JICA JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
BRAZILIAN COOPERATION AGENCY (ABC), MINISTRY OF EXTERNAL RELATION
SEPLAN-PLANNING AND COORDINATION SECRETARIAT OF STATE OF CEARA (CEARÁPORTOS)
SDE-STATE SECRETARIAT OF ECONOMIC DEVELOPMENT (CIPP/GTP)
SEINFRA-INFRASTRUCTURE SECRETARIAT OF STATE OF CEARA

No.

PECEM INDUSTRIAL AND PORT COMPLEX DEVELOPMENT PLAN IN THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT

VOLUME III

MARCH 2006

INTERNATIONAL DEVELOPMENT SYSTEM Inc. (IDS)
NIPPON KOEI Co., Ltd. (NK)

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FINAL REPORT

FOR

THE STUDY

ON

PECEM INDUSTRIAL AND PORT COMPLEX DEVELOPMENT PLAN

IN

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PREFACE

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct a study on Pecem Industrial and Port Complex Development Plan and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Kobune of International Development System Inc. and consists of International Development System Inc. and Nippon Koei Co., LTD. between February, 2005 and March, 2006.

The team held discussions with the officials concerned of the Government of the Federative Republic of Brazil and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Federative Republic of Brazil for their close cooperation extended to the study.

March 2006

KAZUHISA MATSUOKA,
Deputy Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

March 2006

Mr. Kazuhisa MATSUOKA
Deputy Vice President
Japan International Cooperation Agency

Dear Mr. MATSUOKA,

It is my great pleasure to submit herewith the Final Report of “Pecem Industrial and Port Complex Development Plan in the Federative Republic of Brazil”.

The Study Team comprised of International Development System Inc. and Nippon Koei Co., Ltd. conducted studies in the Federative Republic of Brazil over the period between February 2005 and March 2006 according to the contract with the Japan International Cooperation Agency (JICA).

The Study Team compiled this report, which proposes the long-term development plan to the target year 2022, the short-term development plan to the target year 2012 and the strategic port management and operation plan for Pecem Port, through close consultations with officials of the Federal Government, Ceara State Government and other authorities concerned.

On behalf of the Study Team, I would like to express my sincere appreciation to the Federal Government, Ceara State Government and other authorities concerned for their cooperation, assistance, and heartfelt hospitality extended to the Study Team.

We are also very grateful to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and Embassy of Japan in the Federative Republic of Brazil for valuable suggestions and assistance during the course of the Study.

Yours faithfully,

Koji Kobune

Koji KOBUNE,
Team Leader
Pecem Industrial and Port Complex Development Plan
in the Federative Republic of Brazil

Location Map of the Study Port

Pecem Port and its Surroundings

Abbreviation

AAE	Strategic Environment Evaluation
ABC	Brazil Cooperation Agency
ABRATEC	Brazil Association of Public use Container Terminal
AL	Alagoas
AM	Amazonas
ANTAQ	National Agency of Waterway Transport
ANTT	National Terresrial Transport Agency
AP	Amapá
ASEAN	Association of Southeast Asian Nations
ASSFAP	Pecem´s Families Association
Av.	Average
B/C	Benefit/Cost
b/d	barrels/day
B/water	Breakwater
BA	Bahia
BACTSSA	buenos aires container terminal services S.A.
BEC	State Bank of Ceara
BNB	Bank of Northeast of Brazil
BNDES	National Bank of Development
BOI	Board of Investment
BR-xxx	Designation of Brazilian federal highway
C.Y.	Container Yard
C/S	Central/South
c1	Type of Petroleum Chemical Product
c2+	Type of Petroleum Chemical Product
C3	Type of Petroleum Chemical Product
C4	Crude Gasoline
C5+	Type of Petroleum Chemical Product
CAGECE	Water and Sewer System Company of Ceara
Cap	Capita
CCT	Colon Container Terminal
CE	Ceará
CE xxx	Ceara State highway
CEDIN	State Industrial Development Board
CEGAS	Ceara Gas Company
CFN	Companhia Ferroviária do Nordeste
CFS	Container Freight Station
CFSL	Conversion Factor for Skilled Labor
CFUL	Conversion Factor for Unskilled Labor
CGTF	Thermoelectric generated energy Plant of Fortaleza
CHESF	Hydroelectric Company of São Francisco River
CIF	Cargo, Insurance and Freight
CIPP	Pecem Industrial Port Complex
CIS	Commonwealth of Independent States
CMA CGM	Compagnie Maritime d'Affrètement & Compagnie Générale Maritime
CNT	National Transport Confederation
COELCE	Ceara Electric Company
COEMA	State Environment Council

COGERH	Hydrologic Resources General Company
CONAMA	National Environment Council
CRAS	Reference Center for Social Assistance
CSX-WT	CSX World terminals
CTO	Ceara Terminal Operator
CVM	Valores Formuladaturs' Commission
CVRD	Companhia Vale do Rio Doce
CVT	Technological Training Center
DECON	Consumer Rights Department
deg	Degree
DERT	State Highway Department
DHN	Bureau of Hydrolgeology and Navigation
DNER	National Transport Infrastructure Department
DNIT	National Transport Infrastructure Department
DRI	Direct Reduced Iron
DWT	Dead Weight Tonnage
E	East
EAS	Simplified Environmental Study
EDI	Electronic Data Interchange
EIA	Environmental Impact Study
EIRR	Economic Intern Return Rate
EMBRAPA	Brazilian Livestock and Agriculture Company
ENE	East-North-East
EPZ	Environment Protection Zone
ES	Espirito Santo
ESE	East-South-East
EVA	Environmental Viability Study
F/D	Floating Dock
FAO	Food and Agriculture Organization
FDI	Industrial Development Fund
FIEC	Federation of the Industries of Ceara State
Fig.	Figure
FINOR	Fund of Investment of Northeast Region
FIRR	Financial Intern Return Rate
FMR	Fortaleza Metropolitan Region
FOB	Free On Board
FUNCEME	Ceara State Foundation of Meteorology and Hydrologic Resources
GASFOR	Gas Pipeline
GDP	Gross Domestic Production
Gis	Geographic Information System
GL	Ground Level
GM	Metacenter to the Center of Gravity
GRT	Gross Registered Tonnage
GTP	Participative Group of Work
GW	Gigawatt
GWT	Gross Weight Tonnage
H	Height
H/Hi	Wave height at point of interest over incident Wave height ratio
há	Hectare
HHWL	Highest High Water Level

HP	Horsepower
Hs	Wave Height
HWL	High Water Level
Hz	Hertz
IALA	International Association of Lighthouse Authorities
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources
IBGE	Brazilian Institute of Geography and Statistics
ICMS	Brazilian Excise Tax
ICTSI	International Container Terminal Services Inc.
IDACE	Institute of Rural Development of Ceara
IDB	Inter-American Development Bank
IDM	Municipality Development Index
IDS	International Development System
IEE	Initial Environment Evaluation
IMO	International Maritime Organization
INEMET	National Institute of Meteorology
INPH	National Institute of hydrologic Research
IPECE	Institute of Economic Research of Ceara State
IR	Infrared
ISPS	International Ship and Port Facility Security
J2	Jota Dois
JICA	Japan International Cooperation Agency
Kd	Stability Coefficient
Kg	Kilogram
KN	KiloNewton
kV	kilovolt
KWh	Kilowatt/hour
Kxx	Radius of Gyration
Lat	Latitude
LI	License of Installation
LLDPE	Linear Low Density Polyethylene
LLWL	Lowest Low Water Level
LNG	Liquefied Natural Gas
LO	License of Operation
LOA	Length Over All
Long	Longitude
LP	Previous License
LPG	Liquefied Petroleum Gas
LS	Lump sum
LT	Lifting Tonnage
LWL	Low Water Level
m	Meter
m/s	meter/second
m^3	Cubic meter
MA	Maranhão
Max	Maximum
MDF	Medium Density Fiber
MG	Minas Gerais
MHWN	Mean Higher High Water Neap
MHWS	Mean Higher High Water Spring

MISC	Miscellaneous
MIT	Puerto manzanillo International Terminal
MLWN	Mean Lower Low Water Neap
MLWS	Mean Lower Low Water Springs
mm/ye	millimeter/year
MMA	Ministry of Environment
MMBTU	Million British Thermal Units
MOL	Mitsui O.S.K. Lines, Ltd
MS	Mato Grosso do Sul
MSL	Mean Sea Level
MT	Mato Grosso
MTC	Manzanillo International Container terminal
MTI	Ministry of Trade and Industry
MW	Megawatt
N	Newton
N/A	Not available
NAVIS	Navy Automated Video Information System
NE	North-East
NGO	Non-Governmental Organization
NK	Nippon Koei
NNE	North-North-East
NNW	North-North-West
NPV	Net Present Value
Nqgc	Number of Quay side Gantry Crane
Nr	Number
Nrtg	Number of Rubber Tyred Gantry Crane
Ns	Stability Number
NUTEC	Industrial Technology Center
NVOCC	Non-Vessel Operating Common Carrier
NW	North-West
O&M	Operations & Maintenance
OOCL	Orient Overseas Container Line
P&O	Peninsular & Oriental (shipping company)
PA	Pará
PAIF	National Plan for Family Assistance
PB	Parnaíba
PCA	Environmental Control Plan
PDR	Rational deforestation Plan
PE	Pernambuco
PET	Polyethylene Terephthalate
PI	Piauí
PIANC	Permanent International Association of Navigation Congresses
PMF	Forest Management Plan
PP	Polypropylene
PPA	Pluriannual Plan
Pqgs	Productivity of Quay side Gantry crane
PR	Paraná
PRAD	Plan of Recovery of Degraded Areas
PROARES	Social Reforms Support for Children and Adolescent Development Program
PROVIN	Industrial Development Incentive Program

Prtg	Productivity of Rubber-Tyred Gantry crane
PS&D	Production, Supply & Distribution
PU	Polyurethane
PVC	Polyvinyl Chloride
QSGC	Quay Side Gantry Crane
R$	Brazilian Real
RAA	Environmental Consulting Report
RAS	Simplified Environmental Report
RCA	Environmental Control and Monitoring Report
Re	Brazilian Real
Rec	Recession
REFAP	Refinery Alberto Pasqualini
RIMA	Environmental Impact Report
RJ	Rio de Janeiro
RLAM	Refinery Landulpho Alves/Mataripe
RMF	Metropolitan Region of Fortaleza
RMG	Rail-Mounted Gantry crane
RN	Rio Grande do Norte
RO	Roráima
RO/RO	Roll on/Roll off
RPBC	Refinery President Bernades/Cubatão
RS	Rio Grande do Sul
RTG	Rubber-Tyred Gantry crane
S	South
S.B.R.	Styrene Butadiene Rubber
Samp	Sample
SBF	Secretariat of Forest and Biological Diversity
SC	Santa Catarina
SCA	Secretariat of Amazon Coordination
SCF	Standard Conversion Factor
SDE	Secretariat of Economic Development
SE	Sergipe
SE	South-East
SEBRAE	Brazilian Support Service for micro and small companies
SECULT	Secretariat of Culture
SEINFRA	Secretariat of Infrastructure
SEMACE	Secretariat of environment of Ceara
SENAC	National Service of trade training
SEPLAN	Secretariat of Planning and coordination
SESC	Trade Social Service
SINE	National employment System
SOMA	State Secretariat General of Environment
SP	São Paulo
sq.m	Square Meter
SQA	Quality in the Human Settlement
SRH	Secretariat of Water Resources
SSA	Stevedore Service of America
SSE	South-South-East
SSW	South-South-West
SUDENE	Superintendency of Development of Northeast Region

SW	South-West
TECON	Container Company S.A. (Terminal de Contêineres S.A.)
TEP	Temporary jetty
TEU	Twenty-foot equivalent unit
TOR	Terms of reference
Tp	Wave Period
TP&E	Tarcísio Pinheiros & Economistas
TPA	Third Party Administrator
Troll	Natural Period of Rolling of the Waves
TWH	Terawatt/hour
Tz	Mean Wave Period
U	Wind speed
U.S.A.	United States of America
UFC	Federal University of Ceara
ULCV	Ultra Large Container Vessel
US	United States (of America)
US$	US Dollar
USBC	United States Border Control
USC	Ceara Steel Factory
USDA	United States Department of Agriculture
UVA	University of Vale do Acaraú
V	Volt
VAT	Value Added Tax
Vb	Lump Sum
Vel	Velocity
VSL	Vessel
VTMS	Vessel Traffic Management Services
WNW	West-North-West
WSW	West-South-West
YB	Year Book
ZPMC	Shanghai Zhenhua Port Machinery Co., Ltd.

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CHAPTER 10 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS FOR SHORT-TERM DEVELOPMENT PLAN

CHAPTER 9 SHORT-TERM DEVELOPMENT PLAN OF PECEM PORT

9.1 Basic Concept of Development of Pecem Port

The Short-Term Development Plan has been made as the first phase plan within the framework of the Long-Term Development Plan that has been proposed as the target and guideline for phased development plans (see Section 6.8 of Chapter 6). The Short-Term Plan includes the proposed project (see Section 9.8) for which feasibility has been assessed from standpoints of national economy and financial viability (see Sections 9.9 and 9.10).

The Short-Term Development Plan has presupposed its target year of 2012 as a given condition. On this condition, the Long-Term Development Plan has been divided into two phased plans taking account of various aspects including size and configuration of the entire plan and economical phasing of construction works. The first phase plan corresponds to the said Short-Term Development Plan and the second phase plan to the remaining portion of the Long-Term Development Plan. The target year of the second phase plan should be 2022 or before.

From the above, the following concept of the development of Pecem Port has been proposed:

<u>Expansion Plan</u>

- Establishment of new marine terminals
- Construction of new breakwaters
- Creation of a new access channel and basins
- Installation of new railway sidings

<u>Development Plan of the Existing Facilities</u>

- Extension of the existing breakwaters (the west and south breakwaters)

9.2 Port Capacity Analysis

9.2.1 Purpose of the Analysis

The port capacity analysis has been made on the assumption that the port expansion and the existing port development proposed in the Short-Term Plan are completed by the target year of 2012. The same computer simulation model as used in making the Long-Term Plan has been applied (refer to Section 6.1 of Chapter 6).

The capacity analysis has been made according to the following two main purposes:

- To estimate the required number of berths
- To estimate the required storage areas

The berth allocation conditions by vessel type, which were used in the simulation, are shown in Table 9.2.1.

Table 9.2.1 Ship Sizes and Berth Allocation

Cargo Item	Ship Type	Ship Size	Representative Principal Dimensions (DWT/TEUs)	LOA (m)	Draft (m)	Beam (m)	Annual Cargo Throughput in 2012 ('000	Berth Allocation Pier 1 No. 1	Pier 1 No. 2	Pier 2 No. 3	Pier 2 No. 4	Pier 3 No. 1	Pier 3 No. 2	Pier 3 No. 3	Container Berth No. 1	Container Berth No. 2
Solid Bulk Cargo																
Iron Ore Pellets	Ore Carrier	Panamax(L)	72,000	225.00	13.52	32.20	2,500	O								
Cokes	Bulk Carrier	Panamax(S)	51,000	182.00	12.00	32.20	120					O	O			
					Solid bulk total		2,620									
Liquid Bulk Cargo																
Refined Petroleum	Petroleum Tanke	Large1	106,000	240.99	14.90	42.00	1,045			O	O					
					Liquid bulk total		1,045									
Break-bulk Cargo																
Thick Slabs	Bulk Carrier	Panamax(S)	51,000	182.00	12.00	32.20	1,500		O			O	O			
Steel Rolls	Bulk Carrier	Handy Size	45,000	186.00	10.95	30.40	147		O			O	O			
Steel Billets	Bulk Carrier	Small 3	26,000	168.05	10.00	25.33	75		O			O	O			
Bagged Cement	Multi-purpose Shi	Multi-purpose	32,000	188.00	11.65	27.70	120		O			O	O			
Fresh Fruits	Reefer Ship	Reefer	6,100	133.92	7.60	15.80	227							O		
					Break- bulk total		2,069									
			Conventional total ('000 tons)				5,734									
Container																
	Main Line Ship	Post-Panamax	9,200	346.98	14.50	46.00									O	O
		Panamax (4th)	4,800	294.00	13.50	32.20									O	O
		Panamax (3rd)	3,700	243.00	12.50	32.20									O	O
					Main line total		295									
	Coaster		1,400	170.00	9.50	24.80	58									
	Feeder Ship		1,400	170.00	9.50	24.80	94								O	O
			Container total ('000 TEUs)				447									

Source: JICA Study Team

9.2.2 Required Number of Berths

(1) Multi-purpose Berths

The following three berths have been planned as so-called "multi-purpose berths" for handling break-bulk cargoes including steel products and bagged cement, and solid bulk cargo excluding iron ore pellets. Fresh fruits are planned to be handled at Berth No.3 of Pier 3 with a cold storage behind the berth.

- Berth No.2 at Pier 1 (Existing berth)
- Berths No.1 and No.2 at Pier 3 (Planned new berths)

According to the results of the simulation, in the berth allocation conditions shown in Table 9.2.1 the resulting seaside service level in 2012 is 4.4% for annual cargo throughputs of 2 million tons of the above-mentioned cargoes which satisfies the criterion of 10%.

On the other hand, if the number of the planned new berths as multi-purpose berths is reduced to one from two, the resulting seaside service level jumps to 13.6%, exceeding the 10% level. And if the number of planned new berths is further reduced to zero from one, the resulting seaside service level jumps to 324.8% , far exceeding the 10% level, where a considerable number of off-shore waiting ships is observed due to the saturation in terms of berth capacity (see Figure 9.2.1). Thus, the optimum number of the new berths has been determined as two.

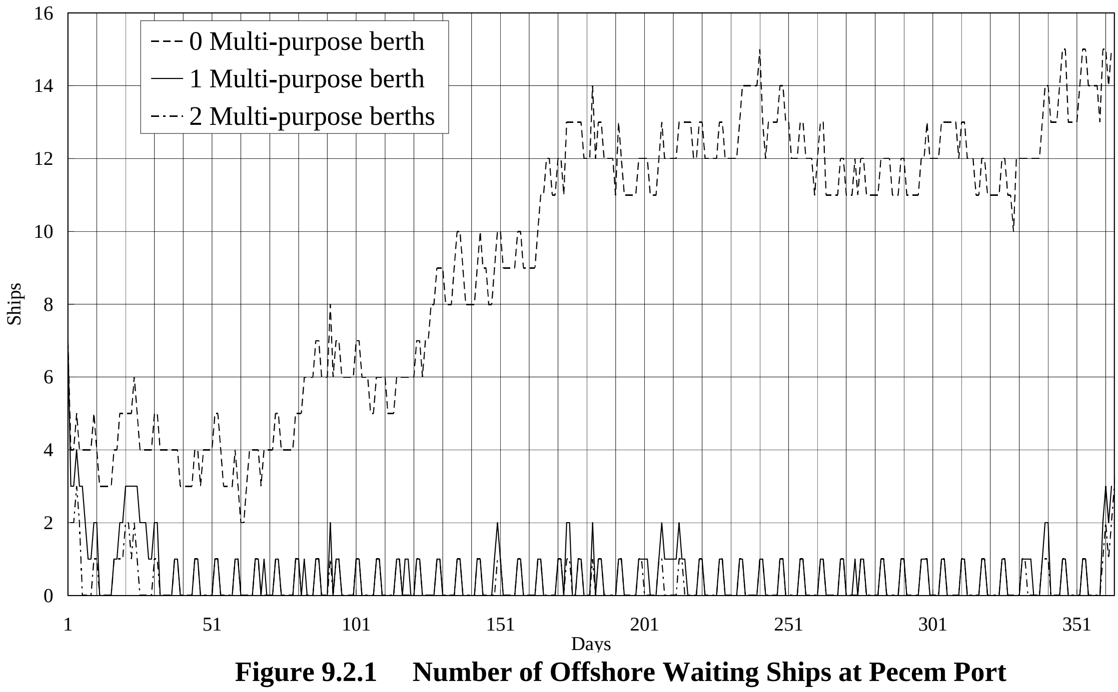


Figure 9.2.1 Number of Offshore Waiting Ships at Pecem Port

(2) Container Berth

In the Short-Term Plan stage, a container berth with a length of 540m has been planned to receive 447,000 TEUs of containers of in the target year 2012. The representative vessel sizes of the design vessels are in the range of 170m – 347m in LOA (Length Overall) and 25m - 43m in moulded breadth (refer Table 9.2.1). Hence, the berth with a length of 540m could receive one main-line ship and one coaster (feeder or cabotage ships) simultaneously. In the simulation, on the assumption of container ship arrival schedule on the basis of weekly services by shipping routes and the installation of container gantry cranes, it has been verified that the berth length is adequate to serve the above-mentioned container throughput in the target year without incurring any container ships' waiting off shore.

9.2.3 Required Storage Capacity

By using the simulation model, the storage capacities required in 2012 have been estimated by cargo item on the same assumption mentioned in Section 6.1.3 of Chapter 6, and have been compared with the existing storage capacities,.

Containers

The resulting fluctuation of container number dwelling at a container stacking yard is shown in Figure 9.2.2.

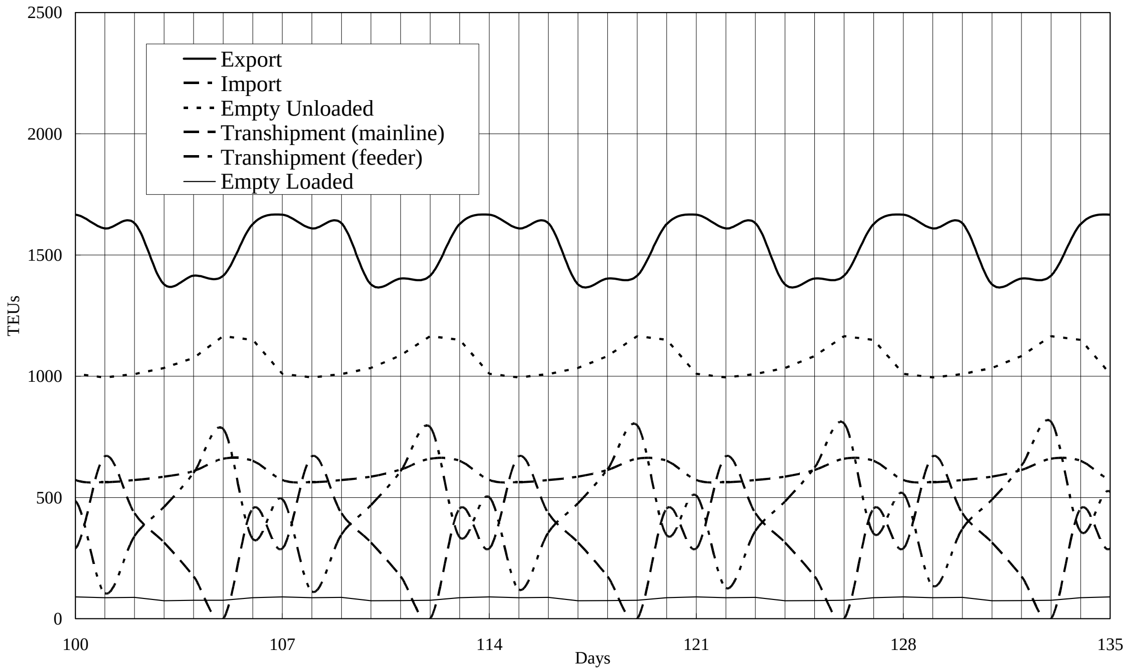


Figure 9.2.2 Number of Containers Dwelling at Container Stacking Yard

According to the result of the simulation, the required container stacking capacities and the corresponding ground slots (loss parameter: 1.25) in the condition of using RTG system by container category have been computed as follows:

Container Category	Required Capacity (TEUs)	Tiers	Required Ground Slots
Export (Laden)	1,666	3.8	548
Import (Laden)	660	3.5	236
Transhipment (main line)	670	3.8	220
Transhipment (Feeder)	812	3.8	267
Empty (unloaded)	1,165	4.0	388
Empty (loaded)	90	4.0	30
	5,063		1,663

As shown above, in 2012, the required container stacking capacity and ground slots are estimated as 5,100 and 1,700 in terms of TEUs, respectively.

On the other hand, current container stacking capacity at Pecem Port is around 8,900 TEUs. Taking account of "Loss Parameter" mentioned above to estimate the actual required capacity to cope with different shipping line services, actual capacity is estimated as approximately 7,100 TEUs on the condition of current container-handling system using reach-stackers. By 2012, however, the open yard for general cargo storage temporarily used for container stacking as shown in the table below, viz. A – F, and R – U, needs to be surrendered for the storage of steel products (mainly of thick slabs). By deducting that capacity, actual container stacking capacity is estimated as around 4,500 TEUs (5,643 TEUs/1.25) (see Table 5.2.2 in Section 6.1.3 of Chapter 6).

Thus, by comparing the required capacity of around 5,100 TEUs in 2012 with that mentioned above, the container stacking capacity needs to be increased by the preparation of new stacking yard and/or introduction of new container-stacking system, viz. RTG system.

Break-bulk Cargoes

The resulting fluctuation of the required areas of open yards and transit sheds in 2012 is shown in Figure 9.2.3.

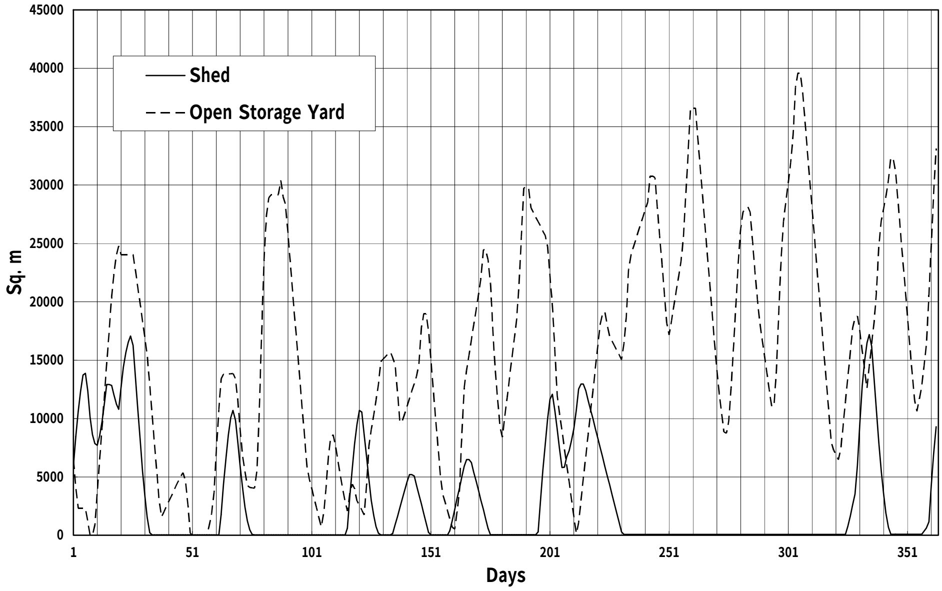


Figure 9.2.3 Required Areas of Open Yards and Transit Sheds

According to the result of the simulation shown in the above figure, the required storage areas in the consideration of loss parameter (1.25) are summarized below:

Type of storage	Area (sq. m)
Open yard	49,500
Transit shed	21,500

As to open storage, 100,000 sq. m of the existing yard will be sufficient for the required area indicated above in 2012. On the other hand, as to transit sheds, 15,000 sq. m of the existing floor space will be insufficient in 2012 both for conventional cargo storage and CFS. Assuming that 2,000 sq. m of the existing floor space is allocated for CFS, new transit sheds with floor space totalling 8,500 sq. m need to be prepared by 2012.

From the above, the storage capacities additionally required by 2012 are summarized in table 9.2.2.

Table 9.2.2 Summary of Required Storage Capacities in 2012 at Pecem Port

Stored Cargo		Storage capacity				Additionally required storage area (sq.m)
Category	Annual throughput ('000 tons/TEUs)	Unit	Existing	Required	Balance	
Cokes	120	tons	0	33,885	-33,885	16,100
Break-bulk cargo	1842	sq. m (open yard)	100,000	49,485	50,516	-
		sq. m (shed)	13,000	21,489	-8,489	8,489
Fresh Fruits	227	tons	0	5,044	-5,044	5,521
Containers (Yard)	447	TEUs (yard)	4,200	5,100	-900	-
		sq.m (CFS)	2,000	1,844	156	-

Source: Estimated by the JICA Study Team

9.2.4 Necessity of a Dedicated Container Railway Yard

The existing railway sidings are placed in front of the existing warehouses No.1 and No. 2. These sidings were originally designed for break-bulk cargoes brought into/out of the warehouses. Thus, sidings having accesses to the container yard need to be newly installed to be diverted from the existing access railway line.

9.3 Port Improvement Plan of the Existing Facilities

9.3.1 Extension of the Existing Breakwater

It has been proposed to extend the existing west breakwater by 300 m to reduce wave agitation especially due to swells in front of Piers No.1 – No.3. By the extension, the probability of penetrating waves not exceeding 50 cm will increase to 95.8% from the current level of 89.7% at the tip of Pier No.1 (see Section 6.5 of Chapter 6). The probability in front of Pier No3 has been estimated as 95.9%.

9.4 Port Expansion Plan

9.4.1 Necessity of Port Expansion

To meet the forecast demand for the increase in cargo-handling capacity in the stage of the Short-Term Plan, it is necessary to expand port capacity. The new off-shore port area needs to be placed to the east of the existing off-shore port area within the framework of the Long-Term Development Plan.

9.4.2 Marine Terminals

The required number, scale and type of marine terminals at the expanded port area have been verified by computer simulation. In the first step, some number, scale and type of terminals have been assumed, and then it has been verified whether the required service level has been satisfied. In the case when the required service level has not been satisfied, different figures has been input for further simulation trials. After this trial and error procedure, eventually, the optimum number, scale and type of required marine terminals have been determined as shown below.

(1) Off-shore Container Terminal

It has been planned to prepare an off-shore container terminal. The principal dimensions of the design container ship of Post-Panamax type are:

- 9,200 TEUs capacity
- LOA: 347 m
- Summer draft: 14.5 m
- Moulded breadth: 46 m

There are two main purposes in preparing a full-scale off-shore container terminal. One is to surrender Pier 1 to the handling of iron ore pellets and steel products after the start of steel mill operations. The other is to improve container handling efficiency by the preparation of container gantry cranes and shortening hauling distance between dockside and container stacking yard, and to upgrade operational service level of reefer container handling by the preparation of reefer plugs close to on-dock.

Main facilities and equipment (see Section 6.4.6) are:

- Berth

  Length: 540 m

  Water depth: 16 m

- Quayside container gantry cranes

  Number of units: 2

  Out reach: 50 m (18 rows)

  Back reach: 16m

  Rail span: 30 m

- RTG (Rubber Tired Gantry Cranes)

  Number of units: 4

  Specification: 4 high 5 over type

  Rail span: 23.47 m

- Terminal Area

  Length alongside: 540 m

  Width: 300 m

  Area: 16.2 ha

- Apron Area

  Length alongside: 540 m

Width: 57 m

Area: 3.1 ha

- Container stacking yard

  Length alongside: 450 m

  Width: 243 m

  Area: 10.9 ha

  Ground slots: 2,472 TEUs

  Dry containers: 2,340 TEUs

  Reefer containers: 432 TEUs

  Stacking capacity: 10,656 TEUs

  Dry containers: 9,360 TEUs

  Reefer containers: 1,296 TEUs

  Reefer plugs: 648 Units

(2) Off-shore Multi-purpose Terminal

It has been planned to prepare an off-shore multi-purpose terminal equipped with transit sheds just behind its berths at Pier 3 (with a length of 680m and a width of 100m). The principal dimensions of the design bulker of Handy-size type for steel products, etc. are:

- 45,000 DWT
- LOA: 186 m
- Summer draft: 11.0 m
- Moulded breadth: 30.4m

There are two main purposes in preparing off-shore multi-purpose terminal. One is to receive break-bulk cargoes such as steel products overflowed from Pier 1 The other is to improve break-bulk handling efficiency by the preparation of transit sheds behind berths within the manoeuvring distance of forklift trucks (15 m from berth face), consequently diminishing current double handling operations observed both on Pier 1 and the existing warehouse on land.

Main facilities are:

- Berth

  Length: 520 m

  Water depth: 16 m

- Transit sheds

  Number of sheds: 1

  Length: 150 m per unit

  Width: 50 m

Floor space: 7,500 sq. m

(3) Off-shore Fruits Terminal

The only means to receive reefer ships is to prepare a terminal equipped with a cold storage just behind a berth. Thus, it has been planned to prepare an off-shore fruits terminal. The principal dimensions of the design reefer ship are:

- 6,100 DWT
- LOA: 134 m
- Summer draft: 7.6 m
- Moulded breadth: 15.8 m

Main facilities are:

- Berth

  Length: 160 m

  Water depth: 16 m

- Cold storages

  Length: 110 m

  Width: 50 m

  Floor space: 5,500 sq. m

9.4.3 Required Dimensions of a New Sea Channel and Basins

(1) Necessity of a New Sea Channel

To have access to the new off-shore port area to be expanded in the direction of the east, it is necessary to create an access channel. A one-way channel has been verified to be sufficient by computer simulation.

(2) Alignment

Taking account of the statistical wave directions off the Port, the channel direction of N0° has been judged adequate.

(3) Width

The bottom width of the planned one-way sea channel has been designed by applying prevailing guidelines including the PIANC Guideline for the representative principal dimensions of the design vessels. To design the access channel, ULCV (Ultra Large Container Vessel) with a breadth of 57 m (22 rows) and LOA of 381 m have been considered. According to the PIANC Guideline, the required channel width has been estimated at 210 m (see Section 6.3.3 (3) of Chapter 6).

On the other hand, according to the deviation angle method (angle = 15°, L = 381 m, B = 57 m) the required channel width is 211 m almost the same as the figure derived from the PIANC Guideline. Thus, in this study, 210 m has been applied as the planned bottom breadth of the sea channel

(4) Water Depth

The water depths of the planned one-way sea channel and basins within the expanded port area protected breakwaters have been designed by applying the prevailing guidelines including PIANC for the representative principal dimensions of the design vessels. According to the PIANC Guideline, water depth of 16 m is required by applying multiplier of 1.1 for design draft of 14.5 m in inside basins. On the other hand, water depths of 16.5 m are required in the open sea according to the method considering ship movements that was recently developed in Japan (see Section 6.3.3 (4) of Chapter 6)..

(5) Turning Basin

The turning basin within the expanded port area protected breakwaters has been designed so as to provide a turning circle with a diameter of twice of the LOA of the design vessel. The maximum length among design vessel is 381 m. Thus a diameter of 760 m for turning circle has been considered in the design of the turning basin.

(6) Basin for Port Service Boats

The basin for port service boats including tugboats, pilot boats and survey boats has been planned so as to keep required calmness for those small boats by placing the secondary breakwaters. The principal dimensions of the design boat are:

- LOA: 33 m
- Draft (from the bottom of propeller): 3.6 m
- Moulded breadth: 10 m
- Main engines: 4,200 HP in total

9.4.4 Required Breakwaters

Breakwaters are required for the new off-shore port area to protect the inner channel, turning basins and berths. The new breakwaters need to be placed so as to halt the waves in the outer sea penetrating to the port waters from ENE as wind waves and NE as swell (see Section 9.5.1 (4)).

9.4.5 Facility Layout Plan

The off-shore port expansion area in the Short-Term Plan has been planned to be placed to the east of the existing off-shore port area within the framework of the Long-Term Development Plan (see Figure 9.4.1). The main components of the plan are shown in Table 9.4.1.

Table 9.4.1 Facility Components in the Layout Plan of the Short-Term Plan

Components			Dimensions
Access channel		Bottom width (m)	210
		Water depth (m)	16.5
Basins		Water depth (m)	16
Breakwaters		Main breakwater north part	1,220
		Main breakwater east part	570
		Sub-breakwater (m)	620
		West breakwater (extension) (m)	300
		Total	2,710
Revetment		Length (m)	270
Marine Terminal	Container Terminal	Berth length (m)	540
		Water depth (m)	16
	Multi-purpose Terminal	Berth length (m)	520
		Water depth (m)	16
		Sheds ('000sq. m)	7.5
	Fruits Terminal	Berth length (m)	160
		Water depth (m)	16
		Cold Storage('000sq. m)	5.5
Land use for expansion (ha)		Terminal area (off-shore)	25.0
		Terminal area (land)	11.1
		Total	36.1

Source: JICA Study Team

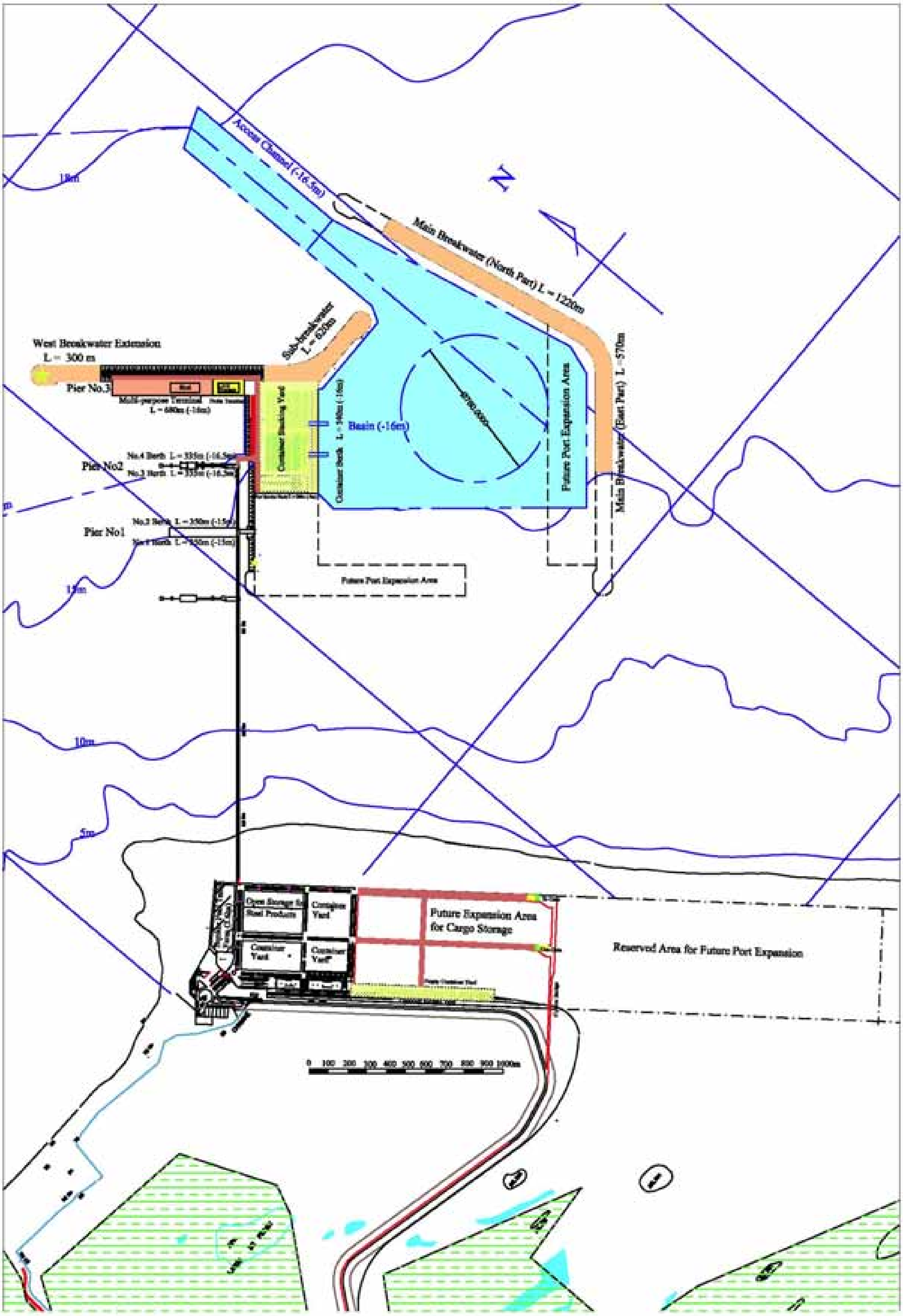


Figure 9.4.1 Facility Layout Plan in the Short-Term Development Plan

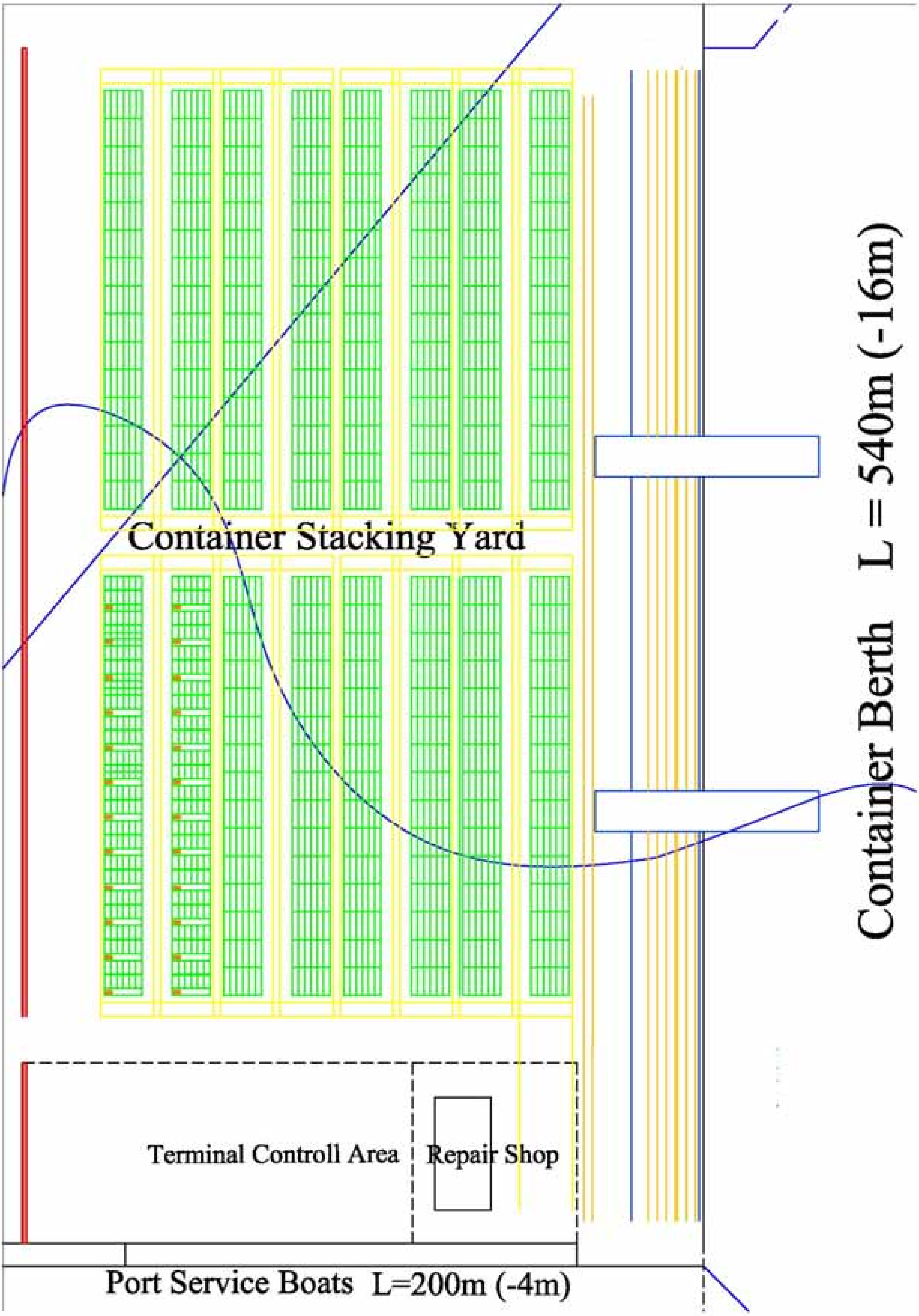


Figure 9.4.2 Facility Layout Plan of the Container Terminal (Scale 1:2,500)

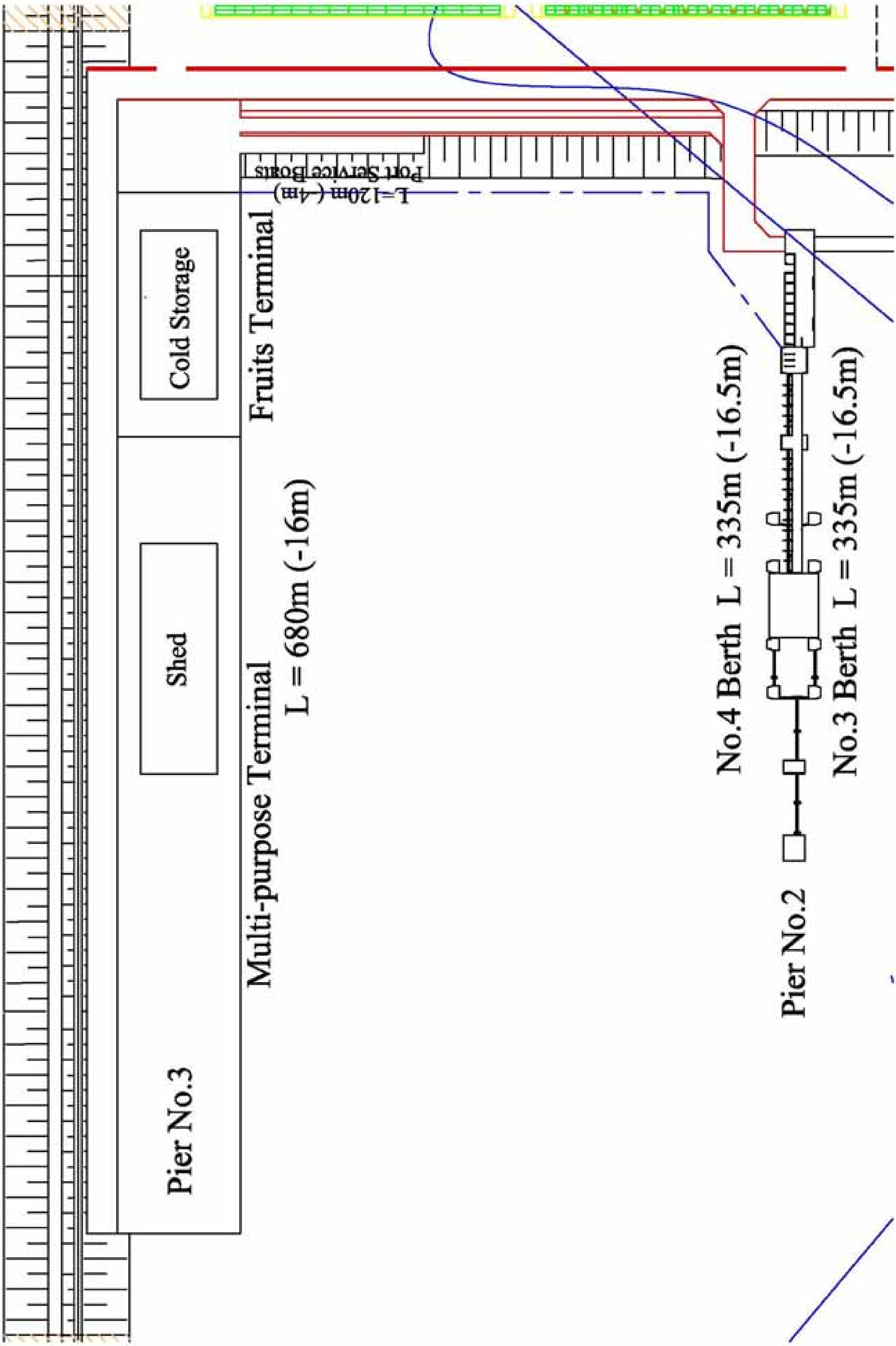


Figure 9.4.3 Facility Layout Plan of the Multi-purpose Terminal (Scale 1:3,500)

9.4.6 Cargo –Handling System

Cargo handling operation system in short-term project is just a passing point to accomplish long-term operation system in the master plan.

To that end it is necessary to improve the efficiency of the current whole operation system and implement such an efficient system for handling containers and break-bulk cargoes.

(1) Present Condition of Pecem Port

Currently, 9 container vessels call at Pecem port per week. The average number of container handling by one vessel is 250 to 300 boxes. The dwelling time of such vessels is around 8 ~ 10 hours. Container operations are conducted using Mobile Harbour Cranes and the current gross productivity average approximately 15 boxes per hour.

In order to adapt adequately to larger container vessels and the increase in the number of containers to be handled in the near future, it is important to increase the skill of crane operators and labours, thereby improving the efficiency of overall container and break-bulk cargo operations.

(2) Establishment of Separation Area in Piers

In the case of both-side operations at the berths No.1 and No.2 of Pier 1 which has a total width of 45m, the operational efficiency will not be high due to the usage of the narrow area for both mobile harbour crane operations and truck traffic.

In order to resolve this issue, it is recommended that the operation area and traffic area be separated and a waiting area for trucks be designated.

(3) Enhancement of the Newly Introduced Container Handling Equipment

Since Pecem Port is affected by strong winds in container operations in comparison with other ports, the following devices should be also introduced to the newly introduced container handling equipment.

1. In order to maintain high efficiency in container operation with high performance “anti-sway-stop” device should be installed to quay side gantry crane and RTGs.
2. In order to secure safe container operations with high performance, “rail-cramp” device should be installed to quay side gantry crane to resist the strong winds.
3. With regard to quay side gantry crane and yard equipment, “anti-shudder” structure should be applied to resist gale, taking into consideration the environment of operation.
4. “Breaking devices” of each container handling equipment should be powered up as usual.

(4) Required Cargo Handling Equipment for Short-Term Plan

In this section, the required number of container handling quay side gantry cranes (QSGCs), and container yard handling equipment (RTGs) and tractors and trailers will be estimated.

1) Quay Side Gantry Crane

The available number of quay-side gantry crane for handling container at a port is a governing factor in determining the turnaround time of container ships. Hence, it is necessary to provide the optimum number of container handling machines to ensure the completion of loading and discharging container operations within the shortest possible port stay time.

Table 9.4.2 Forecast of Annual Container Throughput in terms of TEU (Short-Term Plan)

Project Year	2012
Foreign Container Throughput	317,000TEU
Transhipment & Domestic Container	129,000TEU
Total Handling by TEUs	447,000TEU

Source: JICA Study Team

The required number of quay-side container gantry cranes (QSGC) to handle the annual container throughput of 447,000 TEU as shown in the above table 9.4.2 has been roughly estimated to be three (3) by using the following formula.

$$Nqgc = A / (T \times \mu1 \times \rho \times Pqgc \times \mu2 \times E)$$

Where

Required number of QSGCs (Units)

Nqgc = Required number of quay-side gantry crane(unit).
A = Annual throughput in 447,000 TEUs
T = Maximum annual available working hours During the year (Available working day per year 365 days and actual working hours 24 hours per day = 8,760 Hrs)
ρ = Berth occupancy ratio (0.60)
Pqgc = Productivity of quay-side gantry crane on the basis of net (27 boxes / hour / unit).
μ1 = Percentage of a availability Peaking Factor (=0.8)
μ2 = Container loading / discharging operation efficiency ratio 0.8
E = Conversion rate of 20’ / 40’ (applied result of 2004, 20’x30% and 40’x 70%) = 1.72 TEU/Box).

Calculations of Short Term (2012)

Nqgc= (8,760 x 0.8 x 0.55 x 26 Boxes x 0.8 x 1.72) =137,895

= 447,000 TEUs / 137,895 = 3.01 3 Units

The required unit number of quayside container gantry cranes (QSGS) in the target year of 2012 has been reduced to be two (2) from three (3) as indicated above for condition of being supported by the existing two units of mobile harbour cranes (see Table 9.4.3).

Table 9.4.3 Required Units of Quay-side Gantry Cranes

Project Year	2012
Forecast Annual Container Throughput by TEUs	447,000 TEUs
Requirement of New Quay side Gantry Crane (Nqgc)	2 Units
Existing Mobile Harbour Crane	2 Units

Source: Calculated by JICA Study Team

2) Yard Equipment (Rubber Tire Mounted Gantry Crane (RTGs))

The RTGs installed at the marshalling yard just behind the quay side must be operated in good combination together with quay side gantry cranes.

Their job assignment is to handle containers which are carried by tractor-trailer units between quay side and the marshalling yard as well as between the marshalling yard, and re-handling and/or pre-marshalling yards, CFS, container repair shop, Bureau of Customs cargo inspection, etc.

For quay side operation, one (1) or two (2) units of RTGs will be adequate to work in combination with one quay side gantry crane.

In general the operation efficiency of RTGs is reduced to approximately 18 boxes per hour by unit for re-handling containers stacked in three or four tiers stow, in hoisting or lowing operations across stacks, block movement, etc.

The required number of RTGs used at the marshalling yard is estimated by the following formula on the assumption that all containers loading/discharging will be stacked once in the marshalling yard.

Nrtg = Nrtg 1 + Nrtg 2 + Nrtg 3
= 2 x Nqgs + (λ x A) / (T x μ 1 x Prtg x μ 2 x E) + 1

Where

Required number of RTGs (Units)
Nrtg 1 = Required number of RTGs, mainly for QSGC operation (units)
Nrtg 2 = Required number of RTGs mainly used for C.Y. operation (units) (Basically: 1 unit RTG x 1 unit QSGC).
Nrtg 3 = Required number of RTGs stand-by to cope with per marshalling operation immobilization due to repairs, maintenance or other unforeseen circumstances (assumed as 1 unit).
A = Annual throughput in 447,000 TEUs
T = Maximum available working hours for the year (8,760 hours)
λ = Peaking factor to the daily average handling demands (λ Max storage box + Max gate activity) / (Min storage box + Min gate activity) = 1.913.
Prtg = Productivity of RTGs = (18 boxes/hr/unit).
μ1 = Percentage of availability = (0.8)
μ2 = Container handling efficiency = (0.8)
E = Conversion rate of 20’ / 40’ ratio 1.72 TEU/box)

Calculations of Short Term (2012)

λ : 447,000 / 1.72 = 259,000 Boxes
259,000/52/7days = 714 Boxes/days
Exclude transhipment box (29%)
Average gate transaction: 714 boxes x 0.71 =507 boxes/day
Max, storage (714 Boxes x 1.3) x 0.7 660 Boxes/Day
Min, storage (714 Boxes x 0.7) x 0.7 355 Boxes /Day
(929 + 660) / (500 + 355) = 1.86

Nrtg = 2 x Nrtg + (1.86 x 447,000TEU) / (8,760 x 0.8 x 18 boxes x 1.72)
= (2 x 3) +(829,500)/(216,967.7) = 9.82 10.0 units

Assuming that in 2012 containers of 446,000 TEUs will be handled at proposed new berths and marshalling yard of the new off-shore container terminal, the required number of RTGs has been calculated as follows (see Table 9.4.4).

Table 9.4.4 Required Number of RTGs

Project Year	2012
Forecast Annual Throughput Container in TEUs	447,000 TEUs
Estimate in yard total handling Containers (2.7 times of the basic throughput)	1,120,500 Moves
Annual available working hours	8,760 hours
Total required units for Quay-side Operation (Nrtg1)	4 Units
Nrtg1 + Nrtg2	10.0 Units
Nrtg 3 (Nrtg 1 + Nrtg 2) x 10%	1.0 Units
Number of Required New RTGs	4.0 Units
Existing Equipment (RS/TLIFT)	7.0 Units

Source: JICA Study Team

3) Yard Prime-Mover (Tractor-Trailer Units)

The terminal yard prime-movers with trailer run are used to haul containers between quay side apron and marshalling yard, which are loaded or discharged onto or from container vessels. They are also used to move containers within the marshalling yard. Job cycle time of a tractor-trailer unit depends on the distance between the quay-side gantry crane and the marshalling yard. The required number of tractors and trailers for the operations on the proposed terminal has been estimated as follows:

Travel speed of tractor and trailer:	Average 20 km/hr
Handling cycle time under the gantry crane:	1.5~2.0 minute/container
Handling cycle time under the RTGs:	2.0minute/Container
Handling Productivity of gantry crane (2012):	27 boxes / hour
Container berth length and width (2012):	450 m / 60 m

As for yard trailers, the minimum required number should be equal to that of prime movers. In addition to the minimum number, additional number of units must be prepared for temporary container storage; it is often necessary to keep a container loaded on a trailer in a yard in order to meet operational needs or to speed up the container operations. The required number of trailer for each operation has been estimated as shown in Table 9.4.5 including the above-mentioned allowance, which has been assumed to be 20%. Not only systematic operation but also management of the tractors/trailers are of great importance in the container terminal operations.

Table 9.4.5 Estimated Number of Required Tractors/Trailers

Target Year		2012
For container loading /discharging operation		15 Units
For marshalling yard & CFS repair shop box movement		Tractor x 3 Units Trailer x 5 Units
Total unit	Tractor	18 Units
	Trailer	20 Units

Source: JICA Study Team

4) Utilization of Existing Equipment

The estimated required numbers of container-handling machines in the stage of the short-term plan have been summarized in Table 9.4.6. In the estimation, it has been assumed that two (2) vessels would berth simultaneously along the berth with a length of 540m. It has been also taken account that the existing container handling machines including the mobile harbour cranes and reach-stackers would be used together with newly procured machines.

Table 9.4.6 Summary of Short Term Number of Container Handling Equipment

Project Year		2012
New Quay Side Gantry Crane		2 Units
Existing Mobile Harbour Crane		2 Units
New Rubber Tiered Mounted Gantry Crane (RTGs)		4 Units
Existing Reach-Stacker		5 Units
Prime Mover	Tractor Head	18 Units
	Trailer(Chassis)	20 Units

Source: JICA Study Team

(5) Container Handling Productivity

The average container handling productivity at berths No.1 and No.2 observed during the site survey by the JICA study team from April – May 2005 is shown in Table 9.4.7. Currently container operation efficiency is greatly influenced by the surge of a vessel by waves especially in swell.

Table 9.4.7 Average Gross Productivity of Laden and Empty Container

Operation Status	By Self Gear on Board	By Mobile Harbour Carne
Discharging Operation	8 ~ 9 Boxes	15 ~ 16 Boxes
Loading Operation	7 ~ 8 Boxes	14 ~ 15 Boxes

Source: Site Survey by JICA Study team
*Gross productivity: total operation containers/total operation hours/equipment.

The observed productivities of the mobile harbour cranes used at Pecem Port are low compared to other ports including some European ports and Pusan Port in Korea, achieving approximately 23 to 25 boxes per hour. It is necessary to improve the productivity of mobile harbour cranes by upgrading the skill of crane operators so as to cope with an increase in the number of calling vessels in the near future,

(6) Conventional Break-Bulk Cargo Handling System

1) Avoiding direct loading/discharging onto/from truck

The current handling of conventional cargoes on dockside at Pecem Port is generally performed with ship's cranes or derricks, which discharge mainly steel coils onto a platform of a trailer or load iron billets from a trailer directly, as so-called direct loading/discharging. Although these direct operations reduce the possible damages of both cargoes and trailers during operations, productivity is lower than the operations when cargoes are once placed on apron of a quay. Landing cargoes (steel coils) on small platform of trailer bed makes the cycle time longer and dangerous in operations.

2) Proper use of cargo handling equipment and tool

Cargo damage is likely to happen during the discharging/loading operation rather than the sea transportation. The lack of adequate cargo handling equipment and tool, such as sling spreaders and suitable attachment for fork-lift is a main factor.

3) Timely instruction of tractor driver (waiting distance position)

It has been observed that the tractor driver was waiting at a distant position even when a break bulk cargo was being discharged due to a lack of proper instruction by a vessel operation supervisor. In order to prevent such waiting loss time, it is necessary that proper and timely instructions be provided by the supervisor or the shore side workers leader.

4) Training of equipment operator and signal man

To upgrade the skill of equipment operators, training for accurate response to hand signal is required. To send a signal properly to a equipment operator, it is necessary to locate a signal man properly. Hand signal should be standardized in order to avoid misunderstanding among the ports.

9.4.7 New Gate and its Operations

It is planned to install belt conveyors to transport iron ore pellets to the steel mill at CIPP close to the existing gate. It is said that this could cause a negative impact on current gate operations. To resolve the probable problem, the new gate in the east of the existing container yard has been proposed based on the gate traffic estimate in the range of maximum and minimum levels in the future (see Table 9.4.8 and Figs 9.4.4 and 9.4.5).

Table 9.4.8 Gate Containers Transaction

Total Transaction (TEU / 1.72)	Transshipment (30%)	Local Delivery (70%)	Daily Transaction		Annual Throughput
			Maximum	Minimum	
260,000 Boxes	78,000 Boxes	182,000 Boxes	650 Boxes	350 Boxes	447,000TEU

Source: JICA Study Team

Average local container receiving and delivery:

182,000 Boxes/52 weeks/6.5 days = 538.5.69   500 Boxes/day

The peak receiving and delivery ratio increase 30% per day

Maximum (Peak day): 500 boxes x 1.3 = 650 Boxes/day
Minimum (Non-peak day): 500 boxes x 0.7 = 350 Boxes/day

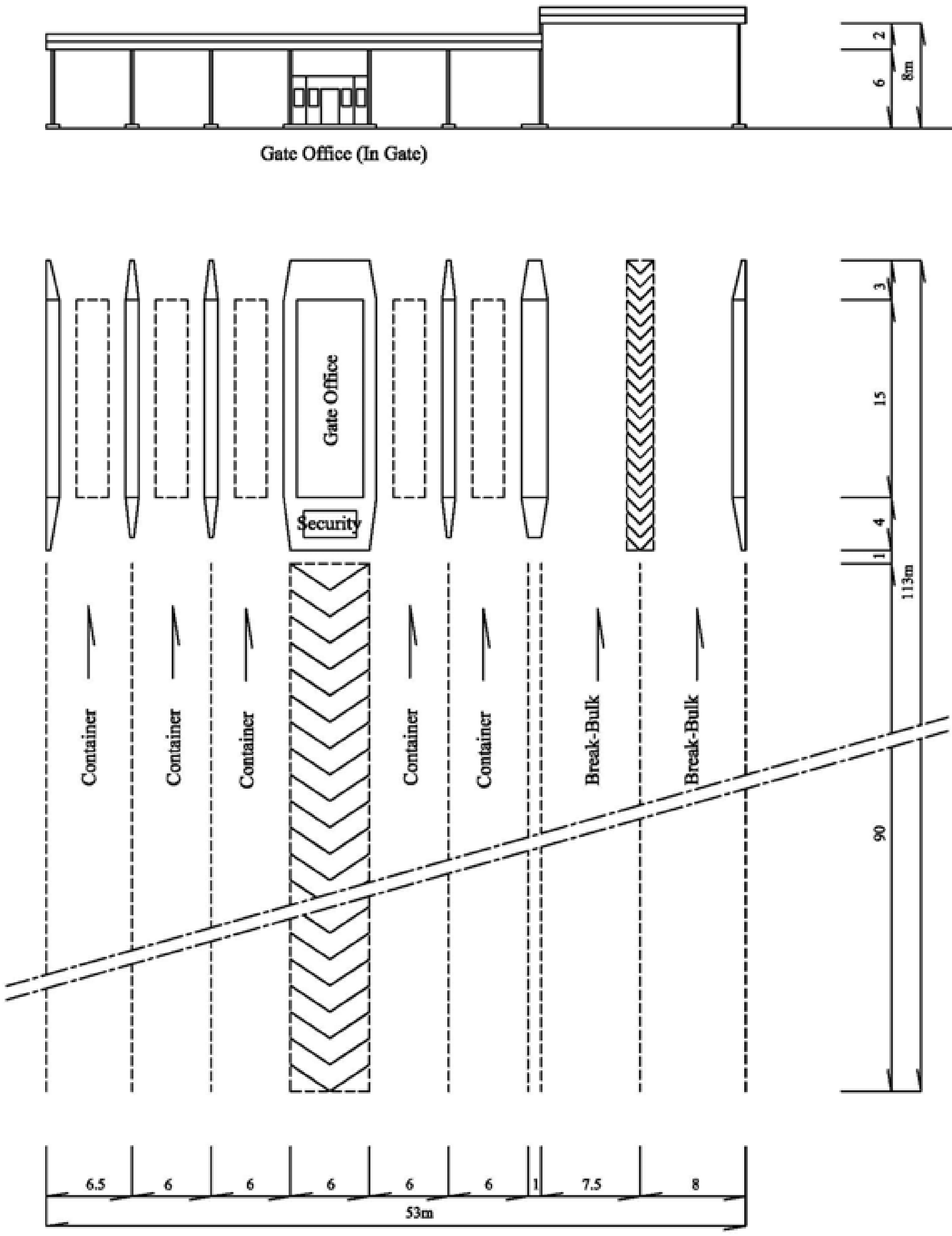


Figure 9.4.4 Facility Layout Plan of a New In Gate (Scale: 1:500)

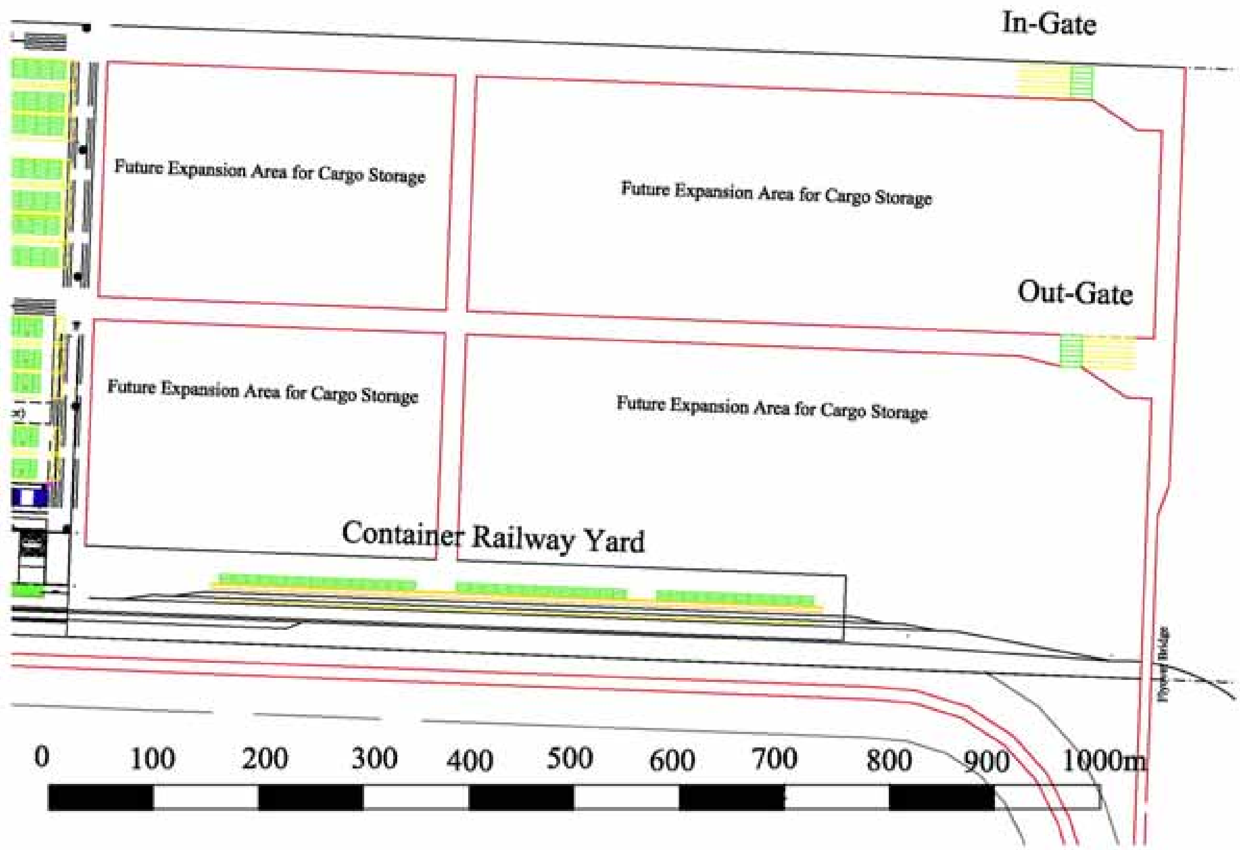


Figure 9.4.5 Layout Plan of New Inner Port Road

9.4.8 Container Railway Yard Plan

Dedicated container railway yard has been proposed to cope with the anticipated increase in the demand for container railway transport from/to Pecem Port (see Figs. 9.4.5 and 9.4.6) RMG (Rail-mounted Gantry Crane) has been included in the entire plan and has been proposed to install the second phase plan after the Short-Term Plan.

Long Span Rail mounted gantry crane:		1 Unit
Specification:	Rail span:	16.7m
	Out Reach:	9m
	Hoisting height	8.0 meters
	Hoisting capacity:	40.0 tons
	Power source:	Electricity high voltage

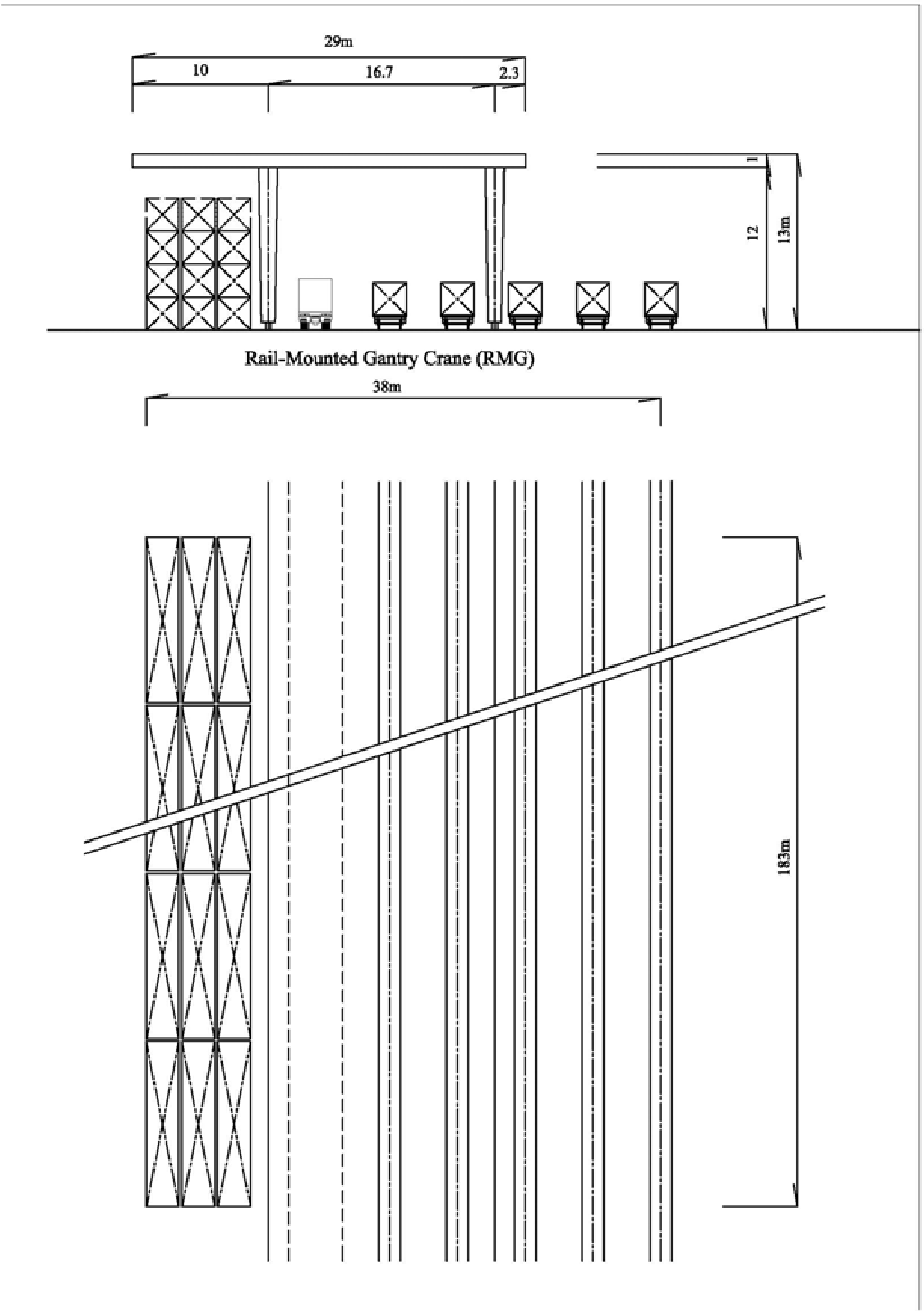


Figure 9.4.6 Facility Layout Plan of a Container Railway Yard

9.5 Hydrological and Coastal Study

9.5.1 Calmness for Short-Term Development Plan

The calmness projections for short-term development plan have been made by using the same numerical computation as the study for the long-term development plan. The detailed methodology was presented in Section 6.5.1 in Chapter 6.

The points for consideration are as below.

To determine the necessary length of the West Breakwater to secure sufficient calmness for Pier No.1, especially for swell waves

To determine the necessary length of the Main Breakwater to secure the container berth

Several different lengths of breakwater have been investigated in this study. The input conditions for incident waves are shown in Table 9.5.1, and the layout of the breakwaters and estimation points for calmness are shown in Figure 9.5.1.

Table 9.5.1 Input Conditions for Incident Waves

Wave Direction	T1/3(s)	Smax	Water Level	Remark
NNE	10	30	MSL	Swell Wave
NE	10	30	MSL	Swell Wave
ENE	8	20	MSL	Sea Wave
ESE	7	10	MSL	Sea Wave

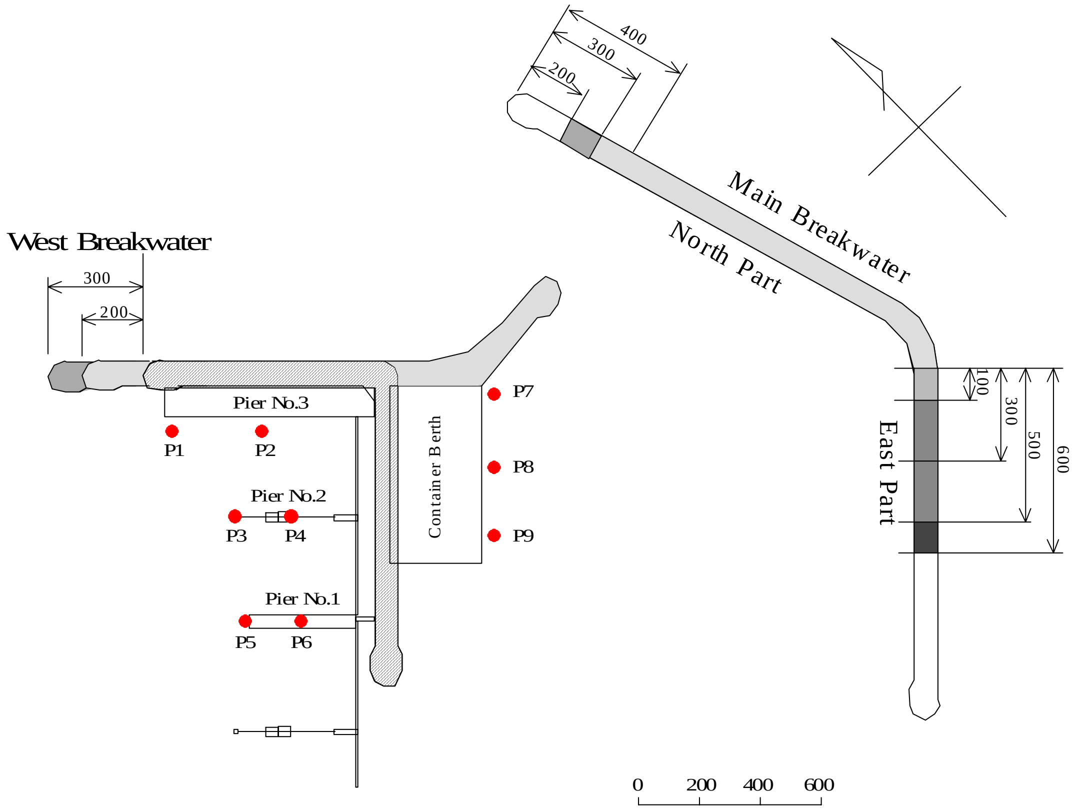


Figure 9.5.1 Study Layout of Breakwaters and Estimation Points

The threshold wave height and target frequency of calmness are applied as bellow according to Japanese port design standards (refer to Section 6.5.2 on Chapter 6).

Table 9.5.2 Input Conditions for Incident Waves

Berth	Threshold Wave Height Hcr (cm)	Terget Frequency (%)	Remark
Pier No.1	50	More than 97.5	for General Cargo Handling
Pier No.2	50		for Unloading of Oil
Pier No.3	30		for Container Cargo Handling
Container Berth	30		for Container Cargo Handling

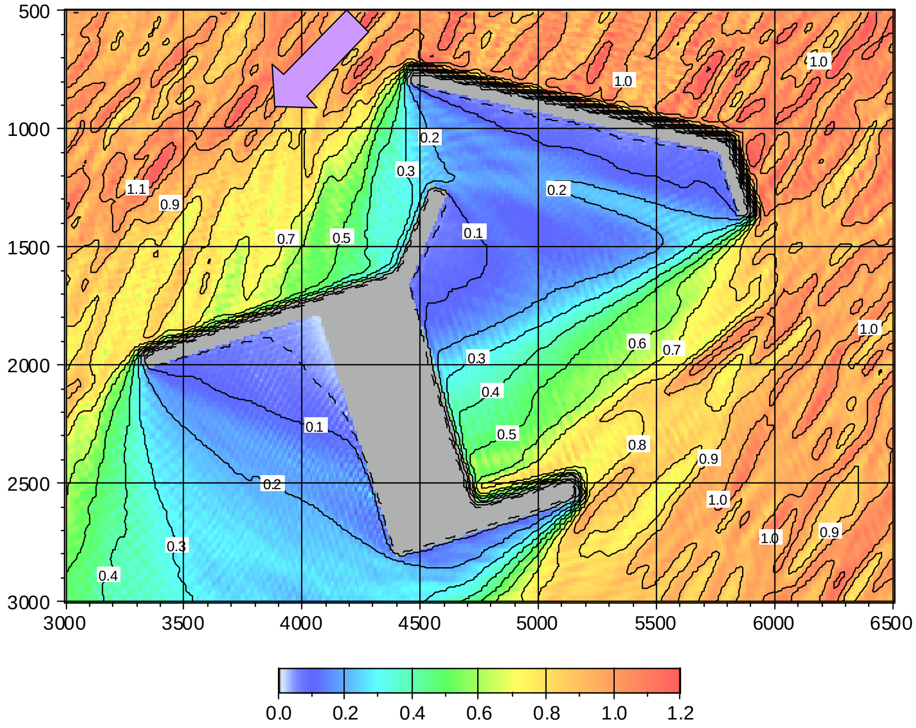
Figure 9.5.2 shows the comparison of wave fields for sea waves that are incident from the ESE direction with different lengths of the East Breakwater. Figure 9.5.3 shows the comparison of wave fields for swell waves that are incident from the NE direction with different lengths of the North Breakwater. These results show that the different lengths for each breakwater influences the calmness at the container berth.

Figure 9.5.4 shows the results of calmness projections in front of the container berth for each different lengths of the Main Breakwater. Figure 9.5.5 shows the same information for Piers No.1 to No.3.

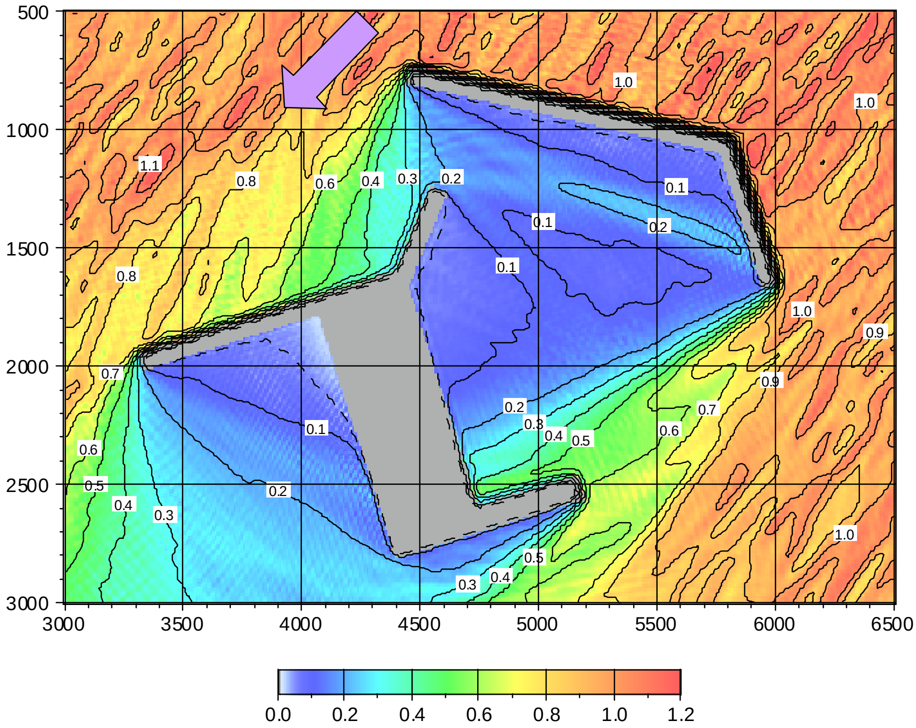
The calmness at the container berth decreases from the offshore side (P7) toward the onshore side (P9). When the shortening of the north breakwater does not exceed 300 m, sufficient calmness is secured. From this, the shortening of the North Breakwater has been proposed as 300m for the short-term development. When the length of the East Breakwater is more than 600 m, sufficient calmness is secured. From this, the length of the East Breakwater has been proposed as 600 m.

Even though the calmness at Piers No.2 and No.3 is secured if the extension of the West Breakwater is 200 m, the calmness at Pier No.1 is still insufficient. When the extension of the West Breakwater is 300 m, the calmness at Pier No.1 also becomes to be sufficient. From this, the extension of the West Breakwater has been proposed as 300 m.

The calmness for proposed final layout is summarized in Table 9.5.3.

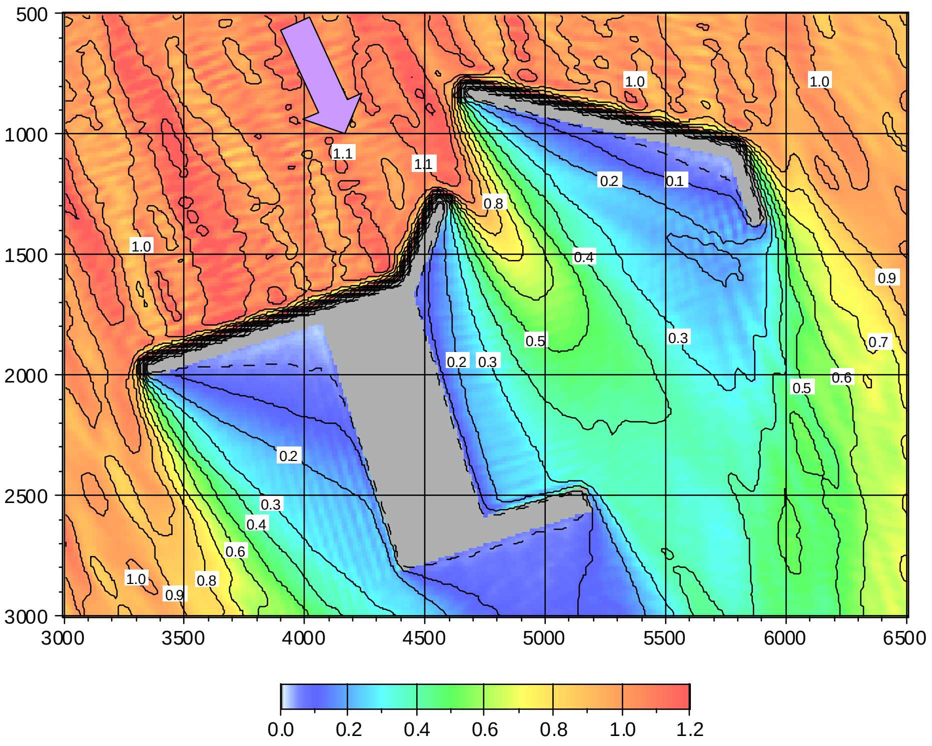


(1) 300m of East Breakwater (ESE for Sea Waves)

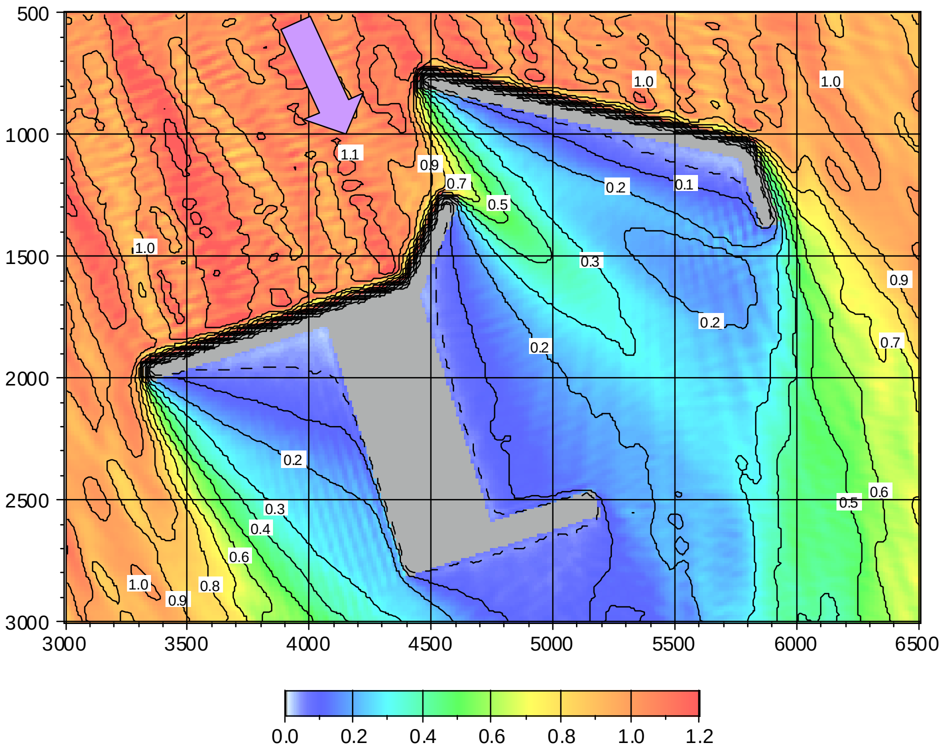


(2) 600m of East Breakwater (ESE for Sea Waves)

Figure 9.5.2 Difference for the Length of the East Breakwater

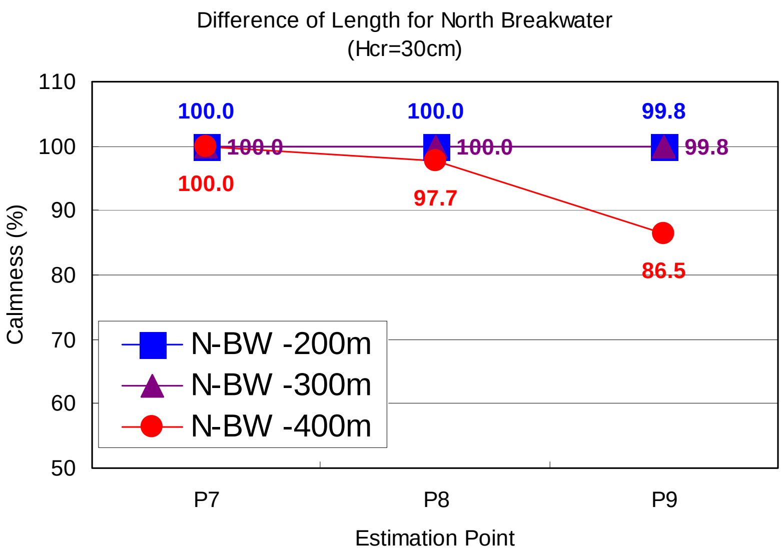


(1) -400m of North Breakwater (NE for Swell Waves)

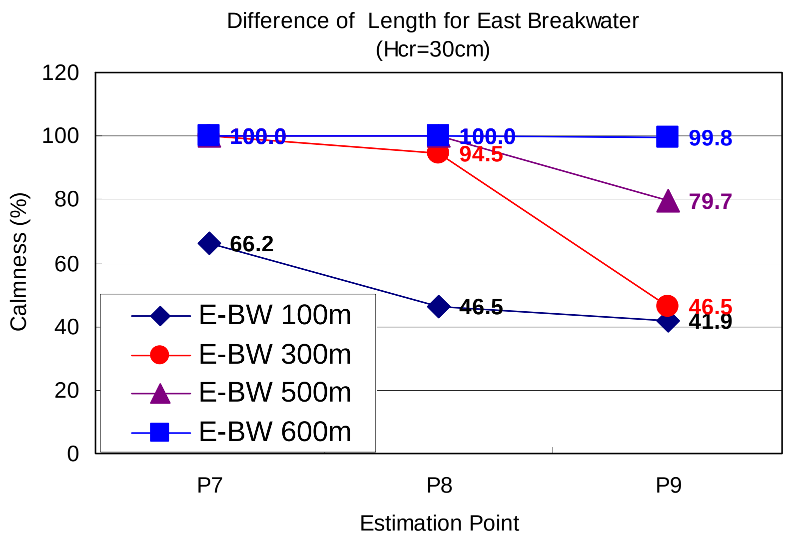


(2) -200m of North Breakwater (NE for Swell Waves)

Figure 9.5.3 Difference for the Length of the North Breakwater

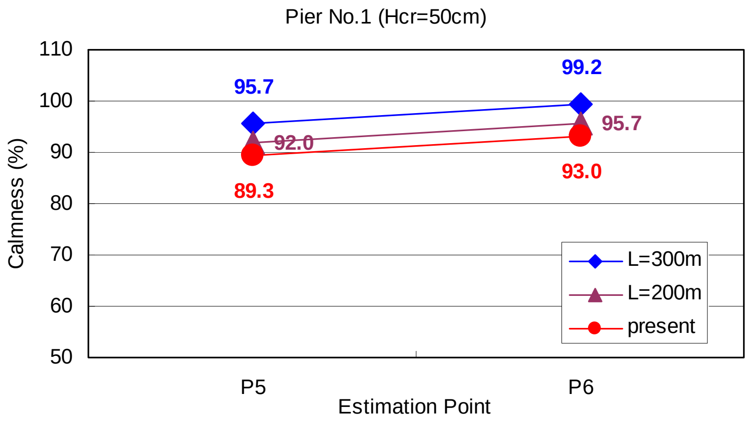


(1) Difference for the North Breakwater

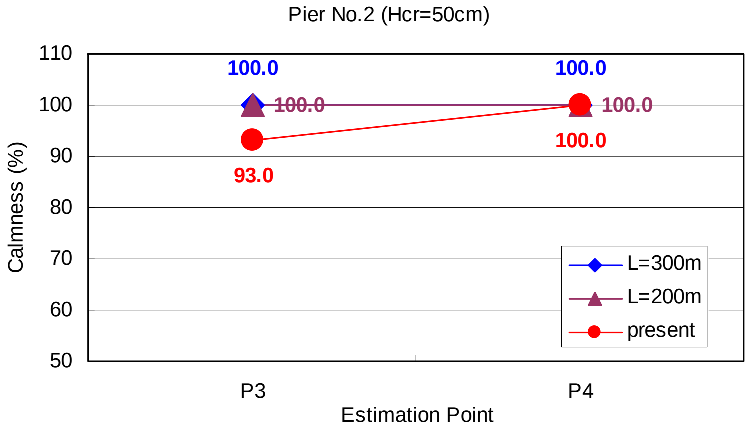


(2) Difference for the East Breakwater

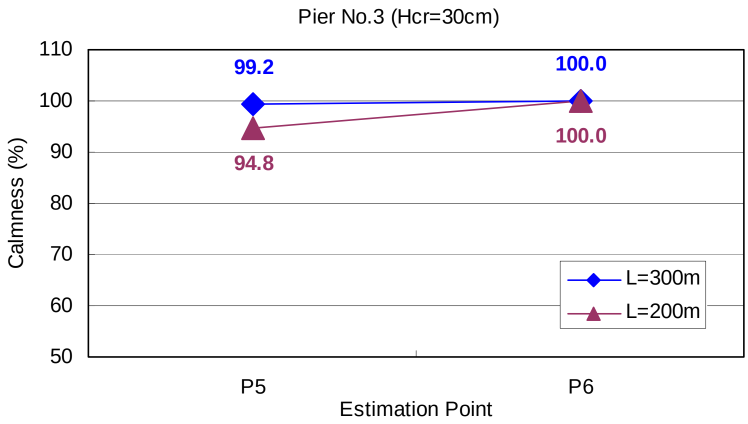
Figure 9.5.4 Calmness at the Container Berth



(1) Pier No.1



(2) Pier No.2



(3) Pier No.3

Figure 9.5.5 Calmness at Piers No.1 to No.3

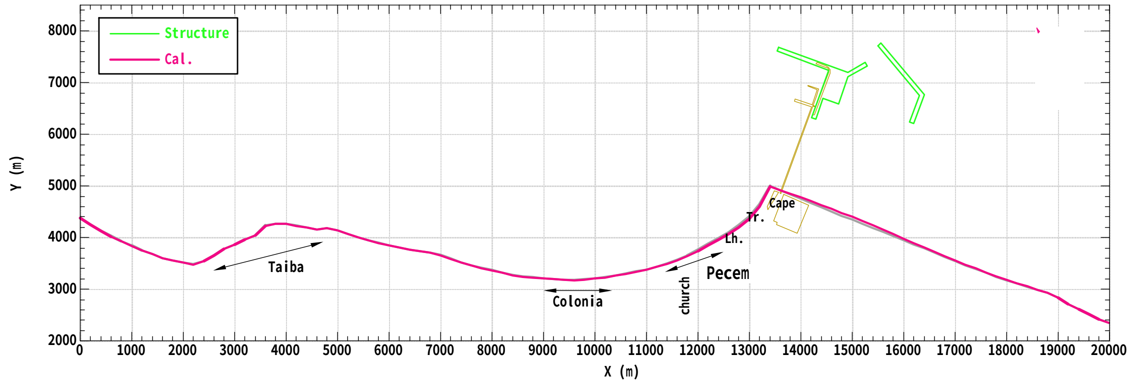
Table 9.5.3 Calmness for the Proposed Layout

Berth	Position	Point No.	Hcr(cm)	Short-Term Plan	Present
Pier No.3	Head	1	30	100%	-
	Center	2		100%	-
Pier No.2	Head	3	50	100%	93.0%
	Center	4		100%	100%
Pier No.1	Head	5	50	95.7%	89.3%
	Center	6		99.2%	93.0%
Container Berth	Offshore	7	30	100%	-
	250m	8		100%	-
	450m	9		99.8%	-

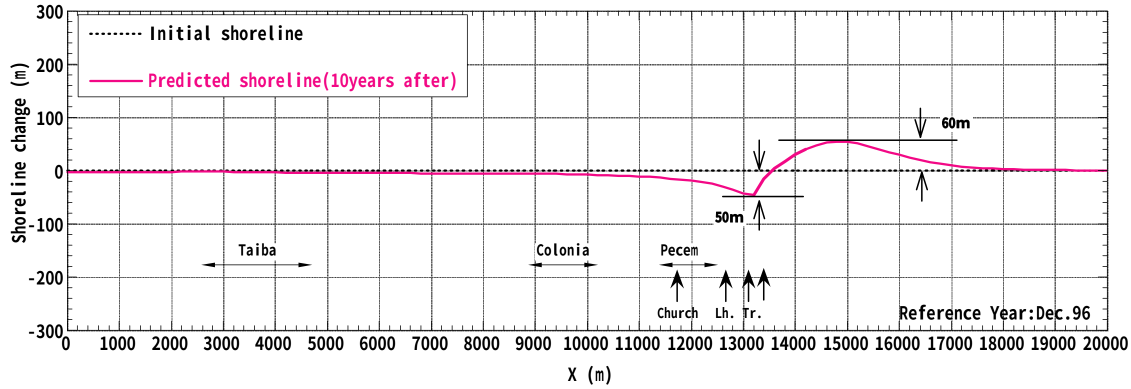
9.5.2 Coastal Impact Study

The characteristics of littoral drift and the process of shoreline change until now were presented in the Section of 6.5.3 in Chapter 6. The coastal impact for the short-term development plan is presented in this section. The prediction method is the same as that in the study for the long-term development plan using the same model of numerical computation. Figure 9.5.6 shows the predicted shoreline after 10 years for the layout of the short-term development plan, and Figure 9.5.7 shows the comparison of shoreline change for the layout of the existing port, short-term and long-term development plans after 20 years. The pattern of shoreline change is almost the same as that for the long-term development plan; however, the degree of change is considerably decreased with about a 70% reduction. This change of tendency is caused by a decrease of the wave shadow area due to shortening the length of the breakwater.

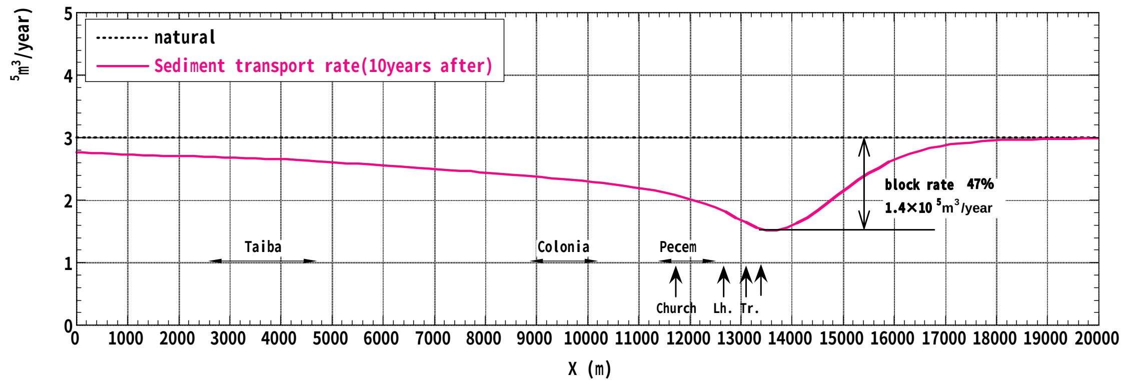
Table 9.5.4 shows the sediment balance for each development term. The sand deposition due to the offshore port facility is estimated about 100,000 to 130,000 m3/year. This estimated volume for the short-term development plan is about 80% of that for the long-term development plan. The computation result shows that the retreat occurs from the north area of Pecém village to Colonia village over ten years. However, it is difficult to predict the area of retreat under the condition of dynamic equilibrium of littoral drift considering the influence of the cape. That explains why it is very important to do the monitoring surveys to determine the influence of the existing port.



(1) Predicted Shape of Shoreline



(2) Shoreline Change Based on the Initial (Present) Shoreline



(3) Change of Littoral Transport Rate

Figure 9.5.6 Predicted shoreline for the Short-Term Development Plan (After 10 Years)

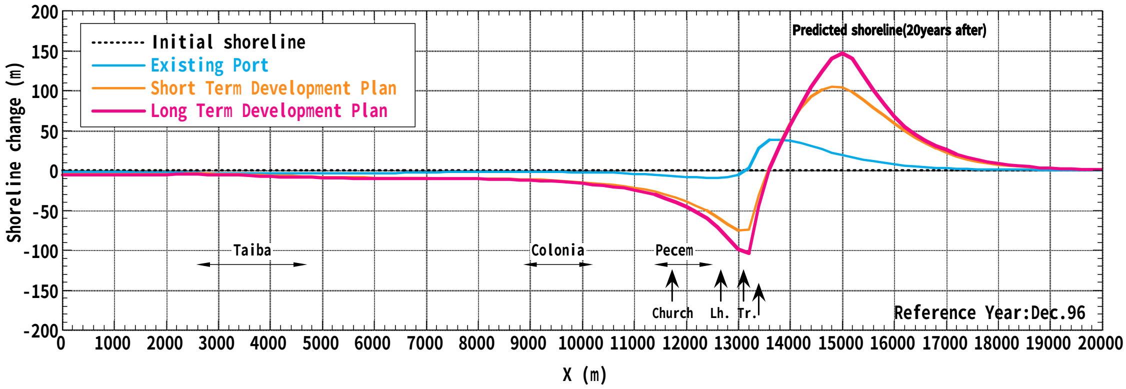


Figure 9.5.7 Comparison of Shoreline Change for Each Layout

Table 9.5.4 Sediment Balance for the Short-Term Development Plan

Layout	Net annual littoral transport (m3/year)		Sediment Loss due to Natural Conditions (m3/year)	Net Accumulation due to Existence of Port (m3/year)
	Up-Drift Side (East Side)	Down Drift Side (West Side)		
Existing Port	280,000 - 360,000	210,000 - 280,000	40,000	30,000 - 40,000
Short-Term Development Plan	280,000 - 360,000	140,000 - 190,000	40,000	100,000 - 130,000
Long-Term Development Plan	280,000 - 360,000	120,000 - 160,000	40,000	120,000 - 160,000

9.6 Design

9.6.1 Design Manuals, Standards and Codes

As presented in Section 6.6.1 in Chapter 6 for the study of the long-term development plan, the Japanese Design Manual (Technical Standards and commentaries of Port and Harbour Facilities in Japan, 1999) and some specific part of the Shore Protection Manual (1977, 1984) have been adopted for the design of these port facilities.

9.6.2 Design Criteria

Since a detailed discussion of design criteria has been presented in Section 6.6.2 in Chapter 6, only the results are presented below.

(1) Tide Condition

HHWL +3.20 m, LLWL (=DHN) 0.00 m

HWL +2.70 m, LWL +0.30 m

(2) Estimation of Design Waves

Table 9.6.1 Design Wave Heights (offshore and 18m depth)

Return Period (Year)	N	NNE	NE	ENE	E	ESE
H_0 (m)	2.1	2.4	2.8	2.3	3.2	2.9
$H_{1/3}$ (=H_s) (m) (at -18m depth)	2.1	2.4	2.9	2.1	2.9	2.7
T_p (s)	13.7	14.2	15.9	7.7	7.7	7.7
$T_{1/3}$(=T_p/1.05) (s)	13.0	13.5	15.1	7.3	7.3	7.3

(3) Seismic Load

0.05 (kh).

(4) Subsoil Condition

Table 9.6.2 Preliminary Design Soil Parameters

Stratum	Composition	N-Value	Unit Weight γ_t(kN/m^3)	Int. Friction Angle	Comp. Strength (N/mm^2)
Upper Stratum	Sand	10 to 50	18	30 °	-
Lower Stratum	Gneiss	Over 50	18	35 °	>100

9.6.3 Design of Breakwaters

As mentioned in Section 6.6.3 in Chapter 6, two types of breakwaters have been proposed, that is the berm type and the conventional type. For the west and sub breakwaters, which are connected to the existing breakwater, berm type breakwaters with the same dimensions as the exiting breakwaters have been proposed to minimize wave overtopping impacting the newly constructed berth. For the Main breakwaters, the conventional type of breakwaters has been proposed to reduce the volume of rocks as compared to the existing type of breakwater. The representative dimensions and size of armour stones are shown in Table 9.6.3, and the typical cross section of each breakwater at the trunk portion is shown in Figures 9.6.1 to 9.6.3.

The design concept and the detailed explanation were presented in Section 6.6.3 in Chapter 6.

Table 9.6.3 Representative Dimensions of Berm Breakwaters

Item	Short Term Development Plan			
	West and Sub Breakwater		Main Breakwater	
Type	Berm Type		Conventional Type	
Length	Extension of West Breakwater	300m	North Part	1220m
	Sub Breakwater (inc. Sea Wall Part)	620m	East Part	570m
	Total	920m	Total	1790m
Crest Elevation	Crown Part	+8.00	Crown Part	+6.00
	Berm Part	+6.00		
Crown Width	Crown Part	10m	Crown Part	5m
	Berm Part	5m		
	Slope Part	8m		
	Total	23m		
Slope Gradient	1:1.25		1:1.5 (for outer) 1:1.25(for inner)	
Size of Armour Rock	1-6ton		4-6ton	

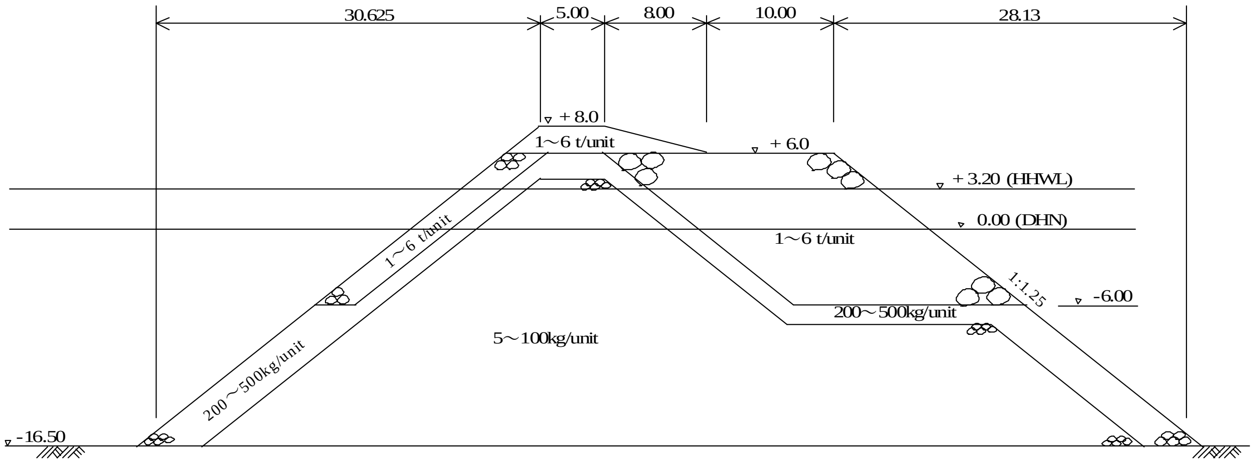


Figure 9.6.1 West and South Breakwaters (Berm Type)

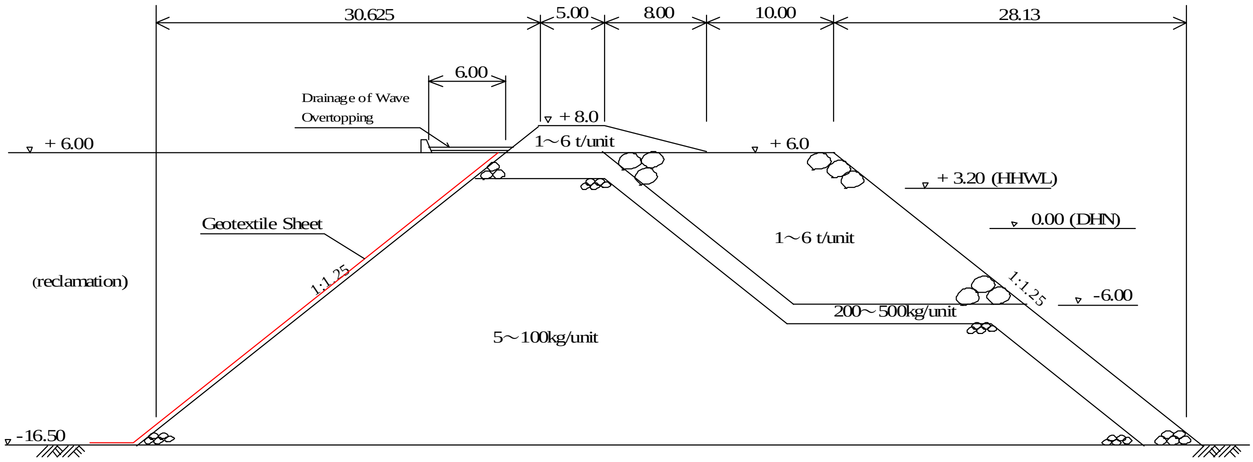


Figure 9.6.2 Seawall Portion (Berm Type)

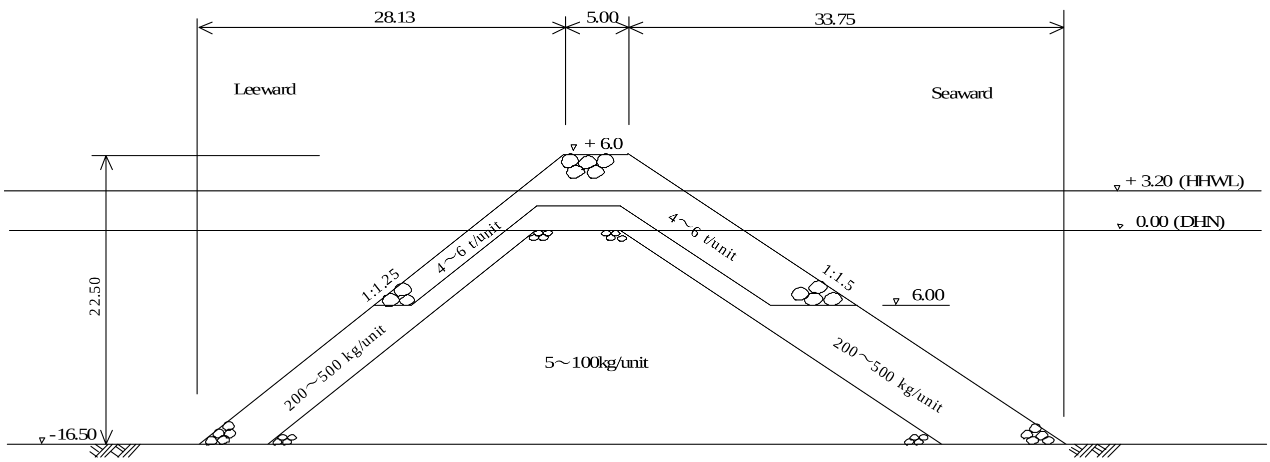
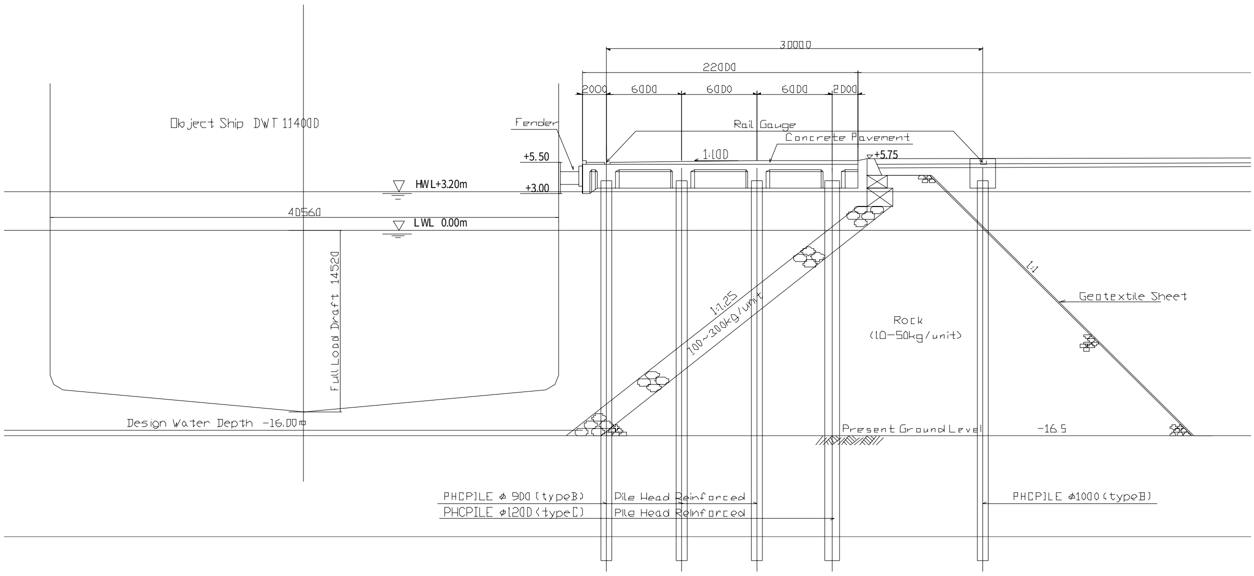


Figure 9.6.3 Main Breakwater (Conventional Type)

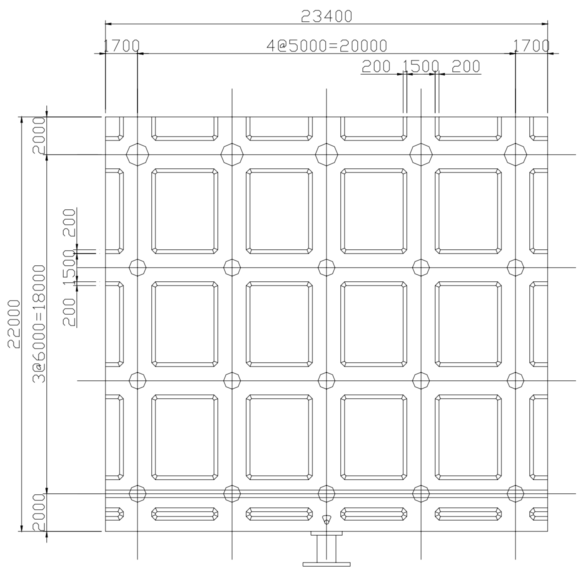
9.6.4 Design of Quaywall

As mentioned in Section 6.6.4 in Chapter 6, the pile pier type with vertical piles the same as existing Pier No.1 has been proposed for the Multi-Purpose and Fruit Berth (Pier No.3) in consideration with the urgent implementation period (Urgent Project). Here, the pre-tensioned spun high strength concrete pile (PHC) was proposed to be applied following the same method as the existing piers. From the result of the structural calculations, pile diameters from 900mm to 1,200mm were required when the same materials for the fabrication of the piles as used before was assumed, because of the heavy surcharge (refer to Table 6.6.11). Further detailed design study is considered necessary to decide the dimension of the piles. For the Container berth, which will be constructed in the Remain Project of Short-Tterm Plan, concrete caisson type structures have been proposed in consideration of the subsoil condition and the results of the cost estimate. The proposed structures types for the Multi-Purpose and Fruit Berth (Pier No.3), and Container Berth are shown in Figures 9.6.4 to 9.6.5.

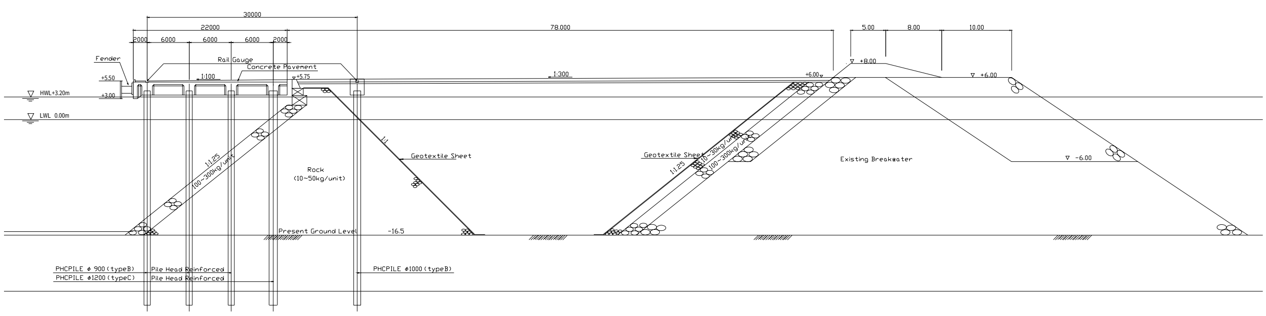
A detailed explanation has been presented in Section 6.6.4 in Chapter 6.



(1) Typical Cross Section

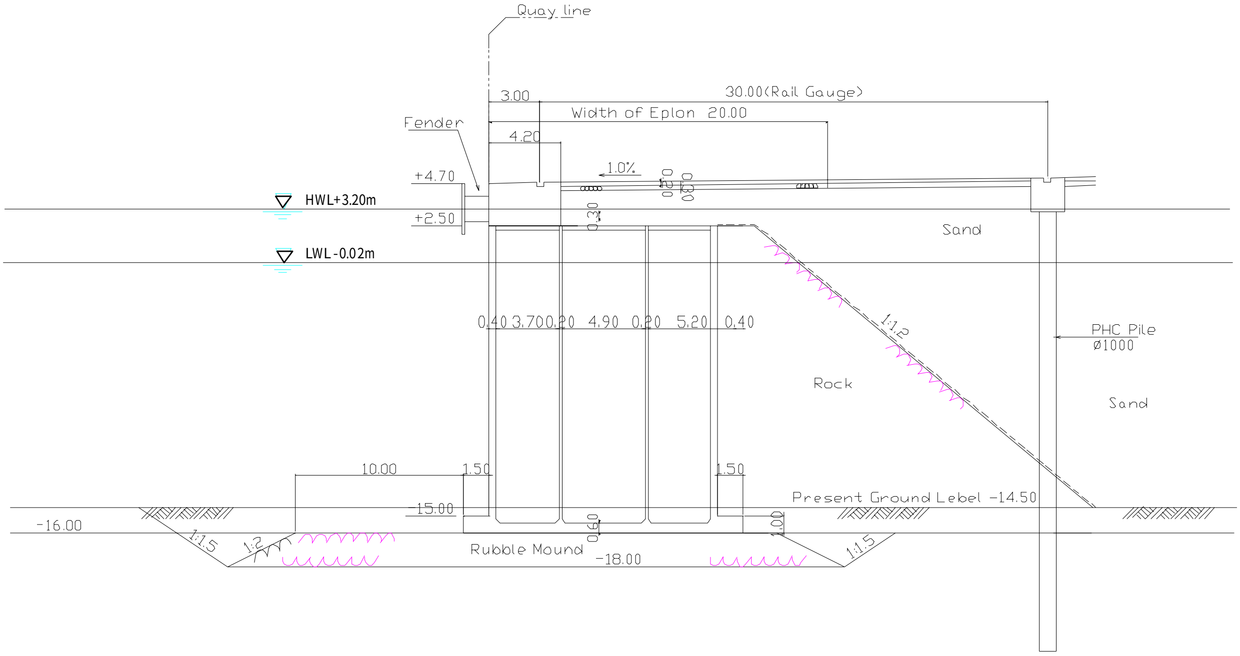


(2) Plan of Pier Deck

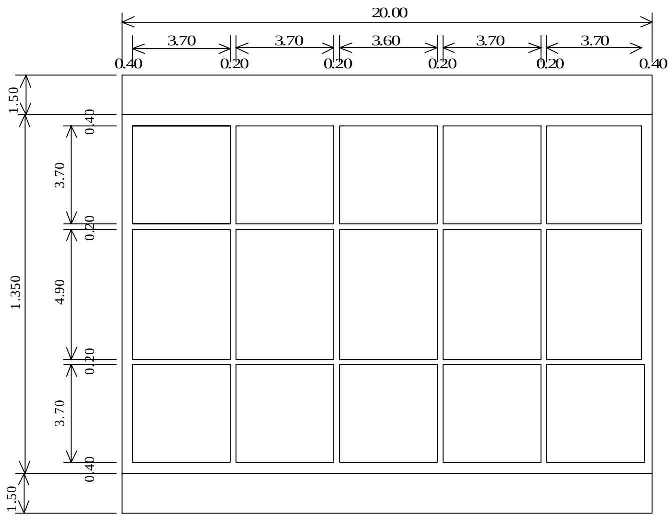


(3) Typical Cross Section Pier No.3

Figure 9.6.4 Multi-Purpose and Fruit Berth (-16m) (pier No.3) (Pilled Pier Type)



(1) Typical Cross Section



(2) Plan

Figure 9.6.5 Container Berth (-16m) (Concrete Caisson Type)

9.6.5 Design of Temporary Revetment

As the container terminal will be constructed to provide only for two berths, which will be situated on the offshore side in the short-term development (Remain Project), the temporary revetment shown in Figure 9.6.6 is required. This area is a planned to be utilized as a temporary basin for port service boats and working craft in the long-term development. Therefore, a length of face line should be maintained using a vertical wall. Figure 9.6.7 shows the proposed typical cross sections of the revetment with and without a vertical wall.

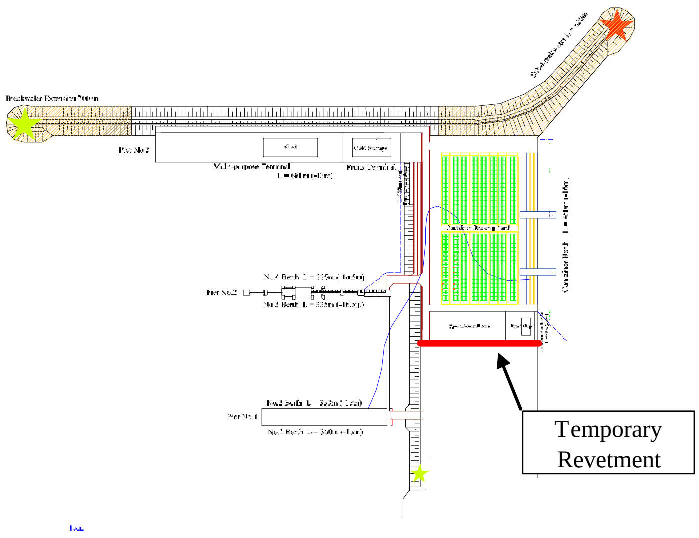
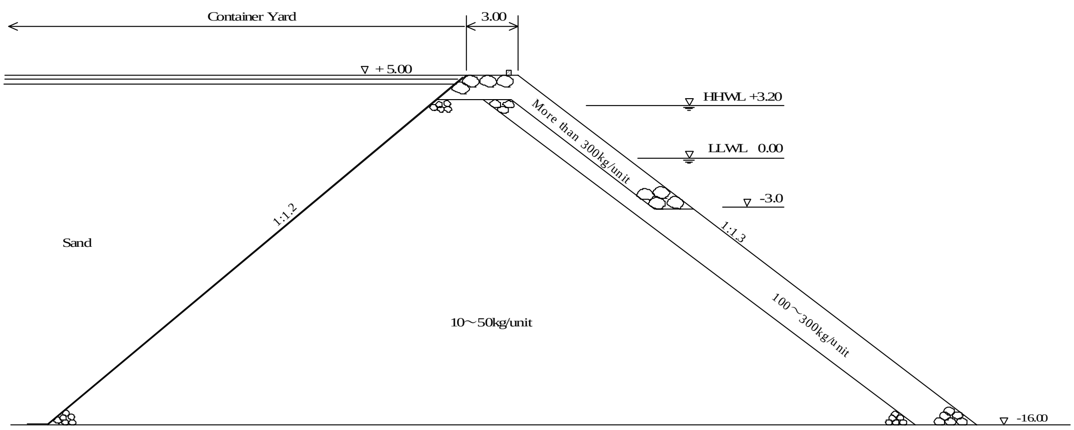
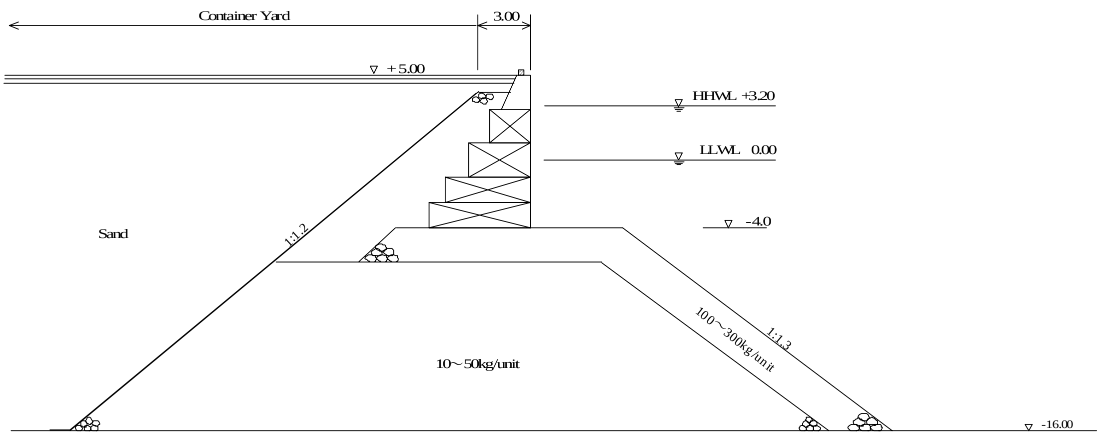


Figure 9.6.6 Location of Temporary Revetment



(1) Without vertical wall



(2) With vertical wall at a basin for port service boats

Figure 9.6.7 Typical Cross Section of Revetment

9.6.6 Design of Temporary Port Road in Urgent Project

In Remain Project of the First Phase, a port road will be constructed on the existing breakwater. This road, with four lanes is planned to be utilized for access to both the container yard and Pier No.3 (refer to Section 6.6.7 in Chapter 6). However, Pier No.3 should be constructed in Urgent Project, and therefore it is necessary to prepare another port road to access Pier No.3 in Urgent Project. As mentioned above, this port road will be used temporarily until the completion of the permanent port road on the existing breakwater in the Remain Project . It was originally planned to use a pile pier type bridge the same as the existing access bridge. However, considering cost comparison and the utilization of the space between Piers No.2 and No.3 as the basin for port service boats, it is proposed to use the rubble structure type. This is constructed inside of the existing breakwater to widen the crown part of breakwater as shown in Figure 9.6.8. The typical cross section of the temporary port road is shown in Figure 9.6.9.

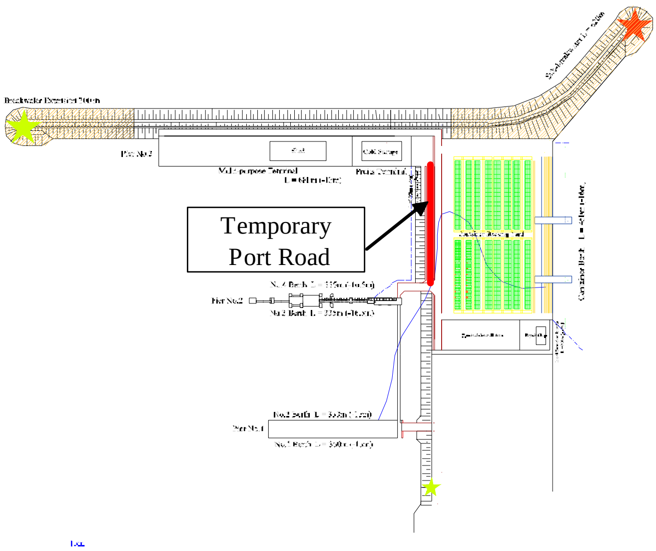


Figure 9.6.8 Location of Temporary Port Road (Rubble Type)

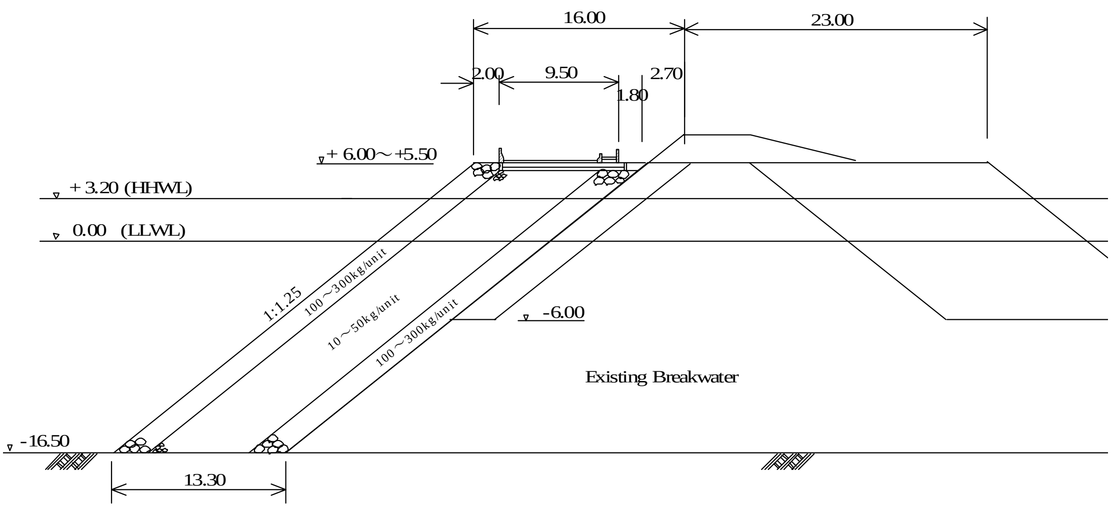


Figure 9.6.9 Typical Cross Section of Temporary Port Road

9.6.7 Connection from Existing Access Bridge to Temporary Port Road

An 80m section is required to act as a connection to join the existing access bridge and the temporary port road as shown in Figure 9.6.10. This section has been proposed to be constructed as a combined pier structure and rubble mound. Figure 9.6.11 shows the image of this part before (Urgent Project) and after (Remain Project) construction of the port road. To specify the dimension for this connection, it is necessary to check the trace line for a tractor-trailer rig while turning. Figure 9.6.12 shows the predicted trace line for the semi trailer with a length of 19m and a width of 2.5m. The proposed junction is shown in Figure 9.6.13. A further detailed design study should be executed to decide the dimension of the piles.

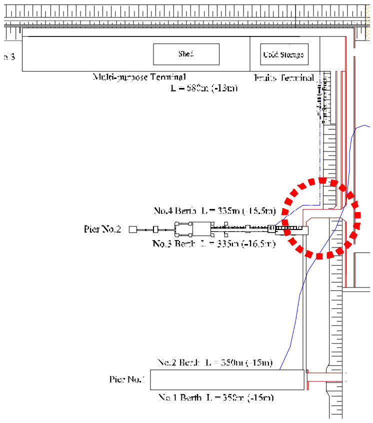
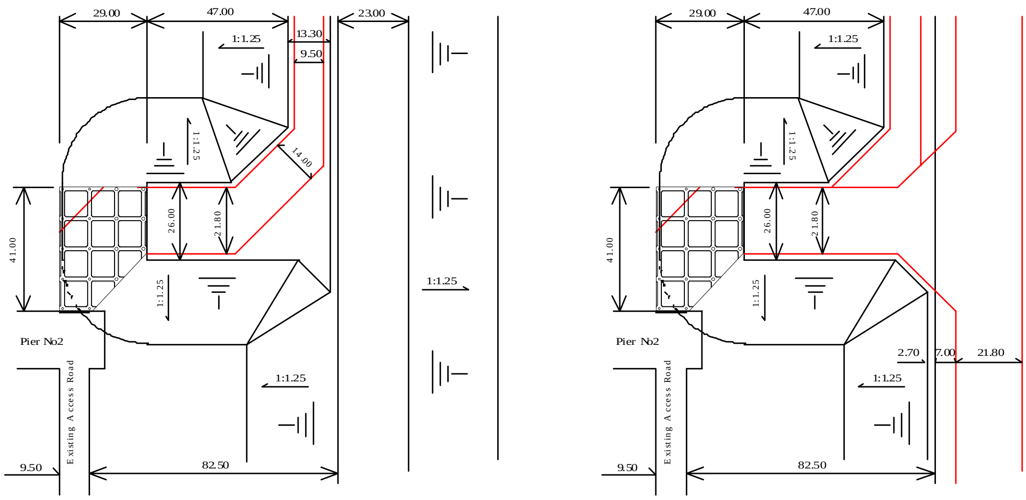


Figure 9.6.10 Location of Connection



(1) Urgent Project (2) Remain Project

Figure 9.6.11 Image of Connection

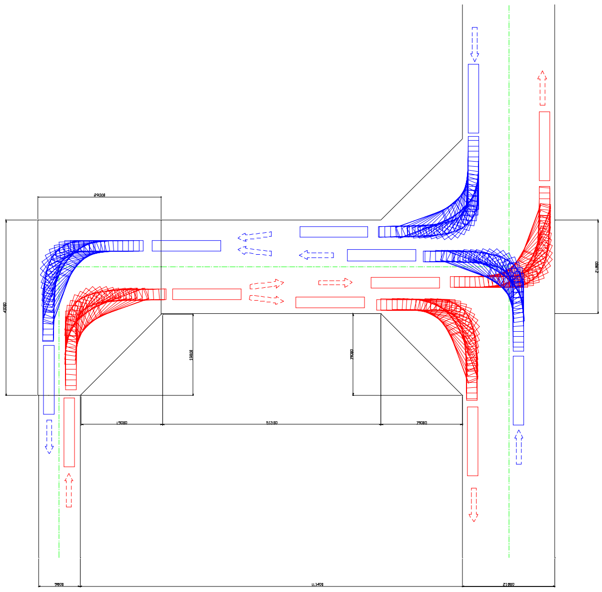
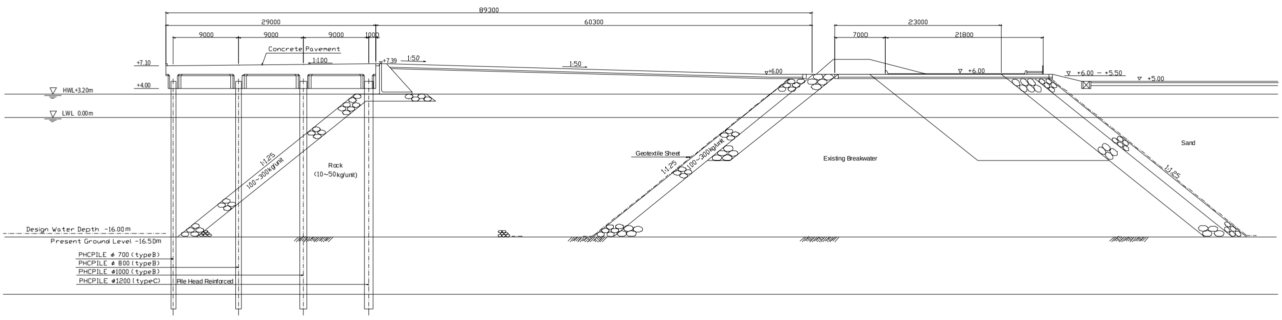
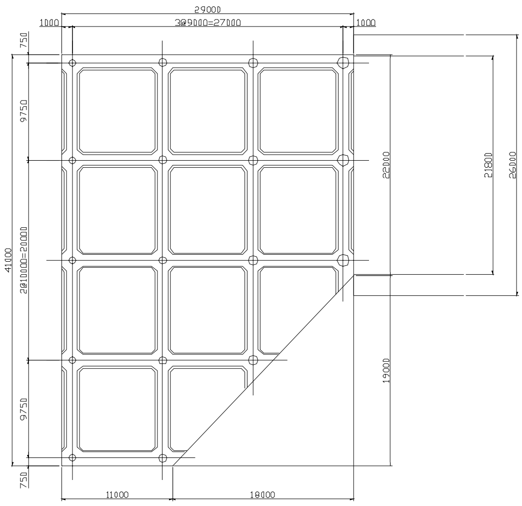


Figure 9.6.12 Trace Line for Semi Trailer



(1) Typical Cross Section of Connection



(2) Plan of Pier Part

Figure 9.6.13 Connection

9.7 Cost Estimates

9.7.1 Cost Estimates

The Port of Pecém is a new port, construction for which began in the middle of 1996 and was completed in 2001. Therefore, the construction history is very recent, and the construction methods and actual costs are therefore applicable for the coming Project. The basis for the cost estimates of the Study are mostly dependant on the results of analyzing as-built records of the construction of the new Pecém port.

Exchange rate: 1 US$ = R$ 2.30
1 R$ = Yen 50 (Yen 1 = 0.020 R$)
As of 10, Aug on Central Bank of Brazil

(1) Unit Price

Based upon the unit prices the former port project contracted in 1996, SEINFRA, which is a counterpart organization to the Study, has analyzed and set forth current unit prices. The unit prices are reliable enough for the cost estimation of the study. The proposed offshore facility components are similar to the existing facilities.

SEINFRA re-examined the unit prices of the former project to determine current prices and he found that the price of stones will be approximately 70% higher than the list shown to the JICA Study Team previously. The main changes are as follows.

Armor stone	100-1000kg	quarry to site	1m3	20.59R$	→	34R$
Armor stone	1 – 6 tons	quarry to site	1m3	26.30R$	→	42R$
Rubble stone	5-100kg	quarry to site	1m3	20.59R$	→	34R$

(2) Portion of Local and Foreign Currency

All of the civil works, including buildings, shall be financed with Local Currency. All materials such as steel & iron products, mechanical & electrical goods, secondary concrete products and elemental raw materials shall be provided in Brazil. Execution, construction machinery, equipment and floating equipment shall be also procured in Brazil. However, when concrete caisson structures are constructed at the container and fruits & multipurpose quays, a floating dock for fabricating the caissons may be procured from abroad. The depreciation charge is only a very small portion of the construction cost of the facility component. Therefore, it can be neglected as a foreign portion, but put into the local currency ledger.

All of the Items for Procurement of Equipment shall be purchased using Foreign Currency. All of the nominated equipment shall be transported as a module directly to the site. Therefore, no local currency obligations such as erection cost will arise.

(3) Major Methods of Execution

1) Stones

All kinds of stones are mined at the JACURUTU quarry about 21 km from Pecém port. The stones consist of granite containing much quartz and are suitable for use for marine construction. The stone vein extends from the top of the mountain to deep underground. The reserves seem adequate for the project.

An exclusive access road from the quarry to the port is available but has been unused for 4 years. The access road can be reused with a little maintenance.

a) Use of stones:

Table 9.7.1 shows the quantity to be used by stone size and phase.

Table 9.7.1 Stone to be used by size and phase

Unit : m3

Facility	Size	Urgent	Remain	Total
Quay, Revetment	10-50 kg	488,000	331,000	819,000
	10 -300kg	112,000	91,000	203,000
Breakwater	5 -100 kg	226,500	1,392,200	1,618,700
	200-500 kg	58,500	445,960	504,460
	1 – 6 ton	83,100	370,690	453,790
	(4 – 6 ton)			
Total		968,100	2,630,850	3,598,950

Stone size and amount

Rubble stone	5 – 300 kg	2,640,000 m3
Armour stone	200 – 500 kg	500,000 m3
Armour stone	1 – 6 tons	450,000 m3
TOTAL		3,590,000 m3

Amount of each facility

Breakwater	2,570,000 m3
Revetments and quaywall	1,020,000 m3

Unit price of stones includes preparation of quarry site, mining and selection of stones, deposit of unsuitable soil, loading on dump truck, transport to the site and dumping cost.

2) Concrete

a) Concrete centre at the site

A concrete centre equipped with a mixing & batching plant, pre-stressed concrete pile factory, cement silo, stock yard for coarse and fine aggregate, and pre-cast concrete products factory will be constructed west of Pecém port. The centre may be maintained and operated up to the end of the Short Term Plan. Total consumption of concrete and steel is roughly estimated as follows.

Planned consumption of concrete:	120,000 m3
Steel bar including steel strand wire	12,000 tons

b) Use of concrete

A great deal of concrete is used for concrete caissons, PC piles, super-structure of Pier No.3 and the middle & super structure of access bridges. The use of concrete for the Short Term Plan is shown Table 9.7.2.

Table 9.7.2 Use of concrete for the Short Term Plan

Description		Detail	Phase I	Phase II	Total	Remark
Temporary port road		pile	336		336	
		insert concrete	80		80	
		super-structure	1,020		1,020	
	concrete pavement		1,363		1,363	
						2,799
Pier No.3						
	foundation	pile	13,705		13,705	
		insert concrete	3,090		3,090	
	superstructure	beam & slab	13,239		13,239	
	crane girder		1,632		1,632	
	accessories		1,087		1,087	
	bulk head	concrete blocks	7,466		7,466	
						40,219
Container berth						
	concrete caisson	caisson		27,702	27,702	
		cover concrete		1,836	1,836	
		super concrete		4,990	4,990	
	crane girder	pile		2,136	2,136	
		insert concrete		486	486	
		girder		1,737	1,737	
						38,887
Container terminal						
	pavement			24,071	24,071	
	Port road			2,981	2,981	
						27,052
Revetment (-4m quay)						
		concrete block		8,280	8,280	
		in-situ concrete		621	621	
						8,901
On land works						
		Retaining wall		1,200	1,200	
		gate		200	200	
						1,400
	TOTAL		43,018	76,240	119,258	

3) Concrete caisson

Concrete caissons will be fabricated on a floating dock, which will be procured from abroad. Two caissons will be fabricated at a time. The two completed caissons will be launched and towed to the planned position and set up temporally. The floating dock will have two hoisting cranes at the top of the wings and it will be accompanied by a floating crane of 200 tons lifting capacity and a tug boat of 1000 HP.

Number of caissons to be fabricated	27 units
Use of concrete	29,500 m3
Use of steel bar	2,500 tons

4) Piling works

Pile structures are designed for Pier No.3 and the temporary port road

Number of PPC piles

Pier No.3	750 units
Temporary port road	17 units

Method of pile work: Cost estimates have been made using the same design as the existing facilities at Pecém port. Piles are designed as pre-cast, pre-stressed concrete piles. To set up a PPC pile, after being piloted into position, the steel casing will be driven into the rock layer, materials inside the casing will be excavated, and the casing filled with underwater concrete. All of the in-situ works will be executed from a self elevated platform or otherwise by means of canti-travellar.

Both the number and cost of PC pile foundation occupy an important portion in the Pier No.3. Table 9.7.3 shows the cost breakdown of PC pile foundation of Pier No.3.

Table 9.7.3 The cost breakdown of PC pile foundation of Pier No.3

Item		Description	detail	unit	quantity	unit price	amount
1		Foundation of pier					
	1-1	Production of PC piles	φ900	m	20,300.00	1,440.00	29,232,000.00
	1-2	Transport piles on access bridge		m	20,300.00	520.00	10,556,000.00
	1-3	production of pile pins for rock		units	580.00	3,200.00	1,856,000.00
	1-4	Supply steel casing D=120 cm		tons	748.20	7,510.00	5,618,982.00
	1-5	Set up and driving casing	31m	m	17,980.00	37.00	665,260.00
	1-6	mount concrete for set up pile in soil		m	208.00	3,200.00	665,600.00
	1-7	Penetrate soil D=113cm hole	5m/pile	m	2,900.00	456.00	1,322,400.00
	1-8	Penetrate rock D=113cm hole	8m/pile	m	4,640.00	3,060.00	14,198,400.00
	1-9	mount concrete for set up pile in rock		m	348.00	13,000.00	4,524,000.00
	1-10	Extract casing pile		m	17,980.00	170.00	3,056,600.00
	1-11	Underwater concrete surrounding pile	3.8m3/pile	m3	2,204.00	561.00	1,236,444.00
	1-12	Production of PC piles	φ1200	m	5,075.00	1,980.00	10,048,500.00
	1-13	Transport piles on access bridge		m	5,075.00	715.00	3,628,625.00
	1-14	production of pile pins for rock		units	145.00	3,200.00	464,000.00
	1-15	Supply steel casing D=150 cm		tons	233.40	7,510.00	1,752,834.00
	1-16	Set up and driving casing	31m	m	4,495.00	46.00	206,770.00
	1-17	mount concrete for set up pile in soil		m	82.60	3,200.00	264,320.00
	1-18	Penetrate soil D=143cm hole	5m/pile	m	725.00	730.00	529,250.00
	1-19	Penetrate rock D=143cm hole	8m/pile	m	1,160.00	4,896.00	5,679,360.00
	1-20	mount concrete for set up pile in rock		m	139.20	13,000.00	1,809,600.00
	1-21	Extract casing pile		m	4,495.00	170.00	764,150.00
	1-22	Underwater concrete surrounding pile	6.1m3/pile	m3	885.00	561.00	496,485.00
		Sub total	900-1200	units	725.00	135,966.32	98,575,580.00
						135,000.00	97,875,000.00

(4) Cost estimates

1) Composition of cost item

Cost estimate is composed of the following items:

A	Offshore Civil Works			
	Port road and temporary port road		m	1,015
	Breakwater		m	2,710
	Container Terminal offshore (d=300m)		m	540
	Reclamation		m3	4,040,000
	Pier No.3		m	680
	-4m port service boats		m	276
	Dredging		m3	500,000
B	Civil Works on land			
	Site preparation, Fences, Gates, Buildings		Ha	20
	Railway,		m	2,700
C	Procurement of Equipment	gantry crane, etc	units	39
D	Total of Construction Cost		A+B+C	
E	Engineering Services		(A+B) x 3% + C x 1%	
F	Contingency		D x 10%	
G	Project Cost	(Excluding VAT)	D + E + F	

2) Project cost

The preliminary project cost is R$ 616 million as shown in Table 9.7.5. An engineering service cost of 3% is estimated in the total cost of the civil works and training of equipment operators is estimated to be 1% of cost for procurement of equipment.

Table 9.7.4 Preliminary Project Cost for Short Term Development Plan (1)

Item		Description	Detail	Unit	Quantity	Unit Price	Amount
A		CIVIL OFFSHORE WORKS					
1		Mobilization / Demobilization					
	1-1	Sea & land transport of equipment	in Brazil	LS	1		3,000,000
	1-2	Floating dock and other materials	from abroad	LS	1		4,000,000
		TOTAL of ITEM 1					7,000,000
2		Temporary works					
	2-1	Access road					
	2.1.1	Access road near and in the port	200mx7m	m2	1,400	95	133,000
	2.1.2	Deposit sediments of the quarry		L.S	1		0
	2.1.3	Repairing works of surface paving	10m2x20	m2	200	95	19,000
	2.1.4	Transport material above		m3	880	17	14,960
		Sub total					166,960
							166,000
	2-2	Container Berth and Pier No.3					
	2.2.1	Soil investigation and testing	35x20units	m	700	64	44,800
		Sub total					44,800
	2-3	Quarry site					
	2.3.1	Soil investigation and testing	35mx10units	m	350	64	22,400
		Sub total					22,400
		TOTAL of ITEM 2					233,200
3		Temporary port road					
	3-1	Temporary port road					
	3.1.1	Stone foundation		sum	1		2,130,000
	3.1.2	Foundation of pile		units	17	142,000	2,414,000
	3.1.3	Beams and Supporting/staging works		m2	1,008	1,430	1,441,440
	3.1.4	Slab concrete and accessories		m2	1,008	1,040	1,048,320
	3.1.5	Concrete pavement for road		m2	670	207	138,690
	3.1.6	Temporary port road on the breakwater	L=475m	m2	4,512	1,010	4,557,120
		TOTAL of ITEM 3		m2	6,190	1,890	11,699,100
4		Pier No.3					
	4-1	Foundation works					
	4.1.1	Pier fondation	φ1000	units	725	135,000	97,875,000
	4.1.2	Super structure of pier	22m width	m	680	37,000	25,160,000
	4.1.1	Crane girder		m	1,360	2,250	3,060,000
	4.1.2	Accessoris		m	680	7,900	5,372,000
	4.1.1	Bulkhead foundation		m	710	26,000	18,460,000
	4.1.2	Bulkhead concrete		m	710	9,320	6,617,200
	4.1.1	Reclamation		m3	709,000	9	6,381,000
		Sub total		m	680	239,596	162,925,200
	4-2	Pavement & Building / Equipment					
	4.2.1	Port road at Pier No.3	20mx680m	m2	13,600	96	1,305,600
	4.2.2	Building of Shed	150x50x2	m2	7,500	1,210	9,075,000
	4.2.3	Building of Cold Storage	120x50x1	m2	6,000	1,210	7,260,000
	4.2.4	Yard pavement external buildings		m2	14,340	96	1,376,640
	4.2.5	Yard pavement concrete D=250mm		m2	10,300	96	988,800
	4.2.6	Yard pavement PC panel		m2	1,300	510	663,000
		Sub total		m	680	30,396	20,669,040
		TOTAL of ITEM 4		m	680	270,000	183,600,000
5		Breakwater					
	5-1	Sub-breakwater		m	620	57,100	35,402,000
	5-2	Main breakwater		m	1,790	39,900	71,421,000
	5-3	West breakwater		m	300	57,400	17,220,000
		TOTAL of ITEM 5		m	2,910	42,626	124,043,000

Table 9.7.5 Preliminary Project Cost for Short Term Development Plan (2)

Item		Description	Detail	Unit	Quantity	Unit Price	Amount
6		Container terminal					
	6-1	Container Berth					
	6.1.1	Foundation works		m	540	4,890	2,640,600
	6.1.2	Concrete caisson		units	27	2,000,000	54,000,000
	6.1.3	Super structure and accessories		m	540	15,300	8,262,000
	6.1.4	Crane foundation L=35m 108units		m	536	33,000	17,688,000
		Sub total		m	540	152,946	82,590,600
	6-2	Container Terminal					
	6.2.1	pavement		m2	145,800	140	20,412,000
	6.2.2	Reclamation		m3	2,989,000	10	29,890,000
	6.2.3	Port road		m	547	3,110	1,701,170
		Sub total		m	540	96,302	52,003,170
	6-3	Basin for port service boats	-4m quay				
	6.3.1	Concrete works		m	276	29,600	8,169,600
	6.3.2	Foundation works		m	276	22,500	6,210,000
		Sub total		m	276	52,100	14,379,600
	6-4	Juncktion of breakwaters					
	6.4.1	Concrete caisson and foundation	20m+20m	m	40	120,000	4,800,000
		TOTAL of ITEM 6		m	540	284,766	153,773,370
7		Channel & Basin					
	7-1	Dredging		m3	430,000	18	7,740,000
	7-2	Navigation aids		LS	1	500,000	500,000
		Sub total		LS	1		8,240,000
		TOTAL of ITEM 7		LS	1		8,240,000
		TOTAL OF OFFSHORE WORKS					488,588,670
B		CIVIL ON LAND WORKS					
	1	Site preparation		Ha	20	11,550	231,000
	2	Fence with seaside retaining wall		m	2,000	270	540,000
	3	Gate/Watch house, Truck scale		LS	1		600,000
	4	Railway	for container	m	2,700	1,800	4,860,000
		TOTAL OF ON LAND WORKS					6,231,000
		TOTAL OF CIVIL WORKS					494,819,670
C		Procurement of equipment					
	1	Quay Side Gantry Crane		units	2	17,000,000	34,000,000
	2	Rubber Tire Mounted Gantry Crane		units	4	2,800,000	11,200,000
	3	Tractor head / Trailer		units	33	150,000	4,950,000
		TOTAL OF EQUIPMENT					50,150,000
D		TOTAL OF CONSTRUCTION COST					544,969,670
E		Engineering services					
	1	Consultation of the Project	Civil x 0.03	%	494,819,670	0.03	14,844,590
	2	Training of equipment	Equipment x 0.01	%	50,150,000	0.01	501,500
		Sub Total					15,346,090
F		Indirect Cost + Contingency		%	560,315,760	0.10	56,031,576
G		GRAND TOTAL	Exclude VAT				616,347,336
		Equivalent Japanese Yen				¥	30,817,366,806

3) Cost portion of Short Term Plan

Construction cost of the Short Term Plan is divided into four components as shown in Table 9.7.6.

Table 9.7.6 Preliminary Project Cost for Short Term Plan (1)

1

								Cost breakdown for financial analysis								
								Material		Fuel,machinery		skilled L		Unskilled L		F/C
Item		Description	detail	unit	quantity	unit price	amount	%		%		%		%		
A		Off shore Works														
	1	Mobilization and Demobilization		LS	1		7,000,000	10	700,000	90	6,300,000	0	0	0	0	
	2	Temporary works		LS	1		233,200	18	41,976	44	102,608	22	51,304	16	37,312	
	3	Temporary port road		m2	6,190	1,890	11,699,100	36	4,211,676	36	4,211,676	14	1,637,874	14	1,637,874	
	4	Pier No.3		m	680	270,000	183,600,000	33	60,588,000	38	69,768,000	14	25,704,000	15	27,540,000	
	5	Breakwater														
	5-1	Sub-breakwater		m	620	57,100	35,402,000	26	9,204,520	46	16,284,920	16	5,664,320	12	4,248,240	
	5-2	Main breakwater		m	1,790	39,900	71,421,000	26	18,569,460	46	32,853,660	16	11,427,360	12	8,570,520	
	5-3	West breakwater		m	300	57,400	17,220,000	26	4,477,200	46	7,921,200	16	2,755,200	12	2,066,400	
	6	Container terminal														
	6-1	Container Berth		m	540	152,946	82,590,600	33	27,254,898	40	33,036,240	12	9,910,872	15	12,388,590	
	6-2	Container Terminal		m	540	96,302	52,003,170	24	12,480,761	37	19,241,173	18	9,360,571	21	10,920,666	
	6-3	Basin for port service boats	-4m quay	m	276	52,100	14,379,600	40	5,751,840	28	4,026,288	15	2,156,940	17	2,444,532	
	6-4	Juncktion of breakwaters		m	40	120,000	4,800,000	30	1,440,000	43	2,064,000	12	576,000	15	720,000	
	7	Channel & Basin		LS	1		8,240,000	22	1,812,800	57	4,696,800	12	988,800	13	1,071,200	
		Sub Total					488,588,670	30	146,533,131	41	200,506,565	14	70,233,241	15	71,645,334	
B		On land works														
	1	Site preparation		Ha	20	11,550	231,000	10	23,100	60	138,600	20	46,200	10	23,100	
	2	Fence with seaside retaining wall		m	2,000	270	540,000	30	162,000	20	108,000	20	108,000	30	162,000	
	3	Gate/Watch house, Truck scale		LS	1		600,000	40	240,000	20	120,000	20	120,000	20	120,000	
	4	Railway	for container	m	2,700	1,800	4,860,000	45	2,187,000	20	972,000	15	729,000	20	972,000	
	5	Parking lot		m2	0	90	0	60	0	10	0	10	0	20	0	
		Sub Total					6,231,000	42	2,612,100	21	1,338,600	16	1,003,200	20	1,277,100	
		TOTAL OF CIVIL WORKS					494,819,670	30	149,145,231	41	201,845,165	14	71,236,441	15	72,922,434	
													skilled		unskilled	
									yearly income				16,000		10,000	
									total number				4,452		7,292	
									project year		6.5 years		685		1,122	
									work at site		50%		342		561	

Table 9.7.7 Preliminary Project Cost for Short Term Plan (2)

2

								Cost breakdown for financial analysis								
								Material		Fuel,machinery		skilled L		Unskilled L		
Item		Description	detail	unit	quantity	unit price	amount	%		%		%		%		
C		Procurement of equipment														
	1	Quay Side Gantry Crane		units	2	17,000,000	34,000,000	100	34,000,000							F/C
	2	Rubber Tire Mounted Gantry Crane		units	4	2,800,000	11,200,000	100	11,200,000							F/C
	3	Tractor head / Trailer		units	33	150,000	4,950,000	100	4,950,000							F/C
	4															
	5															F/C
		Sub Total					50,150,000	100	50,150,000		0		0		0	
D		Total of construction cost					544,969,670	37	199,295,231	37	201,845,165	13	71,236,441	13	72,922,434	
E		Engineering services														
	1	Consultation of the Project	Civil x 0.03	%	494,819,670	0.03	14,844,590									
	2	Training of equipment	Equipment x 0.	%	50,150,000	0.01	501,500									
		Sub Total					15,346,090									
F		Indirect Cost + Contingency		%	560,315,760	0.10	56,031,576									
G		GRAND TOTAL	Exclude VAT				616,347,336									
		Equivalent Japanese Yen				¥	30,817,366,806									

9.7.2 Construction Schedule

(1) Construction schedule of the major facility components

1) Overall schedule

Table 9.7.8 shows the Construction Schedule for the Short Term Plan.

Table 9.7.8 Construction schedule for the Short Term Plan

					Short Term						
					Urgent			Remain			
				2006.July→	2006	2007	2008	2009	2010	2011	2012
Item		Description		amount							
A		Off shore Works									
	1	Mobilization & Demobilization	LS	1							
	2	Temporary works	LS	1							
	3	Access Road & Bridge									
	3-1	Temporary port road	m	440	juncktion	road					
	4	Pier No.3	m	680	170m	340m	170m				
	5	Breakwater									
	5-1	Sub-breakwater	m	620			200m	420m			
	5-2	Main breakwater	m	1,790			300m	600m	600m	290m	
	5-3	West breakwater	m	300	70m	150m	80m				
	6	Container Terminal									
	6-1	Container Berths	m	540					260m	280m	
	6-2	Container Terminal	m	540							540m
	6-3	Reclamation	m3	2,989,000							2,989,000m3
	6-4	Revetment (-4m quay)	m	276						276m	
	7	Channel & Basin	LS	1					Dredging	Navigation aids	
B		On land works									
	1	Site preparation	Ha	20				20Ha			
	2	Fence with seaside retaining wall	m	2,000					1,000m	1,000m	
	3	Gate/Watch house, Truck scale	ls	1							
	4	Railway	m	2,700				900m	900m	900m	
C		Procurement of equipment									
	1	Quayside Gantry Crane	unit	2							2 units
	2	Rubber Tire Mounted Gantry Cran	unit	4							4 units
	3	Tractor head & Trailer	unit	33							33 units

Year is shown as the Fiscal Year that start in April and end in March of next year

2) Breakwaters

The construction period for the breakwaters for the short term plan is set at 6 years. According to Table 9.7.8, stones would mostly be installed in Remain Project for the construction of Main Breakwater. Table 9.7.9 shows the use of stones during Remain Project.

Table 9.7.9 Use of stones for Phase II

Description			Remain	Total	2,008	2,009	2,010	2,011
West breakwater					PhaseI/II			
	Armor stone 300-500kgkg		0	20,775	20,775	0	0	0
	Armor stone 4-6ton		0	14,625	14,625	0	0	0
	rubble stone 5-100kg		0	56,750	56,750	0	0	0
Sub breakwater								0
	Armor stone 300-500kg		1.0	146,940	73,470	73,470	0	0
	Armor stone 1-6ton		1.0	70,600	35,300	35,300	0	0
	rubble stone 5-100kg		1.0	543,740	271,870	271,870		
Main breakwater								
	rubble stone 5-100kg		1.0	853,300	121,900	243,800	243,800	243,800
	Armor stone 300-500kg		1.0	387,800	55,400	110,800	110,800	110,800
	Armor stone 4-6ton		1.0	222,320	31,760	63,520	63,520	63,520
Temporary port road (crushed stone)			0	0	0	0		0
Bulkhead of Pier 3 (mainly 5-100kg)			0	89,600	89,600	0	0	0
	Total			2,406,450	771,450	798,760	418,120	418,120

* Offshore transport : all breakwaters 620,000m3

Necessary equipment

ITEM	Cycle time etc.	Capacity	Number
Dump trucks	18m3x6time/day	30 tons	26 units
Bottom open carrier	350m3x2time/day	350 m3	4 fleets
Carrier with grab bucket	300m3x1time/day	500 tons	3 fleets

3) Container and Grain Berth

To fabricate concrete caissons, a floating dock of 6,000 ton-capacity will be procured from abroad. Two concrete caissons will be constructed at the same time. As it takes 55 to 60 days to complete a pair of caissons, the caisson fabrication cycle time is estimated as one month. Fabrication of caissons may become a critical path object for the construction schedule.

The floating dock for caisson fabrication has two hoisting cranes, accompanied by a floating crane of 200 tons lifting capacity and a 1,000 Hp tug boat.

Fabrication of the caissons starts the first year of Phase II (2009). The total number of caissons is 30 units for the container berths and the junctions. The working procedure for the caissons will be as follows.

Excavation → Rubble mound → Levelling of mound →
Fabrication of caisson → Launching caisson → Placing
→ Filling with sand → Cover concrete → backing rubble stone
→ Filter fabric sheet → Reclamation → In-situ concrete
→ Pavement

(2) Construction projection

Considering the schedule of the each facility component, an overall schedule has been prepared for the construction projection as shown in Table 9.7.10. The image of progress for the implementation work is shown in Figures 9.7.1 and 9.7.2.

Table 9.7.10 Construction Projection for the Short Term Plan

Unit: '000 R$

Local currency (open bar)
Foreign currency (grey bar)

				Short Term							
				Urgent			Remain				
			2006.July→	2006	2007	2008	2008	2009	2010	2011	2012
Item		Description	Amount								
A		Off shore Works	R$								
	1	Mobilization & Demobilization	7,000,000	7,000							
	2	Temporary works	233,200	233							
	3	Access Road & Bridge									
	3-1	Temporary port road	11,699,100	5,850	5,850						
	3-2	New access bridge	0								
	4	Pier No.3	183,600,000	45,900	91,800	45,900					
	5	Breakwater									
	5-1	Sub-breakwater	35,402,000				11,329	24,073			
	5-2	Main breakwater	71,421,000				12,142	24,283	24,283	10,713	
	5-3	West breakwater	17,220,000	4,305	8,610	4,305					
	6	Container Terminal									
	6-1	Container Berths	82,590,600						39,643	42,947	
	6-2	Container Terminal	22,113,170								22,113
	6-3	Reclamation	29,890,000							9,864	20,026
	6-4	Revetment (-4m quay)	19,179,600							9,590	9,590
	7	Channel & Basin	8,240,000						2,746	2,747	2,747
		Sub Total	488,588,670	63,288	106,260	50,205	23,470	48,357	66,673	75,861	54,476
B		On land works									
	1	Site preparation	231,000					231			
	2	Fence with seaside retaining wall	540,000						270	270	
	3	Gate/Watch house, Truck scale	600,000								600
	4	Railway	4,860,000					1,620	1,620	1,620	
		Sub Total	6,231,000	0	0	0	0	1,851	1,890	1,890	600
C		Procurement of equipment									
	1	Quayside Gantry Crane	34,000,000			34,000					
	2	Rubber Tire Mounted Gantry Crane	11,200,000								11,200
	3	Tractor head & Trailer	4,950,000			1,650					3,300
	4	Loading/Unloading Machine	0								
		Sub Total	50,150,000	0	0	35,650	0	0	0	0	14,500
D		Total of construction cost	544,969,670	63,288	106,260	85,855	23,470	50,208	68,563	77,751	69,576
E		Engineering services									
	1	Consultation of the Project	14,844,590	2,423	2,422	2,000		2,000	2,000	2,000	2,000
	2	Training of equipment	501,500			251		250			
		Sub Total	15,346,090	2,423	2,422	2,251		2,250	2,000	2,000	2,000
F		Indirect Cost + Contingency	56,031,576	6,571	10,868	8,811	2,347	5,246	7,056	7,975	7,158
G		GRAND TOTAL	616,347,336	72,282	119,550	96,917	25,817	57,703	77,619	87,726	78,734
				288,749			327,599				

Equivalent Japanese Yen 30,817,366,806

Year is shown as the Fiscal Year that start in April and end in March of next year

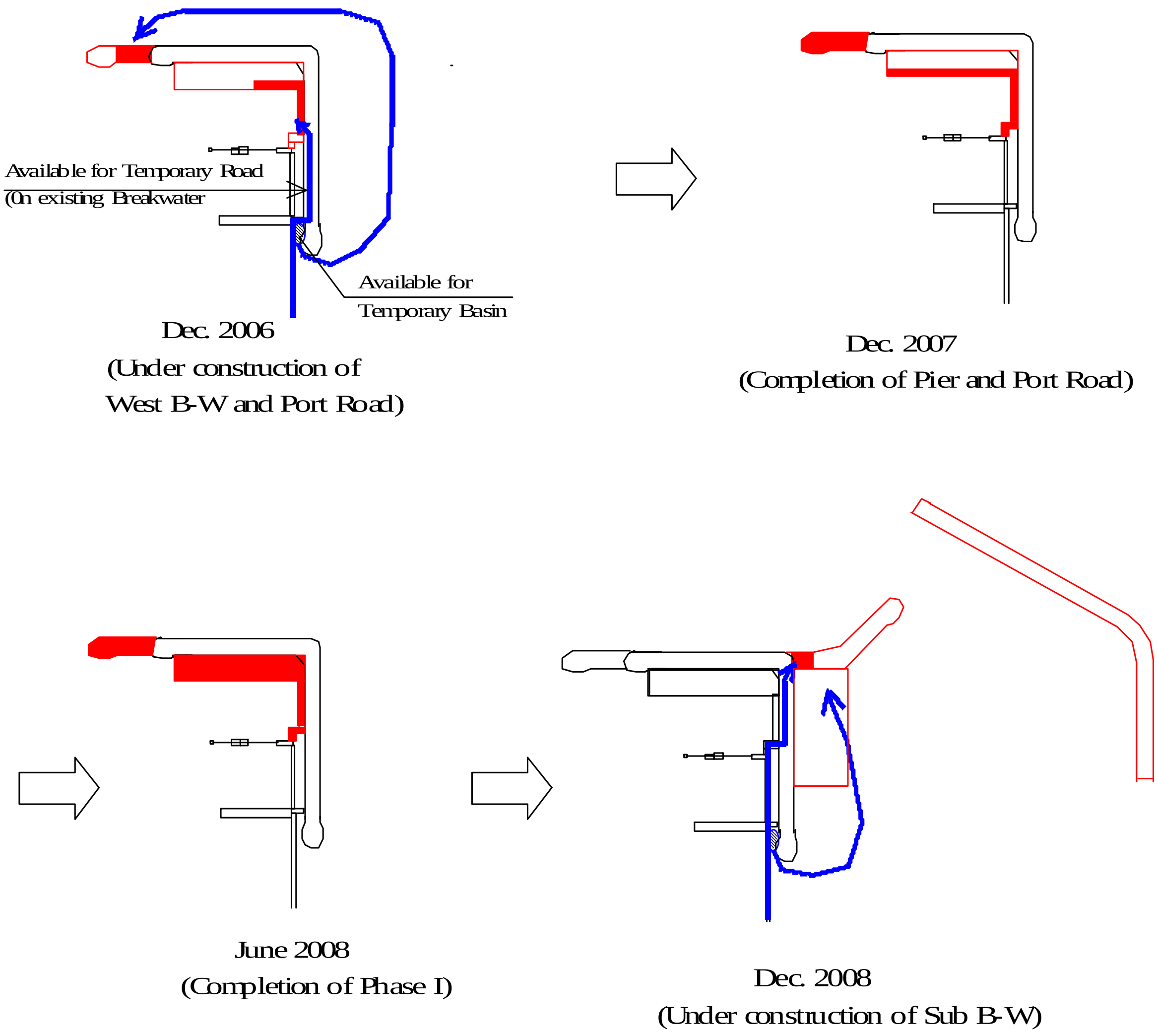
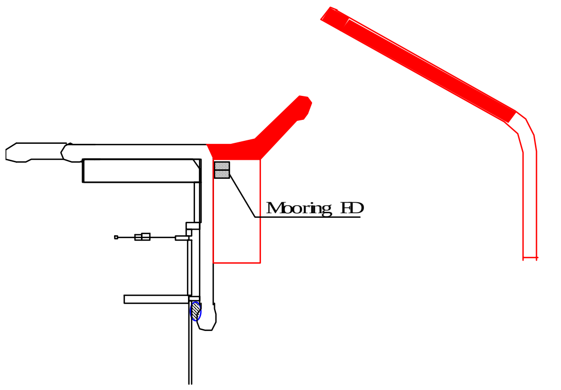
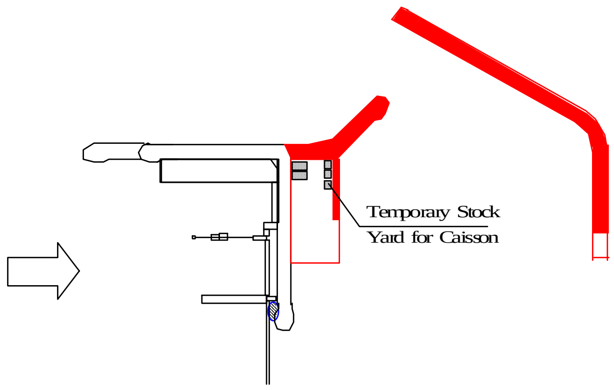


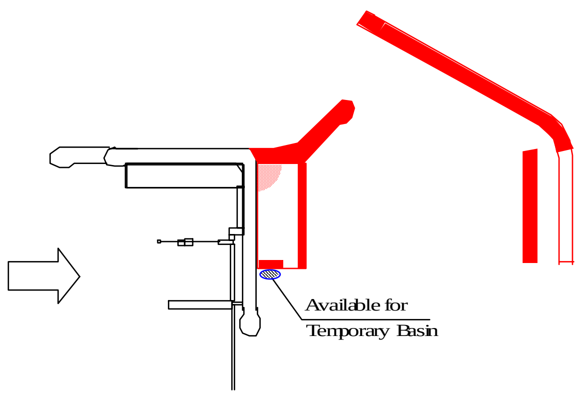
Figure 9.7.1 Progress for the Implementation Work (Urgent Project)



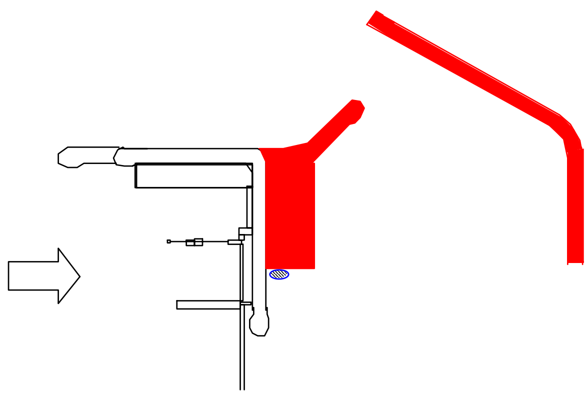
Dec. 2009
(Under construction of Main B-W)
(Mobilization of FD for fabrication of Caisson)



Dec. 2010
(Under construction of Caisson Walf)



Dec. 2011
(Completion of Main B-W and Quaywall)
(Under construction of Reclamation and Revetment)



Dec. 2012
(Completion of Phase II)

Figure 9.7.2 Progress for the Implementation Work (Remain Project of 1st Phase)