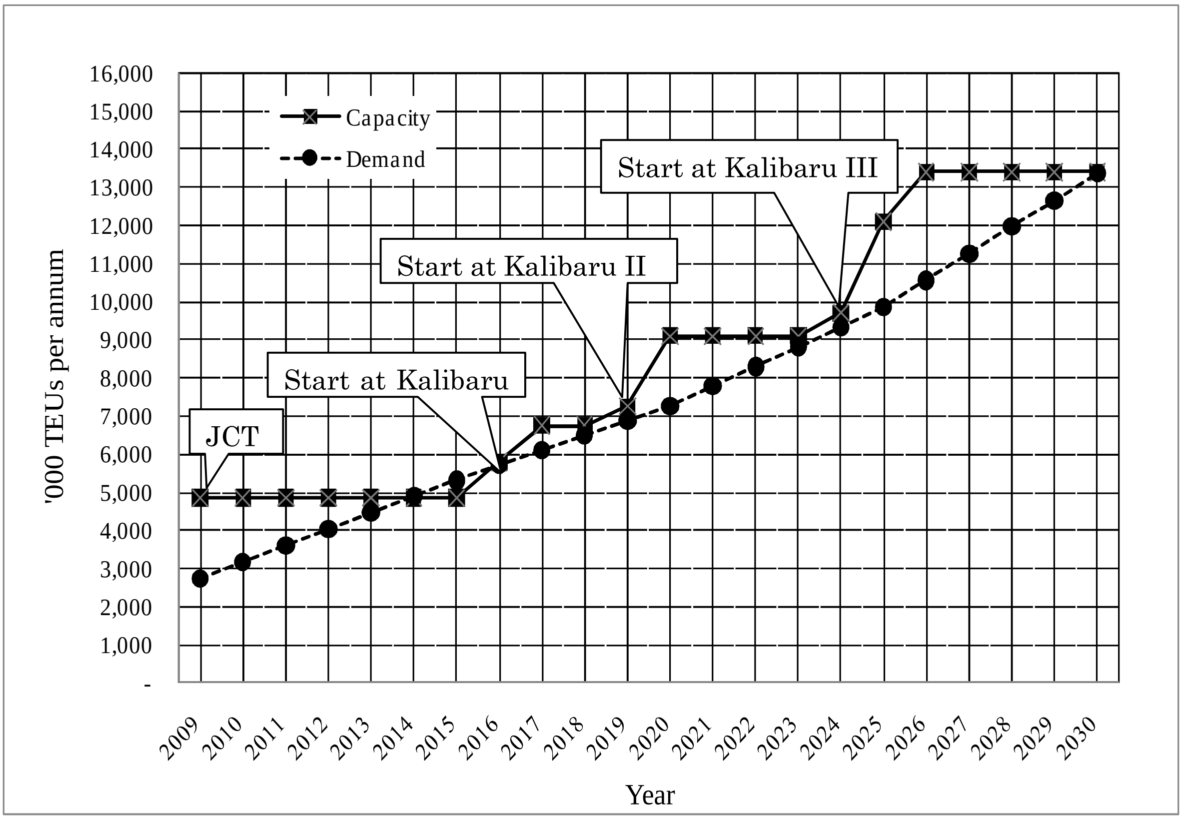
Source: JICA Study Team

Figure 5.1.2-2 Relocation plan of Breadwaters for Development of Phase 1 and 2

(2) Preliminary Design of Quay wall Development

1) Phased Development of New Terminal at North Kalibaru

The new container terminal at North Kalibaru in the Tanjung Priok Terminal is planned to be developed by phases according to the progress of traffic demands as shown in the following graph.



(Concentration of all required facilities at Kalibaru Area)
Source: JICA Study Team

Figure 5.1.2-3 Phased Development of New Container Terminal

Corresponding development of container berths requirement is worked out in the following sequences assuming that the urgent new terminal will be developed at North Kalibaru in Tanjung Priok to meet the traffic demands by 2019 and subsequently all required facilities are developed at Kalibaru area under Alternative 1 to meet the demands by 2030.

Table 5.1.2-6 Phased Development of Terminal Facilities at Kalibaru

Kalibaru Phase 1 (2014 - 2019)	Target of Capacity: 1.9 million TEU	
Container Terminal (Phase 1)	Quay Length 1,200 m; Depth -15.5 m	Capacity Development; 1.9 million TEU
Removal of existing breakwaters, Breakwaters and Revetment construction, Channel and basin improvement and development by dredging, Access road construction are carried out.		
Kalibaru Phase 2 (2020 – 2024)	Target of total Capacity: 5.1 million TEU	
Container Terminal (Phase 2):	Quay Length 2,000 m; Depth -15.5 m	Capacity Developed: +3.2 million TEU
Breakwaters and Revetment construction, Channel and turning basin development by dredging, Access Road along the coast construction is carried out.		
Phase 3 (2025 - 2030)	Target of Capacity: 9.4 million TEU	
Container Terminal (Phase 3)	Quay Length 2,600 m; Depth -15.5 m	Capacity Developed: +4.3 million TEU
Breakwaters and Revetment construction, Channel and turning basin development by dredging, is carried out.		

Source: JICA Study Team

2) Code and Standards for Preliminary Design of Quay wall

The design criteria of marine and civil works conform to the following design standards and reference:

- Indonesian Standard PBI (Peraturan Beton Indonesia 90-91) 80, Indonesian Concrete Design
- Standards National Indonesia 1991-63 Design Standards of Concrete Structure
- Standards Design Criteria for Ports in Indonesia, 1984
- Technical Standards and Commentaries for Port and Harbor Facilities in Japan, 2002
- Indonesia Highway Capacity Manual in 1997 Ministry of Highway and Public Works

3) Design Criteria

The details of design criteria are described in Section K Design Criteria for Port Facilities, Supporting Report of Engineering and Survey (SRES) March 2011.

Objective Ship Size

The dimensions of the container ships ”Post Panamax” used for the design of new terminal facilities at North Kalibaru in the Tanjung Priok Port are summarized below. The same type of container ship will call at Cilamaya new terminal and Tangerang new terminal.

Table 5.1.2-7 Objective Container Ship Size

Dead Weight Ton (DWT)	87,545
Loading Volume (TEU)	5,648
LOA (m)	318
Beam (m)	40.06
Draft (m)	14.0

Source: Containerization International

Tide, Current and Wave Conditions and Design Wind

The tide level, current, and design wind of Tanjung Priok Terminal is summarized below. These conditions are applied to preliminary design of terminal facilities of Cilamaya and Tangerang new terminals, considering that these sites are located close to each other, have similar conditions and are in the same seismic region.

Table 5.1.2-8 Tide, Current and Wave Conditions of Tanjung Priok Terminal

	Tanjung Priok Port
Tide (cm)[1]	
High Water Level (HWL)	+91.00
Mean Sea Level (MSL)	+48.00
Design Low Tide Level (DLT)	0.0
Current (m/sec)[2]	
Maximum velocity	0.50
Wave at Berth,	
Significant Wave Height H1/3(m)	0.50 m
Significant Wave Period T1/3	Less than 2 sec
Wave at Revetment	
Design Wave Height (m)	1.5 m
Design Wave Period (sec)	Less than 2 sec
Wave at Breakwater	
Significant Wave Height H1/3 (m)	3.00m
Significant Wave Period T1/3	Around 8 sec

Source 1,2: Dinas Hidro-Oseanografi, Indonesia

Table 5.1.2-9 Design Wind at North Coastal Area

Item	Design Value	Remarks
Wind Velocity	V = 49 m/s	West Java area, 20 m/sec Max. for last 30 years
Wind Pressure	p = 245 kg/m2 p = 196 kg/m2 p = 147 kg/m2	h > 30m 9 m < h < 30m 0 m < h < 9m

Source: Technical Standards and Commentaries for Port and Harbor Facilities in Japan, 2002

Subsoil Condition

The location of bore holes of soil investigation carried out by JICA Study in 2002/2010 and its soil profiles of the east side of the Tanjung Priok and inside the basin area are shown in Section C of SRES.

According to the geotechnical investigation on the west side of the Tanjung Priok Terminal area, the following parameters are used for the preliminary design for the new terminal facilities.

The soil investigation at the planned site of the new container terminal at North Kalibaru was carried out in November/December 2010. The preliminary design is carried out tentatively by using the following soil data obtained from the nearest soil investigation carried out by this Study in 2010. The output of the latest soil investigations is incorporated for the preliminary design of berthing facilities and revetment of Phase 1 Urgent Development Project at North Kalibaru.

Borehole No.3 at the Noth Kalibaru for new berthing area

-5.0 m	Silty Clay N = 0, ϕ = 0
-13.0 m	Sandy Silt N= 6 – 38, γt = 1.53 tf/m3, γ' = 0.53 tf/m3
-24.0 m	Silty Clay, N = 38 - 52 c = 30 kPa, ϕ = 30°, γ' = 0.9 tf/m^3
-30.0 m	Dense to very dense sand N = more than 50 c = 0 kPa, ϕ = 35°, γ' = 1.5 tf/m^3

Crown Height

The crown height of the berth is normally determined by the following formula:

H = HWL + (1.0 to 2.0 m);
(large vessel with a water depth of 4.5 m or more and tidal range smaller than 3.0m).

The crown height greatly affects the construction cost of the port. The strength of the quay wall structure and reclamation volume are proportional to the crown height. On the other hand, as it becomes lower, the chance of the berth being flooded by high waves becomes larger.

As a preliminary design of the container quay wall structure at Tanjung Priok Terminal, the crown height is set at 3.5m from DL (+3.0m from MSL) considering the ship size and required efficiency of cargo handling operation.

HWL + 2.0 m + H1/3 = + 3.5 m

This crown height of the quay wall is applied for the case of Cilamaya and Tangerang new terminal facilities. The ground level of yard pavement is set by applying this height.

Seismic Coefficient

The seismic coefficient for the proposed port facility and access road structure at North Kalibaru area are computed by applying the following factors:

According to the regional seismic coefficient (Kh1) zones of Indonesia as shown in Figure K.1.7 in Section K, SRES, West Jawa province is located in zone 3 of the regional seismic coefficient under stiff soil,

C = 0.05
Stiffness Factor of structures; K = 1.0
Importance Factor; I = 1.5
K_h = K x C x I = 1.0 x 0.05 x 1.5 = 0.075
K_v = not considered = 0

Considering the importance of Tanjung Priok Terminal facility, it is therefore recommended to adopt 0.1 for Kh for the Port facilities.

This seismic coefficient is applied for preliminary design of the new terminal facilities at Cilamaya and Tangerang.

Loads on the Wharf

Quay wall structure of container terminal is designed to sustain the quay container cranes. There are number of heavy loaded cranes in the world market, requiring heavy foundation works for the quay wall structure. The popular type and load of crane is adopted for preliminary design. The berth dimension for objective ship is set as Length 360m, Depth -15.5m DL Crown height +3.50 DL.

Quay crane Rail Gauge :	30 m
Overall Weight : approximately:	1,300 tf/unit
Nominal rated capacity:	41 tf under spreader

The following load conditions of QGC and related live loads in the apron and yards are described in Section K, SRES.

Live load and load conditions of QGC (Quay Gantry Crane);	35 kN/m2
Live load of container yards and Road in the terminal;	45 kN/m2
Load of RTG (Rubber Gantry Crane)	
Load of Container box in Container yard	

In the design of the apron, only trailer trucks and standard trucks with full loaded containers are considered as handling equipment.

The following wheel loads are considered:

Standard Truck (H22 - 44) :	8.0 tf/wheel
Tractor Trailer (40') :	5.8 tf/wheel

The above live loads and wheel loads for preliminary design of the new terminal at North Kalibaru are also applied for the new terminal facilities at Cilamaya and Tangerang.

Tractive Force and Berthing Force

Mooring

Tractive force acting on mooring bitts is set at 100 tf per unit for the vessels from 20,000 to 100,000 GT equivalent to 23,000 to 115,000 DWT covering both Panamax and Post Panamax sizes. The spacing should be 30 m for Post Panamax vessels, and a minimum number of 8 units should be provided for each berth.

Fender System

In design of the fender system to absorb the shock of ship berthing energy, berthing speed of vessels with assistance is assumed to be 0.10 m/sec, perpendicular to the face line.

The corresponding berthing angle to the face line is taken as 10 degrees at quarter-point berthing. Rubber fenders are installed at intervals of 12.0 m. Fender frame is attached as parts of fender system. Reaction by fender is 157-160 tons and absorbing energy 95.85 t-m.

The above tractive and mooring forces for preliminary design of the new terminal at North Kalibaru are applied for the quay wall of 87,000 DWT in the new terminal of Cilamaya and Tangerang.

Strength and Quality of Construction Material

The strength and quality requirement of construction materials shall conform to Japan Industrial Standard (JIS) and other applicable standards used in Indonesia.

The strength, quality requirement and unit weight of the respective materials are described in Section K, SRES

Other conditions

The increase in the allowance stress of the material, surcharge loads during earthquakes and safety factors for earthworks and foundations are described in Section K of SRES.

4) Design of Quay wall Structure.

Comparison Study of Quay wall Structure

The optimum type of quay wall structure is studied and selected from 5 alternatives i.e. 1) Concrete Block type, 2) Caisson type, 3) Steel Sheet Pile type, 4) Steel Frame Structure type, 5) Concrete Deck on Open Steel Pipe Pile type.

Initial Study for Selection of Quay Wall Structure

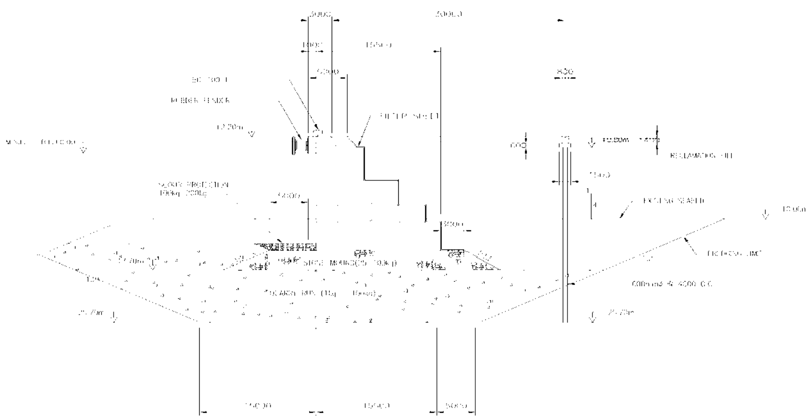
In a study of structural types for a wharf of Container Terminal, the optimum quay wall structural type is studied by evaluating each type with the following aspects:

a) Soil Conditions
b) Construction Materials
c) Construction Methods
d) Construction Period
e) Experience on Similar Projects
f) Maintenance Costs
g) Structural Suitability

In order to select the optimum structural type of the new container berth, the following alternatives are initially considered. These types of structures are commonly adopted for deep-water quay walls:

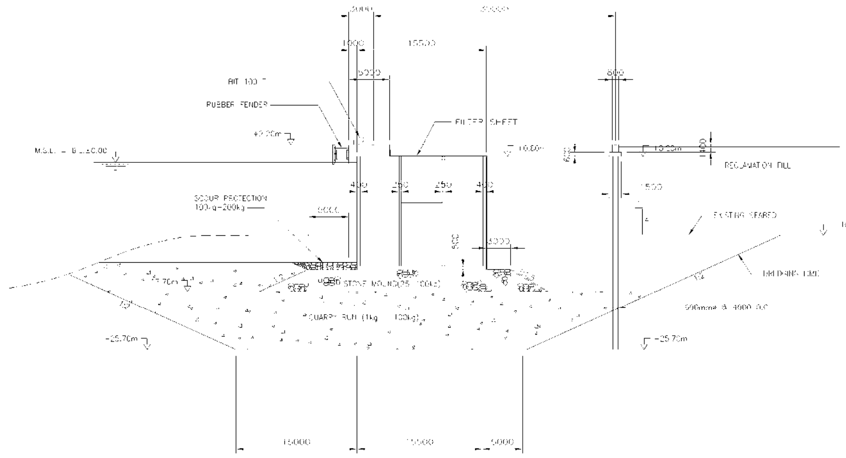
Type 1: Concrete Block Quay Wall
Type 2: Concrete Box Caisson Quay Wall
Type 3: Steel Sheet Pile Quay Wall
Type 4: Steel Pipe Pile Wall and Frame Structure
Type 5: Concrete Deck on Open Steel Pipe Pile Foundation

The typical cross sections of each alternative are shown in Figure 5.1.2-4 - Figure 5.1.2-8. The elevation and distance of the typical cross sections are only for reference and will not be applied to this particular site.



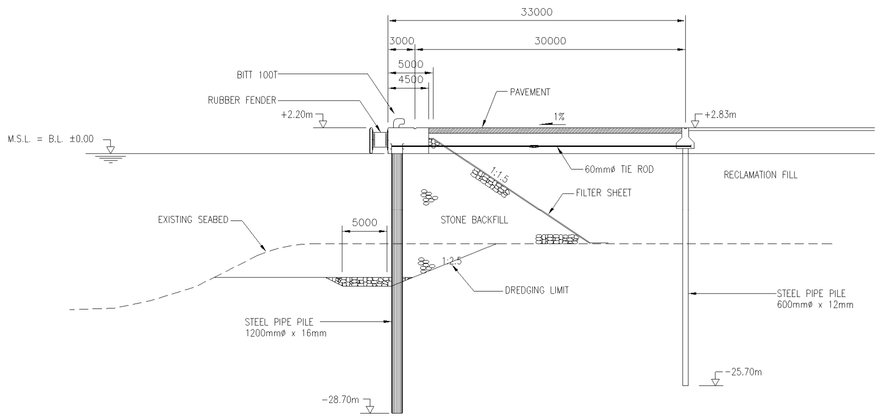
Source: JICA Study Team

Figure 5.1.2-4 Type 1: Concrete Block Quay Wall



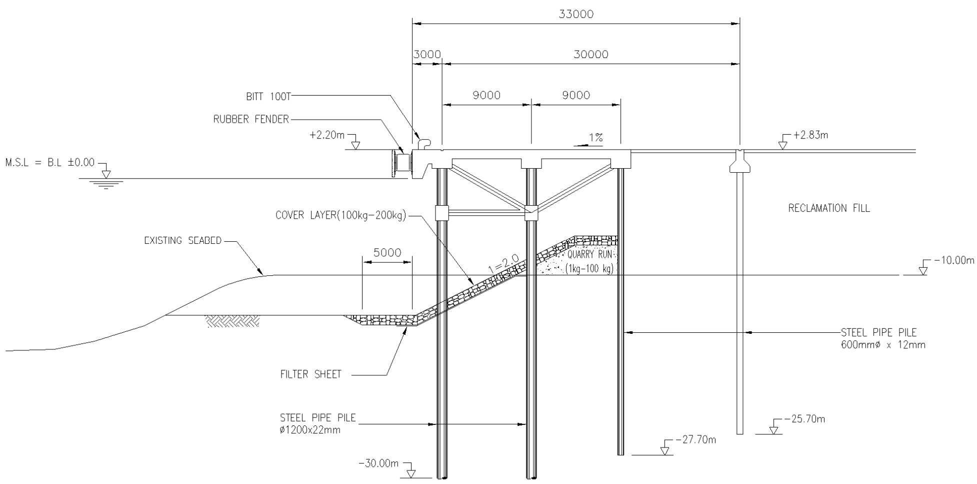
Source: JICA Study Team

Figure 5.1.2-5 Type 2: Concrete Box Caisson Quay Wall



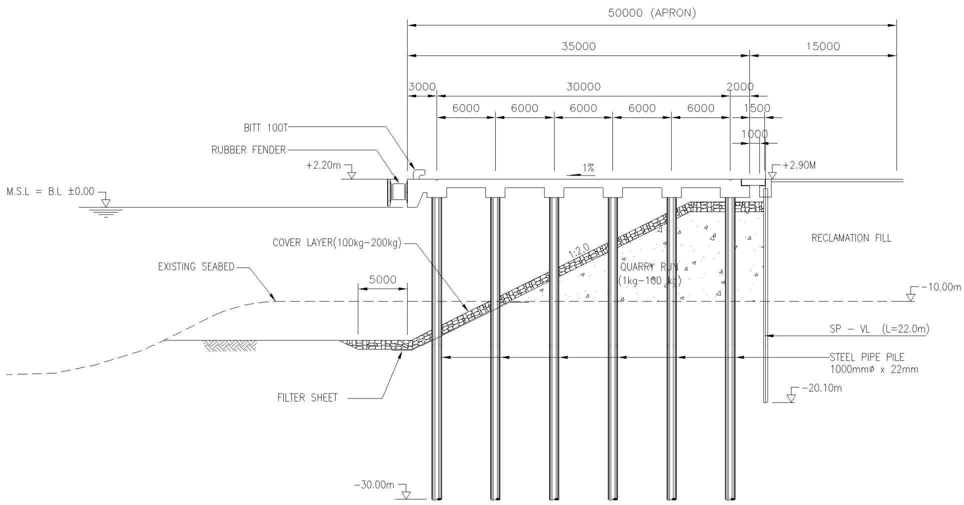
Source: JICA Study Team

Figure 5.1.2-6 Type 3: Steel Sheet Pile Quay Wall



Source: JICA Study Team

Figure 5.1.2-7 Type 4: Steel Pipe Pile Quay and Frame Structure



Source: JICA Study Team

Figure 5.1.2-8 Type 5: Concrete Deck on Open Steel Pipe Pile

Initial Study of Above Alternative Types

a) Soil Conditions

Soil conditions at North Kalibaru (NKB) area were obtained from the limited geotechnical investigation. It reveals that hard materials are present in the middle layer below -20m to 25m from the sea bed at some boring points under the intended wharf location. Above the middle layer is soft to medium dense silty sand or poorly graded sand (indicating N-value average less than 6 blows/ft), and below the middle layer below -25m is hard and dense clayey sand or silty/sandy clay (indicating N-value between 20 and over 50 blows/ft). This material is regarded as the base layer (founding layer).

These subsurface soil conditions are more suited to pile type structures such as Type 3, 4, and 5, because the founding layer for all structural types is considerably below dredge level. As a consequence, in the case of gravity type structures (Type 1 and 2) large volumes of seabed material have to be removed and replaced by a thick stone layer to secure sufficient ground bearing capacity. This is related to Structural Suitability in that the risk of damage or collapse is increased if the structure is founded on softer layers that allow settlement and tilting.

However, in the case of pile type structures in these conditions, the presence of the hard layer and the pile type must be carefully considered, because the piles have to penetrate through the hard layer in order to found in the base layer below. This is therefore related to Construction Methods.

b) Construction Materials

In Indonesia, all steel materials such as steel pipe piles, steel sheet piles etc. are manufactured and produced and some are imported from foreign countries. Therefore if steel materials and reinforced concrete are compared in connection with their cost and/or availability, there will not be a large difference between concrete structure and steel structures as far as procurement is concerned.

The type of structure is selected considering the current environmental protection regulations, in which it is difficult to obtain a large volume of sand for reclamation works and for replacement of soft soil of sea bed for the revetment foundation.

c) Construction Methods

Generally, in the construction of gravity type structures for deepwater quay walls, the structure will be pre-cast and then placed into the final location at site. During the pre-casting of the concrete structure, a dockyard or large space for manufacturing and also a large area for the storage of pre-cast elements will be required.

For the gravity concrete block wall (Type 1), the installation of blocks is important; heavy equipment is required for lifting and placing of blocks, and close adjustment is needed for alignment and level control at the construction works.

For the gravity caisson wall (Type 2), a large open or floating dock is needed for manufacturing the units, which would then be floated out (launched), stored, and finally sunk into position on a prepared rock bed, using marine equipment.

The greatest construction difficulty for these two structures is the preparation of the rubble mound underwater for installation of structures. The surface of rubble mound should be firmed smoothly by skilled divers. In Indonesia there are very few cases of adopting this type of wharf structure and few experienced marine contractors.

For the other three types of piled structure, marine piling techniques are well advanced, employing crane barges and purpose-made steel piling frames to achieve the required penetration and dimensional tolerances.

The presence of the intermittent hard layer has an important effect on the choice of structural type. Interlocking steel piles (Type 3 & 4), whether of sheet type or interlocking pipe type, are especially vulnerable when hard driving is encountered, resulting in split clutches and the necessity to remove and replace damaged piles.

For open pile types (Type 5), piles can be equipped with special driving shoes, and individual pile locations can be pre-drilled to break up the hard layer in advance; however, the cost of the pre-drilling must be accounted for in the overall cost estimation.

The deck structure may be designed as cast in situ or as a combination of pre-cast beams and slabs with in situ topping. In both cases the elevation of the structure must be closely considered to eliminate or minimize working with in situ concrete in or near the tidal zone.

The steel frame or “jacket” type structure (Type 4) is designed to be fabricated elsewhere and brought to site by barge. After pile driving the frame is placed over the piles by a very large floating crane, and fixed by grouting the gaps between piles and frame. The deck is made of relatively light pre-cast panels. The construction method is very different from other types and will require significant resources to supervise fabrication works in the country of origin for the frames. This type will also require considerable expense in mobilizing large cranes from outside Indonesia.

d) Construction Period

The construction period is governed by such factors as the ability and efficiency of the chosen equipment, weather conditions, difficulty of the work and the chosen construction method. The general rule is that the simpler the structural form and detailing, the shorter the construction period. In fact these conditions are common elements for all of the above alternatives.

e) Experience with Similar Projects

Generally, all structural types except for Type 4 already exist on similar container berth quay walls in Indonesia. In cases of deeper draft berths, caissons (Type 2), sheet steel piles (Type 3) and concrete deck on pipe piles (Type 5), are most commonly selected. Indonesian marine contractors have a lot of experience with construction of similar pipe pile type of wharf foundation works (Type 5).

On the other hand, the steel pipe pile wall and frame (Type 4), is a recently devised design based on a hybrid of oil platform experience and a traditional pipe pile wall. To our knowledge, there are only a few examples of its use in deepwater quays.

f) Maintenance Costs

Usually, gravity structures (Type 1 and 2) are more durable than the other types using steel (Type 3, 4, and 5). Maintenance costs for concrete structures related generally to the extent of reinforced elements located in the tidal / splash zone.

In the case of steel structures (Type 3, 4, and 5), adequate corrosion protection will be required and so should be provided. Thus the maintenance cost due to corrosion should be taken into account in the overall cost estimation.

g) Structural Suitability

Generally, the forces imposed on the structure include vessel berthing and mooring and live loads from gantry cranes and other heavy equipment provided for cargo handling on top of the wharf. Usually, such heavy equipment will impose critical point loading onto the structure. Solid type structures, such as gravity types (Type 1 and 2), have the ability to accept horizontal and vertical loads; however, in these conditions, it is necessary to replace the base layer, because the structure itself is very heavy. This is related to Soil Conditions (risk of toppling) as described above.

For the steel sheet pile type (Type 3), the principle is to support active earth pressures behind the wall by a frontage of steel sheet piles, tied back using heavy steel tie rods to a piled anchor beam. This type is structurally quite straightforward and is a suitable alternative in this case.

For the concrete deck on open steel pipe piles (Type 5), there are many similar examples of this type of deepwater quay and this appears to be a suitable structure in consideration of all factors. It should be noted that all the piles are vertical in this case, and special consideration has to be given to seismic loading cases when the structure will tend to sway. It may be that a number of raking piles have to be introduced following detailed design and analysis, to reduce swaying effects.

In particular, this structural type has the advantage of being a single independent structure, able to resist loads from both seismic activity and from the crane. Both crane rails (sea side and rear side) are supported on the same structure.

Evaluation of Initial Study

In view of the above, the initial comparison of the five proposed structural types is summarized in Table 5.1.2-10

Table 5.1.2-10 Initial Evaluation of Berthing Structural Type

Key factors	Type 1		Type 2		Type 3		Type 4		Type 5	
	Concrete Block Wall		Caisson Wall		Steel Sheet Pile Wall		Open Pile & Steel Pipe Pile Frame		Concrete Deck on Steel Pipe Pile	
Soil Conditions	Δ	1	Δ	1	🖶	2	🖶	2	🖶	2
Construction Materials	◎	3	◎	3	🖶	2	🖶	2	🖶	2
Construction Methods	Δ	1	🖶	2	🖶	2	🖶	2	🖶	2
Construction Period	Δ	1	Δ	1		2	🖶	2	🖶	2
Experience on Similar Projects	🖶	2	🖶	2	◎	3	🖶	2	◎	3
Maintenance Costs	◎	3	◎	3	Δ	1	Δ	1	Δ	1
Structural Suitability	🖶	2	Δ	1	🖶	2	🖶	2	◎	3
Evaluation	13		13		14		13		15	

Note: ◎; Advantageous (score 3), ; Good (score 2), Δ; Fair (score 1) Source; JICA Study team
Source: JICA Study Team

Based on the above initial evaluation, three structural types (Type 3, 4 and 5) are extracted as alternatives for further consideration in more detail.

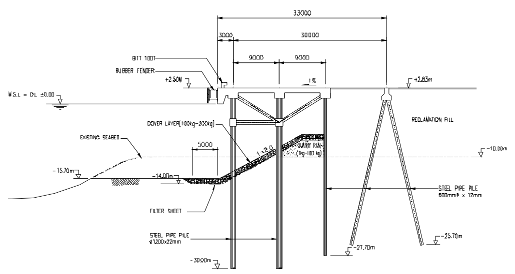
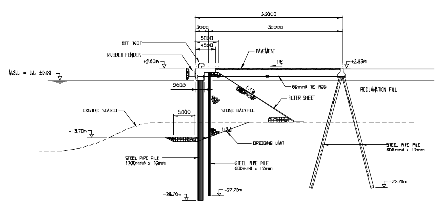
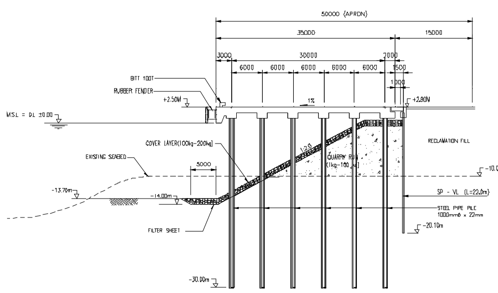
Selection of Quay wall Structure for New Container Terminal

In the detailed comparison of the three structural alternatives for selection of suitable type of quay wall structure, the following aspects which are the key factors are considered for final selection of structure type:

- Construction Methods and Sequence
- Maintenance
- Construction Period
- Construction Cost

As a result of the comparison study, "Concrete deck on Steel Pipe Pile type" is considered suitable as the selected quay wall type for the new container terminal at three candidate sites due to similar soil conditions, seismic conditions, loading conditions and construction methods to be taken. Comparison for three structural alternatives is shown in Table 5.1.2-11.

Table 5.1.2-11 Comparison of Alternative Quay wall Structures

	Steel Pipe Pile Wall and Frame Structures	Description	Construction Method	Maintenanc	Constructio n Period	Cost per Meter	**Evaluation**
Typical Cross Section		SPP; Ø 1200mm x 22 mm, L=32 m, Anchor piles, SPP Ø600 x12 mm, L=30-27 m, Concrete V=7,500 m3/300m(1berth)	Adjustable and flexible to the changes of soil conditions. Fabrication dock,transporting large barge and temporary set up yard are required. Not so many experiences in Indonesia ports	Anti-Corrosion measures are required	24 months	500 Mil Rp/m	Not Recommendable
Typical Cross Section	**Steel Sheet Pipe Pile Type** 	SSPP; Ø 1300mm x 16 mm, L=35 m, Anchor piles, SPP Ø 800 x12 mm, L=25 m, Tie Rod; Ø 80 mm, L=32 m, Concrete V=3,500 m3/300m(1berth)	Adjustable and flexible to the changes of soil conditions. Not so many experiences in Indonesia ports. Large reclamation works are required.	Anti-Corrosion measures are required	28 months	550 Mil Rp/m	Not Recommendable
Typical Cross Section	**Concrete Deck on Open Steel Pipe Pile Foundation** 	SPP; Ø 1000mm x 16 mm, L=32 m, Anchor sheet piles, VL type L=22 m, Concrete V=12,600 m3/300m(1berth)	Adjustable and flexible to the changes of soil conditions. Reclamation volume is minimal. Environmental impact is the smallest among others.	Anti-Corrosion measures are required	28 months	480 Mil Rp/m	Recommendable

Source: JICA Study Team

The basic conditions of selected quay wall structure by preliminary design

The selected type of quay wall is designed with the following loading conditions on piles.

Dead and live load per pile; Pv=250 t/pile
Dead and sea side crane load; Pv=425 t/pile
Dead and land side crane load; Pv=430 t/pile

The above loading conditions are also applied for preliminary design of new berths of 87,000 DWT for new terminals development of Phase 2, 3 of North Kalibaru at Tanjung Priok under Alternative 1and new terminals development in Cilamaya and Tangerang.

The particulars of quay wall are shown in the table below. The typical cross section is shown in Figure 5.1.2-9.

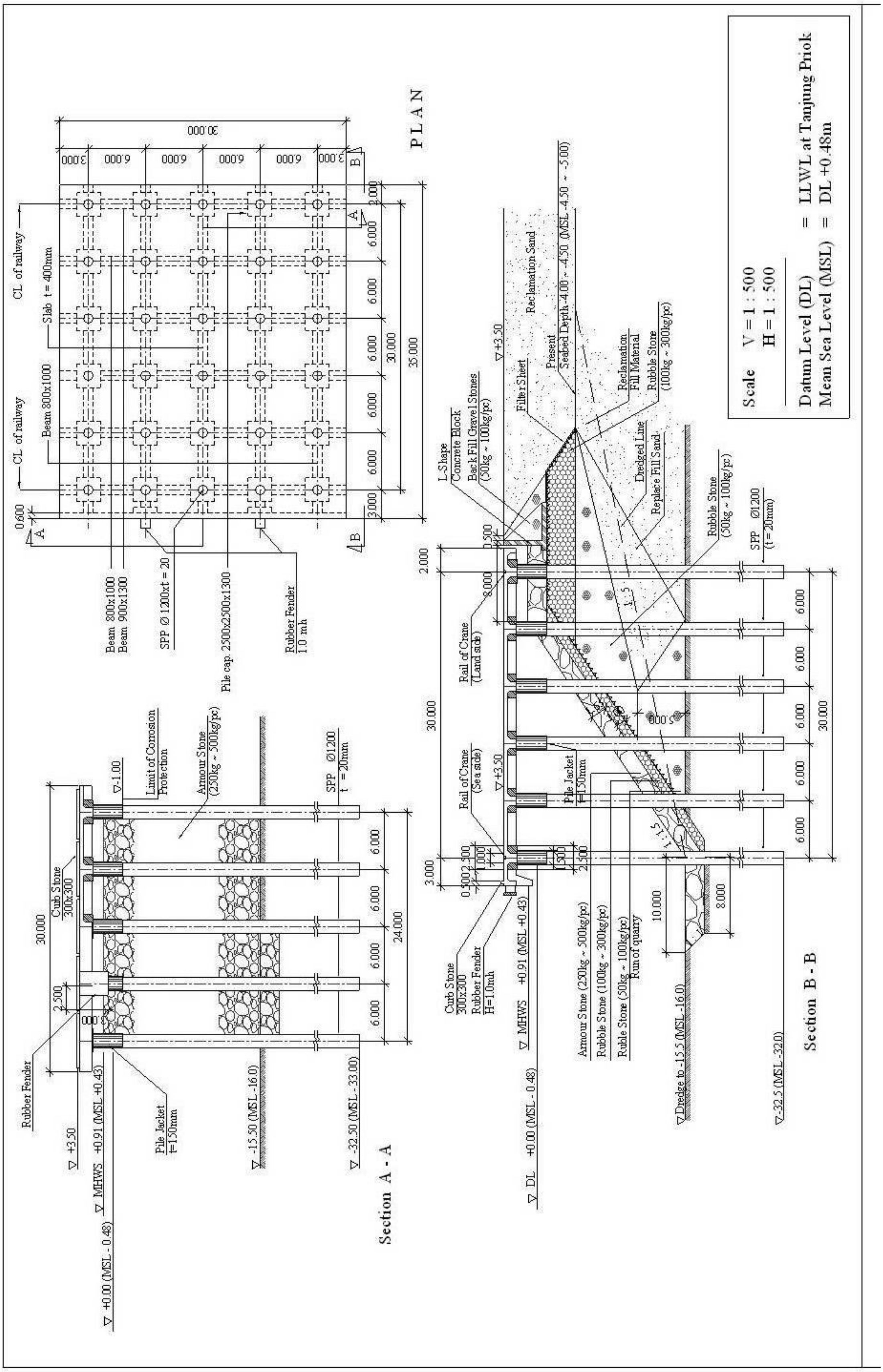
Table 5.1.2-12 Selected Type of Quay wall Structure for New Terminal at North Kalibaru Phase 1

Location	North Kalibaru New Terminal in Tajung Priok
Target Throughput	1,900,000 TEU
Berth Length	1,200m
Berth Water Depth	CDL-15.5m
Number of Berths for Urgent Plan	4
Target Vessel Size	87,545 DWT
Quay wall Structure	Concrete Deck on Open Steel Pipe Pile Ø1200,t=20mm, driven up to - 32.50m DL (N-,50), with retaining wall by concrete blocks on top of rubble mound
Crown Height of Quay wall	CD+3.50m
Terminal Yard Length	600 m
Quay Cranes and Yard Cranes	12 QGC + 30 RTG, 60 units of Yard Tractors
Fender	Rubber Fender 1150H, @12m
Bollard	100 tons @ 30m

Source: JICA Study Team

5) Quay Crane Foundation for Container Berth

One block of the concrete deck on pile is planned by 30 m (length) x 35 m(width), so that the rear container crane rail foundation piles are used from the foundation piles of the concrete deck structure installed at 30 m away for the crane wheel gauge from the sea side foundation piles for crane installation.



Source: JICA Study Team

Figure 5.1.2-9 Section of SPP Type Quay wall Structure (-15.5m CDL) at North Kalibaru