The Kingdom of Cambodia
Port Authority of Sihanoukville

The Kingdom of Cambodia
Preparatory Survey
for
Sihanoukville Port New Container Terminal Expansion Project

Final Report
Summary

July 2022

Japan International Cooperation Agency (JICA)

The Overseas Coastal Area Development Institute of Japan

Nippon Koei Co., Ltd.

Oriental Consultants Global Co., Ltd.

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Exchange Rate
USD 1.00 = JPY 114.00
（as of January 2022）

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Abbreviation

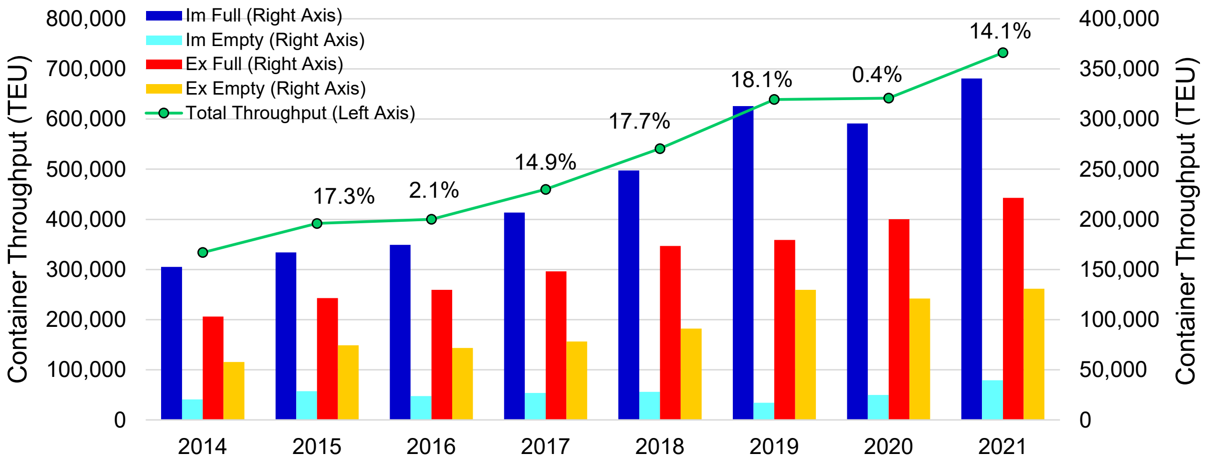
AGV	Automated Guided Vehicle
A-RAP	Abbreviated Resettlement Action Plan
ARTG	Automated Rubber Tired Gantry Crane (RTG)
ASEAN	Association of South East Asian Nations
BRP	Basic Resettlement Plan
CCTV	Closed-circuit television
CDC	The Council for Development of Cambodia
CIY	Customs Inspection Yard
CMP	Cai Mep
CRF	Cambodia Rice Federation
CSEZB	Cambodian Special Economic Zone Board
CSX	Cambodia Securities Exchange
CT	Container Terminal
DFR	Draft Final Report
DHC	Dual Hoist Crane
EBA	Everything but Arms (EU-specific preferential tariff system)
ECNA	East Coast of North America
EDC	Electricitē du Cambodge
EIA	Environmental Impact Assessment
ESMF	Environmental and Social Management Framework
GDCE	General Department of Customs and Excise of Cambodia
GDP	Gross Domestic Product
GMAC	Garment Manufacturers Association in Cambodia
GPV Data	Grid Point Value Data
ICB	Interlocking Concrete Block
IEIA	Initial Environmental Impact Assessment
IPO	Initial Public Offering
ITR	Interim Report
JICA	Japan International Cooperation Agency
JOGMEC	Japan Oil, Gas and Metals National Corporation
JV	Joint Venture
LCB	Laem Chabang
MEF	Ministry of Economy and Finance
MOE	Ministry of Environment
MPT	Multi-Purpose Terminal
MPWT	Ministry of Public Works and Transport
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NCT	New Container Terminal
NK	Nippon Koei Co., Ltd.
OCDI	The Overseas Coastal Area Development Institute of Japan
OCG	Oriental Consultants Global Co., Ltd.
OD	Origin-Destination
ODA	Official Development Assistance
PAS	Port Authority of Sihanoukville (Sihanoukville Autonomous Port)
PBD	Plastic Board Drain
PIANC	The World Association for Waterborne Transport Infrastructure (Former “the Permanent International Association of Navigation Congresses”)
PNP	Phnom Penh
PPAP	Phnom Penh Autonomous Port

PPP	Public-Private Partnership
PPSEZ	Phnom Penh SEZ
QGC	Quayside Gantry Crane
RQD	Rock Quality Designation
RTG	Rubber Tired Gantry Crane
SCFI	Shanghai Containerized Freight Index
SEZ	Special Economic Zone
SHV	Sihanoukville
SP	Stated Preference
SPSEZ	Sihanoukville Port SEZ
SPT	Standard Penetration Test
SSEZ	Sihanoukville SEZ
TCR	Total Core Recovery
TEU	Twenty-feet Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development
VUT	Vung Tau
WAM	Third Generation WAve Models
WB	World Bank
WCNA	West Coast of North America

Chapter 1 Background and Purpose of the Survey

1.1 Background of the Survey

1. The cargo handling at the SHV Port has been increasing steadily for more than a dozen years, and the average annual growth rate for the 10 years from 2011 to 2021 is 11.9% in container cargo volume (TEU), and the throughput in 2021 has reached 733 thousand TEU exceeding 700,000 TEU for the first time.



Source: PAS Statistics

Figure 1-1 Trend of Container Throughput at SHV Port

2. Container cargo has been rapidly increasing; the throughput in 2018 reached 540,000 TEU which exceeds the port's original container handling capacity of 500,000 TEU. Furthermore, after Khmer New Year in 2019, SHV Port experienced a dramatic increase in import containers for several months which resulted in a severe shortage of container yard space and heavy traffic congestion in the container marshalling area. As a result, the Berth Occupancy Ratio (BOR) exceeded 80% and 3-4 ships were always waiting for berthing at the offshore anchoring area, and more than half of container vessels were waiting one day or more based on the record in June. Regarding container dwell time in the yard, monthly average value was more than 8 days for import laden containers from May to November (Target value was set as 4 days in the technical cooperation project). This was a critical situation but due to the dedicated efforts of PAS, the situation has been gradually improved by means of emergency expansion of container yards and introduction of more efficient procedures for container storage. Consequently, the throughput in 2019 reached 640,000 TEU. In 2020, due to the COVID-19 impact in the first half of the year, the throughput was almost the same as in 2019 (0.4% increase). In 2021, the throughput has been increasing sharply again which reach 733 thousand TEU. The current annual handling capacity has been improved at around 750,000 TEUs by means of various measures taken by PAS.

3. Recently, two vessels with a length of 170 m and over have been simultaneously berthing which means the quay crane cannot reach all the container bays of the ship due to the shortage of crane rail length. In these cases, the vessel is forced to change the berthing

direction or to shift the mooring position during berthing. These irregular operations reduce the berth productivity and increase the berth occupancy ratio (BOR), which reduces the possibility of new shipping services calling at SHV Port.

4. Currently, the development of a new container terminal including the first container berth (hereinafter referred to as "NCT1") is underway as the "Sihanoukville Port New Container Terminal Development Project" which is being financed by Japanese ODA loan. This will increase the container cargo handling capacity by about 450,000 TEUs/year[1] (total capacity will reach about 1.20 million TEUs/year) after the commencement of operation in December 2025 (based on the information as of January 2022). Until then, as the capacity shortage would occur again, PAS intends to take additional short-term counter-measures such as extending rails of container crane to the berth No.6 (see Figure 4-6) as well as adding cranes and yards to cope with the future increase in container throughput.

5. If container throughput continues to increase by 10% per year, the container volume will exceed 1 million TEU in 2025 and would reach the terminal capacity of 1.20 million TEUs just one or two years later, i.e., in 2026 or 2027. This means that a capacity shortage could again become an issue a few years after the NCT1 is put into service. For this reason, and considering the required time of construction work as well as the possibility that larger vessels may call at SHV Port in future, it is urgent to examine when new container terminals should be in operation and take necessary actions without delay.

1.2 Purpose of the Survey

6. Based on the backgrounds described above, the Royal Government of Cambodia and PAS have requested JICA to implement a Preparatory Survey for Sihanoukville Port New Container Terminal Expansion Project (hereinafter referred to as "the Project") which includes the second container berth (Hereinafter referred to as “NCT2” including terminal area) and the third container berth (hereinafter referred to as "NCT3" including terminal area) (hereinafter referred to as "the Survey"). Responding to the request above, JICA has decided to carry out the Preparatory Survey in order to verify the necessity and validity of the Project through examining design of the port facilities, project cost, implementation schedule and development scheme, management and operation system, environmental and social considerations, and so forth.

[1] Although 450,000 TEUs was set for the capacity of NCT1 in the design stage, it would be about 430,000 TEUs in accordance with the analysis in this study as described later in the section 5.3.

Chapter 2 Socio Economic Condition

2.1 Population

7. The UN reports that the total population in Cambodia is 16.7 million in 2020. It will reach 19.686 million in 2035 (17.8% increase from 2020), and 21.8 million in 2050 (30.8% increase from 2020) respectively. The annual increase rate will be stabilizing from 1.49% (recent five years) to 0.56% (2045 to 2050).

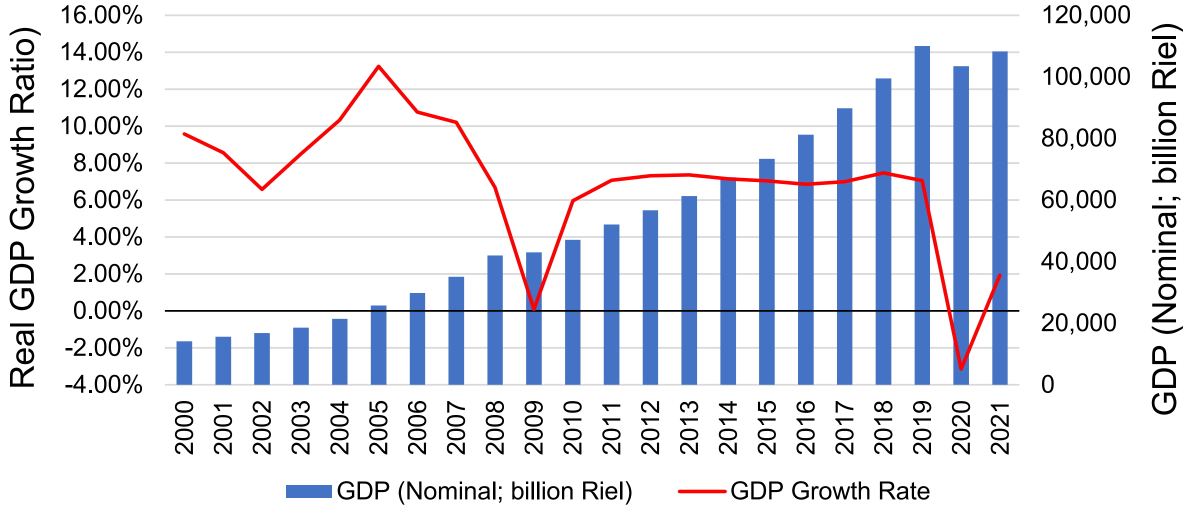
Table 2-1 Projected population in Cambodia

Year	2020	2025	2030	2035	2040	2045	2050
Population(thousands)	16,719	17,806	18,781	19,686	20,527	21,261	21,861

Source :https://population.un.org/wpp/Download/Standard/Population/

2.2 Economy

8. Gross Domestic Product (GDP) in Cambodia was 110.0 trillion Riel (US$26.9 billion) in a nominal value base in 2019. The Real GDP growth rate fell to zero in 2009 after the global financial crisis in 2008 (previously, GDP growth of around 10% had been achieved). After that, it recovered to around 7% and continue the steady growth, but in 2020, due to the impact of COVID-19 pandemic, the growth ratio fell down to minus. In 2021, the growth has recovered to plus but just around 2% according to the preliminary figures by IMF. The exchange rate has been stable with one US dollar being equivalent to approximately 4,000 Riel.



Source :International Financial Statistics - At a Glance - IMF Data

Figure 2-1 Trends of GDP (nominal value) in Cambodia

2.3 Trade

2.3.1 Trends of Trade Value

9. Cambodia became a member of WTO in 2004 and joined ASEAN in 2009. Cambodia has increased its value of trade since eliminating trade barriers and reducing tariff rates as part of its efforts to promote free trade. Exports were valued at US$ 14.82 billion in 2019 while imports were valued at US$ 20.28 billion. No significant fluctuations were observed during the global financial crisis in 2008. Average annual growth rates are 12.7% for exports and 15.6% for imports since 2007 (excluding a slightly minus growth rate in 2009 for imports

2.3.2 Export

10. The total export value in 2019 is $US 14.7 billion. Main export items (2 digits of HS code) are as follows: apparel and clothing accessories (US$8.24 billion, 56%), footwear (US$1.26 billion, 8.6%), articles of leather (US$1.10 billion, 7.5%), electric machinery (US$0.57 billion,3.9%) and cereals (US$0.42billlion, 2.8%).

2.3.3 Import

11. The total import value in 2019 is $US 20.1 billion. Main import items (2 digits of HS code) are as follows: knitted or crocheted fabrics (US$2.67 billion, 13.3%), vehicles other than railway rolling stock and parts and accessories thereof (US$2.36 billion,11.86%), mineral fuels, mineral oils and products of their distillation (US$2.35 billion, 11.7%), machinery, mechanical appliance (US$1.40 billion,7.0%) and electrical machinery (US$1.06billlion, 5.3%).

2.4 Industry

12. Industry wise share of Cambodian GDP is as follows: primary industry accounts for 24.6% of the total, secondary industry accounts for 36.7% and tertiary industry accounts for 38.8%, respectively in 2018. Agriculture is the main primary industry. Rice is the only self-sufficient product which is now also exported. Cassava has also become an important export product. Lumber production is low as international institutions and NGOs are generally opposed to this industry due to its negative impact on the environment.

13. In the secondary industry, the production volumes of knitting fabrics, leather bag and footwear, which have become strategic export goods of Cambodia, are increasing. The production of natural rubber is also increasing. Because of the great demand for public services such as electricity, gas and water supply, construction businesses and other related business to support these public services are also in great demand.

14. In the tertiary industry, the tourism industry represented by Angkor World Heritage has become main industry. The hotel and restaurant business has become very popular in Cambodia.

2.5 Special Economic Development Zone

2.5.1 Cambodia Special Economic Zone (SEZ)

15. In Cambodia, the Cambodia Development Council (CDC) was established under the Foreign Investment Law of 1994. In 2005, the Cambodian Special Economic Zone Commission (CSEZB) was established under CDC, and the special economic zone (SEZ) system was introduced for the first time in December 2005. Under the control of the Commission, Special Economic Zone Administration (SEZ Administration) is established in each special economic zone to provide one-stop service for investment project registration as well as for getting daily license for import/export. There are 46 SEZs approved in Cambodia since 2006.

Source :JICA Survey Team

Figure 2-2 Locations of the Major SEZ in Cambodia

2.5.2 Phnom Penh SEZ（PPSEZ）

16. PPSEZ was established in October 2006. This SEZ is located in the center of the Southern Economic Corridor in the region and has easy access to PNP Port, SHV Port and PNP Airport. As of April 2021, 104 companies are occupying this SEZ, 44 of which are Japanese companies.

2.5.3 Sihanoukville SEZ(SSEZ)

17. Sihanoukville Special Economic Zone in Cambodia (SSEZ) was jointly developed and constructed by private companies from both Cambodia and China. The overall planning area is 11.13 Km^2. The first phase focused on textiles & garments, luggage and leather goods, wood products, etc. as the main development industries. The second phase focused on introducing heavy machines, building materials, home furnishings, auto parts & tires, new photovoltaic materials, fine chemicals which could benefit by being close to the port.

When it's completed, the SSEZ will form an ecological model park comprised of 300 enterprises employing 80,000 to 100,000 industrial workers.[2]

[2] Cambodia Sihanoukville Special Economic Zone (ssez.com)

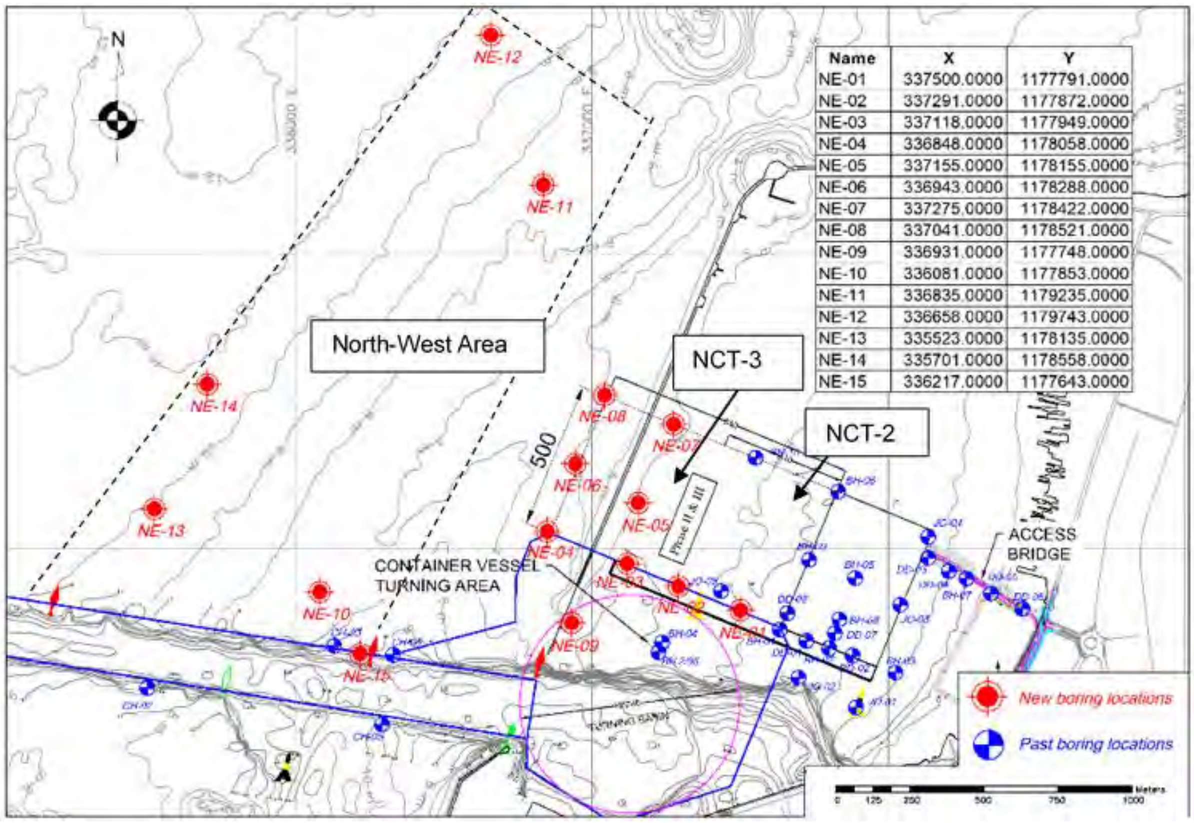
Chapter 3 Natural Conditions

3.1 Topography

18. To obtain necessary information for road planning, The topographic survey was carried out for the area centering on the soil stock yard at the foot of the access bridge connecting NCT1.

3.2 Soil Conditions

19. 9 borings from NE-01 to NE-09 were carried out within project area of NCT2 and NCT3, and 6 borings from NE-10 to NE-15 within North-West area as shown in Figure 3-1. Locations of each boring are decided based on future plan of the new container port such as New Quay alignment, Seawalls protecting and New Container yard.



Source: JICA Survey Team

Figure 3-1 Boring locations in the current study and in the past

3.3 Tides and Currents

3.3.1 Tide Level

20. Tide level (LWL, MSL, HWL, HHWL) used for port planning and construction work in the SHV Port is shown in Table 3-1. Construction Datum Level (CDL), which is upper than ACD by 0.47 m is used as a datum level in this survey.

Table 3-1 Tide Level in SHV Port

Tide Level	CDL	ACD
LWL	+0.00m	+0.47m
Mean Sea Level (MSL)	+0.60 m	+1.07 m
High Water Level (HWL)	+1.43 m	+1.90 m
Highest High Water Level (HHWL)	+1.67 m	+2.14 m

Note: ACD means Admiralty Chart Datum

Source: JICA Survey Team

3.3.2 Currents

21. The tidal current survey was conducted from April 28 to May 13, 1996 in the planned channel water area about 1 km west of the port entrance of SHV, and then from May 14 to May 29 in the water area 300 m south of Koh Poah Island. The prevailing direction of the tidal current is the north-south by the ebb and flood tide, and the maximum flow velocity during the observation period was 1.6 knot (0.8 m / s) in the direction of ebb tide (south-southwest to southwest). After that, there were no surveys conducted for tidal current. The same result is used for the design of this Project.

3.4 Meteorology and Waves

3.4.1 Temperature

22. Monthly temperatures recorded in SHV in 10 years from 2009 to 2018 do not fluctuate much throughout the year. It records approximately 25 ° C to 30 ° C.

3.4.2 Rainfall

23. The annual rainfall during 2009-2018 is as high as 2,000 mm to 2,900 mm, and the average annual rainfall is about 2,600 mm. The rainy season is from May to October, and a maximum of 249.8 mm / day was recorded on September 14, 2019. About 85% of the annual rainfall occurs during the rainy season.

3.4.3 Wind Conditions from the Meteorological Station

24. SHV Port is located in the southern part of Cambodia facing Kompong Som Bay, at latitude 10.61 degrees north and longitude 103.53 degrees east. Wind observations are being carried out at a meteorological station (10° 37′ 59.37″ N, 103° 30′ 16.76″ E) approximately 1.5km south of the port at an observation height of h = 13m. According to the observation, normal wind speed is about 5m/sec. However, during rainy season from June to September, wind speed is about 15m/sec. As a general tendency, the norther wind is predominant from May to January, and the southern wind is predominant from February to April.

3.4.4 Wave Condition

3.4.4 (1) Waves Obtained from SMB Calculation

25. The wind data observed at the meteorological station were converted into ocean winds. Then wave estimation was performed by the SMB method. From the wave data obtained from the wave estimation, the frequency table of wave height and wave direction for the whole year is shown in Table 3-2 and Figure 3-2. According to these results, the

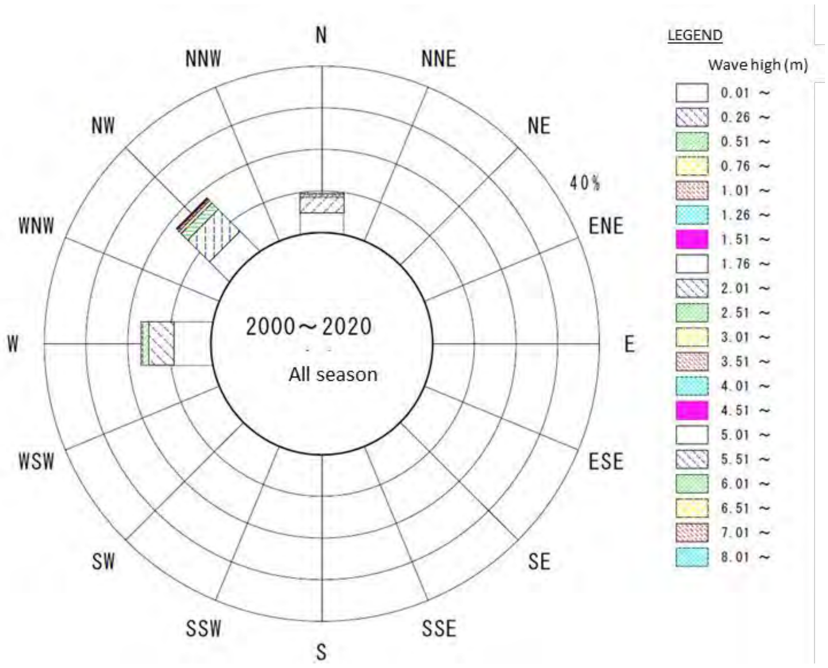
predominant wave direction is the NW direction. However, the maximum wave height is 2.51 (m) with the wave period of 5.40 (s) was from N direction.

Table 3-2 Wave Height Appearance Frequency by Wave Direction (according to SMB Calculation)

2000～2020 (All season) Data collected rate 44.2% (Missing: 102695)

Wave high (m) \ Wave direction	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	Calm	Total
0.01 ～												16276		11645		8744	143	36808
0.26 ～												11403		13686		6726		31815
0.51 ～												2462		4011		1307		7780
0.76 ～												750		1385		544		2679
1.01 ～												143		920		251		1314
1.26 ～												47		192		46		285
1.51 ～												23		288				311
1.76 ～														207		1		208
2.01 ～														187		1		188
2.51 ～																21		21
3.01 ～																		0
3.51 ～																		0
4.01 ～																		0
4.51 ～																		0
5.01 ～																		0
5.51 ～																		0
6.01 ～																		0
6.51 ～																		0
7.01 ～																		0
8.01 ～																		0
Total	0	0	0	0	0	0	0	0	0	0	0	31104	0	32521	0	17641	143	184104

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3-2 Wave Height and Wave Direction Appearance Frequency based on SMB Data

3.4.4 (2) Global Model Wave

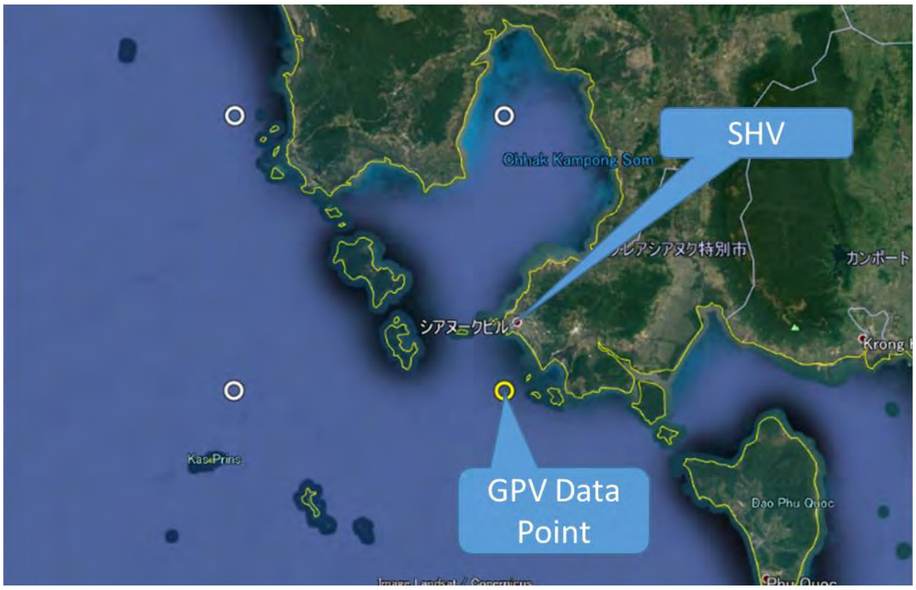
26. Global model wave data (GPV data "Grid Point Value" was purchased to improve the accuracy of the prerequisite wave estimation for detailed calmness analysis and judgment of the necessity of breakwater construction. Global wave estimation is the database uses NCEP; National Centers for Environmental Prediction (National Centers for Environmental Prediction) / NCAR: National Center for Atmospheric Research (National Center for Atmospheric Research) reanalysis sea breeze values as input values, and calculated using the third-generation waves estimation model WAM (the WAve Modeling group). And the output are significant wave height, significant wave period, and wave direction at every hourly agreement world time (see Table 3-3).

27. GPV wave data of the nearest point located to the south of SHV Port was collected. The frequency table of wave height and wave direction for the whole year shows that the maximum wave height is 3.51 (m) obtained at W direction. It can also be seen that waves below 0.5 m are concentrated in SE and SSE direction, and waves over 2.0 m are concentrated in SW, WSW, and W direction.

Table 3-3 Characteristics of Global Model Waves

Database range	75 degrees north latitude to 75 degrees south latitude 0 degrees east longitude to 0 degrees west longitude
Mesh size	Longitude:0.5 degrees; Latitude: 0.5 degrees
Time interval	1 hour
Period	1951-2020
Input Data	NCEP/NCAR Reanalysis NCEP/NCAR Final analysis
Wave calculation model	Modified WAM model

Source: Regarding the reconstruction and utilization of the wave estimation database, Uto et al., Ocean Engineering Journal, 2012, Vol. 68, No. 2, p. I_977-I_982



Source: Google Earth, created by JICA Survey Team

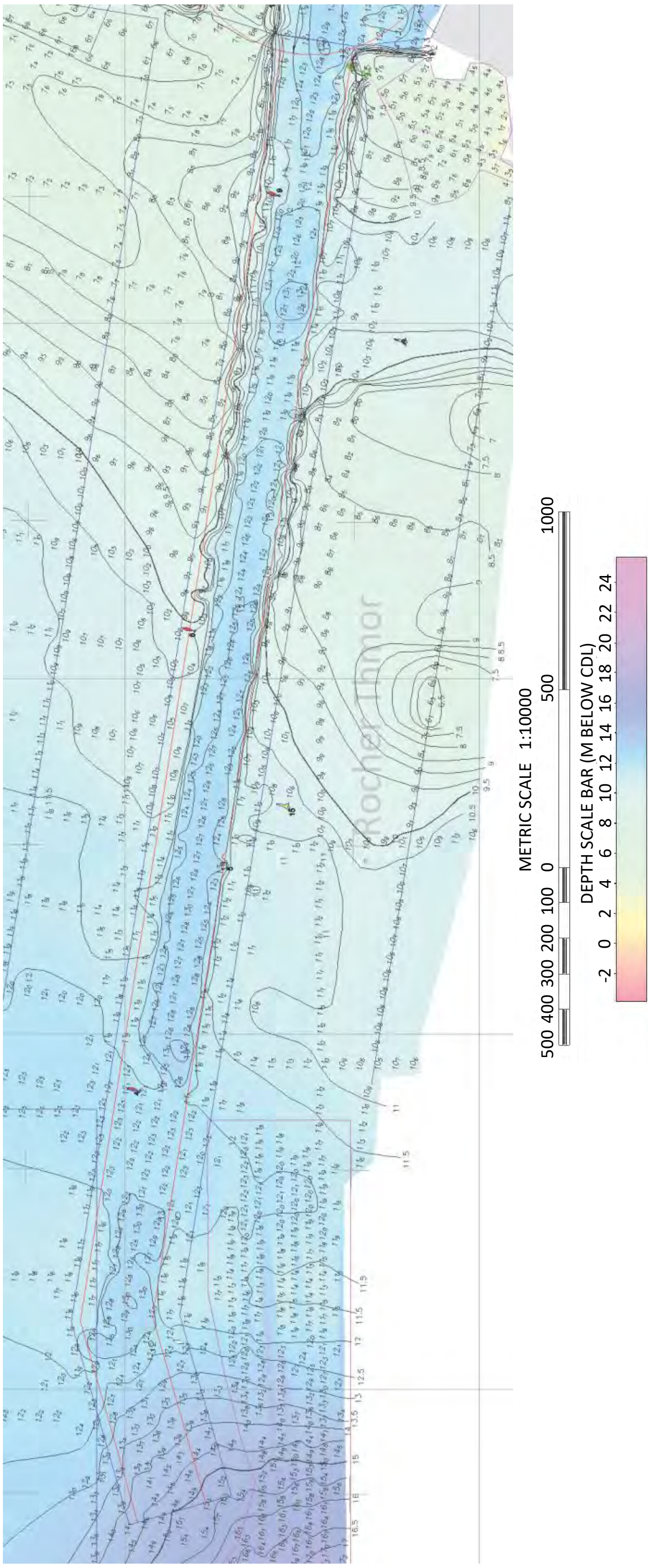
Figure 3-3 GPV Data Collection Point

3.5 Bathymetric and Seismic Survey

3.5.1 Bathymetric Survey

28. Bathymetric survey was carried out in the navigation channel, basin, planned NCT2 and NCT3 terminal sites, and the planned relocation site of the existing breakwater including the existing breakwater site.

29. The navigation channel has been dredged in the "Sihanoukville Port Multipurpose Terminal Development Project" in 2017. The average seabed elevation is about -12 m.

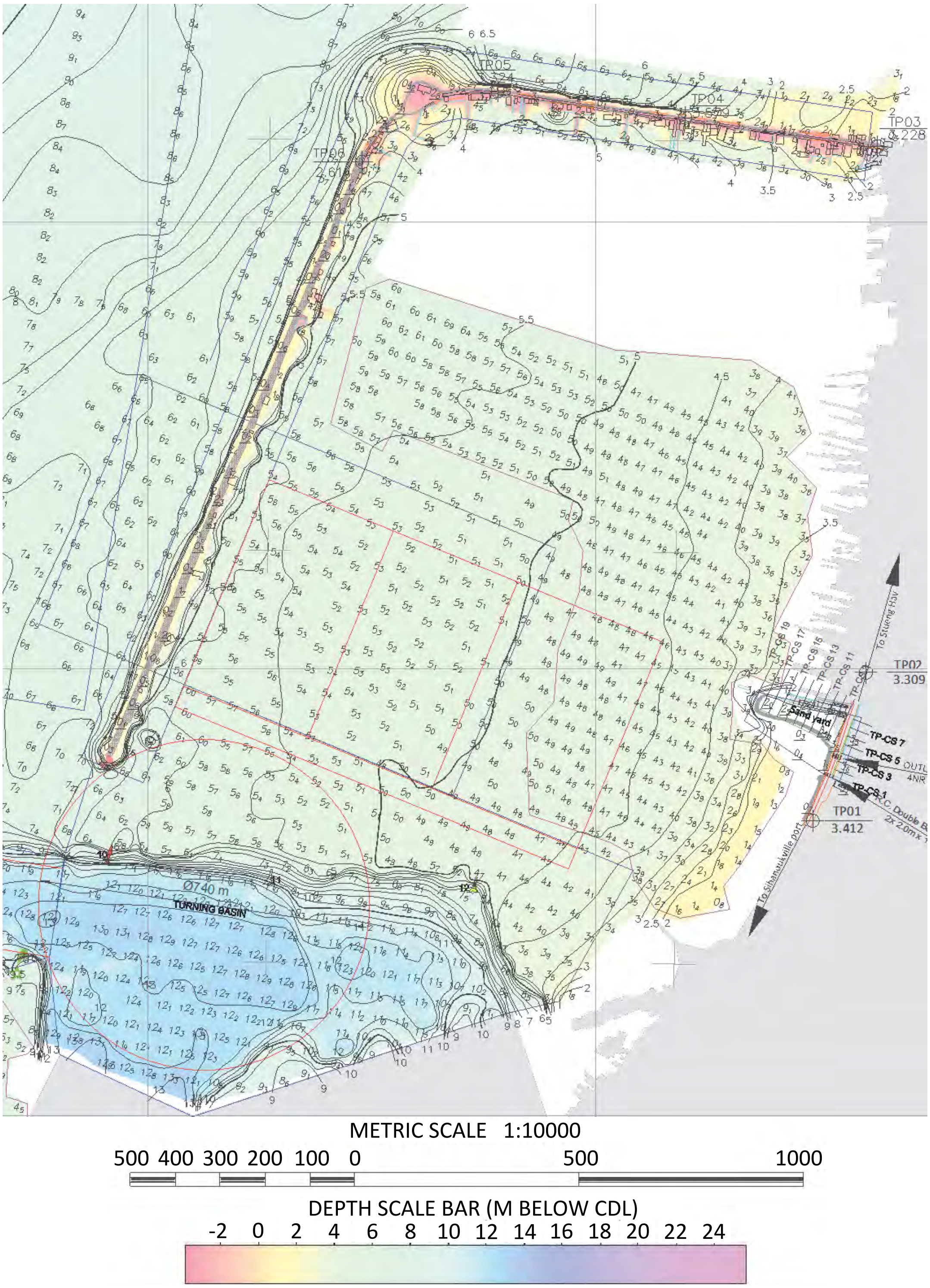


Source: JICA Survey Team

Figure 3-4 Result of Bathymetric Survey (Area A Channel)

30. In the basin, the average seabed elevation is -12 m in front of the Multi-purpose Terminal

and -10 m in front of the existing container terminal. The average seabed elevation is –5 ~ -6m in quay and reclamation areas of NCT2 and NCT3. The average top elevation of the existing breakwater is low from the attachment part to the end. The top elevation from BT-CS 19 (1+700) to the end is lower than MSL since MSL is 0.6 m.



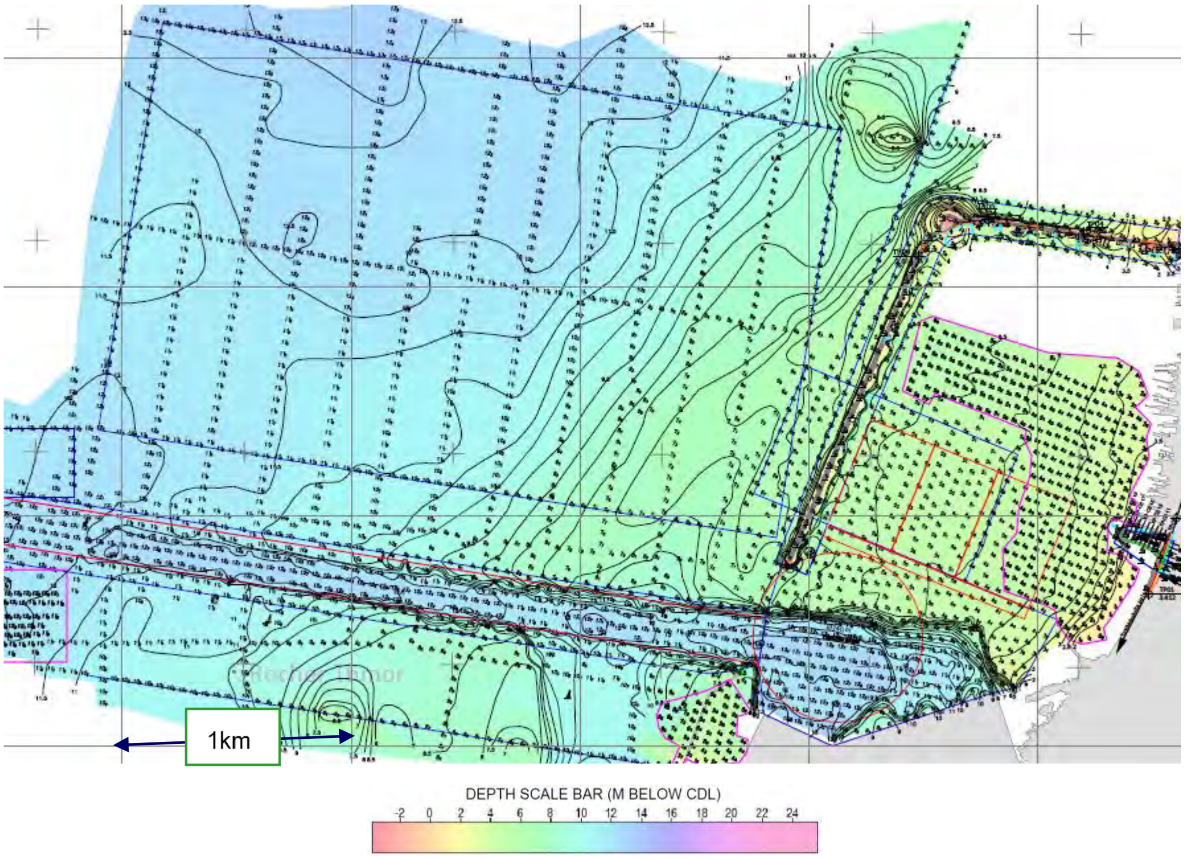
Source: JICA Survey Team

Figure 3-5 Result of Bathymetric Survey (Basin, Terminal, Breakwater)

3.5.2 Seismic Survey

31. Seismic survey was carried out for the area shown in the figure below for the purpose of grasping the water depth and distribution of rock formations in offshore waters where Long-term plans, offshore area of the west side of the existing breakwater as described in later Section 5.4, are targeted, examining suitable sites and scales such as port basin, navigation channel, breakwaters, etc., and obtaining information necessary for examining the cost of dredging and reclamation.

32. As shown in the figure, the planned offshore area for Long term plan has a gentle sea-bed slope of about 0.4% from water depth of -6 m outside the breakwater to water depth of -10m for 1km. After that, the slope is gentler and the water depth is -11m ~ -12 m at 3 km offshore area.

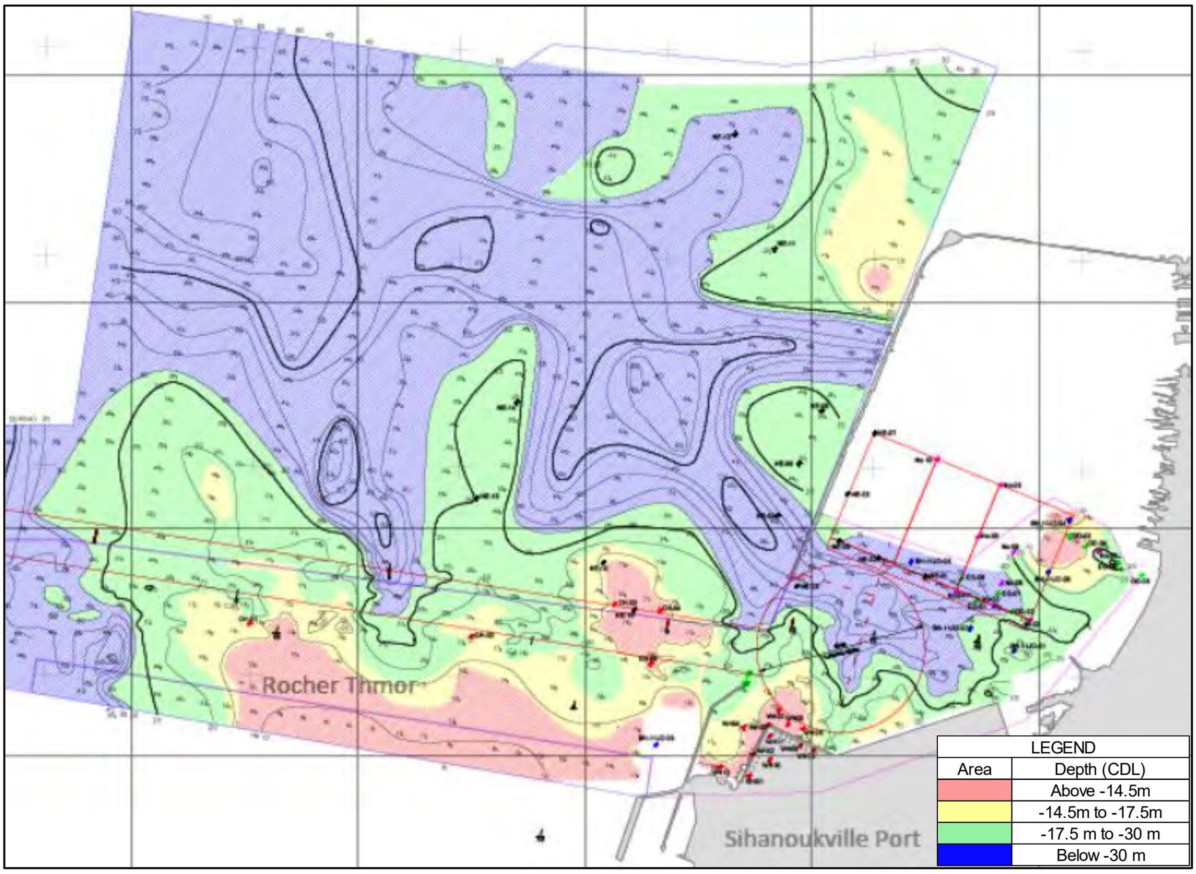


Source: JICA Survey Team

Figure 3-6 Bathymetric Survey Result in the Planned Offshore Area

33. Figure 3-7 is combined color contour map of the rock distribution, which is a bearing layer, based on the result of seismic surveys conducted in the channel and port basin area in 2012 and other outer sea area in 2021. There is a rock layer (shown in red) shallower than the planned depth of -14.5m in the area of 300 m to 800 m near the west side of the port entrance, which should be dredged. The rock area of -17.5 m is shown in beige in case of further deepening in the future. Since it is highly possible that pile-type structures will be adopted for main structures such us quays, the areas shallower than -30 m of the expected required embedment depth are shown in green in Figure 3-7. The rock layer is shallower

toward Kaoh Poah on the south side of the channel, and Rocher Thmor rock can be seen above the sea surface 500 m on the south side of the route.



Source: JICA Survey Team

Figure 3-7 Contour Map of Rock Distribution

Chapter 4 Necessity and Validity of the Project

4.1 Development Policy in the Port Sector

34. Various efforts have been made since the new Constitution was enacted in 1993 including the establishment of PAS and Phnom Penh Autonomous Port (PPAP) in 1998 as the entities in charge of the development, management and operation of the two major ports in Cambodia, i.e., SHV Port and PNP Port respectively. In addition, the Ministry of Public Works and Transport (MPWT) formulated the national port policy in 2013, and established the “General Department of Waterway and Maritime Transport, and Ports” in 2016 which has exclusive jurisdiction over ports and waterways, and is currently preparing for the enactment of the “Port Act”. The following matters will be stipulated in the Port Act: port management system such as classification of ports, definition of port managing body and harbor masters; technical standards and permission procedures for planning, construction and operation; system of port charges and port entry/exit of vessels; channel navigation safety; port security; port environment, etc.

35. On the other hand, the basic port policy of Cambodia is an “Open Sea Policy” that declares freedom of participation in the development and operation of ports. Since the basic idea of the policy is "fair competition on an equivalent basis," priority is not given to a specific port regardless of whether it is a public port or a private port, even if it is deemed necessary from the perspective of ensuring the competitiveness of the country. Therefore, there is no policy that clearly describes the demarcation of roles between SHV Port and PNP Port. In addition, many private ports have been developed since 2000s based on this policy. Although the development plans of these private ports have been approved by the government, appropriate management and administration system for these private ports has not been established.

36. Based on this background, the "Logistics Master Plan" was formulated in cooperation with JICA and the World Bank, which became the base of the "Interim Master Plan on Intermodal Transport Connectivity and Logistics System" formulated by MPWT in January 2020. After that, adding the parts of aviation and multi-modal transportation, the "Intermodal Transport Connectivity and Logistics System Master Plan" was compiled. It will be finally approved by the National Logistics Council in the near future.

4.2 Situation of the Ports in Cambodia

37. The port of SHV faces the Bay of Kompong Som of the Gulf of Thailand in south-western Cambodia. The port of PNP is located on the Mekong river. The two ports are administered by autonomous management bodies following the government ordinance: PAS and PPAP. In addition, provincial (state) governments and private companies are managing their ports which trade general goods between neighboring countries such as Thailand and Vietnam. There are also large port maintenance plans in SEZs around shorelines.

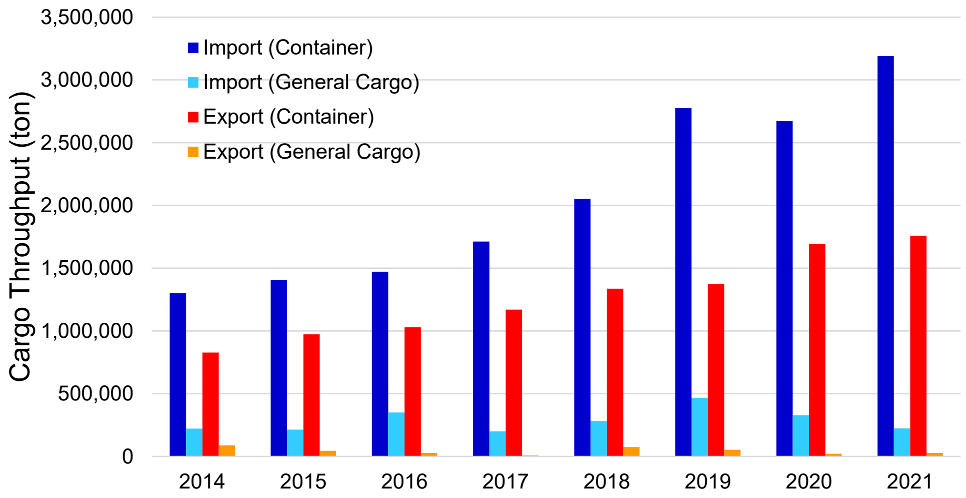
38. Cambodia currently lacks a port law for the orderly development of ports throughout the country. Ports at present are freely and arbitrarily planned by autonomous ports, state

government and private companies.

4.3 Current Situation of SHV Port and Issues

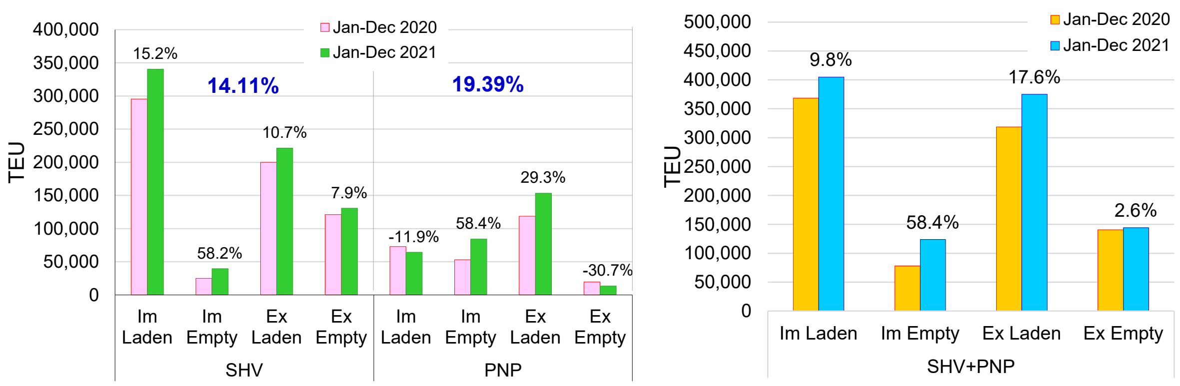
4.3.1 Situation of Cargo Handling at SHV Port

39. The cargo volume handled in SHV Port has steadily increased in the recent years. In particular, the container throughput has shown a year-on-year increase of 14% on average from 2015 to 2019 corresponding to the steady economic growth of Cambodia including the garment industry, with the highest increase of 18% being recorded in 2019. In 2020, due to the impact of COVID-19, throughput fell sharply in February but quickly recovered, and as a result, the container throughput of the year was about the same as in 2019. Container throughput in 2021 reached 732 thousand TEU increasing by 14.1% year-on-year.



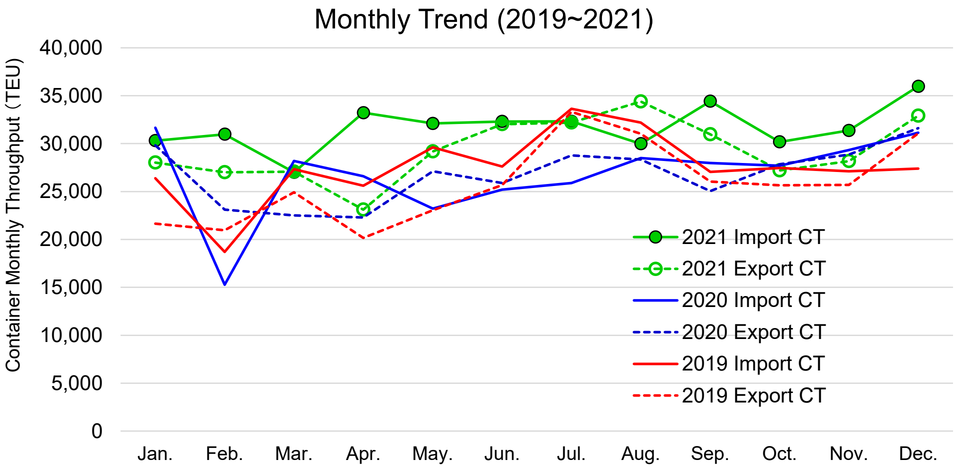
Source :PAS

Figure 4-1 Trend of Cargo Handling Volume at SHV Port



Source :PAS, PPAP

Figure 4-2 Container Throughput at SHV Port and PNP Port (2020 and 2021)



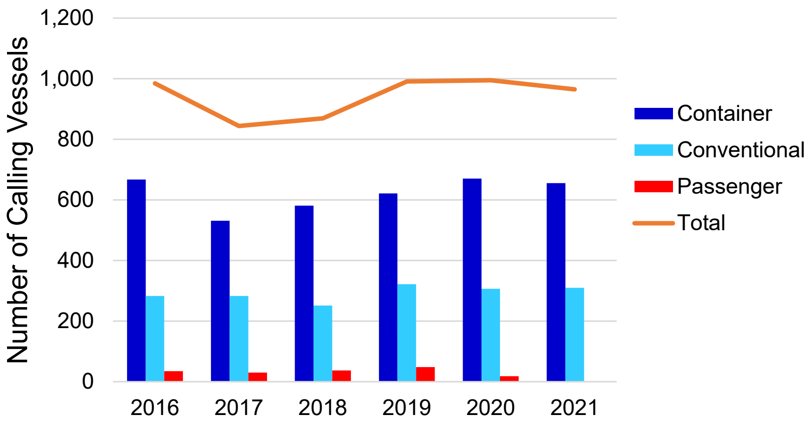
Source :PAS

Figure 4-3 Monthly Trend of Container Throughput at SHV Port

4.3.2 Situation of Calling Vessels at SHV Port

40. The situation of calling vessels at SHV Port for the last 6 years from 2016 to 2021 is shown in the table below (excluding tanker vessels). The number of vessels calling at the port is around 2.7 vessels per day, and the overall trend shows a slight increase. The number of container vessels has shown a stable increase even in 2021, and the number of TEUs per call in 2021 reached a record level of 1071 TEU/call, which indicates that the size of calling vessels is increasing.

Item		2016	2017	2018	2019	2020	2021	2021/2020
Total	Units	985	844	869	991	995	965	-3.0%
Container	Units	667	531	581	621	670	655	-2.2%
Conventional	Units	283	283	251	322	307	310	1.0%
Passenger	Units	35	30	37	48	18	0	
Calls/day (excluding Tanker)		2.7	2.3	2.4	2.7	2.7	2.6	
TEU/call (for Container Vessel)		600	866	932	1,029	958	1,118	



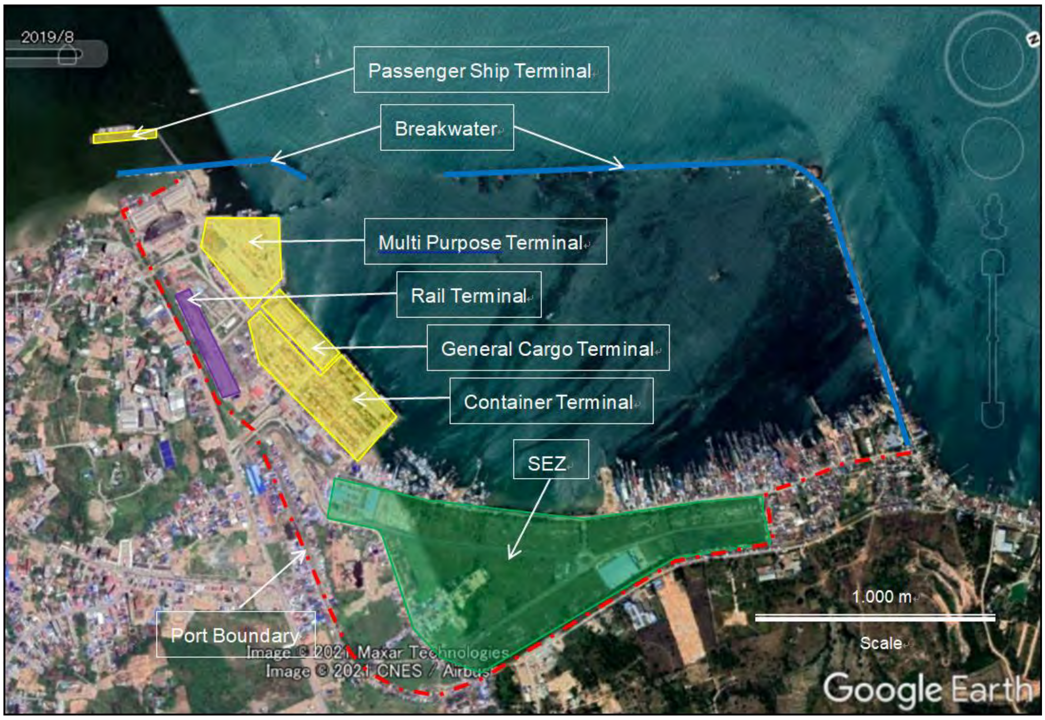
Source :PAS

Figure 4-4 Trend of Number of Ship Calls at SHV Port

4.3.3 Present Situation and Issues of Port Facilities

4.3.3 (1) Facility layout

41. The layout of the facilities in SHV Port is shown in Figure 4-5. The land area of the port is about 170 ha and the water area protected by breakwaters is about 330 ha. Other main port facilities are breakwaters, passenger ship terminal, multi-purpose terminal, general cargo terminal, container terminal, SEZ and rail terminal.



Source: JICA Survey Team (Google Earth)

Figure 4-5 Layout of Facilities in SHV Port

42. The layout of the main facilities including berth, yard and warehouse is shown in Figure 4-6.

Source: JICA Survey Team

Figure 4-6 Layout of Major Facilities in SHV Port

4.3.3 (2) Present situation of the facilities

43. Since the container terminal and the multi-purpose terminal are relatively new, having been constructed in in 2004, there are no structural problems. On the other hand, the passenger ship terminal which was constructed in the 1960s is suffering from severe deterioration (particularly the fenders).

44. Major port facilities as well as the navigational facilities are as follows:

Berthing Facility

Name of Wharf/Terminal	Berth No.	Length (m)	Depth (m)	Max. Vessel Draft (m)
Old Jetty (Outer)	No.1	290m	-9 ~ 13m	-8.5m
	No.3			-9m
	No.2	290m	-6.5 ~ 8m	-7m
	No.4			
New Wharf	No.5	350m	-9m	-8.3m
	No.6			
Container Terminal	No.7	400m	-10.5m	-9.3m
	No.8			-8.8m
Multi Purpose Terminal	No.9	330m	-13.5m	-10.5m
	No.10			
Oil Supply Base Berth	No.11	200m	-7.5m	-6.5m
	No.12			

Storage Facility

Cargo	Facility	Size (ha)	Capacity	Remarks
Container	Yard-C	7.7	2,300 GS	RTG operation
	Yard-B	2.6	800 GS	RTG operation
	Yard-A	1.8	450 GS	RS Operation
	Yard-D	1.8	600 GS	RTG operation
	Yard-A'	1.6	450 GS	RS Operation
	Yard-T	3.5	80 GS	RS Operation
	Yard-F	1.5	400 GS	RS Operation
	Yard-S (for export empty containers)	4.0	1,100 GS	RS Operation
	Reefer Container (Yard-C)	-	54 Boxes	9 Sockets
	Container Freight Station (W/H No 4)	0.6	12 000 Ton	
General Cargo	Warehouses	3.6	72 000 Ton	5 units
	Yard-E	1.8		
	Yard-M (Multi-purpose Terminal)	2.8		

** RTG: Rubber Tired Gantry Crane,*
** RS: Reach Stacker*

Navigational Facilities

Boat	HP	Units
Tugboat (TB Koh Takiev)	3,500	1
Tugboat	1,600	1
Tugboat	950	1
Tugboat	800	2
Tugboat	800	2
Pilot boat	390	1
Mooring boat	175	1
Patrol boat	210	1

Anchorage Areas

A - Southern anchorage area	10º36, 0N 103º28,5E
B - Northern anchorage area	10º39, 5N 103º29,0E
C - Anchorage area for tanker vessels	10º39, 5N103º25, 7E

45. The breakwater is a rubble mound structure constructed in the 1960s; a part of its crown is submerged due to ground settlement. In addition, illegal buildings exist along the entire length of breakwater and fish cultivation frames are installed along the breakwater (see Photo 4-1 and Photo 4-2).

Source: JICA Survey Team

Photo 4-1 Present Situation of the Existing Breakwater

Source: JICA Survey Team

Photo 4-2 Present Situation of the Bending Section of the Existing Breakwater and Buildings

4.3.3 (3) Issues at Present

46. With the increase in container handling volume in recent years, the berth window is almost full at Berth No.7 and No.8. Therefore, some container ships with small number of loading/ unloading containers moor at Berth No.6. Considering the future increase of container throughput as well as the number of ship calls, it is urgent to secure enough berth windows as soon as possible.

47. Recently, two vessels with a length of 170 m and over have been simultaneously berthing which means the quay crane cannot reach all the container bays of the ship due to the shortage of container crane rail length. In these cases, the vessel is forced to change the berthing direction or to shift the mooring position during berthing, or Mobile Harbor Crane (MHC) is used to handle containers which cannot be reached by container crane. These irregular operations reduce the berth productivity and increase the berth occupancy ratio (BOR), which reduces the possibility of new shipping services calling at SHV Port.

48. On the other hand, the container storage yard has been expanded since 2019, however, there would be a shortage in the near future considering the recent growth in container throughput. Therefore, additional container storage yard should be efficiently developed in the near future to secure sufficient yard capacity to cope with the future demand.

49. Issues related to the facility structures are as described in (2) above. A part of the breakwater needs to be demolished in order to keep the access way for the boat mooring inside, due to the new container terminal expansion project and further long-term expansion of the terminal.

4.3.4 Access Situation

4.3.4 (1) Road Access

50. The SHV Port is an important international logistics gateway connecting with the Capital city, PNP, by National Road No.4 (NR4) which is the most important logistics route connecting PNP and SHV. NR4 is also a main highway that supports people's access to the coastal area of SHV, which is a tourist destination.

51. NR4 has a total length of about 220 km linking local city centers, SEZs, airports which are located between PNP and SHV. Road widening plan into 4 lanes (2 lanes x 2 directions) has not been completed in all sections; most sections are still 2 lanes (1 lane x 2 directions). However, in some sections, road widening and/or improvement work has been conducted.

52. On the other hand, the traffic flow of logistics and people going to tourist destinations in SHV has been increasing in recent years. Due to this situation, the burden of traffic on NR4 becomes heavy and which is reaching the road traffic capacity. As described in above, road widening and/or improvement work on NR4 are being partially implemented by MPWT. However, fundamental road improvement such as increasing number of lanes on the whole NR4 has not been progressed, and according to MPWT, such improvement work schedule has not been prepared. In SHV surrounding area, road development works have been carried out according to the development of PNP-SHV Expressway. Particularly, the NH4 from the gate of the Expressway toward SHV Port with the distance of 5.5km has been 6-lane (3 lanes x 2 directions) road, and the remaining section up to SHV Port with the

distance of 3.2km has been repaired as the 4-lane (2 lanes x 2 directions) road. Since the houses and buildings beside this 3.2km section has been set backed, it will be upgraded to the 6-lanes road in the future, while MPWT says it has not the plan yet.

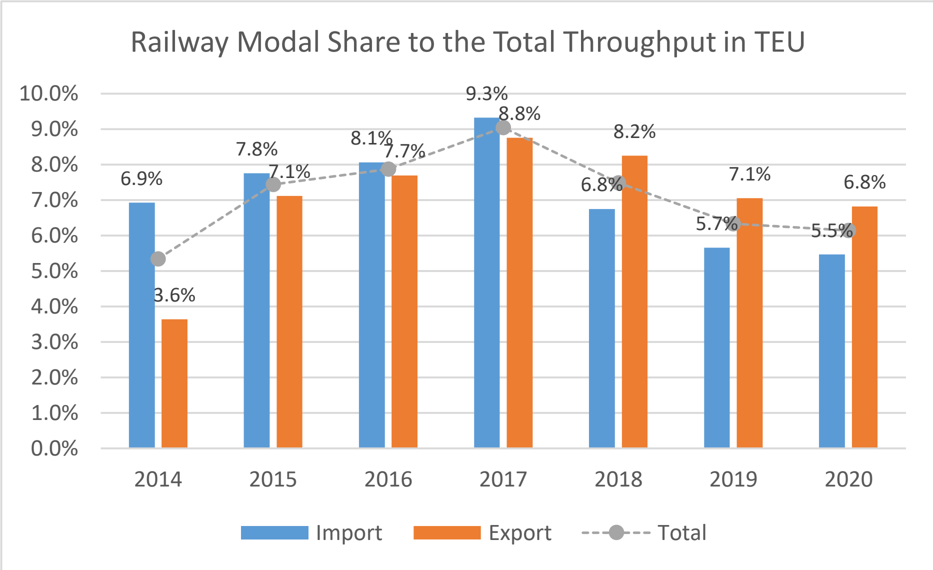
53. In response to such an increase of traffic flow, the PNP-SHV Expressway is being developed. It is expected to be an effective measure against the increase in traffic demand between PNP and SHV.

54. In addition, as related road improvement of Road-146b and Road-148, which are connected to the IC of PNP-SHV Expressway, are being developed by MPWT. The details of the road construction will be verified whether it is acceptable for the traffic volume generated after the construction of the new container terminal, and an appropriate access road plan will be proposed as necessary.

Source :Google Earth、Created by JICA Survey Team

4.3.4 (2) Railway Access

55. PNP-SHV Railway connects SHV Port to PNP with the distance of 264km. The container train service between the port and PNP started in 2014 and is operating every day. Figure 4-7 shows the trend of railway modal share in the total container handling volume at SHV port.



Source : JICA Survey Team

Figure 4-7 Trend of Railway Modal Share of the Containerized Cargo

4.4 Analysis of Seaborne Trades (Containers, General Cargoes and Bulk)

4.4.1 Container Trades Related to SHV and Indochinese Ports

4.4.1 (1) Linkage to the East-West Truck Line

56. The East-West trunk line for container trades is the world busiest navigation route from WCNA (West Coast of North America), across the Pacific Ocean through Asia to Europe, then across the Atlantic Ocean to ECNA (East Coast of North America). Figure 4-8 shows the geographical position of the Indochinese ports on the East-West trunk line. Located right in the center of this trunk line, Indochinese ports have the potential like Singapore to function as a pivot of the east-bound and west-bound navigation routes.

Source: JICA Survey Team

Figure 4-8 Geographical Position of Indochinese Ports on the East-West Trunk Line

57. However, among the Indochinese ports, both Laem Chabang(LCB) Port and SHV Port have a geographical handicap that they are remotely set back from the trunk line. The deviating distance from the trunk line is 731 nautical miles for a round trip; a vessel takes 1.7 days when steaming at 18 knots.

Source: JICA Survey Team

Figure 4-9 Set-back Location from the Trunk Line

58. From the shipping line's viewpoint, it is difficult to incorporate such a setback port in the middle of calling rotation. This is because the transit time to the next port will become longer by the amount of deviation. For example, in the original rotation from Singapore to Cai Mep(CMP), if an additional port call is made to LCB and the rotation is changed to Singapore →LCB→CMP, the arrival of CMP will be delayed by 1.7 days. This leads to an increase in the inventory cost of the goods for 1.7 days, which is an unacceptable service deterioration for the cargo owner.

59. To solve the problem above and maintain the service quality, a shipping line may consider that such a setback port should be allocated as the last discharging port and the first loading port. Moreover, the transit time could be further shortened if the discharging rotation and loading rotation are assigned to the different service routes. In case of LCB Port, some "pendulum services" have been created by several alliances in recent years based on this idea.

60. Currently, 4 pendulum services for Europe (or ECNA)/Asia/WCNA with LCB as the pivot port are in operation by different alliances as follows. In either case, LCB Port is so allocated as the last of discharging port of the eastbound and the first loading port of the westbound.

1. M Alliance: AE6 (Euro/Asia/USWC pendulum service) (max. size: 19,200 TEU)

Pusan-Ningbo-Shanghai-Yantian-TanjungPelepas-Sines-Antwerp-LeHavre-Felixstowe-Algeciras-Singapore-**Laem Chabang**-Nansha-Yantian-Ningbo-Shanghai-Long Beach-Oakland-Pusan

2. The Alliance: FP2 (Euro/Asia/USWC pendulum service) (max. size: 14,220 TEU)

Laem Chabang-VungTau-Singapore-Colombo-Rotterdam-Hamburg-Antwerp-Southampton-Jeddah-Singapore-**Laem Chabang**-Vung Tau-Hong Kong-Yantian-Long Beach-Oakland-Yokohama-Hong Kong-**Laem Chabang**

3. Ocean Alliance: PE1 (USEC/Asia/USWC pendulum service) (max. size: 14,414 TEU)

Yantian-Vung Tau-Singapore-Port Klang-Colombo-Halifax-New York/New Jersey-Norfolk-Savannah-Charleston-Port Klang-Singapore-**Laem Chabang**-Vung Tau-Yantian-Los Angeles-Oakland-Yantian

4. Cosco: AACI (S Asia/E Asia/USWC pendulum service) (max. size: 10,060 TEU)

Laem Chabang-Haiphong-Shanghai-Ningbo-Long Beach-Seattle-Lianyungang-Shanghai-Ningbo-Shekou-Nansha-Singapore

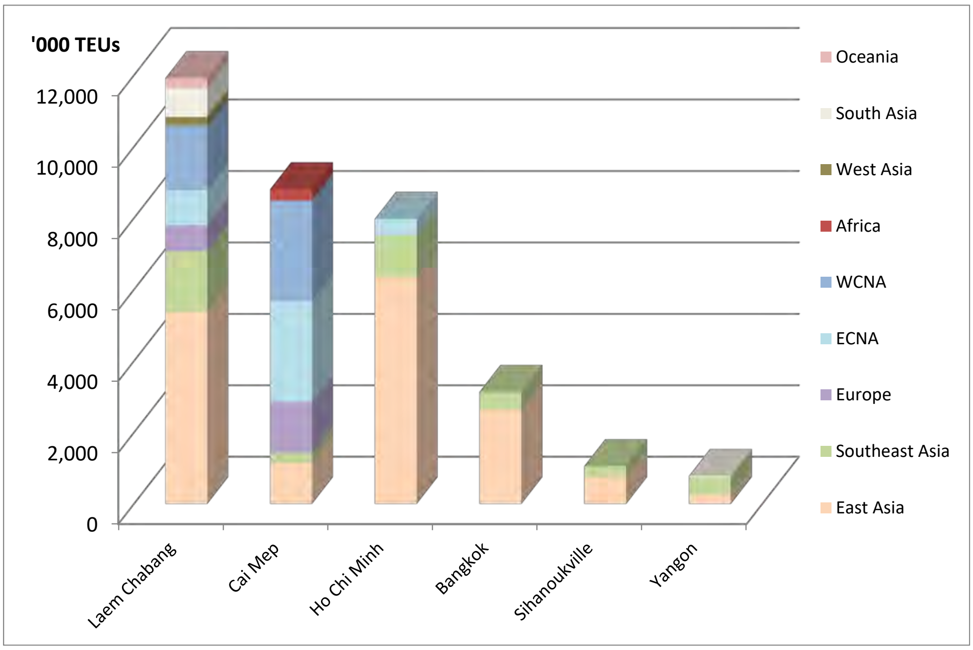
61. When shipping lines were managing their service routes independently, they operated East-West trunk line by separating it into partial trade sections such as Asia/Europe, Asia/WCNA, Europe/ECNA, etc. As those shipping lines have been organized under the major alliances in recent years, it has become possible for them to integrate multiple sections into one service route in a pendulum shape with deploying larger container vessels.

4.4.1 (2) Container Services Calling at Indochinese Ports

62. Annual TEU capacities deployed for major Indochinese ports (LCB, CMP, Ho Chi Minh, Bangkok, Yangon and SHV) are shown in Figure 4-10. Annual TEU capacity is calculated by multiplying the average vessel size of each service by the number of port calls per year.

63. Of the 6 major ports, LCB Port has the largest TEU capacity and most diversified trade routes. CMP Port has the 2nd largest capacity which mainly consists of deep-sea trade routes such as ECNA, WCNA and Europe, and, unlike LCB, rather few Intra-Asia trade routes. As CMP Port is located right on the East-West trunk line, it is advantageous to attract larger vessels than LCB Port is, and there is a role sharing with Ho Chi Minh Port, which is mainly for Intra-Asia trades.

64. Just like Ho Chi Minh Port, Bangkok Port, SHV Port and Yangon Port are mainly served by Intra-Asia trades (including feeders with neighboring hub ports).



Source: Prepared by JICA Survey Team based on MDS data base as of August 2020

Figure 4-10 Yearly TEU Capacity Deployed for 6 Major Indochinese Ports by Trade

4.4.1 (3) Container Services Calling at SHV Port

65. Table 4-1 shows the container services of shipping lines calling at SHV Port. Currently, the services are limited to Intra-Asia trade connecting China, Japan, South Korea and Taiwan, and feeders which shuttle between SHV and Singapore or Tanjung Pelepas. Since there are no Deep-sea services such as Europe, WCNA or ECNA. At this moment, the cargoes

bound for those destinations are transshipped to the mainline vessels at nearby hub ports such as Singapore, Tanjung Pelepas, CMP, and Hong Kong.

Table 4-1 Container Services Calling at SHV Port (as of August 2020)

Operator/service name	Slot charterer	Rotation of ports	Service frequency p.a.	Nos of ships deployed	Fleet capacity (TEU)	Average size (TEU)	Maximum size (TEU)	Annual capacity (TEU)
CNC LINE/GOLD STAR/TS LINES - CVC	ZIM	Shanghai/Ningbo/Nansha/Shekou/HongKong/Da Nang /Sihanoukville/Ho Chi Minh /Shekou/Shanghai	52	3	5,300	1,767	1,800	91,867
COSCO - RBC2	CNC Line	Ningbo/Shanghai/Shekou/Sihanoukville/Bangkok/Laem Chabang/Ningbo	52	3	5,288	1,763	1,900	91,659
EVERGREEN - CVT	CNC Line /Interasia	HongKong/Nansha/Shekou/Ho Chi Minh/Sihanoukville/Laem Chabang/HongKong /HaiPhong/Qinzhou/Zhanjiang/HongKong	52	3	5,952	1,984	1,984	103,168
INTERASIA/WAN HAI /YANG MING - CVK	Evergreen	Ningbo/Shanghai/Xiamen/Da Nang/Ho Chi Minh /Sihanoukville/Ho Chi Minh/HongKong/Ningbo	52	3	4,973	1,658	1,805	86,199
QUANZHOU AN SHENG SHPP - CVK		Nansha/Dongguan/Sihanoukville/Ho Chi Minh /Qinzhou/Yangpu/Nansha	52	2	1,396	698	698	36,296
RCL - RSK	Heung-A/ONE	HongKong/Keelung/Taichung/Dongguan/HongKong/Sihanoukville /Songkhla/HaiPhong/HongKong	52	3	1,884	628	628	32,656
SEALAND - IA18	Maersk	Kaohsiung/Taichung/Yentian/HongKong/Sihanoukville/Laem Chabang/Ho Chi Minh/Batangas/Manila/Xiamen/Kaohsiung /HongKong/HaiPhong/Yentian/HongKong /Cebu/Kaohsiung	52	5	5,538	1,108	1,118	57,595
SEALAND - IA88	Maersk	Incheon/Guangyang/Hibiki/Busan/Hakata/Moji/Busan/Shanghai /Ningbo/Ho Chi Minh/Sihanoukville/Laem Chabang/HaiPhong /Xiamen/Shanghai/Incheon	52	5	8,700	1,740	1,740	90,480
SITC - VTX1	COSCO/Hasco	Osaka/Kobe/Busan/Shanghai/HongKong/Ho Chi Minh /Sihanoukville/Bangkok/Laem Chabang/Ho Chi Minh/Ningbo /Shanghai/Osaka	52	6	10,800	1,800	1,800	93,600
WAN HAI - CTK		HongKong/Nansha/Shekou/Sihanoukville/Laem Chabang/ Sihanoukville/HongKong	52	2	2,878	1,439	1,510	74,828
East Asia total	**Nos of services**	**10**	**520**	**35**	**52,709**	**1,506**	**1,984**	**758,347**
SAMUDERA - CES	Advance Cont	Singapore/Sihanoukville/Singapore	52	1	2,181	2,181	2,181	113,412
RCL - RCX	Gold Star	Singapore/Sihanoukville/Singapore	52	1	1,850	1,850	1,850	96,200
SEALAND - CAM FEEDER	Maersk	Tanjung Pelepas/Singapore/Sihanoukville/Tanjung Pelepas	52	1	1,700	1,700	1,700	88,400
Southeast Asia total	**Nos of services**	**3**	**156**	**3**	**5,731**	**1,910**	**2,181**	**298,012**
Total	**Nos of services**	**13**	**676**	**38**	**58,440**	**1,538**	**2,181**	**1,056,359**

Source: Prepared by JICA Survey Team based on MDS data base as of August 2020

4.4.2 Transport Cost and Time in Land Transport

66. When a container is exported from the industrial area near PNP city, there will be the choices of 5 gateway ports; PNP, SHV, CMP, Ho Chi Minh and LCB. The choices of transportation modes will be truck, rail and barge. Geographical locations of the 5 ports and available transportation modes are shown in Figure 4-11 below. Among the transportation modes, railway to SHV Port is currently used only for empty containers or some heavy weight containers. The barge transportation on the Mekong River is not arranged by cargo owners but by shipping lines as mentioned above.

Source: JICA Survey Team

Figure 4-11 Location of Phnom Penh and 5 Gateway Ports with Transportation Modes

67. JICA Survey Team assigned a local logistics consultant to conduct a survey to collect information on inland transportation costs and transit times between selected 13 points in Cambodia and 5 gateway ports (i.e., SHV Port, PNP Port, LCB Port, Ho Chi Minh Port and CMP Port)

68. The results of the survey show that the cost of land transportation to/from the domestic ports, i.e., PNP Port and SHV Port is cheaper than the that of three neighboring ports, i.e., LCB Port, Ho Chi Minh Port / CMP Port, from any points in Cambodia except from the border cities such as Babette and Poipet.

4.4.3 Ocean Freight Rates for Containers

69. JICA Survey Team also conduct a survey to collect information on the ocean freight rates and transit times between selected 9 ports in the world (i.e., Tokyo, Shanghai, JNPT (Jawaharlal Nehru Port), Jebel Ali, Rotterdam, Los Angeles, Sao Paulo, Sydney and Durban) and 5 gateway ports. The survey was conducted in January 2021 when the physical distributions were disrupted around the world due to COVID-19. Therefore, it should be noted that the overall freight rates are considerably higher than usual.

70. It is found that the freight rates of SHV Port and PNP Port are higher for imports and lower for exports than those at the 3 neighboring ports (Ho Chi Minh Port, CMP Port, and LCB Port), which reflects the current global situation of empty container shortage due to the impact of the COVID-19 pandemic, and consequently a demand for container supply from Cambodian ports which have ample container inventory. Similar results were obtained in the survey before COVID-19, i.e., in the “Study on Strengthening Competitiveness and Development of SHV Port” in 2011. This is because Cambodian ports have a relatively small capacity of calling vessel for the cargo volume, or the variation of shipping services is less than that of the neighboring ports, and this implies that the structure of shipping patterns has basically not changed since 2011.

4.4.4 Impact of COVID-19 on the Ocean Freight Rates

71. Currently many transport infrastructures in the world cannot keep up with the rapid recovery of the traffic demand, which causes logistics disruptions and surges of ocean freight rates in a global scale. The empty container shortage is making the situation worse. It is uncertain when the situation will return to normal. According to Shanghai Shipping Exchange, China Containerized Freight Index (CCFI) for WCNA began to rise in June 2020 when the 1st wave of the infection was over, and the factories reopened. Due to the increase started again from May 2021, it has reached 4 times of that before COVID-19. CCFI for Europe trade began to rise late in November 2020, but it has risen sharply since then, and is now 5 times higher than that before COVID-19.

4.4.5 Traffic Volume shares between Phnom Penh Industrial Area and 5 Gateway Ports

72. JICA Survey Team assigned a local logistics consultant to conduct a survey to estimate the traffic volume shares between PNP industrial area and 5 gateway ports (i.e., SHV Port, PNP Port, LCB Port, Ho Chi Minh Port and CMP Port) for export and import respectively. The results are shown in the tables below. In terms of exports, the share of the neighboring countries' ports, i.e., Ho Chi Minh port, CMP Port and LCB Port, is extremely small. This reflects the result of the survey in the previous section, that is, the land transportation cost to/from SHV Port/PNP Port is lower than that of the neighboring countries' ports. In fact, exports rarely use the neighboring countries' ports except in an emergency. On the other hand, it shows that there are a certain amount of imports using Ho Chi Minh port or CMP Port which are relatively close to PNP.

Table 4-2 Traffic Volume Shares between Phnom Penh Industrial Area and 5 Gateway Ports

Inland route shares to/from gateway ports (exports/imports)

To/From Gateway Port →		PNH Port		SHV Port		HCM Port (Cat Lai)		HCM Port (Cai Mep)		Laem Chabang Port		Total	
From/To cargo origin/destination ↓		TEUs /year	Share (%)	TEUs /year	Share (%)	TEUs /year	Share (%)	TEUs /year	Share (%)	TEUs /year	Share (%)	TEUs /year	Share (%)
Phnom Penh Industrial Area (PP SEZ or PNH dry port)	Export	900	20%	3,313	72%	166	4%	166	4%	50	1%	4,595	100%
	Import	227	22%	588	58%	100	10%	100	10%	0	0%	1,015	100%

Source: JICA Survey Team

4.4.6 Simulation on the Extra Calling of Mainline Vessels at SHV Port

4.4.6 (1) Scenarios for the Extra Calling of Mainline Vessels at SHV Port

73. Following 4 scenarios are assumed based on the tendency of vessel deployment by shipping lines as stated in the previous sections.

4.4.6 (1) a Scenario 1

74. This is the case of extra calling at SHV as the last discharging port after LCB on a return leg from Europe, or as the first loading port before LCB on an eastbound leg for WCNA, just like the pendulum services

Source: JICA Survey Team

Figure 4-12 Scenario 1 for Extra Calling

4.4.6 (1) b Scenario 2

75. Similarly to Scenario 1, it is assumed that SHV will be called as the last discharging port or the first loading port, but by an extended navigation from CMP instead of LCB. Since CMP isn’t setback from the East-West trunk line, vessels tend to call at CMP in the middle of rotation. Therefore, it is considered that the probability is lower than in Scenario 1.

Source: JICA Survey Team

Figure 4-13 Scenario 2 for Extra Calling

4.4.6 (1) c Scenario 3

76. This is the case of extra calling at SHV in between LCB and CMP. Since the transit time of export cargoes loaded in LCB becomes longer, measures to attract Thai shippers would be necessary by discounting the freight rates. However, export cargoes from LCB are much larger in volume than those from SHV and include many time-sensitive cargoes such as auto assembly parts and garments. In the real seaborne container trades, many shippers of such urgent cargoes may switch to other container services with shorter transit times rather than enjoy a slight reduction in freight rates, as it would be more serious for such time-sensitive shippers to lose the opportunity to sell their products in the market. This will lead to a significant drop in the cargo volume to be loaded at LCB. Consequently, the probability is considered lower than in Scenario 2, as shipping line’s profitability will be much

deteriorated in this scenario.

Source: JICA Survey Team

Figure 4-14 Scenario 3 for Extra Calling

4.4.6 (1) d Scenario 4

77. In the case of the Scenario 1, it is assumed that SHV Port is called at after Singapore on a return leg from Europe, and would be the first loading port before LCB and/or CMP on an eastbound leg for WCNA.

Source: JICA Survey Team

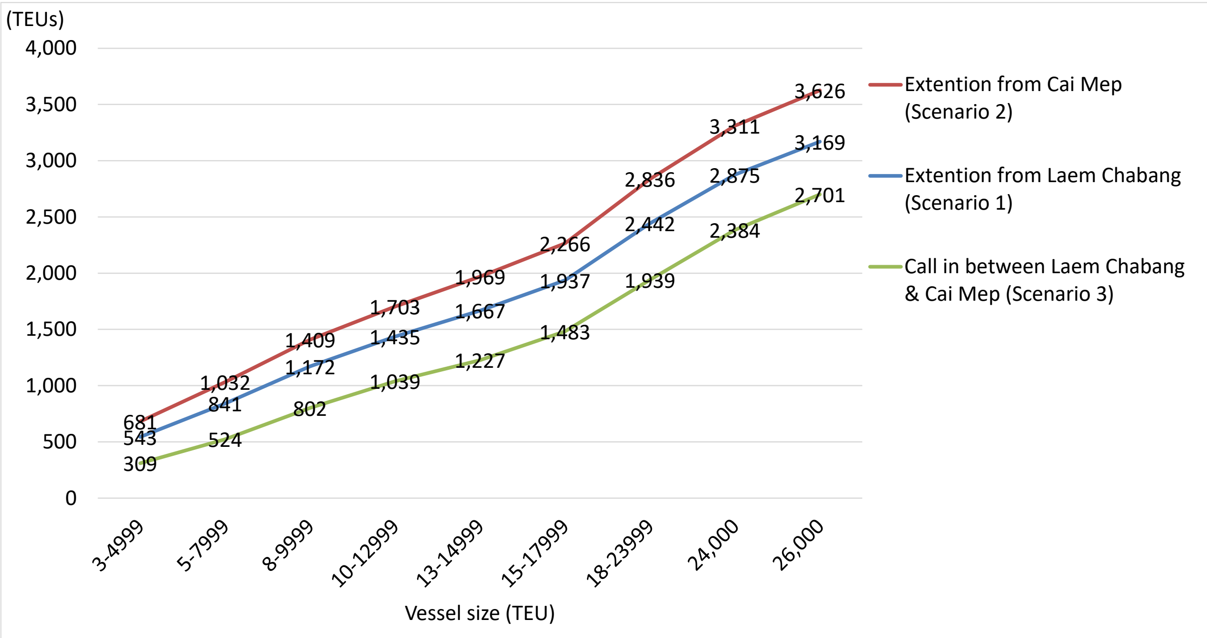
Figure 4-15 Scenario 4 for Extra Calling

4.4.6 (2) Evaluation of Possibility on the Extra Calling of Mainline Vessels at SHV Port

78. When a shipping line considers an additional call at the port that is not in the current rotation in its service, the shipping line may compare the additional cost required for that port call with the additional revenue obtained from it. If the additional revenue per call is expected to exceed the additional cost, the decision will be made to call at that port. (the revenue here is equal to "net profit" that is a residual by deducting the costs attributed to the cargoes such as empty container repositioning cost, agency commission for sales promotion, overhead administration cost, etc.) The additional cost consists of the port charges and the vessel operating cost for the deviation from the original navigation route and the stay at the port. However, the stevedoring cost of the container at the port is not included in the additional cost here, because the shipping line will reimburse the stevedoring cost fully from the

shipper/consignee in the form of "terminal handling charge".

79. The minimum laden TEUs required for an additional port call can be calculated by dividing the total additional cost per call by the net profit rate per TEU (USD 150/TEU is assumed here regardless of trade route). Figure 4-16 shows the minimum laden TEUs by ship size. The TEU value shown here represents the total laden containers of both imports and exports. Empty containers shall not be considered.



Source: JICA Survey Team

Figure 4-16 Minimum laden TEUs required for an additional call (by scenario, vessel size)

4.5 Demand Forecast of Container Cargo

80. The flow of demand forecast is shown below. At first, the preconditions for the demand forecast were set and the analysis was carried out using the macro-economic model and the micro-economic model. Then, the results were compared and evaluated.

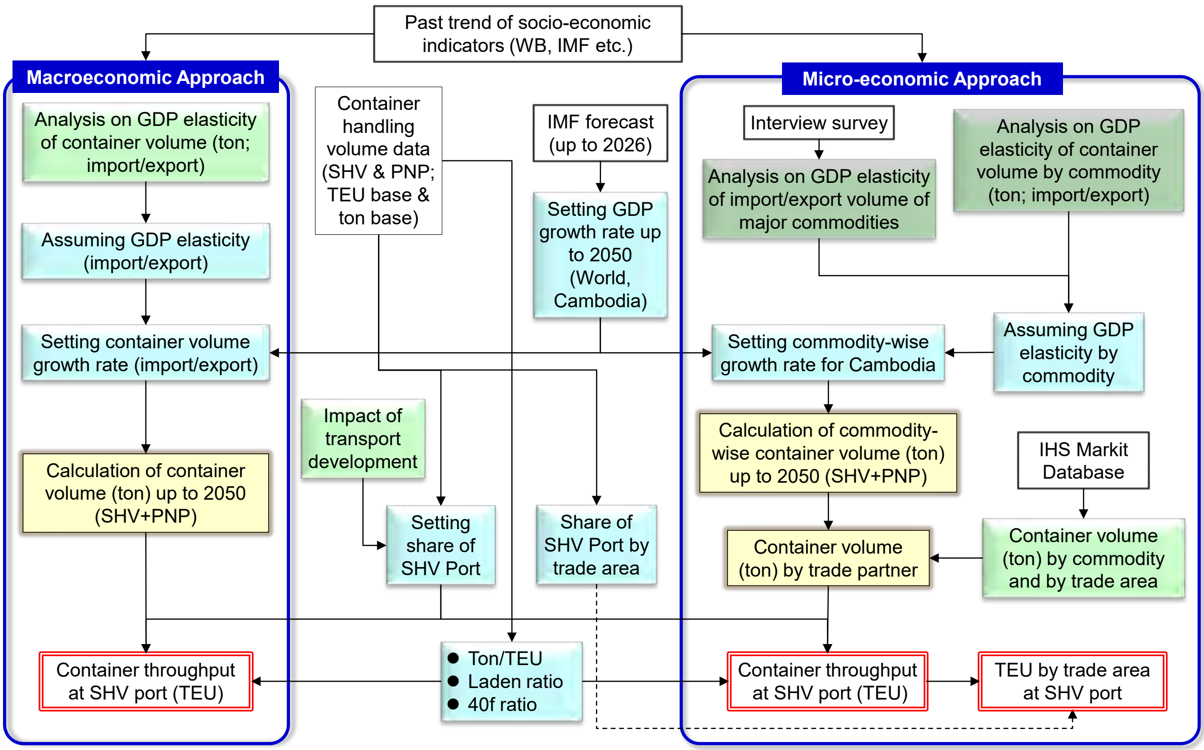


Figure 4-17 Flow of Demand Forecast

81. In the macroeconomic forecast, after setting three growth scenarios (high growth, stable growth, and low growth), future container cargo demand is estimated in consideration of the correlation between the real GDP (Cambodia and the world) and the container handling volume at SHV Port and PNP Port. In addition, the impact of the commencement of the expressway between SHV and PNP as well as the impact of the expansion of the shipping network to/from North America and/or Europe.

82. In the forecast by the microeconomic approach, based on the analysis on the past cargo trends by commodity and by trade partner area, the future container cargo by commodity as well as by trade partner are predicted. In addition, based on the evaluation of the total volume with the estimation result by the macroeconomic model, the container volumes by trade partner are estimated using the macroeconomic forecast value as the control total.

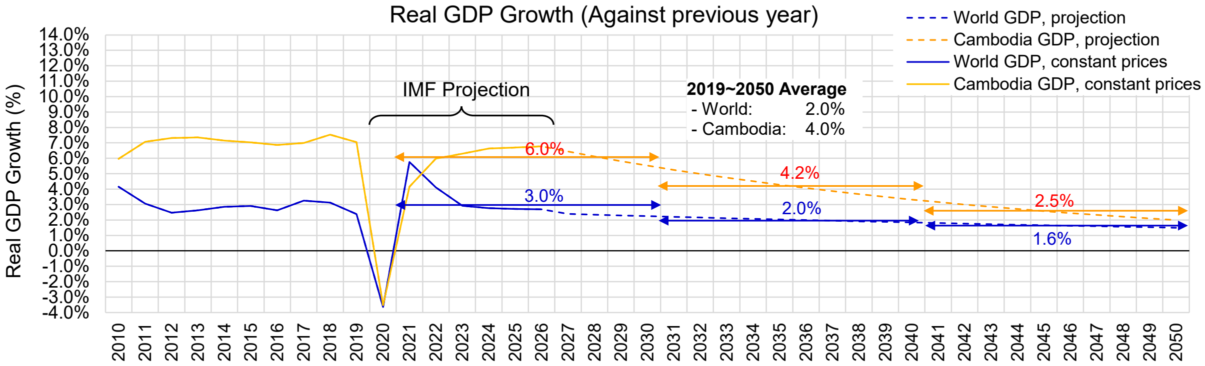
4.5.1 Preconditions for Demand Forecast

4.5.1 (1) Assumption of Real GDP Growth Rates in Future

83. Regarding the past trend of socio-economic indicators, World Bank Development Indicators is used, while as for Real GDP growth rates from 2021 to 2026, the prediction provided by International Monetary Fund (IMF, as of April 2021) is used. In 2020, due to the COVID-19 pandemic, the world's real GDP growth rate was -3.642% while Cambodia's was -3.532%. It is also noted that the average annual growth rate from 2019 to 2026 is 4.65% for Cambodia while 2.44% for the world based on IMF's data.

84. As for the future Real GDP growth rates of Cambodia will be based on the IMF's forecast until 2026, and then gradually decreases to 2.0% in 2050. According to this assumption, the

average growth rate from 2019 to 2050 is calculated as 4.0%. As for the world Real GDP growth rates, it is also assumed to gradually decrease in the long term and is set as 1.5% in 2050 which is 1% down from the average growth rate from 2019 to 2026 (2.44%). According to this assumption, the average growth rate of the world from 2019 to 2050 is calculated as 2.0%.



Source :IMF

Figure 4-18 Real GDP Growth (against previous year) in Future

4.5.1 (2) Laden Container Volume (TEU) and Cargo Volume (ton)

85. As for the container cargo volume (ton) to/from Cambodia, the total of SHV and PNP Port data is used. As the tonnage of import and export at SHV Port and PNP Port were obtained after 2011, the tonnage before 2010 were extrapolated up to 2003 using the TEU growth rate during the period.

4.5.1 (3) Ton/TEU for Laden Container

86. The past trend of ton/TEU for laden container in each port are shown below. Future figures of ton/TEU are set by applying the average value over the past 10 years. (SHV: 9 ton/TEU for import, 8 ton/TEU for export)

Table 4-3 Container Cargo Weight per TEU '(ton/TEU)

	Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Ave.
Import (ton/TEU)	SHV	8.87	8.64	8.33	8.51	8.42	8.43	8.28	8.25	8.87	9.03	8.6
	PNP	12.16	12.80	13.68	14.51	15.79	15.93	16.23	16.23	16.41	15.59	14.9
Export (ton/TEU)	SHV	7.09	7.57	8.28	8.02	8.01	7.94	7.90	7.71	7.65	8.46	7.9
	PNP	5.92	5.88	6.54	6.44	6.67	6.22	6.52	5.78	5.18	4.97	6.0

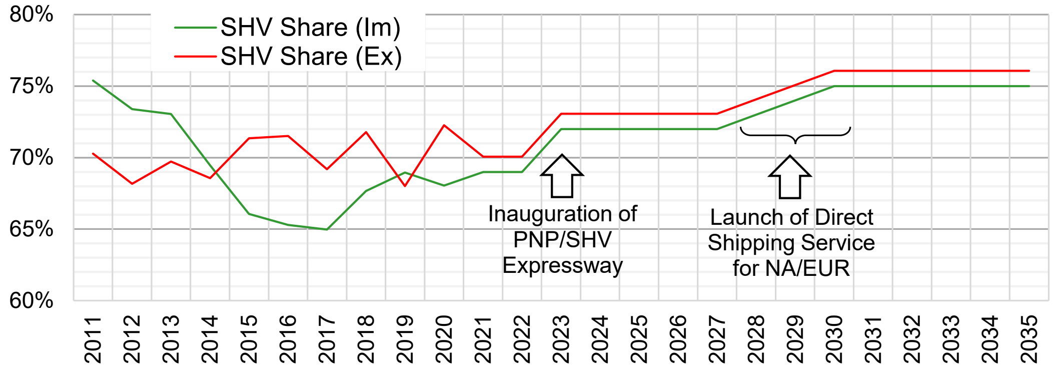
Source: PAS and PPAP

4.5.1 (4) Assumption of Container Cargo Handling Share of SHV Port

87. The future container cargo handling share of SHV Port (to the total of SHV and PNP Port) is set taking into consideration the past trend of the share since 2011 and the impact of the development of expressways between PNP and SHV (scheduled to be completed on September of 2022,information as of August of 2021) as well as the launch of shipping services to/from Europe (EUR) and North America (NA) at SHV port.

88. The expressway will enhance the appeal of SHV Port. According to the logit model based on transportation time and cost, which will be separately prepared for economic analysis, it

is expected that the share of SHV Port will increase at least by 3% after the launch of the expressway. In addition, the attractiveness of SHV Port will also increase with the launch of the direct shipping services to/from EUR/NA. According to the logit model, it is expected to increase by 3 to 4%. Based on this analysis, the future share of SHV Port is assumed as follows: the past average share will be applied from 2021 to 2023, then after the opening of the expressway, the share will increase by 3%, and it will increase again from 2029 to 2030 by 3%.



Source :PAS and JICA Survey Team

Figure 4-19 Assumption of Container Cargo Handling Share of SHV Port

4.5.2 Demand Forecast by Macroeconomic Approach

4.5.2 (1) Method of Forecast

89. Based on the past data of container handling volume (tons) in Cambodia, which is the summation of SHV and PNP Port, the trend of the relation to the socio-economic indicators of Cambodia as well as that of the world are analyzed, then, the future growth rate and volumes (tons) of container cargoes are estimated for import and export. Future import and export container cargo weight of SHV and PNP Port are calculated assuming future shares of SHV Port.

90. The total volume (TEU) of the laden containers at each port is estimated using average tonnage per TEU (ton/TEU) and the laden container ratio by import/export. The laden container ratio of either import or export is adjusted so that the yearly TEU of import and export is the same at each port, but not exceed 95%.

Table 4-4 Calculation Method of Container Cargo Throughput

Calculation Formula

	A	B	C	D	E	F	G	H	K
	GDP Growth Ratio	GDP Elasticity	Container Growth Ratio	Prior Year Handling Volume	Handling Volume	Unit Weight	Handling Volume	Laden Container Ratio	Total Handling Volume
Unit	%	-	%	ton	ton	ton/TEU	TEU	%	TEU
Import	-	-	1+A×B	-	C×D		E/F	SHV: 95% (Max) PNP: G/(K/2)	SHV: G(Import)/H×2 PNP: G(Export)/H×2
Export	-	-	1+A×B	-	C×D		E/F	SHV: G/(K/2) PNP: 95% (Max)	

Source :JICA Survey Team

4.5.2 (2) Forecast Result by the Macroeconomic Approach

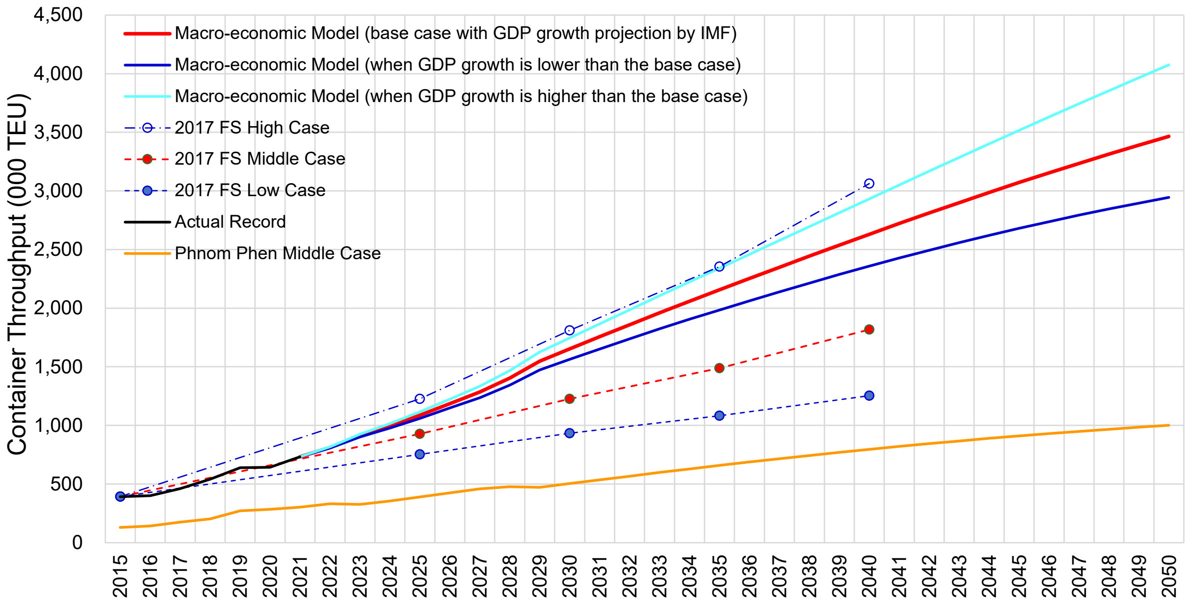
91. The real GDP growth rate shown in Figure 4-18 is set as the middle growth scenario while the low and high growth scenarios adopt a growth rate that is minus 0.5% or plus 0.5% of the middle growth scenario, respectively.

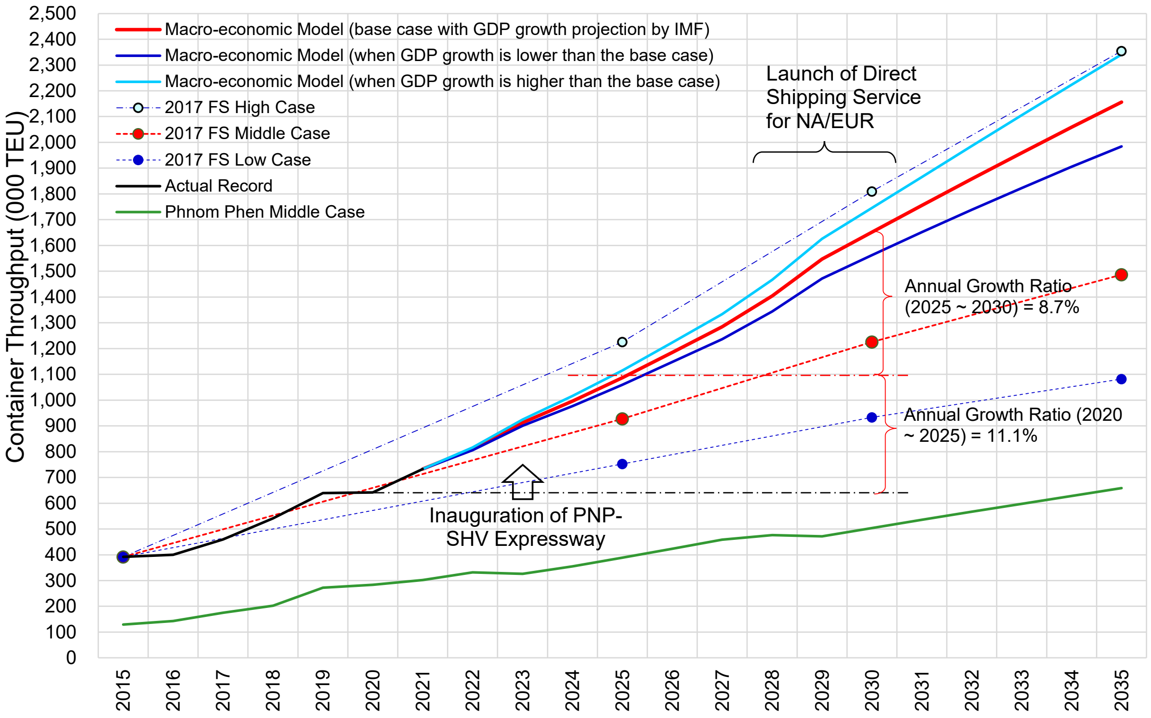
Table 4-5 Container Throughput Forecast for SHV Port and & PNP Port (Middle Case) (Macroeconomic Approach)

Year	SHV(TEU)							PNP(TEU)						
	Import			Export			Total	Import			Export			Total
	Full	Empty	Total	Full	Empty	Total		Full	Empty	Total	Full	Empty	Total	
2015	167,125	28,729	195,854	121,463	74,502	195,965	391,819	45,751	13,005	58,756	58,756	11,731	70,487	129,243
2020	295,631	25,011	320,642	200,058	121,142	321,200	641,842	80,456	58,041	138,497	131,366	20,994	152,360	290,857
2025	516,342	27,176	543,518	375,161	168,356	543,518	1,087,036	121,028	73,298	194,325	184,609	9,716	194,325	388,651
2030	784,599	41,295	825,894	569,404	256,490	825,894	1,651,788	157,634	94,186	251,819	239,228	12,591	251,819	503,639
2035	1,024,064	53,898	1,077,962	744,281	333,681	1,077,962	2,155,924	205,744	123,414	329,159	312,701	16,458	329,159	658,317
2040	1,249,390	65,757	1,315,147	899,739	415,408	1,315,147	2,630,294	251,015	146,895	397,910	378,014	19,895	397,910	795,820
2045	1,458,785	76,778	1,535,563	1,028,789	506,773	1,535,563	3,071,125	293,084	161,898	454,982	432,233	22,749	454,982	909,965
2050	1,645,772	86,620	1,732,391	1,130,812	601,579	1,732,391	3,464,782	330,652	169,451	500,102	475,097	25,005	500,102	1,000,204

Year	SHV+PNP						Total (TEU)		
	Import			Export					
	Full	Empty	Total	Full	Empty	Total	Full	Empty	Total
2015	212,876	41,734	254,610	180,219	86,233	266,452	393,095	127,967	521,062
2020	376,087	83,052	459,139	331,424	142,136	473,560	707,511	225,188	932,699
2025	637,370	100,473	737,843	559,771	178,073	737,843	1,197,140	278,546	1,475,687
2030	942,233	135,480	1,077,713	808,633	269,081	1,077,713	1,750,865	404,561	2,155,426
2035	1,229,808	177,312	1,407,121	1,056,982	350,139	1,407,121	2,286,790	527,451	2,814,241
2040	1,500,404	212,653	1,713,057	1,277,753	435,304	1,713,057	2,778,158	647,956	3,426,114
2045	1,751,869	238,677	1,990,545	1,461,023	529,522	1,990,545	3,212,891	768,199	3,981,090
2050	1,976,423	256,070	2,232,493	1,605,909	626,584	2,232,493	3,582,332	882,654	4,464,986

Source: PAS and PPAP





Source：JICA Survey Team

Figure 4-20 Container Throughput Forecast for SHV Port and & PNP Port (Macroeconomic Approach)

4.5.3 Demand Forecast by Micro-economic Approach

92. In the micro-economic approach, the future volume is predicted from the relationship between the statistical data of major trading items and economic indicators. Then, we analyze the ratio of each major commodity in the five trade routes. Based on that ratio, the container handling volume by area of the world is estimated.

93. In the PAS and PNP Port statistical data, the commodity of container cargo is classified as follows.

【SHV Port】

- Import
  (1) Fabric, (2) Garment, (3) General Cargo (Machinery, General Cargo and Others)
- Export
  (1) Rice, (2) Garment, (3) General Cargo

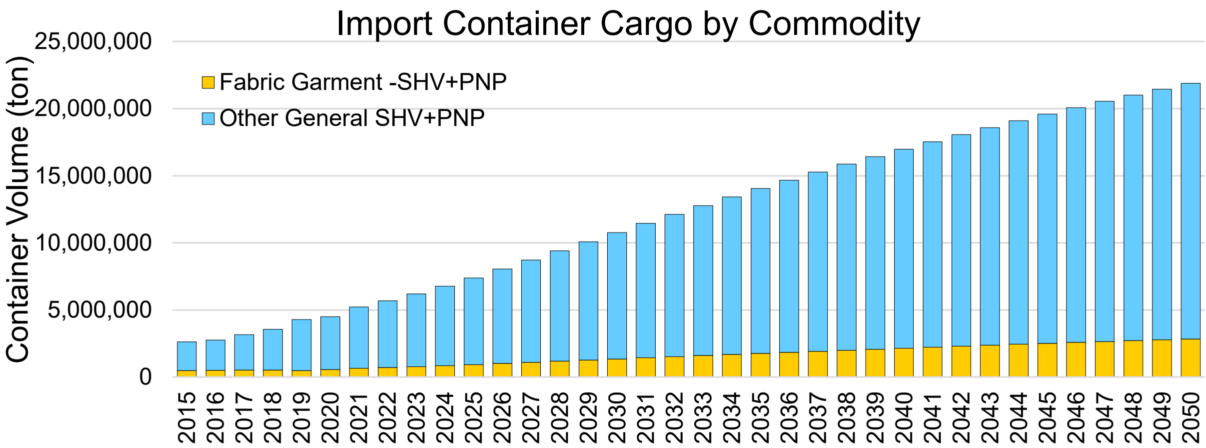
【PNP Port】

- Import
  (1) Garment, (2) General Cargo (Construction Material, Household Goods, Food & Beverage and Others)
- Export
  (1) Garment, (2) Rice, (3) General Cargo

94. Since the classification method of commodities differs between SHV Port and PNP Port, the following classifications is used in the analysis.

- Import
  (1) Garment, (2) General Cargo
- Export
  (1) Garment, (2) Rice, (3) General Cargo

95. Summary of the estimated import container cargo volume (summation of SHV Port and PNP Port) by commodity are shown below.



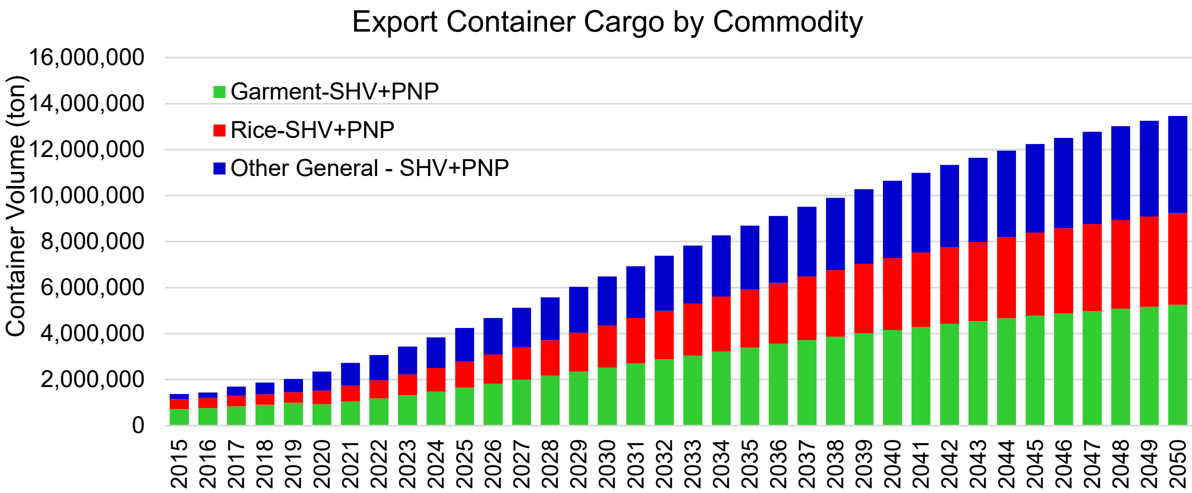
000 ton

	2025	2030	2035	2040	2045	2050
Garment & Fabric	928	1,354	1,767	2,155	2,517	2,839
General Cargo	6,456	9,418	12,292	14,829	17,075	19,056
TOTAL	7,384	10,771	14,059	16,984	19,592	21,896

Source :JICA Survey Team

Figure 4-21 Estimates of Import Container Cargo by Commodity

96. Summary of the estimated export container cargo volume (summation of SHV Port and PNP Port) by commodity are shown below.



Source :JICA Survey Team

Figure 4-22 Export Container Cargo by Item (SHV Port and PNP Port)

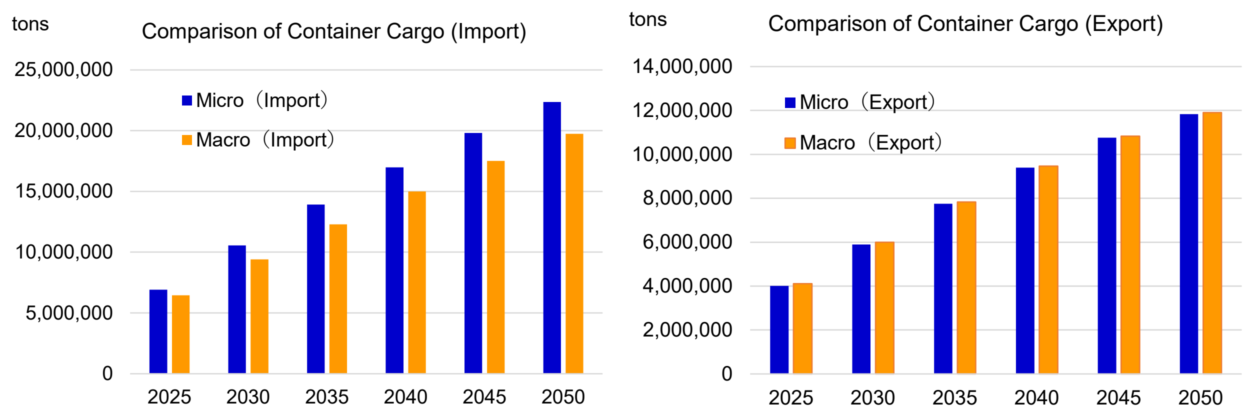
4.5.4 Comparison of MACRO and MICRO Forecasts

97. Comparing the forecast results by the macroeconomic approach and those by the micro-economic approach, the estimated container volume of import/export (Cambodia total; SHV Port and PNP Port) in micro-economic approach is about 10% higher than that in the macroeconomic approach. In general, the projection by the micro-economic approach tends to fluctuate compared to the projection by the macroeconomic approach. Therefore, the estimate by the macroeconomic approach is adopted as the possible future demand. Regarding the future demand by trade area, the forecast by the micro-economic approach is modified using the projection by the macroeconomic approach as the control total.

Table 4-6 Comparison of Demand Forecast by Macro-economic Model and Micro-economic Model (Ton base)

ton

	2025	2030	2035	2040	2045	2050
Micro（Import）	6,915,947	10,560,203	13,913,974	16,975,480	19,820,530	22,361,126
Micro（Export）	4,005,235	5,896,995	7,752,243	9,398,778	10,759,823	11,829,828
Micro（Total）	11,627,229	17,251,083	22,751,113	27,629,934	31,829,928	35,362,105
Macro（Import）	6,454,274	9,415,190	12,288,767	14,992,677	17,505,414	19,749,258
Macro（Export）	4,111,358	5,993,730	7,834,540	9,470,935	10,829,362	11,903,286
Macro（Total）	10,565,632	15,408,920	20,123,307	24,463,612	28,334,776	31,652,544



Source: JICA Survey Team

Figure 4-23 Comparison of Import Container volume（Macro and Micro）

98. Demand forecast in TEU base by micro-economic model is shown below, which is calculated in the same way in the macro-economic model.

Table 4-7 Container Demand Forecast in TEU Base (Micro-economic Model)

Year	SHV(TEU)							PNP(TEU)						
	Import			Export			Total	Import			Export			Total
	Full	Empty	Total	Full	Empty	Total		Full	Empty	Total	Full	Empty	Total	
2025	553,276	29,120	582,396	365,478	216,918	582,396	1,164,791	129,685	59,625	189,309	179,844	9,465	189,309	378,619
2030	880,017	46,317	926,334	560,214	366,119	926,334	1,852,667	176,804	70,951	247,755	235,367	12,388	247,755	495,510
2035	1,159,498	61,026	1,220,524	736,463	484,061	1,220,524	2,441,048	232,954	92,747	325,701	309,416	16,285	325,701	651,402
2040	1,414,623	74,454	1,489,077	892,884	596,193	1,489,077	2,978,154	284,212	110,667	394,878	375,134	19,744	394,878	789,756
2045	1,651,711	86,932	1,738,643	1,022,183	716,460	1,738,643	3,477,286	331,845	120,216	452,061	429,458	22,603	452,061	904,122
2050	1,863,427	98,075	1,961,502	1,123,834	837,669	1,961,502	3,923,005	374,381	122,635	497,016	472,165	24,851	497,016	994,032

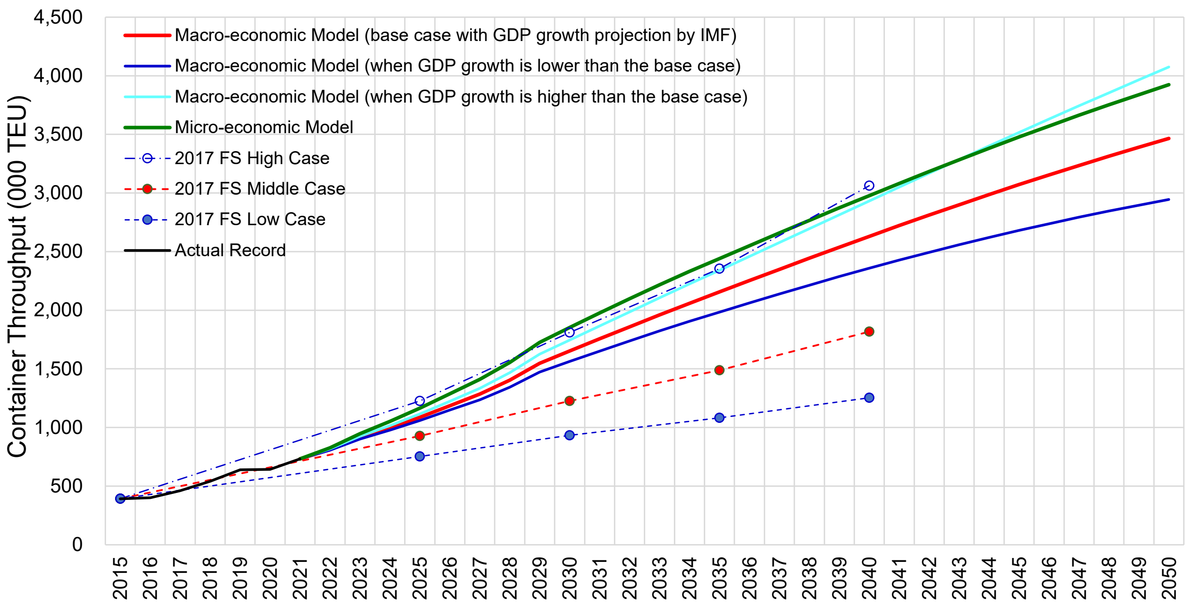
Year	SHV+PNP						Total (TEU)		
	Import			Export					
	Full	Empty	Total	Full	Empty	Total	Full	Empty	Total
2025	682,961	88,744	771,705	545,322	226,383	771,705	1,228,282	315,128	1,543,410
2030	1,056,821	117,268	1,174,089	795,582	378,507	1,174,089	1,852,403	495,775	2,348,177
2035	1,392,452	153,773	1,546,225	1,045,879	500,346	1,546,225	2,438,331	654,119	3,092,450
2040	1,698,835	185,120	1,883,955	1,268,018	615,937	1,883,955	2,966,853	801,058	3,767,911
2045	1,983,556	207,148	2,190,704	1,451,641	739,063	2,190,704	3,435,197	946,211	4,381,408
2050	2,237,808	220,710	2,458,518	1,595,999	862,519	2,458,518	3,833,807	1,083,230	4,917,036

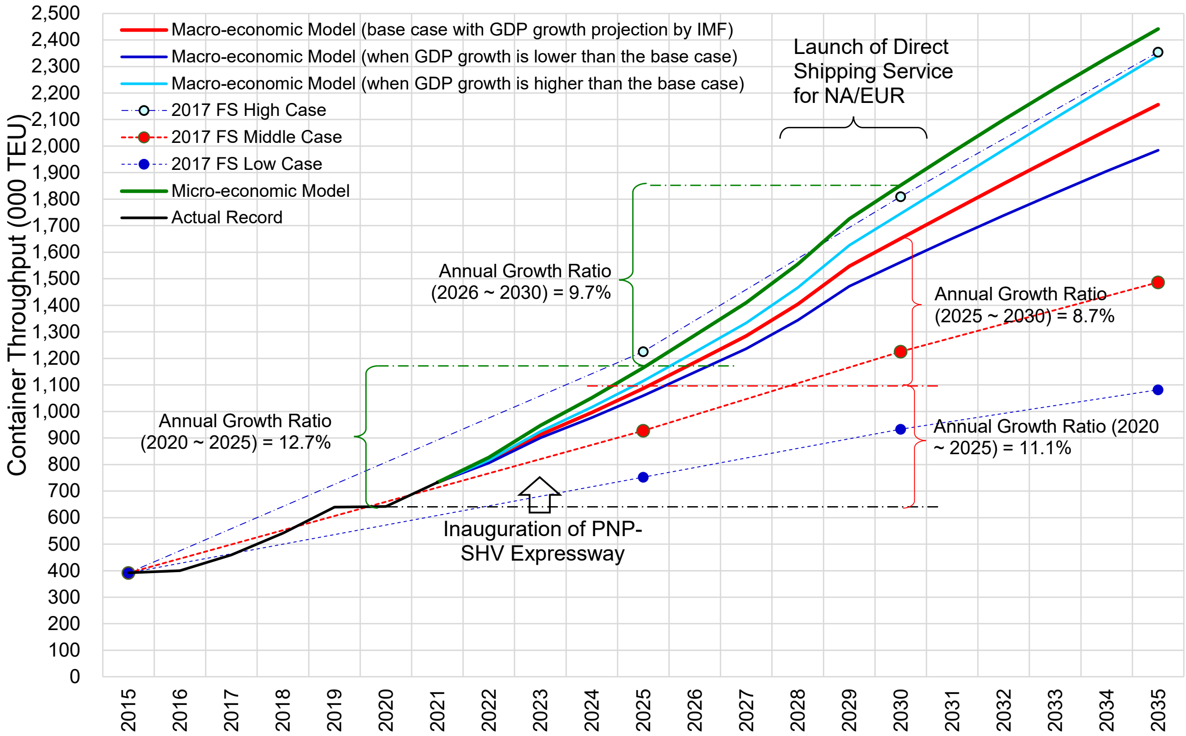
99. Table and figure below show the comparison of the demand forecast result between the macro-economic model and micro-economic model. In the long term, the demand increasing ratio forecasted by micro-economic model would be slow down rather than that by macro-economic model.

Table 4-8 Comparison of Demand Forecast by Macro-economic Model and Micro-economic Model (TEU base)

TEU

	2025	2030	2035	2040	2045	2050
Micro(Total)	1,164,791	1,852,667	2,441,048	2,978,154	3,477,286	3,923,005
Macro(Total)	1,087,036	1,651,788	2,155,924	2,630,294	3,071,125	3,464,782





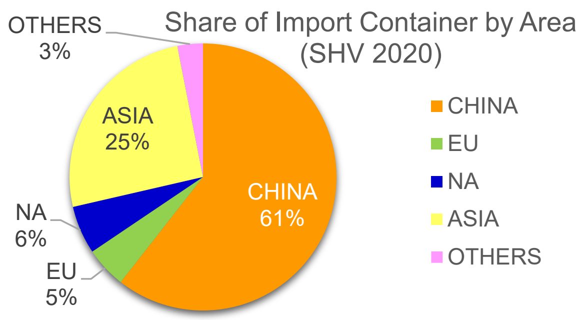
Source: JICA Survey Team

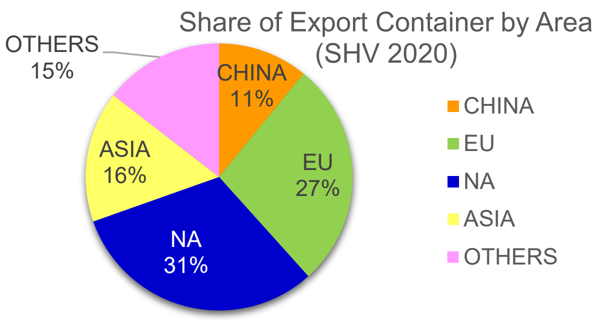
Figure 4-24 Summary of Container Demand Forecast for SHV Port

4.5.5 Container Cargo by Trade Area

100. Using the container demand forecast (tons) by commodity in the micro-economic approach, and assuming the share of the trade area by import/export commodity, the import/export container cargo volume by trade area is estimated. (Trade areas are classified 5 areas; China, Asia other than China, Europe, North America, and other regions.) Then, assuming the share of SHV Port in each trade area, the import/export container volume handled at SHV Port is estimated.

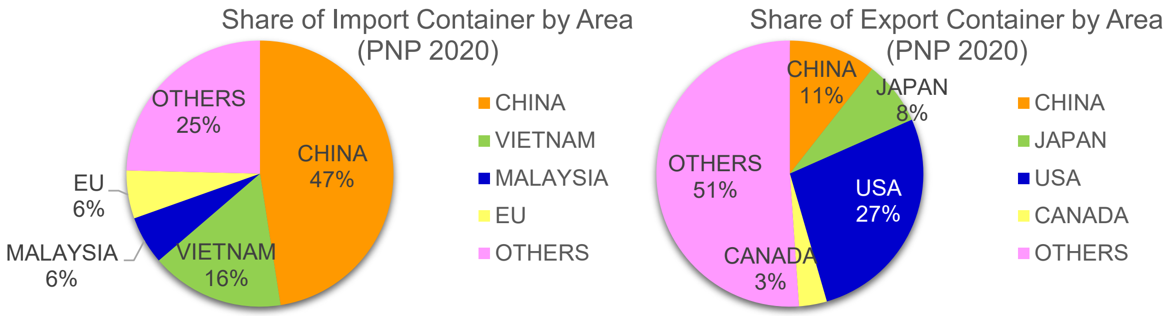
101. The share of each trade area for import/export is set with reference to IHS data including past records from 2011 to 2020 and forecasts from 2021 to 2035. The share of SHV Port in each trade area is set as the share which is calculated by the record of import/export container cargo volume by region in 2020 in each port (SHV Port, PNP Port).





Source: PAS, PPAP.

Figure 4-25 Share of Container Cargo by Area (SHV Port)



Source: PAS, PPAP.

Figure 4-26 Share of Container Cargo by Area (PNP Port)

102. As the summary of the analysis, the container volume (TEU) by trade area is shown in the table below.

Table 4-9 Estimated Container Volume (TEU) by Trade Area
(SHV Total, Upper: Laden, Lower: Laden + Empty)

Year	Asia (Exc. China)	China	EUR	NA	Others	Total
2025	298,034	214,825	172,387	116,311	89,946	891,503
2030	454,745	323,800	264,422	178,400	132,636	1,354,004
2035	598,811	413,979	348,877	236,382	170,296	1,768,345
2040	729,004	504,472	423,270	285,660	206,722	2,149,129
2045	847,214	587,855	485,815	328,516	238,173	2,487,574
2050	950,393	661,708	536,005	364,279	264,200	2,776,584

Year	Asia (Exc. China)	China	EUR	NA	Others	Total
2025	342,022	233,658	241,265	153,557	116,534	1,087,036
2030	520,737	352,063	370,119	235,387	173,481	1,651,788
2035	683,747	450,444	487,073	310,840	223,820	2,155,924
2040	834,109	549,291	595,720	377,796	273,378	2,630,294
2045	973,863	641,223	696,274	440,419	319,346	3,071,125
2050	1,098,684	723,385	785,691	496,707	360,315	3,464,782

Source: JICA Survey Team

4.5.6 Possible Time to Realize Direct Shipping Services to/from NA/EUR

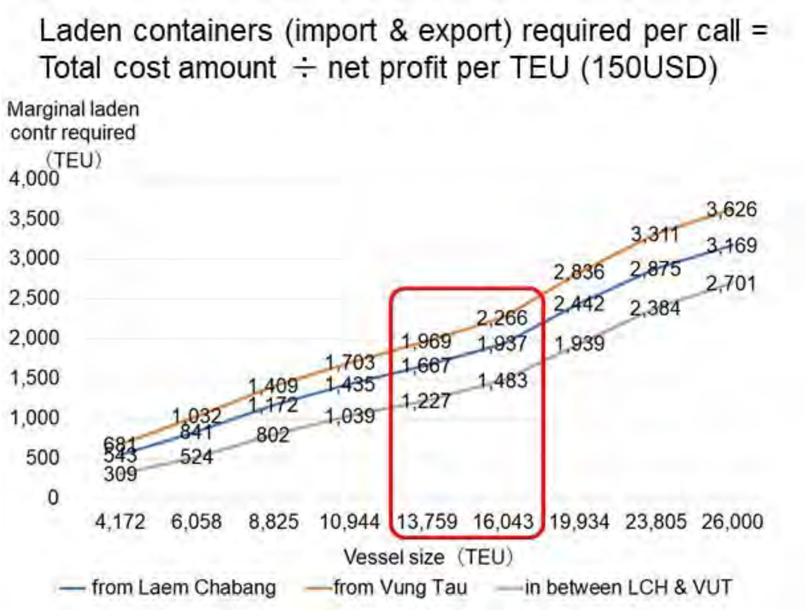
103. Based on the demand forecast shown above, laden containers by trade partners will reach around 270,000 and 180,000 TEU for EUR and NA respectively in 2030.

104. Assuming 2 weekly services, around 2,000 TEU per call for EUR and 2,500 TEU per call for NA will be expected, while around 1,300 TEU per call for EUR and 1,600 TEU per call for NA will be expected assuming 3 weekly services.

105. Based on the analysis in the Section 4.4, it is found that approximately 1,200 TEU of laden container (loading/unloading) per call would be at a sufficient level for 14,000 TEU class to call at SHV Port, and therefore, it is expected that shipping lines to/from EUR/NA will call at SHV Port in the late 2020.

Table 4-10 Estimated Laden Container by Trade Partners

			# of weekly service			
			in case of 3 per week		in case of 2 per week	
Year	Laden (TEU)		TEU/call		TEU/call	
	EUR	NA	EUR	NA	EUR	NA
2025	172,387	116,311	1,105	746	1,658	1,118
2030	264,422	178,400	1,695	1,144	2,543	1,715
2035	348,877	236,382	2,236	1,515	3,355	2,273
2040	423,270	285,660	2,713	1,831	4,070	2,747
2045	485,815	328,516	3,114	2,106	4,671	3,159
2050	536,005	364,279	3,436	2,335	5,154	3,503

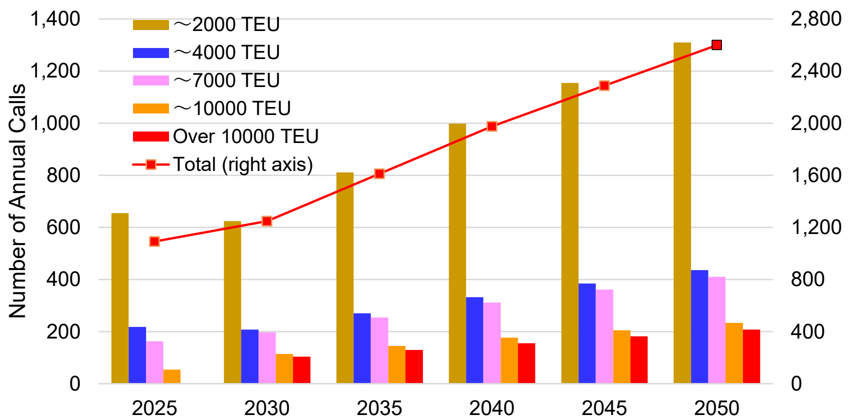


Source: JICA Survey Team

Laden Containers Required per Call (referred to Figure 4-16)

4.5.7 Estimate of Number of Ship Calls

106. Based on the estimated laden container volume (TEU) by such direction as EUR, NA, etc., the number of ship calls at SHV Port can be estimated assuming the number of containers loaded/unloaded per ship call as well as the distribution of ship sizes.



Share of the Number of Ship Calls
For Ports in Indocina

TEU Class	EUR/NA	Others
1001-2000		60%
2001-4000		20%
4001-7000	20%	15%
7001-10000	30%	5%
1001-12000	10%	
12001-14000	35%	
14001-15000	5%	
Total	100%	100%

Source: MDS Data (2018 - 2020)

	TEU				# of Weekly Service (revised)				# of call			
Year	EUR	NA	Others	Total	EUR	NA	Others	Total	EUR	NA	Others	Total
2025	241,265	153,557	692,214	1,087,036				21				1,092
2030	370,119	235,387	1,046,281	1,651,788	2	2	20	24	104	104	1,040	1,248
2035	487,073	310,840	1,358,011	2,155,924	3	2	26	31	156	104	1,352	1,612
2040	595,720	377,796	1,656,778	2,630,294	4	2	32	38	208	104	1,664	1,976
2045	696,274	440,419	1,934,432	3,071,125	4	3	37	44	208	156	1,924	2,288
2050	785,691	496,707	2,182,383	3,464,782	5	3	42	50	260	156	2,184	2,600

Including Existing Berth

	TEU per call				# of calls by TEU class									Berth	
Year	EUR	NA	Others	Total	~2000 TEU	~4000 TEU	~7000 TEU	~10000 TEU	Over 10000 TEU	~12000 TEU	~14000 TEU	~15000 TEU	Total (right axis)	# of Berth Required	BOR
2025				995	655	218	164	55	0	0	0	0	1,092	3	61.7%
2030	3,559	2,263	1,006		624	208	198	114	104	21	73	10	1,248	4	58.4%
2035	3,122	2,989	1,004		811	270	255	146	130	26	91	13	1,612	5	60.8%
2040	2,864	3,633	996		998	333	312	177	156	31	109	16	1,976	6	61.9%
2045	3,347	2,823	1,005		1,154	385	361	205	182	36	127	18	2,288	7	62.2%
2050	3,022	3,184	999		1,310	437	411	234	208	42	146	21	2,600	8	61.0%

Source: JICA Survey Team

Figure 4-27 Estimation of Number of Ship Calls

4.6 Infrastructure Development Projects Surrounding SHV Port

4.6.1 Sihanoukville Port SEZ

107. Sihanoukville Port SEZ (SPSEZ) was developed using a Japanese ODA loan and opened in May 2012 having a total area of 70ha and a sales area of 45ha (48 lots). SPSEZ is managed by PAS, and currently, three Japanese companies (OJITEX, Union Gakki and AEON Mall) and a local business company (Cambrew) are conducting business in the area. At present, the adoption of a “Free Port” concept for SHV Port including the SPSEZ is being examined, and it is expected that more port-related companies will be located in the SEZ area.

4.6.2 Road Development Project

108. Currently, access by road to and from the existing SHV Port is mainly by NR4. Under the JICA Preparatory Survey for Sihanoukville Port New Container Terminal Development Project conducted in 2017, the access roads connecting NR4 to the first berth of new container terminal (i.e., NCT1) was already studied to provide smooth traffic flow for container cargo vehicle traffic and local traffic as part of the aforementioned project.

109. In addition, on-going construction of PNP - SHV Expressway (scheduled to be completed in September of 2022) and rehabilitation of the road section connected to SHV Port from the expressway interchange located near Stung Hav Port (i.e., Road146b and Road148), which is planned to be completed by August 2022, provides a new alternative transport route for SHV Port related cargo vehicles.

110. In particular, the development of expressway and rehabilitation of the provincial roads being planned and implemented under MPWT to strengthen the road network connectivity between SHV and PNP, which is the major logistics bases, has a great impact on the traffic.

Source :Google Earth、Created by JICA Survey Team

Figure 4-28 Location Map of Major Road Development Plan Related to New Container Terminal Development

111. Figure 4-29 shows the road layout near the New Container Terminal.

Source :Google Earth、Created by JICA Survey Team

Figure 4-29 Location Map of Road Development Plan Surrounding SHV Port

4.7 Positioning and Necessity of the Project

112. Based on the above examination, the necessity and urgency of the development of NCT2 and NCT3 is clear in the light of the container cargo demand by 2035. In addition, by planning the target vessels of NCT2 and NCT3 to cover the wider shipping network including North America and Europe, i.e., Cambodia's major export partners, it will be possible to reduce international logistics costs to/from those regions avoiding the transshipment at Singapore and receiving larger vessels at SHV Port. Thus, it can be clearly stated that the development project of NCT2 and NCT3 will bring substantial benefits to the whole Cambodian economy. The economic analysis is now being carried out and will be described in the Chapter 10.

Chapter 5 Port Development Plan

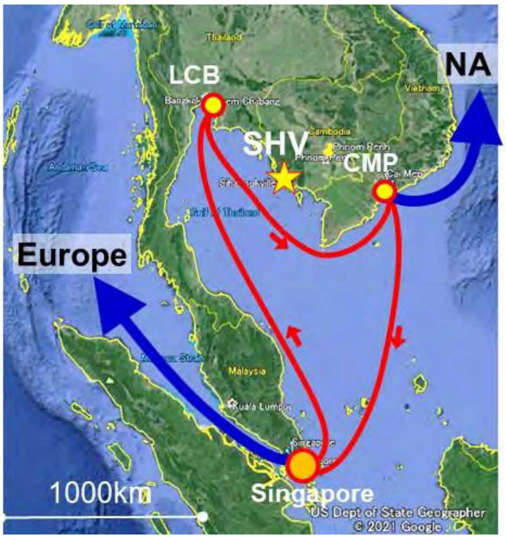
5.1 Basic Policy for Port Planning

113. Europe and North America (NA) are major and important trade partners of Cambodia. However, SHV Port has had no direct shipping service connecting with those regions. Accordingly, export/import containers to/from Europe/NA region must be transshipped in Singapore. This is a disadvantage in terms of logistics time and cost compared to neighboring countries which have direct shipping services with Europe and NA. Therefore, new container terminals, NCT2 and/or NCT3, should be designed examining the possibility to attract direct shipping service with Europe and/or NA, which will reduce the logistics cost to/from Cambodia and enhance the Cambodian economy.

114. On the other hand, it would be difficult for SHV Port to attract brand-new direct shipping service. Instead, it is more realistic to put an additional call at SHV Port utilizing the existing shipping services calling at LCB and/or Vietnamese ports such as CMP / Vung Tau (VUT) which already have direct services with NA and/or Europe.

115. Previous and next ports centering on LCB, CMP/VUT are listed focusing on 10,000 TEU and over class vessels deployed in the shipping services of Europe/NA, which shows that most vessels are heading from LCB to CMP/VUT, while there are very few vessels heading in the reverse direction.

116. Regarding the shipping service connecting with Europe and/or NA, current calling patterns at LCB, CMP/VUT and possible patterns adding a call at SHV Port (Case-A and Case-B) are depicted below.



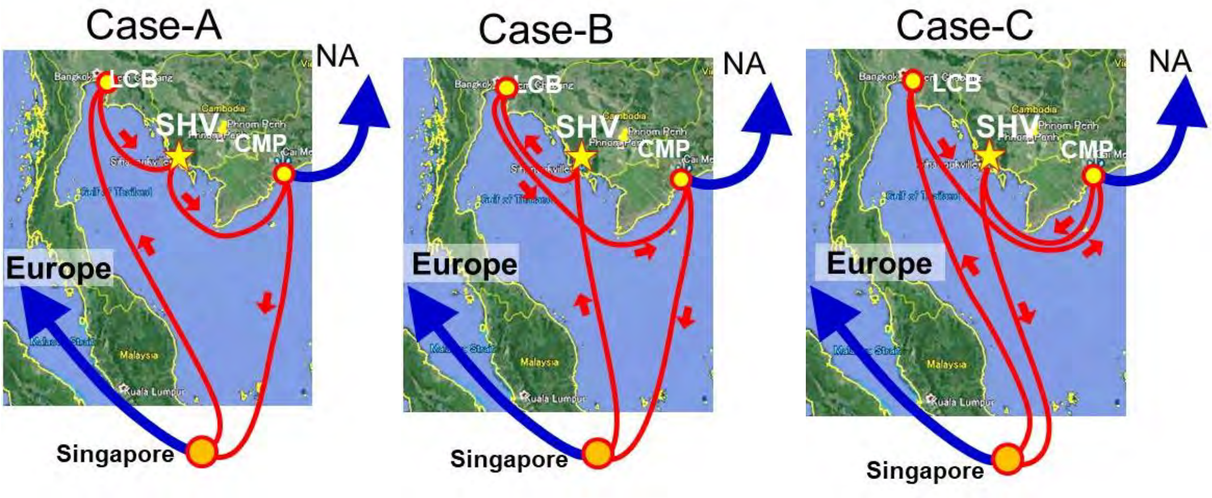
Source: JICA Survey Team

Figure 5-1 Current Calling Patterns of EUR/NA Shipping Service Centering on LCB, CMP/VUT

117. Given the current port call patterns, the most realistic way to call North American / European route services to SHV Port is to call SHV Port on routes that call at nearby large ports such as LCB Port and CMP Port. Therefore, it is considered that the cases that can be considered

as the SHV Port call pattern are as follows.

- Case-A: Calling at SHV on the way from LCB to CMP/VUT
- Case-B: Calling at SHV before LCB,
- Case-C: Calling at SHV after CMP/VUT.



Source: JICA Survey Team

Figure 5-2 Cases of Calling Patterns to SHV Port

118. The current calling pattern (Base Case) and the pattern of Case-A (On the way from LCB to CMP/VUT), Case-B (Calling at SHV before LCB) and Case-C (Calling at SHV after CMP/VUT) are depicted in Figure 5-2 and the total navigational distance (indicated by the red line in the figures) in each case are shown in Table 5-1. The navigational distance in Case-A and that in Case-B are almost the same as the Base Case, while that in Case-C is around 300 NM longer than the other cases which means that the feasibility of Case-C would be inferior to that of other cases. In other words, the transit time for Thai and/or Vietnamese export cargo which are loaded at LCB or CMP will be longer than the current pattern because Case-C is a rotation that brings SHV Port to the last loading. For Case-A, the transit time would be a bit longer for export cargo loaded in LCB. Therefore, the pattern with the highest possibility of calling at SHV Port is Case-B, followed by Case-A. The Case-C would be considered to be unrealistic.

Table 5-1 Comparison of Navigational Distance (Current, Case-A ~ C)

	SP-LCB	LCB-CMP/VUT	CMP/VUT-SP	LCB-SHV	SHV-CMP/VUT	SP-SHV	Total
Current	800NM (1)	599NM (2)	620NM (3)	-	-	-	2,020NM
Case-A	800NM (1)	-	620NM (4)	256NM (2)	370NM (3)	-	2,046NM
Case-B	-	599NM (3)	620NM (4)	256NM (2)	-	621NM (1)	2,096NM
Case-C	800NM (1)	599NM (2)	-	-	370NM (3)	621NM (4)	2,390NM

** NM = Nautical Mile (1 NM = 1.852 km)*

Source: JICA Survey Team

119. Based on the above analysis, the design vessels for the development of a new container terminal are to be set considering the Case-A or Case-B is realized as the possible calling pattern at SHV Port by trunk lines such as EUR/NA services. Then, the specifications of the new container terminals as well as the channel and basin are examined.

5.2 Design Vessel

120. Based on the MDS database, which compiles shipping service data, the status of shipping service calling at LCB and CMP/VUT is shown below. LCB has around 80 weekly services of which 8%~10% are EUR/NA route, while CMP/VUT has more than 20 weekly services of which more than half are EUR/NA routes.

121. Size distribution of container vessels calling at LCB and CMP/VUT for Europe and/or NA route is shown below. The share of over 10,000 TEU class has been increasing in recent years.

122. Based on the MDS data from 2018 to 2020, more than 90% of total calls at LCB and/or CMP/VUT are by vessels of 15,000 TEU or less for Europe route and by vessels of 14,000 TEU or less for NA route respectively. As for routes covering the Indo-Pacific region, vessels of 10,000 TEU or less account for more than 90% of total calls at LCB and/or CMP/VUT.

123. Based on the vessel size analysis, design vessels are set as shown below: i.e., 15,000 TEU class for the Europe/NA route and 10,000 TEU class for the Indo-Pacific route. (LOA and Beam are the same for 14,000 TEU class and 15,000 TEU class.)

Target	Vessels currently deployed for service in the Indo-Pacific region	Vessels currently deployed for North America / Europe service	
TEU DWT	10,000 TEU 120,000 DWT	(14,000 TEU) (150,000 DWT)	15,000 TEU 160,000 DWT
LOA Beam Draft	LOA =350 m Beam=49 m Draft=15.0 m	(LOA=370m Beam=51m Draft =15.5m)	LOA=370m Beam=51m Draft =16.0m

5.3 Short Term Port Development Plan

5.3.1 Planning of Quaywalls and Layout Plan of Terminal

5.3.1 (1) Length and Depth of Quaywalls

5.3.1 (1) a The dimensions of design ships

124. The required length and water depth depend on the size of design ships. In the examination of the design ships in the previous section, the dimensions of design ships by shipping regions are as shown in Table 5-2.

Table 5-2 Dimensions of Design Ships

Shipping Area	Ship type（TEU）	Ship size（DWT）	LOA(m)	Beam(m)	Draft(m)
Shipping routes in Indian and Pacific regions	10,000	120,000	350	49	15.0
Shipping routes to/from North America and Europe	15,000	160,000	370	51	16.0

Source: JICA Survey Team (based on Clarkson Database)

5.3.1 (1) b Required length and depth of Quaywall

125. The required length of quaywall shall be determined by considering the overall ship length (LOA) of the design ship and the space required for tying ships with bollards at the stern

and bow. Generally, the angle between the quaywall face line and mooring rope is between 30 to 45 degrees. However, considering the continuous terminal of NCT2 and NCT3 and the low frequency of ship berthing by large size ships, the required length of quaywall can be determined as follows: LOA+2 x Beam/2 (see Figure 5-3).

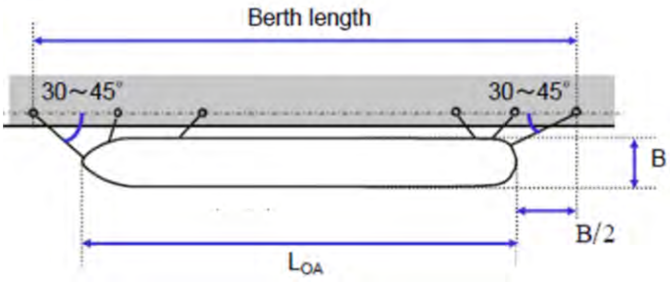


Figure 5-3 Determination of Quaywall Length

5.3.1 (1) c Required Water Depth of Quaywall

126. Generally, the required water depth of a quaywall is determined by considering the draft of the design ship and a margin equivalent to 10% of the draft to prevent the ship's hull from touching the seabed due to the ship's movement.

127. When it becomes necessary to deepen the quaywall depth in the future while the terminal is in operation, the access channel dredging can be conducted when no ships are present. However, it will be difficult to conduct dredging in front of the quaywall while the terminal is in operation, thus it is recommended to secure the ultimate target water depth in the initial construction stage. In addition, larger container vessels expected to call the port in future can navigate the access channel by utilizing the tide (maximum tidal range is 1.4m) and berth at the terminal with the ultimate targeted water depth. From this viewpoint, it is reasonable to dredge quaywall depth to its ultimate target depth in advance.

128. Based on the above, the dimensions of the quaywall are set as shown in Table 5-3.

Table 5-3 Dimensions of the Quaywall by Design Ship Size

Ship Size (TEU)	Ship Size (DWT)	Quaywall Length: L (m)	Quaywall Depth: D (m)
10,000	120,000	400	16.5
15,000	160,000	430	17.5

Source: JICA Survey Team

5.3.1 (2) Dimension and Capacity of the Container Terminals

129. The container handling capacity depends on the handling productivity of gantry cranes on the pier side and the container handling productivity in the container yard. The smaller of the above two handling productivities determines the container handling capacity.

130. Conditions for the container handling capacity estimates are shown in Table 5-4.

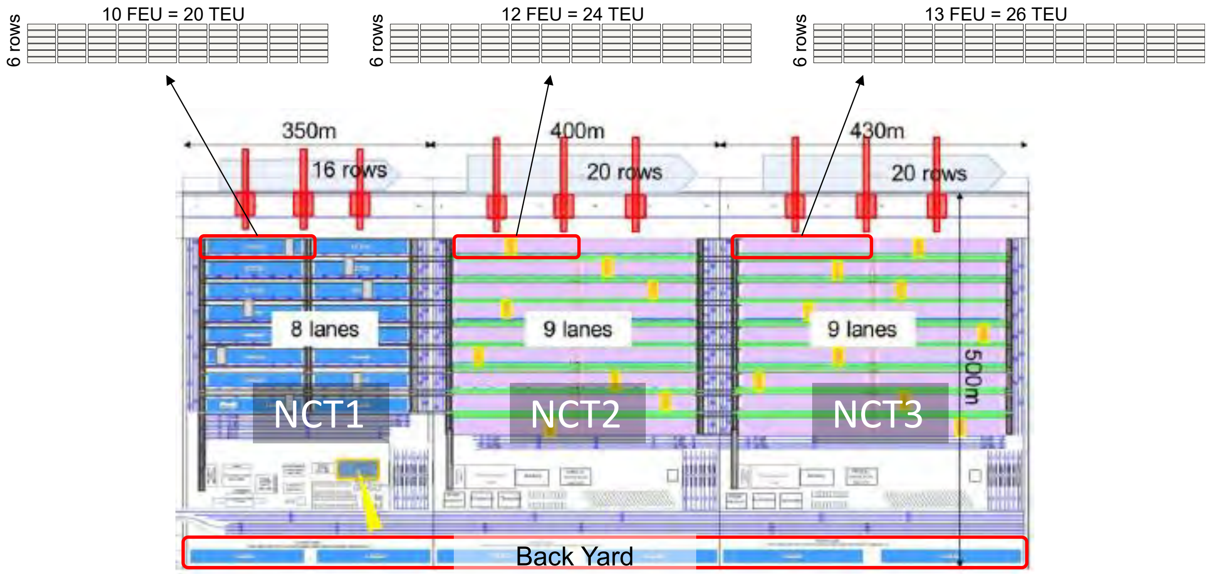
Table 5-4 Conditions for Container Handling Capacity Estimation

	NCT1	NCT2 / NCT3		Existing CT
Design Vessel	4,000TEU 60,000DWT	10,000TEU 120,000 DWT	15,000TEU 160,000 DWT	-
Length of Berth	L=350 m	L=400 m	L=430 m	L=400 m
Terminal Width	500 m	500 m	500 m	350 m
# of Ground Slot (TEU)	2,200 TEU (including backup area)	2,880 TEU (including backup area)	3,100 TEU (including backup area)	4,300 TEU (including SEZ yard (1,400) and Yard-B' (200)
QC	3 units (16 rows)	3 units (20 rows)	3 units (20 rows)	6 units (12 rows)

5.3.1 (2) a Annual Handling Capacity of Container Yard

131. The annual handling capacity (TEU/year) of the container yard is calculated under the following conditions. The backyard is a yard for storing export empty containers which follows the planning concept of NCT1.

N: Number of Ground Slots
= 1,920 (6 rows x 20 x 16 bays) + 280 (Backyard) ≒ 2,200TEU (NCT1)
= 2,592 (6 rows x 24 x 18 bays)+ 288 (Backyard) ≒ 2,880TEU (NCT2)
= 2,808 (6 rows x 26 x 18 bays)+ 293 (Backyard) ≒ 3,100TEU (NCT3)
L: Average number of layers for stored container = 4.5 for RTG yard, 3.5 for RS yard
A: Availability at container handling space = 0.75
P: Peak ratio (Ratio of volume of peak day to average volume in a week) = 1.4
S: Average storage (dwelling) days of container in a yard = 4 days for import containers and export laden container, 6 days for export empty container



132. The annual handling capacity of a container yard is basically calculated by the following formula.

- Annual Handling Capacity of Container Yard = N * L * A * P * (365/S)

<Berth Length = 400m and 430m>

Ground Slot inside the Port: **2,592** (400m) **2,808** (430m)

	400m			430m		
	CY		Back Yard	CY		Back Yard
	Import & Export Full	Export Empty		Import & Export Full	Export Empty	
Ground Slot	2,137	455	288	2,314	494	312
Average Number of Layers for Stored Boxes	4.5	4.5	3.5	4.5	4.5	3.5
Average Yard Occupancy Ratio	0.75	0.75	0.75	0.75	0.75	0.75
Peak Day Factor of a Week	1.4	1.4	1.4	1.4	1.4	1.4
Average Container Storage Days (Dwell Time)	4.0	6.0	6.0	4.0	6.0	6.0
Annual Capacity	470,000	66,800	32,900	509,100	72,400	35,600
	470,000	99,700		509,100	108,000	
Total	**569,700**			**617,100**		

<Berth Length = 350m (NCT1) and 300m>

	NCT1 (350m)			300m (Reference)		
	CY		Back Yard	CY		Back Yard
	Import & Export Full	Export Empty		Import & Export Full	Export Empty	
Ground Slot	1,598	322	240	1,424	304	192
Reefer Plug	-		-	-		-
Average Number of Layers for Stored Boxes	4.5	4.5	3.5	4.5	4.5	3.5
Average Yard Occupancy Ratio	0.75	0.75	0.75	0.75	0.75	0.75
Peak Day Factor of a Week	1.4	1.4	1.4	1.4	1.4	1.4
Average Container Storage Days (Dwell Time)	4.0	6.0	6.0	4.0	6.0	6.0
Annual Capacity	351,600	47,200	27,400	313,300	44,500	21,900
	351,600	74,600		313,300	66,400	
Total	**426,200**			**379,700**		

5.3.1 (2) b Annual Handling Capacity of QGC

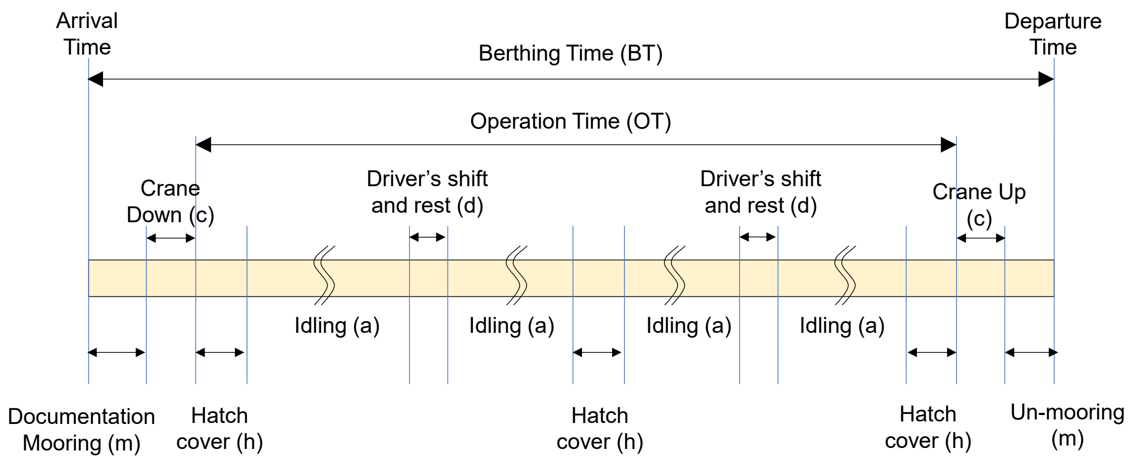
133. Annual Handling Capacity of QGC (TEU/year) is calculated under the following conditions.

N: Number of Quay Cranes = 3
Pn: QGC productivity (net) = 30 move/hour
E: Handling efficiency = 0.9 (considering idling time, hatch cover handling etc.)
(Pg: QGC productivity (gross) = 27 move/hour (= 30 x 0.9))
D: Operable days = 360 days
R: Crane operation ratio = 0.9 (e.g., 21 hours in a day)
B: Berth Occupancy Ratio (BOR) = 65%
T: TEU/box ratio = 1.65

134. The annual handling capacity of a QGC is calculated by the following formula.

- Annual Handling Capacity of QGC = N * Pn * E * D * 24 * R * B * T

		NCT1	400m	430m
# of Berth		3	3	3
QGC Productivity (move/hr; net)	Pn	30	30	30
Handling efficiency	e	90%	90%	90%
QGC Productivity (move/hr; gross)	Pg=Pn*e	27.0	27.0	27.0
Operable Days	d	360	360	360
BOR (Berth Occupancy Ratio)	b	65%	65%	65%
Operation Ratio	r	90%	90%	90%
Annual QGC Productivity (box/year/QGC)	Cb=Pg*d*b*r	136,469	136,469	136,469
TEU/Box Ratio	t	1.65	1.65	1.65
Annual QGC Productivity (TEU/year/QGC)	Ct=Cb*t	225,174	225,174	225,174
# of QGC/berth	n	3	3	3
Annual Handling Capaciy (TEU/year)	H=Ct*n	**675,521**	**675,521**	**675,521**



$$Handling\ Efficiency = \frac{OT-(h+d+a)}{OT} \qquad Operation\ Ratio = \frac{OT}{BT}$$

5.3.1 (2) c Container Terminal Capacity

135. Based on the above calculation, the terminal capacity is determined by comparing the yard side capacity and the quay side capacity and then adopting the smaller (critical) figure. As can be seen below, in this case the terminal capacity is determined by the yard capacity.

Terminal	Quay Side Capacity	Yard Capacity	Terminal Capacity
NCT1	675,521	426,200	426,200
NCT2	675,521	569,700	569,700
NCT3	675,521	617,100	617,100

5.3.1 (3) Setting of development options and evaluation

5.3.1 (3) a Setting of development options

136. Based on the above-mentioned examinations, dimensions of quaywall and terminal are set as shown in Table 5-5.

Table 5-5 Dimensions of Quaywall and Terminal for Development Options

Target Destination		Indo-Pacific region	North America / Europe
Design Vessel (TEU / DWT)		10,000 TEU / 120,000 DWT	15,000 TEU / 160,000 DWT
Length of Berth		400 m	430 m
Terminal Width		500 m	500 m
Depth of Berth		-16.5 m	-17.5 m
Width of Basin in front of Berth		65 m	65 m
Handling Equipment (Tentative)	QC	20 row x 3 units	20 row x 3 units
	RTG	10 units (1 over 5)	10 units (1 over 5)

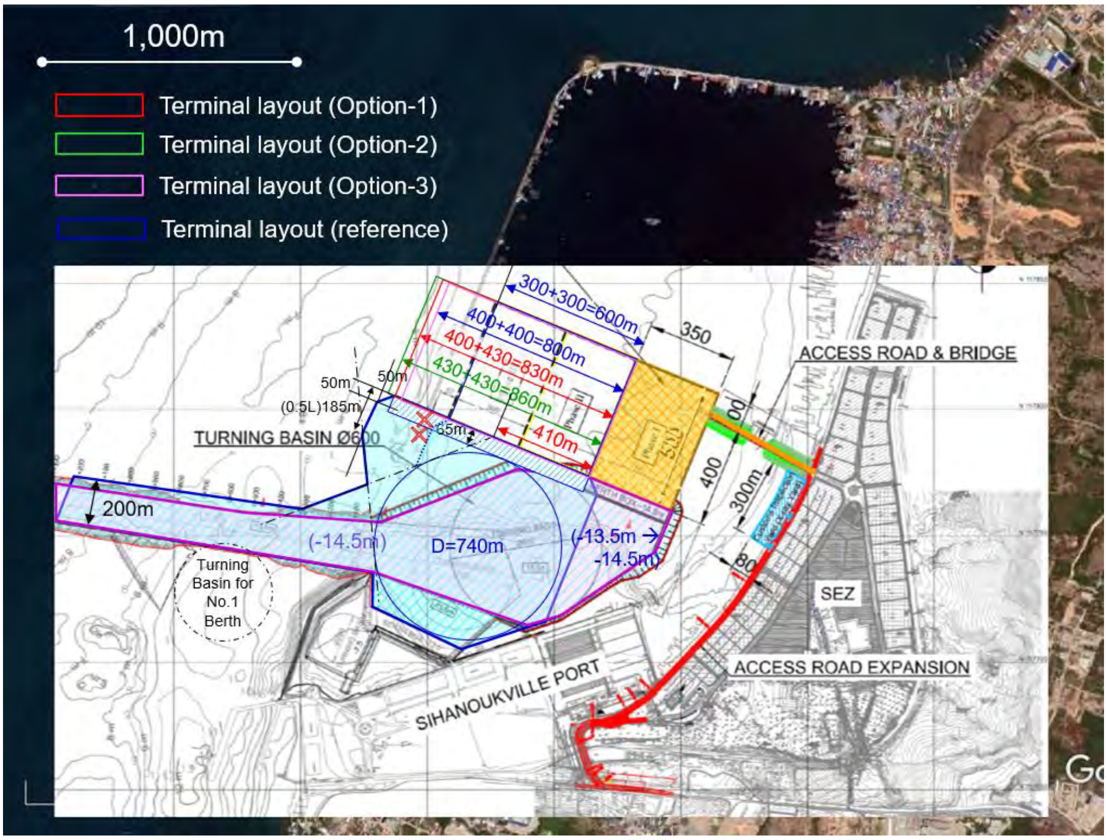
137. The following three development options with different combinations of design ships allocated to NCT2 and NCT3 are shown in Table 5-6. (The capacity of the existing container terminal in the table (about 0.8 million TEU) will be described later section 5.3.1 (3) c.

Table 5-6 Development Options

Items		Option-1	Option-2	Option-3	(2017 FS)
Concept		To receive vessels to/from the whole Indo-Pacific region in the late 2020s (CT2); and expand the shipping network covering Europe/NA region in the early 2030s (CT3).	To expand the shipping network covering not only Indo-Pacific region but also Europe/NA region in the late 2020s.	To cover the shipping network for the whole Indo-Pacific region, which might make it possible to receive vessels to/from Europe/NA with the integrated operation of the three terminals.	
Design Vessel	CT2	10,000TEU	15,000TEU	10,000TEU	(around 3,500TEU)
	CT3	15,000TEU	15,000TEU	10,000TEU	(around 3,500TEU)
Berth Dimension	CT2	L=400m, D=16.5m	L=430m, D=17.5m	L=400m, D=16.5m	L=300m, D=14.5m
	CT3	L=430m, D=17.5m	L=430m, D=17.5m	L=400m, D=16.5m	L=300m, D=14.5m
Total Length (inc. CT1)		830m (1,180m)	860m (1,210m)	800m (1,150m)	600m (950m)
Annual Capacity	CT1~CT3	1.61 million TEU	1.66 million TEU	1.57 million TEU	1.19 million TEU
	Existing CT	0.8 million TEU	0.8 million TEU	0.8 million TEU	0.8 million TEU
Demand (million TEU)		1.7 million TEU (2030), 2.2 million TEU (2035), 2.6 million TEU (2040)			

Source: JICA Survey Team

138. Figure 5-4 shows the layout of the three development options above.



Source: JICA Survey Team (Google Earth)

Figure 5-4 Layout of Development Options (NCT1 to NCT3)

5.3.1 (3) b Evaluation of Development Options

139. The table below shows the comparison of the development options. Based on the demand forecast, the shipping service to/from Europe/NA will be realized around 2030 with 2 or 3

weekly calls. Accordingly, it is desirable that at least NCT3 be designed targeting 15,000 TEU class. As for NCT2, the demand at the timing of its operation might not be sufficient to attract the shipping service to/from Europe/NA. Therefore, NCT2 would be better to be designed targeting 10,000 TEU class vessels which are the maximum size deployed in the Indo-Pacific region, which results in the cost reduction. In case that NCT1 and NCT2 are operated as a sequential berth, it is possible to receive a 15,000 TEU class vessel. Based on the consideration above, the option-1 is recommended.

Table 5-7 Comparison of the Development Options

Items	Option-1	Option-2	Option-3	(reference)
Concept	To receive vessels to/from the whole Indo-Pacific region in the late 2020s (CT2); and expand the shipping network covering Europe/NA region in the early 2030s (CT3).	To expand the shipping network covering not only Indo-Pacific region but also Europe/NA region in the late 2020s.	To cover the shipping network for the whole Indo-Pacific region, which might make it possible to receive vessels to/from Europe/NA with the integrated operation of the three terminal.	
Length (CT1-CT3)	830m (1,180m)	860m (1,210m)	800m (1,150m)	600m (950m)
Terminal Construction Cost & Handling Equipment Cost (Option-1 = 1.00)	1.00	1.01	0.98	0.85
Capacity (+existing CT) million TEU	1.61 (+ 0.8)	1.66 (+ 0.8)	1.57 (+ 0.8)	1.19 (+ 0.8).
	Able to cope with the demand up to 2035 (2.2 million USD)			Not able to cope with the demand in 2035.
Demand Forecast	1.7 million TEU (2030) / 2.2 million TEU (2035) / 2.6 million TEU (2040)			
Social & Environmental Consideration	To demolish a part of the existing breakwater (700m)			No need to demolish the existing breakwater

5.3.1 (3) c Capacity of the Existing Container Terminal

140. In order to examine the timing of NCT2 and NCT3 development, the relation between the future demand and the terminals' capacity should be carefully verified. As the capacities of the new container terminals (NCT1 to NCT3) have already been evaluated, the capacities of the existing container terminal are evaluated. The terminal capacities including the new container terminals are summarized below:

Table 5-8 Annual Capacity pf the Existing Container Terminal (TEU/year)

TEU

Terminal		Quay Side Capacity	Yard Capacity	Terminal Capacity
Existing CT	Present	785,327	753,900	753,900
	Stage-1	854,825	753,900	753,900
	Stage-2	896,524	782,200	782,200
	Stage-3	1,063,319	782,200	782,200
	Stage-4	1,063,319	807,800	807,800
	Stage-5	1,063,319	773,100	773,100

Present	*Operational efficiency of QGC is lowered due to the berth shift operation*
Stage-1	*Berth Shift Operation is resolved. The crane rail is extended by 25m to berth No.6. A mooring dolphin is introduced 25m from the east end of berth No.8.*
Stage-2	*Berth No.6 is converted to a container berth with the extension of crane rail to No.6. Warehouse No.5 is demolished and the container yard "Yard-B'" is developed. The number of QGC remains at 5 units.*
Stage-3	*Same as Stage-2 but the number of QGC is 6 units (1 QGC is added.)*
Stage-4	*Dwelling days of export empty container is improved.*
Stage-5	*Dwelling days are further improved. The yard for export empty containers in SEZ area is returned to SEZ for its original use.*

Source: JICA Survey Team

141. The following event timeline is assumed in calculating the terminal capacity. In addition those measures, additional Mobile Harbor Crane(s) will be expected to installed in 2023, by which further improvement of the terminal capacity will be expected..

Table 5-9 Assumption of Event Timeline

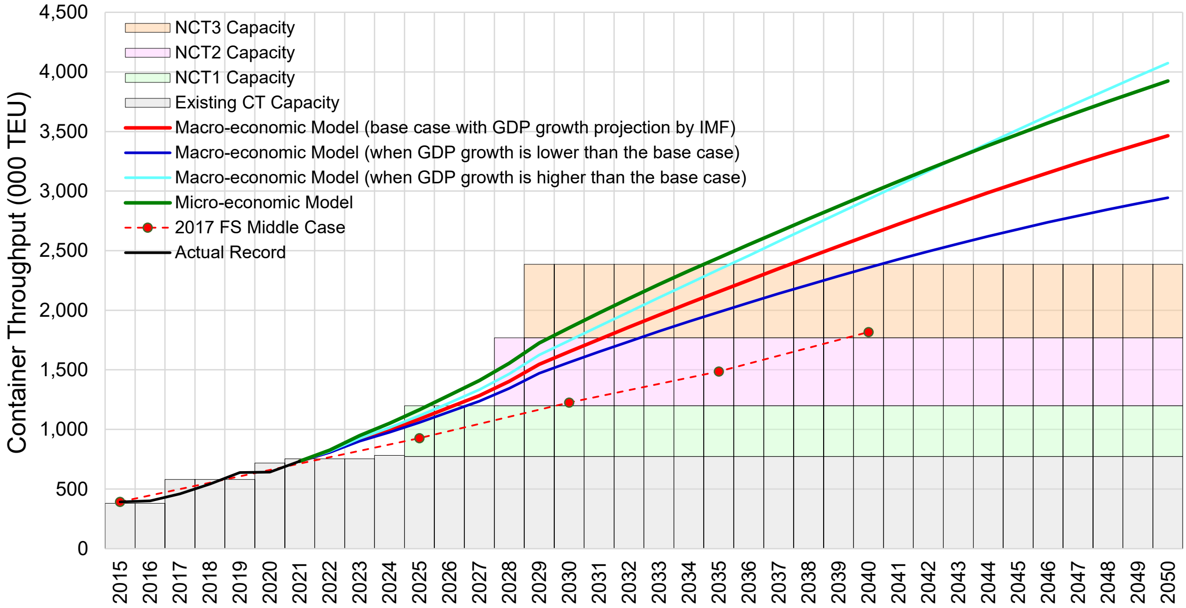
2017	4 units of QGC (2 units were added.)
2020	Extension of yard (Yard-D, SEZ Yard). The number of QGC is 4 units.
2021	The number of QGC is 5 units (1 QGC was added.) Yard capacity was improved in accordance with the above yard extension.
2022	Stage-1 (Berth Shift Operation is resolved. The crane rail is extended by 25m to the berth No.6. A mooring dolphin is introduced with 25m ahead of the east end of the berth No.8.)
2024	Stage-3 (Berth No.6 is converted to the container berth with the extension of crane rail to No.6. Warehouse No.5 is demolished and the container yard "Yard-B'" is developed. The number of QGC will be 6 units. Berth window will be expanded and ready to received additional ship calls.
2025	Stage-4 (*Dwelling days of export empty container is improved.)* （Commencement of NCT1 operation）
(to be decided)	Stage-5 (Dwelling days are further improved. The SEZ Yard for export empty containers is released to SEZ use.)

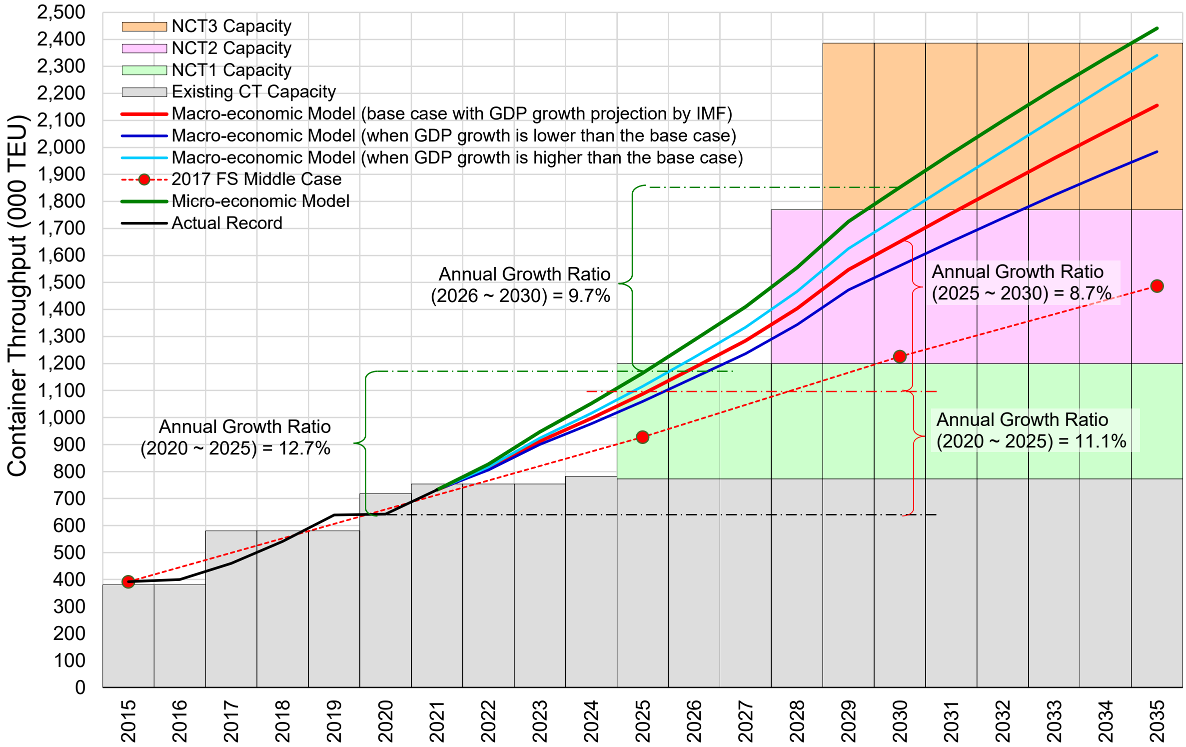
Source：JICA Survey Team

5.3.1 (3) d Development Timeline for NCT2 and NCT3

142. The relation between the demand and capacity is depicted as shown below. This clearly shows that NCT2 should commence operations as soon as possible after the completion of NCT1 and NCT3 around 2029 ~ 2030 to meet the container demand in the base case scenario (of GDP).

143. On the other hand, in order to fill the supply-demand gap in the next few years, it goes without saying that measures to improve the capacity of the existing container terminals are conclusively urgent. In addition to the current measures including crane rail extension to Berth-No.6, it is necessary to explore additional measures to improve the terminal capacity which includes further expansion of container yards, additional installment of QGC(s), RTG(s) and Mobile Harbor Crane(s), and reduction of container dwelling time in the port (particularly for export empty containers as well as import laden containers) etc.





Source: JICA Survey Team

Figure 5-5 Demand and Capacity (upper: 2015 ~ 2050; lower: 2015 ~ 2035)

5.3.1 (3) e Proposed Development Plan of NCT2 and NCT3

144. Based on the capacity - demand analysis, the recommended development plan for NCT2 and NCT3 is shown below (Dimension of channel and basin are described in the later section 5.3.3):

Table 5-10 Development Plan of NCT2 & NCT3

	NCT1	NCT2	NCT3
Design Vessel	4,000TEU 60,000DWT	10,000TEU 120,000 DWT	15,000TEU 160,000 DWT
Target Shipping Network	A part of Indo-Pacific region	Whole Indo-Pacific region	Network covering Europe and North America region
Length of Berth	L=350 m	L=400 m	L=430 m
Depth of Berth	D=14.5 m	D=16.5 m	D=17.5 m
Terminal Width	500 m	500 m	500 m
# of Ground Slots (TEU)	2,160 TEU (including backup area)	2,880 TEU (including backup area)	3,120 TEU (including backup area)
QGC	3 units (16 rows)	3 units (20 rows)	3 units (20 rows)
Terminal Capacity (000TEU)	430	570	620

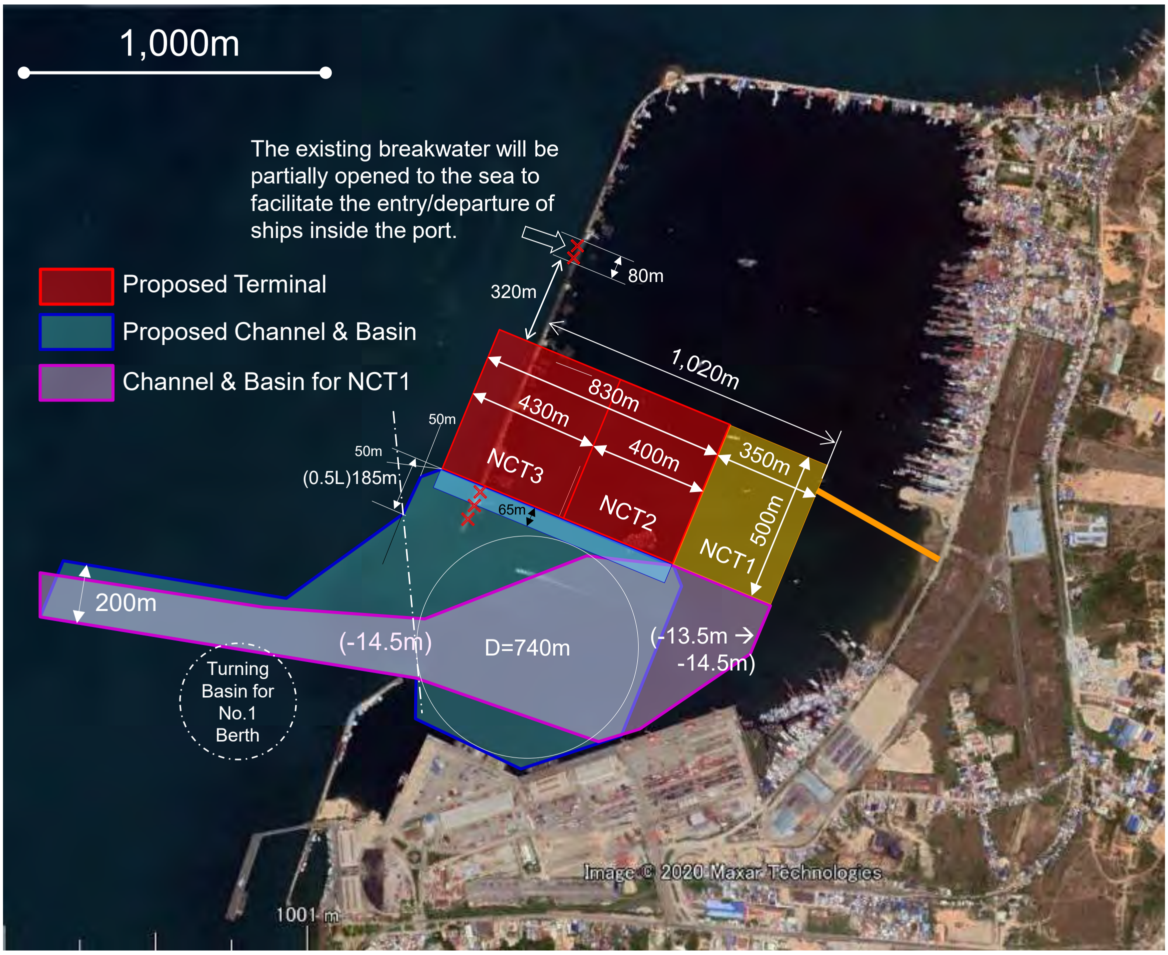


Figure 5-6 Development Plan of NCT2 & NCT3

Source :JICA Survey Team

5.3.2 Planning of Breakwater

5.3.2 (1) Container Terminal

5.3.2 (1) a Demolishment and Reclamation of Existing Breakwater

145. Since the quaywall alignment of the terminal (NCT2 and NCT3) is expected to cross over

the existing breakwater, a section of the breakwater in front of NCT3 needs to be removed and a section overlapped with NCT3 will be in the reclaimed area as it exists. It is possible to utilize the rubble stones recovered from the demolished breakwater for the construction materials of the terminal (NCT2 and NCT3).

5.3.2 (1) b Construction of a New Breakwater

146. The container terminal (NCT2 and NCT3) will be located outside the existing port area after removing a part of the existing north breakwater which will expose the terminal to waves from the south and west. Generally, to secure sufficient calmness for the berthing of large size ships, the occurrence of the operational limit wave height ($H_{1/3}$) of 70 cm for NCT2 and NCT3 and 50cm for the existing container terminal (berth No. 7 to 8) should be less than 97.5%.

147. Based on the above analysis and the direction-wise wave occurrence ratio obtained separately, the analysis results on the cumulative occurrence rate below operational limit wave height by terminals in case of having no new breakwater is shown in Table 5-11.

Table 5-11 Cumulative Occurrence Rate Below Operational Limit Wave Height by Terminals (without new breakwater)

Name of Terminal	Operational limit wave height ($H_{1/3}$) (m)	Cumulative occurrence rate below operational limit wave height (%)
MPT (Multi- Purpose Terminal)	0.50	99.4
Existing CT	0.50	97.9
NCT1	0.70	99.4
NCT2	0.70	99.4
NCT3	0.70	98.9

Source: JICA Study Team

148. When the size of container ships at NCT1, NCT2 and NCT3 during the initial operation period is the same as the container ships at the existing CT, the target operational limit wave height ($H_{1/3}$) for NCT1 to NCT3 shall be set at 50cm. Accordingly, the cumulative occurrence rates below the operational limit wave height can be calculated as shown in Table 5-12. In this case, the target cumulative occurrence rate of 97.5% is secured for subject terminals except for NCT3. Since the deviation from the target cumulative occurrence rate at NCT3 is minimal and the calling frequency to NCT3 of container ships for the existing CT is expected to be small, no operational problem is expected.

Table 5-12 Cumulative Occurrence Rate Below Operational Limit Wave Height by Terminals for the Current Container Ship

Terminal	Operational limit wave height for the current container ship ($H_{1/3}$)	Cumulative occurrence rate below operational limit wave height (%)
NCT1	50cm	98.34
NCT2	50cm	98.17
NCT3	50cm	97.24

Source: JICA Study Team

149. Based on the above findings, it is not necessary to construct a breakwater for the purpose of ensuring the cargo handling limit calmness at the existing CT and NCT1 to NCT3.

150. According to section 6.11.5 “Maintenance of Channel and Basin", siltation at the channel

and basin occurs from the south to the north in the section between the port entrance and about 1,500m offshore. The annual siltation volume is estimated at about 280,000m^3. As countermeasures to prevent siltation in the channel and basin, maintenance dredging and the construction of a siltation prevention groin near the area prone to siltation are generally adopted. The abovementioned 1,500m section is expected to be the area subject to siltation countermeasures. However, the construction of a groin to the south of the port entrance would hamper ship navigation near the cruise ship terminal. Moreover, it would be difficult to completely prevent siltation by the construction of a groin. It is difficult to estimate the local siltation phenomena at the west part of NCT3 using a siltation simulation program. Therefore, in order to examine the necessity of groin construction for preventing siltation instead of maintenance dredging, it is necessary to continuously conduct periodical (twice a year) sounding surveys and analyze the results.

5.3.2 (2) Fishing Port

151. There are large and small size fishing boats and cargo ships in the fishing port area. The dimensions of the ships are estimated as shown in Table 5-13.

Table 5-13 Estimated Dimensions of Large Size Ships in the Fishing Port Area

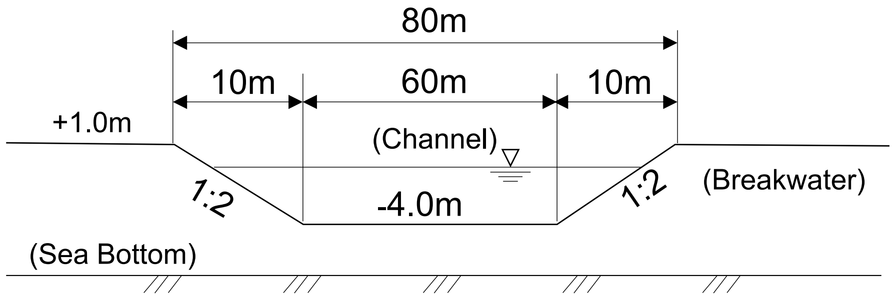
Gross Tonnage (ton)	Length Overall (m)	Breadth (m)	Draft (m)
20 – 30（fishing boat）	14.6 - 17.4	3.7 - 4.6	2.2 - 2.5
Barge	30	10	4.5

Note) the dimensions of barge are based on field observation.

Source: JICA Survey Team (Preparatory Survey for Sihanoukville Port New Container Terminal Development Project)

152. According to technical standards for fishing ports in Japan, the necessary two-way channel width (W) is 5 to 8 times ship width (B). Therefore, the necessary channel width subject to fishing boats given in Table 5-13 is 18.5 to 36.8m. In case of the barge sailing, 6 barges form one convoy of 90m in length and 20m in width having 2 side-by-side and 3 in longitudinal direction. Since the sailing frequency of this barge convoy is small, the channel width of 60m which is 3 times the convoy width will be sufficient. The necessary water depth is estimated at 4 m considering the allowance to the draft of design ships.

153. The length of partial removal of breakwater will be 80m taking into consideration the breakwater crown height of +1.0m as shown in Figure 5-7.



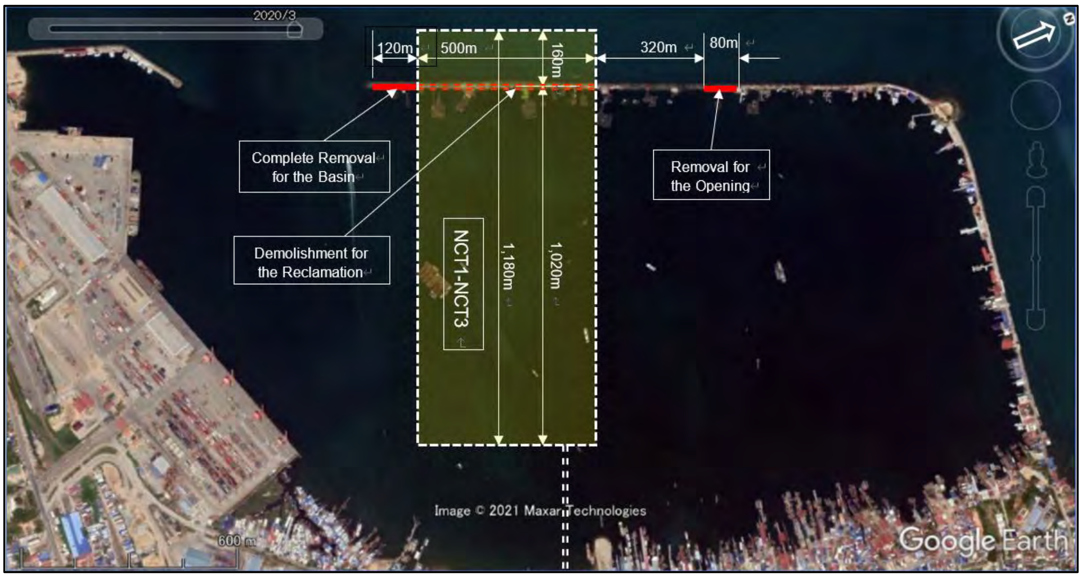
Source: JICA Survey Team

Figure 5-7 Dimensions of the Opening Part of the Breakwater

154. A candidate location for partial breakwater removal is near the bending part of the north side breakwater or near NCT3 on the west side breakwater. Among incident waves through the north side opening, waves from the north will most adversely affect calmness of the fishing port. In addition, at the west opening, the waves from the west will severely affect calmness in the fishing port. Since ports are required to secure the target calmness for a period of 97.5% or more per year, the waves to be examined for the calmness are those with a cumulative frequency occurrence of 97.5% or more. According to the results of calmness calculation for both cases above, the calmness in the fishing port due to the incident waves from the opening does not decrease from the present situation; in fact, a slight improvement in calmness is expected.

155. In order to reduce the negative impact of partial removal of the breakwater on the occupants of the facilities on the breakwater, it is appropriate to provide an opening on the west side of the breakwater where the number of affected occupants is smaller than the north opening area.

156. The layout plan of the breakwater removal is shown in Figure 5-8. The result of the calmness examination in the fishing port based on the breakwater layout shown in Figure 5-8 is described in 5.3.3 **"**Calmness of the Port**".** Generally, the limit wave height (H1/3) for the target calmness of a fishing boat port is set at 30 cm. It is confirmed that the targeted calmness can be achieved by the breakwater layout plan shown in Figure 5-8.



Source :JICA Survey Team

Figure 5-8 Layout Plan of the Breakwater Removal

5.3.3 Calmness of the Port (NCT2&NCT3 and Fish Port Area)

5.3.3 (1) Required Calmness

157. According to the Japanese technical standards for port facilities, the water area in front of the quay wall shall be calm enough to handle cargo 97.5% of the time throughout the year. The water calmness is evaluated by the frequency of wave occurrence in a certain period of time below the critical wave height at which the subject ship can handle cargo.

Table 5-14 Critical Wave Heights for Cargo Handling

Reference Values of Critical Wave Heights for Cargo Handling without the Influence of Swelling or Long-Period Waves

Ship type	Critical wave height for cargo handling ($H_{1/3}$)
Small craft	0.3 m
Medium/large ships	0.5 m
Very large ships	0.7 to 1.5 m

Note: Here, small craft mean ships of roughly 500 GT class or less, which mainly use small craft basins; very large ships mean ships of roughly 50,000 GT class or greater, which mainly use large-scale dolphins or offshore berths; and medium/large ships mean those other than small craft or very large ships.

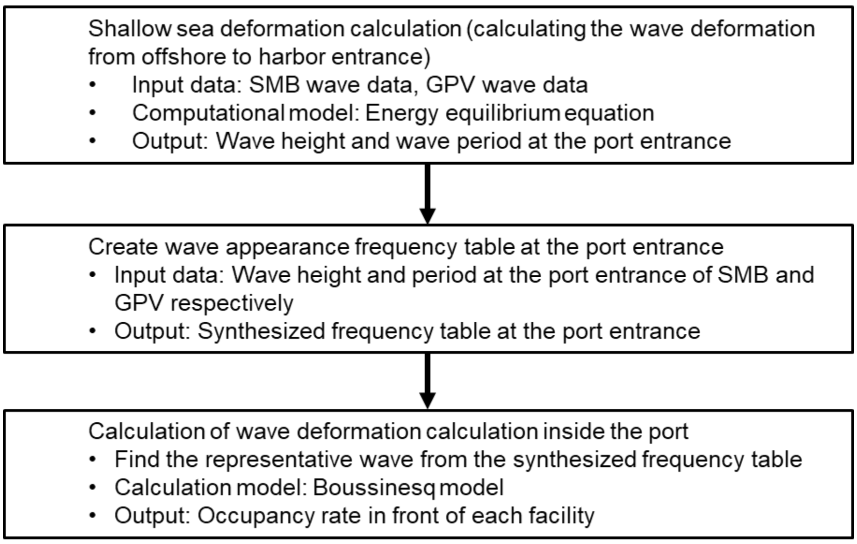
Source: Technical standards and Commentaries for Port and Harbor Facilities in Japan (OCDI, 2020)

158. The critical wave heights for fishing boats and small ships at the fishing port shall be set at 30cm as shown in Table 5-14.

159. The critical wave height for 160,000DWT (15,000TEU) class container ships is not calculated in "Evaluation Manual for Impacts of the Long Period Waves on Port". However, considering ship movement by waves would be smaller in the case of 160,000DWT class than in the case of 50,000DWT class, the critical wave height in front of NCT2 and NCT3 can be set at 0.7m which is the minimum value of the critical wave height for the very large ships.

5.3.3 (2) Calmness Analysis

160. Using the SMB wave data and GPV wave data obtained in 3.4.4, the calmness analysis was conducted by follow procedure (see Figure 5-9).



Source: JICA Survey Team

Figure 5-9 Access Channel and Navigation Routes in SHV Port

161. Table 5-15 shows the occupancy rate in front of the facilities. As can be seen from the table that the occupancy rate is 97.5% or higher at all facilities.

Table 5-15 Input waves for calculation of wave height distribution in SHV Port

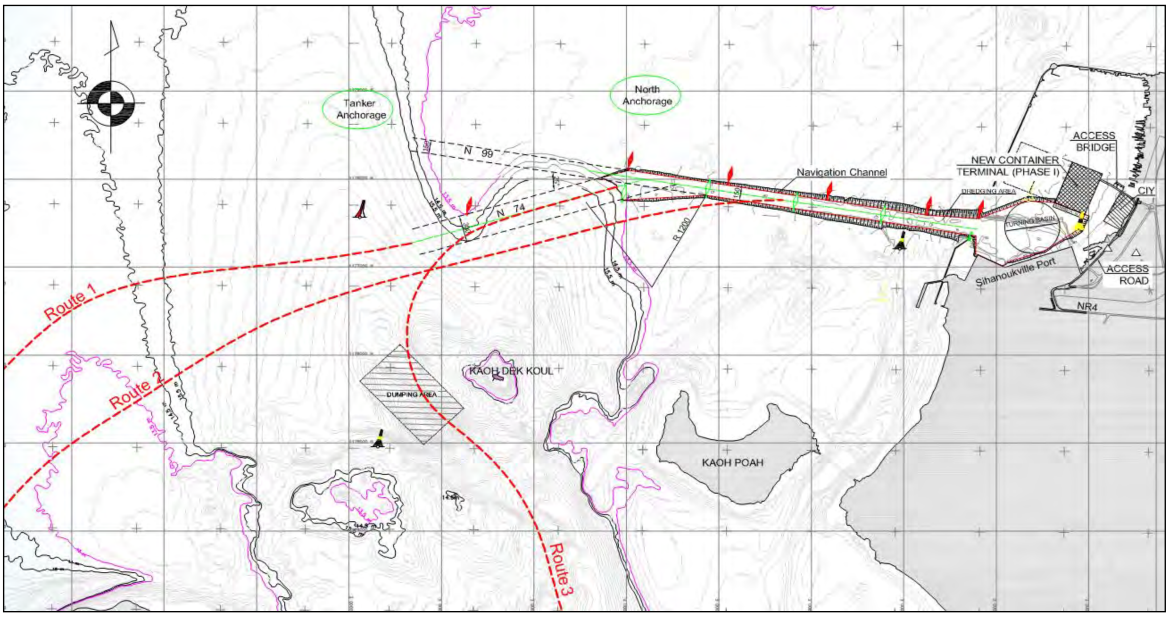
Calculating scenarios		Facility	Limited wave height (m)	Occupancy rate (%)
1	「NCT1,2,3」 completed, No breakwater	(1) MPT	0.5	99.4
		(2) Existing CT	0.5	97.9
		(3) NCT1	0.7	99.4
		(4) NCT2	0.7	99.4
		(5) NCT3	0.7	98.9

Source: JICA Survey Team

5.3.4 Channel and Basin Plan

5.3.4 (1) Channel

162. The channel alignment and the sailing routes are shown in Figure 5-10. Length, width and depth of the existing channel are about 4.5km, 150m and 12.0m, respectively. The width of the channel maintains at 150m for the planned NCT1 with a turning basin of 13.5m in depth and 600m in diameter.



Source: JICA Survey Team

Figure 5-10 Access Channel and Navigation Routes in SHV Port

163. Since the channel length is only 4.5km, ships can pass the channel in 30 minutes at a sailing speed of 5 knots. In the worst-case scenario, a ship could reach the port in about one hour even if the channel is occupied by other entering ship and an out-going ship in the case of a one-lane channel. Judging from the number of ship calls, a one-lane channel would not hinder the port operations. Therefore, a one-lane lane channel is deemed to be sufficient for SHV Port.

5.3.4 (1) a Channel Width

164. The width of a channel depends on the ship width, sailing speed, the degree of oblique sailing due to winds and currents, gradient of the channel dredging slope and positions of navigation buoys. Planning standards for channel width are given in "Technical Standards and Commentaries for Port and Harbour Facilities of Japan (2020)" and "Harbour Approach

Channels Design Guidelines of PIANC (2014)".

165. Based on the major planning conditions shown in Table 5-16, the required width of the channel is calculated by applying the above two standards.

Table 5-16 Planning Conditions of Channel Width

Planning Conditions	Value
Ship size	15,000TEU, 160,000DWT
LOA	370m
Breadth	52m
Draft	Actual:13.0m（Full:16m）
Sailing speed	5 knots
Wind velocity	12m/s
Current velocity	1 knot
Gradient of channel dredging slope	1:15
Interval of buoys	500m

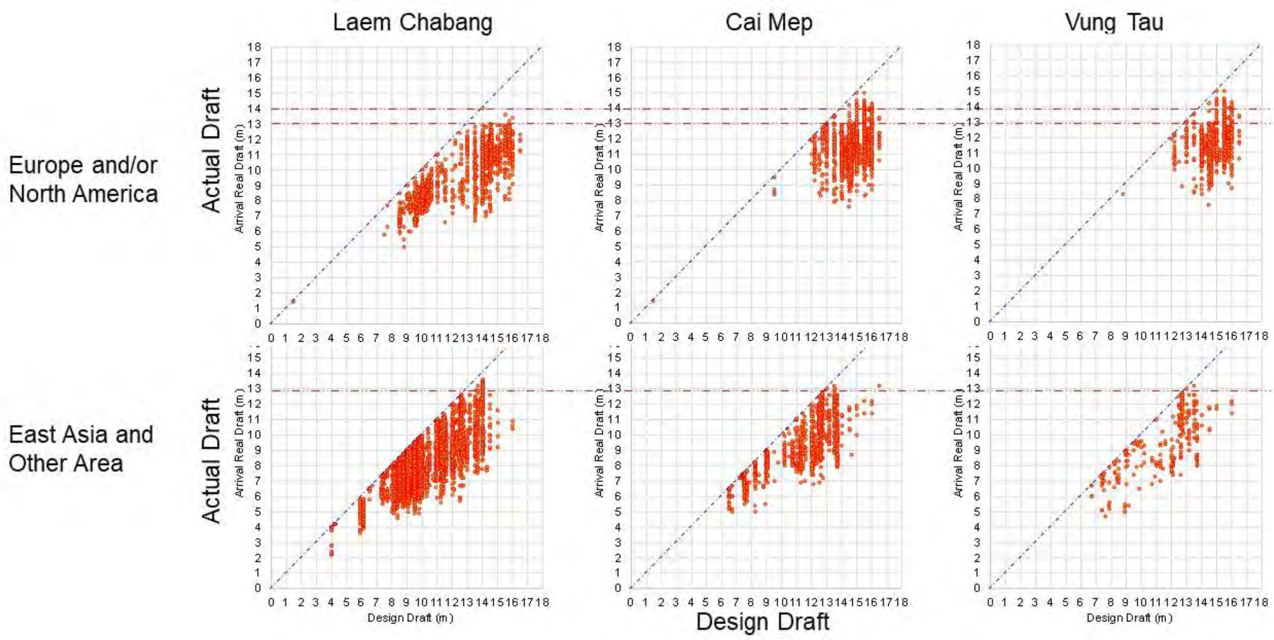
Source: JICA Survey Team

166. The channel width determined from Japanese standards and PIANC standards are 193.8m and 192.4m respectively, thus the required channel depth of SHV Port is recommended to be set at 200m.

5.3.4 (1) b Channel Depth

167. The actual entry/exit drafts of container ships calling at LCB Port and CMP Port differ depending on the handling volume at each port. For this reason, the AIS database (January 2019-October 2020) was used to analyze the design drafts (full-load drafts) of ships entering the port and the drafts entering and leaving the port.

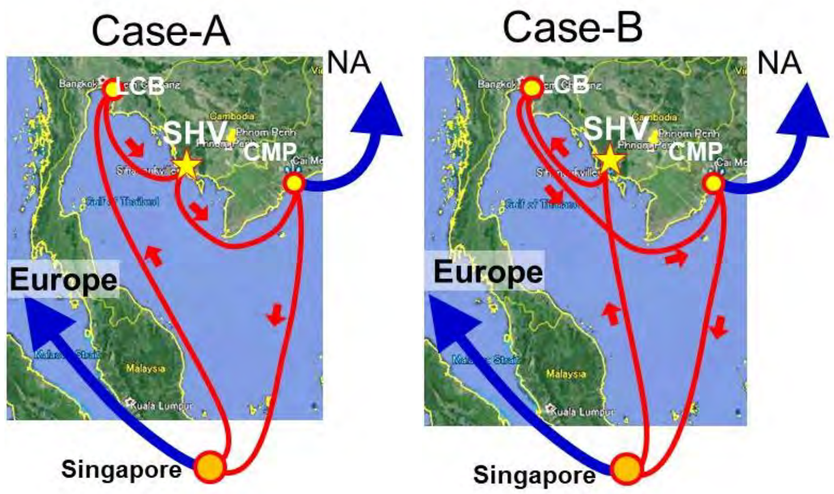
168. Based on the drafts at the time of actual entry at each port, there are very few cases where ships with the draft of 13 m or more enter LCB Port. However, ships with drafts of approx. 14.5 m have called Kai Mep Port and Vung Tao Port.



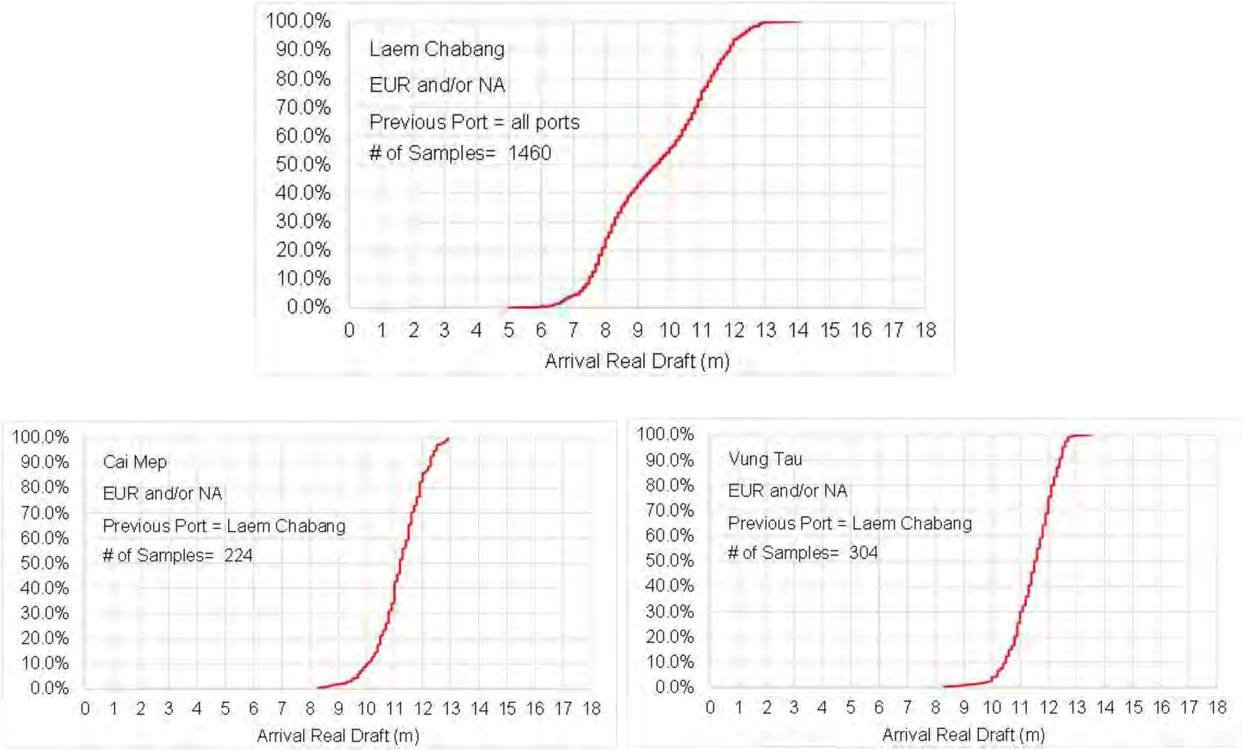
Source: Prepared by JICA Survey Team from the AIS Database

Figure 5-11 The Relation between Entering Drafts and the Design Draft (full) at LCB Port and CMP／VUT Port by Shipping Routes

169. As described in the section 5.1 "Basic Policy for Port Planning", the water depth of the channel and basin is examined in consideration of the calling pattern at SHV Port by the trunk shipping services, i.e., Case-A and Case-B.



170. The figure below shows the cumulative curve of the actual arrival draft at LCB Port and the actual arrival draft CMP/VUT after departure from LCB Port based on AIS data. It is found that vessels with a draft of -13 m or less cover almost all the vessels.



Source: JICA Survey Team based on AIS data

Figure 5-12 Actual Arrival Draft Calling at LCB Port and CMP/VUT Port

171. Based on the above analysis and considering the actual arrival draft at LCB Port and CMP/VUT port, the depth of the channel and basin are to be planned for vessels with a draft of -13m.

172. The depth of the channel must be set in consideration of the under-keel clearance associated with the sway (rolling, pitching, heaving) of a vessel during her navigation. Taking this into consideration, the water depth should be basically set to 1.1 times of a vessel's draft in a port or on a navigation route without influence of big swells in the sea. Therefore, the required channel depth is -14.5m for a vessel with a draft of -13m. In addition, since the possibility and frequency of large container vessels calling at the port, which is a factor in determining the design depth of the channel of SHV Port, depends on the container demand, the -14.5m would be appropriate depth to reduce the initial dredging cost particularly when the demand is not large at the beginning stage.

5.3.4 (2) Basin

5.3.4 (2) a Turning Basin

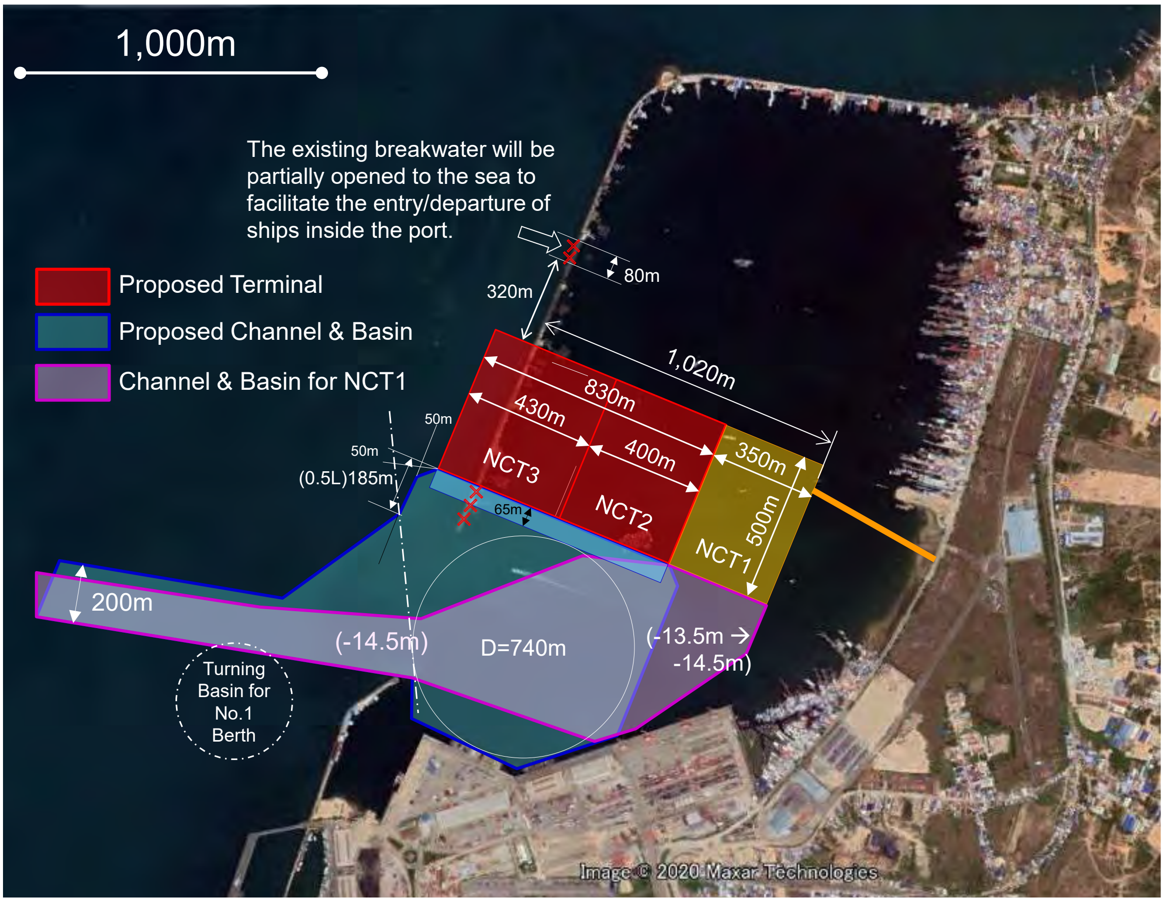
173. The diameter of a turning basin varies by ship length and the way of ship turning. According to the Japanese technical standards for port facilities, the diameter should be 3 times the length of a ship in the case of a ship that turns using its own propulsion power while the diameter should be 2 times the length of a shape in case of using tugboats.

174. PIANC technical standards state that the ship turnings are often assisted by tugs and the required diameter of a turning basin varies depending on whether tugboats are used and the surrounding physical conditions, In principle, the diameter of a basin should be larger

than 2 times the length of a ship.

175. Consequently, the required diameter of the turning basin for container ships of 15,000 TEU (LOA:370m, full draft:16m, actual draft:14m) can be determined at 740m.

176. As a result, the layout of the channel and turning basin of SHV Port is set as shown in Figure 5-13.



Source: JICA Survey Team

Figure 5-13 Configuration and Layout of the Turning Basin

177. Since the depth of the turning basin shall correspond to the depth of the channel, the water depth of the turning basin for 15,000 TEU container ships shall be set at 14.5m.

5.3.4 (2) b Basin in front of the Berth

178. As mentioned earlier, it is assumed that large size container ships will not enter the port with full draft until sometime in the future. However, as they will call in future when the cargo handling volume increase, it is necessary to consider the entrance of full draft ships. Thus, the structure of quaywall shall be designed considering the maximum dimensions of the design ship of 15,000 TEU with full draft of 16.9m. Consequently, the design depth of the quaywall shall be 17.5m.

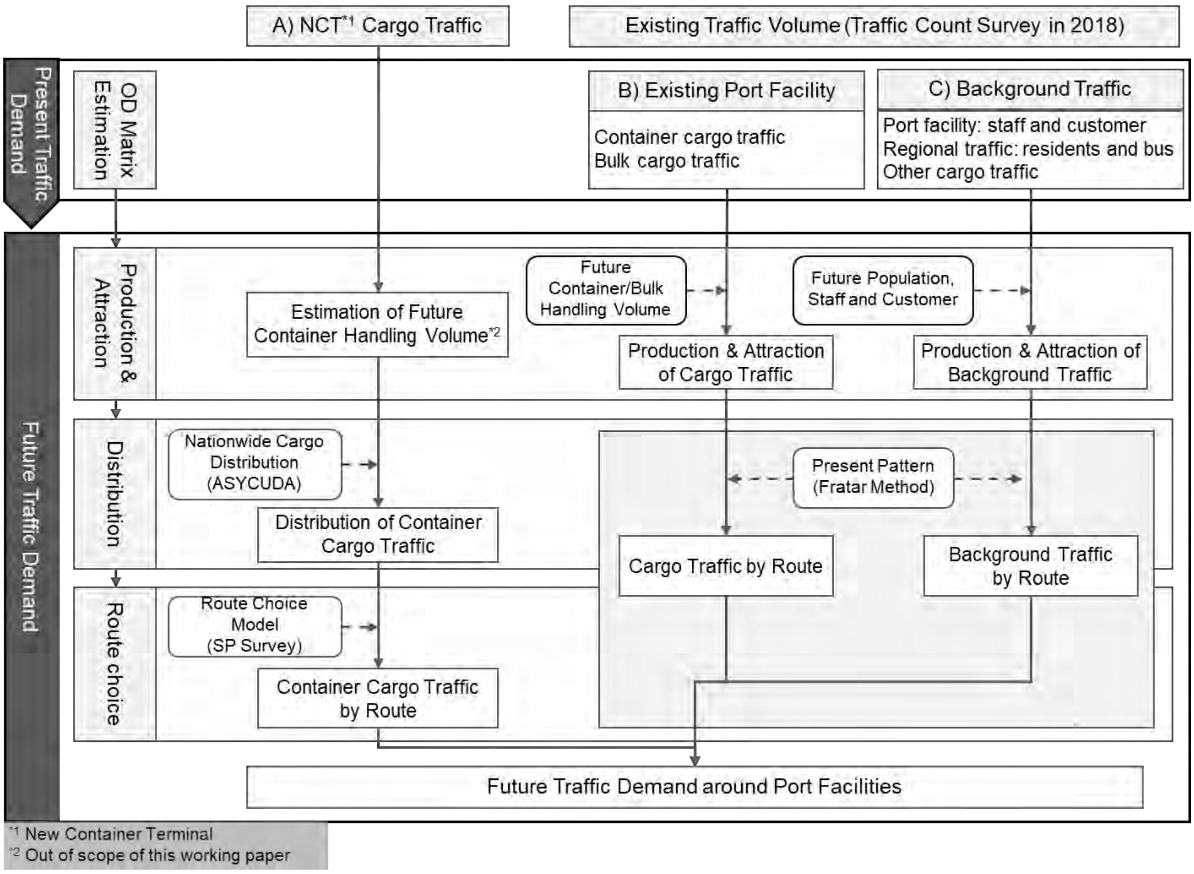
179. The width of the basin in front of the quaywall shall be determined considering the width of the design ship and additional width equivalent to 25% of the ship width for possible lateral movement of ships to an adjacent berth.

5.3.5 Access Road Planning

5.3.5 (1) Traffic Demand Forecast

5.3.5 (1) a Outline of Traffic Demand Forecast

180. Workflow of traffic demand forecast is illustrated in Figure 5-14. It is assumed that traffic demand of the access road and the road sections around the port is classified into three categories, namely A) new container terminal cargo traffic, B) existing port facility cargo traffic and C) background traffic. At the first step, current traffic volume, which are composed on B) existing port facility cargo traffic and C) background traffic, are estimated from the present traffic volume survey conducted in 2018. These estimated present traffic volumes were used as the basis of future traffic demand forecast, of which process is mainly composed of three steps; namely, trip production and attraction, trip distribution and route choice.



Source :JICA Survey Team

Figure 5-14 Workflow for Traffic Demand Forecast

5.3.5 (1) b Future Traffic Volume Generated by New Container Terminal

i) <u>Production and Attraction</u>

181. According to the Middle Growth Scenario of cargo demand forecast, the throughputs of SHV Port in 2035 and 2050 were estimated at 2.16 million TEU/year and 3.46 million TEU/year respectively. Assuming that the existing CT operates at its capacity of 0.77 million TEU/year from 2026, the commencement year of NCT1, the cargo demand of the new container terminal is estimated at 1.38 million TEU/year in 2035 and 2.69 million TEU/year in 2050.

ii) Distribution

182. To convert from container volume into vehicular traffic volume (i.e., trailer), share of container size (20ft, 40ft, and 45ft) and ratio of two 20ft container per trailer were applied. Moreover, it is assumed that for transporting an export container, a trailer enters the port to unload the container and returns empty, and for transporting an import container, an empty trailer enters the port to load the container and leave the port. Table 5-17 and Table 5-18 shows the distribution of container trailer in 2035 and 2050 respectively.

Table 5-17 Distribution of Container Trailer Traffic in 2035 (vehicle/day)

			Preah Sihanouk			Phnom Penh and all other provinces	Kampot and Takeo	Total
			SHV Port NCT	SPSEZ	Preah Sihanouk			
			1	2	3	4	5	
Preah Sihanouk	SHV Port NCT	1		4	644	2,228	111	2,987
	SPSEZ	2	4					4
	Preah Sihanouk	3	644					644
Phnom Penh and all other provinces		4	2,228					2,228
Kampot and Takeo		5	111					111
Total			2,987	4	644	2,228	111	5,973

Source : JICA Survey Team

Table 5-18 Distribution of Container Trailer Traffic in 2050 (vehicle/day)

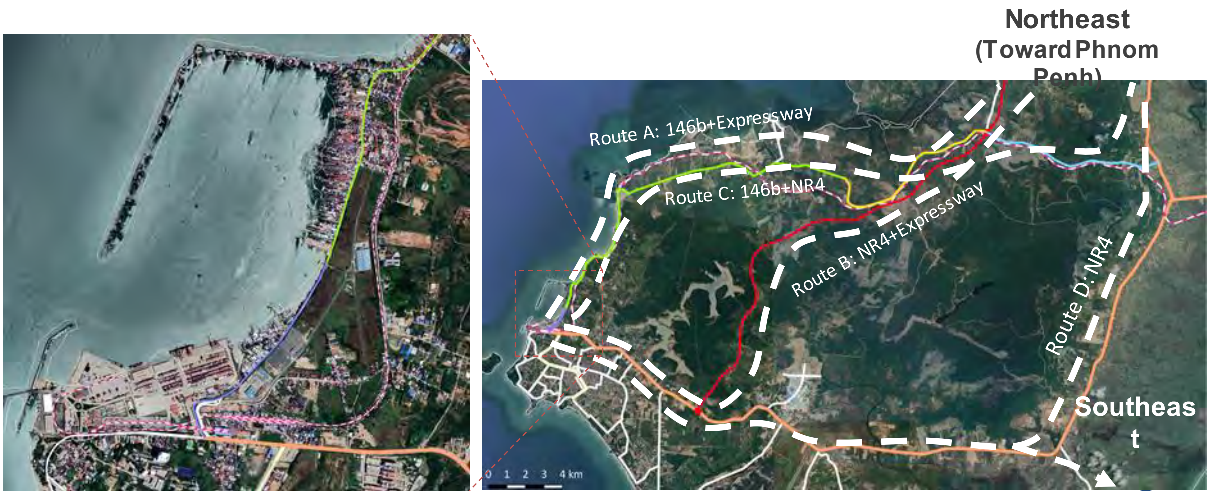
			Preah Sihanouk			Phnom Penh and all other provinces	Kampo t and Takeo	Total
			SHV Port NCT	SPSEZ	Preah Sihanouk			
			1	2	3	4	5	
Preah Sihanouk	SHV Port NCT	1		8	1,253	4,337	216	5,814
	SPSEZ	2	8					8
	Preah Sihanouk	3	1,253					1,253
Phnom Penh and all other provinces		4	4,337					4,337
Kampot and Takeo		5	216					216
Total			5,814	8	1,253	4,337	216	11,627

Source : JICA Survey Team

iii) Route Choice

183. From the distribution of container trailer traffic, the route choice probability of four (4) different routes shown in Figure 5-15 for the O-D pair [1.SHV Port NCT] – [4. Phnom Penh and all other province] was estimated by discrete choice model. Other four zone pairs, the traffic was assigned to specific routes based on the shortest path.

184. The estimated route choice probabilities are shown in Table 5-19.



Source : JICA Survey Team

Figure 5-15 Location Map of Four Alternative Routes for Container Trailer between PNP and NCT

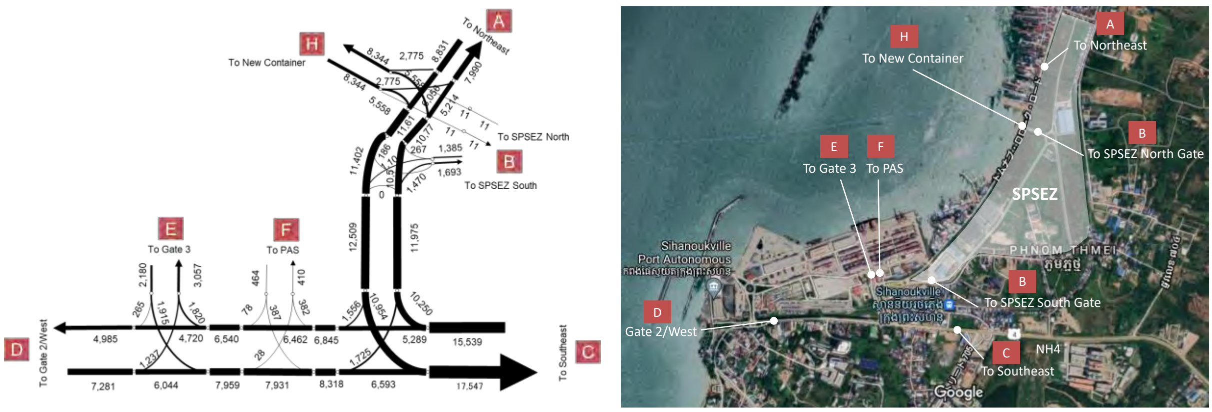
Table 5-19 Route Choice Probability based on Nested Logit Model

Choice probability of Alternative Routes	
A (Expressway + Road146b)	17.0%
B (Expressway + NR4)	9.3%
C (NR4 + Road146b)	27.6%
D (NR4 + NR4)	46.1%
Choice probability of Access Road to NCT	
North	44.6%
South	55.4%

Source : JICA Survey Team

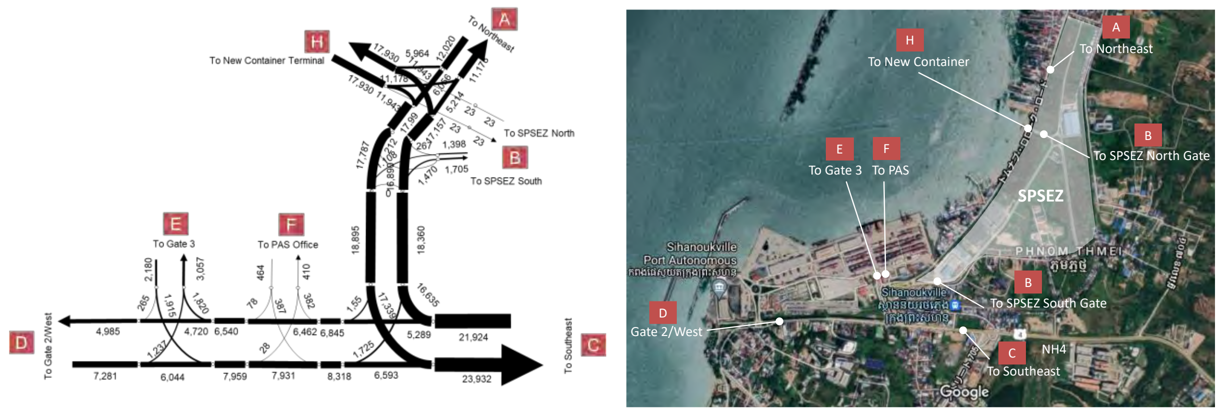
5.3.5 (1) c Results of Traffic Demand Forecast

185. The directional traffic volume in 2035 and 2050 were summarized and illustrated in Figure 5-16 and Figure 5-17 respectively.



Source : JICA Survey Team

Figure 5-16 Directional traffic volume in 2035 (pcu/day)



Source : JICA Survey Team

Figure 5-17 Directional traffic volume in 2050 (pcu/day)

5.3.5 (2) Access Road Plan

5.3.5 (2) a Basic Policy of Access Road Plan

186. Future increases in traffic volume, the opening of new land transportation routes through Road146b and Road148, and the opening of PNP-SHV Expressway will be considered in this study. The basic policy of access road widening improvement plan that maximizes the effect of the new container terminal is shown below.

- Planning of safe and satisfying road improvement for vehicular traffic to the terminal
- Planning of road improvement to minimize adverse effects on local residents

187. Access road improvement is planned with due consideration of the following necessary points.

- An appropriate access road widening improvement or new road development that contributes to smooth traffic is planned in consideration of the traffic lines (including connectivity between the old and new terminals) around the new SHV Port planned site.
- The traffic flow between the new SHV Port and the SEZ will be optimized.
- An access road will be planned as needed based on the surrounding road in 2035 when NCT1~3 are already in operation and future planned target year (2050) including the expansion.

5.3.5 (2) b Basic Conditions for Number of Lane Plan

188. Table 5-20 shows the design criteria to study number of lanes.

Table 5-20 Design criteria

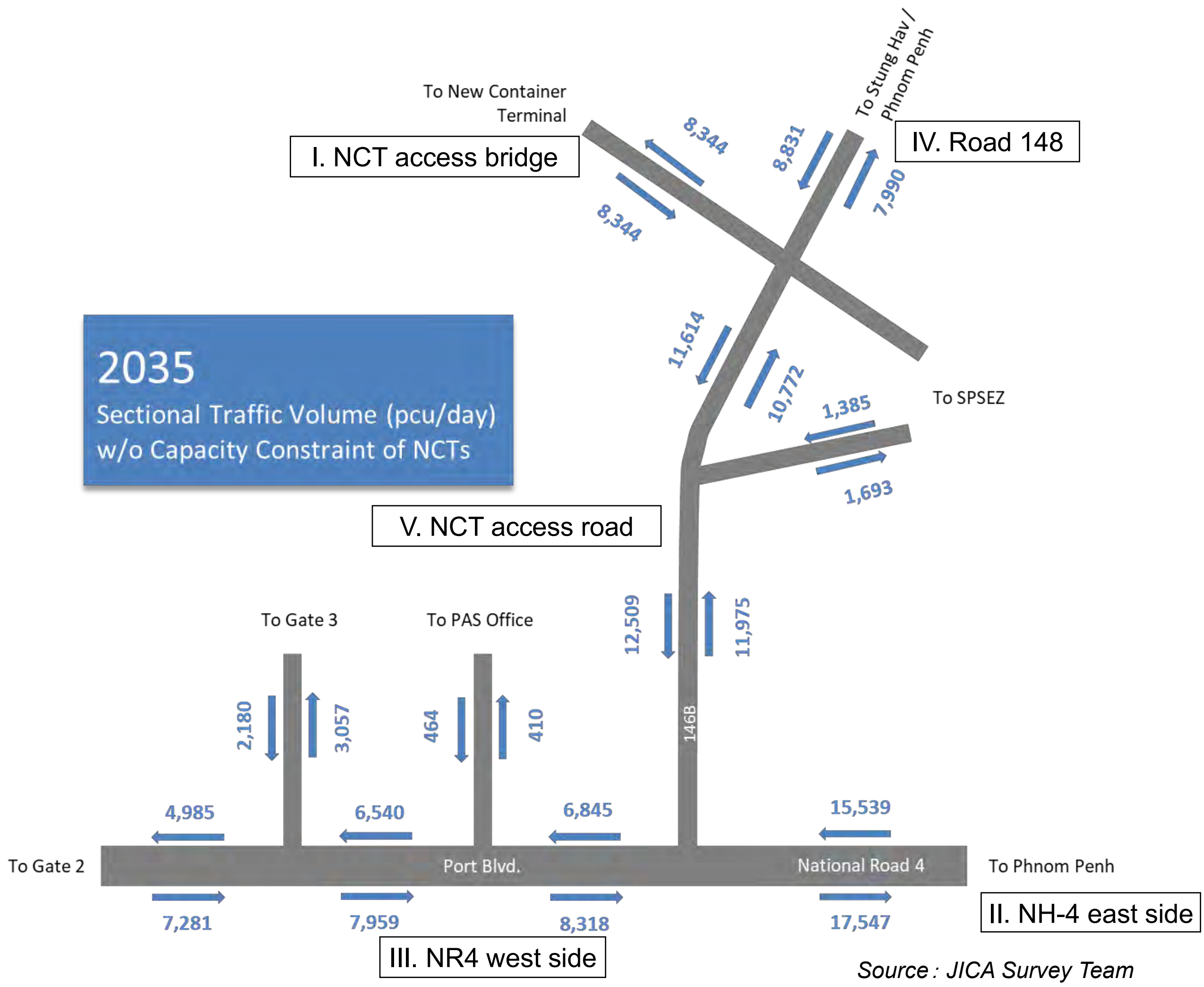
Name of road	Traffic Capacity (pcu/day)	Level of Service
NR4	900	B
Road148	1101	C
NCT access road, NCT access bridge	1401	C

Source : JICA Survey Team

5.3.5 (2) c Checking of Design Number of Lane by Traffic Volume in 2035 and 2050

189. The required number of lanes is calculated based on the results of the above-mentioned

future traffic estimation. Figure 5-18 shows the future traffic volume in 2035.

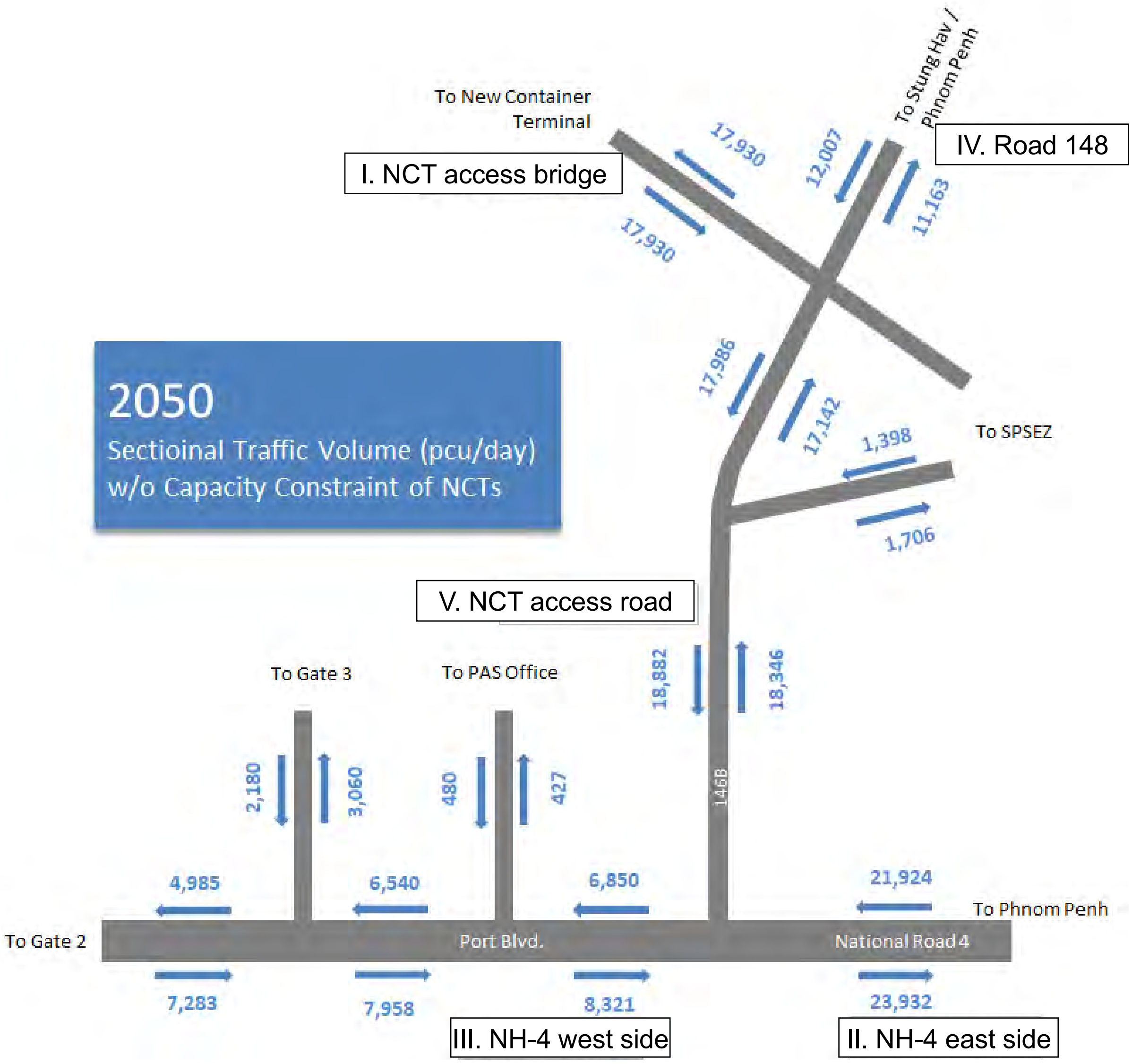


Source : JICA Survey Team

Figure 5-18 Traffic volume in 2035（pcu/day）

190. Based on the traffic volume shown above, traffic processing will be possible depending on the number of lanes on each access road currently under construction in 2035 after the opening of NCT1-3. However, the number of lanes on NR4 is calculated to be 1.95, and it is assumed that the traffic capacity is almost reaches the limit.

191. Figure 5-19 shows the results of future traffic volume estimation in 2050, which is the target of the future full port development.



Source : JICA Survey Team

Figure 5-19 Traffic volume in 2050（pcu/day）

192. Based on the traffic volume shown above, 2 lane (1 lane, 1 direction) of NCT access bridge, NR4 (east side), Road148 and road146b should be necessary to be widening the number of lanes in order to smoothly allow access.

5.3.6 Relation with SPSEZ

193. Relevant organizations including PAS are currently examining how to apply a "Free Port" concept to the SPSEZ which is located just behind SHV Port. Forging good relations with the SPSEZ will be important for the effective operation of the new container terminals (NCT1 to NCT3). However, since the SPSEZ is located outside the port bonded area, traffic between SPSEZ and new container terminals or the existing CT must be via public roads (Route 148). In the long run, when the illegal residents between the access bridge and the existing CT are successfully relocated, these three areas, i.e., New CT, the existing CT and SPSEZ would be operated in an integrated manner physically and systematically.

Source: JICA Survey Team

Figure 5-20 Relation among New CT, Existing CT and SPSEZ

194. It is critical for companies in the SPSEZ to secure a smooth traffic flow (of import/export cargo) between NCT and SPSEZ on the premise of bonded transportation. Therefore, it is desirable to secure direct access from the access bridge to the SPSEZ or vice versa. However, since it shall cross the public road (No.148), it is necessary to take measures such as opening the gate linking both bonded areas in a specific time and providing temporary gates in the NCT side and SPSEZ side. Similar measures are also required for CFS-related cargo generated in the SPSEZ.

195. Another potential cargo that may be transported between the new CT and SPSEZ is transshipment cargo that is stored in the SPSEZ for a while after arrival at the new CT or the existing CT and is exported again. There is no such cargo at present and it is difficult to estimate the future volume of such cargo. However, PAS believes that securing a traffic flow for such transshipment cargo will become necessary in the long term.

5.4 Long-term Port Development Plan

5.4.1 Setting of the Long-term Port Development Options

196. In formulating the development plan of NCT2 and NCT3, it is necessary to identify possible advantages and disadvantages related to the following key planning options for future mid-term and long-term port development in advance.

1) Channel alignment (direction, channel width and channel depth)
2) Difficulty in channel dredging
3) Location and length of breakwater required for securing the calmness of basin.
4) Layout of the future mid-term and long-term port development
5) Entries/departures of fishing boats to/from the existing fishery port

197. The points to be considered in the formulation of port development options as well as advantages and disadvantages of each option are described in Figure 5-21 and Table 5-21.

Table 5-21 Points to be Considered in Formulating Development Options and Advantages and Disadvantages of each Option

Key points		Advantages	Disadvantages
Direction of Terminal Configuration	Same direction with NCT2, NCT3 (A-1, A-2)	･It is easy to secure the turning basin for the future terminal.	･Long access channel to the existing channel is required.
	Same direction with the existing channel alignment (B-1, B-2)	･Wave protection effect is expected for compensating the negative impact of the breakwater demolishment due to the development of NCT2 and NCT3. ･Access channel to the existing channel is shorter than B-1 or B-2.	･It is hard to secure the turning basin for the future terminal.
Direction of Slip	Toward offshore (A-1, B-1)	･No particular advantage is found.	･Ensuring calmness against waves from the west is a concern.
	In parallel with coastline (A-2, B-2)	･Effective use of the existing channel.	･No particular disadvantage is found.

Source: JICA Survey Team

A-1
The same direction with NCT2, NCT3
with the basin open to the west

A-2
The same direction with NCT2, NCT3
with the basin open to the south

B-1
Direction toward the existing channel
with the basin open to the west

B-2
Direction toward the existing channel
with the basin open to the south

Source: JICA Survey Team

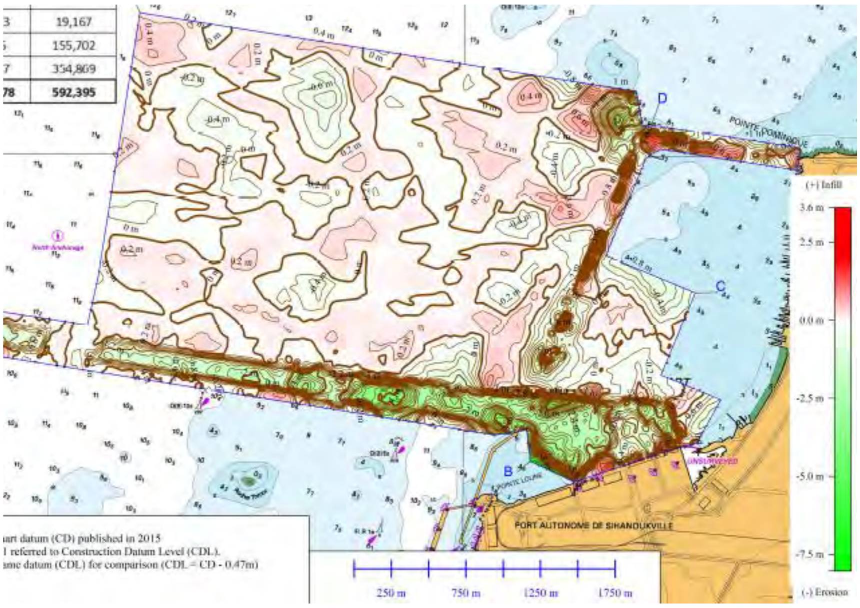
Figure 5-21 Concept of Development Options

5.4.2 Comparison of Long-term Port Development Options

5.4.2 (1) Technical Considerations in Comparing Development Options

5.4.2 (1) a Water Depth change of planned Long Term Development Area

198. In order to grasp the status of sedimentation and scouring on the seabed surface due to currents and waves in the long-term planned water area, the bathymetric survey in 2021 and the chart made under JICA Technical Cooperation Project for Production of Integrated Digital Terrain Model and Electric Navigational Chart in the Kingdom of Cambodia" in July 2013 to December 2016, were compared, and the difference in water depth is only about 0.2 m. From this result, it is thought that a big seabed change was not occurred in the seabed configuration in this water area as long as the balance of the sedimentation and the scouring is stable and was not collapsed by an artificial structure.



Source: JICA Chart (2015), JICA Survey Team (2021)

Figure 5-22 Comparative Water Depth Change in Long Term Planned Area

5.4.2 (1) b Relation between Long Term Plan Layouts and Relevant Water/Rock Layer Depth

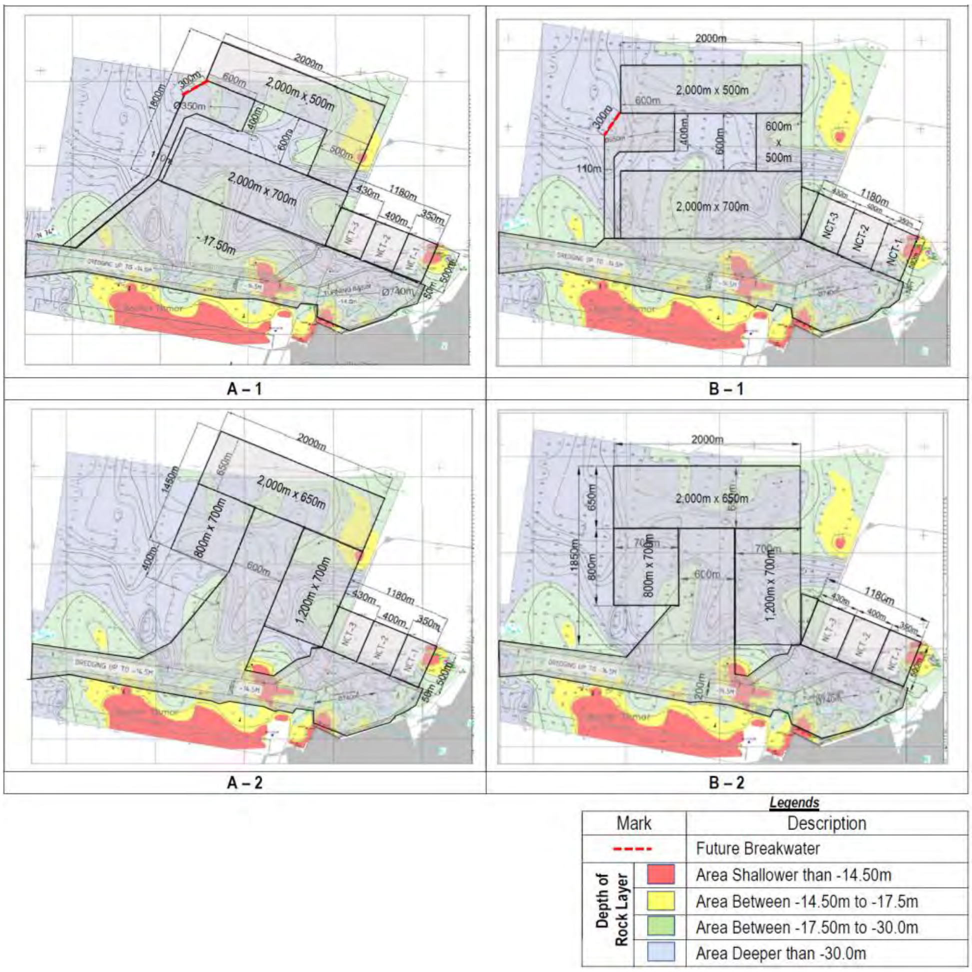
199. As described above, due to the large water depth of the planned area and the existence of shallow rock layer in some areas, it is necessary to pay attention to the following points such as depth of water, depth of rock strata and quay layout, volume of reclamation fill/dredging, etc. of the target water area in order to make it an efficient plan in terms of construction costs.

- The volumes of dredging and reclamation fill should be balanced at most with avoiding rock area as much as possible.
- Depending on the unbalanced dredging volume, the capacity of offshore dumping area at southwest of Koh Dek Koul Island, which is currently planned to increase area, will be insufficient, and the dump area will need to be expanded further. Still, if it is insufficient, then it is necessary to move the dump site to the far offshore, and the dredging work unit price rises according to the dump distance.

- When the rock layer depth is shallow, there is a possibility that other structural types such as gravity type may be applied instead of the pile type due to restricted embedment pile depth. However, the gravity structure at deep water is also expected to be difficult, so it is necessary to carefully consider and determine the terminal layout.
- The length of perimeter revetment/seawall should be utilized for the quay for effective usage of existing deep water as much as possible.
- Since the soft layer thickness increases compared to the area of NCT1-3, the subsoil consolidation settlement will increase to approximately 3 to 4 m, effective soil improvement should be considered to minimize the construction cost and duration.

5.4.2 (1) c Comparison of Long term Plan Layout and Distribution of Soil Layers

200. The comparison of layouts of each long term plan by overlapping the soil layer distribution map is shown in Figure 5-23. Since the capacity of the current offshore soil dumping area is insufficient for dredged soil volume, it is assumed that all of the dredged soil will be diverted as a landfill material and ground improvement will be carried out.



Source: JICA Survey Team

Figure 5-23 Comparison of Rock Layer Distribution and Long Term Terminal Plan Layouts

5.4.2 (2) Comparison of Middle/Long-term Port Development Options

201. General comparison of the long and middle-term port development options as shown in

Table 5-22, which shows relatively high score for the Plan B-2.

Table 5-22 Comparison of the Development Options

Evaluation Items		Plan A-1	Plan A-2	Plan B-1	Plan B-2
Securing calmness of NCT2 and NCT3		No effect on increasing calmness in front of NCT2 and NCT3	No effect on increasing calmness in front of NCT2 and NCT3	○Wave sheltering effect against waves from the west is expected.	○Wave sheltering effect against waves from the west is expected.
Securing calmness of the container berths in the long-term plan		△Breakwater may be required on the west side.	△Breakwater may be required on the west side.	○No problem in securing calmness.	△Breakwater may be required on the west side.
Ship Maneuvering		○No problem in ship maneuvering with the provision of a turning basin near the berths.	○No problem in ship maneuvering with the provision of a turning basin near the berths	X Ship maneuvering may be difficult due to the location of the turning basin at the innermost area.	○No problem in ship maneuvering with the provision of a turning basin near the berths.
Maneuvering of fishing boats		△Ship maneuvering may be difficult due to the narrowness of the water area between the existing breakwater and the planned revetment.	△Ship maneuvering may be difficult due to the narrowness of the water area between the existing breakwater and the planned revetment.	○No problem in ship maneuvering due to the wide water area available off the expected opening portion of the existing breakwater.	○No problem in ship maneuvering due to the wide water area available off the expected opening portion of the existing breakwater.
Construction of general cargo berths		△Thin layer (50cm) dredging for channel and basin is required. For locating the berths at the end of the slip, dredging of 0.5 to 4m in thickness is required.	○Channel and basin for the container terminal can be utilized.	△Thin layer (50cm) dredging for channel and basin is required. For locating the berths at the end of the slip, dredging of 0.5 to 4m in thickness is required.	○Channel and basin for the container terminal can be utilized.
Possibility for future expansion		○Future terminal expansion is possible toward the north but dredging of the basin is required at the existing shallow water area.	○Future terminal expansion is possible toward the north but dredging of the basin is required at the existing shallow water area.	◎Future terminal expansion is possible toward the north.	◎Future terminal expansion is possible toward the north.
Construction cost (M.US$)	Terminal	1.00	0.92	1.08	0.97
	Channel/Basin	1.00	0.76	0.72	0.75
	Access Road	1.00	1.00	1.14	1.14
	Total construction cost	1.00	0.89	0.98	0.95
Overall evaluation		△	○	△	◎

Note) Procurement cost of cargo handling equipment is not included in the construction cost. The relative construction costs calculated for evaluation of alternative plans are based on the unit prices as of August 2020 in the NCT 1 project.

◎: Excellent, ○: Good, △: Fair, X:Inferior

Source: JICA Survey Team

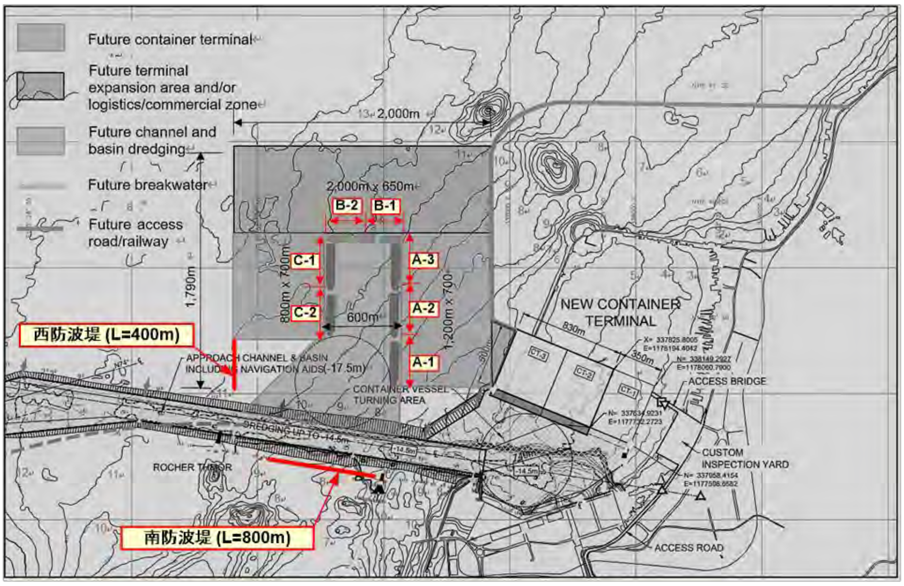
5.4.3 Calmness of the Port (Long Term Plan Option B-2)

5.4.3 (1) Required Calmness

202. In the calmness analysis of Long Term Plan Option B-2, as same as the required calmness set in 5.3.3 (1), the critical wave height for cargo handling works were determined as 0.7 m for quay accommodative to 160,000 DWT container vessel and 0.5 m for quay to 50,000 DWT container vessel.

5.4.3 (2) Calmness Analysis

203. With seven (7) wave directions of the representative waves, four (4) port formation cases such as Case 1: Without Breakwater, Case 2: "With West Breakwater, Case 3: With South Breakwater and Case 4: With West and South Breakwaters were considered into the calculation of the harbor wave height distribution. The evaluation points of the calmness analysis were specified for each quay. (refer to Figure 5-24).

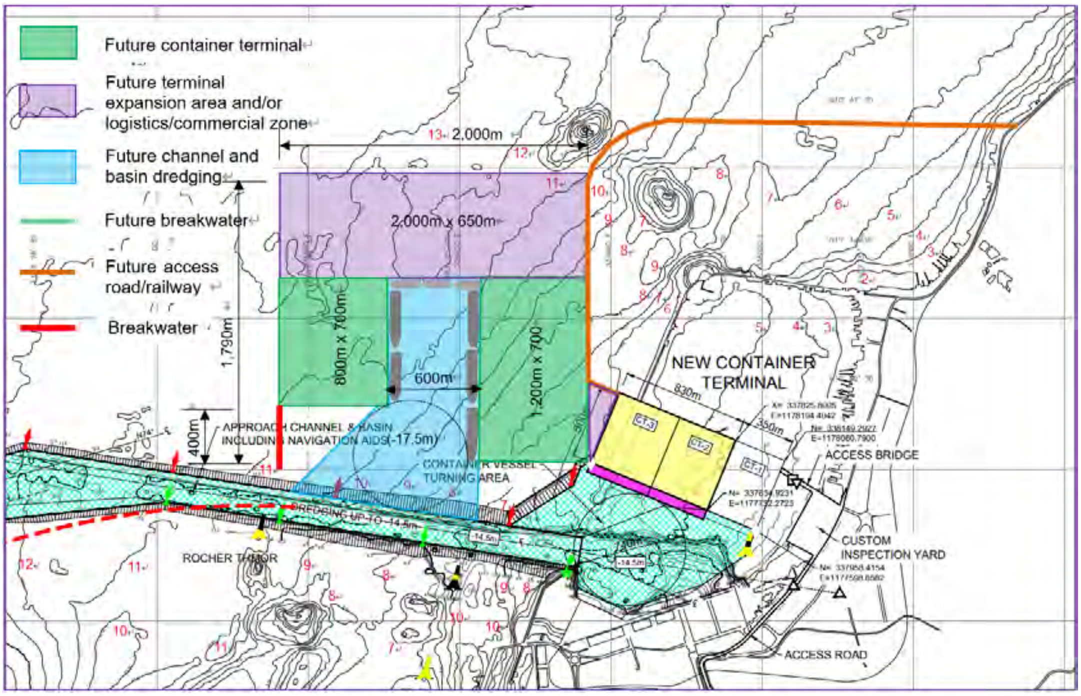


Source: JICA Survey Team

Figure 5-24 Calmness Evaluation Points and Breakwater Locations

204. The occupancy rates of the point A-1 at Case 1 and Case 3 were not satisfied with 97.5%. The results implied that the incident waves coming from west side is dominant rather than the waves coming from south side, so the wave protection for the waves from west side would be required accordingly. Therefore, the Plan B-2 may possibly require to provide a breakwater in the west side to satisfy the occupancy rate for all quays.

205. The proposed final layout of the long-term plan is shown in Figure 5-25. However, before finalizing the long-term plan, a further detailed study for evaluating the necessity of breakwater will be required.



Source: JICA Study Team

Figure 5-25 Proposed Long-term Plan (Plan B-2)

Chapter 6 Conceptual Design of Port Facilities

6.1 Scope of Work

206. As mentioned above Chapters, the maximum target vessel for NCT2 is 10,000TEU (120,000 DWT) and maximum target vessel for NCT3 is 15,000 TEU (160,000 DWT). Scopes the works are illustrated in below table.

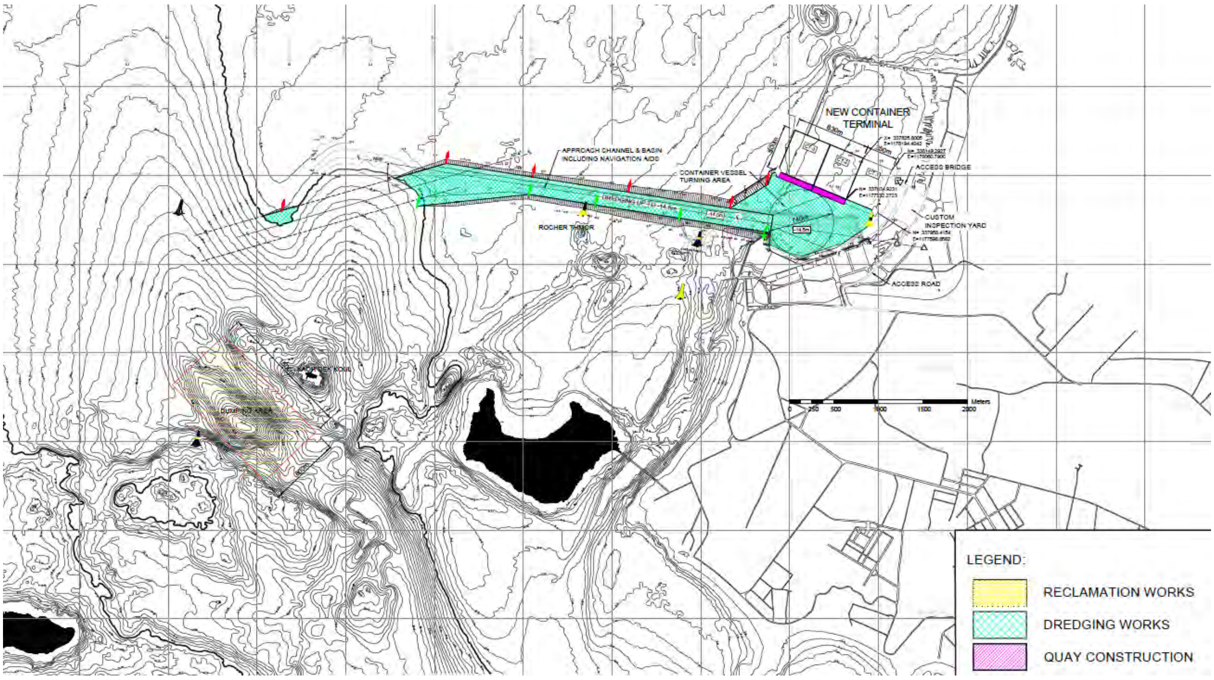
Table 6-1 Scope of Work

Work Items	NCT1 (For reference)	NCT2	NCT3
Quay	+Length: 350m +Width: 35m +Water Depth: 14.5m +Wave Dissipation +Deck on Pile Type	+Length: 400m +Width: 35m +Water Depth: 16.5m +Wave Dissipation +Deck on Pile Type	+Length: 430m +Width: 35m +Water Depth: 17.5m +Wave Dissipation +Deck on Pile Type
Dredging	4.5 million m^3	3.6 mil m3	1.1 mil m3
Breakwater	none	none	Removal and Transfer of Existing Breakwater: 200m removal (120m for NCT3 construction and 80 m for new entrance of existing fish port) and 500m transfer for NCT3 construction
Revetment	1350m	900m	930m
Reclamation	25.4 ha (including CIY(Customs Inspection Yard) and NRA (North Reclamation Area))	18.6ha	20.0ha
Container Terminal Yard	+Ground Slots with 5 stacks for laden containers: 1,920TEU (32,326 m^2), of which Ground Slots with 4 stacks for Reefer containers: 48TEU (1,035m^2) +Ground Slots with 4 stacks for Empty containers (Back yard): 240TEU (4,282m^2) +RTG lanes (8) and Truck Roads: (114,238m^2)	+2,592 Ground Slot and 5 stacks for Laden +60 Ground Slot and 3 stacks for Reefer +288 Ground Slot and 4 stacks for Empty +9 lanes for RTG	+2,808 Ground Slot and 5 stacks for Laden +72 Ground Slot and 3 stacks for Reefer +324 Ground Slot and 4 stacks for Empty +9 lanes for RTG
Terminal Facilities (Buildings)	+Admin. Office: 20x30 m^2 x 5 stories +M&E Workshop: 24x45 m^2 +Worker Building: 13x36 m^2	+Admin. Office (at NCT1): 20x20 m2 x 5 stories +M&E Workshop: 24x45 m2 +Worker Building: 13x36 m2 etc.	+M&E Workshop: 24x45 m2 +Worker Building: 13x36 m2 etc.
Terminal Facilities (Utilities)	Power receiving & transforming equipment, generators, power distribution system, water reservoir & pump house, water distribution system, firefighting system, yard lighting system, reefer power outlets etc.	Power receiving & transforming equipment, generators, power distribution system, water reservoir & pump house, water distribution system, firefighting system, yard lighting system, reefer power outlets etc.	Power receiving & transforming equipment, generators, power distribution system, water reservoir & pump house, water distribution system, firefighting system, yard lighting system, reefer power outlets etc.
Cargo Handling Equipment	QGC: 3 RTG: 9 Yard Trailers: 16 Reach Stackers: 2	QGC: 3 RTG: 10 Yard Trailers: 17 Side Handlers (or Reach Stackers): 2	QGC: 3 RTG: 10 Yard Trailers: 18 Side Handlers (or Reach Stackers): 2
System	Terminal Operation System (TOS)	Upgrade of TOS	Upgrade of TOS
Working Vessels	-	Tug Boat (4,000HP):2 Pilot Boat:1	
Access Road and Access Bridge	Access Bridge: 2 x 2 lanes Access road	-	-

Work Items	NCT1 (For reference)	NCT2	NCT3
Customs Inspection Area	200m×400m Port gates including Customs gates: 7 lanes x 2 directions (32x96 m2)、# of lanes for each direction is variable depending on the traffic volume. X-ray devices will be installed by the Customs Office.		

Source :JICA Survey Team

207. Figure 6-1 shows the Project site for NCT2 and NCT3 including dumping area.



Source: JICA Survey Team

Figure 6-1 Scope of Port Area including Access Channel and Off-shore Dumping Site

6.2 Basic Concept of Design

6.2.1 Design Standard

208. The standard and reference books which are used for the design of berth structure are as follows:

- Technical Standards and Commentaries for Port and Harbour Facilities in Japan (OCDI 2002, 2009 and 2020),
- Japanese Industrial Standards (JIS),
- British Standards (BS),
- Permanent International Association of Navigation Congresses (PIANC 2002),
- Port Designer's Handbook,
- Pile Design and Construction Practice 6th Edition, and
- Others

6.2.2 Design Vessel

209. As shown in the Chapter 5.2, The target ships for NCT2 and NCT3 for design of berth, turning basin and navigation channel are shown in the below Table 6-2.

Table 6-2 Design Vessel for Channel Basin Examination

Ship Dimension	NCT1(For reference)	NCT2	NCT3
Dead Weight Tonnage (DWT)	60,000 DWT	120,000 DWT	160,000 DWT
Carrying Capacity (TEU)	4,000 TEU	10,000 TEU	15,000 TEU
Length Overall (LOA)	285 m	350 m	370 m
Length between Perpendicular (LBP)	272 m	338 m	355 m
Breadth (B)	40 m	49 m	51 m
Full draft (d)	13.8 m	15.0 m	16.0 m

6.2.3 Planned Container Terminal Capacity

210. Planned container terminal capacity are as shown below,

- NCT2 570,000 TEU/Year
- NCT3 617,000 TEU/Year

6.2.4 Natural Conditions

211. Temperature, rainfall, wind, tide, current, wave, earthquake and soil condition are considered as environmental design conditions. Detailed Design Study for NCT1 were reviewed and the design criteria for natural conditions are set-up as below and as mentioned in the Chapter 3.

6.2.5 Tide Conditions for Design

212. Tide Conditions for Design are as below.

- LWL ±0.00 m (CDL)
- HWL +1.43 m

6.2.6 Design Waves

213. The design waves in Return Period 50 years estimated by wave analysis are as follow:

	NCT3 west side revetment		NCT3 north side revetment
To (s)	4.94		4.94
H1/3 (m)	1.63		1.5

Source: JICA Survey Team

6.3 Authority for Approval

214. Due to within the port limit area, the design and construction is mainly required to be approved by PAS basically. Approval authorities are summarized as below. environmental issues are approved by MOE and referred to Chapter 8.

Table 6-3 Approval Authorities

Approval Contents	Organization
Environmental approval for NCT2 and NCT3 (dredging, reclamation, dumping etc.),	MOE
Offshore construction approval	PAS
Approval for sand/stone material	MPWT
Approval for removal of light house tower at SEZ	PAS, States Gov.. MPWT

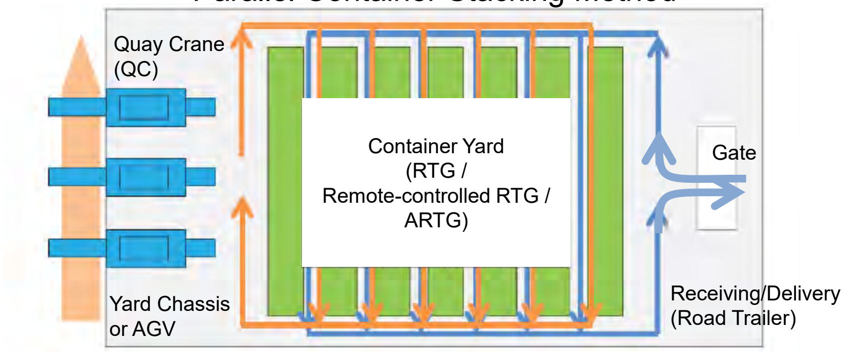
Source: JICA Survey Team

6.4 Container Handling Plan (Concept and Yard Layout)

6.4.1 Container Handling Planning Concept

215. NCT 2 and NCT3 are designed to be operated in unison with the adjacent NCT1, and as in NCT1, the RTG system has been adopted with the storage area arranged parallel to the quay. In addition, the location of the entrance and exit points, the flow line, the storage area, the cargo handling system, etc., were examined on the assumption that the gates for checking containers in and out would be centrally controlled gates that would manage NCT1, 2 and 3 together. In addition to the conventional manual loading and unloading system, the possibility of applying remote control and automation technology to the loading and unloading machines, which is being implemented in Japan, was also investigated and compared.

Parallel Container Stacking Method



Automated Level	Quay/Apron		Container Yard (CY)	Gate
	Quay Crane	Apron ⇔ CY	Yard Crane	CY ⇔ Gate
Manual Terminal	Manned QC	Yard Chassis	Manned RTG	Road Trailer
Level-1 (Remote-controlled yard)	Manned QC (or semi-automated*1)	Yard Chassis	ARTG (Remote-Controlled*1)	Road Trailer
Level-2 (Full Automation yard)	Manned QC (Dual Hoist Crane*2)	AGV	ARTG (Remote-Controlled)	Road Trailer

*1) There is no driver on board. A crane operated by a driver from a remote location to confirm safety operation and to respond in the event of a failure.
*2) The driver is on board, but a crane automatically moves to a predetermined cargo handling position with the touch of a button. Or such a quay crane as a dual hoist crane (DHC) with an automatic second hoist crane.

Source :JICA Survey Team

Figure 6-2 Levels and overview of automation

216. As shown in the figure above, the use of automation technology in container terminals can be classified into Level-1 and Level-2. Level-1 is to automate only RTG (some operations

are remote-controlled), which is similar to what is currently being implemented in Japan. In addition to RTG automation, Level-2 automates trailers running on the premises, mainly by using automatic guided vehicles (AGVs) instead of trailers (some overseas ports have recently started trials to automate trailers themselves). Therefore, in order to examine the possibility of applying this technology to SHV Port, we compared three options: the conventional manual method (Option 1), the Level-1 method of automating RTG (partially remote-controlled) (Option 2), and the Level-2 method of introducing AGV in addition to RTG automation (Option 3).

Table 6-4 Comparison table for the application of automation technology

	Quay	Apron	Container Yard	CY – Gate
Option-1 (Manual)	Manned QC	Yard Chassis	RTG	Road Trailer
Option-2 (ARTG method)	Manned QC	Yard Chassis	ARTG	Road Trailer
Option-3 (AGV method)	Manned QC	AGV or Auto Trailer	ARTG	Road Trailer

Source : JICA Survey Team

217. The results of the comparative study of options 1, 2 and 3 are shown in the following table.

Table 6-5 Comparison table for the application of automation technology

	(per Terminal)	Option-1 (Manual)	Option-2 (ARTG)	Option-3 (AGV)
Economic Factors	Initial Cost (million USD)	1.00	1.13	1.70
	Labor Cost (for 15 years; million USD)	1.00	0.65	0.36
	Number of Operators/Drivers (total)	*285*	*186*	*105*
	QGC	*36 (6 units)*	*36 (6 units)*	*36 (6 units)*
	RTG/ARTG	*120 (20 units)*	*21 (20 units)*	*27(26 units)*
	Yard-trailer	*105 (35 units)*	*105 (35 units)*	*12 (4 units)*
	AGV/Auto-trailer	-	-	*6 (54 units)*
	Reach Stacker	*24 (4 units)*	*24 (4 units)*	*24 (4 units)*
	Maintenance Cost (for 15 years; million USD)	1.00	1.13	1.71
	Total (life-cycle) Cost (for 15 years; million USD)	1.00	1.00	1.36

Other Factors	To improve the work environment	-	○	○
	To reduce human errors and to increase safety	-	○	○
	To reduce the burden of training new staff	-	○	○

* Initial cost includes TOS and other software.
* operator's/driver's salary = 18,000 USD/year
* Maintenance cost is assumed as 5% of the initial cost
* The table does not include the fuel cost.

Source : JICA Survey Team

218. To examine economic efficiency, a comparison was conducted of not only the initial cost, but also the cost incurred by the operator and the maintenance costs over a certain period of time, and it was found that the manual and ARTG systems are almost equal. On the other hand, when AGVs are introduced, the total cost increases by about 36% compared to manual. It was also found that the introduction of the ARTG system has qualitative advantages over the manual system, such as an improved working environment for the

operator, increased safety through reduced human error, and easier operator training. Therefore, in consultation with PAS, it was decided to proceed with the study of Option 1 (manual as at present) or Option 2 (ARTG). Although the RTGs to be installed are different between Option 1 and Option 2, the layout and the quantity of cargo handling equipment are the same.

6.4.2 Specifications and quantities of Cargo Handling Equipment

219. The specifications and quantities of the main loading and unloading equipment for NCT 2 and NCT 3 when option 2 is adopted are shown below.

Table 6-6 Specifications and quantities of main cargo handling equipment

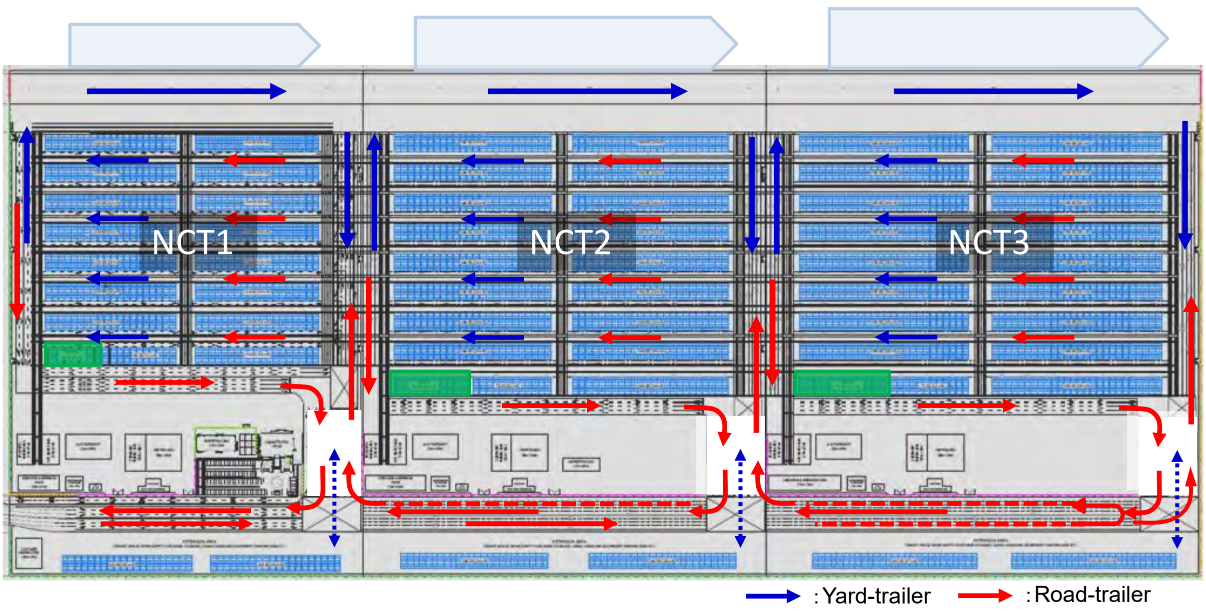
Main Cargo Handling Equipment		NCT1 (Reference)	NCT2	NCT3
QGC	Units	3	3	3
ARTH (Hybrid)	Units	(RTG) 9	10	10
Yard Trailer	Units	16	17	18
Reach Stacker	Units	2	2	2

Source :JICA Survey Team

6.4.3 Yard Layout

6.4.3 (1) Traffic Flow planning

220. The flow line of the road behind the terminal is outlined below. At the time of the opening of NCT1, the plan is to cross the bridge from the port gate, turn left to enter the terminal, and turn right from the terminal to the port gate. However, after the opening of NCT2 and NCT3, there will be many intersections between the two lines. Therefore, vehicles wishing to enter the terminal will go straight to the far end of NCT3, make a U-turn, and then turn right to enter the terminal. However, in case of urgency, it is assumed that traffic guides will be set up to shorten the distance between the empty van pool and the terminal.

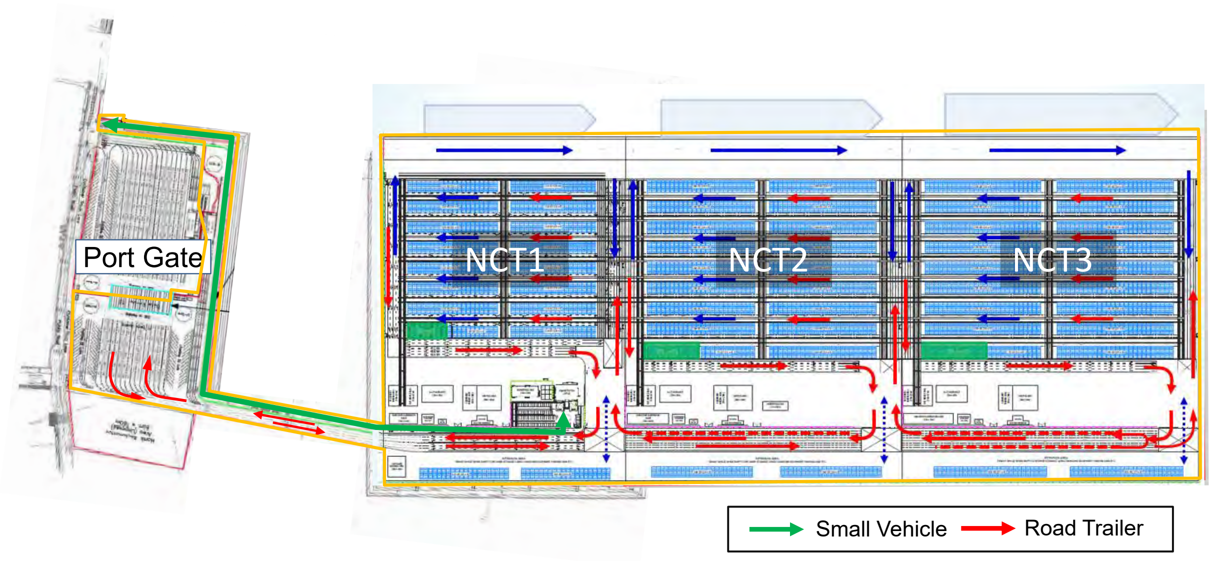


Source: JICA Survey Team

Figure 6-3 NCT2,NCT3 traffic flows

221. Access for PAS personnel involved in terminal operations and forwarders who hand over documents related to the loading and unloading of containers will be via the green line shown in the diagram below to the NCT1 administration building after they undergo the entry check prescribed by SOLAS. The document delivery counter is located on the G floor of the NCT1 administration building for NCT1, 2 and 3. Access to the maintenance shops, worker shops, quayside, and other areas of the NCT1, 2 and 3 terminals will be via the side of the NCT1 administration building. This eliminates the need for small vehicles to access NCT2 and 3, ensures safety by eliminating the need for cross traffic with road trailers.

222. The line of traffic from the terminals to the empty container storage area on the other side of the back road is planned to be the shortest distance between the entrance and exit of each terminal as indicated by the blue dashed arrows in the diagram above. Safety will be ensured by the creation of a zebra zone on the road behind the terminal and, where necessary, the deployment of traffic guards.

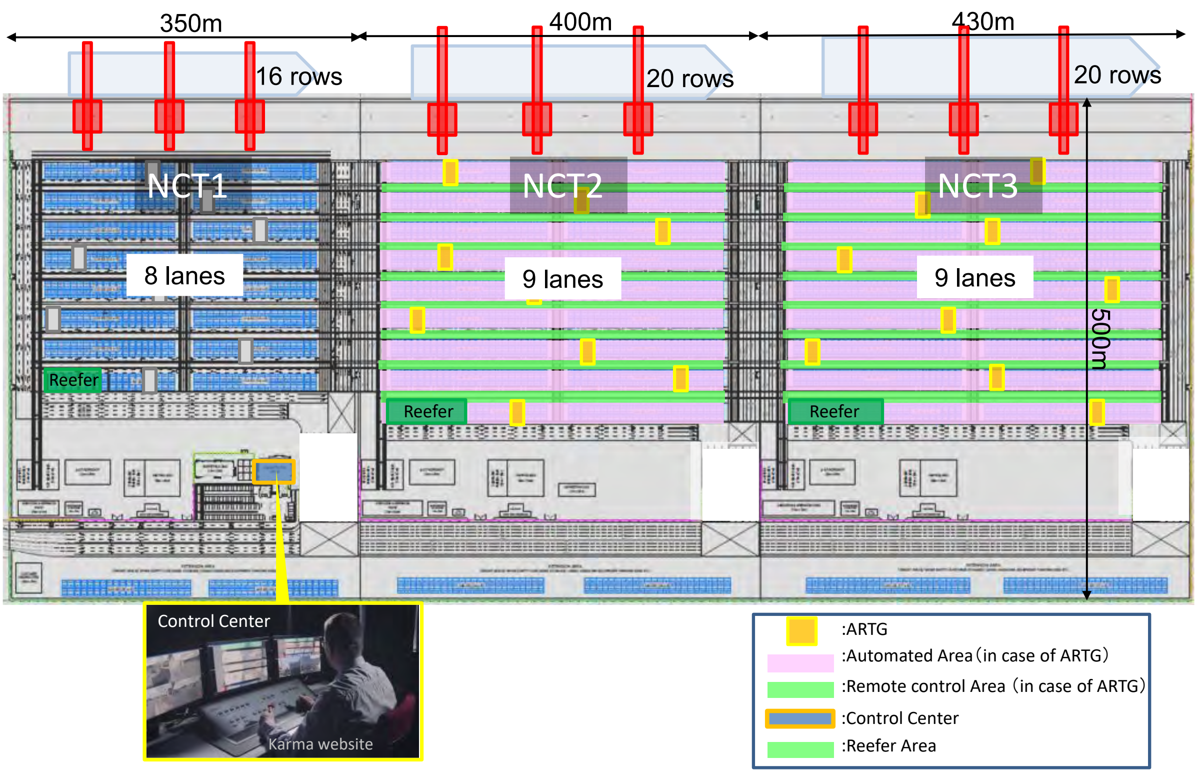


Source: JICA Survey Team

Figure 6-4 NCT1 to NCT3 small vehicle traffic lines

6.4.3 (2) Size and layout of the storage area

223. The layout shown below was prepared based on the required storage capacity and the need for integrated and efficient operation of NCT1 to NCT3. Nine RTG storage lanes are added to the 8 lanes of NCT 1, including one lane on the land side. In this way, when the yard is expanded to NCT2 or NCT3, the facilities in NCT1, such as the administration building and the maintenance shop, can be used for the same purpose and the space in the container yard can be secured.



Source: JICA Survey Team

Figure 6-5 NCT1 – NCT3 Terminal layout

224. The backyard will be equipped for maintenance of machinery and containers, refueling of cargo handling machinery, power supply and water supply to each terminal. The control center will be located on the third floor of the administration building of NCT1 and it is assumed that integrated operation of NCT1, 2 and 3 will be realized. However, during the design of NCT1, additional space at the side of the administration building was secured and thus the administration building can be extended in the future if more space is required due to an increase in staff.

225. The ARTGs to be employed will be remotely operated from a control console in the control center. Fiber optic cables will be laid between the control center and the lighting towers of NCT1, NCT2 and NCT3, and repeaters will be installed in the lighting towers to communicate wirelessly with each RTG.

226. As empty export containers tend to be stored for longer periods of time, the plan is to store them in the van pool behind the ship to further improve efficiency.

227. Regarding reefer containers, the annual throughput of reefer containers was assumed to be approximately 16,000 TEU for NCT2 and 17,000 TEU for NCT3, based on the ratio of actual reefer containers to the annual throughput (about 2.8%). Based on this assumption, the number of actual reefer containers was calculated, and the number of reefer plugs and ground slots required for these containers. As a result, when the number of loading tiers is 4, the number of plugs and ground slots for NCT2 and NCT3 are 120 units and 60 ground slots, and 144 units and 72 ground slots, respectively.

6.5 Port Security Plan

6.5.1 Current status of port security

228. In the " Preparatory survey for Sihanoukville port new container terminal development project, Cambodia" (hereinafter referred to as the "NCT1 Preparatory Survey"), it was reported that Cambodia is a contracting state to the International Convention for the Safety of Life at Sea Protocol of 1974 (SOLAS 74), but Cambodia has not fully complied with the requirements of the ISPS Code, even though the prime minister instructed the Minister of Public Works and Transport to work towards compliance in 2007. Accordingly, the survey team reviewed the current situation in SHV Port.

6.5.2 Port security plan for NCT2 and NCT3

6.5.2 (1) Current status of port security

229. PAS's Port Facility Security Plan has been evaluated and approved by MPWT and registered in IMO's GISIS. Although the security system of PAS has been improved, a national law on security has not yet been established in Cambodia. Therefore, it is necessary to appropriately check the security system and optimize security measures by receiving support from institutions that conduct port security training in Japan, Singapore and other countries.

6.5.2 (2) Status of security facilities

230. Security equipment owned and utilized by PAS such as security fences, lighting, security cameras, and Public Address speakers is adequate. In addition, since the deployment plan for NCT1, which precedes this project, is in progress, security equipment of the same type, size, luminosity, visibility range, etc. will be deployed in principle.

6.5.2 (3) Status of security operation

231. As for container trailers, the gate to be established at NCT1 will be managed by the control center, and the area inside this gate will be the SOLAS area. The entry and exit for vehicles other than container trailers will be via one small gated installed at the time of NCT construction which will allow access control to be effectively conducted. As a result, the traffic flows of container trailers and the other vehicles will be separated in the terminal. However, taking the current status of security operations at PAS into consideration, it seems that the security awareness of the staff is not sufficient, as many motorcycles are seen riding into the container yard. Therefore, it is necessary to conduct strict access control to prevent motorcycles and other vehicles from entering the terminal from the NCT1 administration building area, and to continue to provide security training and enhance the security awareness of PAS staff.

6.5.3 Restricted Area

232. In the NCT1 Preparatory Survey, it was decided that the gate to be newly installed in the land area and the access road leading to the landfill site and NCT1 would be designated as an integrated SOLAS area. Therefore, it is assumed that the SOLAS area will be extended to NCT2 and NCT3 for integrated security management. The following figure shows the assumed security area.

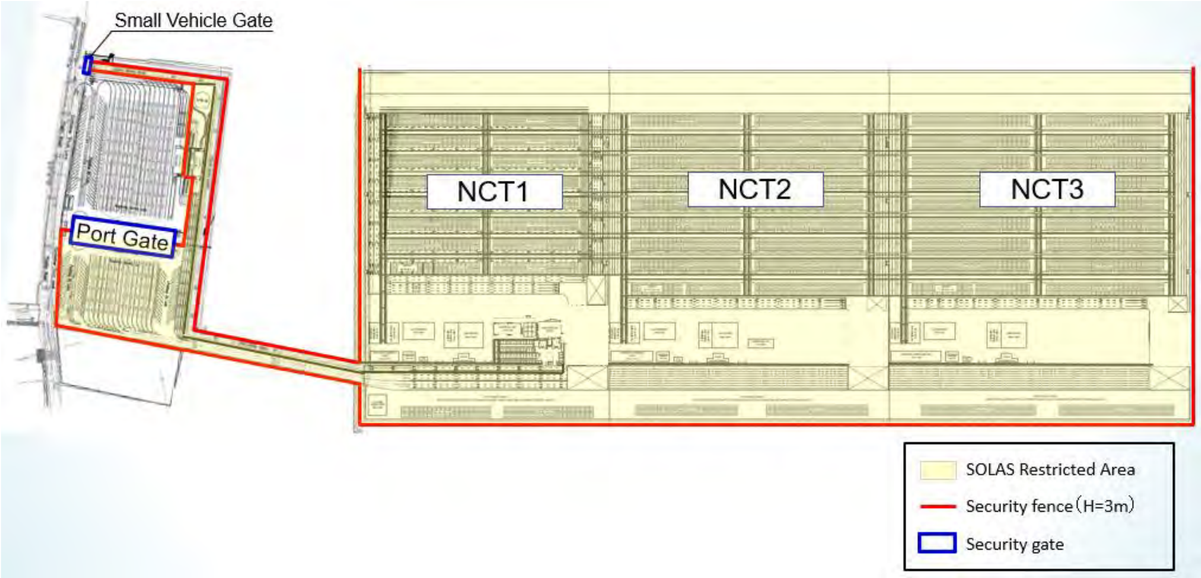


Figure 6-6 SOLAS Restricted Area

233. All trailers entering and leaving NCT1, NCT2 and NCT3 are subject to security checks at the integrated control gates (Port Gates). On the other hand, all other vehicles are checked at the guardhouse (Small Vehicle Gate) located at the entrance to the general vehicle access road. As a result, security checks at the yard entrances and exits of NCT1, NCT2 and NCT3 are not necessary in principle.

6.6 Facility Layout Plan for NCT2 and NCT3

234. The required facilities and their layout plans of NCT2 and NCT3 were determined upon the prerequisites that PAS will continue to undertake operation and maintenance for the both terminals as well in consideration of continuation and shareability with NCT1 facilities, and the specifications and the number of units of cargo handling equipment and other relevant equipment for NCT2 and NCT3 in the future. Figure 6-7 shows NCT2 and NCT3 general facility layout plan and Table 6-7 summarizes relevant facilities required for NCT2 and NCT3. The shown both figure and table contain the layout plan and relevant facilities of NCT1 comparatively for reference purpose.

235. As shown in Figure 6-7 and Table 6-7, The plan provided the container storage system applied RTG method with the provision of container sleepers and RTG traveling lanes, toilets, yard lighting towers, and reefer power outlets in the Marshalling area. In the backyard area, the following facilities were considered to maximize operational area for both terminals such as M&E workshop, RTG parking area, cargo handling equipment parking area, worker’s building (NCT2 only), substation & generator house, water reservoir & pump house, fuel station and its office. In other areas, the same facilities as NCT1 were planned in NCT2 and NCT3.

Source: JICA Survey Team

Figure 6-7 NCT Facility Layout Plan

Table 6-7 Outline of NCT1, NCT2 and NCT3 Facilities

Discerption		NCT1 (Reference)	NCT2	NCT3
Container Terminal Facility Layout Plan				
Basic Dimensions	Terminal Size	350m long x 500m wide	400m long x 500m wide	430m long x 500m wide
Apron Area	Civil Facilities	Quay: -14.5m deep x 35m wide (Deck on pile)、Apron: 28m wide (Co. Pavement), Security Fence	Quay: -16.5m deep x 35m wide (Deck on pile)、Apron: 28m wide (Co. Pavement), Security Fence	Quay: -17.5m deep x 35m wide (Deck on pile)、Apron: 28m wide (Co. Pavement), Security Fence
	Buildings	Yard Toilet	-	Yard Toilet
	Utilities	CCTV Surveillance System, Power/Water Supply Systems, Quay Beacon Lights	CCTV Surveillance System, Power/Water Supply Systems, Quay Beacon Lights	CCTV Surveillance System, Power/Water Supply Systems, Quay Beacon Lights
Marshaling Area	Civil Facilities	8-Container Storage Lanes, Container Sleepers/RTG Travelling Lanes, Service Road (Co. Pavement), Security Fence (west side to be removed when NCT2 completes)	9-Container Storage Lanes, Container Sleepers/RTG Travelling Lanes, Service Road (Co. Pavement), Security fence (west side to be removed when NCT3 completes)	9-Container Storage Lanes, Container Sleepers/RTG Travelling Lanes, Service Road (Co. Pavement), Security fence
	Buildings	Yard Toilet	Yard Toilet	-
	Utilities	6-30m high Yard Lighting Towers, CCTV Surveillance System, Reefer Power Outlets, Reefer Checking Platforms, Fire Hydrants, Perimeter Lighting System	6-30m high Yard Lighting Towers (3 units west side of NCT1 to be reused), CCTV Surveillance System, Reefer Power Outlets, Reefer Checking Platforms, Fire Hydrants	6-30m high Yard Lighting Towers (3 units west side of NCT2 to be reused), CCTV Surveillance System, Reefer Power Outlets, Reefer Checking Platforms, Fire Hydrants, Perimeter Lighting System
Back Yard Area	Civil Facilities	Backyard (Co. Pavement), RTG Parking Area, Equipment Parking Area, Security Fence (west side to be removed when NCT2 completes)	Backyard (Co. Pavement), RTG Parking Area, Equipment Parking Area, Security Fence (west side to be removed when NCT3 completes)	Backyard (Co. Pavement), RTG Parking Area, Equipment Parking Area, Security Fence
	Buildings	Admin. Bldg. w/ Parking Area, Worker's Bldg., M&E Workshop, Substation & Generator House, Water Reservoir & Pump House, Fuel Station, Fuel St. Office	Worker's Bldg., M&E Workshop, Substation & Generator House, Water Reservoir & Pump House, Fuel Station, Fuel St. Office	Worker's Bldg., M&E Workshop, Substation & Generator House, Water Reservoir & Pump House, Fuel Station, Fuel St. Office
	Utilities	Power Receiving & Transforming Equipment/Generators, Water Reservoir & Water Supply Pumps, CCTV Surveillance System, Fire Hydrants, Perimeter Lighting System	Power Receiving & Transforming Equipment/Generators, Water Reservoir & Water Supply Pumps, CCTV Surveillance System, Fire Hydrants, Perimeter Lighting System	Power Receiving & Transforming Equipment/Generators, Water Reservoir & Water Supply Pumps, CCTV Surveillance System, Fire Hydrants, Perimeter Lighting System
Access Area	Civil Facilities	6-lanes NCT Access Road (Co. Pavement), 2-lanes Small Vehicle Road (Co. Pavement), Security Fence	8-lanes NCT Access Road (Co. Pavement), Security Fence	8-lanes NCT Access Road (Co. Pavement), Security Fence
	Utilities	Road Lighting System, CCTV Surveillance System, Fire Hydrants	Road Lighting System, CCTV Surveillance System, Fire Hydrants	Road Lighting System, CCTV Surveillance System, Fire Hydrants
Backup Area	Civil Facilities	Empty Container Storage Yard, Container Washing Area, Security Fence	Empty Container Storage Yard, Security Fence	Empty Container Storage Yard, Security Fence
	Utilities	Perimeter Lighting System, Fire Hydrants	Perimeter Lighting System, Fire Hydrants	Perimeter Lighting System, Fire Hydrants

Source: JICA Survey Team

6.7 Quaywall Design

6.7.1 Natural Conditions for Quaywall

236. Temperature, rainfall, wind, tide, current, wave, earthquake and soil condition are considered as environmental design conditions.

6.7.2 Operational Condition

237. Loading condition on quay structure, design vessel and quay dimensions are considered as operational condition.

6.7.2 (1) Loading Condition

6.7.2 (1) a Surcharge

- Normal case (berthing, mooring and cargo handling): 20 kN/m^2
- Abnormal case (storm and earthquake): 10 kN/m^2

6.7.2 (1) b Cargo Handling Equipment

238. Assumption of Cargo Handling Equipment is Quay Gantry Crane and Reach Stacker only. Mobile Harbour Crane is not considered. Quay Crane Vertical loads for NCT2 & NCT3 target vessels are as follows and Reach Stacker is same with NCT1.

Table 6-8 Quay Crane Dimension

	NCT3	NCT2	NCT1(for reference)
Vessel Size (TEU)	15,000	10,000	4,700
Vessel Size (DWT)	160,000	120,000	60,000
QC Weight (ton)	1230	1230	1082
QC lane width (m)	30	30	30
QC outreach container numbers	20	20	16

Source: JICA Survey Team

Table 6-9 Loads of Quay Crane

Conditions	Position of Wheel	Vertical Load (kN/Wheel)	Horizontal Load (kN/Wheel)
During Cargo Handling (40.6T load, boom down, 20m/s wind)	Sea Side	749	48
	Land Side	509	36
In the case of a storm (No load, boom up, 35m/s wind)	Sea Side	521	42
	Land Side	676	42
During an earthquake (0.05G horizontal load)	Sea Side	776	20
	Land Side	615	20
During a berthing (No load, boom up, 20m/s wind)	Sea Side	387	33
	Land Side	554	41

Source: JICA Survey Team

6.7.2 (2) Design Vessel

239. Maximum design vessel are as below. The comparison study of each design vessels is shown above Section. The minimum design vessel size is 8,000DWT.

Table 6-10 Design Vessels (Maximum)

Item	NCT2	NCT3
TEU	10,000	15,000
DWT	120,000	160,000
LOA (m)	350	370
LBP (m)	340	360
Draft (m)	15.0	16.0
Beam (m)	16.5	17.5
TEU	49	52

Source: JICA Survey Team

6.7.3 Quaywall Design Comparison

240. Quay dimensions are set as follows:

Table 6-11 Quay Dimensions

Item	NCT2	NCT3
Berth Length (m)	400 m	430 m
Berth Design Depth (CDL)	-16.5 m	-17.5 m
Deck Level (CDL)	+3.3 m (same as NCT1)	
Quay Width (m)	35 m (same as NCT1)	

Source: JICA Survey Team

241. Because of the soft soil condition as mentioned above, Pile deck type is more suitable than gravity type such as concrete block and sheet pile type. Three types of pile deck type namely vertical pile type, batter pile type and strut pile type (which was used for NCT1) are compared.

242. From the results of evaluation, Strut Type as same with NCT1 is suitable for NCT2 and NCT3.

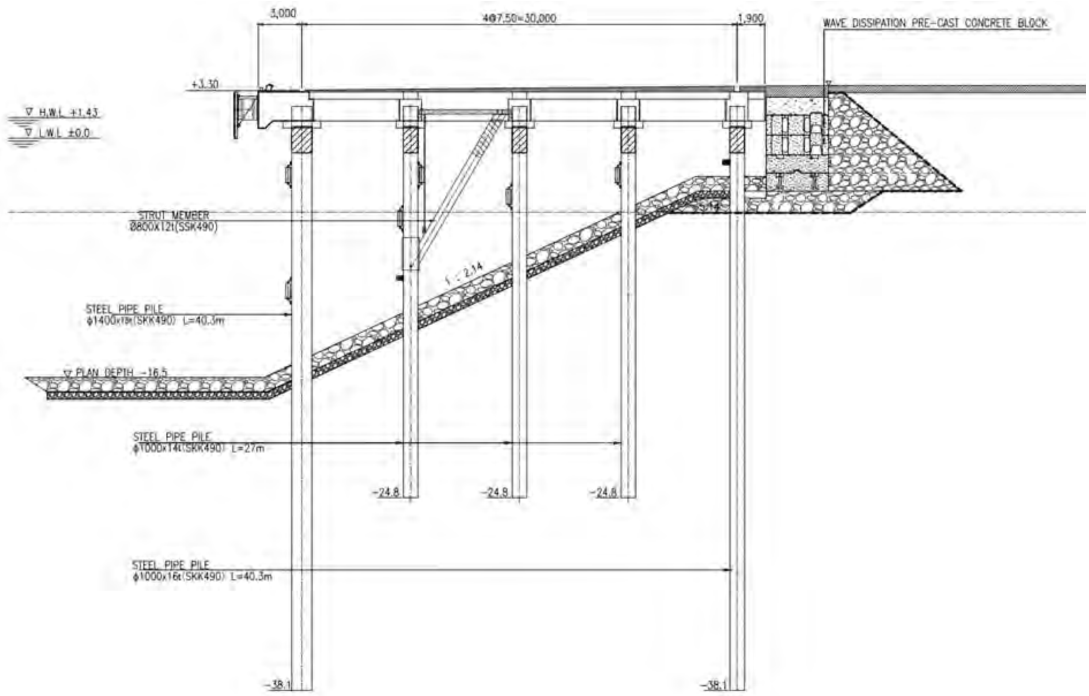
Table 6-12 Evaluation of Quaywall Structure Types

Type	Type -1 Vertical only	Type-2 Combination of vertical and batter	Type-3 Strut
Characteristic	Both of horizontal and vertical loads are resisted by vertical piles only. Therefore, diameter and thickness of piles are normally larger than the other types.	Both of horizontal and vertical loads are resisted by combination of vertical and inclined piles.	This method is not much differing from vertical pile method, but pile diameter and thickness could be reduced by the strut member.
Numbers of Pile per 50m block	70 vertical piles	40 vertical piles + 20 inclined piles	50 piles
Merit	Workability is better.	Good resistance to horizontal loading	+Good resistance to horizontal loading +Good connection to NCT1
Demerit	Horizontal movement is bigger than other types	Good quality pile driving is needed	+High quality pile driving is needed +Shall be imported
Environmental impact	Aspects of noise, vibration, water pollution, traffic congestion are same for all three types.	ditto.	ditto.
Construction Period Ratio	1.0	1.1	1.0
Cost Ratio of Pile	1.0	1.1	1.0
Evaluation	Poor	Average	Good

Source: JICA Survey Team

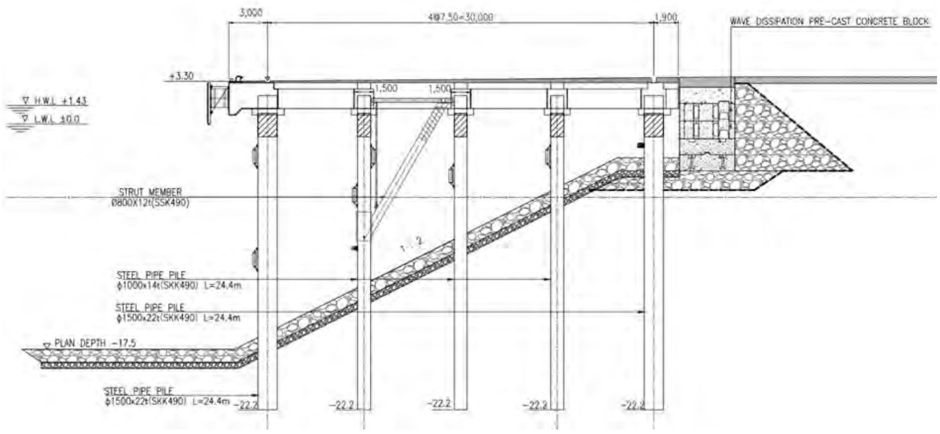
6.7.4 Comparison of Quaywall for Several design Vessels

243. Cost comparison among several quaywall structures which accommodate three target vessels, i.e., 15,000 TEU, 12,000 TEU and 10,000 TEU class was carried out to explore a suitable quaywall structure. The selected structure was finally analyzed in structural design software, STAAD. Pro for several trial and error to be optimized. The typical cross section of the selected quaywall structure are shown below.



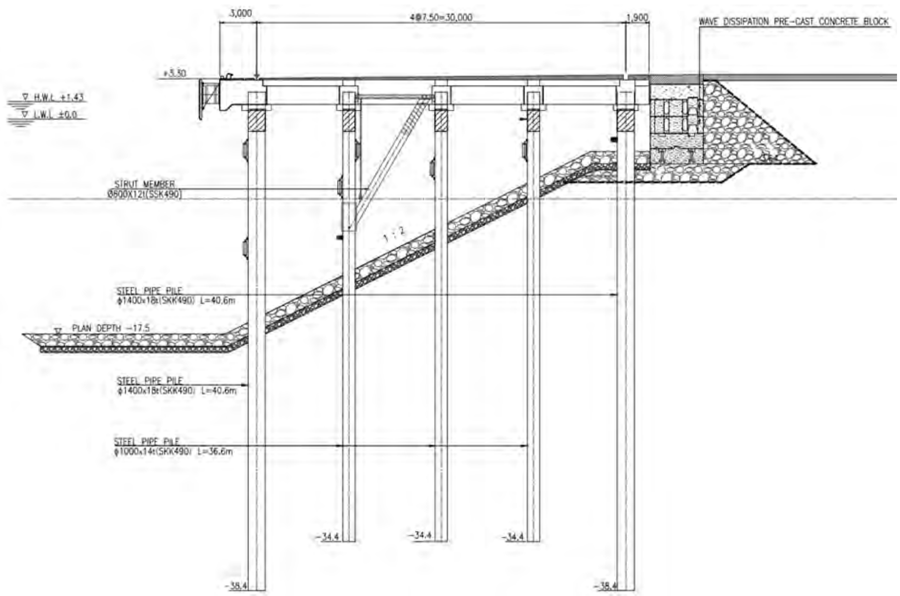
Source: JICA Survey Team

Figure 6-8 Typical Cross Section for 10,000TEU at NCT2



Source: JICA Survey Team

Figure 6-9 Typical Cross Section for 15,000TEU at NCT3A



Source: JICA Survey Team

Figure 6-10 Typical Cross Section for 15,000TEU at NCT3B

6.8 Container Yard Design

6.8.1 Yard Pavement

6.8.1 (1) Operation Conditions

244. The below table show the summary of load conditions by container, truck and cargo handling equipment for each area at NCT2 and NCT3. At SHV Port, loaded containers are handled by RTG basically but sometimes they are handled by Reach-stacker. Therefore, the container yard shall have durability and strength against Reach stacker operation as well.

Table 6-13 Operation Conditions

Area	Container Stacking (stairs)	Container Truck	Reach-stacker	RTG	Mobile Harbour Crane
Dry Container Area	5	Yes	Yes	No	No
Reefer Container Area	3	Yes	No	No	No
Empty Container Area	4	Yes	Yes	No	No
Road Area	none	Yes	Yes	No	No
Truck Lane	none	Yes	Yes	No	No
RTG Lane	none	Yes	Yes	Yes	No
Building Area	none	Yes	No	No	No

Source: JICA Survey Team

6.8.1 (2) Comparison of Pavement Types

245. Three pavement structure types of ICB Pavement, Asphalt Pavement and Concrete Pavement are compared as shown in the below table. From the comparison, concrete pavement is more suitable for NCT2 and NCT3 area than other types.

Table 6-14 Comparison of Pavement Type

Type of Pavement	ICB	Asphalt	Concrete
Initial Cost	Low	High	Middle
Maintenance Cost	Low	High	Middle
Durability	Middle	Middle	High
Construction Period	Middle	Fast	Slow
Continuity to NCT1	Middle	Low	High
Description	Cost of ICB pavement is cheapest but high frequent maintenance is needed. Rainwater easily penetrates and puddles are unlikely to occur.	Because of heavy duty as Reach-stacker, cost of Asphalt pavement is highest.	Cost of concrete pavement is middle but durability and continuity to NCT1 are highest. Repairing period is long. There is risk of concrete cruck after handover by residual settlement.
Evaluation	Average	Poor	Good

Source: JICA Survey Team

6.8.1 (3) Design of Concrete Pavement

246. Because of Load Conditions are same with NCT1 the concrete pavement thickness is referred by NCT1 detailed design.

Table 6-15 Thickness of Concrete Pavement

Unit: mm

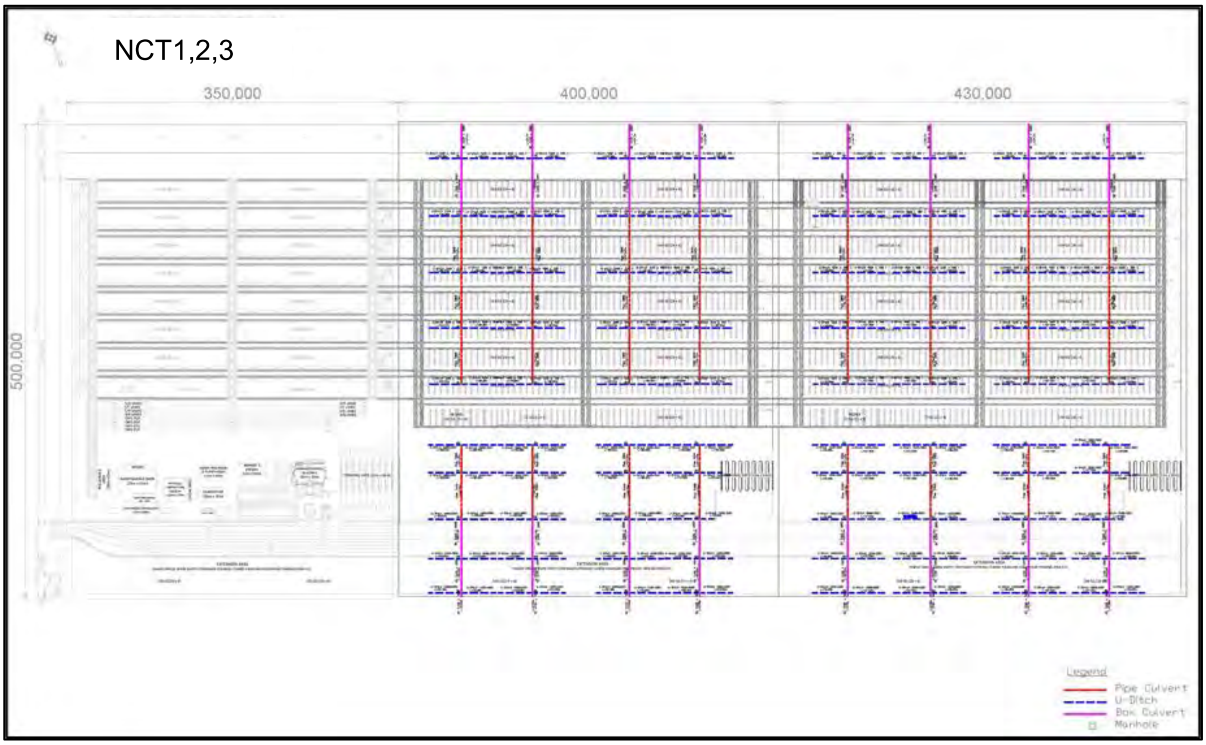
	Concrete	Base	Sub-base	Total	Remarks
Type A	300	200	300	800	Access Road
Type-1	300	200	200	700	RTG service parking area
Type-2	250	200	200	650	Truck Lane and between Container Stacking Plates
Type-3	200	200	200	600	Building and Empty Container Area
Type-4	150	200	200	550	Passenger Car Parking Area
Type-5	250	250	250	750	RTG lane
Type-6	350	250	250	850	Container Stacking Plate

Source: JICA Survey Team

6.8.2 Design of Drainage System

6.8.2 (1) Concept Layout Plan of Drainage

247. NCT2 & 3 will be new mounted and located beside of NCT1 in water area. After NCT3 development, new terminals will be located beside of NCT3. NCT2 & 3 cannot disturb the drain water to the side. Drain directions are berth side and empty container yard side only. Drainage System at NCT1 is also same system. There is watershed at boundary of the container stacking yard and building area at NCT1. The watershed at NCT2 & 3 will be suitable at same location. The maximum design rainfall intensity is 200 mm/h, which is the same as NCT1.



Source: JICA Survey Team

Figure 6-11 Drainage System Layout Plan at NCT2 & 3

6.8.2 (2) Concept Design of Drainage

248. There are some kinds of drainage as U-ditch, culvert, pipe. For the Project, the below drainages are planned.

Table 6-16 Drainage Type

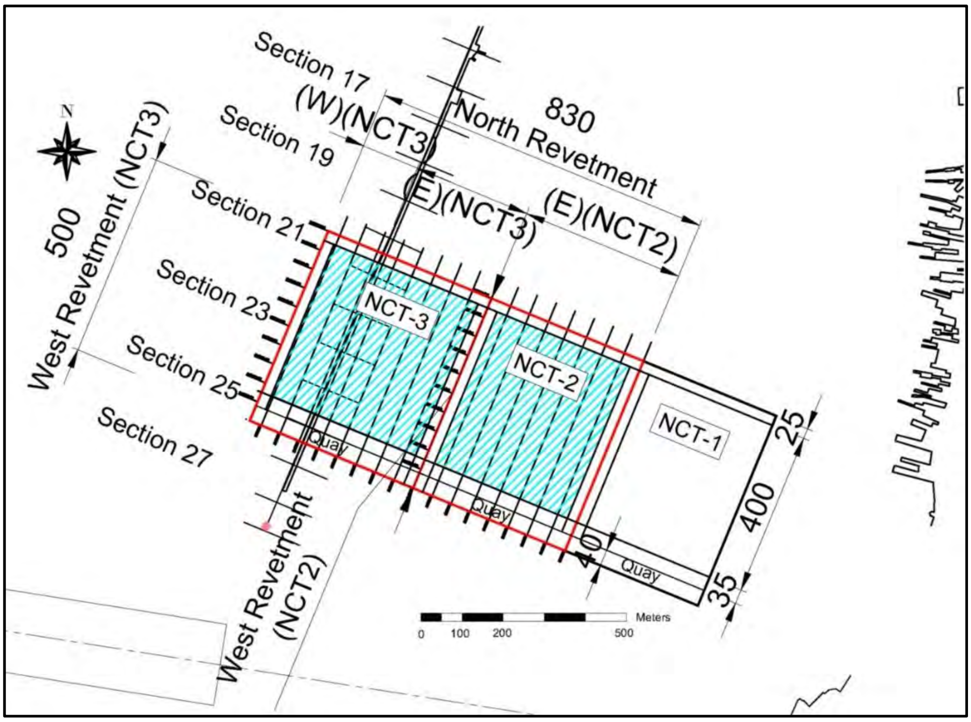
Type	Characteristic	Main Usage on this Project
U-ditch with cover	Available to gather rain surface water and trucks can pass on the ditch.	Container Stacking Yard and surrounding buildings
U-ditch without cover	Available to gather rain surface water and trucks cannot pass on the ditch.	No use in this Project
L shaped drainage	Available to gather rain surface water and trucks can pass on the drainage.	Mainly used for road side gutter
Box Culvert	Strongest	Main Drainage under Container Stacking Yard
Concrete Pipe	Strong	Main Drainage under Building Area
PVC Pipe	Weak but cheapest	Connection from Building to yard drainage

Source: JICA Survey Team

6.9 Terminal Land Formation

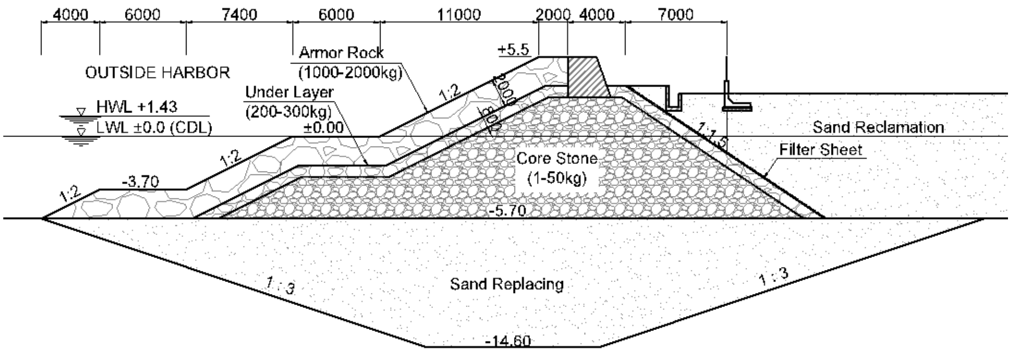
6.9.1 Revetment

249. The Revetment layout in and around the land reclamation is shown below. The soft sub-soil in the upper layer of the alluvium of each revetment area was replaced with a sand layer. The sub-soil improvement to suppress the differential settlement was considered. The revetment was stone mound type.

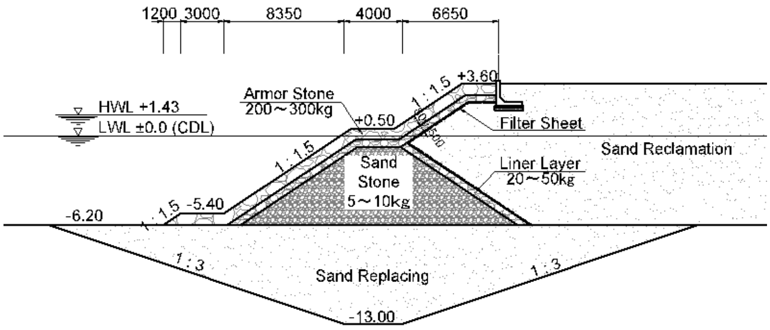


Source: JICA Survey Team

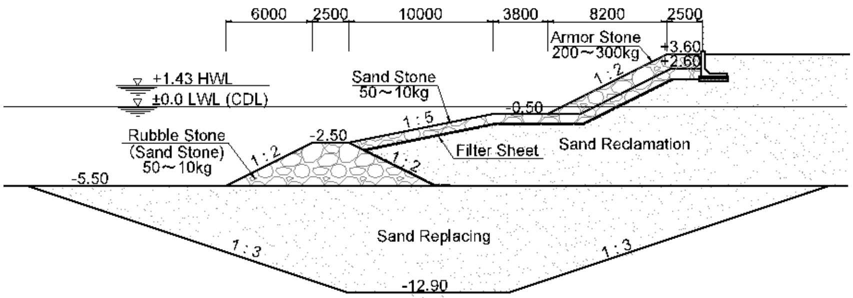
Figure 6-12 Layout Plan of Revetment



NCT3 West Revetment and NCT3 North Revetment (West)



NCT2 North Revetment and NCT3 North Revetment (East)



NCT2 West Revetment

Source: JICA Survey Team

Figure 6-13 Typical Sections of Revetments

6.9.2 Reclamation

6.9.2 (1) Examination of consolidation settlement and soil improvement

250. Investigation on the reclamation at NCT2, NCT3 and Long Term area is summarized as shown in Table 6-17. The following are the key points in summary of consolidation settlement and soil improvement.

Table 6-17 Summary of Settlement and Soil Improvement

Project Area			NCT2	NCT3	Long Term Area
Soil Properties of <1a>	Wn (%)		46	43	69
	Sand (%)		52	50	30
	Ip		11	13	20
	e0		1.36	1.22	1.93
	Cc		0.37	0.47	0.75
	Cv (cm2/day)	by test	0.006	0.004	0.0040
		by Ip	0.29		0.0144
		by sand	0.013		0.0086
Reclamation Work	Reclamation Height (CDL, m)		+3.70		
	Height of Dredged Soil (CDL, m)		-1.50		
	Seabed Depth (CDL, m)		-5.1	-6.1	-9.8
	Area (m2)		400 x 500	430 x 500	-
	Settlement (m)	No Dredged Soil	1.0	2	1.8
		With Dredged Soil	1.4	2	3.6
PBD	1.0 m in square spacing	Installation from +2.0	-16.2 m	-20.7 m	-

Source: JICA Survey Team

- Layer <1a> (the layer just below the seabed with the depth of 5 to 7 m), which is soft and loose sandy clay or silty sand, distribute from seabed bottom with certain thickness. Natural water content (W_n) at NCT2 and NCT3 seem to be nearly the same as 40 % whereas 70 % at NW area. Other parameters such as sand fraction content and Ip shows the similar tendency.

- Reclamation Settlement were calculated as 1.0m at NCT2, 1.6m at NCT3 and 1.8m at NW area. When dredged soil mainly composed by layer<1a> is to be re-used as part of reclamation fill, those settlements become larger such as 1.4m, 2.0m, and 3.6m, respectively. Reason why settlement in case of re-use of dredged soil at Long Term area would be much larger than other project area is larger average depth than other project areas.

- Without PBD for acceleration of consolidation settlement its time required for degree of 90% were 3 years to 8 years at three project areas although there is argument on differences between consolidation coefficients obtained by consolidation test at laboratory, by relationship with sand fraction content and I_p. Therefore, Plastic Board Drain Technique should be utilized as a countermeasure for accelerating settlements.

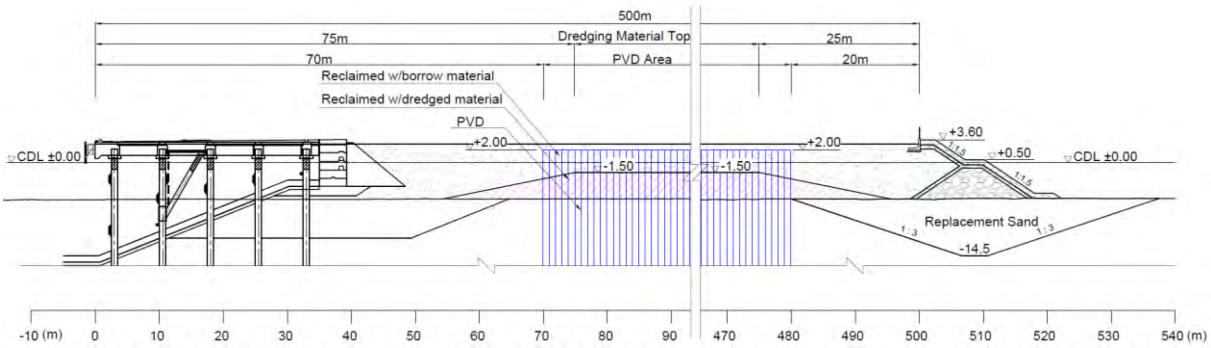
- It is obvious countermeasure for PBD to make a consolidation settlement accelerate. However, due to uncertain consolidation coefficient (C_v), consolidation time by means of PBD may not be clearly designed. Therefore, it could be allowed tentatively to use C_v obtained by consolidation test which give conservative consolidation time. Then consolidation time for U=90 % would be approximately 5 months in case of 1.0m spacing.

- Past settlement of existing breakwater would be estimated as approximately 1m.

6.9.2 (2) Outline of Reclamation

251. Landfills divert dredged soil to the core area of reclamation site as shown in Figure 6-14

below. Dredged soil is placed into a depth below -1.5 m level that can be entered by the bottom dumping barge. In addition, the ground improvement using PVD (Pre-fabricated Vertical Drain) will be carried out in the area range using dredged soil. The remaining volume of the predicted consolidation and residual settlement (1.4 m to 2 m) will be added to the volume of borrow material above -1.5 m level.



Source: JICA Survey Team

Figure 6-14 Typical Cross Section of Reclamation Area and Soil Improvement

252. Breakdown of Reclamation Volume by Terminal NCT2 and 3 and Outline of Soil Improvement were shown in Table 6-18 and Table 6-19.

Table 6-18 Breakdown of Reclamation Volume

(x 1,000 m^3)

Terminal	Dredged Soil	Borrow Material		Total
		Fill	Settlement	
NCT2	596	833	217	1,646
NCT3	730	878	336	1,945
Total	1,326	1,711	554	3,590

Source: JICA Survey Team

Table 6-19 Outline of Soil Improvement (PVD)

Terminal	Space	Length	
	(m)	Depth	Length (m/point)
NCT2	@1.0	+2m to −12.5m	14.5
NCT3	@1.0	+2m to −15 m	17

Source: JICA Survey Team

6.10 Breakwater Design

253. Based on the results of the Port basin calmness analysis in 5.3.3 (2), it was concluded that the breakwater is unnecessary.

254. Sedimentation of Channel and Basin were as described in Chap. 6.11.6. It is conceivable to install groins on both sides of the channel as a measure to prevent channel sedimentation, but assuming that the sedimentation volume per 1 m in the longitudinal direction of the channel is 100 to 300 m^3 / m / year, the construction cost of the groins to be spent as an initial investment, it is considered more realistic to maintain the water depth by regular maintenance dredging after the start of port service.

255. For this reason, it is required to carry out bathymetric surveys on a regular basis after the completion and start of port service, to monitor changes in the water depth of channel and port basin, and carry out maintenance dredging periodically. Maintenance Dredging by TSHD (Trailing Suction Hopper Dredger) of Vietnam etc. is to be carried out every few years depend on the maintenance dredging volume, or domestic SD (Suction Dredger) and CSD (Cutter Suction Dredger) are to be carried out during the seasonal calm sea conditions. (See the figure below) It is conceivable to carry out maintenance dredging work intermittently for a short period of time.

256. In case that the bathymetric survey after the start of port service revealed the location of high sediment speed, it would be necessary to install groins therein.

6.11 Channel and Basin Dredging Plan

6.11.1 Chronological Back Ground

257. Dredging of SHV Port basin and channel, which began at the end of the 1960s, has continued through the following stages of development: ("Year Built" in the table means the completion of dredging works.)

Table 6-20 Basin and channel development stages and relevant built years of SHV Port

No	Quay Name	Berth		Turning Circle		Channel		Remarks
		width	Depth	Dia.	Depth	width	Depth	
		m	m (CDL)	m	m(CDL)	m	m (CDL)	
1	Old Jetty (Berths 1-4)		10					1959
2	Existing New Quay (Berths 5, 6)		-10	385	-7.8	150	-7.8	1970
3	Existing CC Quay (Berths 7, 8)	45	-11.5	360	-10.5	125	-10.5	2005
4	Multi-Purpose Quay (Berths 9, 10)	60	-13.5	400	-12	150	-12	2017
5	NCT1	50	-14.5	600	-13.5	150	-13.5	DD Completed
6	NCT2	65	-16	740	-14.5	200	-14.5	
7	NCT3	65	-17.5	740	-14.5	200	-14.5	

Note: Shown values in 2017 obtained from the post dredging survey of SHV Port during the Sihanoukville Port Multipurpose Terminal Development Project

Source :JICA Survey Team

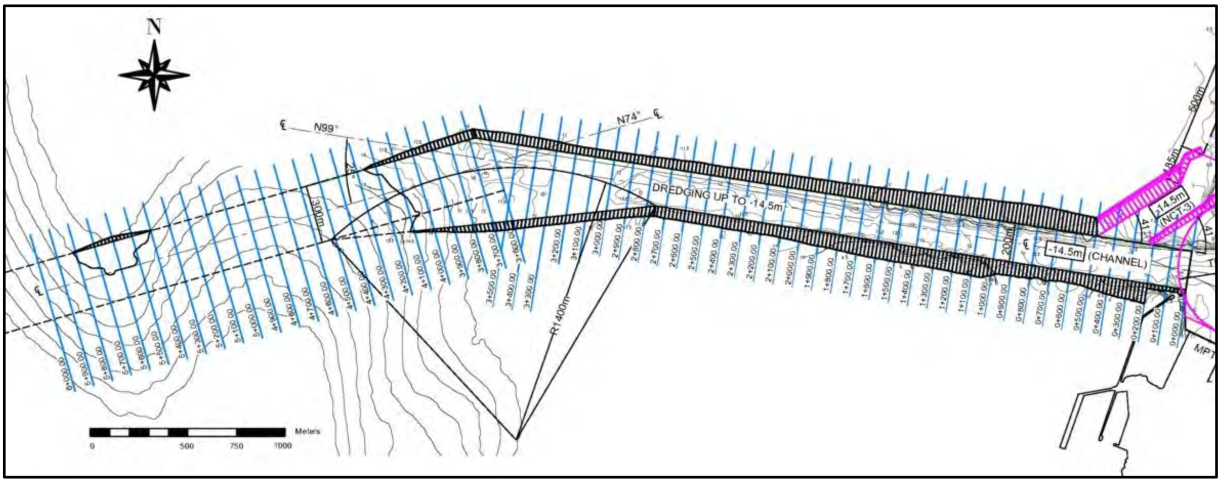
6.11.2 Channel

6.11.2 (1) Channel Alignment and Dimensions

258. The dredging channel is started at the port entrance (the right end of the figure) as Sta.0 km, as shown in Figure 6-15, and ended at 5.6km of the shallow the leftmost point. The Channel is bent on the way at Sta 3.7km to avoid the shallow. The bending angle was reduced to 25 degrees below 30 degrees. The channel length from the port entrance to the -14.5m water area is about 4.2km. The width of the fairway from the bending point to the offshore side was 300 m, and the channel width (slope toe width) from the bending point to the port entrance was expanded by 50 m to the north of the existing channel width of 150 m to 200 m. As a result, the center line of the channel was shifted by 25 meters to the north. The bending part has a turning radius of the ship with about 4 times the LBP (Length between Perpendicular) of 355 m≒1,400 m, and a corner cut is provided inside the bending part as shown in Figure 6-15 so as to secure safe turn.

259. The depth of the channel was CDL-14.5 m, and the slopes on both sides of the channel

were a gentle inclination of 1:15 to reduce the soil deposit on the channel due to siltation described later. By making the slope gentler than 1:10, the channel width can be reduced by a ship width (B) according to the PIANC standard and accordingly, the required width of the channel can also be suppressed.

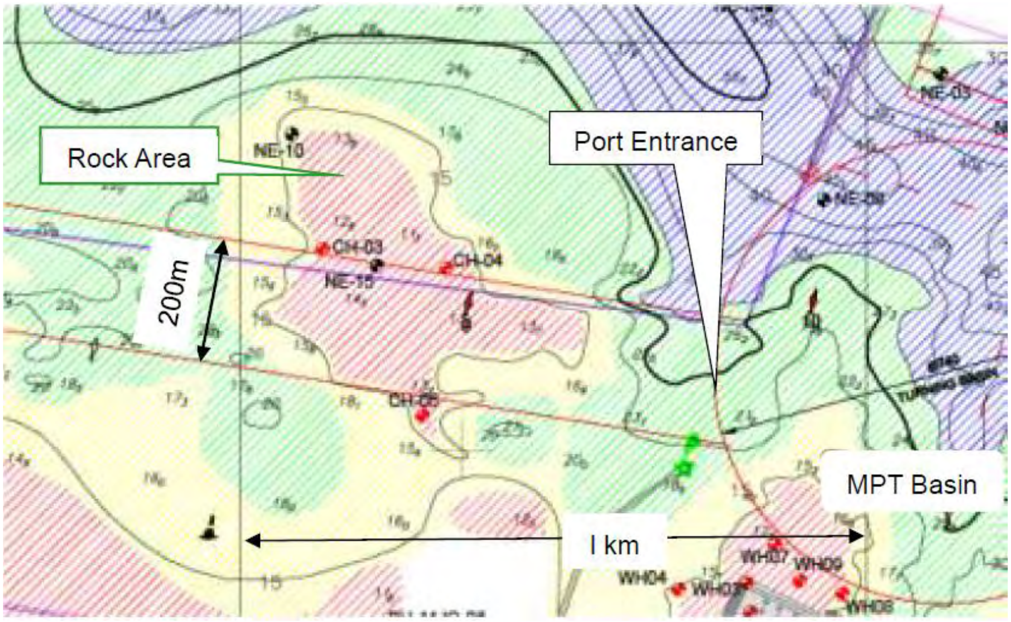


Source: JICA Survey Team

Figure 6-15 Layout plan of Dredging Channel

6.11.2 (2) Channel Cross Section and Soil Condition

260. Figure 6-16 is a contour map showing the depth distribution of the rock stratum near the port entrance. The red colored area indicates a shallower range of rock stratum above -14.5m level. Rock stratum can be seen on the Channel at 300m to 800m west of the port entrance and on the north side of Channel, and in the Multi-purpose basin.

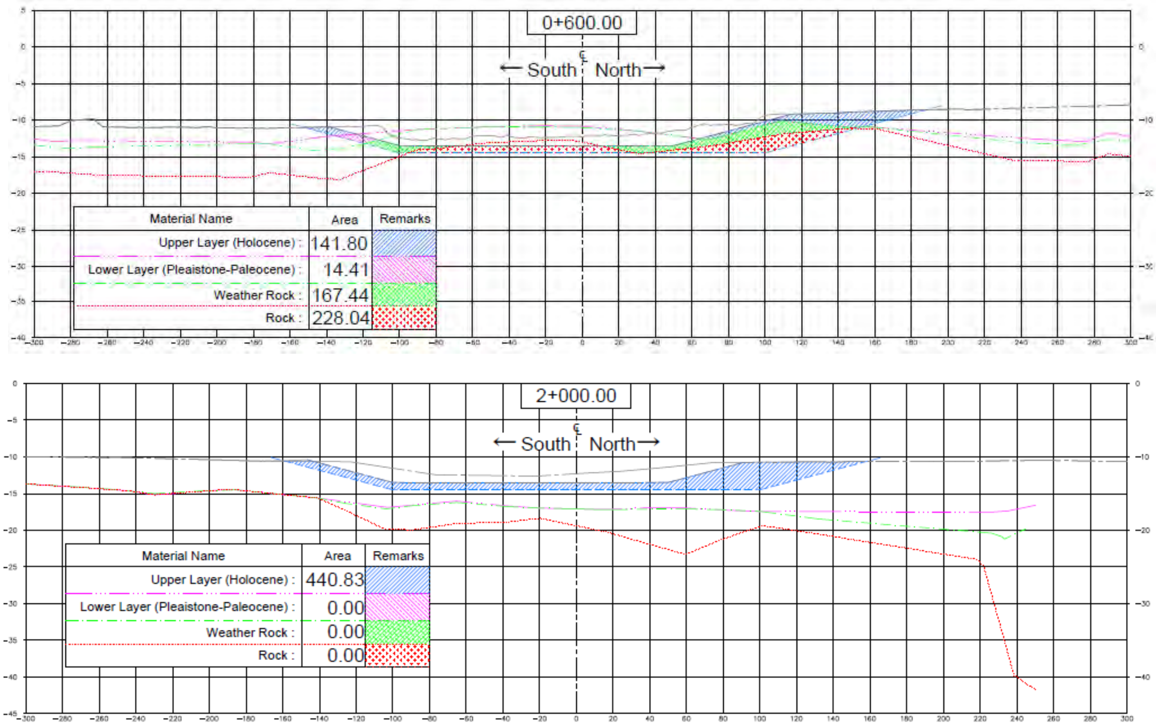


Source: JICA Survey Team

Figure 6-16 Contour Map of top of Rock Stratum at Port Entrance

261. The following Figure 6-17 shows a typical cross-sectional view of the channel dredging area in a shallow rock stratum near the port (600 m from the port entrance) and a cross-sectional

view of the channel in an area with deep rocks on the offshore portion (2000 m from the port entrance). The top elevation of the rock stratum is indicated with a red line. The red colored area in the Figure is the rock stratum to be dredged. Offshore portion beyond Sta 0+800 m, the rock strata are deep and therefore not subject to dredging. The cross-sectional map of the entire length of the channel is prepared later.



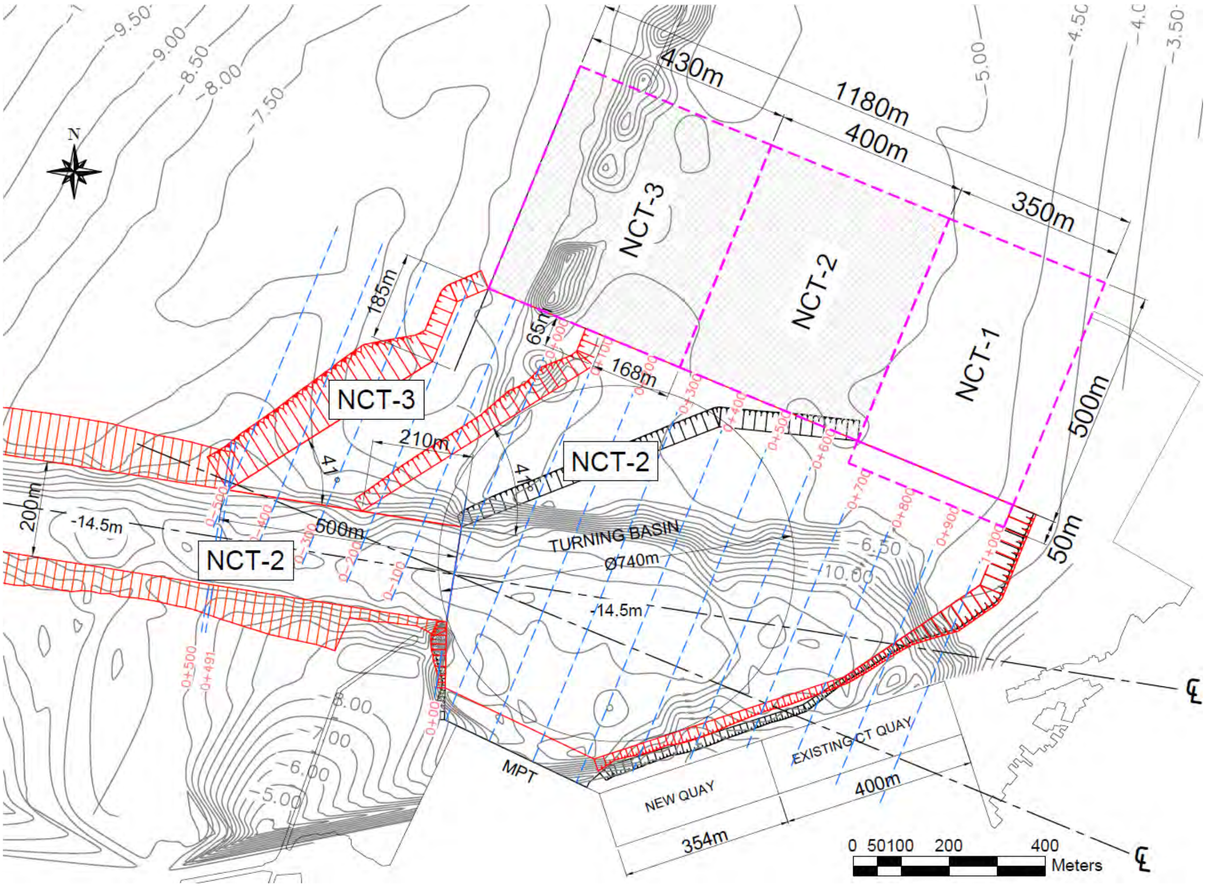
Source: JICA Survey Team

Figure 6-17 Typical Cross Sections of Channel Soil Strata

6.11.3 Basin

6.11.3 (1) Dimension of Basin

262. The basin dredging area is indicated with red line showing side slope toe in Figure 6-18. The dredging area is including a 740 m diameter turning circle and a ship berthing space in front of NCT2 and NCT3. The cross-sectional Sta.(Station) of the dredging area is distanced toward the land side of the basin (right side of the Figure) with the port entrance side as Sta.0 m. The dredging slope of the basin area was 1:5. The side slope along the channel protruding from the port entrance is the same as the channel at 1:15. The slope indicated with black lines in the Figure shows the dredging area of the depth of -13.5 m and the turning circle diameter of 600 m scheduled to be dredged in NCT1 Project. The dredging volume of NCT2 and NCT3 was calculated for the sectional area between this NCT1 dredging surface and the surrounding existing seabed surface and planed depth of NCT2 and NCT3.



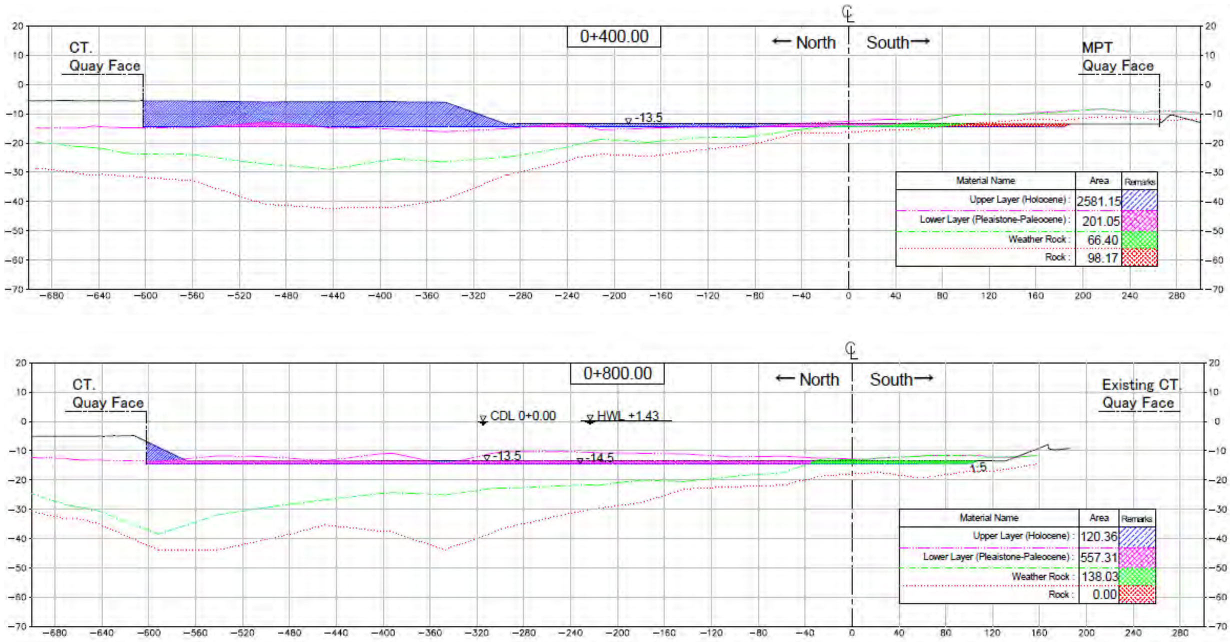
Source: JICA Survey Team

Figure 6-18 Layout Plan of Basin

6.11.3 (2) Basin Cross Section and Soil Condition

263. The typical cross sections at 400 m and 800 m position from the port entrance are shown in the following Figure 6-19. At the 400 m position, there is a rock layer (red part) in front of MPT quay (right side of the Figure). There is a thick original layer of about 8m on the NCT2 and NCT3 quay side.

264. At a position of 800 m, there is a weathered rock layer near the existing CT quay (to the right of the Figure), without a rock stratum. Since most of the dredging will be done in the NCT1 project, the target will be dredging of a thin soil layer of 1 m thickness from -13.5 m to -14.5 m.



Source: JICA Survey Team

Figure 6-19 Typical Cross Sections of Basin Dredging Soil Layers

6.11.4 Dredging Volume

265. Soil layers up to the designated dredging depth of the channel and basin can be classified into four types, from the alluvium of the surface layer to the bottom rock layer as shown in Table 6-21 in terms of the difficulty of the dredging work. The dredging soil volume of each layer is shown in the same Table. This volume is calculated on the bases of layout plan and cross-section of the channel and basin area shown in the previous Chapter. Supposing the dredging work of NCT1 (planned depth -13.5 m) was carried out, and dredging volume to -14.5 m depth below -13.5 m was aggregated.

Table 6-21 Dredging Volume (NCT2＆NCT3 Water Depth: CDL-14.5m)

Soil Stratum	Volume (1,000 m3)				
	Channel	Basin			計
		Sub Total	NCT2	NCT3	
Upper Layer (Holocene) :	1,733	1,851	1,037	814	3,585
Lower Layer (Pleaistone-Paleocene) :	48	755	459	296	803
Weathered Rock :	99	86	73	13	185
Rock :	69	17	14	3	86
Sub Total	1,950	2,709	1,583	1,126	4,658

Source: JICA Survey Team

6.11.5 Dredging Work Methodology

266. In the dredging works of previous projects at SHV Port, soil and sand were mainly dredged by large/heavy grab dredgers and dumped in offshore dumping site by bottom-opening barges. As a result of comparing the dredging method of NCT2 and 3 Project, it is considered that the grab dredging method is suitable as well as NCT1.

267. Dredged soil is dumped by bottom-opening barge to a dump site located approximately 7 km southwest of the port entrance. Some of the dredged soil is diverted to NCT2 and 3

landfill materials. The balance of dredged soil volume of 4.67 million m^3 and reclamation soil volume of 3,59 million m^3 was planned as shown in Table 6-22.

Table 6-22 Balance between Dredging/Reclamation Volume and Diverted Dredged Soil/ Land Dry Fill Materials

Soil Strata	Dredging Volume（1,000 m3）				
	Channel	Basin			Total
		Sub total	NCT2	NCT3	
Upper Layer	1,733	1,851	1,037	814	3,585
Lower Layer	48	755	459	296	803
Weathered Rock	99	86	73	13	185
Rock	69	17	14	3	86
Sub total	1,950	2,709	1,583	1,126	4,658

Reclamation Volume（1,000 m3）				
Material	Soil Strata	NCT2	NCT3	Total
Dredged Soil	Upper Layer	50	419	469
	Lower Layer	459	296	755
	Weathered Rock	73	13	86
	Rock	14	3	17
	Sub total	596	730	1,326
Borrow material	Filling	833	878	1,711
	Settlement	217	336	554
Total;		1,646	1,945	3,590

Source: JICA Survey Team

268. As shown in the Table 6-22 above, the channel dredged soil was discharged at the offshore dumping site, and the upper half of the upper layer (Holocene or alluvium) of the basin as soft soil was also discharged at offshore dumping site. The other half (lower half of the Holocene layer) was diverted to landfill soil, and the soil layers below the Paleocene including weathered rock and rock of the basin area were diverted to the reclamation materials. In addition, the landfill layer above CDL-1.5m in the landfill was reclaimed with borrow material (river sand), and the settlement due to consolidation was added to the reclamation volume with borrow material

6.11.6 Maintenance of Channel and Basin

269. The channel is more susceptible to sedimentation than the basin due to the influence of the north-south tidal current. The effects of the sedimentation/scouring were examined by comparing the results of bathymetric surveys that have been carried out in this Survey.

<Annual Sedimentation Volume>

270. The summary of actual sedimentation record was made in Table 6-23 based on the results of bathymetric surveys of channel and basin as track records that have been carried out several times since 2011.

271. The sedimentation volume in Table 6-23 was divided into three areas: (1) Channel, (2) Basin in front of MPT, and (3) Basin in front of existing CT. The Sedimentation volume was calculated from the difference of water depth between survey timing.

272. The 2011 survey was conducted during the DD survey for MPT development and was used to calculate the sedimentation volume for the frontal water area of the existing CT from 2011 to 2019.

273. The sedimentation volume of the Channel and the Basin was calculated based on the water depth difference between the post dredging survey of MPT carried out in 2017, the survey at NCT1.DD in 2019 and the survey in 2021 for this Preparatory Survey

274. For comparison, the sediment volume for 8.5 years from 2011 to 2019 was converted to 3.7 years from 2017 to 2021 and obtained 55,000 m^3.

275. The sediment volume for other Channel and Basin areas were calculated based on the results of two surveys in 2019 and 2021. As mentioned in the previous Chapter, the sediment volume for the first two years up to 2019 was larger than that in 2021. It is assumed that the sediment by 2019 was during the period when the sea-bottom unevenness was remarkable immediately after dredging, and then the sea-bottom stabilized and settled to the long-period average annual sediment volume. During the period from 2019 to 2021, scouring of channel at some seaside areas was observed.

276. The short-period (assumed) sediment volume was 397,000 m^3 / year by adding 128,000 m^3 / 8.5 years of the existing CT Basin to 828,000 m^3 / 2.2 years from 2017 to 2019.

Table 6-23 Actual Sedimentation Volume in Channel and Basin of SHV Port

Duration	Sediment Years	Actual Sediment Volume (1,000 m^3)					2017 to 2021 (3.7years) Converted Volume (1,000 m3)	Average annual Sediment Volume	Short Period Sediment Volume (1,000 m^3/year)
		Channel	Basin			Total			
			Sub-total	MPT 1)	Existing CT 2)				
2011-2019	8.5		128		128	128	55	15	
2017-2019	2.2	661	167	167		828	957	261	397
2019-2021	1.5	90	38	38		128			
							Total annual Sediment Volume	**276**	

Notes

Bathymetric Survey	Survey Timing
MPT・DD Survey	2011
MPT・Post Dredging Survey	2017.07
NCT1 DD Survey	2019 08
NCT2&NCT3 FS Survey	2021.02

1) Basin in front of MPT

2) Basin in front of Existing CT

Source: JICA Survey Team

277. The total average annual sedimentation volume between 2017 and 2021 was approximately 280 thousand m^3/year, and the short-term sediment rate is anticipated to be approx. 400 thousand m^3/year.

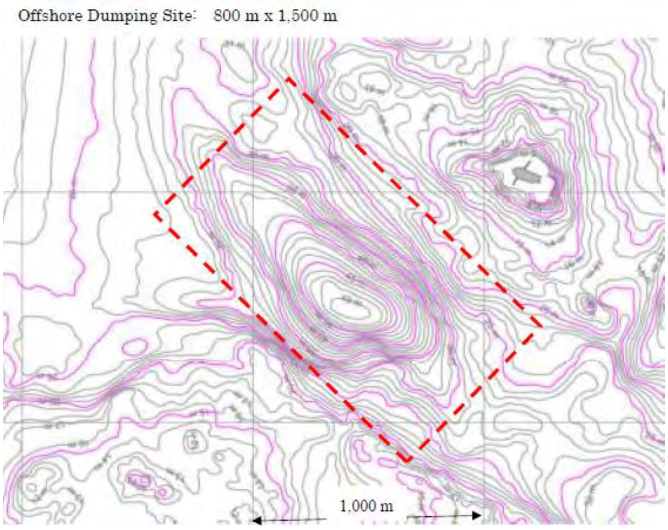
278. Table 6-24 shows the required capacity of the offshore dumping site for NCT1, NCT2 and NCT3 Projects based on the dredged soil volume and the assumed maintenance dredging volume as described above.

Table 6-24 Estimated Volume of Off-shore dumping and required Capacity of Dumping Site

Project	Items	Soil Volume (million m3)
NCT1	Dredging Volume NCT1	4.3
	Marginal Dredging (10 %)	0.4
	Diversion to Land Reclamation	-0.4
	Sub-Total	4.3
	Soil Swell (10%)	0.4
	Maintenance Dredging (4 years)	1.1
	Total	**5.8**
NCT2,3	Dredging Volume NCT 2,3	4.7
	Marginal Dredging (10 %)	0.5
	Diversion to Land Reclamation	-1.5
	Sub-Total	3.6
	Soil Swell (10%)	0.4
	Maintenance Dredging (30 years)	8.1
	Total	**12.1**
NCT1- 3	Grand Total	**17.9**

Source: JICA Survey Team

279. Based on the above-mentioned offshore dumping soil volume, it is proposed that the offshore dump site be a water area of 800 m x 1,500 m, located at approx. 1 km southwest of Koh Dek Koul Island as shown in the following Figure 6-20. In addition, it is necessary to reserve a water area to the northwest of the disposal area shown in Figure 6-20 for the disposal of maintenance dredging material after NCT2 and NCT3 are put into operation.



Source: JICA Survey Team

Figure 6-20 Off-shore Dumping Site

6.12 Preliminary Design of Access Road

6.12.1 Basic Conditions for Road Design

280. According to the results of the traffic volume estimation, the traffic volume at the completion of the maintenance of NCT2 and NCT3 can be sufficiently handled by the NCT Access Road and NCT Access Bridge to be constructed in the NCT1 project. Therefore, it is not necessary to develop new access roads and bridges in this project.（Refer 5.3.5 (2) Access Road Plan）

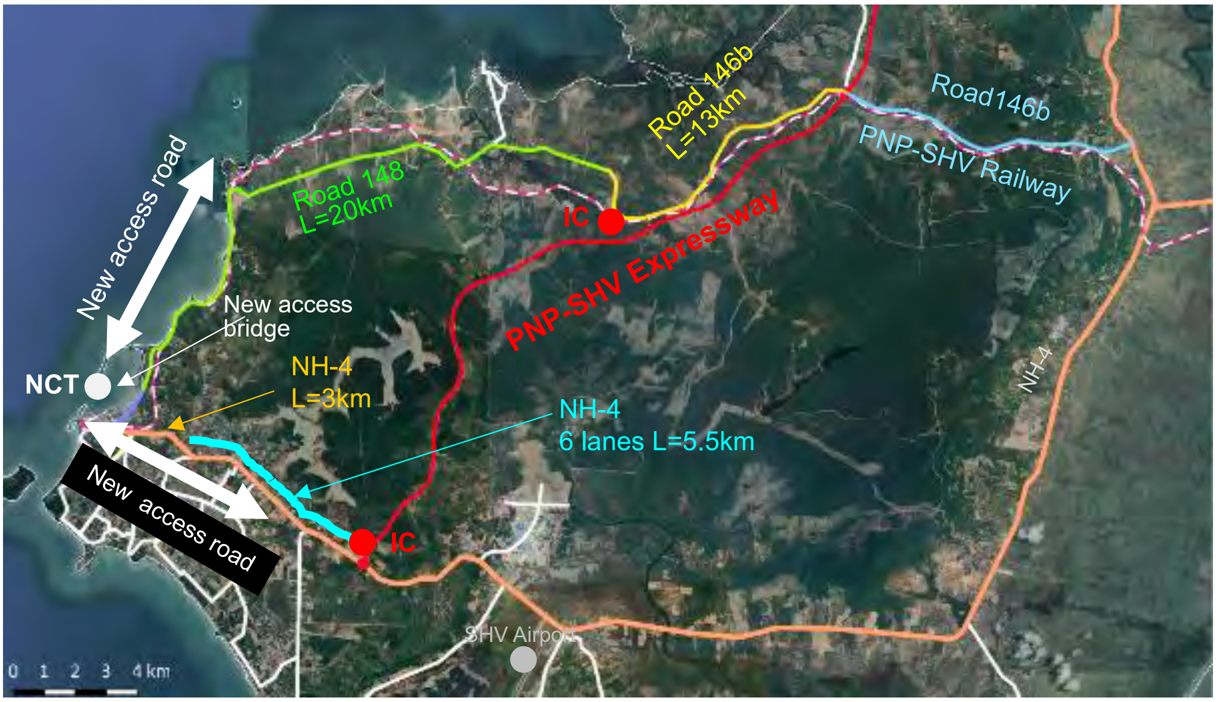
281. In this section, preliminary study of road widening development that satisfies the required number of lanes based on the results of future traffic estimation in 2050 after the completion of NCT2 and NCT3 development will be considered. The development policy for each road is shown below.

282. Major routes connected to NCT shown below and new roads that can access the port will be considered in this study.

Table 6-25 List of candidate Access road

	name	details	type	Manage
1	New access bridge	L=0.5km Number of lane : 2 lane * 2 direction	Port access	PAS
2	Road 148	L=20km W=12m Number of lane : 1 lane * 2 direction	Collector	MPWT/ DPWT
3	NR4	L=3.2km W=20m Number of lane : 2 lane*2 direction *The 5.5km section from the terminal IC to the SHV Port was widened in 2021 in 3 lanes x 2 directions (25m).*	Arterial	MPWT

Source : JICA Survey Team



Source : JICA Survey Team

Figure 6-21 Design target route

6.12.1 (1) Design policy

6.12.1 (1) a New access bridge

283. The current NCT Access Bridge is planned to be constructed as the only road connecting between NCT and land.

284. Road widening (by adding number of lanes) will be compared according to the following two alternatives.

- Alternative-1: widening of existing bridge
- Alternative-2: Construction of a 2-lane bridge with 1 lane x 2 directions in addition to the current bridge

285. When making comparisons, the optimal plan is proposed after giving due attention to multiple points.

6.12.1 (1) b Road 148

286. Road 148 is being rehabilitated by MPWT by a joint venture between Cambodia's and China's company.

287. However, the number of lanes currently being maintained is pavement maintenance with two round-trip lanes. If it is necessary to widen the number of lanes with two or more round-trip lanes, maintenance will be required according to the required number of lanes.

288. It is expected that there will be an impact such as the relocation of residents because certain sections along the Road 148 pass through densely populated areas. Therefore, lane widening will be compared according to the following two alternatives.

- Alternative-1: widening of existing road
- Alternative-2: Construction of a 2 lanes bypass road with 1 lane x 2 directions for a section where widening is considered difficult.

289. When making comparisons, the optimal plan is proposed after giving due attention to multiple points.

6.12.1 (1) c NR4

290. NR4 has already been constructed with 6 lanes 5.5km from the connection with the final IC on the PNP-SHV Expressway toward the port. Therefore, it is considered possible to secure a sufficient traffic capacity by improving the remaining 3.2km section to the SHV Port. In addition, it is assumed that there will be no impact on the roadside environment such as obstacle properties because the securing of road land for road improvement has already been completed.

291. JICA survey team received answer that there are no plans to further extend and maintain the existing 6-lane section on NR4 in the hearing for MPWT. Therefore, it is not expected that the widening project will be implemented as road maintenance necessary for road managers.

6.12.1 (2) Design conditions

292. Various guidelines to be observed in the design are shown below;

- Road Design Standard （Ministry of Public Works and Transport - MPWT）
- Road Structure Ordinance (Japan)
- AASHTO （USA）

293. The number of lanes that need maintenance is shown in Table 6-26 below;

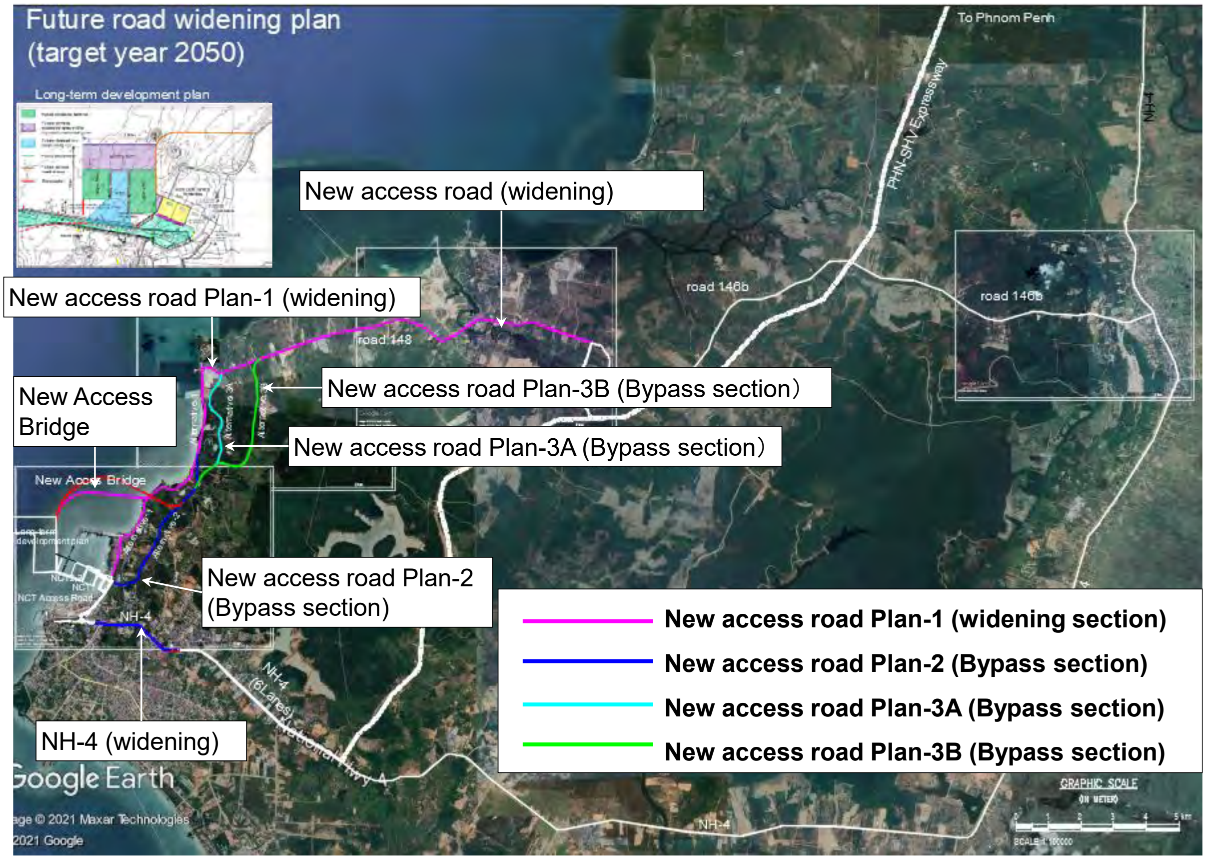
Table 6-26 Plan of lane number

	name	length	Existing number of lane	2050 number of lane
1	New access bridge	L=0.6km	2 lanes * 2 directions = 4 lanes	3 lanes * 2 directions = 6 lanes
2	Road 148	L=33km	1 lane * 2 directions = 2 lanes	2 lanes * 2 directions = 4 lanes
3	NR4	L=3.2km	2 lanes * 2 directions = 4 lanes	3 lanes * 2 directions = 6 lanes

Source : JICA Survey Team

6.12.2 Feasibility Design of New Access Road

294. The related access roads are shown in Figure 6-22 below;

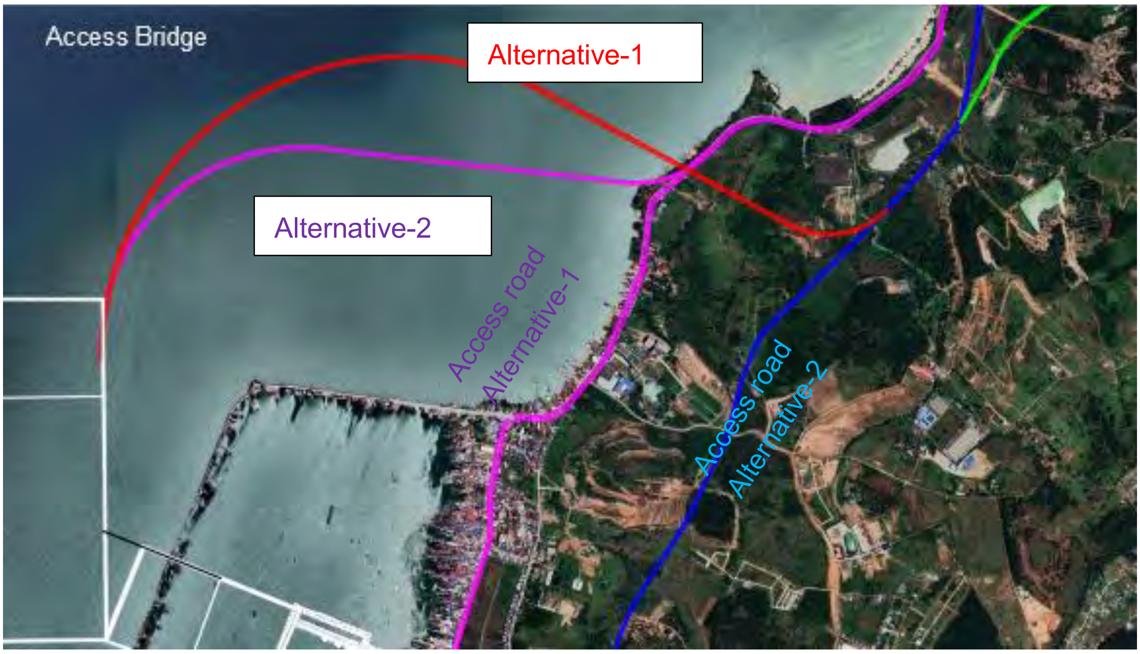


Source : JICA Survey Team

Figure 6-22 Layout of road plan

6.12.2 (1) New access bridge (Long-term Port Development Plan)

6.12.2 (1) a Layout Plan



Source : JICA Survey Team

Figure 6-23 Plan of New access bridge

6.12.2 (1) b Method of widening lane

295. The development of the new access bridge will be examined by widening the existing NCT access bridge and comparing it with the construction of the new bridge. The comparison results are shown in Table 6-27 below.

Table 6-27 Comparison table of widening of bridge

Comparison	Widening existing bridge	New bridge
Summary	A plan to widen the existing NCT access bridge and secure the required number of lanes.	A plan to secure the required number of widening lanes by constructing a new bridge separately from existing bridge.
Economical	If the same plan is implemented for the bridge length, it is expected that the amount will be about the same, but the current widening plan is uneconomical because there is a possibility that a special auxiliary construction method may be required for the current bridge widening work.	
		Good
Traffic processing	The traffic processing capacity during construction is inferior to that of the new bridge plan because traffic restrictions during the current bridge widening work are considered essential.	
		Good
Environmental impact	The current bridge widening plan has less impact on the environment than the new bridge plan because the widening has already been completed.	
	Good	

Source : JICA Survey Team

6.12.2 (1) c Comparison study of New access bridge plan

296. A comparative study was conducted on the connection between NCT and the planned road by the new access bridge. The outline of route comparison for each plan is shown in Table

6-28 below;

Table 6-28 Comparison table of New access bridge Plan

Comparison	Alternative-1	Alternative-2
Summary	The New access bridge will connect to bypass road without connecting to Road 148.	The New access bridge will connect to Road 148.
Economical	Construction cost of Alternative-1 is higher than Alternative-2 due to the need for grade-separated bridge on Road 148.	
		Good
Traffic processing	Traffic congestion will be eased because traffic is dispersed according to Alternative-1 because New access bridge can be separated from existing traffic without connecting to Road 148.	
	Good	

Source : JICA Survey Team

6.12.2 (1) d Comparison study of New access bridge superstructure

297. Most sections of the new access bridge are at sea. The plans at sea were compared by the bridge type or causeway type (embankment). The outline of route comparison for each plan is shown in Table 6-29 below;

Table 6-29 Comparison table of New access bridge superstructure

Comparison	Alternative-A	Alternative-B
Summary	All sea period will be planned with bridges type.	Most of sea period will be planned with causeway type (embankment) and partial required period will be planned with bridge type.
Economical	Construction cost of Alternative-1 is higher than Alternative-2.	
		Good
Environmental impact	In the case of comparison plan 2, there is an impact on the environment because the sea is closed by Causeway construction.	
	Good	

Source : JICA Survey Team

6.12.2 (1) e Proposal of development policy

298. Proposal contents of development policy is shown in below;

Method of widening lane	New bridge development
Route Selection	Connection to bypass routes is recommended with an emphasis on improving traffic processing capacity. (Alternative-1)
Period at sea	Causeway + bridge plan is recommended due to economic efficiency.(Alternative-B)

Source : JICA Survey Team

6.12.2 (1) f Recommendations for maintenance

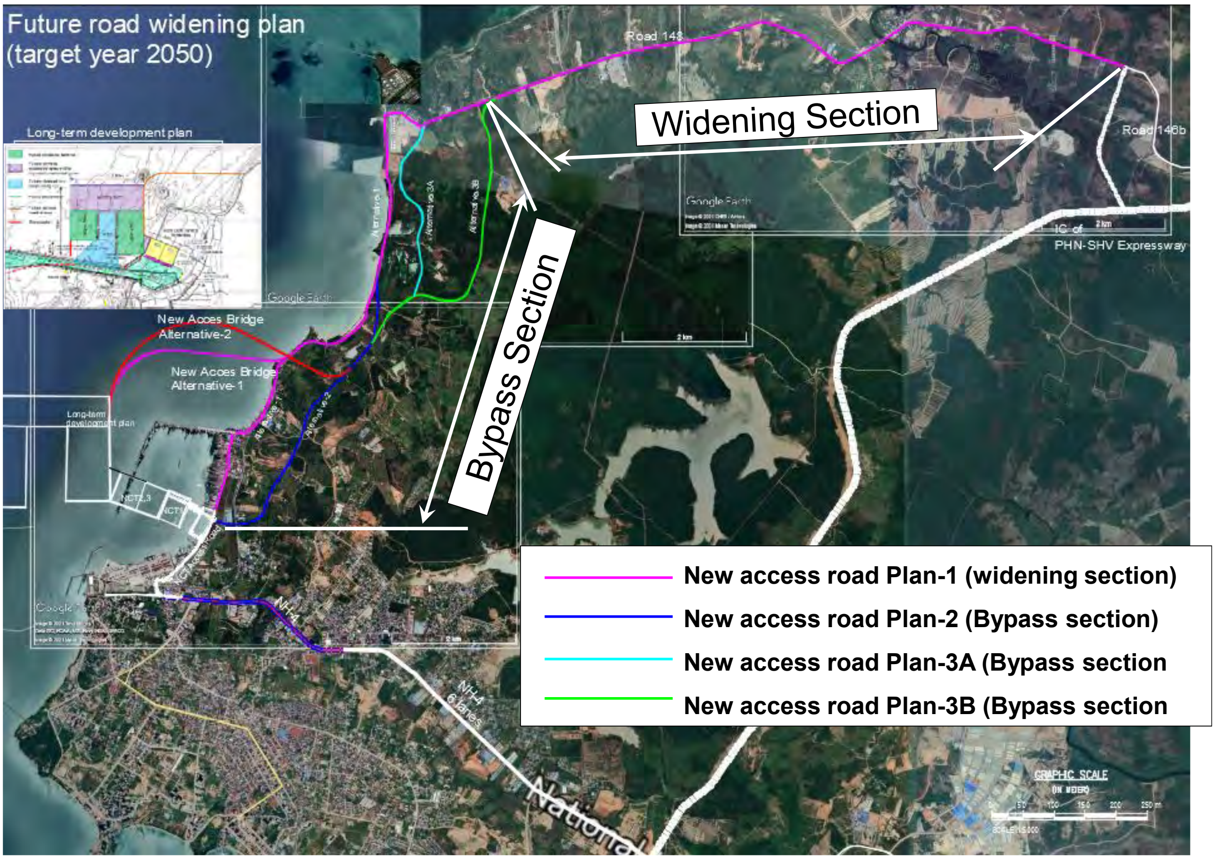
299. It is considered necessary to establish an optimal policy through discussions between roadside residents, PAS, and DPWT counterparts regarding the use of the inland sea area, the impact on the environment, and the economic efficiency of the causeway when deciding the alternative.

300. It is necessary to proceed at the same time as the new access road development with the comparison of whether to connect NCT and Road 148 or to a bypass road that will be constructed as a separate road with Road 148 as a grade separation.

6.12.2 (2) New access road (Road 148)

6.12.2 (2) a Layout Plan

301. The development of new access road will take into consideration the roadside conditions of the existing road (Road 148). In addition, the development is proposed by dividing the entire section of 21km into [Bypass development section] and [Widening of existing road section] as shown in Figure 6-24 from the viewpoint of feasibility and ease of the project.



Source : JICA Survey Team

Figure 6-24 Plan of New access road

6.12.2 (2) b Comparison study of New access road plan (Bypass section)

302. For the bypass section shown in the above, it is necessary to formulate an optimal improvement policy by comparing [existing road widening] or [new bypass road] with 4 lanes (2 lanes x 2 directions) required based on future traffic estimation. The outline of comparison for each plan is shown in Table 6-30 below.

Table 6-30 Comparison table of New access road plan

alternative	widening	bypass
Summary	Widening to existing road to 4-lane bypass road with 2 lane x 2 directions	Construction of a 2-lane bypass road with 1 lane x 2 directions in addition to the existing Road 148 on period
Cost	Widening option is more economical than bypass maintenance because it can be used as much as possible such as the existing road.	
	Good	
Impact on roadside	Relocation of residents will have a large impact on the maintenance because Road 148 does not have the ROW required for widening. On the other hand, it is possible to plan a route that does not affect the relocation of residents in bypass development.	
		Good
Impact on traffic flow	Road 148 has a lot of traffic to NCT, and there is also a lot of traffic to local residents. Most of the traffic volume increased in this maintenance is the traffic volume for NCT, and it is possible to clarify the division of traffic volume in the bypass maintenance for the widening of the existing road, so it is possible to alleviate the traffic congestion on Road 148.	
		Good

Source : JICA Survey Team

6.12.2 (2) c Consideration of New Access Road (Bypass section)

303. When developing New access road, it is desirable to secure the required number of lanes after securing the ROW required for widening for sections that do not pass through residential areas.

6.12.2 (2) d Recommendations for maintenance

304. Since the completion of pavement of existing Road 148 in 1 lanes x 2 directions by MPWT in 2022, it is necessary to investigate the latest situation such as the maintenance status after completion and the impact on the roadside, and reconfirm the impact of widening.

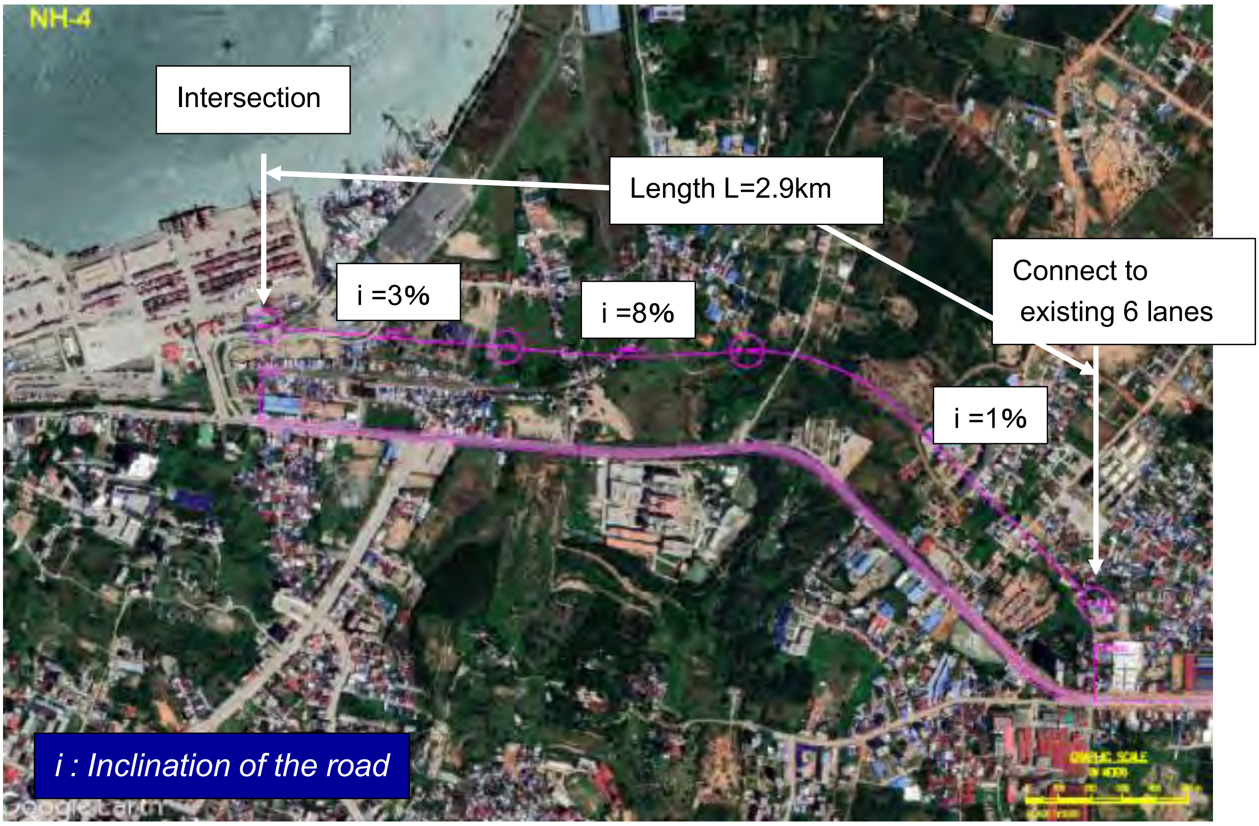
305. When considering a bypass construction, since it is inevitable to cross the railway from Road 148 toward the mountain side, it is necessary to establish the optimum policy after confirming a common understanding in consultation with the counterparts regarding the impact on the railway.

306. In addition, it is considered necessary to carry out an impact assessment rather than conducting a natural condition survey in the hills area.

307. In order to widen the current road, it is necessary to establish an optimal policy through consultation by roadside residents, PAS, and DPWT based on a common understanding of environmental and social considerations, such as land acquisition and resettlement.

6.12.2 (3) NR4

6.12.2 (3) a Layout Plan



Source : JICA Survey Team

Figure 6-25 Plan of NR4

6.12.2 (3) b Recommendations for maintenance

308. It is expected that maintenance will proceed relatively easily because the ROW required for road widening has already been secured by MPWT.

309. The basic policy will be widening of existing roads. However, consideration of set up a climbing lane and longitudinal plan will be necessary because there is slope of 8% or more on existing road.

6.13 Power Supply Planning and Outline Design

6.13.1 Power Supply Status around Study Area

310. Power supply network in study area (SHV City) is under the jurisdiction of Electricity Authority of Cambodia (EDC: Electricite du Cambodge). In SHV city, construction rush of hotels and casinos has continued recently. Considering the aforementioned, Based on discussion between PAS and EDC, PAS have determined to construct 22kV Substation (22kV 20MW-2 pull-in). hereinafter “PAS Substation”) located at vacant space beside the generator building of the existing container terminal within SHV Port. According to information provided by PAS, the building of the Substation was already completed and installation of relevant equipment and devices were commenced in December 2021, and the Substation started operation (power receiving) in the end of March 2022.

311. Transmission line to PAS Substation plans to be supplied from a power Grid Line aside from the transmission line covering SHV City, which is able to provide more stable power

distribution to PAS substation.

6.13.2 Power Receiving and Transforming System

312. NCT1 which is already in the implementation stage of the project, will receive power from the PAS Substation with a high tension of 22 kV, and the high tension step down to a medium tension of 6.6 kV in the Substation Room at NCT1. The stepped down medium tension will be distributed to Gantry Cranes, etc. Power supply to relevant buildings, yard lightings, reefer container outlets will be the power stepped down from the medium tension of 6.6 kV to 400/230 V.

313. The capacity of the PAS Substation was planned as 22kV, 20MW-2 lead-in based on the power demand forecast prepared by PAS for existing port facilities, SEZ and NCT1. From the table, it is understood that totally about 29 MW will be supplied to the existing port facilities, SEZ and NCT1. The rest of 11 MW remained will be the reserve capacity of the Substation and/or the spare capacity for future expansion.

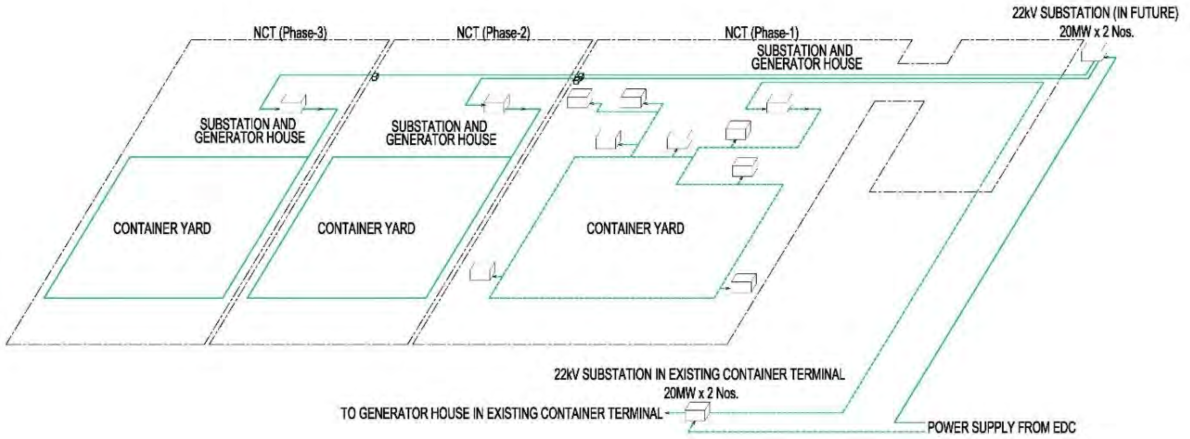
314. Taking into account of the cargo handling equipment, buildings, yard lightings, reefer container outlets, etc., NCT2 and NCT3 demands respectively about 12 MW and 14MW for a total of about 26 MW. Since the reserve capacity of 11 MW kept in the PAS Substation is insufficient, a New PAS Substation (22 kV, 20 MW-2 lead-in) is to be additionally required in some unused land of the port area in SEZ, NCT1 or such.

6.13.3 Power Distribution Planning

315. Figure 6-26 shows a schematic diagram of the power distribution system for NCT2 and NCT3.

316. As shown in the figure, the power distribution to NCT2 will be directly received with a high tension of 22 kV from the New PAS Substation. 22 kV power distributed to NCT2 will be stepped down to medium tension of 6.6 kV at the NCT2 Substation. The stepped down medium tension will be distributed to QGC, etc. as same as NCT1. Power distribution/supply to yard lightings, reefer container outlets will be further stepped down from 6.6kV to low voltage of 400V/230V for their use. As for the power feeding to NCT3, branching from the NCT2 Substation was considered but not same cabled, since possible troubles on primary power distribution side including NCT2 Substation might be occur power outage on NCT3. The New PAS Substation should be designed to distribute power directly and individually for NCT2 and NCT3 with a high tension of 22kV including cargo handling equipment such as QGCs, relevant buildings, yard lightings and reefer container outlets.

317. Generator system will be installed at NCT2 and NCT3 Substations as a backup in case the power supply from the newly installed PAS Substation is interrupted. The generator system will mainly supply electricity to QGCs, yard lightings, reefer container outlets, and other major facilities.



Source: JICA Survey Team

Figure 6-26 Schematic Diagram of Power distribution

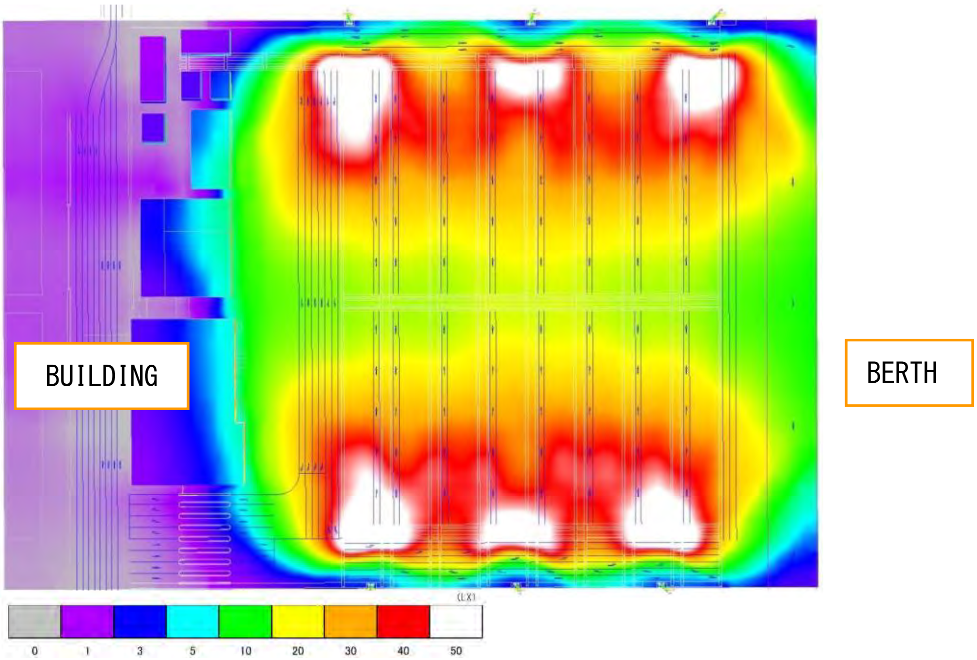
6.13.4 Yard Lighting System

318. Since RTG and yard tractor &trailer etc. run in Container Yard, the lightings in the yard will be required for safety purpose not to interfere with the running of relevant cargo handling equipment. Lighting towers plan to be installed at both side ends of the container yard as same as NCT1. It is also assumed that the average daily lighting hours are twelve (12) hours based on the actual operating record of the existing Container Terminal and the lighting fixtures apply LED type with some advantages such as long durability, less power consumption etc. Table 6-31 shows design criteria of the Illumination Level. An illuminance calculation/analysis within the yard is shown in Figure 6-27, and it shows that the required illuminance is secured as the average illuminance in the yard area. Furthermore, considering the illuminance of the QGC and lighting equipment of the berthing vessel, it is possible to secure enough illuminance that does not hinder cargo handling operation at quay area.

Table 6-31 Design criteria, Illumination Level

Area	Illumination Level, Average
Container Yard	30Lx
Apron (Berth)	75Lx

Source :JIS Lighting Standards :JIS Z9110:2010



Source: JICA Survey Team

Figure 6-27 Illumination Analysis in Container Yard

6.14 Water Distribution Planning and Outline Design

6.14.1 Water Supply System

319. Tap water to NCT1 will be planned to supply from the water main by Sihanoukville Waterworks Corporation that is laid along the existing coastal road running beside SEZ and then will be distributed to the buildings and the water supply system in container yard through the water tank and pumping system, and water supply piping network.

320. For the estimated daily water consumption covering to the entire New Container Terminals (NCT1, NCT2 and NCT3), some discussions were held with PAS and Sihanoukville Water Supply Corporation. The Corporation confirmed possibility to supply the required amount of water. (At the stage of construction of the multi-purpose terminal, the water pressure of the water main was 1.0 MPa or more in the water main pipe line)

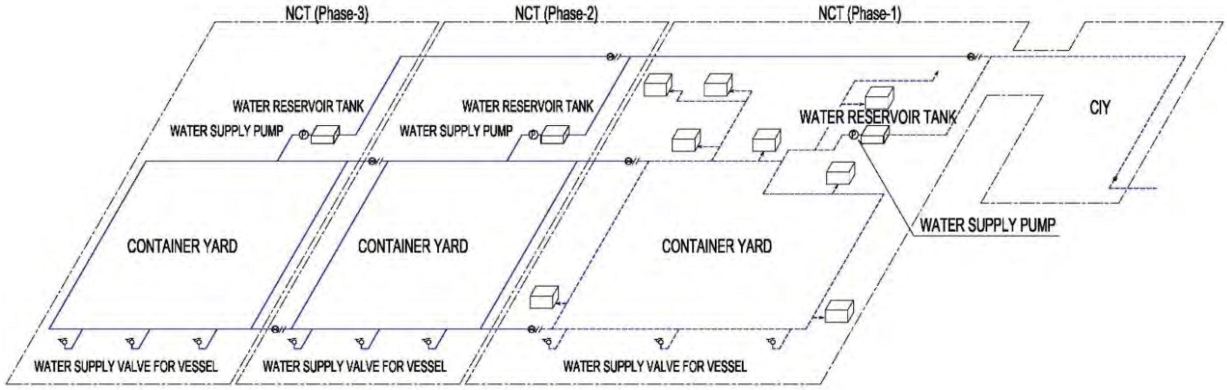
321. Since it is possible to provide water service for NCT2 and NCT3 through the NCT1 water pipeline, the water distribution to NCT2 and NCT3 will be loop water supply systems with separation equipment such as valves and water meters to be installed at each inside NCT2 and NCT3.

6.14.2 Water Supply System

322. Figure 6-28 shows the Diagram of Water Supply System for NCT2 and NCT3.

323. As shown in the figure, water supply to NCT2 and NCT3 will be provided to each relevant buildings and other required within container terminal via water receiving tank with pumping system and water supply piping network through the service pipe branched from the water supply pipe provided for NCT1. The reason why the water supply system in NCT2 and NCT3 is the same system as that in NCT1 is to ensure the water supply between the terminals in

case of the operation failure of the water supply pumps at any terminal.



Source :JICA Survey Team

Figure 6-28 Water Supply System

6.14.3 Fire Fighting System

324. Outdoor fire hydrants deployed based on a water discharge radius of 100 m will be installed in the yard of NCT1, and indoor fire hydrants along with the hose reel provided based on a fire extinguishing radius of 25 m will be installed in each building located inside NCT1.

325. As for firefighting system, the same systems will apply to NCT2 and NCT3 consistently.

326. The water supply pipe to be buried underground for NCT2 and NCT3 will be same high density polyethylene pipe in using of tap water pipeline in consideration of its flexibility against ground subsidence and corrosion resistance against salt. In order to avoid cross-connections with the water pipes, measures such as identification labels should be taken into consideration.

6.14.4 Waste Water Treatment System

327. Water quality of sewage discharged from the toilets in buildings constructed in NCT2 and NCT3 and the wastewater discharged from washbasins etc. do not satisfy the Treated Water Quality Standards stipulated by the Ministry of the Environment of Cambodia. The Standard also do not permit discharge directly to the Sea area without treatment of the waste water. For the above reason, treatment by a merger type septic tank satisfactory of the required water quality standard will be planned to install with NCT2 and NCT3 individually, and the treated wastewater as well as sewage will be discharged to the Sea area through the septic tank and the rainwater drain piping. As for the oil and grease discharged from kitchen, Pantry and maintenance shops will be discharged to Sea after separating oils and fats with a grease trap.

328. The design criteria currently considered for the waste water drain and the sewage system are the followings.

- Amount of influent to the septic tank : same as the amount of daily water supply.
- Underground buried drainage pipe: Not less than 150 mm diameter with the gradient more than 1.0%.
- Intervals between Manholes: 120 times the diameter of the drain pipe in maximum.

- Wastewater drain and sewage piping material: Polyvinyl chloride Pipe considering corrosion, initial cost and workability.
- Treated water quality by Septic Tank: compliant with Water Quality Standards set by the Ministry of the Environment of Cambodia.

6.15 Preliminary Design of Cargo Handling and Security Equipment

329. Utilizing the examination results in "6.4 Container Cargo Handling Plan (Concept and Yard Layout)" the major cargo handling equipment to be introduced will be roughly designed based on Option 2 (ARTG method).

	Quay	Apron	Container Yard	CY – Gate
Option-1 (Manual)	Manned QC	Yard Chassis	RTG	Road Trailer
Option-2 (ARTG method)	Manned QC	Yard Chassis	ARTG	Road Trailer
Option-3 (AGV method)	Manned QC	AGV or Auto Trailer	ARTG	Road Trailer

Source : JICA Survey Team

6.15.1 Quayside Container Crane (QGC)

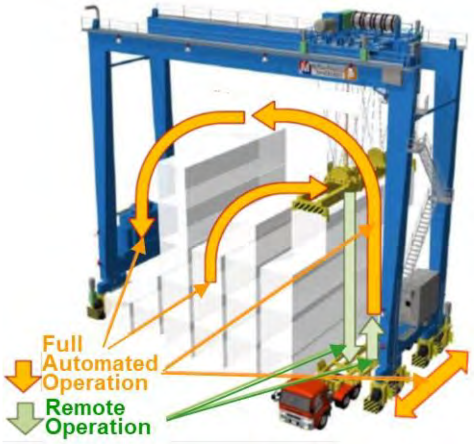
330. For the QGC, a large container crane that can be utilized for on-deck 20-row container ships will be adopted to cope with large container ships expected in future. In order to increase the unloading capacity, a twin-lift telescopic spreader that can unload two 20ft containers at the same time will be adopted. In addition, the hoisting and traversing speeds will be increased. It has sufficient back reach to temporarily unload a hatch cover behind the landside rail.

6.15.2 ARTG (Automated RTG)

331. The ARTG which is used for the container storage yard has the same basic specifications and performance as the manual type RTG used in the normal storage yard, but it is operated remotely and automatically from the remote control panel installed in the operation center.

332. As for the specifications, a hybrid specification RTG with 1 over 5 stacking tiers will be adopted to enhance cargo handling efficiency in the storage yard. In addition, in order to reduce driver fatigue and facilitate driving, the RTG automatic steering system that uses GPS or magnetic tape will be adopted.

333. The range in which ARTG is manually operated from a remote controller is the hoisting / lowering zone of about 1 m above the trailer on the yard trailer when the yard trailer arrives in the chassis lane within the ARTG span. The hoisting or lowering operation including lock / unlock operation in this zone will be manually carried out. The same operator's cab installed in the manned RTG will also be installed in the ARTG in preparation not only for adjustment during automatic operation and operation during maintenance but also for countermeasure in unexpected emergency (for example, in abnormal status of semi-automated operation).



Source: JICA Survey Team

6.15.3 Yard Trailer (Tractor-head and Chassis)

334. The yard trailer will be designed to convey two 20ft containers (Rated Load: 30LT) and one 20ft / 40ft / 45ft container. The chassis section will be constructed so that 4 pieces of Auto-Corns of an on-deck container can be loaded without removing them.

6.15.4 Reach Stacker or Side-Handler for Empty Containers

335. Reach Stacker or Empty Container Handler (Side-Handler) is adopted for use in the empty container storage area behind the gate of the container terminal.

336. Empty Container Handler (Side-Handler) is commonly used for handling empty containers in many container terminals. Reach Stacker is generally used for laden container handling.

6.15.5 Schematic Design of Security Equipment

6.15.5 (1) Type and layout of Necessary Equipment

337. The main equipment required for security under SOLAS is a security fence enclosing the area and a surveillance camera with 360° all-round projection. Security lighting will be replaced by yard operation lights.

338. Security monitoring will be carried out at the guardhouse at the entrance to the public access road, as well as at the administration building to be constructed in NCT1. Remote control of the monitoring cameras will be carried out in the administration building. When NCT2 and NCT3 are expanded in the future, it will be more efficient to extend the system already installed in NCT1 and operate it integrally.

339. As for firefighting, it is assumed that NCT1, NCT2, and NCT3 will be operated as one, so there is no need to place fire trucks at each terminal. However, it will be possible to deploy fire trucks in each terminal as needed.

6.15.5 (2) Required Equipment

340. As shown in the above, the restricted areas of NCT2 and NCT3 would block NCT1 on the land side. Therefore, the restricted area is planned to be developed as an extension of the restricted area of the NCT1 container terminal. The equipment required will therefore be determined by taking into account the equipment to be installed at NCT1. The main

security equipment required for NCT2 and NCT3 is shown in the table below.

Table 6-32 Security equipment required for NCT2 and NCT3

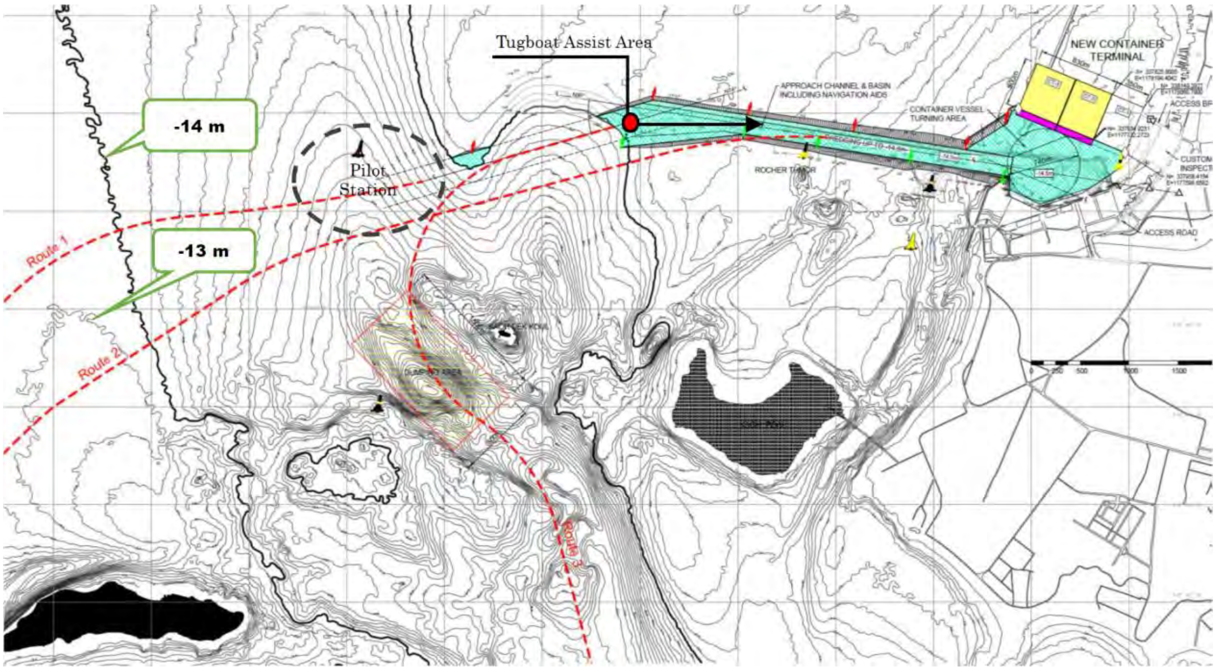
Main Security equipment	Contents
CCTV cameras	High resolution, high number of static pixels, 30x optical zoom or higher, motion detection, public address speaker
Remote monitor	
Fence	Expansion according to the construction of NCT2 and NCT3
Security lighting	Substitute operational lighting
Gate in and out security equipment	Not required as this is done at the entrance to the restricted area

Source : JICA Survey Team

6.16 Navigational Facilities and Equipment

6.16.1 Navigation Aids

341. Container vessels calling at SHV Port currently have a maximum operating draft of 10 meters or less and are free to sail on Route 1 to 3 in Figure 6-29, depending on destinations such as LCB, Singapore, etc. However, since the shallow sea area of about -13m spreads to the north of Kaoh Kaong Kong Island in the lower left of the Figure, depending on the NCT2 and 3 objective vessels need to enter and sail through Route 3 instead of Route 1 or 2. Route 3 is passing west of Koh Dek Koul Island, a small island in the center of the Figure, but the ship's turning radius is about 1,500 meters, so it is considered safe to navigate. Pilot Station and Tugboat Assist Area were indicated in the Figure.



Source: JICA Survey Team

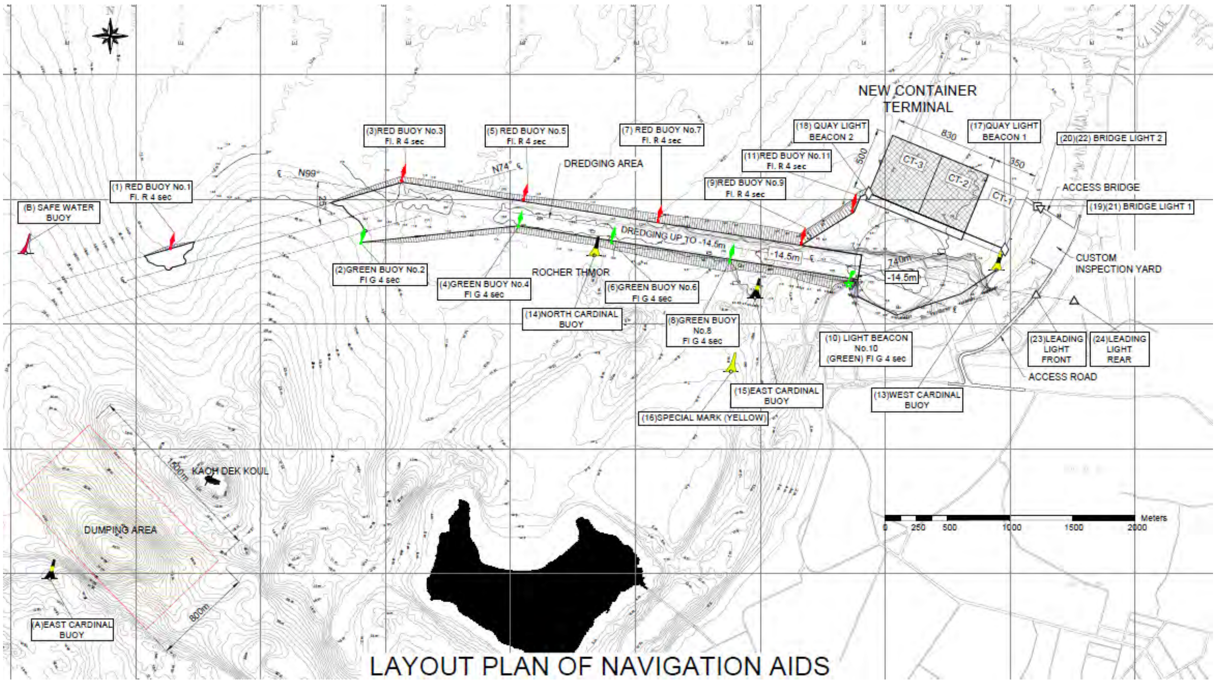
Figure 6-29 Off-shore Navigation Routs and Fairway of Container Vessels

342. The Navigation Aids system at SHV Port consist of 26 light buoys, light beacons, and leading lights for channel and basin, as shown in Figure 6-30. 17 of these are existing and

nine are planned to be installed in NCT1 Project. In NCT2, 3, they were used as it is or by shifting the position.

343. Positional shifting is subject to the following signs:

- Since the north edge of the existing channel (width 150m) is expanded by 50m to 200m, the light buoys along the north edge of the existing channel will be shifted 25m to the north.
- Due to the deepening of the channel, the entrance (offshore side) becomes a depth of -14.5 m, so the entrance light buoy is relocated.
- Relocation of light buoys due to changes in the shape of the basin.
- Since the quay is extended, the quay light beacon at the west corner of the NCT1 quay is relocated to NCT3.
- Since the channel center line moves 25 meters to the north, two leading lights are shifted.



Source: JICA Survey Team

Figure 6-30 Layout of Navigation Aids

6.16.2 Navigation Assisting Vessels

344. In the western waters of the port entrance, north-south tidal current is occurring, reaching up to 1.5 knots. Ships are forced to enter and sail the port at a speed of at least 3-4 knots because they cross this current. When entering the port, it must be stopped in the turning basin, slowing down immediately after entering the port entrance breakwater. Also, when sailing the port, the ship needs to depart the quay and start running, reaching the speed of 3-4 knots above by the time reaching the port entrance. In order to safely perform these maneuvers, tugboats assistance is required, especially when entering the port.

345. Four tugboats are in operation at the port, but none of them are sufficient because of lack of horsepower or old age, except for the 3,500HP tugboat TB Takiev, which was newly built

with ODA in 2017. In addition, there is only one pilot boat to transfer the pilot to the ship, and both horsepower and age are insufficient, and in case of stormy weather or when multiple vessels enter and sail at the same time, the ship side waits for the pilot to board. In order to improve these situations and respond to the larger vessels for NCT2 and NCT3, it is desirable to add the following port assist vessels.

- Tug Boats (4,000HP) 2 units
- Pilot Boat: 1 unit

6.17 Design of Other Facilities

6.17.1 Buildings

346. NCT2 and NCT3 are expected to be operated directly by PAS, along with NCT1 and existing terminals such as container terminals, general cargo terminals, and MPTs. Therefore, the layout of buildings and facilities will be basically arranged with premise of these integrated operations, but the more efficient operation method will be reconfirmed at the Detail Design Stage.

347. Administration Building (20 m x 30 m, 5 stories), Maintenance Shop (24 m x 45 m), Workers Building (13 m x 36 m) are planned on the NCT1. Terminal gate will be located in the CIY (Customs Inspection Yard) across the Access Bridge from the NCT1 yard.

348. Additional staff will be required in NCT2 and NCT3, depending on the expansion of berths and yard. Since it is necessary to have staff involved in terminal operations in the building, staff in charge of accounting in the building, staff maintenance working in the Maintenance shop, workers working in the yard, etc., the Maintenance Shop will be placed one each in NCT2 and NCT3. The Workers buildings can be placed whether one in each of NCT2 and NCT3 or combined in NCT2. And small buildings such as Workers rest house or outside toilet around the quay are also required in NCT2 and NCT3. Location of the buildings is referred to Chapter 6.6.

349. The additional space required for terminal operation worker is Administration Building in NCT1, which is narrow but meets the requirements. However, when requiring additional space for more efficient operation, planned construction site will be in NCT1 (Case-1) and in NCT2 (Case-2). In Case-1, expanded next to the Administration Building of NCT1, and in Case-2, the Workers Building will be a 3-story building to secure space. It would be best to be together in NCT1, but it is desirable to reconfirm with PAS, terminal management policy and number of staff at the time of Detail Design Stage to adopt the most effective plan.

6.17.1 (1) Extension Plan to be Built at the Planned Site beside of NTC 1

350. A five-story building will be planned to be extended at the space of 20 m x 20 m at east side of Administration Building planned in the NCT1. Expansion joint must be installed at the connection point between two buildings in consideration of possibility of different movement of each building depending on the horizontal force such as wind pressure. By the extension, building will be long in the east-west direction, and a passageway which has almost 7 m width will appear in the center of the building, providing a large space.

351. Administration Building planned in NCT1 has toilet on the east side of building. Therefore, toilet planned in expanded portion will be planned in the easternmost part for user convenience. In addition, the elevator will be installed on the opposite side of toilet across central corridor, and staircase will be planned surrounding it. A bright staircase can be provided by installation of vertical long fixed windows on the exterior wall facing the stairs.

6.17.1 (2) The Plan of 3 Stories Workers Building in NCT 2

352. A space for terminal operator will be planned on the 3rd floor in consideration of utility layout in a building same as the Workers Building in NCT1. The building has one entrance, and for improvement of user convenience, one elevator will be installed at the back side across the hall from the entrance. Toilet on each floor will be of the same location to make water supply and drainage as simple as possible. Grease trap will be necessary for treatment of wastewater because of planning of a restaurant inside of the building.

353. However, since Workers Building in NCT2 will be completed just before end of construction period, there is a demerit that the time required for installation of materials and equipment in the operation room of A-RTG and training after installation cannot be secured, and construction period shall be extended.

Chapter 7 Project Implementation Plan

354. Project cost estimate, construction plan and methods, procurement plan, and project implementation schedule are described in the main report.

Chapter 8 Environmental and Social Consideration

355. The Project does not fall under the large-scale project in port sector listed in the JICA Guidelines for Environmental and Social Considerations (April 2010). In addition, the Project does not fall under the sensitive characteristics and sensitive areas listed in the Guidelines, and was classified as Category B as it was considered to have no significant negative impacts on the environment. On the other hand, based on discussions with MOE, it was determined that EIA procedures under Cambodia's environmental law/legislation were required, and the JICA survey team assisted PAS in implementing the EIA procedures under the domestic laws.

8.1 Baseline Data on Environmental and Social Consideration

356. As of January 2022, the field survey has been completed except for the items that should be surveyed during the rainy season, and some of items are under analysis. The TOR of the field survey items are shown in Table 8-33.

Table 8-1 TOR of the Field Survey Items

No.	Field Survey Item	Location	Methodology / Duration	Survey Items/Parameters
1	Air Quality Measurement	2 sites 1 site for Tomnuk Rolork Community) 1 site for the Port area	Dry season, during 24 consecutive hours for 2 locations (1 weekday). Dry season, during 24 consecutive hours. Sampling method is based on Cambodian standard method or international method.	Dust, TSP, PM_{10}, NOx, SO_2, CO, Ozone,Lead
2	Noise and Vibration Level Measurement	2 sites (Ditto)	Daytime measurement for 2 locations (1 weekday). Sampling method is based on Cambodian standard method or international method.	- Equivalent noise level (Lmax, Lmin, LAeq (dB)) - Equivalent vibration level (dB)
3	Water Quality (Sea water)	4 sites (3 layers)	Field survey and sampling (Labo analysis) for 1 season 3 layers for 1layers (surface, middle, deep) Analysis method is based on Cambodian standard method or international method.	pH, Salinity, Temperature, DO, COD, SS, Turbidity, T-N, T-P, Oil&Greese, T-coli, TDS,TSS, BOD5, Detergents,SO_4, Pb.As, Cd.Fe.Hg
4	Water Quality (River flow)	1 site Inflow discharge point to the harbor	Field survey, sampling, and laboratory analysis for 1 season 1 same day for water quality survey(sea water) Analysis method is based on Cambodian standard method or international method.	pH, Temperature, TSS, BOD5, COD, Cr, Oil & Grease, NH_3-N),Detergent, T-N, T-P, Total Coliform
5	Water Quality (Ground water)	1 site Near the SHV port	Field survey, sampling, and laboratory analysis for 2 seasons (Dry season, Rainy season) : same day for water quality survey(sea water) Analysis method is based on Cambodian standard method or international method.	pH, TDS, $CaCO_3$, DO, COD, SS, Turbidity, T-N, T-P, Cl, F,NO_3,SO4,Fe,Hg,Cr,Mn,Al,Cd, Total-coliform,E-coli
5	Sea Sediment	4 sites 2 sites inner the port, and 2 sites outer the	Field survey, sampling, and laboratory analysis Analysis method is based on Cambodian standard method or	pH, Heavy metals (AS,Cd,Cr+6, Cro total, Cu, CN, PB, Hg total, Zn) T-N T-P,PCB

No.	Field Survey Item	Location	Methodology / Duration	Survey Items/Parameters
		port	international method.	
6	Traffic Survey	1 site	Traffic Volume Speed	7 days
7	Ecosystems (Flora and Fauna)	Terrestrial and marine area (located in/around the port development candidate sites)	Field survey within 1 season (to be decided by comments from national expert), Existing data survey and, Interview to experts of Flora/Fauna.	Record the rare species (e.g., IUCN Red List), location, breeding colony, pond, sensitive habitat area, photography
8	Fishing/aqua culture conditions	Fishing village in Sihanoukville City Coastal area People on the existing breakwater	Interview of local fishermen and chief of fishermen's society	Existing fishing conditions Number of fishing boats Fishing area Location of Aquacultures Existing aquaculture conditions (Volume, type of aquaculture, official permission) Required items by EIA

Source: JICA Survey Team

8.2 Environmental Impact Assessment

8.2.1 Environmental Impact Assessment for the Project

357. Table below presents the result of impact assessment including mitigation measures of the Project.

Table 8-2 Result of Impact Assessment

No.	Item	Scoping		Evaluation based on survey results		Reason of Evaluation BC: Before Construction, CP: Construction Phase, OP: Operation Phase
		BC/CP	OP	BC/CP	OP	
Pollution						
1	Air Pollution	✓	✓	B-	B-	CP: Negative impacts on air quality by exhaust gas and dust are anticipated due to increased transportation and operation of heavy equipment/ vehicles temporary during construction activities. Proper mitigation measures such as water spraying and proper routing may minimize the impact. OP: Negative impacts on air quality is anticipated due to increase of container vessels and trucks. However, those impacts are limited as the project area is already developed.
2	Water Pollution	✓	✓	B-	B-	CP: There is a risk of temporary water pollution due to dredging for access water channel construction and depositing dredged material. These impacts should be mitigated by securing proper dumping site and preventing dispersion of suspended matters. OP: In NCT2 and NCT3, a combined septic tank with a treatment capacity that can meet the effluent standard is planned to be installed and discharged to the sea via stormwater drainage pipes. PAS will be responsible of construction and operation of the wastewater treatment facility, and the construction cost is included in the Project. The facility will be in operation in the same timing as NCT 2 and 3 container terminal.

No.	Item	Scoping		Evaluation based on survey results		Reason of Evaluation BC: Before Construction, CP: Construction Phase, OP: Operation Phase
		BC/CP	OP	BC/CP	OP	
						Oily wastes basically generated from the maintenance workshop will be properly collected by a private company (e.g., Cintory Co., Ltd.).
3	Noise and Vibration	✓		B-	B-	CP: The settlement is far enough from the proposed construction site (container terminal), which is located at sea area, thus the impact is considered to be insignificant. In addition, transportation of construction materials is mainly by sea. Some materials and equipment will be transported onshore by vehicles, but the impact is considered to be limited. OP: The existing facility is sufficiently distant from settlements and houses; therefore, it is assessed that there would be no impacts from the operation of the facility. The volume of container trucks is expected to increase in operation phase; therefore, traffic, noise, vibration, and congestion around the roads in the settlement are expected. The impact should be mitigated through careful consideration of the selection of construction routes and vendors along the roads.
4	Bottom Sediment	✓	✓	B-	B-	CP: Most of the dredged material will be used for landfill, while the remaining material will be disposed of at a marine dumping site (located at west side of Koh Dek Koul Island), which has already been approved by the Ministry of Environment, in accordance with Cambodian regulation. The total capacity required for NCT1 and the project at the disposal site is calculated to be 11.2 million m^2, which can be secured judging from the topography of the site. The quality of material on vessel routes to be dredged and disposed is assessed to be within standard values. If sea disposal is required during dredging of foundation works in the landfill area, analysis of toxic metals will be carried out to check whether environmental standards are exceeded, and if abnormal values are found, appropriate disposal methods will be discussed with the MOE. OP: Analysis of bottom sediment in the harbor indicated that sediment may contain hazardous metals. Therefore, analysis should be carried out during dredging and appropriate disposal or treatment should be carried out. At this time, based on the analysis of bottom sediment, concentrations of toxic metals in the bottom sediment in the navigation channel are below the standard values, and it is judged that disposal is feasible. In operation phase, the bottom sediment should be analyzed periodically, and if abnormal values are found, an appropriate disposal method shall be discussed with MOE. In addition, for 30 years after NCT2 and NCT3 are in service, it would be necessary to consider expansion of the disposal area in the northwestern part of the island.
5	Solid Waste	✓	✓	B-	B-	CP: Solid waste such as surplus construction soil,

No.	Item	Scoping		Evaluation based on survey results		Reason of Evaluation BC: Before Construction, CP: Construction Phase, OP: Operation Phase
		BC/CP	OP	BC/CP	OP	
						waste materials, oil and general wastes will be generated. However, the impact would be limited by properly handling these wastes. Management of dredged material is described in “water quality” and “bottom sediment”. OP: Waste from vessels will be properly disposed of in accordance with international law, port regulations and Cambodian national legislation. Therefore, the impact is assessed to be minor.
Natural Environment						
6	Topography and Geographical Features		✓	N/A	B-	The project is not expected to have any topographical or geological impacts, but it was judged that there would be minor impacts due to creation of a landfill site.
7	Hydrology		✓	N/A	B-	CP: The project will not change rivers, lakes, nor utilize groundwater, so no hydrological or morphological impacts are expected. OP: The project will partially block the opening of the existing breakwater, which is expected to have an impact on water quality in the surrounding sea area. However, this will be mitigated by installation of other openings.
8	Flora and Fauna/ Biodiversity	✓	✓	B-	B-	CP/OP: Negative impacts on ecosystems are unlikely as no important ecosystems or habitats of endangered species is located at the project implementation area. Moreover, water quality simulations have shown that the diffusion of turbidity around the marine disposal site is limited and the impact on the surrounding marine ecosystem is expected to be minor. Nonetheless, the aquatic environment of marine area, especially dispersion of turbidity around the disposal site should be monitored accordingly as the same disposal site will be used for the multi-purpose terminal and NCT1.
9	Protected Area			N/A	N/A	The project is not located within a protected area and no impact on protected areas is expected.
10	Coastal Area	✓	✓	D	D	CP: No direct impacts are expected during the construction period due to the distance of the existing facilities from the sea area. OP: No direct impacts are anticipated.
Social Environment						
11	Involuntary Resettlement	✓		B-	N/A	CP: No involuntary resettlement is expected under the project. On the other hand, 21 illegal aquaculture facilities on the existing breakwater should be demolished or relocated; therefore, compensation costs and relocation sites will be finalized with the responsibility of the borrower after DD stage. Those who to be relocated will receive support in forms of compensation, but land could not be guaranteed. OP: No impact is expected during Operation phase.
12	Poverty	✓	✓	B-	B-	CP: Positive impacts on the local economy due to increased commercial opportunity and employment by construction activities are expected. On the other hand, although fishermen subject to relocation do not

No.	Item	Scoping		Evaluation based on survey results		Reason of Evaluation BC: Before Construction, CP: Construction Phase, OP: Operation Phase
		BC/CP	OP	BC/CP	OP	
						include poor people, poor people may be among the fishermen in small boats and be affected by the construction activities. Therefore, boat launch times and safety checks should be implemented to secure their activities. OP: The safety of the fishermen may be affected by the increase in the number of cargo vessels, so measures indicated above should also be implemented during OP.
13	Minorities and Indigenes people			N/A	N/A	The project does not include the area inhabited by minorities; therefore, no impacts are expected.
14	Local Economy (e.g., employment and livelihood)	✓	✓	B-	A+/B-	CP: Some aquaculture operators, who should relocate will lose their means of livelihood; however, this will be guaranteed through compensation or relocation assistance. Temporary positive impact on the local economy is expected because of increased commercial/employment opportunities generated by construction activities. OP: In the long term, after operation phase, the expansion of port facilities would contribute the growth of the local economy, including increased commercial/employment opportunities. On the other hand, after the completion of construction, the termination of temporary construction related employment for local workers may have negative impacts.
15	Land use and utilization of local resources	✓		B-	B-	CP: Some existing aquaculture facilities will be relocated or demolished, and a part of facilities and aquaculture may be negatively affected by deterioration of water quality in the harbor caused by dredging and reclamation works during construction phase. These negative impacts will be mitigated by environmental monitoring of water quality. Also, discussion regarding some facilities on levees would be necessary in view of security. OP: Small boat traffic for aquaculture and fishing outside the harbor may be impeded by container vessels, but new openings in the existing breakwater will be installed, and the impact will be mitigated by checking safe routes and limiting sailing times.
16	Water usage, water rights and rights of community	✓		D	D	CP: The impact on water use and water rights of the local population is minor, as water for construction is planned to be secured from external sources. OP: No impact on water use is expected as the construction is on existing port facilities.
17	Existing social infrastructures and service	✓	✓	B-	B-	CP: The project area is located at a sufficient distance from residential areas and no impact on social infrastructure and services is expected. However, careful consideration should be given to selection of routes for construction related vehicles. OP: Increased container trucks may have an impact along the route, e.g. traffic congestion.
18	Misdistribution	✓		B-	N/A	Specify appropriate compensation and support in the

No.	Item	Scoping		Evaluation based on survey results		Reason of Evaluation BC: Before Construction, CP: Construction Phase, OP: Operation Phase
		BC/CP	OP	BC/CP	OP	
	of Benefits and Damages					ARAP to minimize damage to fishermen and avoid uneven distribution of benefits.
19	Local Conflicts of Interest	✓	✓	B-	B-	CP/OP: There is potential for misdistribution of benefits and damages between port officials and fishermen during both the construction and operation phases. A-RAP should be appropriately planned for compensation and assistance to minimize damage to fishermen and avoid uneven distribution of benefits.
20	Children's Rights	✓		B-	N/A	CP: There are no schools located near the existing facility, and since the transportation will be made mainly by ships, the impact on school routes will be minimal. Also, measures to prevent child labor during construction should be applied, such as, indicating age limitation for employment in the contract specifications and establishing and penalties in case of violation. OP: The project is not expected to have any impact on children's rights during operation.
21	Community Health and Safety (including HIV/AIDS)	✓	✓	B-	B-	CP: Some public health impacts are expected due to the influx of construction workers, as well as increased risks related to sexually transmitted diseases (STDs/STIs), HIV/AIDS and COVID-19 between workers and the local population. To minimize the impact, the environmental manager of the proposed project should train security personnel on safety programs and COVID-19 measures while ensuring the rights of residents and workers are not violated. OP: Minimize impacts by complying with Cambodian laws and ordinances regarding working conditions.
22	Occupational Health and Safety	✓	✓	B-	B-	CP: Although there would be risk of accidents due to the operation of construction equipment and construction vehicles, safety measures will be implemented in accordance with the Labor Law and international good practices, so the impact is expected to be limited. In addition, construction workers will be instructed to wear protective gears such as helmets and safety belts, and warning signs and other safety equipment will be installed in the construction area. For handling of hazardous wastes, a contract with an authorized company will be required. Manuals and safety guidelines for handling of hazardous waste will be developed. OP: Minimize impacts by complying with Cambodian laws and regulations regarding working conditions.
Other						
23	Accidents	✓	✓	B-	B-	CP: Mitigation measures such as selection of construction routes and speed limits shall be implemented, since accidents caused by construction vehicles and boats are a concern. In addition, although the delivery of construction materials is mainly by sea, the number of vehicles involved in construction work is also expected to increase, so

No.	Item	Scoping		Evaluation based on survey results		Reason of Evaluation BC: Before Construction, CP: Construction Phase, OP: Operation Phase
		BC/CP	OP	BC/CP	OP	
						emergency vehicle routes, etc., are to be secured in the event of an accident. OP: It is estimated that number of accidents will increase due to the increased volume of container ships and trucks transporting cargo. Also, there is concern about accident among small boats of fishermen using the existing port and container vessels. The impact will be minimized through security measures such as limiting the departure time of small boats, alerting container vessels when they enter the port, and installing sign boards in the port area.
24	Transboundary Impacts and Climate Change		✓	B-	B-	CP: GHG emissions from the operation of construction equipment and the driving of construction vehicles will be small and are not expected to have a significant impact on climate change. OP: Increased GHG emissions are expected due to increasing volume of container ships and container trucks for cargo transport.

Source: JICA Survey Team

8.2.2 Cumulative Impact

8.2.2 (1) Construction Phase

358. In and surrounding the Project area, the construction work on the Multipurpose Terminal Development Project has already been completed, while the work on the Sihanoukville Port New Container Terminal Development Project (NCT1) is scheduled to start at the beginning of 2023.

359. According to the currently project schedule, the construction periods of NCT1 and NCT2 overlap by nine months from March-November 2025; even assuming that the four months after the start of construction in NCT2 are for preparation and temporary works, there is in effect a five-month overlap. Although there is an overlap between NCT1 and NCT2/NCT3 in the construction period of 5 months in real terms, the cumulative impact is not expected to be significant during construction, as the environmentally hazardous works have been completed in the NCT1 project. On the other hand, if the delay of six months or more in the construction schedule of NCT1 project are caused, it will be difficult to implement NCT2 as per the expected process, and the overall project implementation schedule and impact assessment will need to be reconsidered.

360. The Sihanoukville Port Multipurpose Terminal Development Project, the Sihanoukville Port New Container Terminal Development Project and the Project will continue to expand the capacity of the existing SHV Port facilities. The cumulative impact of the Project and these projects is expected to increase as the number of vessels calling at the port in the future and the number of container-carrying vehicles and other vehicles using the port will increase, and the utilization rate of each terminal will increase. As the Project will come into operation after the two projects in the first stage are in operation, the cumulative impact of the project on the entire port area is expected to be the most significant when the Project start the

operation. Potential cumulative impacts include air quality, noise, water quality, waste, sea and land transports and safety.

361. As these projects have the same project owner, i) the project owner will identify impacts in each project with appropriate environmental management plans focusing on air quality, water quality, safety, etc.; ii) if requested by the affected stakeholders, the relevant stakeholders will be informed of these environmental impacts. It is suggested that an environmental management plan and ongoing monitoring be implemented to ensure that cumulative impacts are identified after project implementation, including consultation with stakeholders, and that mitigation measures are implemented as appropriate.

8.3 Environmental Management Plan and Mitigation Measures

362. Environmental Management Plan and mitigation measures are shown in the table below. If additional items are requested in future discussions with PAS/MOE, the items will be added.

Table 8-3 Environmental Management Plan and Mitigation Measures

Environmental Composition/Parameters	Mitigation Measures	Responsible Unit（RU）/ Implementation Unit（IU）
1. IMPACTS DURING DESIGN/CONSTRUCTION PHASE		
1.1 Impacts during Design Phase		
1)(Structures on and along the breakwater)	➢ The IRC-WG and the PRSC-WG under the guidance of the GDR will provide compensation or assistance to the affected fish cage owners in advance before starting the Project construction.	RU:MEF (GDR)、 IU:IRC-WG、PRSC-WG
2) Safety and Health	➢ The Project owner will consult with MOE and the Preah Sihanouk Province and, if necessary, request the contractor with a preliminary mine clearance survey.	RU：PAS (Project owner) / IU:Construction Contractor
1.2 Impacts during Construction Phase		
1) Topography	➢ The Project owner will require the construction contractor must have engineer/s to monitor such works and to make sure that the works are carried out according to acceptable technical standards.	RU：PAS (Project owner) / IU:Construction Contractor
2) Surface Water Quality	➢ The Project owner will require the construction contractor to monitor sea water quality regularly at the locations as in the design phase by taking samples to MoE's laboratory. In case of any parameter increase in the abnormal conditions and abnormal situation (ex. Outbreak of red tides, Mass mortality in aquaculture and etc) identifying the factors, some mitigations will be implemented. ➢ The Project owner will require the construction contractor to educate the workers and staffs not to throw away wastes into the sea and to provide sanitary latrine in the worker camps. The construction contractor has to make sure that human wastes and construction ones will be packed and kept at the proper locations. ➢ The construction contractor will have to cooperate with local waste collecting company to transport and dispose of wastes at the dumping site. The local waste contractor must be required to have the official licence and sufficient remaining capacity at their disposal site. ➢ The Project owner will require the construction contractor to clean tools and equipment at the prepared location with sedimentation tank. ➢ The Project owner will require the construction contractor to properly prepare fuel storage location, ensuring that no any spillage occurs.	RU：PAS (Project owner) / IU:Construction Contractor

Environmental Composition/Parameters	Mitigation Measures	Responsible Unit（RU）/ Implementation Unit（IU）
	➢ The Project owner will require the construction contractor to check sanitary latrine, avoiding any discharge to the sea. ➢ The Project owner will require the construction contractor to select high quality dredging tools with minimal sedimentation dispersion. ➢ The Project owner will require the construction contractor to set silt fence around construction area to avoid spread turbidity dredging and reclamation works. ➢ The Project owner will require the construction contractor to minimize dredging time so as to minimize turbidity.	
3) Sediment	➢ The Project owner will require the construction contractor to monitor the sediment inside the port and sea route. ➢ If the concentration of toxic metal substances in the sediment exceeds the environmental standard, the contractor should report the matter to PAS and consult with MOE appropriate disposal methods.	RU：PAS (Project owner) / IU:Construction Contractor
4) Air Quality	➢ The Project owner will require the construction contractor to take proper care of vehicles and machineries and to use high quality fuels. The construction contractor will completely avoid overload transportation and congestion of vehicles, causing air pollution. ➢ The Project owner will require the construction contractor to cover materials during transportation and sprinkle water to construction site to reduce dust. ➢ The Project owner will require the construction contractor to spray water regularly along the road to be expanded to reduce dust from the mobilization of vehicles and machineries. ➢ The Project owner will require the construction contractor to monitor dust air pollution and complaint from local residents. If there is any complaint, the construction contractor have to reconsider the applied technical aspects and find the ways to solve those issues. ➢ The Project owner will require the construction contractor to prepare and to strictly implement traffic management plan at the construction sites.	RU：PAS (Project owner) / IU:Construction Contractor
5)Noise and Vibration Levels	➢ The Project owner will require the construction contractor to use vehicles and machineries with low noise and vibration and to take proper care of vehicles and machineries before the Project construction. ➢ The Project owner will require the construction contractor to have a clear timetable for working hours: morning from 07.00 until 11.00 am and afternoon from 13.00 to 17.00 pm. ➢ The Project owner will require the construction contractor to advise all drivers to drive at a low speed without exceeding 60 dB (A) for residential areas and not exceeding 45 dB (A) in some places: schools, hospitals, pagodas and nearby places of residence. No driving will be allowed at night time.	RU：PAS (Project owner) / IU:Construction Contractor
6) Waste/Biodiversity	➢ The Project owner will require the construction contractor to dredge channel and turning basin as in the plan and to regularly monitor water quality (as described in the mitigation measures for water pollution) and to observe turbidity every hour for consecutive 6 hours during dredging of channel and turning basin and transportation of dredged wastes to the dumping sites. If abnormal conditions are identified, the construction contractor should stop dumping operations and the impact on the surrounding area checked. ➢ If the contractor identifies abnormal values in this monitoring during offshore disposal work, it will stop the disposal operation and continue monitoring. The Project owner will require the construction contractor to educate workers, not allowing to dispose wastes to the sea and to cooperate with local waste collector for waste disposal at the dumping sites	RU：PAS (Project owner) / IU:Construction Contractor

Environmental Composition/Parameters	Mitigation Measures	Responsible Unit（RU）/ Implementation Unit（IU）
	as defined by Provincial Department of Environment and local authorities. ➢ Contractors will contract waste disposal contractors who have duly obtained the license. ➢ The Project owner will require the construction contractor to conduct a routine monitoring for the transportation of wastes to the dumping sites.	
7) Local Economic Activity	➢ The Project owner will require the construction contractor to prioritize local residents as the workers and/or staffs during the construction phase.	RU：PAS (Project owner) / IU:Construction Contractor
8) Traffic Condition	➢ The Project owner will require the construction contractor to inform local authorities about the construction period. ➢ The Project owner will require the construction contractor to install traffic signs at the construction sites in particular traffic lights at night time to avoid accidents. ➢ The Project owner will require the contractor to ensure emergency vehicle routes etc. in the event of an accident. The Project owner will require the construction contractor to implement traffic management plan around the construction sites and Samdech HUN SEN road in cooperation with local authorities. ➢ The Project owner will require the construction contractor to educate all the drivers to respect the law on traffic in the Kingdom of Cambodia.	RU：PAS (Project owner) / IU:Construction Contractor
9) Safety and Health	➢ The Project owner will require the construction contractor to provide trainings for the staffs and workers to have a better understanding of the use of vehicles, machineries and related equipment. ➢ The Project owner will require the construction contractor to implement all safety working standards. The provision of Personal Protective Equipment: PPE (glove, footwear, and helmet) will be provided to the staffs and workers based on the nature of works. ➢ The Project owner will require the construction contractor to construct sanitary latrine for the staffs and workers equipped with septic tanks and to provide clean water for general consumption. ➢ The Project owner will require the construction contractor to educate the staffs and workers on sexually transmitted diseases. The construction contractor will cooperate with provincial department of health for epidemics prevention around the Project area.	RU：PAS (Project owner) / IU:Construction Contractor
10) Safety Navigation	➢ The Project owner will require the construction contractors to consult with fishermen and set restrictions on their sailing times and passage routes for fishermen. The rules will be informed to the Project owner and the construction ships. ➢ The Project owner is responsible for safety reminders to the container ships during the construction period.	RU：PAS (Project owner) / IU:PAS/Construction Contractor
2. IMPACTS DURING OPERATION PHASE		
1) Surface Water Quality	➢ All the liquid waste from the port will be discharged to sewage system and then go to water treatment plant. This waste will be checked in advance before discharging to public sewage system. ➢ The Project owner will monitor sea water quality regularly (the sampling sites will be the same as the before-construction sampling sites) by taking samples and send them to the MOE's laboratory. In case of any parameter increase in the abnormal conditions and abnormal situation (ex. Outbreak of red tides, Mass mortality in aquaculture and etc) identifying the factors, some mitigations will be implemented. ➢ The Project owner will educate the workers and staffs not to throw away wastes into the sea and will make sure that	RU：PAS (Project owner) / IU: PAS, Provincial Department of Environment

Environmental Composition/Parameters	Mitigation Measures	Responsible Unit（RU）/ Implementation Unit（IU）
	human wastes and construction ones will be packed and kept at the proper locations. ➢ The Project owner will properly prepare fuel storage location, ensuring that no any spillage occurs. ➢ The Project owner will properly treat all wastewater by the Project using the new wastewater treatment facility to be built at NTC2&3. ➢ The Project owner prohibits vessels calling at the port from discharging ballast water in the port in accordance with the Basel Convention.	
2) Air Quality	➢ The Project owner will regularly monitor air quality in and around the port area and respect the Sub-decree on the Control of Air Pollution and Noise Disturbance 2000. ➢ The Project owner will educate the workers and staffs about energy saving so as to reduce air pollution. ➢ The Project owner will have tree-seedling nursery and green space for those trees.	RU：PAS (Project owner) / IU: PAS, Provincial Department of Environment
3) Noise and Vibration Levels	➢ The Project owner will use vehicles and machineries with low noise and vibration and take proper care of vehicles and machineries. Some mitigation measures will be applied to minimize noise and vibration. ➢ The Project owner will advise all drivers to drive at a low speed without exceeding 60 dB (A) for residential areas and not exceeding 45 dB (A) in some places: schools, hospitals, pagodas and nearby residential areas.	RU：PAS (Project owner) / IU: PAS, Provincial Department of Environment
4) Waste/ Biodiversity	➢ The Project owner will monitor solid waste and liquid one on ships regularly. ➢ The Project owner will carefully observe solid waste and liquid waste on ships. ➢ The Project owner will educate the workers and staffs not to throw away wastes into the sea.	RU：PAS (Project owner) / IU: PAS, Provincial Department of Environment
5) Marine transportation and land one	➢ The Project owner will monitor traffic in and around the Project area so as to take action if any traffic congestion (particularly at the intersection of National Road No.4) occurs. ➢ The project owner will cooperate local traffic police and local authority to manage traffic conditions and will educate drivers about law on land traffic. ➢ The Project owner will instruct ships to respect marine transportation regulations such as duration for parking etc. ➢ The Project owner will install all traffic signs for marine traffic around the Project area for safety.	RU：PAS (Project owner) / IU: PAS, Provincial Office of Marine Transportation and Land Transportation
6) Work Safety	➢ The Project owner will provide training for the staffs and workers to have a better understanding of the use of vehicles, machineries and related equipment. ➢ The Project owner will implement all safety working standards. The provision of PPE (glove, footwear, and helmet) will be provided to the staffs and workers based on the nature of works. ➢ The Project owner will construct sanitary latrine for the staffs and workers equipped with septic tanks and to provide clean water for general consumption. ➢ The Project owner will establish health center in the port area equipped with medical supply and will have doctors. The Project owner will cooperate with the provincial department of health for epidemics prevention around the Project area.	RU：PAS (Project owner) / IU: PAS, Provincial Department of Labour and Vocational Training

Environmental Composition/Parameters	Mitigation Measures	Responsible Unit（RU）/ Implementation Unit（IU）
7) Safety Navigation	➢ The Project owner will consult with fishermen and set restrictions on their sailing times and passage routes for fishermen. ➢ The Project owner will notify the container vessels of the rules set with the fishermen and provides safety reminders.	RU：PAS (Project owner) / IU:PAS

Source: JICA Survey Team

8.4 Environmental Monitoring

363. The monitoring plan is shown in the table below. If additional items are requested in future discussions with PAS/MOE, the items will be added.

Table 8-4 Environmental Monitoring

Environmental Resources	Parameters to be monitored	Place	Timing	Responsible Unit（RU）/ Implementation Unit（IU）
1. Project Design Phase				
1.1 Structure on the breakwater	- Compensation / assistance to fish cage owners	On the breakwater	Before the Project construction	RU: PAS (Project owner) IU: - GDR of MEF - Provincial authority and Sihanoukville municipality
1.2 Construction site	- Cleanliness of the construction site	Construction sites	Before the Project construction	RU/IU: PAS (Project owner)
2. Project Construction Phase				
2.1 Topography	- Dredging location - Depth	In the Project area	Monthly	RU: PAS (Project owner) IU: The construction contractor
2.2 Surface Water Quality	pH, Temperature, Turbidity, Salinity, TDS, TSS, DO, BOD, COD, Oil & Grease, Detergents, SO_4, TN, TP, Pb, As, Cd, Fe, Hg, and Total Coliform	4 locations (Same as baseline survey)	Quarterly	RU: PAS (Project owner) IU: The construction contractor
	Abnormal conditions (e.g. turbidity, occurrence of red tide, oil spills and etc.)	Within the port area	Everyday	RU: PAS (Project owner) IU: The construction contractor
	Turbidity	Around sea dumping sites	At the time of dumping at sea (6 hours)	RU: PAS (Project owner) IU: The construction contractor
2.3 Sediment	As, Cd, Cu, CN-, Pb, Mn, Hg, Mo, Ni, Zn, PCBs	1 location (On dredging route)	Semi-annually	RU: PAS (Project owner) IU: The construction contractor
		1 location each at reclamation sites in NCT2&NCT3	During the floor dreging work of the quay foundation rubble	
2.4 Air Quality	- Dust monitoring - CO, NO_2, SO_2, O_3, TSP, PM_{10}, $PM_{2.5}$ and Pb	2 locations (Same as baseline survey)	Semi-annually	RU: PAS (Project owner) IU: The construction contractor

Environmental Resources	Parameters to be monitored	Place	Timing	Responsible Unit（RU）/ Implementation Unit（IU）
2.5 Noise and Vibration Levels	- Sources of noise and vibration - Noise and vibration measurement	2 locations (Same as baseline survey)	Semi-annually	RU: PAS (Project owner) IU: The construction contractor
2.6 Waste / Biodiversity	Volume of waste Waste treatment methods	In the Project area	Monthly	RU: PAS (Project owner) IU: The construction contractor
2.7 Local Economic Activity	Vendors	Near the Project area along Samdech Hun Sen road	Semi-annually	RU: PAS (Project owner) IU: The construction contractor
2.8 Traffic Condition	- Traffic signs - Traffic activities	- On National Road 4 (in front of the old port) - Along Samdech Hun Sen Street - Around the construction site	- Every day - Weekly - Monthly	RU: PAS (Project owner) IU: The construction contractor
2.9 Health and Safety	Check the health and safety equipment provided to the staffs, including drinking water and toilets.	The Project site	- Every day - Weekly - Monthly	RU: PAS (Project owner) IU: The construction contractor
2.10 Safe Navigation	- Check the rules of Safe navigation of ships in the port area - Number of accidents	The Project site	- Every day - Weekly - Monthly	RU: PAS (Project owner) IU: The construction contractor
3. Project Operation Phase				
3.1 Surface Water Quality	pH, Temperature, Turbidity, Salinity, TDS, TSS, DO, BOD, COD, Oil & Grease, Detergents, SO_4, TN, TP, Pb, As, Cd, Fe, Hg, and Total Coliform	4 locations (Same as baseline survey)	Semi-annually	RU: PAS (Project owner) IU: PAS, Provincial Department of Environment
3.2 Air Quality	- Dust monitoring - CO, NO_2, SO_2, O_3, TSP, PM_{10}, $PM_{2.5}$ and Pb	2 locations (Same as baseline survey)	Annually	RU: PAS (Project owner) IU: PAS, Provincial Department of Environment
3.3 Noise and Vibration Levels	- Sources of noise and vibration - Noise and vibration measurement	2 locations (Same as baseline survey)	Annually	RU: PAS (Project owner) IU: PAS, Provincial Department of Environment
3.4 Safe Navigation	- Check the rules of Safe navigation of ships in the port area - Number of accidents	The Project site	- Every day - Every week - Every month	RU/IU: PAS (Project owner)

Source: JICA Survey Team

8.5 Stakeholder Meeting (SHM)

364. First Stakeholder Meetings (Outline of the Project briefing) were conducted on 2-4 February 2022 with government officials associated with SHV Port and representative of residents in two villages (Sangkat-1 and Sangkat-3) facing the existing port facilities. The SHMs were conducted in small groups, taking into account the COVID-19 infection. A total of five SHMs were held for administrative officials and representatives of the residents, as SHMs were held separately for each of them. There were no objections to the project in all stakeholder consultations, but attendees expressed concern about the impact of the dredging works on water quality and fisheries. The project owner side explained that there are no concerns about impacts on these items and that if these impacts to be occurred, mitigation measures will be implemented (e.g. preparation of new openings in the existing breakwater on the west side, installation of silt fencing to prevent the spread of SS during construction phase, restrictions on construction time, water quality monitoring in construction phase and safety management related to navigation).

365. Second Stakeholder Meeting were held on 25 March 2022, mainly with administrative officials from Sihanoukville province, explaining the contents of the EIA and mitigation measures and monitoring plan. There were no objections to the project, but same as in the first SHM, there were requests to ensure that affected residents are adequately compensated.

8.6 Land Acquisition and Relocation

366. About 620m in the westside of the breakwater will be demolished due to expanding new container terminal. In addition, 80m of the westside of the breakwater will be demolished in order to secure a new gate for small fishing boats.

367. Currently the breakwater in this area is partly occupied by illegally constructed structures such as temporary huts for fish farming. In addition, there are fish cages and floating huts illegally installed along the breakwater for practicing fish farming. Due to demolish the breakwater, these illegal structures need to be relocated, or relocated temporarily during the construction of NCT3.

368. Detailed procedure on resettlement for a Project is stipulated in Sub-decree on the Promulgation of the Standard Operating Procedures for Land Acquisition and Involuntary Resettlement for Externally Financed Projects in Cambodia (2018, hereinafter referred as SOP). In the F/S phase, Executing Agency prepares Basic Resettlement Plan (hereinafter referred as BRP) under the guidance from the General Department of Resettlement (hereinafter referred as GDR), and submit it to the GDR for endorsement. After the endorsement, the BRP is approved by Inter-ministerial Resettlement Committee (hereinafter referred as IRC).

369. In order to identify the number of affected households, a survey including loss inventory and socio-economic survey (site reconnaissance and hearing) were conducted from July to August 2021 by sub-contractor between the end of westside of the breakwater and the area to be demolished for small boats. As a result, 21 fish farms were found in this area.

370. All identified affected households are practicing fish farming along the breakwater in a family scale and their residence are located in the Sihanoukville City. Accordingly, the affected structures on the breakwater area not used for residence but used for a workshop of fish farming.

371. All identified households are owner of fish farm. Most of the owner installed simple structures on the breakwater using as workshop and installed fish cages along the breakwater. Some owners installed floating hut above the sea together with fish cage. About 30 to 750 fishes are kept growing in a cage for 8 to 15 months depending on the fish type. The raised fishes are sold to middleman who come to buy at each fish farm. These fishes are sold mainly at local markets in Sihanoukville City where there is a strong demand from hotels and restaurants. After the COVID-19 pandemic, the demand became weaker and some of the owner decrease the scale of business or suspended temporarily

372. Identified structures on the breakwater are made of wooden pillars and walls and use for workshop of fish farm. Because of simple structure, these structures can be easily dismantled and transported to new location. As for the floating huts and fish cages, it can be relocated by boats without demolishing.

373. The following type of groups were categorized as vulnerable during the socio-economic survey;

1. Poor households (those below the poverty line as defined nationally),[3]
2. Female headed poor households,
3. Landless household below the poverty line,
4. Elderly headed household without any means of support
5. Disabled headed household and,
6. Customary land users and indigenous people.

374. Based on the survey result, there is no households identified as vulnerable.

375. Based on the instruction from GDR, Cut-Off date of the Project was declared at the stakeholder meeting organized by PAS on 7 December, 2021. Affected persons, local authorities (village, Sangkhat, City and Provincial Government), GDR and Officer of PAS were participated in this meeting.

376. Since the affected households of the Project are al illegal occupiers at the State land, there will be no compensation for land loss. However, lump sum payment to support lost income will be provided. As the request for relocation assistance varies which, some fish farming owners expressed their preference of relocation to alternative location inside of breakwater, whereas some fish farming owners did not make their relocation preference clear, two relocation assistance option are prepared as Option 1) for the affected persons who prefer to relocate inside of breakwater and Options 2) for the affected persons who prefer to relocate outside of breakwater by themselves. Finalization of the relocation sites will be made after the D/D phase by consulting each affected household. The detail of amount both for the business relocated to a new site as well as relocate on-site will be discussed with the affected households and determined by Replacement Cost Study (RCS) after D/D

[3] Under poverty line defined as $2.4/capita/day or $72/capita/month (Ministry of Planning, 2021)

phase. Support for the livelihood restoration will be proceeded by the IRC-WG and the PRSC-WG under the guidance of the GDR.

377. Based on the clarified eligibility for each type of loss, entitlements, implementation issues/guidelines and responsible organization were considered by referring SOP for preparing an entitlement matrix of the Project. Details of entitlement and implementation issues/guidelines will be update by the GDR in cooperation with Inter-Ministerial Resettlement Committee-Working Group (IRC-WC) and Provincial Resettlement Sub-Committee-Working Group (PRSC-WG) after carrying out a Detailed Measurement Survey (DMS) and replacement cost study (RCS).

378. The Provincial Grievance Redress Committee will be established by the Provincial Governor in consultation with the IRC. The procedures follow a two-phased approach to redress grievances. In the first phase, the affected persons seek assistance at the commune level to resolve the grievance under an informal process. The complaint by the affected persons will be discussed with the leader of PRSC-WG under mediation of the commune chief or a community elder. This is followed by a 3-step formal second phase when a solution is not found during the first phase.

379. The existing Project Management Unit (PMU) in the PAS is to be in charge for the Project. In relation to the tasks related to compensation and relocation, PMU participate as a member of the IRC-WG and assist the PRSC-WG.

380. During the detailed design phase, PAS will request MEF for established IRC-WG. After detailed design phase, a consultation meeting will be organized for explaining the process of the DMS prior to the DMS and then DMS will be carried out with the full involvement of displaced persons by IRC-WG in cooperation with PRSC-WG. The Replacement Cost Survey (RCS) will be re-implement for updating the result in parallel with DMS. The RCS will be implemented by the independent organization appointed by IRC. Compensation amount will be calculated based on the result of RCS and the budget allocation to the compensation will be requested by the IRC.

381. The budget for the relocation under the Project is allocated from the national budget by the Cambodian Government. Once the budget is approved by the MEF, it will be released to the GDR's project designated account. The actual payments are made in a public place by the PRSC-WG in close collaboration with the IRC-WG. The PRSC-WG will inform the commune or the village office on the schedule dates for the commencement of the payments at least 3 days in advance. A notice will be placed at the Commune and Village office and community hall, if any, ant the same time. On the date for the payments, a public consultation meeting will be conducted to explain the procedures that will be followed prior to the commencement of the payment to each individual affected person.[4]

382. The state of relocation and compensation are to be monitored by following indicators;

1. Progress of the relocation and disbursement of compensation, and
2. Grievances and requests from the PAPs and the solutions.

[4] XI. Budget Disbursement and Payment, SOP

383. The monitoring of 1 will be continued until the completion of relocation and compensation and the monitoring of 2 will be continued until the end of construction phase.

384. Throughout the resettlement planning process, formal and informal consultations were undertaken with key stakeholders, including Government Officials, affected persons and communities. During each consultation, the information such as the Project's purpose, affected area and process of resettlement plan of the project was provided and opinion and advice for the Project and the resettlement planning were collected. Opinions and requests on resettlement support were collected in order to prepare entitlement.

385. Based on GDR instruction, a stakeholder meeting was held inviting main stakeholder of the Project including affected persons, village head, community leaders and provincial officials. At the meeting, PAS explained the Project's entitlement policy, the schedule of resettlement plan in line with the Project's implementation schedule by using Project Information Brochure (PIB). Also, opinions and requests on the Project and the resettlement plan was collected. PAS declared the Project's Cut-Off date at the meeting. Prior to the meeting, the PIB was prepared based on the GDR instruction. It contains generic information of the Project such as the Project's location, affected area, cut-off date, replacement cost study and contact address translated in local language and endorsed by the GDR. It was delivered to all participants at the meeting. All affected persons attending the stakeholder meeting were agreed with relocation policy. Compensation and implementation schedule of relocation will be detailed at the compensation committee to be established in the next phase.

386. After signing of loan agreement, there will be three more consultations before disbursement of compensation to affected households. The first one will take place prior to the DMS stage. It purposes for the displaced persons to confirm the loss of assets and the measurements and fully understand the basis on which the compensation will be paid for the loss assets and other entitlements. The second consultation will be held prior to the signing of the agreement/contract for the compensation package. It purposes to explain the compensation package to all the displaced persons. Each displaced person will be provided the draft contract and explained compensation amount. The third consultation meeting will be conducted when the compensation payments are ready to be disbursed. Prior to commencement of the compensation payment, the affected households are informed about the grievance readdress mechanism and the procedures to follow in case they have any complaints about the compensation payments. These consultation meetings will be organized by IRC-WG and PRSC-WG.

8.7 Gender Mainstreaming

387. The Cambodian Government clearly stated in the Rectangular Strategy Phase IV 2018 and the National Strategic Development Plan (2019-2021) that women are considered the backbone of the Cambodian economy and society. Because it is so, to strengthen gender equality for improving socio-economic situation and to promote the advancement and empowerment of women are the goal of the national strategy. Based on the strategy, the Ministry of Women Affairs formulated the Neary Rattanak V(the 5 years strategic plan V

2019-2023 for promoting gender equality and women's empowerment). It focuses on promoting gender mainstreaming in policies, strategic plans, and development programs across all sectors and all levels, especially in key strategic areas related to the economy, education, health, legal protection, governance and climate change.

388. In accordance with the Rectangular Strategy, National Strategic Development Plan and Neary Rattanak V, PAS mainly practices following three policies;

- Equal pay for equal jobs: Female employees are assured the same jobs for the same wages and the same position as male employees.
- Preferential employment of women: Women are preferentially employed in case the candidate's condition are the same.
- Additional benefit to female employee: The following additional benefit are provided to female employees for creating comfortable working environment;

389. A women's association under the Ministry of Women's Affairs is organized in PAS. All female employees in PAS are member of the women's association. It is divided into 7 groups and a leader is selected in each group. Head, deputy head and accountant were selected among members and they work for communicating with the Ministry of Women's Affairs and managing the women's association during off-duty hours as a volunteer.

390. Main tasks for the women's association are coordination with the Ministry of Women's Affairs, providing support on the member's mental and physical problem, domestic violence and sexual harassment.

391. According to the officers cooperated for the hearing, they are very much satisfied with their working environment from the gender mainstream points of view such as no gender gaps on wages or performance appraisal, provision of childcare and nursing care. They suggested that assistance measures such as providing gender training including sexual harassment for all employees, physical and technical support to career minded women officer, would be recommended to promote the advancement and empowerment of women in the future.

392. Female officer accounted for 10% of PAS's total officer and female officer in a management position was 7% in total management position in 2020.

393. In the ratio of male and female by the department in PAS, Human resources/Administration department, account for 40% in total female officer. On the contrary, female ratio was 0% at the department of operator and engineer which accounts for nearly half officer in PAS. As mentioned in the previous section, there is no discrimination based on gender at the recruitment for operator. However, it has been no female applicant due to working environment requiring long time operation work in a closed space. With advancing job automation and development of remote controlling technology of heavy machinery from office, chances to increase female candidate for operator position will be very high.

394. At present, there is very limited female engineer in Cambodia due to few female students majoring engineering at university.[5] Considering the trend that the female students at

[5] Based on the hearing by PAS's officer.

engineering department have been increasing[6], female applicants for engineering position would be also increased near future.

8.8 Analysis of Climate Change Impact

395. According to the Aqueduct Water Risk Atlas (Aqueduct World Resources Institute (wri.org)), this area has been diagnosed as an area at very high risk of coastal flooding. Therefore, it was determined that the project would need to address the rising sea level.

396. The latest Intergovernmental Panel on Climate Change (IPCC) the Sixth Assessment Report (AR6) predicts a maximum global average sea-level rise of 1.01 m by 2100, based on 1995-2014. The top edge height of the project is +3.3m CDL at the jetty and +3.5m CDL at the landfill, in line with NCT1 project, so there is no concern about submergence even if the water surface rises to the maximum predicted in the AR6 by IPCC. The height here was planned at the planning stage of NCT1 project with an additional +30 cm height to account for the effects of climate change.

[6] Female ratio at the engineering department in Institute of Technology of Cambodia was 16% in 2011. It was increased to 21% in 2020. (hearing form Institute of Technology of Cambodia).

Chapter 9 Project Implementation and Operation Scheme

9.1 Organizational Profile of PAS

9.1.1 Institutional Situation of PAS

397. Port of SHV, former Port of Kompong Som, was developed after Cambodia gained independence from France and opened in 1956. The port stopped operations for a time due to damage suffered during the civil war but was reopened in 1979 despite the continuation of the civil war. After the civil war, the port was renamed SHV Port in 1991 and resumed public services.

398. The port was a government managed port until 1998, and then became characterized as a state-owned autonomous port by the Sub-decree No.50 on the Establishment of PAS promulgated on 17 July 1998. PAS is under the supervision of MEF in regard to financial matters and MPWT in regard to technical matters. The Sub-decree stipulates that board members of PAS shall consist of seven members, namely representatives of MPWT, CDC, MEF, MOC, Preah Sihanoukville Province, Labor Union and Chairman of PAS. As PAS can collect tonnage dues from calling ships, it has characteristics similar to a government entity. On the other hand, PAS pays corporate tax, which means that it also functions as a commercial enterprise.

399. The government of Cambodia's policy is to change state-owned companies to joint stock companies. In this connection, PAS made an initial public offering in July 2017 and was listed on the Cambodian Security Exchange. As the status of PAS was changed to a listed company, it falls under the Law on the General Statute of Public Enterprises (Kram No.CS/RKM/0696/03) on 17 June 1996, and the Prakas on Corporate Governance for Listed Public Enterprises (No.013/10 SECC, 15 December, 2010) was applied after 2017. The Prakas on Corporate Governance stipulates that independent directors and non-executive directors should be included as members of the Board of Directors.

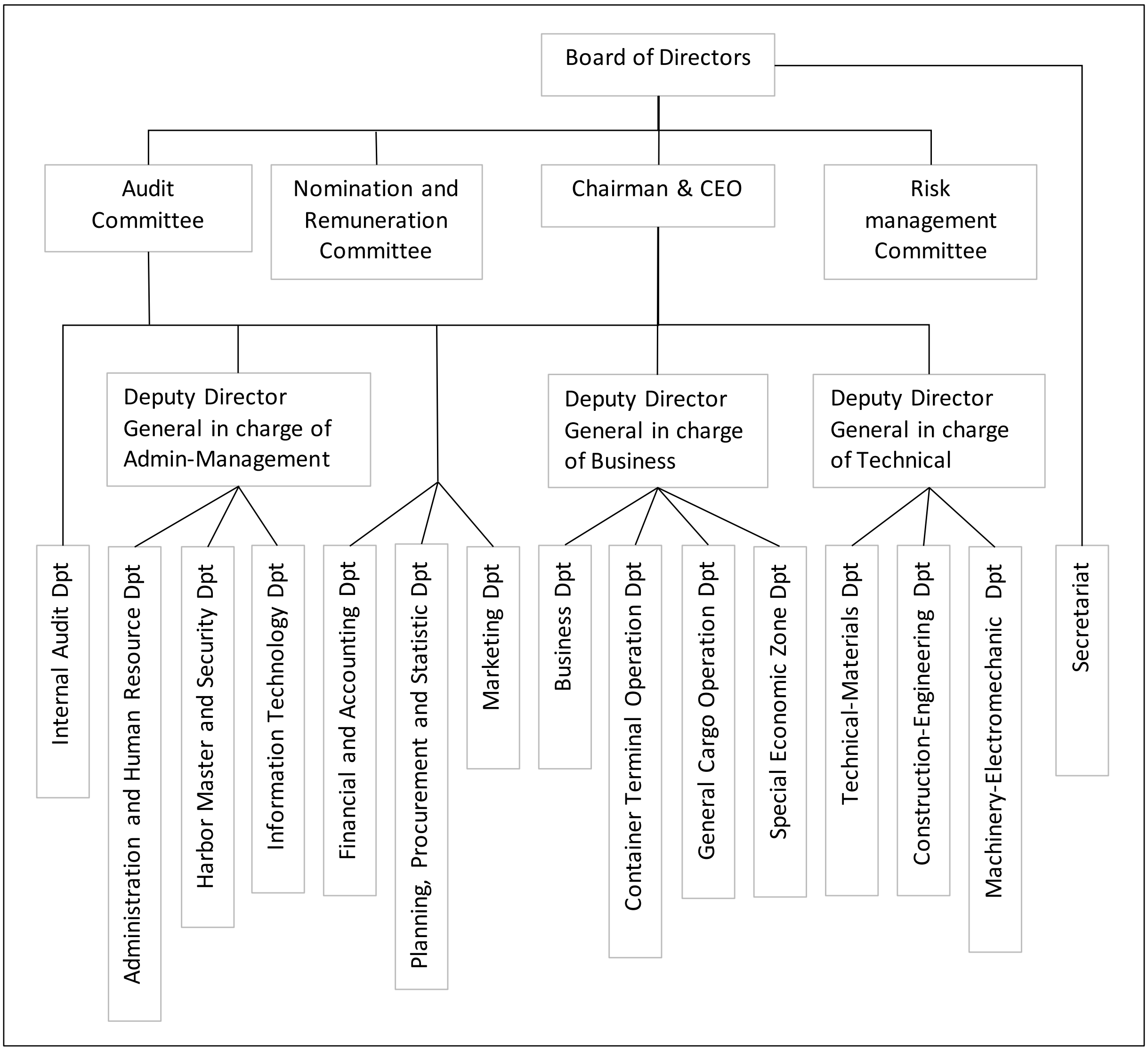
400. Following the rule of the abovementioned Prakas, the first shareholders meeting nominated one non-executive director as a representative of shareholders, and one independent director in March 2018. A representative of the labor union was nominated by the union, and representatives of each related ministry were nominated by each ministry. The government then promulgated the Sub-Decree No.608 on the Appointment of members of Board of Directors of Sihanoukville Autonomous Port on 25 June, 2018. Board of Directors of PAS now consists of seven members, namely, representatives of MPWT, MEF, MOC, Labor Union of PAS, CEO of PAS, non-executive member as a representative of shareholders, and an independent director.

9.1.2 Organizational Structure of PAS

401. The number of PAS employees stands at 1,076 at the end of December 2020. In addition, there are 340 contract workers who are mainly assigned to Container Terminal Operation, General Cargo Operation, and Technical Material Departments.

402. PAS provides all services in the port land area and port waters including pilotage, towage,

berth allocation, mooring, unmooring, stevedoring, warehousing, storage, channel maintenance, port facility development, port security control and other necessary services. In this regard, PAS has departments of operations, harbor master, equipment maintenance, business management and organizational administration as shown in Figure 9-1. PAS is therefore categorized as a service port.



Source: Annual Report of PAS, 2020

Figure 9-1 Organizational Structure of PAS

403. PAS has characteristics of a public enterprise as a state- owned company and also of a joint stock company. Accordingly, the management of PAS has to both protect to the public interest as well as generate profits. Balancing these two aims, PAS needs to rationalize the number of staff members and develop human resources for improving operations. In particular, the following measures should be taken to improve operations of the new terminals.

- To establish an operational organization for the new container terminals (NCT1-NCT3)
- To recruit new staffs such as crane operators, (A)RTG operators, etc.
- To conduct job training for workers engaged in the operation of the new container

terminals including on-the-job training

- Rationalize the number of workers in the existing container terminal operation department (303 employees and 167 contract workers) and general cargo department (179 employees and 60 contract workers) by shifting workers to the new container terminals (NCT1-NCT3)

9.2 Financial Situation of PAS

9.2.1 Profit and Loss of PAS

404. Operating revenue of PAS has increased every year till 2019 in line with container throughput and reached USD 82 million. Although container throughput increased by 0.4% in 2020, operating revenue decreased by 5.9% from the previous year. As the operating expenditure also decreased by 3.3% in 2020, the earnings before tax decreased to 65% of the previous year due to a hike in financial cost. In 2021, operating revenue increased by 9.8% and reached a record high, USD 84 million, and the earnings before tax also reached a record high, USD 27 million.

9.2.2 Financial Soundness of PAS

405. Earnings before Interest and Tax (EBIT) ratios from 2017 to 2020 range from 24%-27% which is a fairly good level. EBITDA ratios range from 35%-38%, which indicates strong profitability. However, amount of depreciation has increased and reached 34% of the EBITDA in 2020, which may bring a decline in liquidity. Large amount of debt due to foreign exchange losses (particularly due to the appreciation of the yen) is undermining profitability. In 2021, the EBIT and EBITDA ratios improved significantly to 36% and 47%, respectively, due to a large increase in pre-tax income.

406. Return on Assets (ROA) is in a rage of 1.9% -3.4% and return on Equity (ROE) is 3.8% - 7.0 % in the year from 2017 to 2020, which are less than a so-called target level of a private company (ROA 5%, ROE 10%). However, it is considered as an appropriate level due to the fact that PAS invests large amount in long life infrastructure. In 2021, ROA and ROE improved considerably to 6.6% and 11.9%, respectively, and those show a good profitability as a private enterprise.

9.2.3 Liabilities of PAS

407. The total of short and long term liabilities of PAS reached 687.5 billion Riel (USD 170 million) as of 31 December 2020, and the Debt Equity Ratio (D/E) is about 100%. While the proper range of D/E is different according to industry types and company management, it is nearly the same as D/E of the Port Authority of Thailand (i.e. 92% in 2019). Liabilities increase rate was 16.7% in 2017 and has maintained a low level since 2018, which implies that a large investment has recently been completed. The revenue liabilities ratio in 2020 was 0.45, and liabilities account for twice the annual revenue. In 2021, the long-term debt reduced to KHR 643 billion (USD 158 million), in which yen loans from JICA reduced to KHR 469 billion (USD 115 million) at the end of 2021.

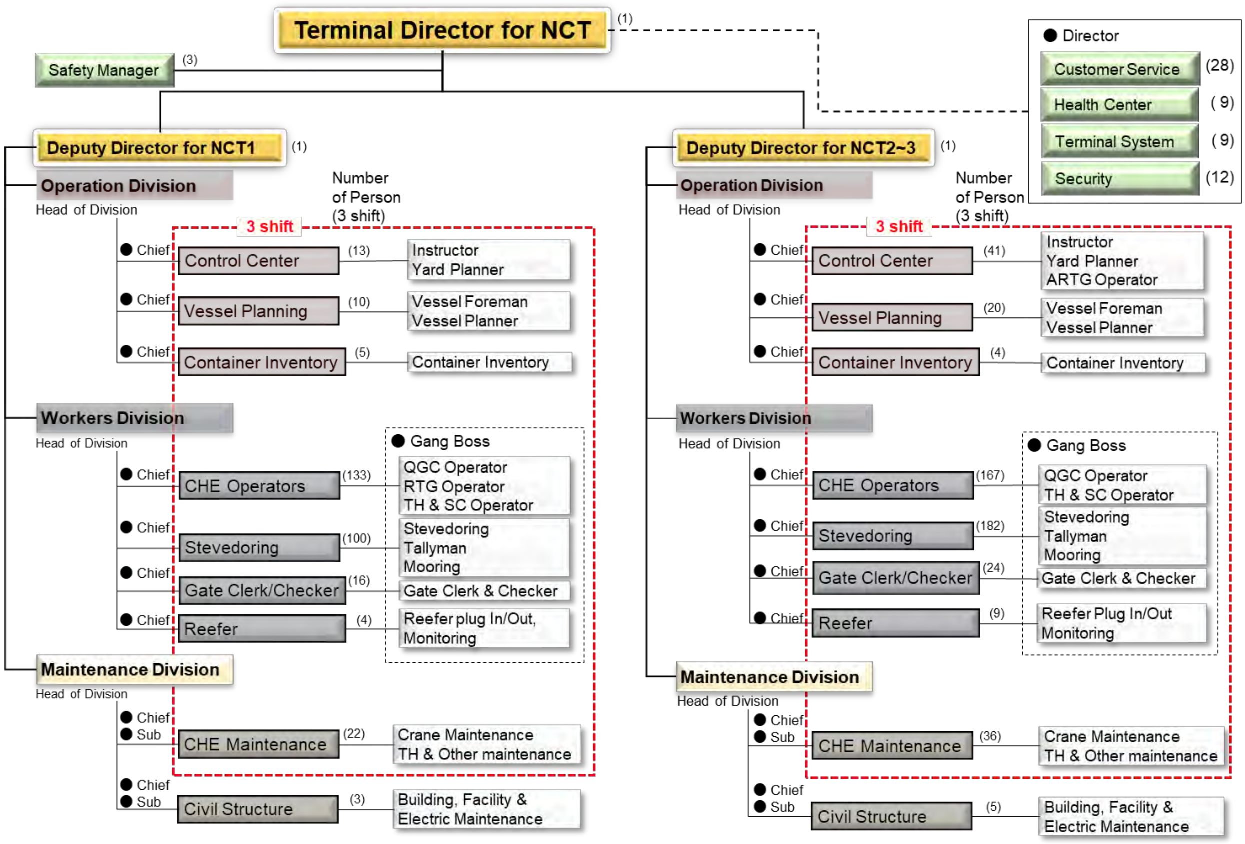
9.3 Operational Structure of the Container Terminal

9.3.1 Operation, Maintenance, and Management for NCT2 and NCT3

408. In order to manage the new container terminals in an integrated manner, it is important to appoint a terminal director before the opening of NCT1, taking into account the future expansion to NCT2 and NCT3. The Terminal Director will be responsible for establishing an organizational structure suitable for SHV Port for effective planning of management, operation, maintenance and personnel for the entire NCT1, 2 and 3 terminals without delay. The draft organizational chart including NCT1, NCT2 and NT3 is shown in Figure 9-2 below.

409. The issues to be addressed in the organizational structure when NCT2 and NCT3 open are securing human resources and measures related to A-RTG, which is planned to be introduced for the first time in NCT2. The number of personnel shown in Figure 9-2 represents the number of personnel when NCT1 , NCT2 and NCT3 are in full operation. Table 9-1 shows the number of posts and staff for full operation of NCT1, NCT2 and NCT3. Since the total number of personnel is not necessary from the opening of each terminal, personnel will be employed in stages. Since the existing container terminal and general cargo terminal have a large number of experienced staff and workers, it is desirable to utilize these persons flexibly according to the quantity and content of work in NCT1, NCT2 and NCT3. Based on these matters, the employment and contractual forms of personnel need to be examined in the detailed plans, etc. in the future.

410. The size of the workforce needs to be increased for operations, field workers, maintenance, and management. As the required training depends on the type of work, it is necessary to recruit and train personnel in advance. In particular, the A-RTGs to be introduced in NCT2 and NCT3 are assumed to require more maintenance personnel than in the case of RTGs due to the increased dependency on the system.



Source: JICA survey team

Figure 9-2 Draft NCT2 - NCT3 Management Organization

Table 9-1 Number of Posts and Staff for NCT1, NCT2 and NCT3

	NCT1		NCT2		NCT3		NCT2+3		NCT1-3 Total		
	Pos.	Staff	Pos.	Staff	Pos.	Staff	Pos.	Staff	Pos.	Staff	Building
Grand Total	**127**	**343**	**101**	**279**	**84**	**233**	**185**	**512**	**312**	**855**	
Management	1	1	2	2	0	0	2	2	3	3	3rd Floor
Operation	14	28	14	34	13	31	27	65	41	93	
Workers	87	253	68	200	62	182	130	382	217	635	
Cargo Handling Equipment Operators	45	133	28	82	29	85	57	167	102	300	Worker Building
Stevedoring	34	100	32	94	30	88	62	182	96	282	Worker Building
Gate Clark, Checker, etc.	6	16	6	18	2	6	8	24	14	40	1st Floor
Reefer	2	4	2	6	1	3	3	9	5	13	1st Floor
Maintenance	11	25	11	27	6	14	17	41	28	66	
Cargo Handling Equipment Maintenance	8	22	8	24	4	12	12	36	20	58	M&E Workshop
Civil Structure Maintenance	3	3	3	3	2	2	5	5	8	8	M&E Workshop
Others	14	36	6	16	3	6	9	22	23	58	
Customer Service	7	15	3	7	2	6	5	13	12	28	Ground Floor
IT(Terminal)	2	6	1	3	0	0	1	3	3	9	1st Floor
Health Center	2	6	1	3	0	0	1	3	3	9	Ground Floor
Security(Terminal)	3	9	1	3	1	0	2	3	5	12	Ground Floor

9.3.2 Efficiency Brought by Integrated Operation of NCT 1, 2, and 3

411. In the case of vessel loading and unloading, the berth of the vessel can be determined in accordance with the container layout in the yard, which improves the efficiency of cargo handling operations. In addition, when the yard storage is changed due to unexpected changes in vessel assignments, a larger yard provides more options for re-storage, making it easier to respond flexibly to problems that may arise.

412. Since the number of cargo handling machines will increase, it will be possible to concentrate the available cargo handling machines in berths with high workloads to promote efficient operation. For example, if a machine breaks it can be easily replaced to ensure that the ship's schedule is maintained.

413. By using a large area for stacking containers, when congestion is expected, containers can be dispersed into other area to reduce the height of the storage area and increase the operational efficiency of RTGs. On the other hand, when the terminal is not busy, containers can be concentrated in a certain area where work can be conducted by a fewer number of RTGs, effectively reducing the operating costs of cargo handling equipment.

414. As for repairing yards or inspecting cargo handling equipment, it is easy to move containers to other storage areas across the terminal, making it possible to systematically and effectively maintain the yard and cargo handling equipment.

415. By consolidating the administration buildings, electricity, water and other charges will be integrated, which will reduce management and maintenance costs.

416. By consolidating the gates procedure for the three container terminals (NCT1 ~ NCT3) at one gate, and by introducing automated procedures at the gate, the time for passing the gate and the number of personnel will be reduced.

9.4 Maintenance Plan and Maintenance-teams of Facilities

9.4.1 Civil Engineering Structures and Facilities in Port

9.4.1 (1) Channel and Turning Basin Area

417. The purpose of channel maintenance dredging is to maintain safe navigation depth for ships. Construction methods and maintenance dredging methods that ensure safe navigation of ships are required. Safe navigation of commercial vessels is the first priority. Dredging operations may have to be suspended to allow a commercial vessel to pass safely. Accordingly, use of a self-propelling dredger that can move quickly is recommended for channel dredging. Small and compact dredgers such as Trailer Suction Hopper Dredger (TSHD) or Sand Barge are common self-propelling dredgers. Grab Dredger is generally used in turning basins and tight spaces.

418. Sand Barge is also used for maintenance dredging. A smaller version of the TSHD is the Sand Barge, which has the same basic system and functions. The hopper capacity of Sand Barge is 1,000 m3 class, which is about one-fifth of TSHD. In case completion of maintenance dredging of the channel is required in a short period of time, the number of ships shall be increased. The cost of mobilization and demobilization of sand barge is lower than that of TSHD.

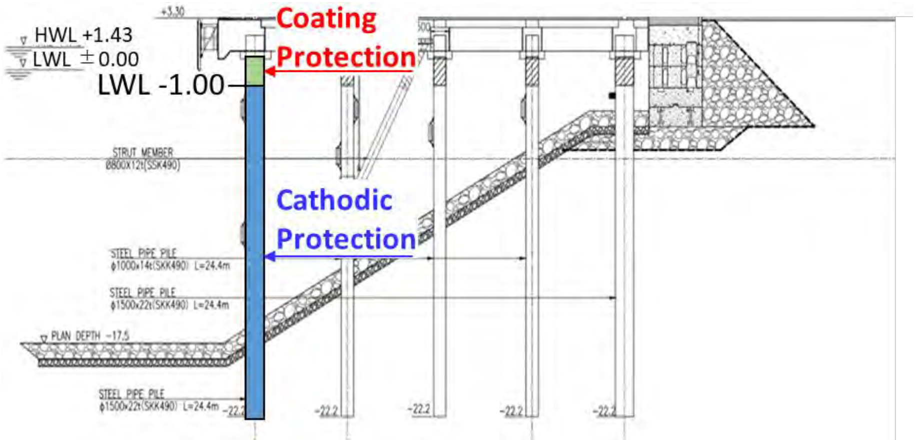
419. Maintenance dredging by Grab Dredger is effective in narrow areas such as turning basins. Dredging operation needs to be carried out at a safe distance from the quay wall and existing port facilities due to the unexpected movement of the dredging Grab. It is necessary to keep a safe distance for prevention of damage to quay wall facilities such as fenders. Maintenance dredging alongside of the quay wall is generally done manually because dredging machines cannot be deployed.

420. Another method of maintenance dredging is to dredge deeper the area which shows remarkable sediment phenomenon and to create a kind of deep spot at the seabed. If the deep spot could trap the sediment from the surrounding area and reduce the tendency of sedimentation in the vicinity, it may be possible to increase the efficiency of dredging which may result in reducing the cost of maintenance dredging.

9.4.1 (2) Port Steel Structure

421. Among port steel structures, pile members of pier steel structures are especially subject to severe corrosive environments in contact with seawater. The steel pipe piles and underwater strut pipe adopted in this project are important structures in the design, which can be regarded as the foundation of structures. Underwater strut structure enables high structural strength of the pier and reduce the number of steel pipe piles. In case the corrosion deterioration of these important steel structures is progressed, it will cause critical damage to the pier structure and be difficult to keep its function. The most important issue is to control corrosion degradation, maintain the required performance of the facility, and realize the continuation of its functions.

422. Corrosion degradation of pier steel structures is protected by coating protection (protection by petrolatum + titanium cover) and cathodic protection. It is necessary to maintain these control functions and to carry out appropriate repairs promptly when defects are detected. Figure 9-3 shows the applied range of corrosion protection methods. Coating protection is applied to the splash zone, and cathodic protection is applied to the underwater zone.



Source :NCT1 D/D Report

Figure 9-3 Examples of the applied range of the corrosion protection method

423. As for the coating protection (Petrolatum cover), defects such as exposed steel, damage to the coating material, and damage to the titanium cover are conducted by visual-observation and recorded. In the case of cathodic protection, the anticorrosion management potential is measured periodically and the fluctuations of the potential are monitored. If any problems are found in any type of protection, investigation of its reasons and immediate repairing are conducted. In order to prevent repeatable incidents and damages, appropriate prevention measurement should be implemented. In addition, general periodical inspections such as investigations of deformation in underwater areas by divers, and consumption / fall of

anodes should be carried out systematically.

9.4.1 (3) Container yard

424. Container yards require flatness for the smooth movement of heavy machinery such as trailers and RTGs. To ensure the efficient movement of cargo in the container yard, which is the main objective of maintenance, the focus point is the efficient usage of the yard. Stacking plates, where heavy containers are placed, and concrete pavement, where container trailers and forklifts pass, are important inspection places and points. Although concrete pavement with high durability which is sufficient bearing power of ground is secured in design, deformation may occur due to repeated load and tire friction. In addition, deterioration of the joints of concrete pavements may allow rainwater to penetrate the subgrade and affect the bearing power of ground of the subgrade. It is important to maintain the functional soundness of the container yard by identifying issues through regular inspections and promptly introducing countermeasures as required.

9.4.1 (4) Road and Bridge

425. Concrete pavements of road have the advantages of high durability, reduced life cycle costs, and environmental friendliness. Further extension of service life is achieved by proper inspection and maintenance. Inspection and maintenance of roads that are also used by general vehicles contribute not only to port operations but also to the social economy by ensuring the safety and convenience of passing vehicles. Furthermore, the establishment and operation of a road maintenance and management system is an effective way for quickly eliminating factors that prevent safe passage, such as dealing with road defect, dealing with traffic problems caused by falling objects, and dealing with oil leaks caused by traffic accidents. Maintenance of public road also contributes to the development of neighboring area.

426. Strict quality control is enforced during bridge construction because a bridge is an indispensable structure for normal port operation. Probability of defects is thus less than other port facilities. However, early detection of defects and implementation of appropriate countermeasure is necessary because interruption of port facility by defects of a bridge can have a huge negative impact on port operation. Therefore, regular inspection to grasp the defect of structure and component of bridge is required to enable timely repairs. In case a vessel collides with the bridge foundation, emergency inspection and repair work should be conducted.

9.4.1 (5) Maintenance of Fenders and Bollards

427. Maintaining appropriate functions of fenders and bollards is important for efficient port operation and safe cargo vessel operation and container handling. These berthing facilities are vital for ensuring the safe navigation of cargo vessels. Safe berthing becomes jeopardized when fenders and bollards are damaged and thus regular inspections are important. Immediate measures must be taken when a defect is detected.

9.4.1 (6) Revetment

428. Revetment is an important facility from the viewpoint of protecting the container yard from

erosion by wave or rainfall. Dysfunctional revetment may cause an enormous negative impact on port functions due to erosion of the container yard. Therefore, regular inspection of top elevation, deformation, and slope shape etc. of revetment is necessary to confirm the current status. When a defect or deformation is detected, proper countermeasure shall be taken immediately.

9.4.1 (7) For Implementation of Maintenance

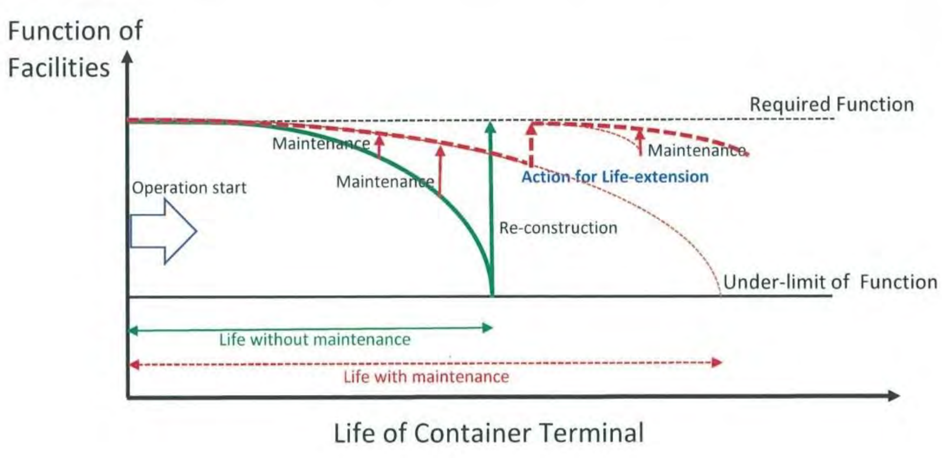
9.4.1 (7) a Introduction of Systematic Maintenance

429. Maintenance of a port facility is conducted to extend the life of the port facility. A facility deteriorates due to operation and age-related degradation. Regular inspections are conducted to detect and diagnose and based on findings corrective measures and a maintenance plan can be prepared. It is also important to keep inspection records for each port facility, and based on the records, create and implement an optimal maintenance plan.

430. Port facilities in Cambodia are currently not being systematically and regularly maintained. It is crucial for PAS to recognize the necessity and importance of maintenance by referring to Japanese maintenance methods and experience, and to establish maintenance methods that are adaptable to the facilities, organization, and surrounding environment of SHV Port.

431. Maintenance is also important from an economic perspective. If partial repair is not enough to restore the functions of the port due to long-term insufficient maintenance, and substantial reconstruction is required, the cost will be huge, and the port operation will have to be interrupted for a long time for construction. In addition, if an accident occurs due to functional failure caused by aging facilities, compensation and functional recovery may require significant costs.

432. On the other hand, there is a method of further extending the service life of port facilities by taking actions for life extension after a certain level of deterioration and aging has progressed. Image of life extension of a port facility is shown in Figure 9-4.



Source : JICA Survey Team

Figure 9-4 Image of Life Extension of Port Facility

9.4.2 Cargo Handling Equipment

9.4.2 (1) Implementation of Preventive Maintenance for Continuous Use of Cargo Handling Equipment

433. The maintenance of cargo handling equipment is performed for the purpose of maintaining the initial function of the cargo handling equipment and preventive maintenance. Maintenance involves not only regular inspections but also the management of regular replacement spare parts which is vital for avoiding equipment failure and maintaining the equipment in good working order.

434. Cargo handling equipment enters a stable period with few failures after the initial problems which typically occur immediately after delivery. However, due to the passage of time and frequency of use, moderate or more serious failures will likely occur. This is often likened to the “Bathtub Curve” as shown below. For this purpose, the results of periodic inspections carried out on all cargo handling equipment should be recorded and made into a database. The inspection results are evaluated and analyzed to conduct repairs of fatigued parts and replace parts at appropriate times. It is also necessary to formulate a maintenance plan and implement preventive maintenance measures such as preventing the recurrence of defects.

9.4.2 (2) Database of Maintenance Information and Inventory Management of Regular Replacement Parts

435. The main purpose of maintenance management is to maintain the capacity and function of the cargo handling equipment and thereby maintain the capacity of the container terminal. Through daily inspections and regular inspections, it is important to diagnose defects, deterioration, and aging of all cargo handling equipment and implement appropriate preventive maintenance measures.

436. In order to prevent the recurrence of defects and troubles, it is necessary to replace regular replacement parts and deteriorated parts that are due for replacement, and therefore it is necessary to manage the inventory and inventory of parts and periodical replacement parts in case of emergency. If these are not done properly, when a malfunction occurs in the cargo handling equipment, it will not be possible to quickly return the cargo handling equipment to the Operation Department, which will result in lower container handling efficiency. As a result, the handling capacity of the quay and the storage capacity of the container yard will also decrease, and container ships may be forced to wait offshore for berthing. This will be disadvantageous to ship owners and customers.

437. By recording the results of periodic inspections carried out on all cargo handling equipment and preparing a database to evaluate and analyze the results, it is possible to manage parts that need to be replaced on a regular basis and important parts that will result in cargo handling equipment being out of service for a long period of time when a problem occurs. Periodical replacement parts and parts that are important for continuous use of the cargo handling equipment can be replaced in a timely manner even if a defect occurs by regularly arranging and stocking the parts, and the cargo handling equipment can be returned to cargo handling of the Operation Department in a short period of time. As a result, not only the quay capacity but also the container handling capacity of Container Yard is continuously secured.

9.5 Necessary Challenges and Technical Cooperation

438. PAS plans to develop and operate NCT2 and NCT3 on their own. Therefore, it will be necessary to pay careful attention to recommendations and outcomes of the "Project for Capacity Development on Container Terminal Management and Operation in Sihanoukville Port Phase 2", and to improve their services and terminal operation proficiency.

Chapter 10 Project Evaluation

10.1 Indicators on Project Effect

10.1.1 Quantitative indicators for the project

439. Operational goal of NCT2 and NCT3 project is to achieve the projected number of containers. Due in part to the COVID-19 pandemic, container throughput in 2020 increased by only 0.4%, however, the growth rate in 2021 is 14.1% (732,000 TEU) comparing to that in 2020. This suggests that the container handling volume in the port of SHV has fully recovered. However, since there may be some fluctuation in cargo handling throughput at the initial stage of the project, the target year should be set two years after NCT2 and NCT3 commence operations.

440. In order to achieve the container throughputs in the target years, berth utilization at SHV Port needs to be maximized. Therefore, berth occupancy rate in NCT2 and NCT3 should be around 60%, which is said to be the standard level of berth occupancy. In addition, since the berths of NCT2 and NCT3 have sufficient depth to accommodate larger vessels, another goal is to realize ship call by 10,000 TEU class vessel at NCT2 and 15,000 TEU class vessel at NCT3 in the target year, respectively.

441. Finally, another effect of the NCT2 and NCT3 project is to eliminate berth waiting time. At one time, vessels had to wait 43 hours per week on average for a berth at SHV Port, although at present most vessels do not have to wait for berthing. However, effective measures need to be taken to ensure that excessive berth waiting time does not again become an issue.

Table 10-1 A set of quantitative indicators

Indicators	Items	Baseline	Target (two years after operational commencement; Year 2031)
Operational and effect indicators	Annual container throughput	Actual record of the existing CT in 2021: 730,000TEU	Total container throughput (Existing CT, NCT1, NCT2 and NCT3): 1.7 million TEU
Operational indicators	Annual average of Berth Occupancy Rate (Berthing time / Berth Operable time)	Actual berth occupancy rate of the existing CT in 2021: 62%	Annual average of Berth Occupancy Rate for the existing CT, NCT1, NCT2 and NCT3: 60% (According to international standards, the average annual berth occupancy rate is said to be ranging from 55% to 65%.)
	Size of largest vessel call	The largest vessel calling at the port in 2021: 26,000DWT	Projected largest vessel calling at NCT3: 160,000DWT, 15,000TEU class
(Reference) Effect indicators	Ship's waiting time	Average waiting time 43.0 hour (June 23 to 29, 2019)	No waiting time at NCT2 and NCT3

10.1.2 Qualitative indicators for the project

442. Launch of NCT 2&3 operation is going to significantly contribute to strengthen logistics capacity in Cambodia, attract vessels deployed in the North America and/or European

shipping route by increasing cargo handling capacity, and eventually boost Cambodia's trade and economy. There are three policy goals related to this project.

Strengthening logistics capacity in Cambodia.

443. The operation of NCT2 and NCT3 will provide Cambodia with sufficient capacity to cope with the increasing volume of containers by itself. It will definitely support the growth of trade. In addition, Cambodia will be able to reduce its dependency on ports in neighboring countries such as Vietnam and Thailand. This means that Cambodia can save transport time and mileage when transporting international containers from/to the Cambodian territory. Furthermore, by securing the required length and depth of the berths as well as improving the container handling capacity, the number of calls to the port including from North American and European region will be expected, which is the basic policy of the project planning.

Economic security

444. It is vital for Cambodia to own and operate its own container terminals in the light of economic security and the port of SHV is expected to fulfil this need (especially as SHV Port is the only Deep-sea port facing an ocean in Cambodia).

445. In addition to the port of SHV, there are three other options for handling international containers. The first option is to transport containers down the Mekong River by ship and access container vessels from ports in CMP or Saigon in South Vietnam. The second option is to cross the border by land using truck transport and access ports in South Vietnam. The third option is to cross the border by truck to the port of LCB in Thailand. All options require the use of ports in foreign countries. While it is important to maintain a degree of freedom in route selection, it is more important to have an efficiently operated port in one's own territory which vessels call from various routes.

Trade strategy

446. Cambodia's exports are dominated by textile goods, which account for around 70 percent of total exports. Other export goods are agricultural goods such as rice and cassava, shoes, furniture and other light industry products. In transporting agricultural goods, there has been a shift from conventional break bulk to container to preserve the quality of goods. In textile transport, fiber and fabrics are first imported from China and then processed into clothing, footwear, travel goods and so on.

447. These finished products are exported to Europe, North America and East Asia by container. It is vital to efficiently transport these goods at low cost in order to successfully compete in the global market. Therefore, it is necessary for the port of SHV to ensure efficient container transport as well as accessibility to the world market through near sea routes and trunk lines.

448. Based on the above consideration, qualitative effects of the project listed below should be monitored periodically.

1) Increasing the number of ship calls at SHV Port including shipping service to/from North America and Europe.
2) Facilitating trade to/from Cambodia

10.2 Economic Analysis

449. In the economic analysis, annual total container transport cost and time are calculated when the NCT2 and NCT3 project is carried out as the with-case, and when it is not carried out as the without-case. Project viability is evaluated based on project cost and additional benefits generated by the results of the with-case.

450. In this study, the development of NCT2 and NCT3 is proposed to meet the future container demand in the port of SHV. When setting cases for the economic analysis, future demand will be accommodated at NCT2 and NCT3 in the with-case. While in the without-case, future demand is to be accommodated at the other ports such as PNP Port and CMP Port.

451. The benefits of NCT2 and NCT3 operation will include lower inland transport costs and port-related charges as well as savings in transport time. The benefits of cost reduction and time savings have traditionally belonged exclusively to importers in an economic analysis. However. exporters also benefit in that the volume of export goods may increase as the market price is reduced, and export related businesses obtain some benefit when the transport cost is reduced.

452. It is, however, difficult to allocate benefit between importers and exporter since it is not clear when the exporter receives benefits. Thus, the benefit related to export containers is not taken into account in the EIRR calculation.

453. Project cost is represented by economic price. NCT2 is scheduled to open in 2028 and NCT3 in 2029. Annual investment schedule for NCT 2&3 is shown below.

454. The maintenance cost of NCT2 and NCT3 infrastructure is set as 1.0% of initial cost based on the PAS's record. The maintenance cost of cargo handling machines is set as 5.0% based on the PAS's record. In addition, maintenance cost of channel and basin is set based on siltation data on the existing channel in the port of SHV.

455. Each facility will be replaced after its service life. For instance, the service life of cargo handling equipment will end during the project term and it is thus necessary to replace them. Replaced facilities are assumed to have the same specifications as the first ones at the same costs.

456. Fuel and labor costs are components of operational cost. Fuel cost per one container box is calculated based on the operational records of the existing container terminal. Future operational cost is obtained by multiplying the unit fuel cost and future container handling volume. Labor costs are estimated based on the composition of the workforce (i.e., ratio of full time/part time workers and their ages), and their average salary in PAS.

457. The logit model indicates that the EIRR of the NCT2&3 project is 23.3% which clears the threshold value for project viability (generally said to be 10%). Based on the above analysis, EIRR was updated and finalized in the appraisal mission by JICA.

458. When the project cost increases by 10% and the container demand simultaneously decreases by 10%, the EIRR is still 18.0%. The results indicate that the NCT2&3 project is absolutely viable from an economic standpoint as the threshold value for project viability is generally said to be 10%.

Table 10-2 Sensitive analysis of EIRR

Base case	23.3%
10% Cost up	22.0%
10% Demand down	19.0%
10% cost up & 10% demand down	18.0%

10.3 Financial Analysis

10.3.1 Financial Analysis of the Project

459. The following assumptions are made in conducting the financial analysis of NCT2 and NCT3.

- The project term for the evaluation is 40 years (including the construction period) from 2023 to 2062.
- The evaluation method is financial internal rate of return (FIRR).
- NCT2 and 3 are assumed to open in March 2028 and June 2029, respectively.

460. Service lives of the facilities are assumed to be shown in the below table based on similar examples in other projects. Each facility will be replaced after the end of its service life. For example, the service life of cargo handling equipment will end during the project term and it will thus be necessary to replace them. Replaced facilities are assumed to have the same specifications as the first ones at the same costs.

Table 10-3 Service Lives of the Facilities

Facilities	Service Lives
Channel, Basin	50 years
Reclamation Land	50 years
Wharf, etc.	50 years
Yard Pavement, Drainage, etc.	50 years
Electric Equipment	15 years
Utility	15 years
Building	50 years
Quay Gantry Crane	25 years
RTG	15 years
Tractor & Chassis, etc.	10 years
Harbour Craft	15 years

Source: JICA Survey Team

461. The revenues from NCT2, 3 operations consist mainly of revenues related to handling containers and the others related to handling vessels.

462. As for the revenues related to containers, cargo handling charges and container storage charges are the main components. For cargo handling charges we calculate the revenues by multiplying the number of containers handled in the terminals with the charges in the latest tariff obtained from PAS in August 2021. For container storage charges we calculate the revenues by multiplying the number of containers with the container storage charges based on the target dwell days set by PAS as of November 2021. The target dwell days is 4 days for imported containers regardless of empty or full and exported full containers while 6 days for exported empty containers. The tariffs are shown in the tables below. The number of containers handled in NCT2, 3 is based on the results of the demand forecast in the

previous chapter.

463. As for the revenues related to vessels, tonnage dues, channel dues, pilotage fees, tugboat fees, port clearance fees, berth fees and mooring & unmooring fees are the main components. We calculate the revenues by multiplying the number of vessels calling at the terminals with the charges in the latest tariff obtained from PAS in August 2021. The tariff is shown in the tables below. We use the lowest weekday daytime charge in order to avoid excessive revenue estimations. The number of vessels calling at NCT2 and NCT3 is based on the results of the demand forecast in the previous chapter. In the demand forecast above, the number of the vessels was estimated by TEU Class but we convert TEU to GRT* because the charges are GRT-based.

* GRT: Gross Registered Ton which is a unit that expresses the size of a vessel in volume

464. As for personnel costs, when automated RTGs are installed, the number of required personnel can be reduced compared with conventional operations. The number of required personnel for operating NCT2 and NCT3 in this way is described in the previous chapter. We calculate the personnel costs by multiplying the number of the required personnel with assumed average salary. The personnel is composed of permanent workers and contracted workers and we assume its composition ratio and average salary of each worker type based on interviews with PAS.

465. As for maintenance costs for port facilities, we assume 1% of the initial costs for civil engineering structures and buildings while 5% of the initial costs for cargo handling equipment and mobilities based on the actual costs incurred of the past operations in the existing container terminal. We assume that their costs will incur from the opening time of each new terminal. In addition, maintenance dredging cost for the channel and basin is set based on the past siltation in the port.

466. As for the other operating costs such as fuel costs except the items above, we estimate the unit cost by dividing the actual costs corresponding to them in the past operations in the existing container terminal by the number of containers handled. The unit cost is an averaged value among actual data from 2018 to 2020. And we calculate the costs by multiplying the unit cost with the number of containers handled in the new terminals each year.

467. As for operational costs related to vessels such as pilotage and tugboats, we estimate the unit cost by dividing the actual operational costs including personnel costs, operation & maintenance costs, fuel costs, etc. by the number of vessels calling at the port based on PAS data. The unit cost is an averaged value among actual data from 2018 to 2020. And we calculate the costs by multiplying the unit cost with the number of vessels calling at the new terminals each year.

468. The financial analysis was conducted under the operational conditions described above, using the base case of the macro model as a future cargo demand scenario. As a result, FIRR is calculated to be 7.7%. Based on the analysis, FIRR was updated and finalized in the appraisal mission by JICA.

469. We also carried out a sensitivity analysis related to uncertainties of revenues and project

costs. High and low cases are examined for scenarios in which revenues and project costs increase or decrease by 10%. The results range from 5.6% to 9.9% (see the table below).

Table 10-4 The Results of Sensitivity Analysis related to Changes in Revenues and Costs

		Revenue		
		Low Case (-10%)	Base Case	High Case (+10%)
Project Cost	High Case (+10%)	5.6%	7.0%	8.3%
	Base Case	6.3%	7.7%	9.1%
	Low Case (-10%)	7.1%	8.6%	9.9%

Source: JICA Survey Team

470. If this project was implemented with a yen loan, the interest rate of the loan from JICA to MEF would be 0.75%. And PAS will receive sub lease of the yen loan from MEF. The sub lease terms are based on Cambodian laws and regulations including the Ordinance of the Ministry of Economy and Finance (Prakas No. 809, Dec. 1, 2021 on Policies and Procedures Governing the Provision of State Loan to Public Administration Institutions, Public Enterprise, Joint Ventures Company that State Owns Minority of Public Shares and Banking and Financial Institutions) and will be determined in consultation with PAS and MEF on a project-by-project basis. Incidentally, the interest rate of the yen loan from JICA to MEF when signing the loan agreement for NCT1 was 0.01% and the interest rate of the sub lease from MEF to PAS was 1.26%. All FIRR results exceed the assumed interest rate of the yen loan and the interest rate of the past sub lease from MEF to PAS. Therefore, this analysis shows this project is financially feasible.

10.3.2 Financial Management of PAS with New Terminals

471. Assuming that PAS will develop and operate NCT2 and NCT3 in addition to the existing terminal, financial management of PAS is examined as follows. As PAS has used yen loans in the past to finance container terminal development, conditions of previous loans are summarized as shown in Table 10-5. Assumed conditions of the yen loan for NCT2 and NCT3 are also shown in the same table.

Table 10-5 Conditions of the Past Yen Loans and Assumptions for New Loan

Yen Loans	CP-P3 Rehabilita-tion	CP-P4 Expansion	CP-P6 SEZ (ES)	CP-P8 SEZ (CW)	CP-P10 Multi-Purpose		CP-21 New CT1	New CT2&3
Original Contract with MEF								
Currency	Yen	US Dollar	Yen	Yen	Yen		Yen	Yen
Interest	3.50%	3.70%	3.85%	3.85%	2.50%		1.11%	1.11%
Service	0.10%	-	0.15%	0.15%	0.10%		0.15%	0.15%
Revised on 23 August 2012					Construc-tion Period	Operation Period		
Revised Interest	2.85%	-	2.85%	2.35%	1.50%	2.50%	-	-
Revised Service	0.15%	-	0.15%	0.15%	0.15%	0.00%	-	-
Loan agreement with Japan	Yen	Yen	Yen	Yen	Yen		Yen	Yen
Date	9/24/1999	11/26/2004	3/20/2006	3/31/2008	8/21/2009		8/7/2017	-
L/A (million yen)	4,142	4,313	318	3,651	7,176		23,502	-
Interest (Construction)	1.00%	0.90%	-	0.01%	0.01%		0.01%	0.75%
Interest (Consultant)	0.75%	0.90%	0.90%	-	0.01%		0.01%	0.01%
Loan Period (Construction)	30	30	-	40	40		40	30
Grace Period (Construction)	10	10	-	10	10		10	10
Loan Period (Consultant)	40	30	30	-	-		40	30
Grace Period (Consultant)	10	10	10	-	-		10	10

Source：PAS and JICA Survey Team

472. All of the long-term debts of PAS are yen loans listed in the above table. The outstanding debts of PAS are estimated under conditions of the new loan for NCT2 and NCT3, in which the interest rate of sub-loan from MEF is assumed to 1.26%, and the redemption period is 30 years with a grace period of 10 years.

473. Due to the fact that the period of redemption of the yen loan for NCT1 is 40 years and that for NCT2 and NCT3 is 30 years, the outstanding debts will reach the maximum level just after the completion of NCT2 and NCT3

474. Total repayment of principal and interest will reach the maximum level in around 2035.

475. In case that PAS develops and operates new terminals NCT2 and NCT3, their operating revenue, operating expense, operating profit, net profit and other financial indicators are estimated. Based on the result, just after the opening of NCT3, annual operating revenue will reach around USD 170 million and increase to approx. USD 230 million when NCT3 is operated at full capacity.

476. After the opening of NCT2, EBIT margin will temporally decrease to about 8% due to the increase of depreciation cost, however, it will rebound to a level of around 25% in several years. Cash flow of PAS will have no deficit during the project period. In this connection, PAS will be able to manage the new terminal project without financial difficulties.

Chapter 11 Conclusion and Recommendation

11.1 Conclusion and Recommendation

477. The SHV Port, with its favorable location in terms of water depth, has supported Cambodia's economy and society as the largest gateway sea port for foreign trade. While Cambodia's trading partners are spread all over the world, Europe, North America and China have a particularly large share of the trade volume. However, there are currently no direct container shipping services to Europe and North America, and trade with these regions has to be transshipped in Singapore and other countries. On the other hand, ports in Vietnam and Thailand have direct shipping services to/from these regions, which would be a disadvantage for Cambodia in terms of lead time and transportation cost.

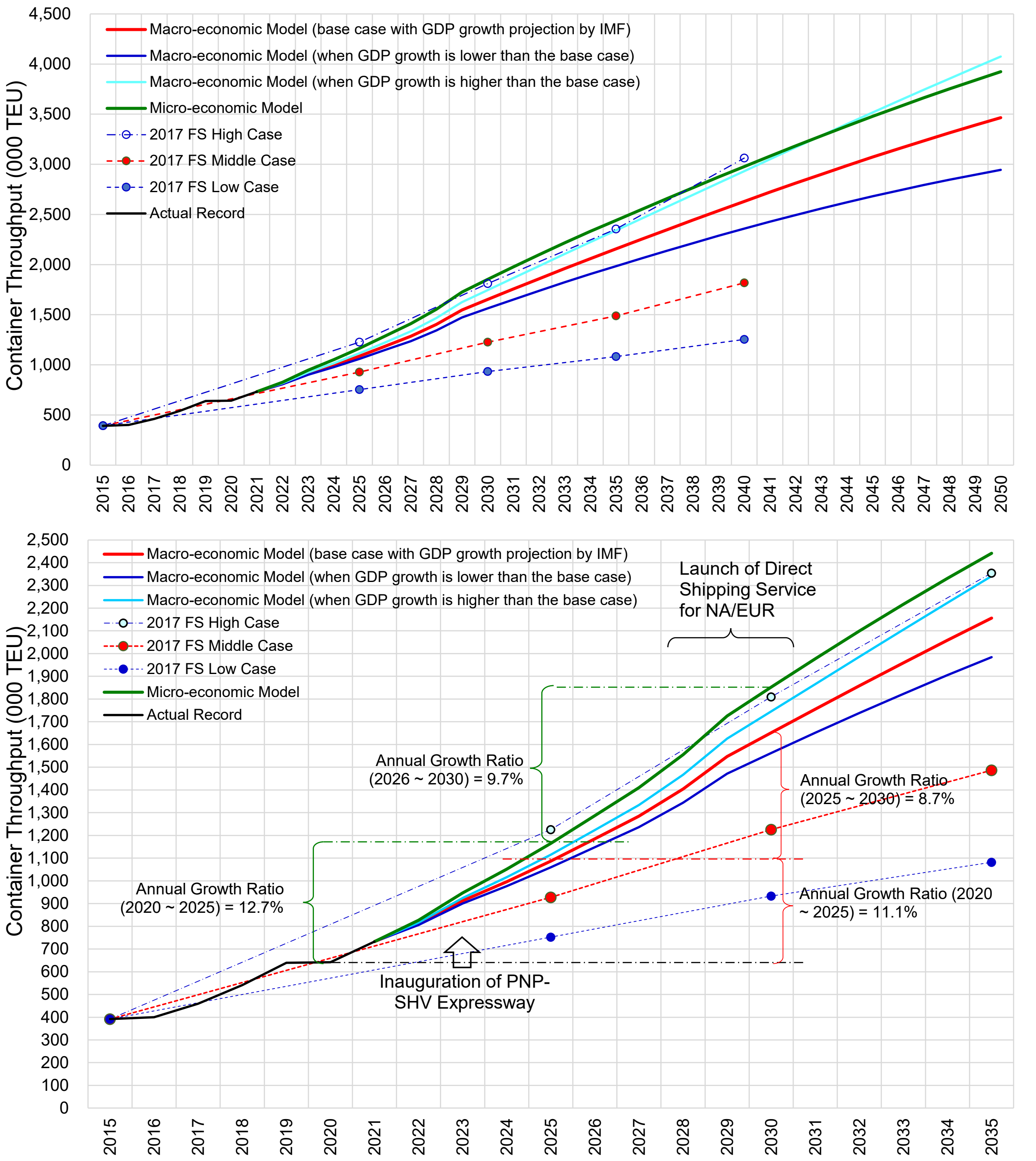
478. On the other hand, container handling volume at SHV Port has been growing steadily at an annual growth rate of over 10% since the 2010s, and the impact of the COVID19 pandemic has been limited to the throughput in 2020. Based on Cambodia's economic growth strategy centering on the trade, steady growth in demand is expected to continue in the future. According to the demand analysis by macro-economic as well as micro-economic models, the container cargo demand is forecasted as shown below.

Table 11-1 Container Demand Forecast (Upper: Macro-economic Mode (Base Case), Lower: Micro-economic Model)

Year	SHV(TEU)						
	Import			Export			Total
	Full	Empty	Total	Full	Empty	Total	
2025	516,342	27,176	543,518	375,161	168,356	543,518	1,087,036
2030	784,599	41,295	825,894	569,404	256,490	825,894	1,651,788
2035	1,024,064	53,898	1,077,962	744,281	333,681	1,077,962	2,155,924
2040	1,249,390	65,757	1,315,147	899,739	415,408	1,315,147	2,630,294
2045	1,458,785	76,778	1,535,563	1,028,789	506,773	1,535,563	3,071,125
2050	1,645,772	86,620	1,732,391	1,130,812	601,579	1,732,391	3,464,782

Year	SHV(TEU)						
	Import			Export			Total
	Full	Empty	Total	Full	Empty	Total	
2025	553,276	29,120	582,396	365,478	216,918	582,396	1,164,791
2030	880,017	46,317	926,334	560,214	366,119	926,334	1,852,667
2035	1,159,498	61,026	1,220,524	736,463	484,061	1,220,524	2,441,048
2040	1,414,623	74,454	1,489,077	892,884	596,193	1,489,077	2,978,154
2045	1,651,711	86,932	1,738,643	1,022,183	716,460	1,738,643	3,477,286
2050	1,863,427	98,075	1,961,502	1,123,834	837,669	1,961,502	3,923,005

Source: JICA Survey Team



Source: JICA Survey Team

Figure 11-1 Container Demand Forecast for SHV Port

479. Based on the demand forecast, the necessity and urgency of the development of NCT2 and NCT3 is clear in the light of the container cargo demand by 2035. In addition, by planning the target vessels of NCT2 and NCT3 to cover the wider shipping network including North America and Europe, i.e., Cambodia's major export partners, it will be possible to reduce international logistics costs to/from those regions avoiding the transshipment at Singapore and receiving larger vessels at SHV Port. Thus, it can be clearly stated that the development project of NCT2 and NCT3 will bring substantial benefits to the whole Cambodian economy.

480. Regarding the specific plan of NCT2 and NCT3, the following vessels are to be set as the

target vessels based on the analysis on the specifications of container vessels calling at LCB in Thailand and CMP in Vietnam which are deployed in the shipping services connecting South-east Asia and Europe and/or North American region.

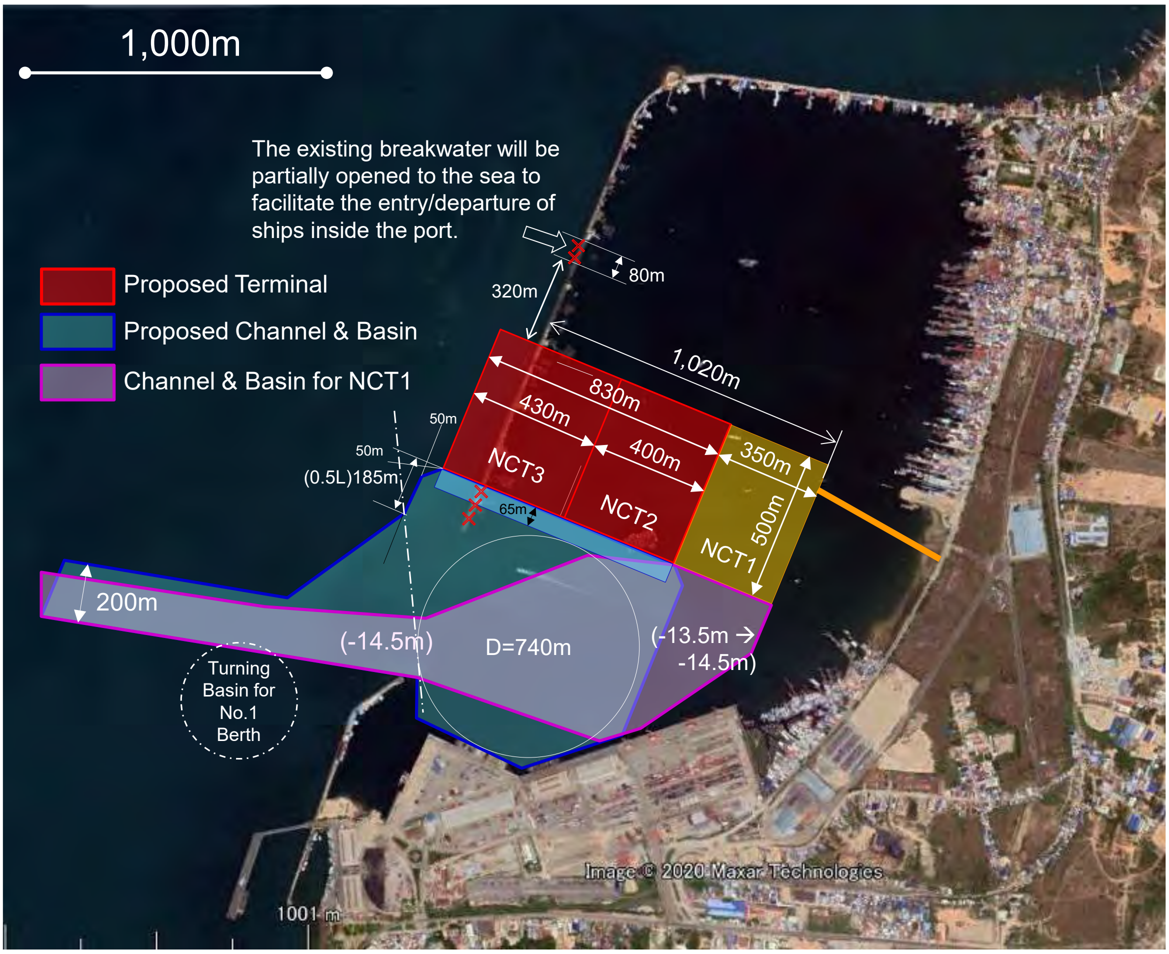
Table 11-2 Dimensions of Design Ships

Shipping Area	Ship type（TEU）	Ship size（DWT）	LOA(m)	Beam(m)	Draft(m)
Shipping routes in Indian and Pacific regions	10,000	120,000	350	49	15.0
Shipping routes to/from North America and Europe	15,000	160,000	370	51	16.0

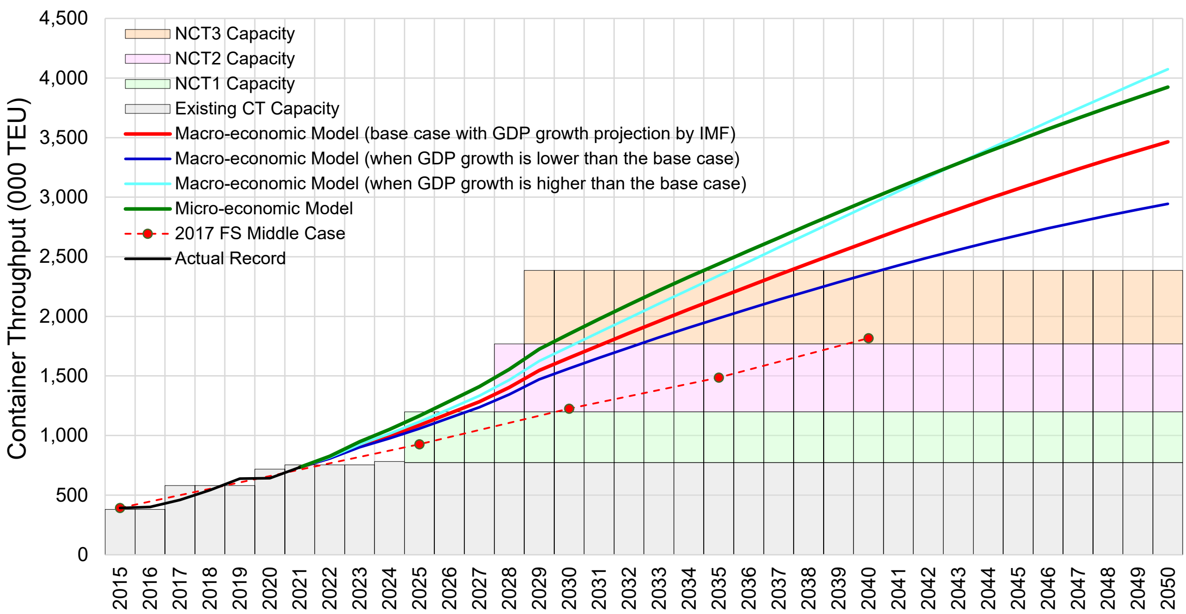
Source: JICA Survey Team (based on Clarkson Database)

481. The specifications of the NCT2 and NCT3 as well as the alignment of the channel and turning basin are shown below. The depth of the channel and basin is set at -14.5 m, based on the analysis of the actual draft of vessels calling at LCB in Thailand and CMP in Vietnam which are deployed in the shipping services connecting South-east Asia and Europe and/or North American region. On the other hand, the depths in front of the quay wall are set at -16.5 m for NCT2 and -17.5 m for NCT3, subject to the maximum planned vessel specifications. This is because that there would be a possibility to receive vessels with fully loaded in the long term, and in such a case, increasing the depth in front of the quay wall will become difficult.

	NCT1	**NCT2**	**NCT3**
Design Vessel	4,000TEU 60,000DWT	10,000TEU 120,000 DWT	15,000TEU 160,000 DWT
Target Shipping Network	A part of Indo-Pacific region	Whole Indo-Pacific region	Network covering Europe and North America region
Length of Berth	L=350 m	L=400 m	L=430 m
Depth of Berth	D=14.5 m	D=16.5 m	D=17.5 m
Terminal Width	500 m	500 m	500 m
# of Ground Slots (TEU)	2,160 TEU (including backup area)	2,880 TEU (including backup area)	3,120 TEU (including backup area)
QGC	3 units (16 rows)	3 units (20 rows)	3 units (20 rows)
Terminal Capacity (000TEU)	430	570	620



482. The relationship between the demand forecast and the handling capacity of the new container terminal based on the proposed development plan is as follows. The commencement year of the terminals are set based on the project schedule described later; i.e., February 2028 for NCT2 and May 2029 for NCT3.



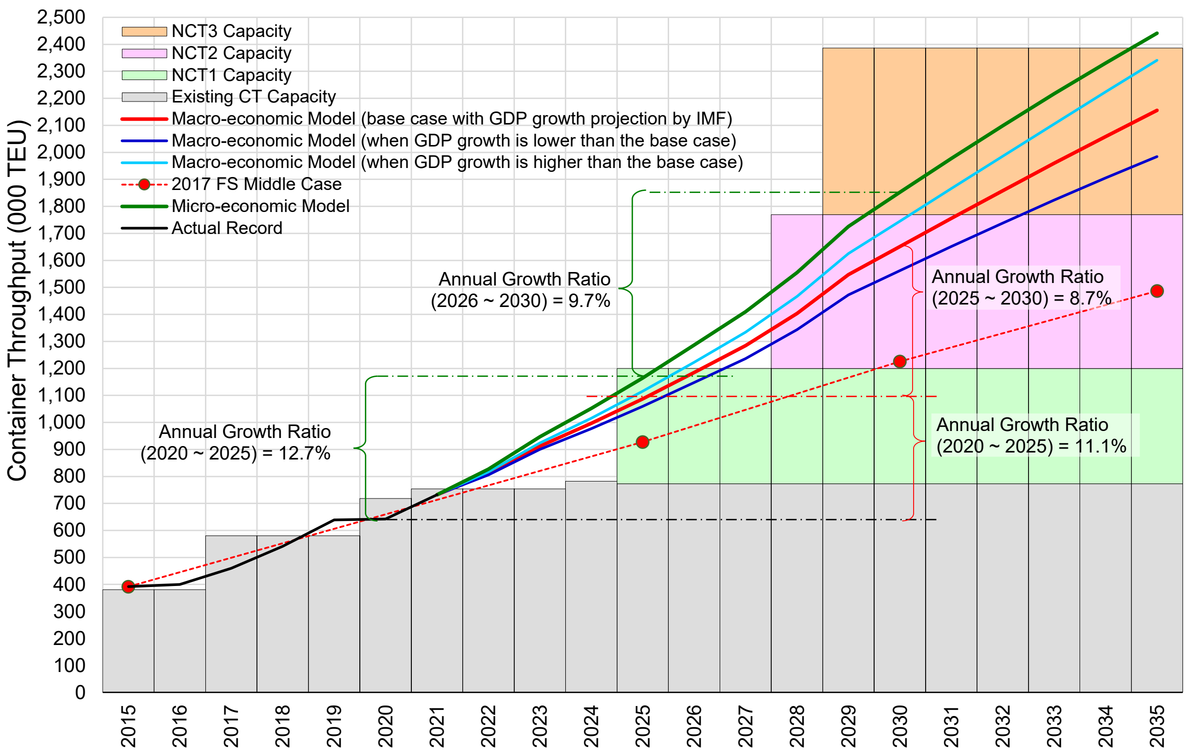


Figure 11-2 Demand and Capacity (upper: 2015 ~ 2050; lower: 2015 ~ 2035)

483. As the NCT3 development will make it difficult for fishing boats going out from the port, a part of the existing breakwater (80m) will be demolished for the passage of fishing boats. The calmness of the fishing port will be maintained even after opening the breakwater according to the tranquility analysis. In addition, as a result of the tranquility analysis in the front of NCT2 to NCT3, it is confirmed that there is no need for a new breakwater.

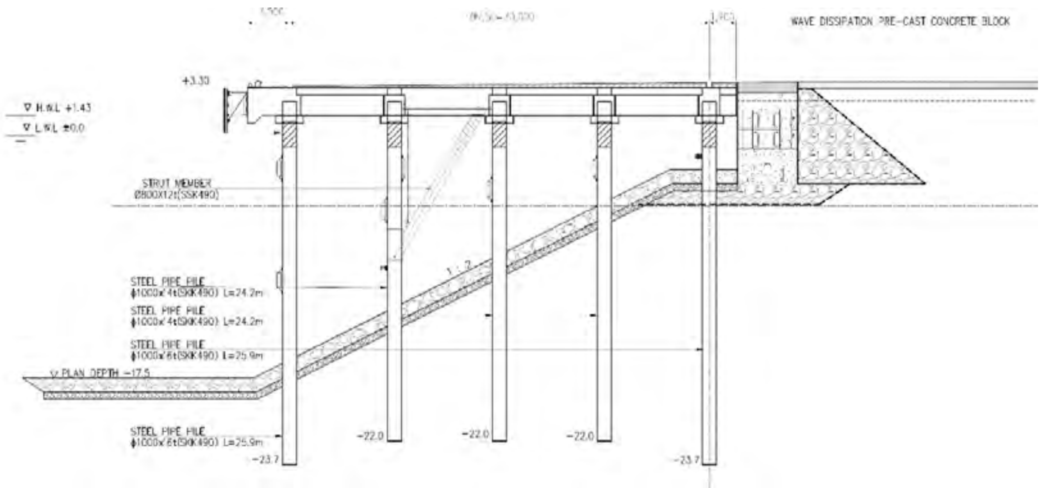
484. Since a part of the existing breakwater needs to be removed or reclaimed by the development of NCT3, compensation will be required for those who are currently living and/or running businesses on the breakwater.

485. Scopes of the works for NCT2 and NCT3 development are shown in the table below.

Work Items	**NCT1 (For reference)**	**NCT2**	**NCT3**
Quay	+Length: 350m +Width: 35m +Water Depth: 14.5m +Wave Dissipation +Deck on Pile Type	+Length: 400m +Width: 35m +Water Depth: 16.5m +Wave Dissipation +Deck on Pile Type	+Length: 430m +Width: 35m +Water Depth: 17.5m +Wave Dissipation +Deck on Pile Type
Dredging	4.5 million m^3	3.6 mil m3	1.1 mil m3
Breakwater	none	none	Removal and Transfer of Existing Breakwater: 200m removal (120m for NCT3 construction and 80 m for new entrance of existing fish port) and 500m transfer for NCT3 construction
Revetment	1350m	900m	930m
Reclamation	25.4 ha (including CIY(Customs Inspection Yard) and NRA (North Reclamation Area))	18.6ha	20.0ha

Work Items	NCT1 (For reference)	NCT2	NCT3
Container Terminal Yard	+Ground Slots with 5 stacks for laden containers: 1,920TEU (32,326 m^2), of which Ground Slots with 4 stacks for Reefer containers: 48TEU (1,035m^2) +Ground Slots with 4 stacks for Empty containers (Back yard): 240TEU (4,282m^2) +RTG lanes (8) and Truck Roads: (114,238m^2)	+2,592 Ground Slots and 5 stacks for Laden +60 Ground Slot and 3 stacks for Reefer +288 Ground Slot and 4 stacks for Empty +9 lanes for RTG	+2,808 Ground Slots and 5 stacks for Laden +72 Ground Slot and 3 stacks for Reefer +324 Ground Slot and 4 stacks for Empty +9 lanes for RTG
Terminal Facilities (Buildings)	+Admin. Office: 20x30 m^2 x 5 stories +M&E Workshop: 24x45 m^2 +Worker Building: 13x36 m^2	+Admin. Office (at NCT1): 20x20 m2 x 5 stories +M&E Workshop: 24x45 m2 +Worker Building: 13x36 m2 etc.	+M&E Workshop: 24x45 m2 +Worker Building: 13x36 m2 etc.
Terminal Facilities (Utilities)	Power receiving & transforming equipment, generators, power distribution system, water reservoir & pump house, water distribution system, firefighting system, yard lighting system, reefer power outlets etc.	Power receiving & transforming equipment, generators, power distribution system, water reservoir & pump house, water distribution system, firefighting system, yard lighting system, reefer power outlets etc.	Power receiving & transforming equipment, generators, power distribution system, water reservoir & pump house, water distribution system, firefighting system, yard lighting system, reefer power outlets etc.
Cargo Handling Equipment	QGC: 3 RTG: 9 Yard Trailers: 16 Reach Stackers: 2	QGC: 3 RTG: 10 Yard Trailers: 17 Side Handlers (or Reach Stackers): 2	QGC: 3 RTG: 10 Yard Trailers: 18 Side Handlers (or Reach Stackers): 2
System	Terminal Operation System (TOS)	Upgrade of TOS	Upgrade of TOS
Working Vessels	-	Tug Boat (4,000HP):2 Pilot Boat:1	
Access Road and Access Bridge	Access Bridge: 2 x 2 lanes Access Road	-	-
Customs Inspection Area	200m×400m Port gates including Customs gates: 7 lanes x 2 directions (32x96 m2)、# of lanes for each direction is variable depending on the traffic volume. X-ray devices will be installed by the Customs Office.		

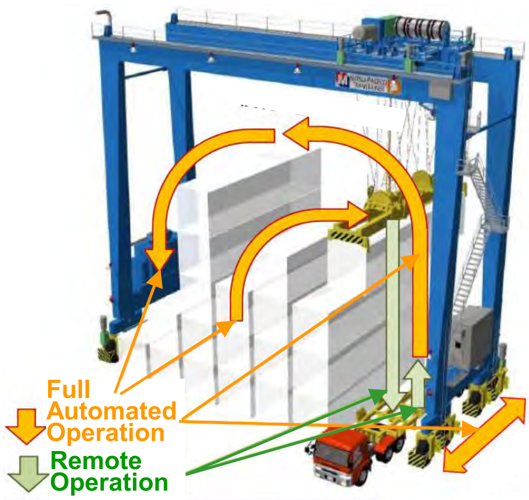
486. As for the structure of quay walls of NCT2 and NCT3, the strut pile type, the same used in NCT1, is adopted as shown below.



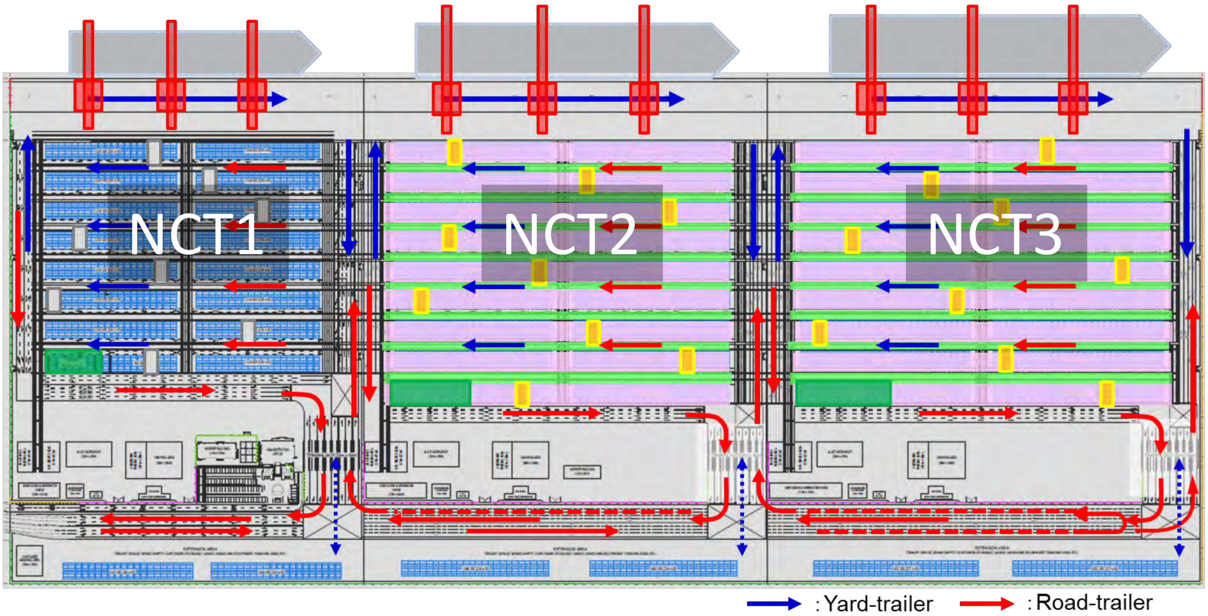
Source: JICA Survey Team

Figure 11-3 Typical Cross Section of Strut Pile Type

487. As for the cargo handling system in the terminal, the automated, i.e., remote-controlled, hybrid RTG (ARTG) system is proposed to be installed, which has advantages over the conventional manual RTG system by increasing productivity per worker, improving working environment for operators, increasing operational safety through reduced human error and simplifying operator trainings.

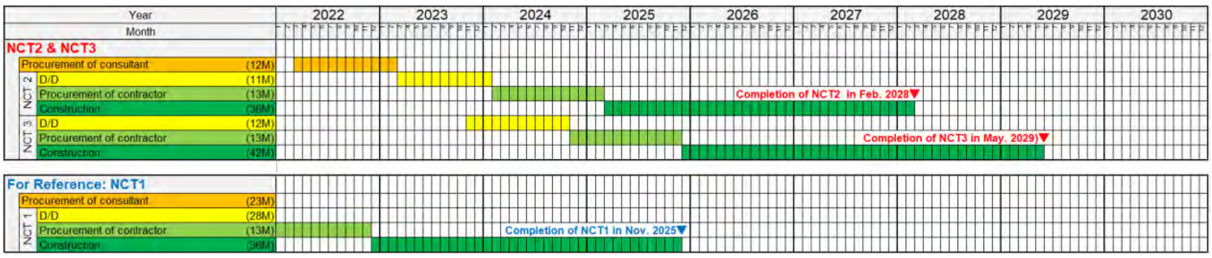


488. The layout plan of the terminal facilities are shown below.



Descriptions			NCT1	NCT2	NCT3
Ground Slots (including back-yard)		TEUs	2,200	2,800	3,100
Yard Capacity		TEUs	432,000	570,000	614,000
Number of Cargo Handling Equipment	QGC	Units	3	3	3
	RTG (Hybrid type)	Units	9	-	-
	ARTG (Hybrid type)	Units	-	10	10
	Yard Trailer	Units	16	17	18
	Reach Stacker / Side Handler	Units	2	2	2

489. The project schedule is assumed to be as follows based on the proposed construction schedule etc.



490. The economic analysis was conducted based on the base case demand forecasted by the macro-economic model. The results show the project is economically feasible with an EIRR of 23.3%. Based on the economic analysis in the Survey, EIRR was updated and finalized in the appraisal mission by JICA.

EIRR	23.3%
Initial cost(US$)	US$491,355,077
Total cost incl. maintenance cost(US$)	US$2,323,732,492
Transport cost reduction(US$)	US$7,731,324,683
Travel time reduction(US$)	US$1,904,927,192
Grand total cost reduction (US$)	US$9,636,251,875

491. In addition to the base case, sensitivity analysis is also conducted and results are shown below. In each case, it is confirmed that the EIRR would not fall below 10% which is generally considered to be the threshold for EIRR.

Base case	23.3%
10% Cost up	22.0%
10% Demand down	19.0%
10% cost up & 10% demand down	18.0%

492. Based on the financial analysis using the base case of the macro-economic model as a future cargo demand scenario, FIRR is calculated to be 7.7%. Sensitivity analysis is also conducted and results are shown below. All FIRRs range from 5.6% to 9.9% which shows that the project is financially feasible. Based on the financial analysis in the Survey, FIRR was updated and finalized in the appraisal mission by JICA.

		Revenue		
		Low Case (-10%)	Base Case	High Case (+10%)
Project Cost	High Case (+10%)	5.6%	7.0%	8.3%
	Base Case	6.3%	7.7%	9.1%
	Low Case (-10%)	7.1%	8.6%	9.9%

493. If this project was implemented with yen loan, the interest rate of the loan from JICA to MEF would be 0.75%. And PAS will receive sub lease of the yen loan from MEF. The sub lease terms are based on Cambodian laws and regulations and will be determined in consultation with PAS and MEF on a project-by-project basis, Incidentally., but the interest rate of the yen loan from JICA to MEF when signing the loan agreement for NCT1 was 0.01% and the interest rate of the sub lease from MEF to PAS was 1.26%.All FIRR results exceed the assumed interest rate of the yen loan and the interest rate of the past sub lease from MEF to PAS. Therefore, this analysis shows this project is financially feasible.

494. Regarding the environmental and social considerations, Environment Impact Analysis (EIA) has been conducted showing that the impact of the project and existence of NCT2 and NCT3 is considered not significant. In addition, the amount of compensation for those who are living and/or running businesses on the existing breakwater is estimated to be approximately 27 million USD.

495. In conclusion, the project, the development of NCT2 and NCT3, will provide SHV Port with sufficient port capacity to handle the future container cargo demand which is expected to increase with the economic development in Cambodia. In addition, direct shipping network with North America and/or Europe enable the country's cargo to be transported directly to/from those regions without relying on the ports of neighboring countries such as Vietnam and Thailand, or without being transshipped/relayed at other countries, This means that the time and cost required for international container transport to/from Cambodia can be reduced and which will greatly contribute to the promotion of trade and the enhancement of the competitiveness of the Cambodian economy by increasing the efficiency of container transport as well as strengthening access to global markets.

496. In particular, since exports from Cambodia such as garment and other products of light manufacturing industry are mostly shipped by container to North America, Europe and East Asia, efficient logistics for those products with lower cost is crucial for competing in the global market and for attracting foreign capital investment. In addition, from the perspective of economic security, it is important to have large container terminals in the country attracting vessel calls with various shipping networks.

497. The economic benefits (cost savings and time savings) after completion of the Project are estimated to exceed US$300 million per year compared to the "without project" case, which includes the benefits of the mother vessel callings at SHV Port. The EIRR is expected to exceed 20%, and the FIRR is expected to be over 7%, indicating that this project is economically and financially viable. The EIRR is expected to be over 20% and the FIRR around 7%, indicating that the project is economically and financially viable.

498. Therefore, it is concluded that the timely implementation of the project is the key to reaping the economic and financial benefits that the port and the country can enjoy.

11.2 Issues to be Noted

499. The issues to be noted in the project implementation are as follows.

500. In the midst of the prolonged COVID-19 pandemic which may alter supply chains, it is necessary to proceed with the project carefully. paying close attention to the future demand of containers globally as well as the trends of container handling volume at SHV Port and other surrounding ports. In particular, it is necessary to pay attention to the demand before the construction of NCT3. In addition, it would be expected that the container terminal handling capacity may exceed the terminal capacity, i.e., the current terminal and NCT1, before NCT2 is put into service, so it is necessary to pay attention to cargo trends and take appropriate measures to further improve the handling capacity of the current terminal and NCT1.

501. Since the construction schedule of NCT2 partially overlaps with that of the preceding NCT1 construction, it is necessary to coordinate the construction plans of the two projects to ensure they are implemented in a timely manner. Particular attention needs to be paid to the progress of the NCT1 construction. The same issue also exists between NCT2 and NCT3. Therefore, regular meetings between the contractors and the consultants involved in the development of NCT1, NCT2 and NCT3 should be held to coordinate the implementation schedule.

502. There would be a possibility that sedimentation might occur in the channel and basin when deepened to 14.5m. Since it is difficult to estimate the amount of sedimentation beforehand, the change of the water depth during the construction period should be regularly monitored and the result should be reflected in the subsequent maintenance dredging if necessary. Conducting simulations to estimate sediment volume would also be useful.

503. It was concluded that there is no need to build a new breakwater to ensure tranquility in front of the NCT2 and NCT3 in this survey. However, real data on waves. tides and currents have not been observed at the actual site of SHV Port, and therefore it is desirable to obtain and analyze oceanographic data in the future to determine whether the tranquility in front of NCT2 and NCT3 can be maintained.

504. Since the project contains widening of the channel to cope with the large size of vessels, shifting the channel centerline, and modifying the slope beside the channel, it is important to confirm the safety of the vessel navigation under these conditions. Therefore, it is desirable to confirm navigational safety by conducting vessel simulation and/or training of

pilots using ship maneuvering simulators.

505. As it will be the first time to introduce automated RTGs (ARTGs) in Cambodia, it will take time for on-site testing of the equipment including ARTGs and training of operators. Therefore, coordination between the civil works and equipment installation are indispensable for commencing terminal operations on the target date. It should also be noted that on-site adjustment and commissioning of the ARTG must not affect NCT1 operation. In particular, it is important to secure an area and a time for test operation of the ARTG and other handling equipment in the yard via TOS (Terminal Operation System).

506. NCT2 and NCT3 areas are separate from the existing port and SEZ, and this means that there will be three independent bonded areas. Therefore, well-coordinated port security among those areas is necessary in terms of hardware aspect as well as software aspect. In addition, since some cargo will move among the three areas, it is necessary to ensure bonded transport between the areas and to promote efficiency of import/export procedures through IT with close coordination and cooperation with customs authorities. In particular, the Port Gate to be installed at the new container terminal will only enhance gate procedures if the National Single Window system in Cambodia is realized. Therefore, it is necessary for PAS to encourage the relevant ministries and agencies to modernize the customs system before NCT2 comes into service.

507. After the completion of the expressway, it is possible that traffic restrictions might be imposed on the roads around SHV Port, which could cause congestion around the port area. Therefore, it is necessary to monitor the latest road situation and regulations in the surrounding area, and to coordinate closely with the road administrators, i.e., MPWT and DPWT. In addition, access routes to the new container terminal, including NCT2 and NCT3, will be used by both port-related vehicles and conventional vehicles, and congestion could be severe in accordance with the increase of container cargo. Therefore, it is necessary to coordinate closely with the road administrators on a daily basis and take necessary traffic control measures so as not to impede the flow of container cargo in/out of the new container terminal when needed.

508. Since the fishing villages and communities exist in the vicinity of the construction area, it is necessary to prepare sufficient countermeasures to minimize the impact of the construction work as much as possible, and to respond to complaints properly in case.

[END]