Ministry of Treasury and Economic Management,
Ministry of Infrastructure and Public Utilities,
Republic of Vanuatu

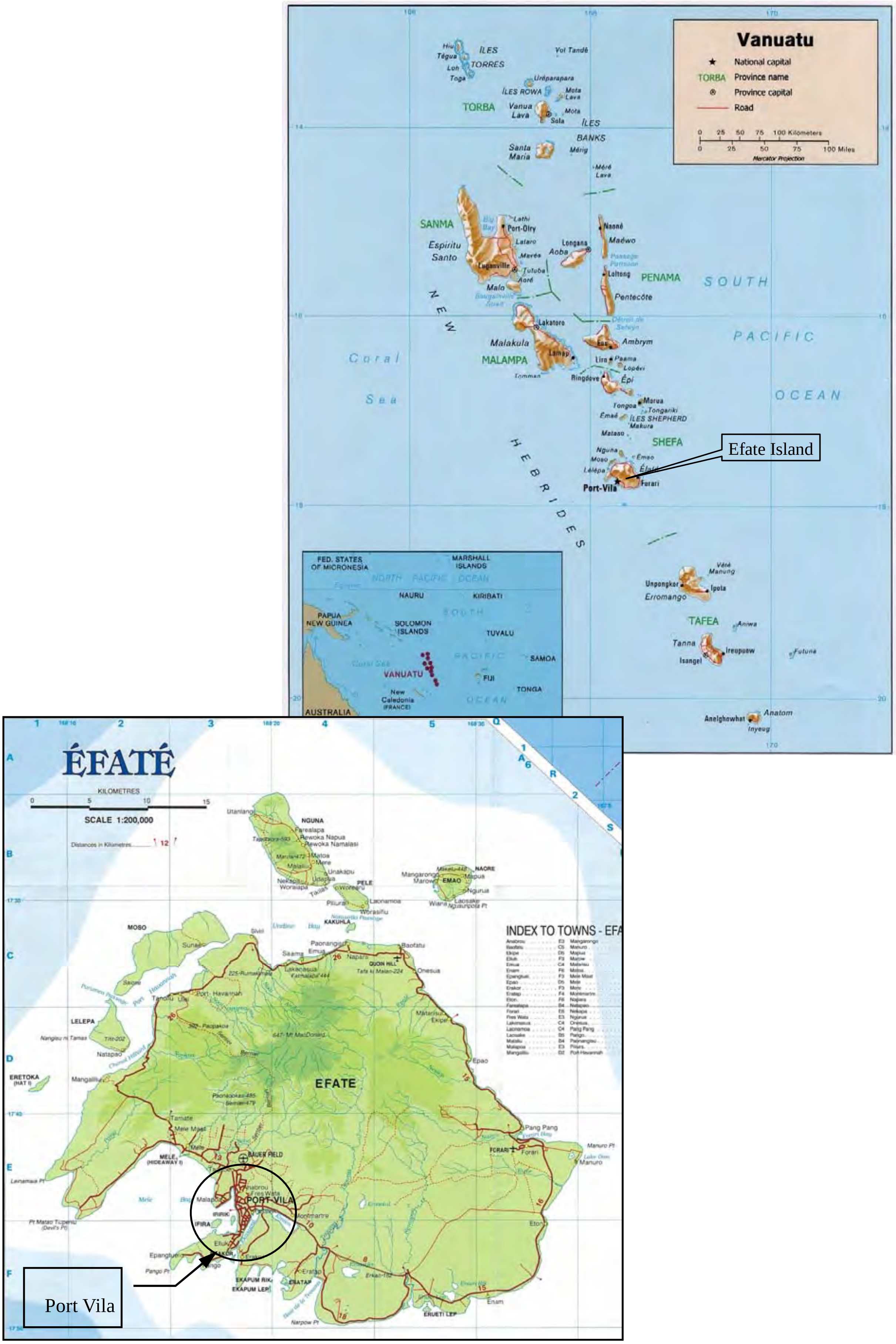
PREPARATORY STUDY FOR THE PROJECT ON INTERNATIONAL MULTIMODAL PORT AT STAR WHARF IN PORT VILA (REVIEW OF THE QUANTITY SURVEY)

FINAL REPORT

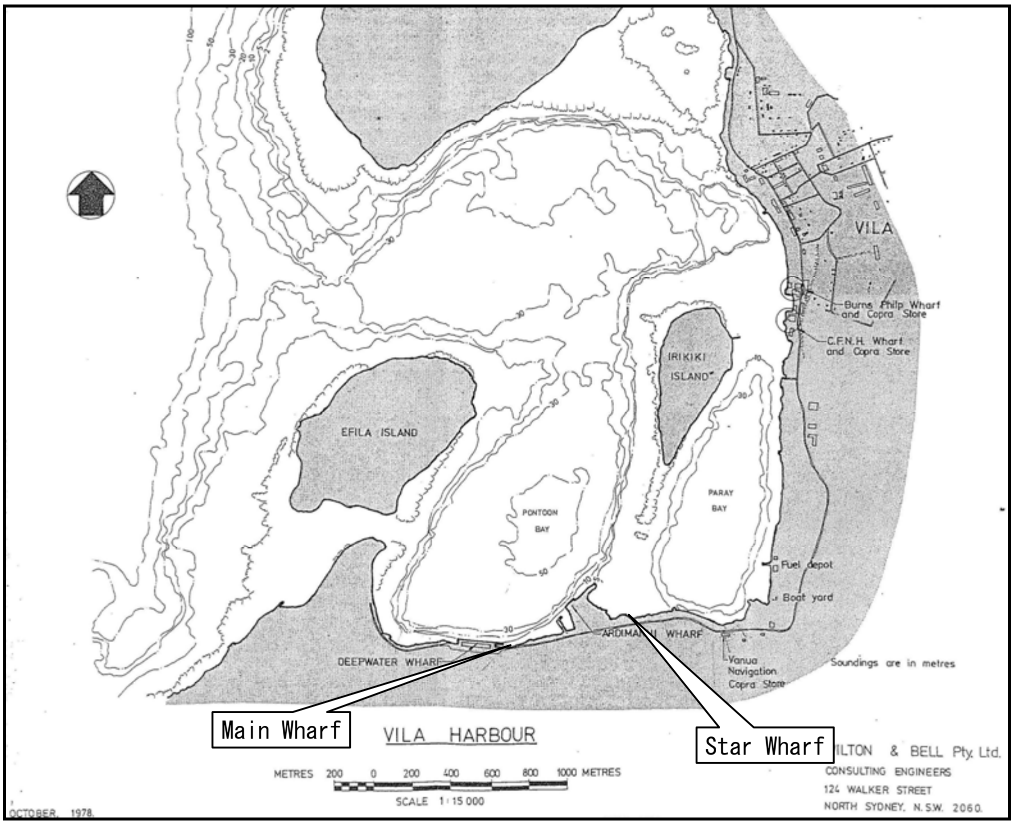
DECEMBER 2011

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ECOH CORPORATION



Efate Island and Port Vila



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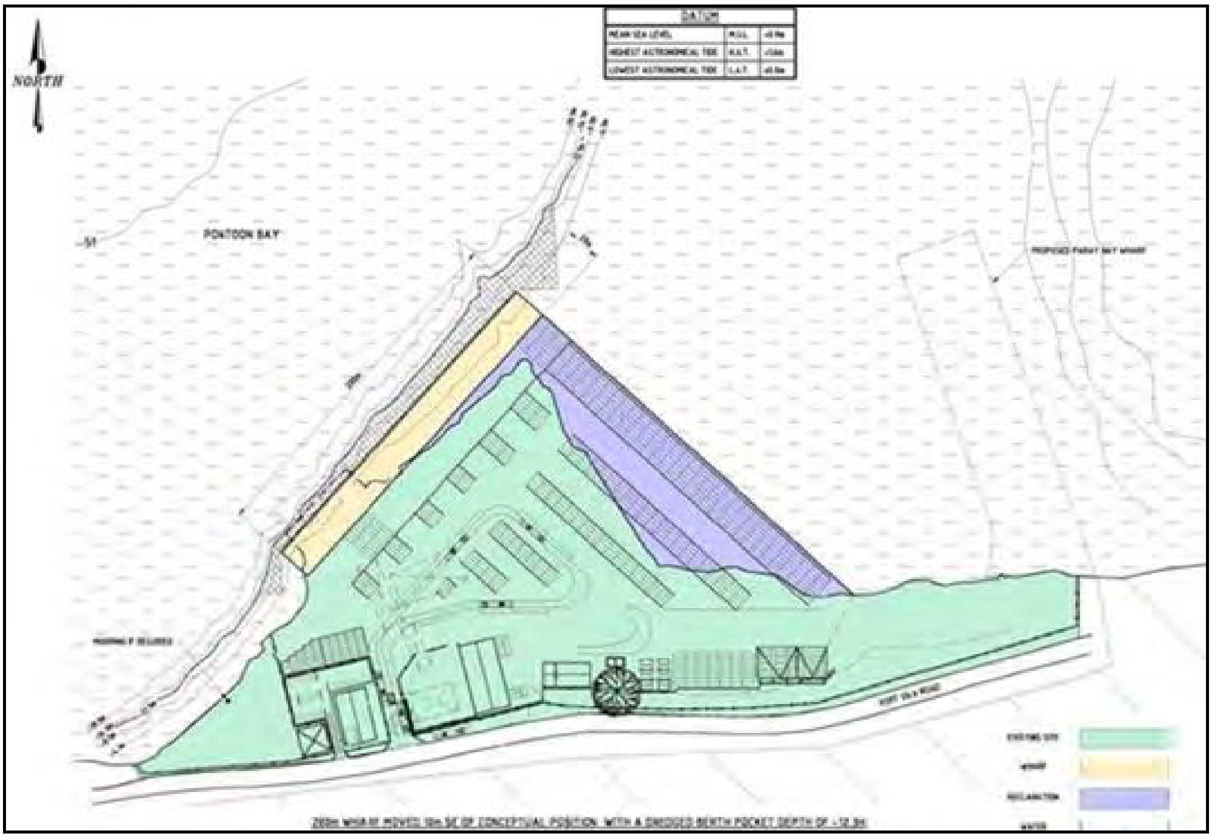
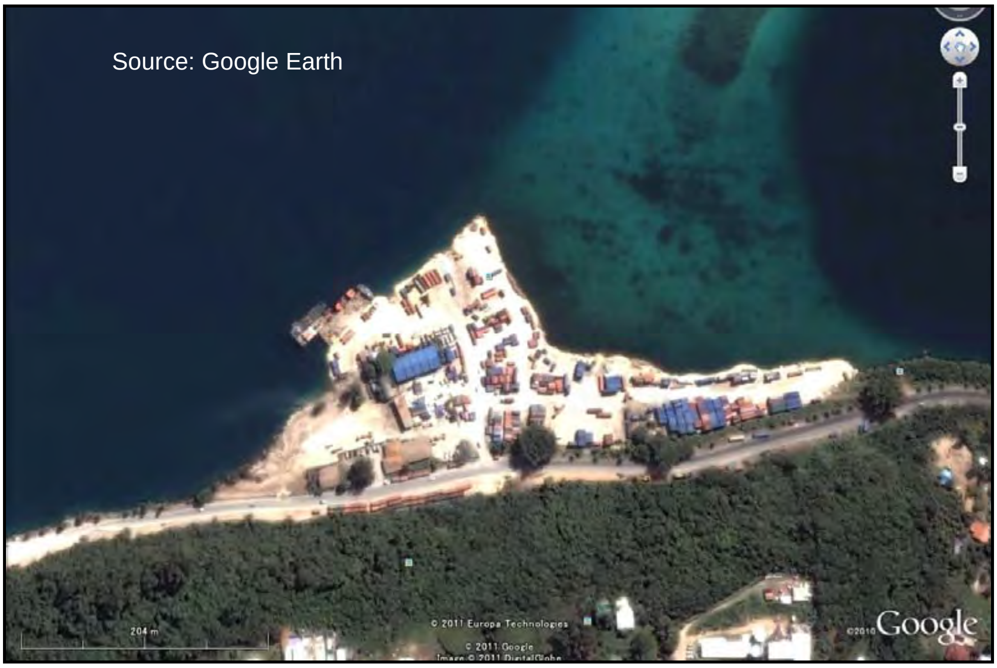


Plan of Proposed Star Wharf



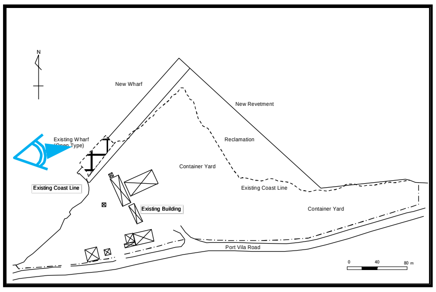


Photo-1 Overall View of Star Wharf

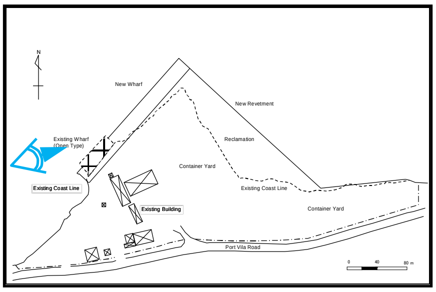


Photo-2 Domestic Wharf in Star Wharf

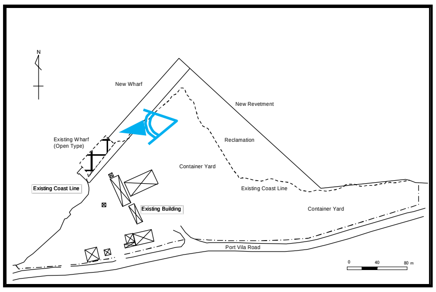
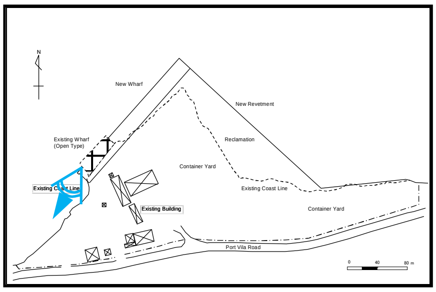


Photo-3 Deteriorated Facility for Domestic Cargoes



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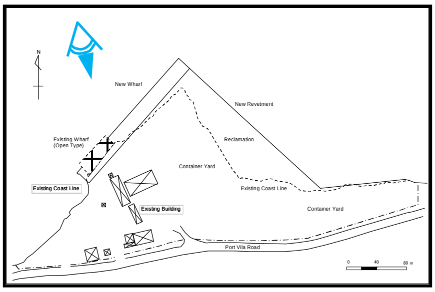


Photo-5 Northern Revetment and Domestic Wharf

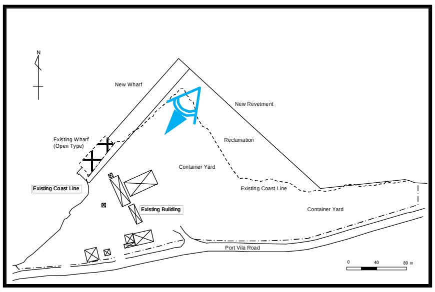
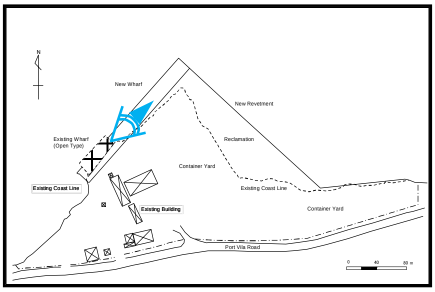


Photo-6 Yard behind Domestic Wharf



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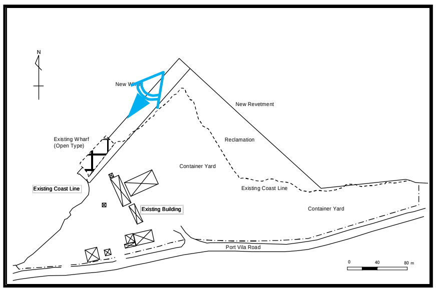
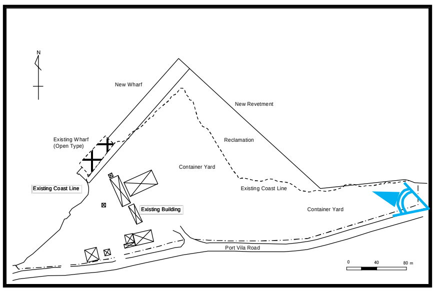


Photo-8 Northern Revetment



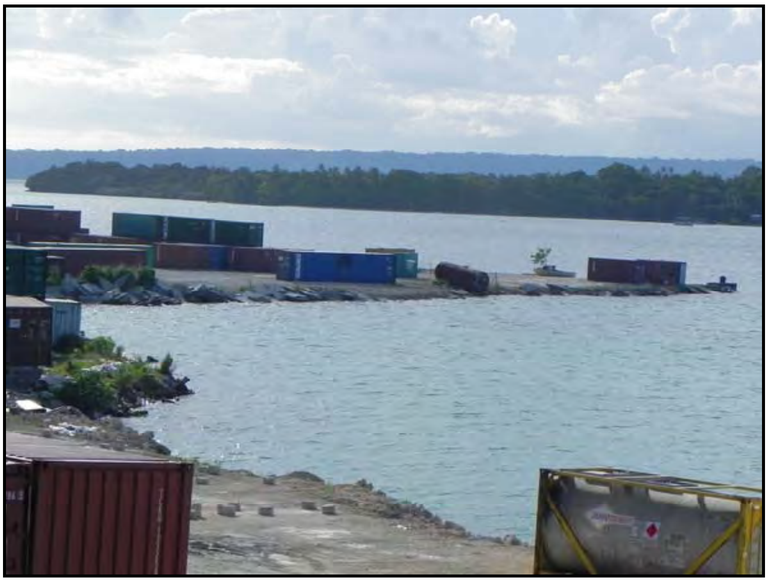


Photo-9 East View of Star Wharf

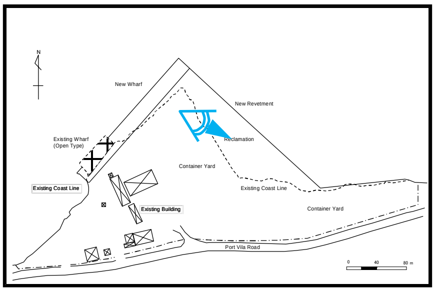


Photo-10 East Revetment

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1.1 Project Background

Republic of Vanuatu has attained high economic growth exerting pulls by the recent construction related industries and tourism industry, on the other hand, there are still many problems remaining on the economic infrastructures such as roads, ports and harbors. Thus, the Government of Republic of Vanuatu has purposed to improve port facilities of Port Vila as the most important issue in the Priorities & Action Agenda 2006-2015 that is national long-term plan and the middle-term plan for 2007 to 2011. Especially, as this port is not met with the ISPS Code (The international Ship and Port Security Code) and has a structure that is enabling for container cargos, the Government of Japan has executed the Grant Aid Cooperation for the Project for "Improvement of Port Vila Main Wharf (during 2007 and 2009)" and strengthened the safety of this port, the yard improvement (for bulk cargo to container cargo) at the international wharf and etc.

However, recently in this port, calling vessels including large cruise ships are increased rapidly as well as increasing handling cargoes according to the economic development. The cruise ships have priorities than cargo ships and there occur often that the cargo ships are obliged to suspend her cargo handling or wait at offshore by cruise ships calling. With that, the Government of Republic of Vanuatu has planned total development of this port including domestic wharf has asked a Bankable Feasibility Study (BF/S) concerning the development of wharf for international cargos to AusAID in order to expand jetty and yard for international cargoes and it was completed in July, 2010. After this, the Government of Republic of Vanuatu has requested Yen Loan to the Government of Japan concerning the realization of the project according to the BF/S in September, 2010.

JICA has dispatched a fact-finding team in February, 2011 and confirmed required components and basic items concerning yen loan and at the same time, technical assistance and training related with the above BF/S were made by dispatching 4 experts in the field of Port Facilities, Port Development, Financial Analysis and Environmental Social Consideration in March, 2011. In accordance with the result of these, in the study of relevance of this project there found that the jetty structure is proposed by steel pipe piles one in the BF/S and the cross section structure of the steel pipe pile structure jetty was different from the steel pipe pile structures that are generally used in Japan and the structures comparison in view of each cost was not done. In addition, in the analysis of the proposed structure, it was found that there is a possibility to be cheaper by adopting pile supported jetty which is common in Japan.

This study aims at comparison study between proposed structure by BF/S and the structure designed in accordance with Japan Standards and re-estimation of the cost for the re-designed structure based on the BF/S report. In accordance with the scheme, re-design shall be done using the design conditions decided in the BF/S except the conditions apparently inconvenient.

1.2 Present Condition of Port Facilities in Port Vila

(1) General

Port of Port Vila is the main international trade port in Vanuatu catching up with the Port of

Luganville in Santo Island. This port, as shown in Photo 2.1.1-1, is located at the east side of Port Vila urban district and the expansion to land side area is difficult due to the existence of backside hills. Star Wharf is located at 500 m east of the Main Wharf where container vessels are berthed and used as the container yard for international cargoes. Containers unloaded at the Main Wharf are immediately transported to the Star Wharf and stored. There are wharves for domestic cargoes including aged jetty at the east side of the wharf and are used by domestic ferry boats connecting islands in Vanuatu and small international ferry boat to have a service between New Caledonia.

Only the wharf for bulk cargoes has been there in Port of Port Vila in the past and as it has the problem that could not meet with the rapid increase of container cargoes, the improvement of Main Wharf to the wharf for container cargoes has just completed in March, 2010 by the project for "Improvement of Port Vila Main Wharf" under Japanese Grant Aid Cooperation. The planned contents are consisted of the improvement of approach between wharf and the container yard, pavement of container yard, improvement of warehouse for bulk cargoes and etc. ECOH CORPORATION has been engaged in the bunch of consultant services from the Basic Design Study to the Detailed Design and the Supervision of Construction Works.

And, next to the improvement of port facilities, a JICA senior volunteer has been dispatched to Ports and Marine Department from April, 2011 and supports the operation and management of port facilities in its soft aspect.

Photo 1.2-1 Aerial Photo of Port Vila

(2) Present Condition of Main Wharf

1) Outline of Port Facilities

Photo 1.2-2 shows the picture just after the completion of the improvement of main wharf constructed by Japanese Grant Aid Cooperation. As this photo shows, container yard, warehouse for bulk cargoes, administration facilities and etc. are there at the back of wharf facilities of jetty structure. Summary of each port facility is as shown below.

・Wharf　　　　　　：Length 213m, Water depth in front -10.7m
・Container Yard　　：Pavement area 7,000m^2
・Warehouse for bulk cargoes ：Total floor area 1,100m^2
・Administration Facility ：Floor area 280m^2

And as this port is inevitable to make pilot to board on ship and assist by tug boat, a tug boat and a pilot boat are induced for the promotion of safety navigation to calling ships together with the improvement of port facilities.

・Tug Boat：LOA 31m, 250 GRT, HP of main engine 1,600 hp x 2 engines
・Pilot Boat　　：LOA 12m, 11 GRT,　HP of main engine 180 hp x 2 engines

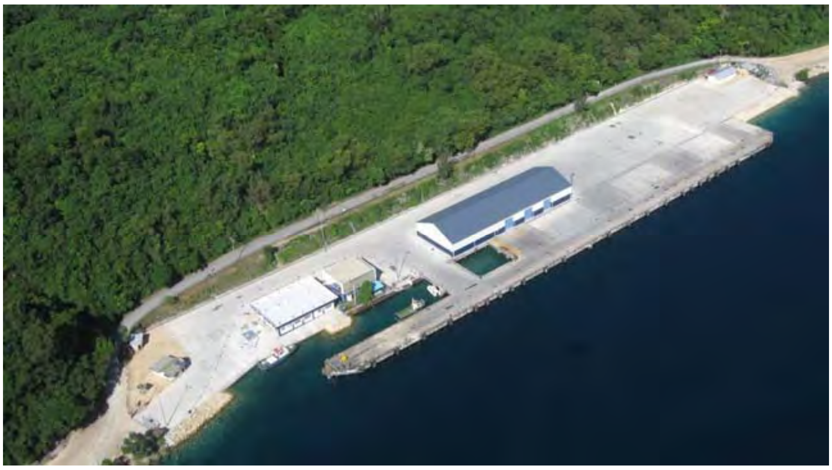


Photo 1.2-2　Aerial Photo of Main Wharf
(March, 2010 just after facility completion)

2) Calling Ships

Cruise ships other than international container vessels and tankers are called in Port of Port Vila where are found with extraordinary congestion.

The number of calling vessels to Port of Port Vila in 2010 was 168 of which number of cruise ships is 78 and it occupies about one half of the total. The priority of calling vessels is given to cruise ships, emergency boats, cargo vessels and tankers respectively and as low priority vessels like container vessels, tankers and etc. cannot use wharf when the cruise ships get enter the port, there possibly call into Santo Port nearby changing calling order.

Regular service navigation lines and main calling ports for the container vessels to call Port of Port Vila are as follows. Greater Bali Hai is shipped from Japan and Swire Shipping sends ships from Australia.

・Greater Bali Hai（Pusan→Yokohama→Tarawa→Fiji→Numea→Port Vila→Santo→Honiara）
・Swire Shipping（Brisbane→Numea→Port Vila→Fiji→Samoa→American Samoa→Tarawa）
・Pacific Direct Line（Auckland→Numea→Fiji→Port Vila→Santo）
・Sofrana Shipping（Auckland→Brisbane→Port Molesby→Honiara→Port Vila）
・Neptune Pacific Line（Sydney→Brisbane→Port Vila→Noro→Honiara）

Figure 1.2-1 Calling route of Greater Bali Hai **Figure 1.2-2 Calling route of Swire Shipping**

Table 1.2-1 shows calling schedule to Port of Port Vila of each shipping company in September. Other than this, oil and gas tankers call into the port. Wharf occupation days in a month is about 14 days but the port calling is possible to be overlapped due to the frequent change of arrival of container vessels on the way of their navigations. Cruise ship schedule calling the port is also shown in the Table. As calling schedule of a Swire Shipping vessel and a vessel from Sofrana Line is overlapped at the middle of September, the schedule shall be pressed for change. More adjustment of schedule shall be required at the high season of cruise ships calling to the port.

Table 1.2-1 Calling schedule of Container Vessels and Cruise Ships

		Shipping Line					Port Occupancy
2011	Cruise Ship	Swire Shipping	Sofrana	Pacific Direct Line	Neptune Pacific Line	Greater Bali Hai	
Sept. 01		Forum Fiji					Forum Fiji
02							
03							
04					(Forum Fiji)		
05				Southern Fluer			Southern Fluer
06							
07							
08	◎ Pacific Dawn						◎ Pacific Dawn
09							
10							
11							
12							
13	◎ Pacific Jewel		Sofrana Saville				◎ Pacific Jewel Sofrana Saville
14		Capt. Tasman					Capt. Tasman
15	◎ Pacific Dawn						◎ Pacific Dawn
16					(Capt. Tasman)		
17							
18							
19							
20							
21							
22							
23				Southern Fluer			Southern Fluer
24							
25							
26							
27						South Islander	South Islander
28							
29							
30							
Frequency	2 ship calls/month	2 ship calls/month	1 ship calls/month	2 ship calls/month	(2 ship calls/month)	1 ship call/month	6 ship calls/month
In-port Days	6 days/month	6 days/month	4 days/month	6 days/month	(6 days/month)	2 days/month	14 days/Month

Annual number of cruise ships calling to the port in 2010 is 78 and it is expected to be 114 in 2012. It runs increasing tendency recently. The shipping company which allocates ships into the port most is P&O Cruises (present Carnival Line) and Pacific Dawn, Pacific Jewel and Pacific Sun are shipped many times. The number of calling cruise ships to the port is average 7 per month only by P&O Cruise, the number of calling cruise ships shall be increased with other cruise shipping companies.

In the mean time, the ship size of Pacific Dawn is as follows:

・LOA 245.1m, 70,285 GRT, Draft 7.0m

・Fixed number of passenger 2,050 persons, Number of Crew 696 persons

4) Handling of Containers

Concerning the container handling, no large size forklift is allowed to go into the wharf due to the load limitation. Loaded containers discharged from a container ship are transported to the backside container yard by container-movers which axial load is small as shown in Photo 1.2-3. The containers are loaded onto trailers by large size forklifts and transported to the container yard in the Star Wharf. In occasions of cruise ships' calling, handling containers are not allowed at the Main Wharf for a safety purpose.

Photo 1.2-3 Container mover

As a result of a visual survey of handling containers from Sofrana Surville of Sofrana Shipping, the cycle time of one container was 5 minutes in the fast case and it took more than 10 minutes in the slow case. The workability of ship's cranes is the same as other ports but the inefficiency is caused by shortage of necessary number of land transporting vehicles.

Therefore, container handling efficiency at the Main Wharf is understood as very inefficient affected by load limitation of wharf, limitation cargo handling machinery, slow cargo handling time, container transportation to Star Wharf and so forth.

(3) Present Condition of Star Wharf

1) Outline of Star Wharf

A container yard and a domestic cargo wharf are in the Star Wharf as shown in Photo 1.2-4 and it is operated and managed by IPDS (Ifira Port Development Service Co., Ltd.) The domestic cargo wharf is located at the west side and separated by container yard and net fence. Water area of west side of Star Wharf is sharp and deep bottom topography so that the extension of wharf facility is difficult. In contrast to this, tombolo is formed between Iririki Island and the east side where the water depth is comparatively shallow and ship navigation is not possible and therefore, it is not good for the construction of wharf.

Present aerial photo of Star Wharf is shown in Photo 1.2-4 and the aerial photo that is considered to be taken before 1987 although exact year is unknown is shown in Photo 1.2-5. It is understood that the Star Wharf has been π type reclamation shape at first, and thereafter it has been expanded gradually by reclamation. And facility like small craft basin is found at the west side entrance though it is reclaimed now.

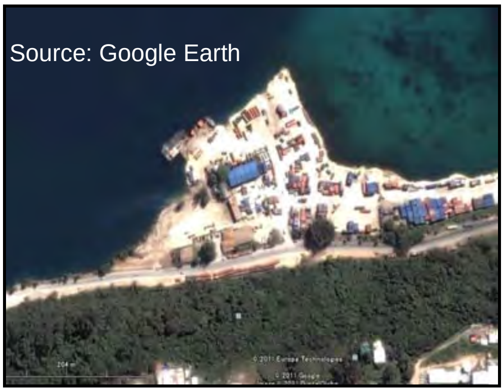


Photo 1.2-4 Star Wharf (Present)

Photo 1.2-5 Star Wharf (before 1987)

2) Container Yard

The container yard occupies most of the east side of Star Wharf. Administration facilities, work shop and etc. are located at the area neighboring domestic wharf in the west side. The container yard, as shown in Photo 1.2-6, is not paved and there are many uneven parts which cause trouble of container handling machines like forklift and it leads to the low efficiency of container handling work. And as containers become muddy during their handling, mud cleaning by water is required from quarantine purpose before the export of empty container.

Photo 1.2-7 shows Star Wharf at the time around 2008 and it is understood that the container yard is full of containers and even road is used for their storage. In addition to the rehabilitation of Main Wharf under the Japanese Grant Aid Cooperation in 2010, container yard is effectively used by the dispatch of experts for container cargo handling from AusAID and the efficiency and safety of container cargo handling has been improved a lot comparing before.

Photo 1.2-6 Handling by Forklift

Photo 2.1.1-7 Container Yard around 2009

3) Domestic Wharf

The domestic wharf is located at construction area of the new wharf at the west side of the Star Wharf and it is used by ships for domestic navigation related to Ifira Shipping. There is a very old deteriorated jetty as the facility in Domestic Wharf and there are neither land facilities like passenger terminal etc. nor the service facilities. Jetty facility is not so used due to the ageing and the ferry connected with islands, as shown in Photo 2.1.1-8, is berthed utilizing rubble mound wharf at the north side of jetty. Vanuatu is an islands country consisted of about 80 islands being spread 1,200 km from north to south and it is important to improve wharves for domestic cargoes and passengers connecting international port and isolated islands since the international cargo wharf is limited to Port of Port Vila and Port of Luganville in Santo Island.

Photo 1.2-8 Ferry Berthing

Photo 1.2-9 Cargo Handling at Domestic Wharf

The improvement of Domestic Cargo Wharf is separately planned by the co-financing of the Government of New Zealand and ADB. The project site is comparatively shallow area located at east side of Star Wharf as shown in Photo 1.2-1. This plan is in a stage where the Consultant for the detailed design is just called in October, 2011 by ADB.

In conjunction with the improvement of Star Wharf, the removal work of existing domestic wharf must be commenced after completion of new Domestic Wharf since the existing domestic wharf will not be existed in Port Vila when this project is implemented. The Government of Vanuatu has acknowledged that the schedule adjustment shall be necessary between two projects and therefore, this is regarded as no obstacle to this project.

2. Outline of Star Wharf Development Plan

2. Outline of Star Wharf Development Plan

BF/S related with Rehabilitation of Port of Port Vila International Multi Wharf has been completed in July, 2010 with SOROS ASSOCIATES consigned by AusAIDS under the request from the Government of Vanuatu. The outline of facilities plan is shown below.

2.1 Effects by Rehabilitation of on Star Wharf

Main Wharf, as described previously, is located at 500 m west of Star Wharf and cargo vessels represented by international container vessels and cruise ships are calling at present. The Government of Vanuatu put emphasis on the improvement of port facilities as the most important issue and has requested to the Japanese Government for the project of "Improvement for Port Vila" under the scheme of Grant Aid Cooperation. As the result, aiming strengthening of the safety and the functions to improve yard in international wharf as the emergency response and the project was completed in 2010. The consistency between the improvement project of Main Wharf executed by Japan and this project is considered to be as follows, and the main issues in Port of Port Vila shall be resolved by this project.

・Wharf occupation ratio of Port of Port Vila exceeds 64% and calling frequency of container vessels and cruise ships is considered to be also increased in the future, therefore, it shall be necessary to construct a new wharf.

・Cargo vessels cannot be berthed while the highest priority cruise ship is calling and the cargo handling of cargo ships shall be in trouble. And, the container handling works shall be prohibited at the Main Wharf in respect of securing the passenger's safety.

・The quay of Main Wharf has load limitation and as cargo handling machine like large size forklift that is inevitable to handle containers, temporary storage works at the container yard shall be necessary.

・The container yard in Main Warf limits its function as temporary storage of containers due to the limited area therefore, the extra transportation works to Star Wharf shall be necessary.

The above issues shall be resolved by the construction of exclusive use wharf for container vessels at Star Wharf by the execution of this project. Main Wharf shall be exclusively used by cruise ships but the following application can be considered.

・Applying as backup berth when container vessels are calling overlapped

・Applying as backup space of container yard for Star Wharf

・Applying warehouse for bulk cargoes in Star Wharf as place for bonded cargoes to be needed long period storage

2.2 Summary of Facilities and Equipment

The summary of port facilities and equipment that were studied in BF/S concerning the improvement of Star Wharf is as shown in Table 2.2-1 and each facility location is shown in Figure 2.1.2-1. Out of these, facilities of administration building and cargo handling equipment are separately executed by the Government of Vanuatu and are not included in this project.

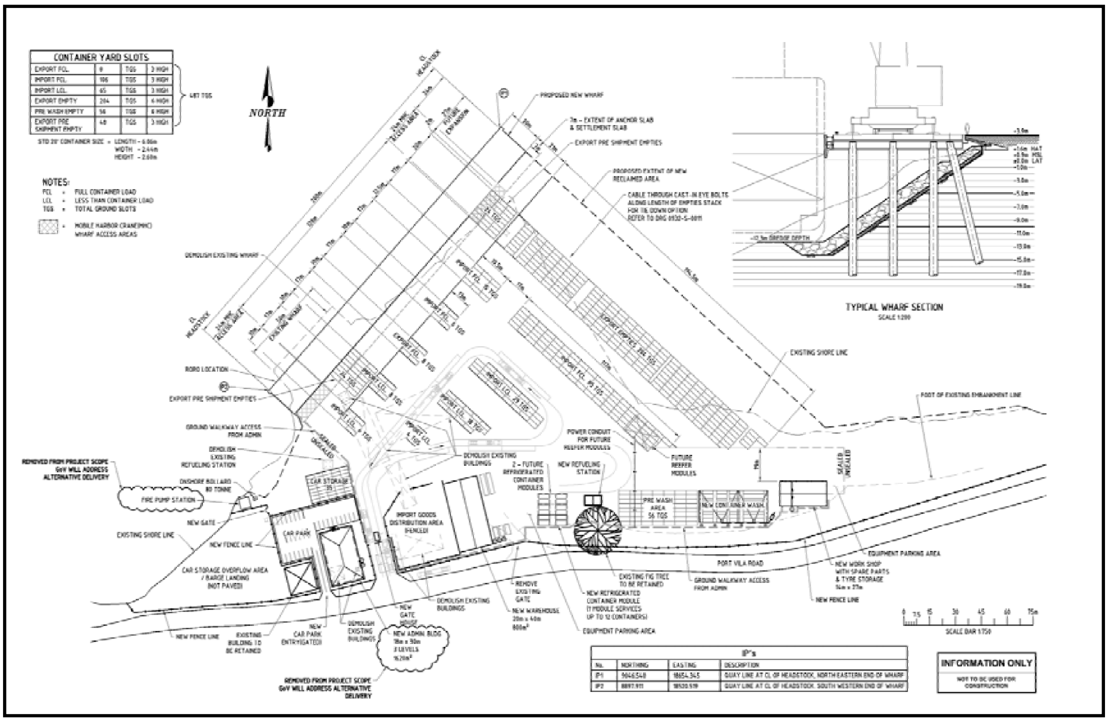


Figure 2. 2-1 General Layout of Facilities in Star Wharf

Table 2. 2-1 Summary of Facilities and Equipment

Works	Name of Facility	Size
1) Civil Facility	Wharf	200 m×20 m
	Dredging	62,500 m^3
	Reclamation	31,000 m^3
	Revetments	30,400 m^2
	Pavement	32,700 m^2
	In-port Road	1,200m^2
2) Architectural Facility	Warehouse Building	Approx. 40m×20m
	Workshop Building	Approx. 27m×14m
	Administration Building	Approx. 40m×18.2m（3 Stories）
	Reefer Container Power Tower	Approx. 6m×3.5m
	Container Wash Bay	Approx. 39m×17m
	Drains	Approx. 550m
	Gatehouse	Approx. 3m×2m
	Refueling Station, Leakage Containment Tank, Fence, others	
3) Cargo Handling Equipment	Mobile Harbor Crane	
	Heavy ForkLifts	
	Empty Container Handle	

2.3 Planning Concept of Wharf Facilities

The sizes of quay facilities to be reviewed by this project are as follows and in comparison with “Technical Standards and Commentaries for Port and Harbor Facilities in Japan” the relevancy of the sizes is studied.

・Length of Wharf : 200m ・Width of Wharf : 20.0m
・Water Depth of Wharf : -12.3m ・Wharf Crown Height : +3.9m

According to “Design Standards and Commentaries for Port and Harbor in Japan” the main sizes of container berth in case that vessels cannot be specified are set, the standards present that the wharf for 30,000 DWT class container vessel is set with the length of 250 m and the water depth of -12.0m.

(1)Design Vessel

The design vessel is a container vessel allocated at regular intervals to Port of Port Vila and actually set Challenger class container vessel of Swire Shipping and Greater Bali Hai, that is Ro-Ro ship as shown below.

・Tasman Mariner (China Navigation) : DWT ton 25,561, LOA 184.9m
Full Draft 10.6m, Breadth 27.6m

・South Islander (Greater Bali Hai) : DWT ton 17,800, LOA 160.73m
Full Draft 9.38m, Breadth 25.0m

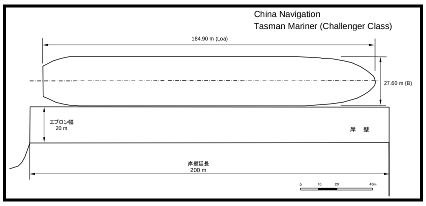
Photo 2.3-1Tasman Mariner (Swire Shipping)

Photo 2.3-2 South Islander (Greater Bali Hai)

(2) Design Length of Wharf

Figure 2.3-1 and 2 show the berthing condition to the berth of designed vessels. In case of Tasman Mariner (China Navigation), the LOA is 184.9 m against wharf length of 200 m and the rooms at bow and stern sides are secured with only about 8 m that may be possible for mooring although about 20 m rooms is necessary for mooring cables. And in case of South Islander (Greater Bali Hai), the LOA is 160.73 m and although the rooms at bow and stern sides are about 20 m, ramp way is equipped at the stern for conveying vehicles therefore, it is necessary to berth shifting a little bit to bow side . In this case, although the rooms at bow side are not enough for mooring cables, the mooring of ships is considered to be possible.

Therefore, design length of wharf is considered to be no problem for mooring of designed vessels although it is a little bit shorter in case of considering sizes of design vessels.



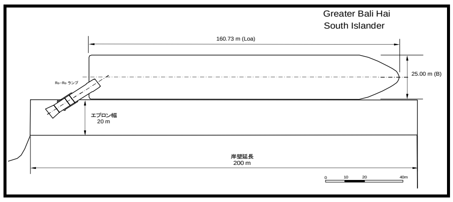


Figure 2.3-1 Mooring of Tasman Mariner **Figure 2.3-2 Mooring of South Islander**

(3) Design Water Depth of Wharf

The design water depth of wharf as Table 2.3-2 shown, is set as -12.3 m including 10% allowance of ship's up and down, 0.5m room for soft soil layer and etc. based on the maximum draft of design vessels.

Table 2.3-1 Setting of Design Water Depth of Wharf

Depth Factors	(metres)
Max loaded draft (MV Tasman Mariner)	10.6
Movements due to waves (assume vessels will leave the berth well before 0.66Hs for large vessels at Tp> 10 secs is reached)	0 .0
An allowance of 10% of the loaded draft, for under-keel clearance (UKC) for trim, atmospheric pressure	1 .1
Allowance for berth siltation	0.0
Character of bottom, soft	0.50
Sounding accuracy – assume a best case scenario of 0.1 m for echo sounding	0.1
Minimum water depth below LAT	12.3

10% of allowance of the maximum draft of design vessels is basically considered to be advisable in the standard of Japan and the design water depth shall be -12.0m according to the standard as below. The water depth of a wharf for 30,000 DWT container vessel is set as 12.0 m in case that the vessel cannot be specified.

Design water depth of wharf = maximum draft of design vessels + allowance (10% of maximum draft)

＝10.6m＋10.6m×0.1＝11.7m → 12.0m

According to the officer of Vanuatu Government, as the project area is the waters where sand deposition near the wharf is apprehended, maintenance dredging shall be necessary in future for securing wharf water depth. However, there is no dredger in Vanuatu and he had intention to have deeper depth of wharf for securing allowance of sand deposition.

Incidentally, the draft of "Tasman Provider" that is the same type of vessel with design vessel called on March 17, 2011 was 6.8 m at the bow and 7.2 m at the stern.

Concerning -12.3 m wharf water depth that was set by BF/S, although there are some rooms to study design concept mentioned above, the wharf water depth is to verify in accordance with the Japanese design standard as -12.3 m from the stand point of this study.

(4) Design Crown Height of Wharf

In order to cope with the sea level rise by future climate change, the existing ground level of container yard at the back of wharf shall increase 0.9m more, namely as DL+3.9m, design crown height of wharf is set the same. According to the Japanese standards, the above 1.0 to 2.0 m from mean monthly-highest water level is often used in case of tide difference within 3.0 m in large scale mooring facility. As the mean-monthly-highest water level at Port of Port Vila is DL+1.6m, it becomes DL+3.6 m at the maximum, although about 0.3 m is higher, it is considered to be no problem as the usage of container vessels.

(5) Structural Profile of Wharf

The report of BF/S proposes pipe pile structures shown in Figure 2.3-3 based on the above sizes. According to SOROS that made the BF/S, this structural profile is popular one in advanced countries like Australia, Europe and USA. It was compared among usual pipe piled wharf structure, the above pipe piled wharf structure, caisson structure and sheet piled structures. However, the comparative design was looked like done on the desk study only and the study concerning economic aspect like comparison of estimated construction cost of each structural type was supposed not to be done. In case of Japanese ports and harbors, proper structural type is selected considering economic aspect based on the estimated construction cost and construction method among several structural types. Therefore, it is considered to have a possibility of cheaper cost one by comparative design.

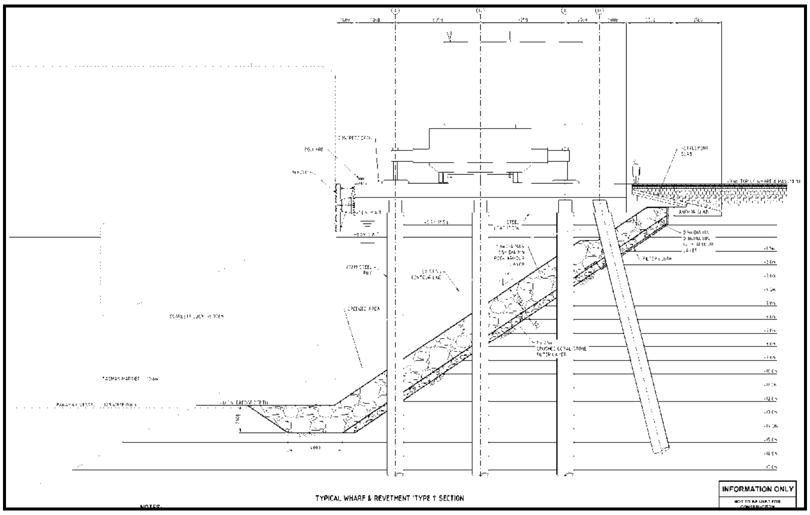


Figure 2.3-3 Structural Profile of Wharf Facilities

2.4 Summary of Project Cost Estimation

(1) Summary of Cost Estimation Result

The estimation of project cost is done excluding cargo handling machines and administration building which will be separately procured and the result of cost estimation is as shown in Table 2.4-1.

As the procurement style of this project is premised on Silver Book (EPC Contract) out of terms and conditions of FIDIC Construction Contract, being different from the separate order between detailed design & construction supervision and construction works by Red Book, the cost for

Engineering and Construction Management are included in the construction cost. According to SOROS that made BF/S, the cost estimation of project cost was made estimating work quantity from the standard cross sections and others of wharf facilities and land facilities that are included in the plan and obtained the cost multiplying the unit price. The estimated unit prices were set based on the Australian Construction Handbook, unit prices of past similar projects and the quotations from 3 Australian construction companies and one Vanuatu construction company. And the piling works for the jetty are assumed the works from land side since the land works will be about 30% cheaper than marine piling works.

The following points can be understood from the overview of construction cost.

- Price Escalation is not included in the construction cost due to the premise of urgent execution of project.
- Physical Contingency was estimated as 15% which is about 5% bigger than general construction contract due to the premise of EPC contract, perhaps.
- The overhead in case of Japan is set lower as 6.90% of cost price for civil works and 7.56% for architectural works when the construction cost exceeds 3 billion yen.
- 10% as the profit is calculated however, the profit is not included in the cost of estimation of Japanese cost estimation standard.

Table 2.4-1 Overview of Construction Cost by BBF/S

Area	Description	Civil & Concrete	Structural Steel	Totals (US$)
1	General Site	1,876,259		1,876,259
2	Building Earthworks	112,348		112,348
3	Building Concrete	1,484,111		1,484,111
4	Marine Earthworks	23,767,550		23,767,550
5	Marine Concrete	8,750,759		8,750,759
6	Warehouse		182,262	182,262
7	Workshop		120,849	120,849
8	Container Wash		168,852	168,852
9	Refrigerated Module		38,999	38,999
10	Container Storage		505,916	505,916
11	Loading Area		0	0
12	Administration		0	0
13	Refuelling		9,186	9,186
14	Demolition		890,873	890,873
15	Wharf		2,675,220	2,675,220
	Labour & Materials Totals	35,991,027	4,592,156	40,583,184
	Engineering			918,600
	Client Representation			
	Construction Management		5.00%	2,029,159
	Contractor Mobilization/Demobilization (Piling & Dredging including Marine Earthworks)			459,300
	Construction Equipment Rental (Crane for building assembly)			459,300
	Concrete & Compaction Testing			156,162
	Field Backcharges		0.00%	
	Sales & Use Tax			
	General Liability Insurance		0.72%	292,199
	Freight		Steel	1,923,774
			Pavers	542,560
			Containers	133,700
	Permits		Buildings	27,558
			Environmental	142,383
	Escalation		Excluded	
	Subtotal 1			47,667,880
	Contingency (subtotal 1)		15.00%	7,150,182
	Subtotal 2			54,818,062
	Overhead (subtotal 2)		5.00%	2,740,903
	Profit (subtotal 2)		10.00%	5,481,806
	Grand Total		US$	63,040,771

(2) Material Unit Price

Construction materials are presumed to procure from Australia for almost of materials except concrete. As there is no unit price table included in the report, only the following limited items can be understood as material unit prices. These unit prices are considered to be referred from "Australian Construction Handbook" (edited by Rawlinsons) since the material unit prices of Vanuatu are posted there. For reference, each unit price in US$ and converted Japanese yen price are shown below.

Concrete	US$ 202.10/m^3	JP ¥18,444/m^3 (US$ 1.00= JP ¥ 91.26)
Steel re- bar	US$ 1,222/ton	JP ¥111,520/ton
Steel Beams	US$ 2,985/ton	JP ¥272,411/ton

As steels and reinforcing bars when procuring from Australia are imported from other countries like Japan, the unit prices are considered to be expensive. Meanwhile, Steel Reinforcing Bars is about JP¥80,000/ton and Structural Steel is about JP ¥150,000/ton when procuring directly from Japan.

(3) Change of Construction Cost by Fluctuation of Exchange Rate

The estimation of construction cost was made as of March, 2010 however, as the values of US$ and AU$ have been substantially changed after that, the change of construction cost by the exchange rate is studied. The construction cost shown in Table 2.4-1 is estimated by the AU$ basis and converted to US$ with the following exchange rates.

Time of Exchange: March 16, 2010

Exchange Rate: AU$ 1.00 = US$ 0.9186

While, it has been changed as follows when obtains past 6 months average rate up to the end of July, 2011 as the latest exchange rate

Exchange Rate: US$ 1.00 ＝ JP¥ 81.51

AU$ 1.00 ＝ JP¥ 85.30   AU$ 1.00 = US$ 1.0465

Table 2.4-2 shows the project cost of yen values from the US$ basis and AU$ basis obtained by the latest exchange rate. With this comparison table, it is understood that the construction cost at the time of March, 2010 was 5.676 billion yen and it changes to 5.139 billion yen exchanged from US$ and 5.854 billion yen exchanged from AU$. The re-estimation of construction cost shall be necessary by understanding that the construction cost converted to Japanese yen is substantially changed by the fluctuation of exchange rate.

Table 2.4-2 Fluctuation of Construction Cost by Exchange Rate

		Mar 2010	Aug 2011	
Exchang Rate	AU$	US$0.92	US$1.0468	
	US$	JPYen 90.05	JPYen81.51	
	AU$	JPYen 82.72		JPYen85.30
Project Cost	US$	US$63,041,000	US$63,041,000	
	AU$	AU$68,627,000		AU$68,627,000
	JPYen	JPYen 5,678,800,000	JPYen5,138,500,000	JPYen5,853,900,000

2.5 Construction Cost for Wharf

The construction cost for the wharf based on the breakdown list of estimation per item included in BF/S report is US$43,293,000 (JP¥3,950,000,000) as shown in Table 2.5-1 and it is about 70% of the total construction cost US$63,041,000 (JP¥5,677,000,000). Unit price per m^2 is calculated as about 1 million Japanese yen/ m^2 from the wharf area (length 200m x width 20m= 4,000m^2.

The construction cost of wharf is generally varied with the construction conditions of project site or sizes of the wharf (water depth and the length). The cost estimation is resulted from each wharf. As this project plans the saving of construction cost with the execution of piling works for the wharf from land side without using working boats for piling that needs transportation cost from foreign countries, it is considered to be relevant construction method. However, comparing with the past wharf construction projects by Grant Aid Cooperation, this construction cost is looked a little bit expensive.

Table 2.5-1 Summary of Wharf Construction Cost

Area	Description	Civil & Concrete	Structural Steel	Totals (US$)	Totals (Yen) US$1.00=¥91.26
1	General Site (Site Survey, Geotech, Site Cleaning)	765,193		765,193	¥69,832,000
2	Building Earthworks	0		0	
3	Building Concrete	0		0	
4	Marine Earthworks (Dredging & Piling)	16,453,395		16,453,395	¥1,501,537,000
5	Marine Concrete (Wharf Deck)	8,750,760		8,750,760	¥798,594,000
6	Warehouse		0	0	
7	Workshop		0	0	
8	Container Wash		0	0	
9	Refrigerated Module		0	0	
10	Container Storage		0	0	
11	Loading Area		0	0	
12	Administration		0	0	
13	Refuelling		0	0	
14	Demolition		0	0	
15	Wharf (Box Beam, Fender, Bollard)		2,215,919	2,215,919	¥202,225,000
	Labour & Materials Totals			28,185,267	¥2,572,188,000
	Engineering		2.2%	620,076	¥56,588,000
	Client Representation				
	Construction Management		5.0%	1,409,263	¥128,609,000
	Contractor Mobilization/Demobilization (Piling & Dredging incl in Marine Earthworks)			367,400	¥33,529,000
	Construction Equipment Rental (Crane for building assembly)			367,400	¥33,529,000
	Concrete & Compaction Testing			78,081	¥7,126,000
	Field Backcharges		0.00%		
	Sales & Use Tax				
	General Liability Insurance		0.72%	202,934	¥18,520,000
	Freight		Steel	1,282,516	¥117,042,000
			Pavers	0	¥0
			Containers	80,200	¥7,319,000
	Permits		Buildings	0	¥0
			Environmental	142,383	¥12,994,000
	Escalation		Excluded		
	Subtotal 1			32,735,520	¥2,987,444,000
	Contingency (subtotal 1)		15.00%	4,910,328	¥448,117,000
	Subtotal 2			37,645,848	¥3,435,560,000
	Overhead (subtotal 2)		5.00%	1,882,292	¥171,778,000
	Profit (subtotal 2)		10.00%	3,764,585	¥343,556,000
	Grand Total		US$	43,292,725	¥3,950,894,000

Exchange Rate: AU$ 1.00 = US$ 0.9186 (March 16, 2010, Proposed by BF/S)
Exchange Rate: US$ 1.00=Yen 91.26 (March 16, 2010, Rate @JPN Bank)

3. Re-design of Star Wharf Structure in BF/S

3. Re-design of Star Wharf Structure in BF/S

3.1 Design Conditions

The re-design study follows the fundamental dimensions of the wharf, a design ship and surcharge loads indicated in BF/S; they are appropriate from the engineering view points.

The natural conditions to be applied to the design shown in BF/S are appropriately set up; the soil conditions are obtained from 12 borehole profiles, which are relatively proper as a feasibility study. The BF/S does not clarify accurate information of soil conditions and soil conditions are presumed from the existing information given by the BF/S.

(1) Dimensions of Wharf, Ship Size and Surcharge Loads

1) Dimensions of Wharf

a) Length: 200m

b) Elevation of Crest: CDL +3.90m

c) Depth: CDL -12.3m

d) Width of Apron: 20m

e) Face line of Wharf: indicated in the figure below

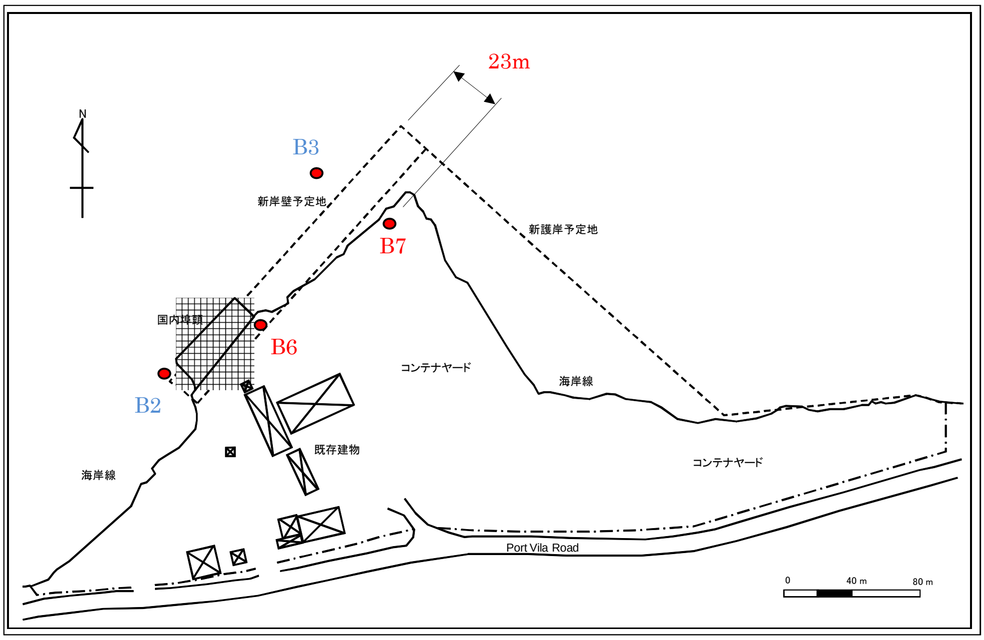


Figure3.1-1 Alignment of New Wharf Faceline

2) Ship Size and Surcharge Loads

a) Design ship: 25,561 DWT, Loa = 184.9m Breadth = 27.6m

b) Tractive Force by Ship: 1,000kN

c) Average Static Surcharge Load: 30 kN/m^2

d) Live Loads: 540 kN of a maximum front load and 145 kN of a rear load by a toplifter

e) Service life: 50 years

3) Natural Conditions

Most natural conditions applied to BF/S, except soil conditions, are derived from the conditions used for the Project for Improvement of Port Vila Main Wharf under the Japanese grant aid scheme. They are appropriate conditions for the present study and the soil conditions are set up based on the borehole profiles as shown Figure 3.1-2 The soil information is obtained from two borehole profiles of B3 and B7 referring to neighboring borehole information.

a) Tide

Highest Astronomical Tide	HAT	+1.6 m	
Mean High Water Springs	MHWS	+1.3 m	
Mean Sea Level	MSL	+0.9 m	
Mean Low Water Springs	MLWS	+0.4 m	
Lowest Astronomical Tide	LAT	0.0 m	: Chart Datum

(Tide levels are referred to chart datum)

b) Wave: $H_{1/3}$ = 0.9m, T = 12sec

c) Seismic force: Kh = 0.2

d) Soil: Elevations show depth from the Chart Datum

RL-1.1m

Filling material γ ' = 10 kN/m^3 ϕ =30°

Av N = 2

RL -6.1m

Sandy gravel γ ' = 10 kN/m^3 ϕ =35°

Av N=10

RL-12.1m

Beach deposits

γ ' = 10 kN/m^3 ϕ =35°

Av N=6

RL-21.1m

Bioclastic limestone

γ ' = 10 kN/m^3 ϕ =35°

Av N ＞ 30 or 50

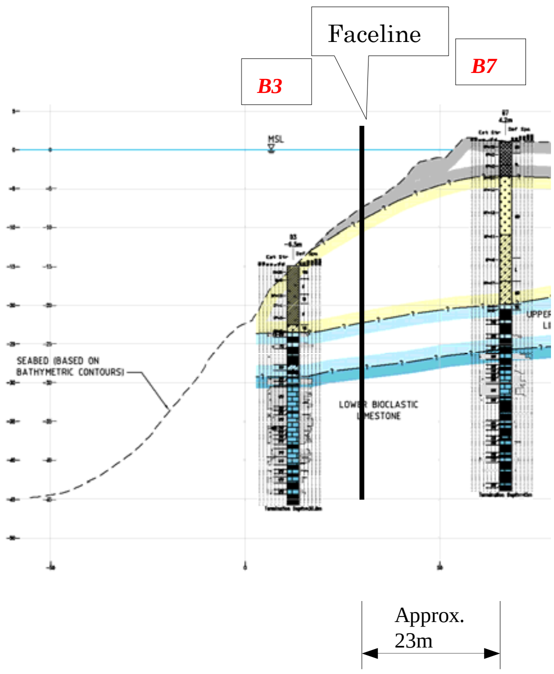


Figure 3.1-2 Locations of Boreholes and Wharf Faceline

3.2 Selection of Wharf Structure

(1) Structure Types of Wharf Facilities in Japan

The structural type of wharf can be selected from various types such as wharves of gravity-type, sheet piles, wharf with relieving platform, cellular sheet piles, pipe piles for the ports in Japan and the proper structural type has been selected considering water depth and ground and construction conditions out of these types.

Following characteristics and design methods of mooring facilities are introduced in "Technical Standards and Commentaries for Port and Harbour Facilities in Japan" (The Ports and Harbours Association of Japan)

- Gravity type quay wall: Caisson Type, L-shaped block type, cellular block type, block type
- Sheet Pile quay wall: Steel sheet pile Type, Double sheet pile Type, Pipe pile Type, Cantilevered sheet pile type
- Open type wharf: Pile type, circular cylinder or square cylinder type, bridge type
- Wharf with relieving platform
- Cellular bulkhead type: Steel sheet pile cellular bulkhead type, Steel plate cellular bulkhead type
- Floating Type: Reinforced concrete made pontoon type, Steel made pontoon type

The structural type applicable to the Star Wharf may be the caisson type as a gravity type, the steel pipe pile type or the vertical pile type to open wharf type since the wharf water depth is -12.3 m that is comparatively deeper. Summary and characteristics of each structural type are explained as follows.

(2) General Description of Applicable Structure Types

➢ Gravity Type Quay Wall

The gravity type quay wall is resisted to external forces like earth pressure and residual water pressure with deadweight of the wall and frictional force. Figure 3.2-3 shows the design example of caisson type quay wall. In case of deeper water depth, the caisson type quay wall is often adopted and it is a Japanese home construction field. At the construction, floating dock or dry dock shall be needed.

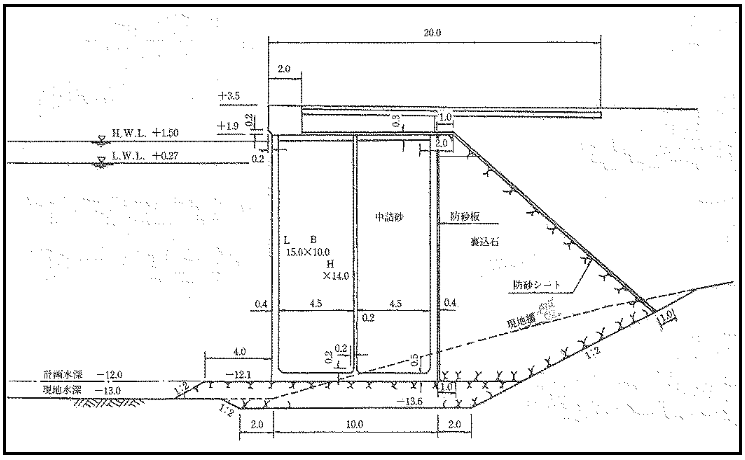


Figure 3.2-1 Example of Gravity Type Quay Wall Design (Caisson Type)

➢ Sheet Pile Quay Wall

The sheet pile quay wall is the mooring wharf to make earth retaining wall by piling sheet piles.

There are steel, reinforced concrete, pre-stressed concrete and lumber as the material for sheet piles, the steel sheet piles are mostly used. Steel sheet pile can be used for the mooring wharf with deeper water depth due to the large allowable stress intensity and the large section modulus. Cross section of steel sheet pile which is usually used is u-type, box type and pipe with joint. Figure 3.1-4 shows the design example of usual sheet pile quay wall.

In case that wharf water depth is deeper, double sheet piles type or steel pipe pile type are adopted and it is the strong identified structure for Japan where steel pipe piles are producible.

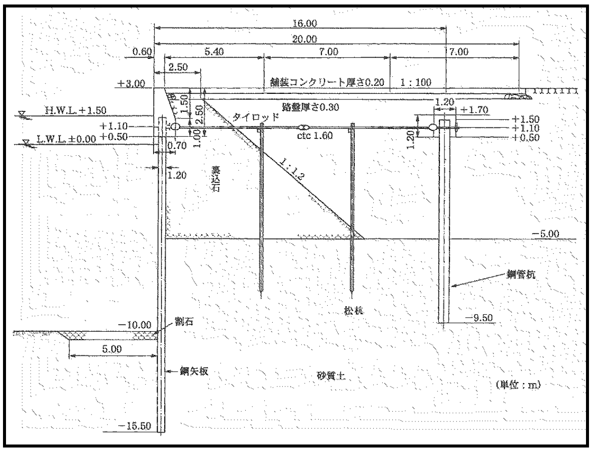


Figure 3.2-2 Example of Sheet Pile Quay Wall Design

- Open Type Wharves

The open type wharf is generally a structure to have wharf in front of earth retaining revetment. The earth retaining revetment has the structure to resist against earth pressure being backside of earth retaining walls and the slippage.

Main Wharf in Port of Port Vila is the open type one and it is popular type in Japan and world. The structural type proposed for Star Wharf is basically pipe piled type and it is considered to be derived from this type.

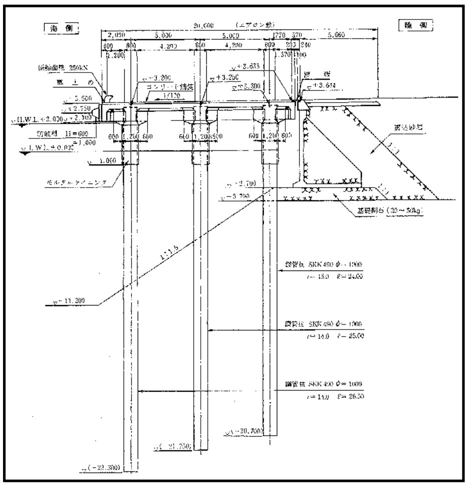


Figure3.2-3 Example of Sheet Pile Quay Wall Design

(3) Comparison of Wharf Structure Types

An appropriate structure type for the Star Wharf is selected with comparing the three types of wharf structure indicated above. With consideration of purchase conditions of construction equipment and material and of natural conditions, selection of the structure is made on the basis of the engineering view points as follows:

- Characteristics of structure
- Relative advantages in construction of the structure
- Relative advantages in transportation of equipment
- Construction cost

Preliminary design is made for the three types of piling types such as a PHC pile type, a steel pipe pile type and steel pipe pile with struts type, in addition to a caisson type and a steel pipe sheet pile type.

1) Caisson Type

- Structure

Soil improvement of the subsoil such as sand compaction piles for supporting the caisson structure is required because of deep elevation of hard foundation for the structure. Requirement of marine crafts for the works will result in higher CAPEX. A larger structure among the other types will be required due to relatively high seismic force. A larger volume of dredged material will be needed; the transportation cost will be higher than other types of structure. The above characteristics will induce higher CAPEX.

- Construction

Temporary installation mounds for completed caissons will be required near the site. Construction of temporary mounds may not be allowed, considering the seabed topography and impacts to coral by the execution. Minimization of concrete for facilities is recommended because of low productivity of proper concrete aggregates.

- Transportation

Floating docks for manufacturing caissons will be required and they should be safely towed except cyclone seasons in the Asian countries such as Japan, Korea, etc. Longer charter may cause higher CAPEX.

2) Steel Pipe Sheet Pile Type

- Structure

A steel volume for this type of the structure requires about three times of weight for open-type wharf on steel pipe pile, since the continuous steel pipe sheet piles with embedded length longer than that of the open-type wharf will be applied; the captioned structure is relatively inappropriate in CAPEX.

- Construction

The same machinery as open-type wharf structure is applied. Additional filling material should be obtained from other supply sources to secure the necessary area for the container yard.

➢ Transportation

Smaller sizes of construction equipment will be applied on comparison of a caisson type structure. It will results in reduction of CAPEX.

3) Pretention High Strength Pile Type

➢ Structure

Reinforced concrete piles will not be used for the said piling system; pretension high strength (PHC) concrete piles of 1200 mm in diameter will be applied. Piles of 30m length will be divided into 3 parts and the divided piles should be mechanically connected in the site. For preventing dispersion of grout injected into piles for testing proper connection, measures for the prevention should be taken in the sea.

Pre-boring for setting piles will be required because piles of insufficient strength cannot be driven into hard strata and it may result in higher CAPEX. Repeated bending forces by ships likely cause micro cracks that will induce development of rust of steel strands. It concludes PHC piles will secure lower durability in comparison with steel piles

➢ Construction

Weight of a PHC pile is about 39 tons while an equivalent steel pile weighs about 10 tons; larger lifting capacity of a crane will be needed and setting piles on the sea will be made with using a crawler crane on the barge. Frequent cracking may occur at any construction stages such as loading, transporting and setting piles and difficult quality control will be required for the works.

➢ Transportation

Almost same diameter of PHC piles as steel piles will be applied for the structure. Additional cost will be needed due to heavier weight of PHC piles.

4) Open-type Wharf on Steel Pipe Piles

➢ Structure

The structure is more common structure in comparison with a PHC pile type and is applied to many ports in the world. The proposed structure in the BF/S is composed with headstocks of H shaped steel members for combining heads of piles for increasing high rigidity. A service life of the structure will be secured with applying an appropriate cathodic protection method. Application of the method to the structure will cost higher than concrete structure.

➢ Construction

A crane with lower capacity for lifting a steel pile than that for a concrete pile can be applied and it will be mounted on the floating pontoon. Few difficulties for controlling quality in construction may occur compared with execution of works using concrete piles, and higher constructability is secured.

➢ Transportation

A smaller size of a crane can be applied for construction. Reduction of transportation costs will be achieved with using a chartered ship on which equipment and material be loaded.

5) Open-type wharf on Steel Pipe Pile with Struts

➢ Structure

The type originally developed by Japanese firms has an advantage to widen the pile spans than normal piling system. The advantage will results in reduction of number of steel pipe piles and the type is included in options of the structure for its selection.

The structure is of rigid frames composed with embedded steel pile piles strengthened by struts in the sea. Application of the structure will minimize a construction period since reduction of a number of piles and pre-fabrication of struts members can shorten a construction period. Preliminary design of a typical cross section of the structure is shown in Figure 3.2-4.

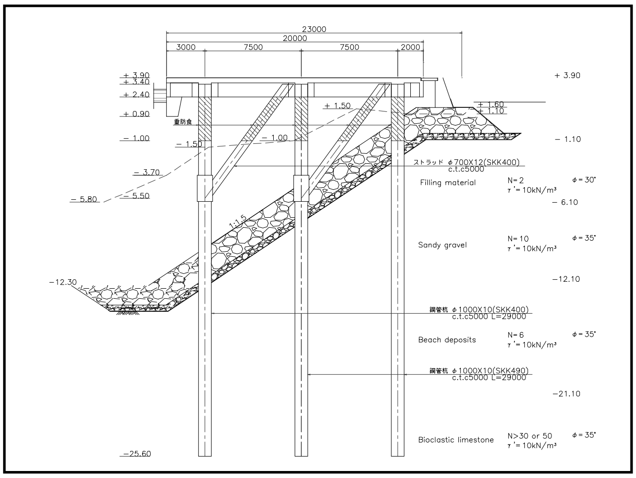


Figure3.2-4 Typical Cross Section of Wharf Structure with Struts

➢ Construction

A crane with lower capacity for lifting a steel pile than that for a concrete pile can be applied and it will be mounted on the floating pontoon. Few difficulties for controlling quality in construction may occur compared with execution of works using concrete piles, and higher constructability is secured.

Fixtures of short pipes for struts are fastened down with injection of grout into the fixtures; it will be easily completed under usual quality control in the site. .

➢ Transportation

A smaller size of a crane can be applied for construction. Reduction of transportation costs will be achieved with using a chartered ship on which equipment and material be loaded.

Table 3.2-1 shows the comparison of the five types of structure with brief description of the above and for each cost of the structure. The cost of each structure shows relative figures based on 100% of the cost of the open-type wharf on steel pipe pile.

Table 3.2-1(1) Comparison of Wharf Structure

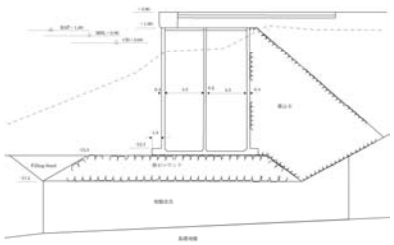
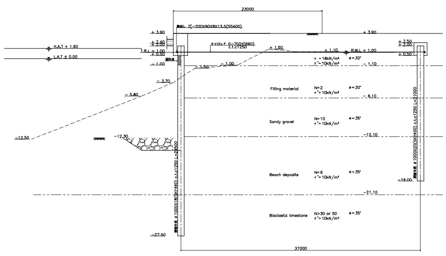
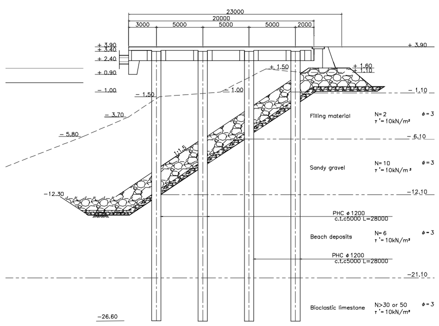
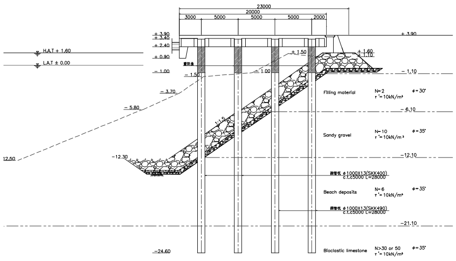
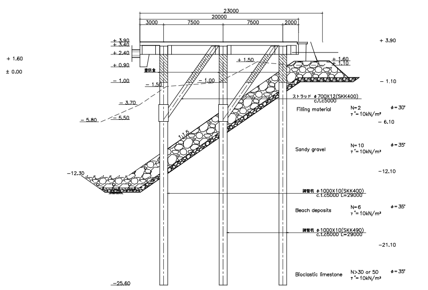
Structure Type	Evaluation Viewpoints		Rating
Caisson Type 	Structure	Improvement of subsoil for foundation. No rust expected. Larger caisson required against sesmic force. Huge Dredging Volume: largest volume in the Table.	5
	Construction	Temporary mounds for installing caissons not to be safely secured with minimization of impacts to seawater. Difficulty to obtain a large volume of concrete aggregates.	
	Transportation	Difficulty to safely tow floating docks (FD) from foreign countries. Higher cost required to charter FD for long period.	
	Capex	120	
Steel Sheet Pipe Pile Type 	Structure	Longer embedded length than the steel pipe pile type. A larger volume of steel required.	3
	Construction	Machinery for driving piles required. Driving piles can be made on land; possible minimization of machinery	
	Transportation	Minimum volume of cargo freight for machinery. Largest volume of steel required in Table.	
	Capex	118	
PHC Pile Type 	Structure	Pre-boring required for setting piles into the foundation. Inherent defects as low durability against repeated bending moment. Constant maintenance required for rehabilitating surface cracks.	4
	Construction	Larger lifting capacity required to manage heavy concrete piles. Difficult control of quality due to frequent cracking on piles in driving, transporting, etc.	
	Transportation	Higher transportation cost required due to most heavy weight of material.	
	Capex	106	

Table 3.2-1(2) Comparison of Wharf Structure

Structure Type	Evaluation Viewpoints		Rating
Open Type of wharf on Steel Pipe Piles 	Structure	Higher durability of piles against bending moment. Necessary service life secured with anti-corrosion measures.	2
	Construction	Possible minimization of Fleet of marine crafts and machinery	
	Transportation	Transportation cost of equipment and large number of piles minimized with a chartered vessel.	
	Capex	Basic Cost：100	
Open Type of wharf on Steel Pipe Piles with struts 	Structure	Spans of piles widened with struts; necessary volume of steel minimized.	1
	Construction	Possible control of quality to fix struts with easy measures of injection of grout.	
	Transportation	Transportation cost of equipment and large number of piles minimized with a chartered vessel.	
	Capex	97	

As a result of the above evaluation, lower ratings are given to the caisson and PHC types comparing the structure of steel-pipe-pile types. In the review study on the Star Wharf Project, following three types of structure are preliminarily designed for evaluation of the each cost as shown Figures from 3.3-5 to 3.3-7.

- Steel Sheet Pipe Pile Type
- Open Type of wharf on Steel Pipe Piles
- Open Type of wharf on Steel Pipe Piles with struts

Even in the design of BF/S, a surcharge of stacked containers of 30kN/m^2 might cause a circular slip around the top part of the revetment close to the concrete deck; no stability of the structure is secured. For improving the stability to secure the necessary safety factor against circular slips, cap concrete structure of the revetment is enlarged to 4.2m at the top as shown Figures 3.3-6 and 3.3-7. As a safer management against the slip, 7m width should be minimum reserved between the edge of the revetment and the boundary of stacking containers in the yard.

The comprehensive analysis of the slip in the detailed design stage should be made based on the additional soil data and detailed surveys.

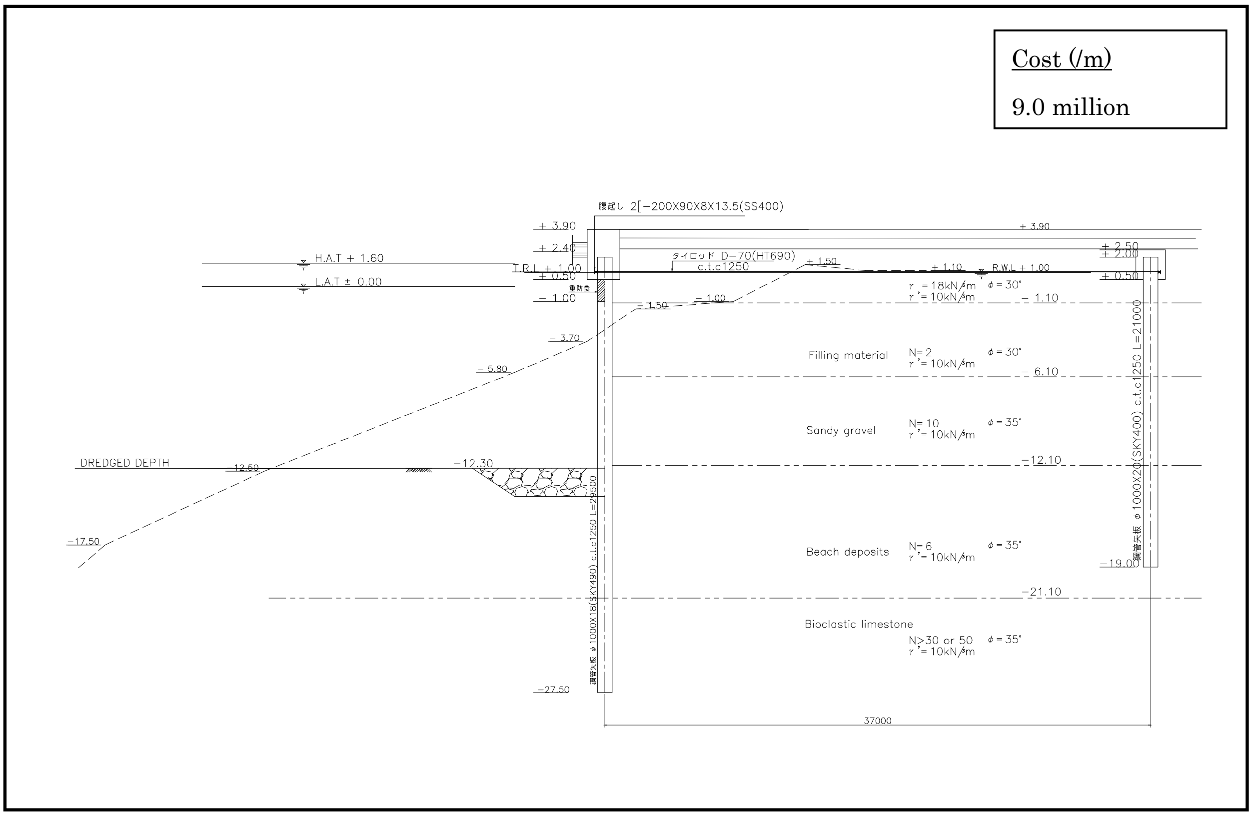


Figure 3.2-5 Typical Cross Section of Steel Pipe Pile Type (Option 1)

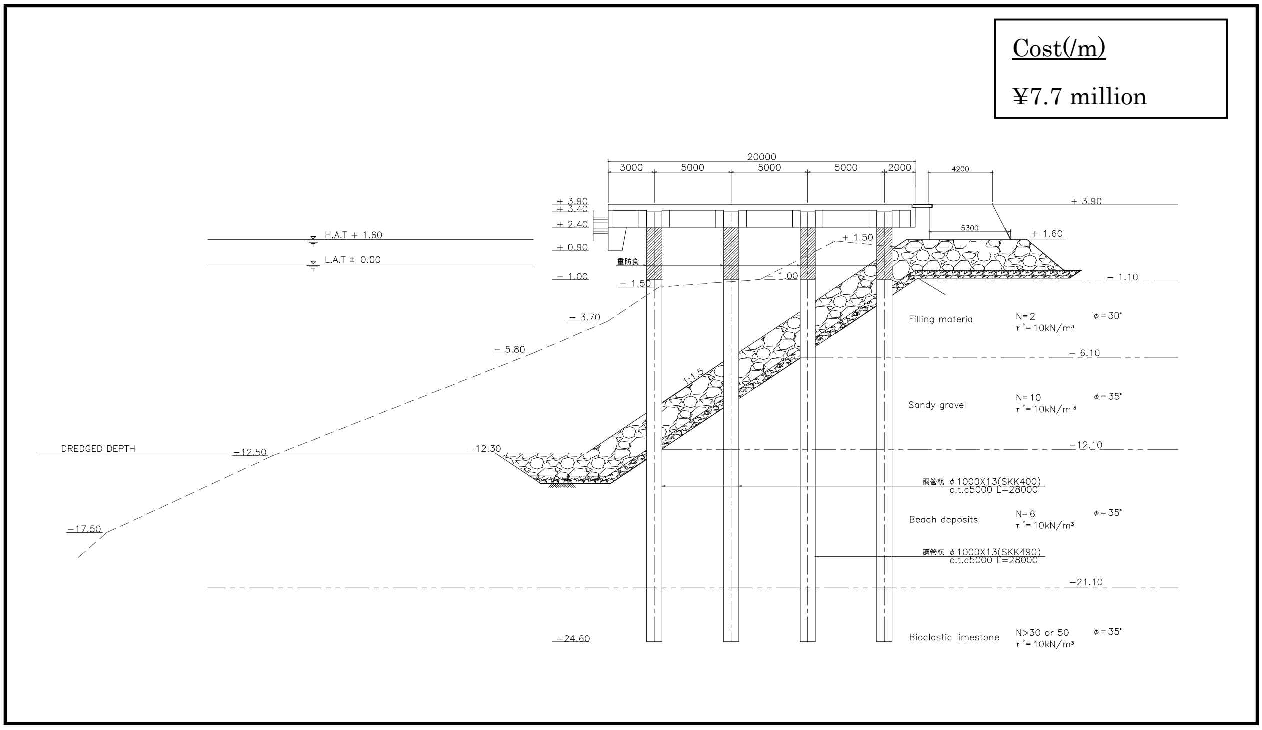


Figure 3.2-6 Open Type of wharf on Steel Pipe Piles (Option 2)

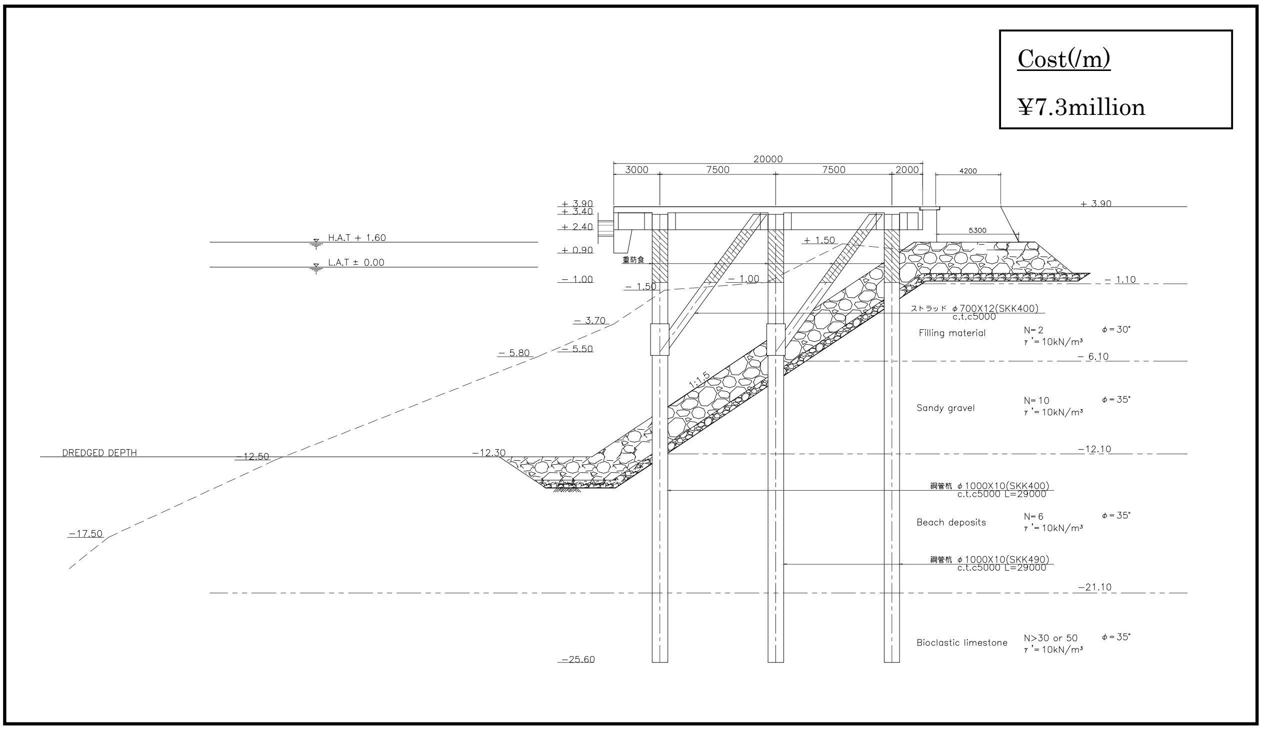


Figure 3.2-7 Open Type of wharf on Steel Pipe Piles with Struts (Option 3)

As a result of comparison of costs for the three options, the third option is expected to minimize a project cost under the site conditions. Minimization of the construction period is also expected due to a fewer number of main piles than those of Option 2.

The open type of wharf on steel pipe piles with struts, therefore, is recommended as the berthing facility at the Star Wharf.

3.3 Preliminary Design of Wharf Structure

As discussed in the previous section, the open-type wharf on steel pipe piles with struts is proposed as an appropriate structure for the Star Wharf. The section describes the preliminary design of the structure based on the design conditions indicated in the section “3.1 Design Conditions”.

(1) Cross Section and Plan of Structure

A cross section and a plan of the structure are shown as below:

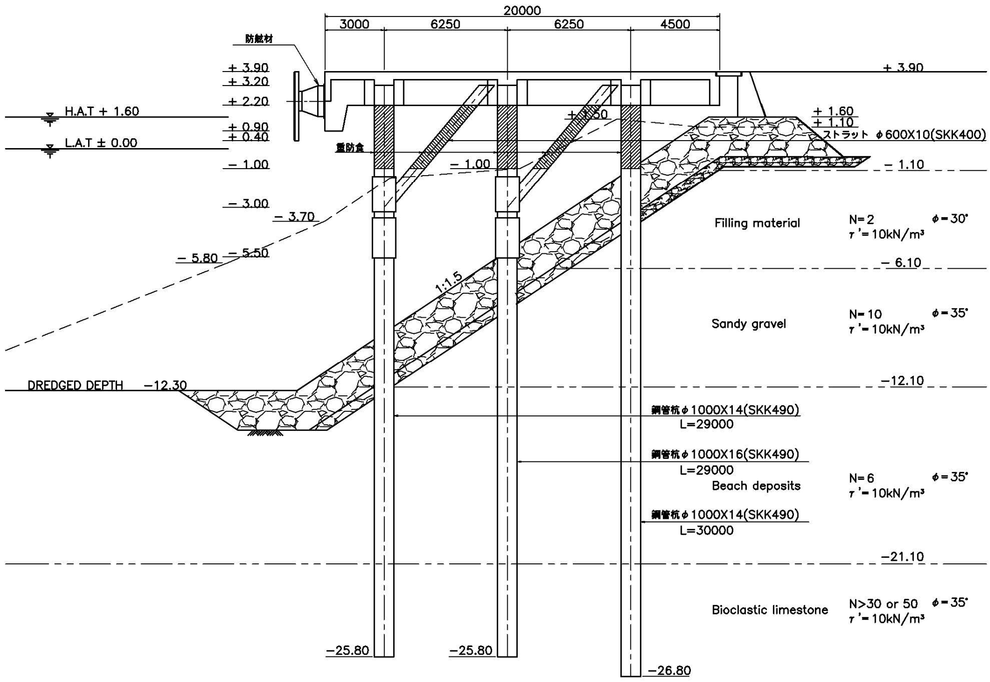


Figure3.3-1 Cross Section of the Structure

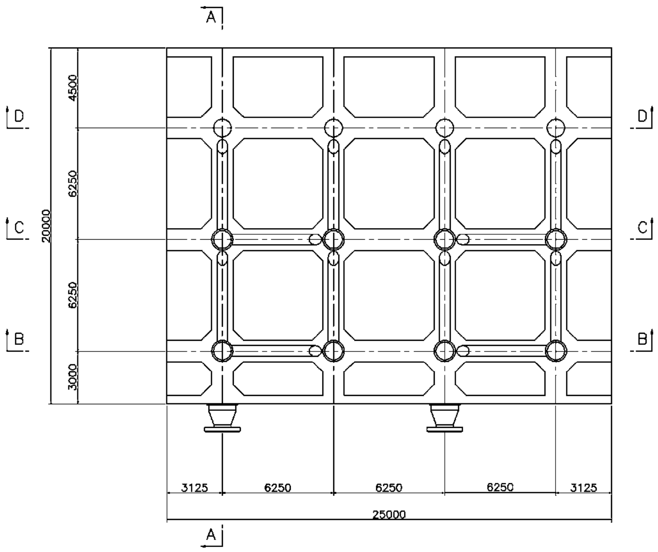


Figure 3.3-1 Plan of Wharf Deck and Piles

(2) Analysis of Structure

As shown in the previous section, the advantage of the structure is to secure wider spans of steel piles; reduction of required number of steel piles can be made. All the longitudinal and rectangular spans of piles are 6.25m for a deck block as shown in Figure 3.3-2.

In analyzing the structure, a longitudinal section and a cross section of the structure are examined respectively.

1) Examination of Cross Section

A structural frame model for analysis is shown in Figure 3.3-3.

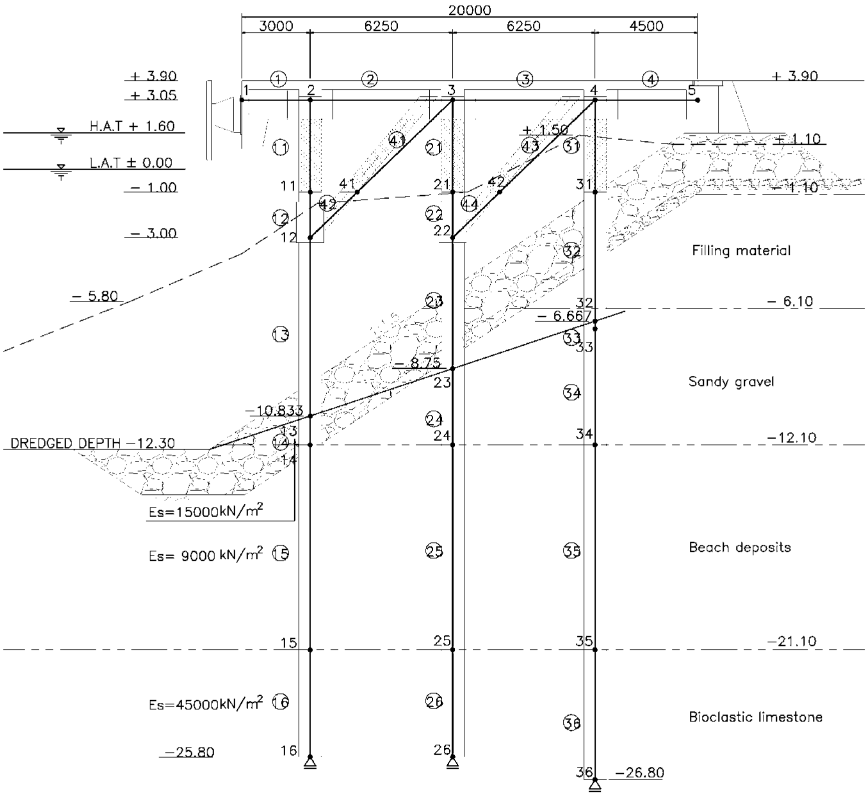


Figure 3.3-3 Frame Model for Analysis

Four cases for different surcharge loads are analyzed as follows:

a) No seismic force: static and live loads in the yard without tractive force by a ship
b) No seismic force: static and live loads in the yard with tractive force by a ship
c) Seismic force: displacement to offshore
d) Seismic force: displacement toward land

Results of the above analyses are shown in Figures from 3.3-4 to 3.3-7.

a) No seismic force: static and live loads in the yard without tractive force by a ship

Displacement: δ = 0.67cm ＜ 5.0cm

Bearing capacity

		Pile No.1	Pile No.2	Pile No.3
Bearing	Applied forces	2130.2	2367.1	3002.7
	Allowable capacities	2583.0	2635.0	3364.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

“ok” : satisfying allowable strength

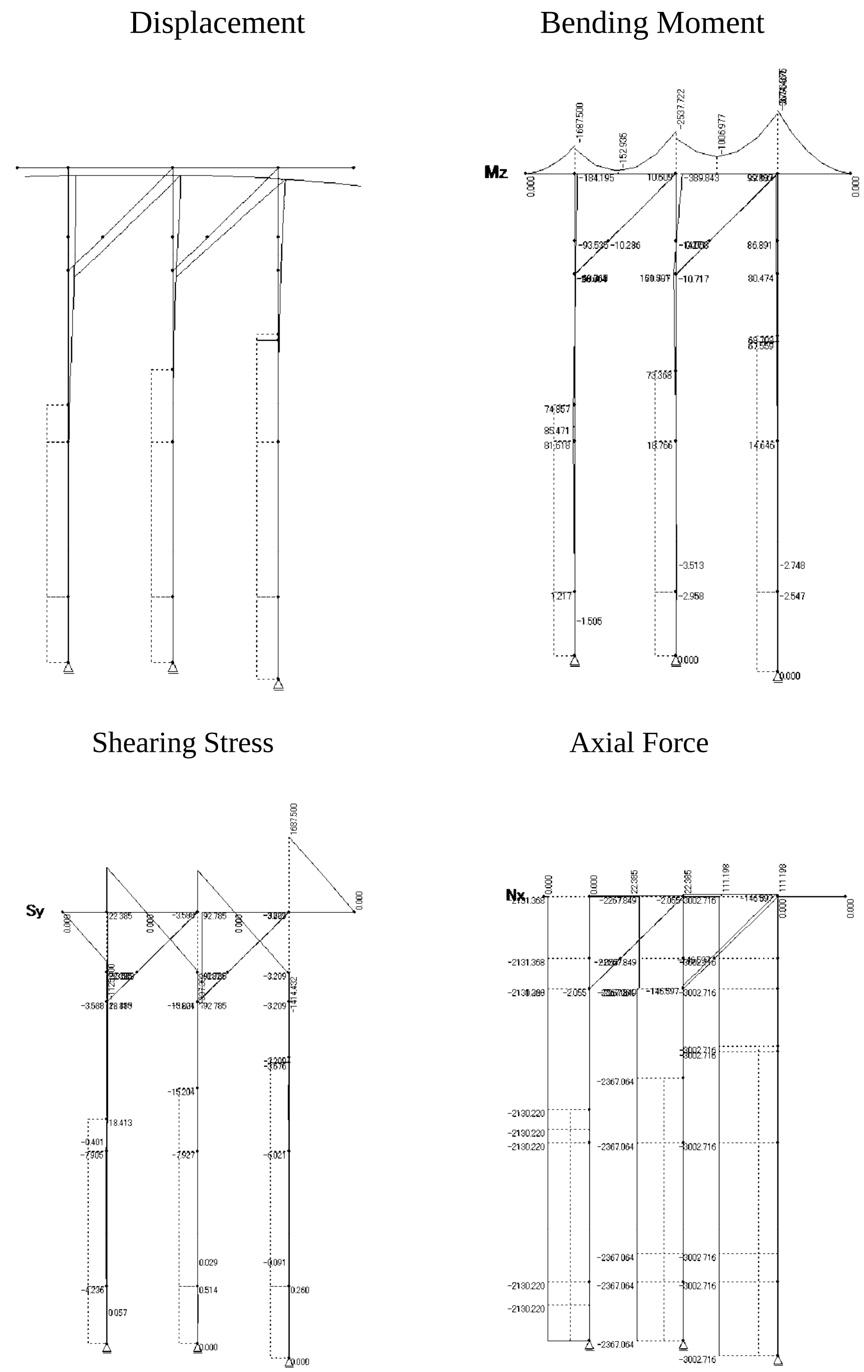


Figure3.3-4 Results of Analysis (1)

b) No seismic force: static and live loads in the yard with tractive force by a ship

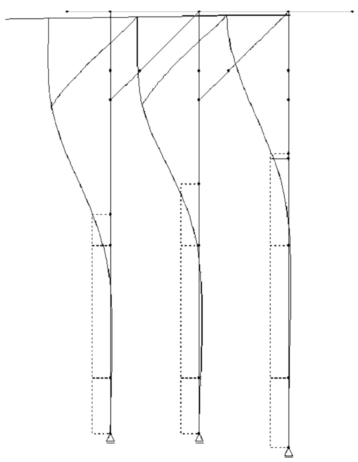
Displacement: δ = 6.60cm ＜ 10.0cm

Bearing capacity

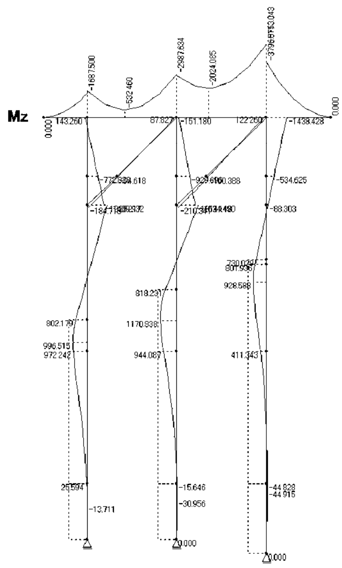
		Pile No.1	Pile No.2	Pile No.3
Bearing	Applied forces	1575.8	2080.9	3843.3
	Allowable capacities	4304.0	4392.0	5607.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

“ok” : satisfying allowable strength

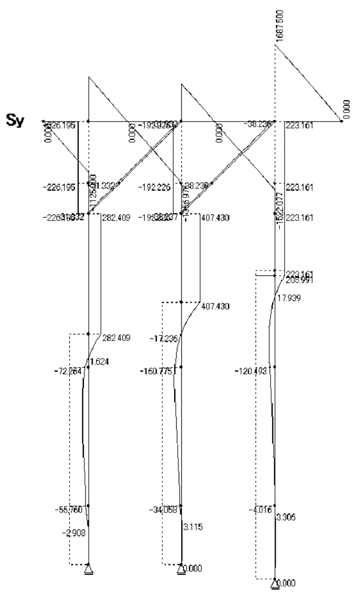
Displacement



Bending Moment



Shearing Stress



Axial Force

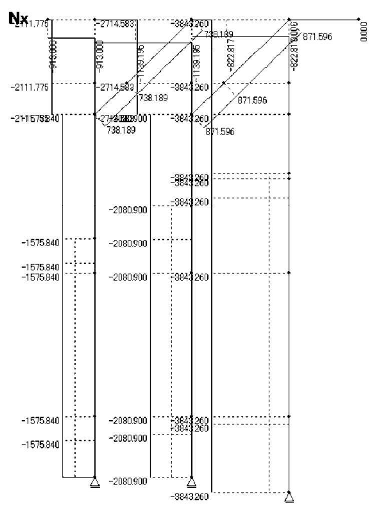


Figure 3.3-5 Results of Analysis (2)

c) Seismic force: displacement to offshore

Displacement: δ = 6.77cm ＜ 10.0cm

Bearing capacity

		Pile No.1	Pile No.2	Pile No.3
Bearing	Applied forces	2280.7	2128.5	1215.8
	Allowable capacities	4304.0	4392.0	5607.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

“ok” : satisfying allowable strength

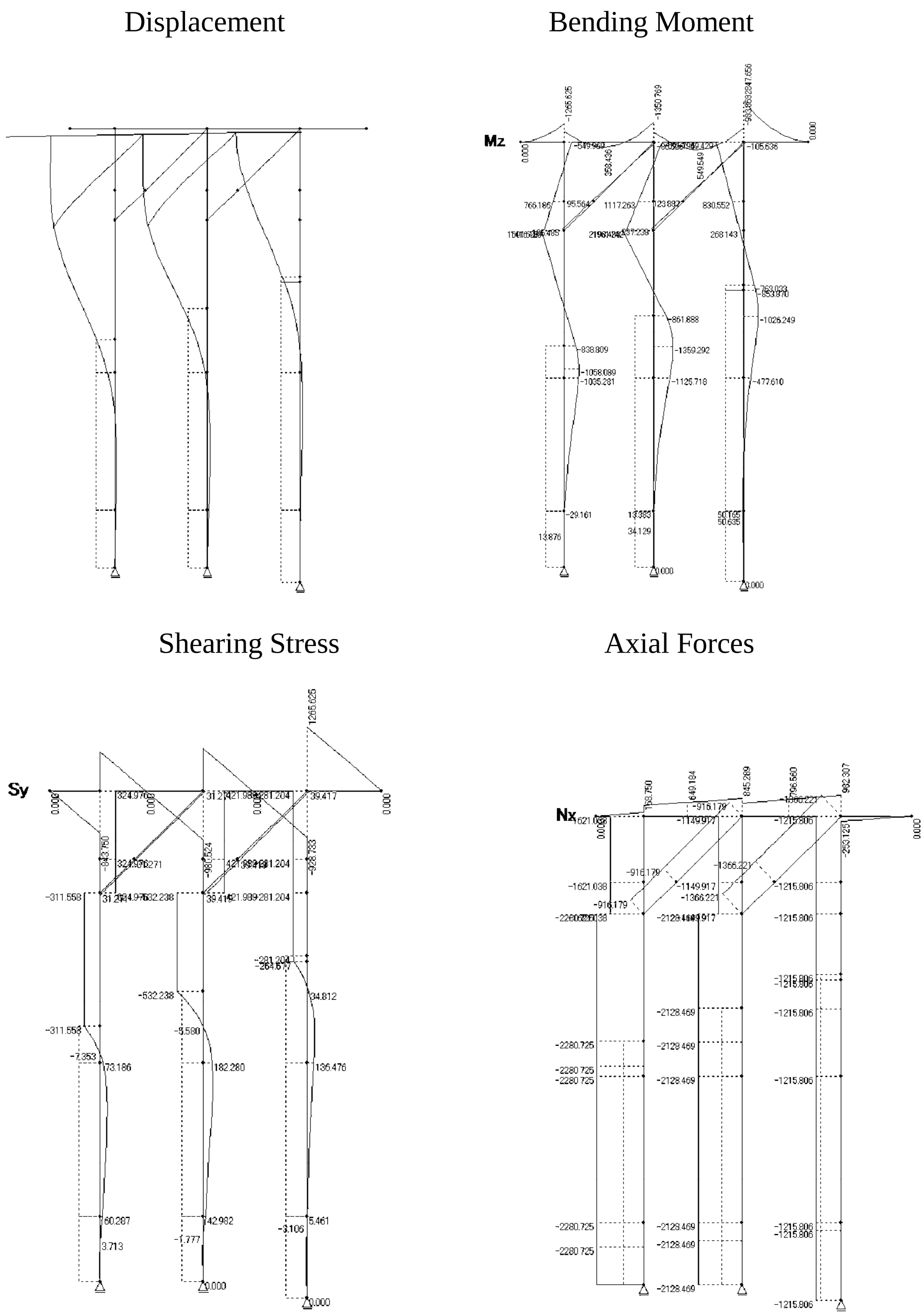


Figure 3.3-6 Results of Analysis (3)

d) Seismic force: displacement toward land

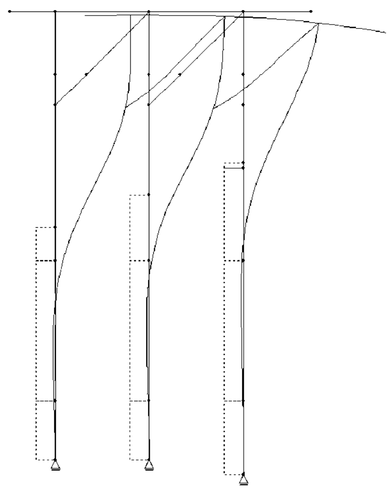
Displacement: δ = 7.78cm ＜ 10.0cm

Bearing capacity

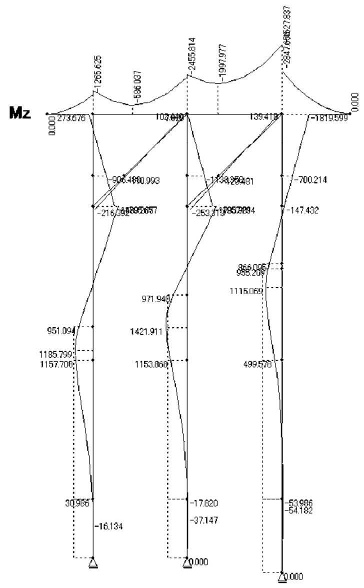
		Pile No.1	Pile No.2	Pile No.3
Bearing	Applied forces	914.6	1422.1	3288.3
	Allowable capacities	4304.0	4392.0	5607.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

“ok” : satisfying allowable strength

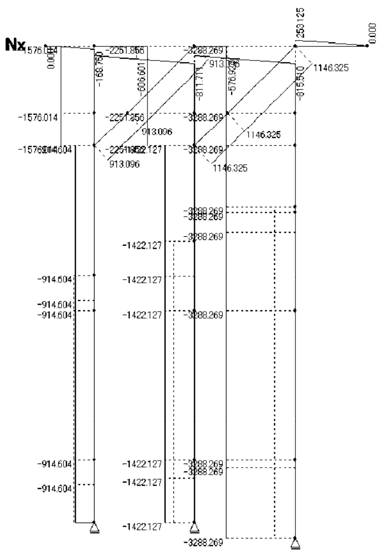
Displacement



Bending Moment



Shearing Stress



Axial Force

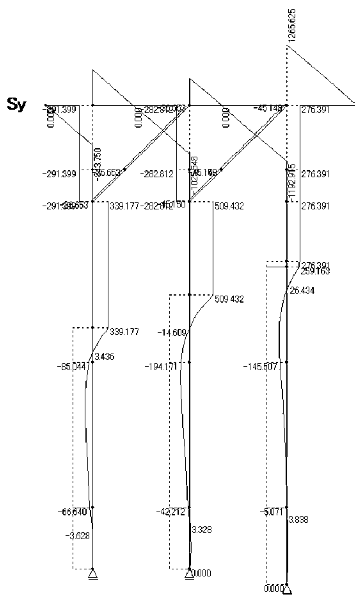


Figure 3.3-7 Results of Analysis (4)

All the members of the structure in the tables are effectively allowable, as indicated in the Tables from3.3-1 to 3.3-4 for checking bearing capacity of the members.

Table 3.3-1 Check of Sectional Stress in Case "a)"

			Pile No1	Pile No2	Pile No3	Strut
Pile Head	Member	Pile dimensions	φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality	SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A (cm^2)	433.7	494.6	433.7	185.4
		Z ($cm^{3)}$)	10542	11976	10542	2689
		r (cm)	34.9	34.8	34.9	20.9
	Length of buckling	L (cm)	1388.3	1180.0	971.7	869.9
		L/r	39.8	33.9	27.8	41.6
	Sectional Force	Number	11	21	31	43
		N (kN)	2131.368	2267.849	3002.716	146.597
		M (kNm)	184.195	389.843	99.887	22.521
	Sectional Stress	σ (N/mm^2)	49.1	45.9	69.2	7.9
		σb (N/mm^2)	17.5	32.6	9.5	8.4
	Allowable Stress	σa (N/mm^2)	156.5	163.5	170.8	120.6
		σba (N/mm^2)	185.0	185.0	185.0	140.0
	Check	σ/σa+σb/σba	0.409	0.456	0.457	0.125
	Verification		≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile in the sea	Member	Pile dimensions	φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality	SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A (cm^2)	410.1	471.1	410.1	171.2
		Z ($cm^{3)}$)	9970	11405	9970	2484
		r (cm)	34.8	34.8	34.8	20.8
	Length of buckling	L (cm)	1388.3	1180.0	971.7	869.9
		L/r	39.9	33.9	27.9	41.8
	Sectional Force	Number	12	22	32	44
		N (kN)	2131.368	2267.849	3002.716	146.597
		M (kNm)	93.535	171.507	86.891	10.717
	Sectional Stress	σ (N/mm^2)	52.0	48.1	73.2	8.6
		σb (N/mm^2)	9.4	15.0	8.7	4.3
	Allowable Stress	σa (N/mm^2)	156.3	163.5	170.7	120.5
		σba (N/mm^2)	185.0	185.0	185.0	140.0
	Check	σ/σa+σb/σba	0.383	0.376	0.476	0.102
	Verification		≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile embedd	Member	Pile dimensions	φ1000×14	φ1000×16	φ1000×14	
		Quality	SKK490	SKK490	SKK490	
	Sectional Performance	A (cm^2)	429.0	489.9	429.0	
		Z ($cm^{3)}$)	10428	11862	10428	
	Sectional Force	Number	14	24	34	
		N (kN)	2130.220	2367.064	3002.716	
		M (kNm)	85.471	73.368	68.708	
	Sectional Stress	σ (N/mm^2)	49.7	48.3	70.0	
		σb (N/mm^2)	8.2	6.2	6.6	
	Allowable Stress	σa (N/mm^2)	185.0	185.0	185.0	
		σba (N/mm^2)	185.0	185.0	185.0	
	Check	σ/σa+σb/σba	0.313	0.295	0.414	
	Verification		≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	

Table 3.3-2 Check of Sectional Stress in Case" b)"

				Pile No1	Pile No2	Pile No3	Strut
Pile Head	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	433.7	494.6	433.7	185.4
		Z	(cm^3)	10542	11976	10542	2689
		r	(cm)	34.9	34.8	34.9	20.9
	Length of buckling	L	(cm)	1388.3	1180.0	971.7	869.9
		L/r		39.8	33.9	27.8	41.6
	Sectional Force	Number		11	21	31	43
		N	(kN)	2111.775	2714.583	3843.260	871.596
		M	(kNm)	772.828	929.696	1438.428	122.260
	Sectional Stress	σ	(N/mm^2)	48.7	54.9	88.6	47.0
		σb	(N/mm^2)	73.3	77.6	136.4	45.5
	Allowable Stress	σa	(N/mm^2)	234.7	245.3	256.2	210.0
		σba	(N/mm^2)	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.472	0.504	0.838	0.440
	Verification			≦1.0···ok	≦1.0···ok	≦1.0···ok	≦1.0···ok
Pile in the sea	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	410.1	471.1	410.1	171.2
		Z	(cm^3)	9970	11405	9970	2484
		r	(cm)	34.8	34.8	34.8	20.8
	Length of buckling	L	(cm)	1388.3	1180.0	971.7	869.9
		L/r		39.9	33.9	27.9	41.8
	Sectional Force	Number		13	23	33	44
		N	(kN)	1575.840	2080.900	3843.260	871.596
		M	(kNm)	1409.932	1524.490	730.029	210.341
	Sectional Stress	σ	(N/mm^2)	38.4	44.2	93.7	50.9
		σb	(N/mm^2)	141.4	133.7	73.2	84.7
	Allowable Stress	σa	(N/mm^2)	234.5	245.3	256.0	210.0
		σba	(N/mm^2)	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.673	0.662	0.630	0.646
	Verification			≦1.0···ok	≦1.0···ok	≦1.0···ok	≦1.0···ok
Pile embedd	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	
		Quality		SKK490	SKK490	SKK490	
	Sectional Performance	A	(cm^2)	429.0	489.9	429.0	
		Z	(cm^3)	10428	11862	10428	
	Sectional Force	Number		14	24	35	
		N	(kN)	1575.840	2080.900	3843.260	
		M	(kNm)	996.515	1170.838	928.588	
	Sectional Stress	σ	(N/mm^2)	36.7	42.5	89.6	
		σb	(N/mm^2)	95.6	98.7	89.0	
	Allowable Stress	σa	(N/mm^2)	277.5	277.5	277.5	
		σba	(N/mm^2)	277.5	277.5	277.5	
	Check	σ/σa+σb/σba		0.477	0.509	0.644	
	Verification			≦1.0···ok	≦1.0···ok	≦1.0···ok	

Table 3.3-3 Check of Sectional Stress in Case “c)”

				Pile No1	Pile No2	Pile No3	Strut
Pile Head	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	433.7	494.6	433.7	185.4
		Z	($cm^{3)}$)	10542	11976	10542	2689
		r	(cm)	34.9	34.8	34.9	20.9
	Length of buckling	L	(cm)	1388.3	1180.0	971.7	869.9
		L/r		39.8	33.9	27.8	41.6
	Sectional Force	Number		11	21	31	43
		N	(kN)	1621.038	1149.917	1215.806	1366.221
		M	(kNm)	766.186	1117.263	1969.429	123.887
	Sectional Stress	σ	(N/mm^2)	37.4	23.2	28.0	73.7
		σb	(N/mm^2)	72.7	93.3	186.8	46.1
	Allowable Stress	σa	(N/mm^2)	234.7	245.3	256.2	180.9
		σba	(N/mm^2)	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.421	0.431	0.783	0.627
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile in the sea	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	410.1	471.1	410.1	171.2
		Z	($cm^{3)}$)	9970	11405	9970	2484
		r	(cm)	34.8	34.8	34.8	20.8
	Length of buckling	L	(cm)	1388.3	1180.0	971.7	869.9
		L/r		39.9	33.9	27.9	41.8
	Sectional Force	Number		13	23	32	44
		N	(kN)	2280.725	2128.469	1215.806	1366.221
		M	(kNm)	1601.623	2198.480	830.552	237.238
	Sectional Stress	σ	(N/mm^2)	55.6	45.2	29.6	79.8
		σb	(N/mm^2)	160.6	192.8	83.3	95.5
	Allowable Stress	σa	(N/mm^2)	234.5	245.3	256.0	180.7
		σba	(N/mm^2)	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.816	0.879	0.416	0.896
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile embedd	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	
		Quality		SKK490	SKK490	SKK490	
	Sectional Performance	A	(cm^2)	429.0	489.9	429.0	
		Z	($cm^{3)}$)	10428	11862	10428	
	Sectional Force	Number		14	24	35	
		N	(kN)	2280.725	2128.469	1215.806	
		M	(kNm)	1058.089	1359.292	1026.249	
	Sectional Stress	σ	(N/mm^2)	53.2	43.4	28.3	
		σb	(N/mm^2)	101.5	114.6	98.4	
	Allowable Stress	σa	(N/mm^2)	277.5	277.5	277.5	
		σba	(N/mm^2)	277.5	277.5	277.5	
	Check	σ/σa+σb/σba		0.557	0.570	0.457	
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	

Table 3.3-4 Check of Sectional Stress in Case “d)”

				Pile No1	Pile No2	Pile No3	Strut
Pile Head	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	433.7	494.6	433.7	185.4
		Z	(cm$^{3)}$	10542	11976	10542	2689
		r	(cm)	34.9	34.8	34.9	20.9
	Length of buckling	L	(cm)	1388.3	1180.0	971.7	869.9
		L/r		39.8	33.9	27.8	41.6
	Sectional Force	Number		11	21	31	43
		N	(kN)	1576.014	2251.856	3288.269	1146.325
		M	(kNm)	906.488	1138.358	1819.599	139.418
	Sectional Stress	σ	(N/mm^2)	36.3	45.5	75.8	61.8
		σb	(N/mm^2)	86.0	95.1	172.6	51.8
	Allowable Stress	σa	(N/mm^2)	234.7	245.3	256.2	210.0
		σba	(N/mm^2)	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.465	0.528	0.918	0.541
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile in the sea	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	410.1	471.1	410.1	171.2
		Z	(cm$^{3)}$	9970	11405	9970	2484
		r	(cm)	34.8	34.8	34.8	20.8
	Length of buckling	L	(cm)	1388.3	1180.0	971.7	869.9
		L/r		39.9	33.9	27.9	41.8
	Sectional Force	Number		13	23	33	44
		N	(kN)	914.604	1422.127	3288.269	1146.325
		M	(kNm)	1705.677	1957.294	866.095	253.313
	Sectional Stress	σ	(N/mm^2)	22.3	30.2	80.2	67.0
		σb	(N/mm^2)	171.1	171.6	86.9	102.0
	Allowable Stress	σa	(N/mm^2)	234.5	245.3	256.0	210.0
		σba	(N/mm^2)	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.712	0.742	0.626	0.804
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile embedd	Member	Pile dimensions		φ1000×14	φ1000×16	φ1000×14	
		Quality		SKK490	SKK490	SKK490	
	Sectional Performance	A	(cm^2)	429.0	489.9	429.0	
		Z	(cm$^{3)}$	10428	11862	10428	
	Sectional Force	Number		14	24	35	
		N	(kN)	914.604	1422.127	3288.269	
		M	(kNm)	1185.799	1421.911	1115.069	
	Sectional Stress	σ	(N/mm^2)	21.3	29.0	76.6	
		σb	(N/mm^2)	113.7	119.9	106.9	
	Allowable Stress	σa	(N/mm^2)	277.5	277.5	277.5	
		σba	(N/mm^2)	277.5	277.5	277.5	
	Check	σ/σa+σb/σba		0.487	0.537	0.662	
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	

2) Examination of Longitudinal Section

Each row of piles, which are longitudinally situated in three rows, are analyzed with applying the following frame modeling for analysis. Loads in the seismic force case are applied for analysis based on the cross sectional analysis.

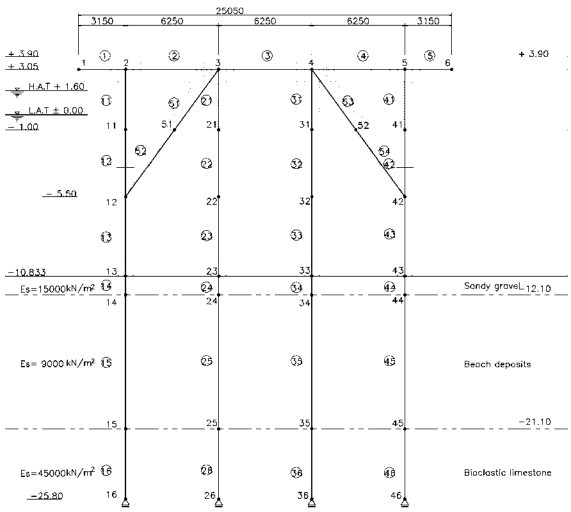


Figure 3.3-8 Frame Modeling for Seaside Row

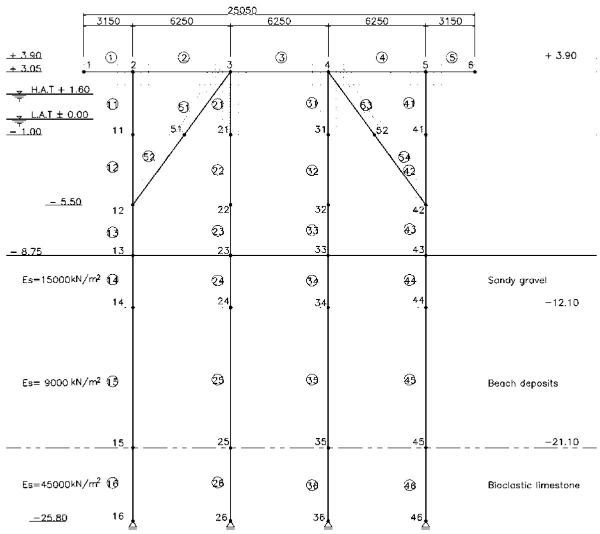


Figure3.3-9 Frame Modeling for Middle Row

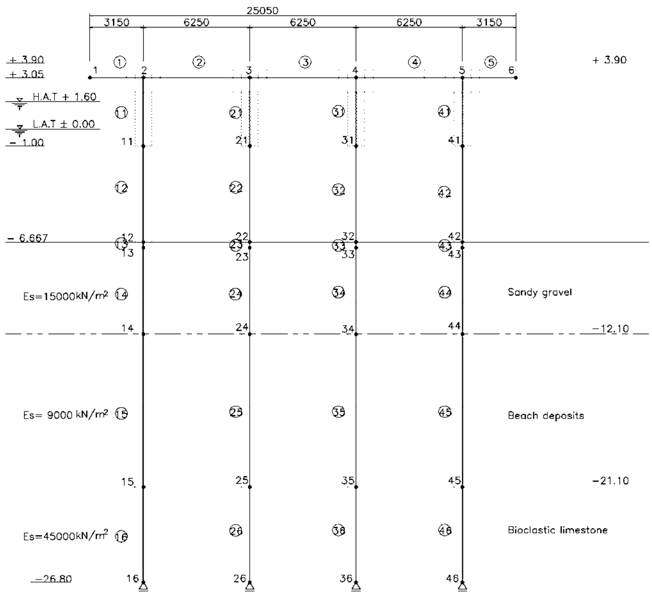


Figure 3.3-10 Frame Modeling for Land Side Row

The results of analyses are shown in Figures from 3.3-11 to 3.3-13.

a) Sea Side Row

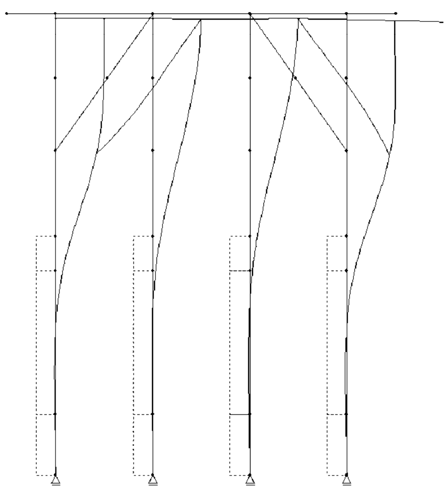
Displacement: $\delta = 6.96cm < 10.0cm$

Bearing capacity

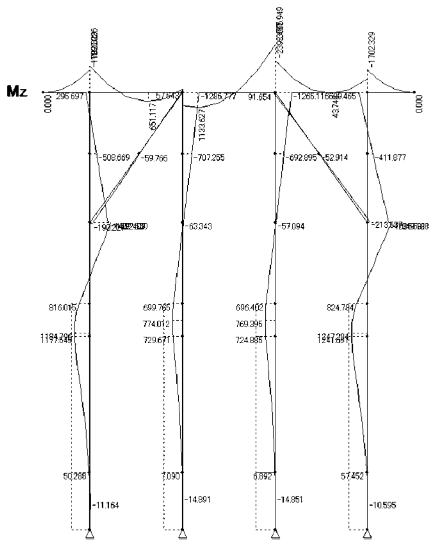
		Pile No.1	Pile No.2	Pile No.3	Pile No.4
Bearing	Applied forces	1500.0	2074.1	1982.1	3039.1
	Allowable capacities	4304.0	4304.0	4304.0	4304.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

"ok" : satisfying allowable strength

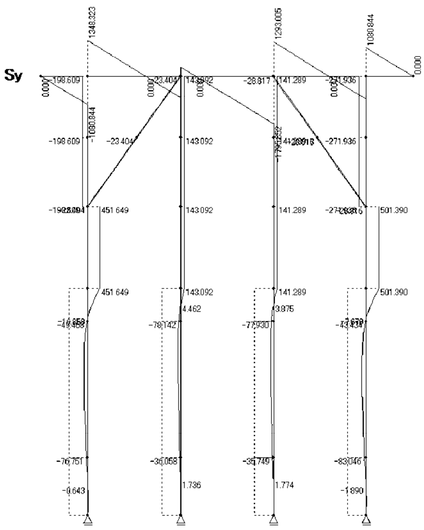
Displacement



Bending Moment



Shearing Stress



Axial Forces

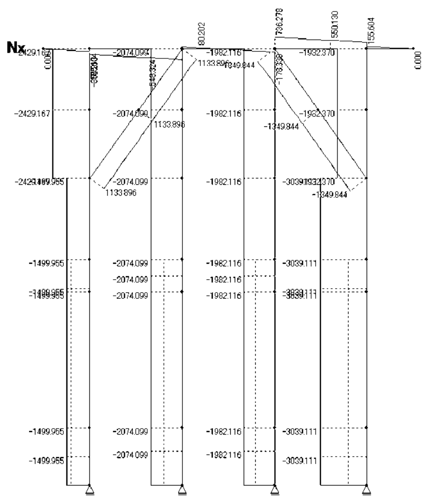


Figure 3.3-11 Results of Longitudinal Analysis (1)

b) Middle Row

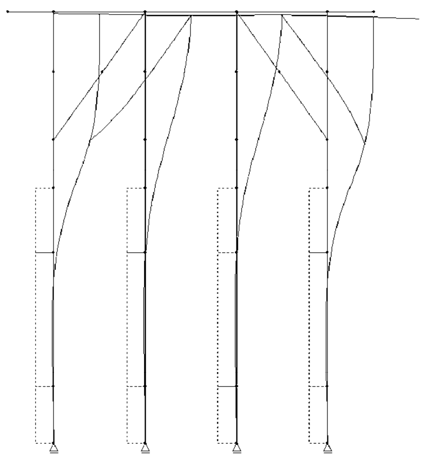
Displacement: δ = 6.95cm ＜ 10.0cm

Bearing capacity

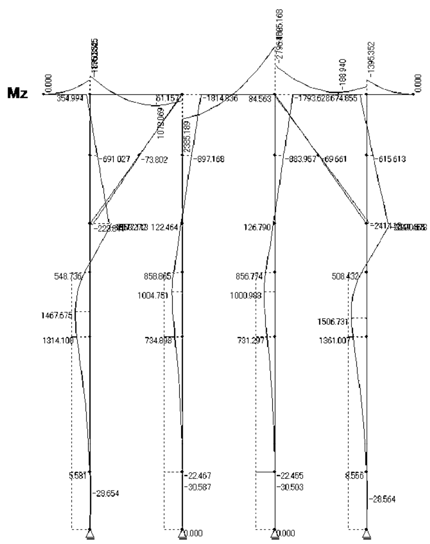
		Pile No.1	Pile No.2	Pile No.3	Pile No.4
Bearing	Applied forces	641.7	1778.5	1526.2	3098.9
	Allowable capacities	4392.0	4392.0	4392.0	4392.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

“ok” : satisfying allowable strength

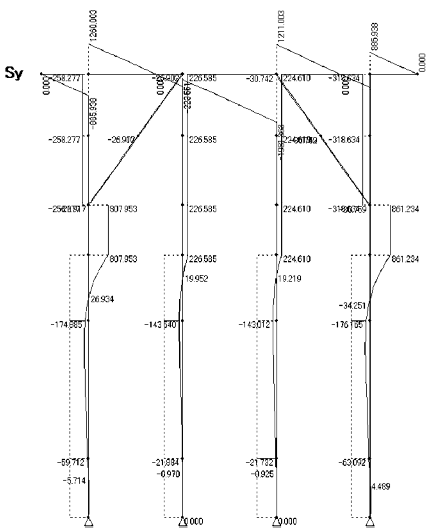
Displacement



Bending Moment



Shearing Stress



Axial Force

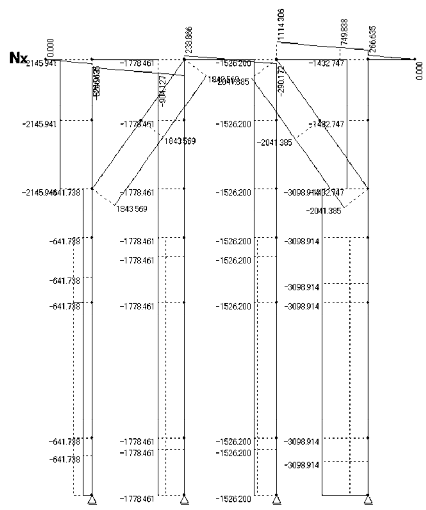


Figure 3.3-12 Results of Longitudinal Analysis (2)

c) Land Side Row

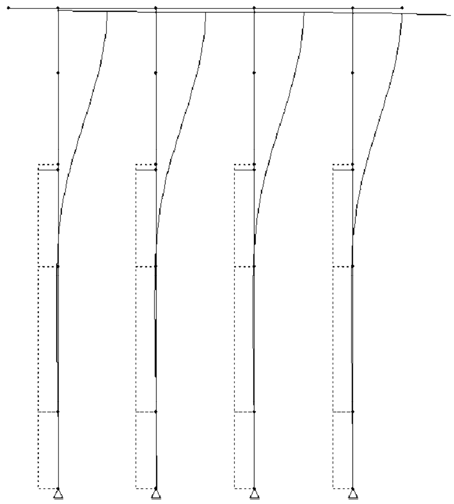
Displacement: δ = 6.95cm ＜ 10.0cm

Bearing capacity

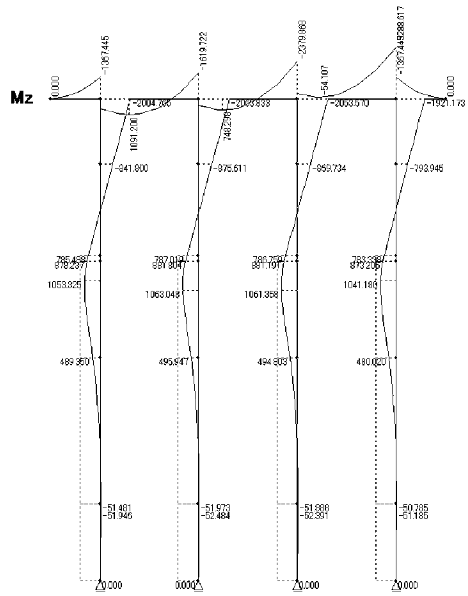
		Pile No.1	Pile No.2	Pile No.3	Pile No.4
Bearing	Applied forces	1368.4	1631.9	1700.5	2203.5
	Allowable capacities	5607.0	5607.0	5607.0	5607.0
	Verification	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

"ok" : satisfying allowable strength

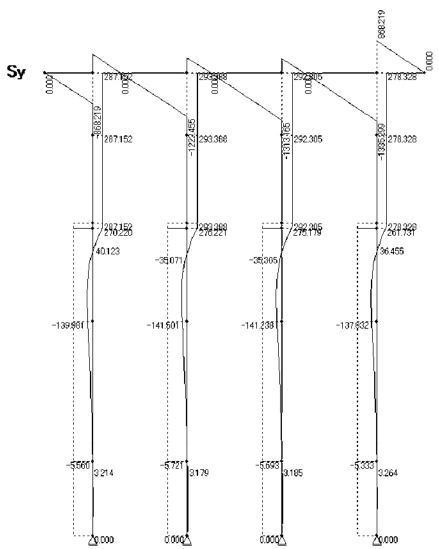
Displacement



Bending Moment



Shearing Stress



Axial Force

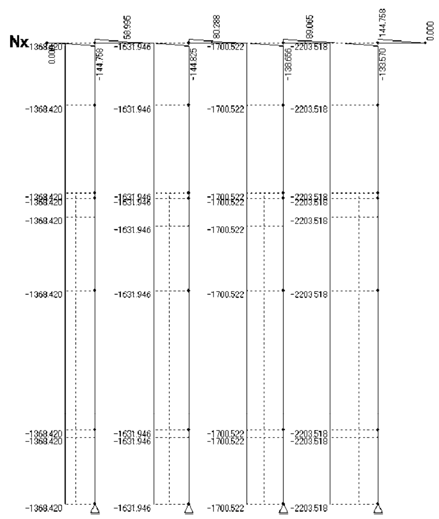


Figure 3.3-13 Results of Longitudinal Analysis (3)

All the members of the structure in the tables are effectively allowable, as indicated in the Tables from3.3-5 to 3.3-7 for checking bearing capacity of the members.

Table 3.3-5 Check of Piles in Sea Side Row

			Pile No1	Pile No2	Pile No3	Pile No 4	Strut
Pile Head	Member	Pile dimensions	φ1000×14	φ1000×14	φ1000×14	φ1000×14	φ600×10
		Quality	SKK490	SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A (cm^2)	433.7	433.7	433.7	433.7	185.4
		Z (cm^{3})	10542	10542	10542	10542	2689
		r (cm)	34.9	34.9	34.9	34.9	20.9
	Length of buckling	L (cm)	1388.3	1388.3	1388.3	1388.3	1059.1
		L/r	39.8	39.8	39.8	39.8	50.7
	Sectional Force	Number	11	21	31	41	53
		N (kN)	2429.167	2074.099	1982.116	1932.370	1349.844
		M (kNm)	508.669	1286.777	1265.116	689.465	91.654
	Sectional Stress	σ (N/mm^2)	56.0	47.8	45.7	44.6	72.8
		σb (N/mm^2)	48.3	122.1	120.0	65.4	34.1
	Allowable Stress	σa (N/mm^2)	234.7	234.7	234.7	234.7	169.8
		σba (N/mm^2)	277.5	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba	0.413	0.644	0.627	0.426	0.591
	Verification		≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile in the sea	Member	Pile dimensions	φ1000×14	φ1000×14	φ1000×14	φ1000×14	φ600×10
		Quality	SKK490	SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A (cm^2)	410.1	410.1	410.1	410.1	242.9
		Z (cm^{3})	9970	9970	9970	9970	4107
		r (cm)	34.8	34.8	34.8	34.8	24.3
	Length of buckling	L (cm)	1388.3	1388.3	1388.3	1388.3	1059.1
		L/r	39.9	39.9	39.9	39.9	43.6
	Sectional Force	Number	13	22	33	43	54
		N (kN)	1499.955	2074.099	1982.116	3039.111	1349.844
		M (kNm)	1592.630	707.255	696.402	1849.128	213.537
	Sectional Stress	σ (N/mm^2)	36.6	50.6	48.3	74.1	55.6
		σb (N/mm^2)	159.7	70.9	69.8	185.5	52.0
	Allowable Stress	σa (N/mm^2)	234.5	234.5	234.5	234.5	178.5
		σba (N/mm^2)	277.5	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba	0.732	0.471	0.458	0.984	0.559
	Verification		≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile embedd	Member	Pile dimensions	φ1000×14	φ1000×14	φ1000×14	φ1000×14	
		Quality	SKK490	SKK490	SKK490	SKK490	
	Sectional Performance	A (cm^2)	429.0	429.0	429.0	429.0	
		Z (cm^{3})	10428	10428	10428	10428	
	Sectional Force	Number	14	24	34	44	
		N (kN)	1499.955	2074.099	1982.116	3039.111	
		M (kNm)	1184.796	774.012	769.395	1247.294	
	Sectional Stress	σ (N/mm^2)	35.0	48.3	46.2	70.8	
		σb (N/mm^2)	113.6	74.2	73.8	119.6	
	Allowable Stress	σa (N/mm^2)	277.5	277.5	277.5	277.5	
		σba (N/mm^2)	277.5	277.5	277.5	277.5	
	Check	σ/σa+σb/σba	0.535	0.442	0.432	0.686	
	Verification		≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	

Table 3.3-6 Check of Piles in Middle Row

				Pile No1	Pile No2	Pile No3	Pile No 4	Strut
Pile Head	Member	Pile dimensions		φ1000×16	φ1000×16	φ1000×16	φ1000×16	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	494.6	494.6	494.6	494.6	185.4
		Z	(cm^3)	11976	11976	11976	11976	2689
		r	(cm)	34.8	34.8	34.8	34.8	20.9
	Length of buckling	L	(cm)	1180.0	1180.0	1180.0	1180.0	1059.1
		L/r		33.9	33.9	33.9	33.9	50.7
	Sectional Force	Number		11	21	31	41	53
		N	(kN)	2145.941	1778.461	1526.200	1432.747	2041.385
		M	(kNm)	691.027	1814.836	1793.628	674.855	84.563
	Sectional Stress	σ	(N/mm^2)	43.4	36.0	30.9	29.0	110.1
		σb	(N/mm^2)	57.7	151.5	149.8	56.4	31.4
	Allowable Stress	σa	(N/mm^2)	245.3	245.3	245.3	245.3	169.8
		σba	(N/mm^2)	277.5	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.385	0.693	0.666	0.321	0.798
	Judgent			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile in the sea	Member	Pile dimensions		φ1000×16	φ1000×16	φ1000×16	φ1000×16	φ600×10
		Quality		SKK490	SKK490	SKK490	SKK490	SKK400
	Sectional Performance	A	(cm^2)	471.1	471.1	471.1	471.1	242.9
		Z	(cm^3)	11405	11405	11405	11405	4107
		r	(cm)	34.8	34.8	34.8	34.8	24.3
	Length of buckling	L	(cm)	1180.0	1180.0	1180.0	1180.0	1059.1
		L/r		33.9	33.9	33.9	33.9	43.6
	Sectional Force	Number		13	23	33	43	54
		N	(kN)	641.738	1778.461	1526.200	3098.914	2041.385
		M	(kNm)	2077.113	858.865	856.774	2290.578	241.113
	Sectional Stress	σ	(N/mm^2)	13.6	37.8	32.4	65.8	84.0
		σb	(N/mm^2)	182.1	75.3	75.1	200.8	58.7
	Allowable Stress	σa	(N/mm^2)	245.3	245.3	245.3	245.3	178.5
		σba	(N/mm^2)	277.5	277.5	277.5	277.5	210.0
	Check	σ/σa+σb/σba		0.712	0.425	0.403	0.992	0.750
	Judgent			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile embedd	Member	Pile dimensions		φ1000×16	φ1000×16	φ1000×16	φ1000×16	
		Quality		SKK490	SKK490	SKK490	SKK490	
	Sectional Performan	A	(cm^2)	489.9	489.9	489.9	489.9	
		Z	(cm^3)	11862	11862	11862	11862	
	Sectional Force	Number		14	24	34	44	
		N	(kN)	641.738	1778.461	1526.200	3098.914	
		M	(kNm)	1467.675	1004.751	1000.988	1506.731	
	Sectional Stress	σ	(N/mm^2)	13.1	36.3	31.2	63.3	
		σb	(N/mm^2)	123.7	84.7	84.4	127.0	
	Allowable Stress	σa	(N/mm^2)	277.5	277.5	277.5	277.5	
		σba	(N/mm^2)	277.5	277.5	277.5	277.5	
	Check	σ/σa+σb/σba		0.493	0.436	0.416	0.686	
	Judgent			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	

Table 3.3-7 Check of Piles in Land Side Row

				Pile No1	Pile No2	Pile No3	Pile No 4
Pile Head	Member	Pile dimensions		φ1000×14	φ1000×14	φ1000×14	φ1000×14
		Quality		SKK490	SKK490	SKK490	SKK490
	Sectional Performance	A	(cm^2)	433.7	433.7	433.7	433.7
		Z	($cm^{3)}$	10542	10542	10542	10542
		r	(cm)	34.9	34.9	34.9	34.9
	Length of buckling	L	(cm)	1180.0	1180.0	1180.0	1180.0
		L/r		33.8	33.8	33.8	33.8
	Sectional Force	Number		11	21	31	41
		N	(kN)	1368.420	1631.946	1700.522	2203.518
		M	(kNm)	2004.765	2063.833	2053.570	1921.173
	Sectional Stress	σ	(N/mm^2)	31.6	37.6	39.2	50.8
		σb	(N/mm^2)	190.2	195.8	194.8	182.2
	Allowable Stress	σa	(N/mm^2)	245.4	245.4	245.4	245.4
		σba	(N/mm^2)	277.5	277.5	277.5	277.5
	Check	σ/σa+σb/σba		0.814	0.859	0.862	0.864
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile in the sea	Member	Pile dimensions		φ1000×14	φ1000×14	φ1000×14	φ1000×14
		Quality		SKK490	SKK490	SKK490	SKK490
	Sectional Performance	A	(cm^2)	410.1	410.1	410.1	410.1
		Z	($cm^{3)}$	9970	9970	9970	9970
		r	(cm)	34.8	34.8	34.8	34.8
	Length of buckling	L	(cm)	1180.0	1180.0	1180.0	1180.0
		L/r		33.9	33.9	33.9	33.9
	Sectional Force	Number		12	22	32	42
		N	(kN)	1368.420	1631.946	1700.522	2203.518
		M	(kNm)	841.800	875.611	869.734	793.945
	Sectional Stress	σ	(N/mm^2)	33.4	39.8	41.5	53.7
		σb	(N/mm^2)	84.4	87.8	87.2	79.6
	Allowable Stress	σa	(N/mm^2)	245.3	245.3	245.3	245.3
		σba	(N/mm^2)	277.5	277.5	277.5	277.5
	Check	σ/σa+σb/σba		0.440	0.479	0.483	0.506
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok
Pile embedd	Member	Pile dimensions		φ1000×14	φ1000×14	φ1000×14	φ1000×14
		Quality		SKK490	SKK490	SKK490	SKK490
	Sectional Performance	A	(cm^2)	429.0	429.0	429.0	429.0
		Z	($cm^{3)}$	10428	10428	10428	10428
	Sectional Force	Number		14	24	34	44
		N	(kN)	1368.420	1631.946	1700.522	2203.518
		M	(kNm)	1053.325	1063.048	1061.358	1041.180
	Sectional Stress	σ	(N/mm^2)	31.9	38.0	39.6	51.4
		σb	(N/mm^2)	101.0	101.9	101.8	99.8
	Allowable Stress	σa	(N/mm^2)	277.5	277.5	277.5	277.5
		σba	(N/mm^2)	277.5	277.5	277.5	277.5
	Check	σ/σa+σb/σba		0.479	0.504	0.510	0.545
	Verification			≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok	≦1.0･･･ok

(3) General Description of Structure

Based on the analysis results, the cross-sectional and plan structure of the wharf are proposed as shown in Figure 3.3-14. It is proposed that a plan of the 200m wharf be divided into eight blocks of 25m each for the construction.

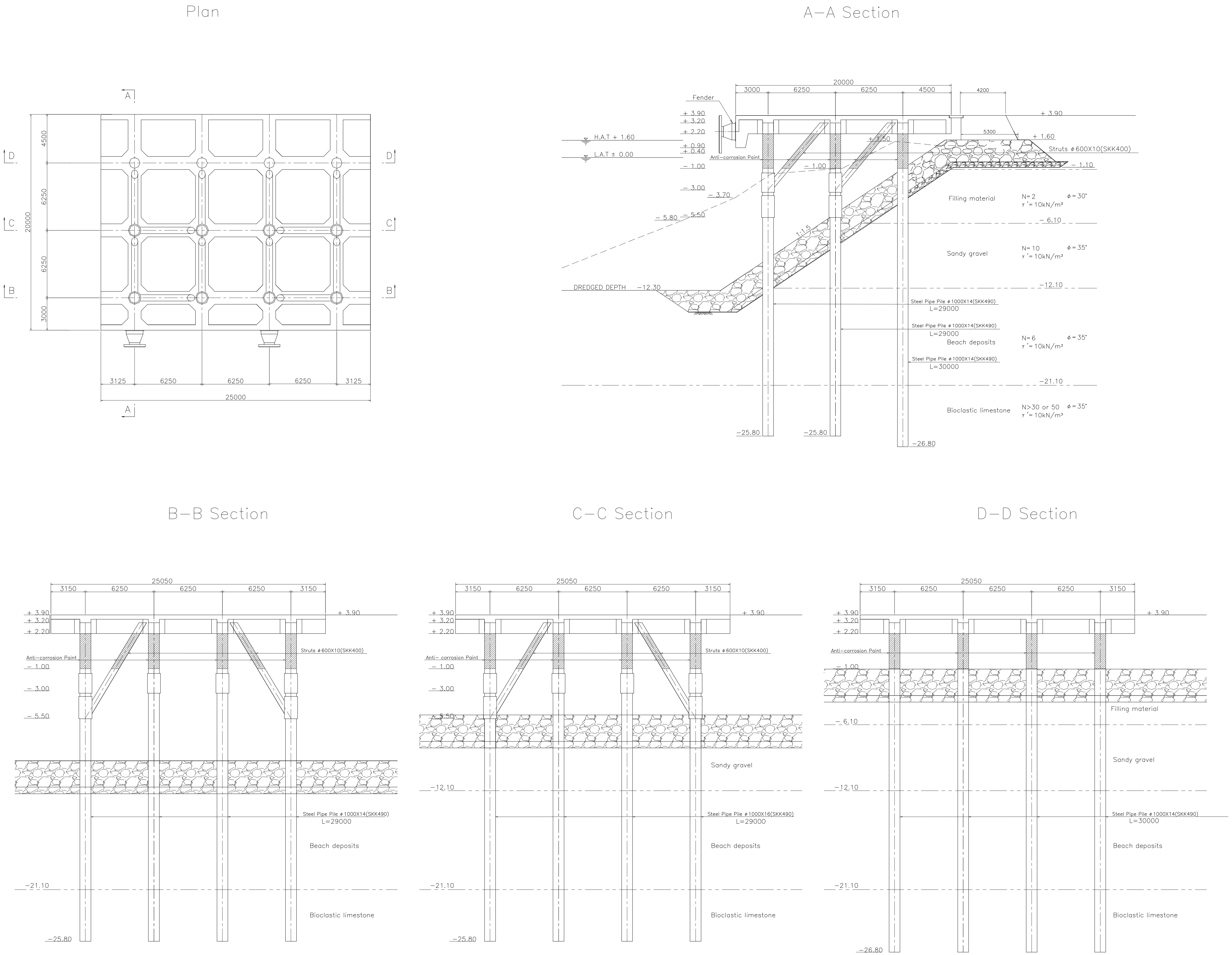


Figure 3.3-14 Plan and Typical Cross Sections of Structure at Star Wharf

3.4 Another Port Structure to be Designed

The BF/S report proposes the seawall to deposit dredged spoils for preventing dispersion of the spoils; however, the structure of the facility will not suit the purpose as shown in Figure 3.4-2 because the this type of structure will not limit the area in dumping dredged soils.

The present study proposes the appropriate structure for prevention of the dredged spoils as shown in Figure 3.4-3.

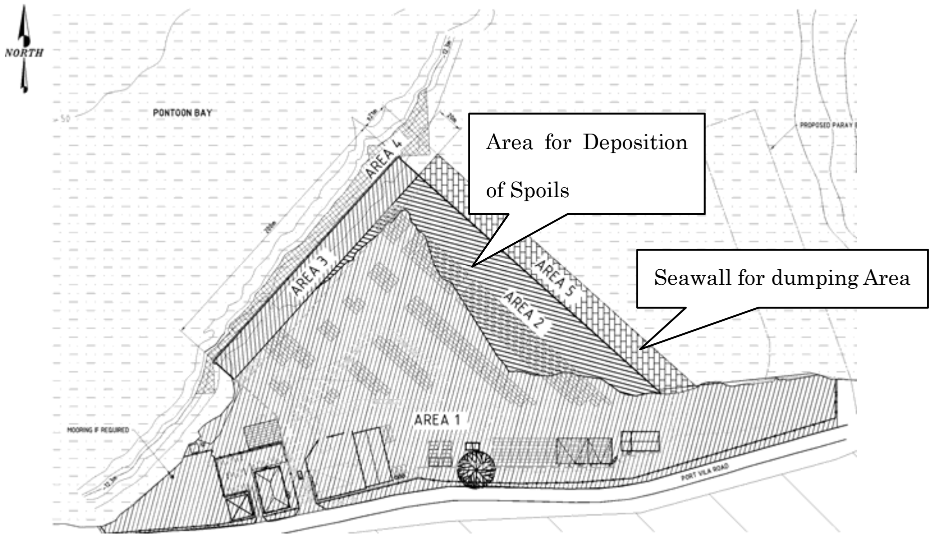


Figure 3.4-1 Locations of Area for Dumping Dredged Spoils and Seawall

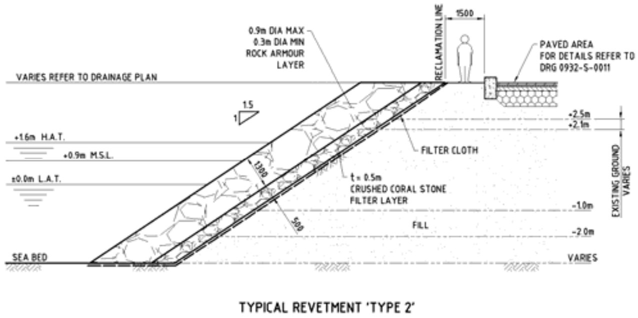


Figure 3.4-2 Structure of Seawall Proposed in BF/S

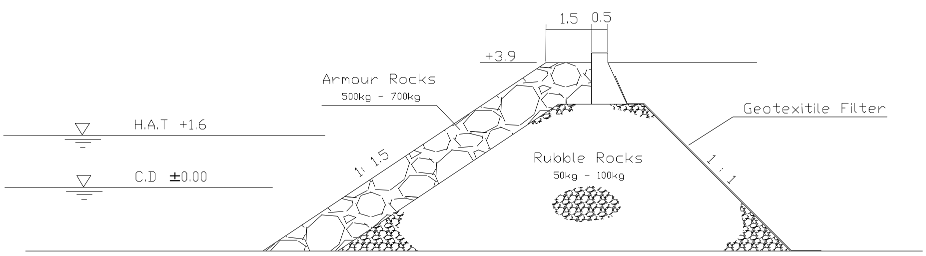


Figure 3.4-3 Proposed Structure for Limiting Dumping Area

3.5 Review of Design and Cost estimation of Architectural Facilities

Essentially, the cost estimate is made based on quantity for each construction items described in drawings. However, design drawings in this project in the BF/S report are just for reference and some quantities are not clarified from them. For example, there are descriptions of length, width and height of architectural facility but the size of fabricated steel members are not indicated. With that, the quantity is calculated assuming members to be generally used in Japan while the slight differences on the volume of re-bars and fabricated steel might be made.

Like this, as it is considered that there are some problems of cost estimation related with architectural matters are contained in the BF/S report, re-cost estimation was made picking up items and their quantities based on the drawings and break-down of that report.

Issues concerning architectural design and the cost estimation in the BF/S report are described below.

(1) Issues in Design

- Extra toilets in this area are required in the yard for operation workers.
- As the sizes of fabricated steel of the members of the buildings are not described, the quantity in this cost estimation is calculated empirically setting up the sizes of fabricated steels based on the drawings. It is considered that less quantity of fabricated steel be applied with reviewing design by Japanese construction method.
- Solar energy generation
    - The system proposes the capacity of solar panels is set to be two times of necessary electric energy power and the half of generated power is consumed at night.
    - The generated power with the 72 panes will be in the range from 11 to 13 kw/day. The number of panels should be reconsidered.
    - The quantity of battery should be studied well. In addition, the economical design shall be possible by handling not as nine modules like original design but by making one total system.
    - Economical design is proposed with equipping larger capacity of storage battery and minimizing the space for the battery.

(2) Issues in Cost Estimate

Following issues are confirmed by studying the cost estimate in BF/S documents.

- The following items are missing in the above document.
    - Temporary Construction Cost: Scaffolding, Batter Board, Marking and etc.

- Cost for finishing: Steel sheet roof material, Steel sheet wall material, Fitting cost, Plastering work cost, Painting work cost, etc.
- Cost for electric work: Incoming panel, Distribution board, Cable, Lighting apparatus Solar Generation System, and other all necessary cost for electric works of buildings
- Gate House : All cost related with Gate House
- Forming area: Forming area being necessary for concrete casting is too small

- The cost estimate method is different from the one in Japan. The cost estimate for a building is made with separation of two categories of foundations and building structure above foundations.
- Estimated costs following the Japanese method seems bigger than the Australian consultant. The cost estimated by the latter method seems lower than the former method since the unlisted items might be included in the contingency".

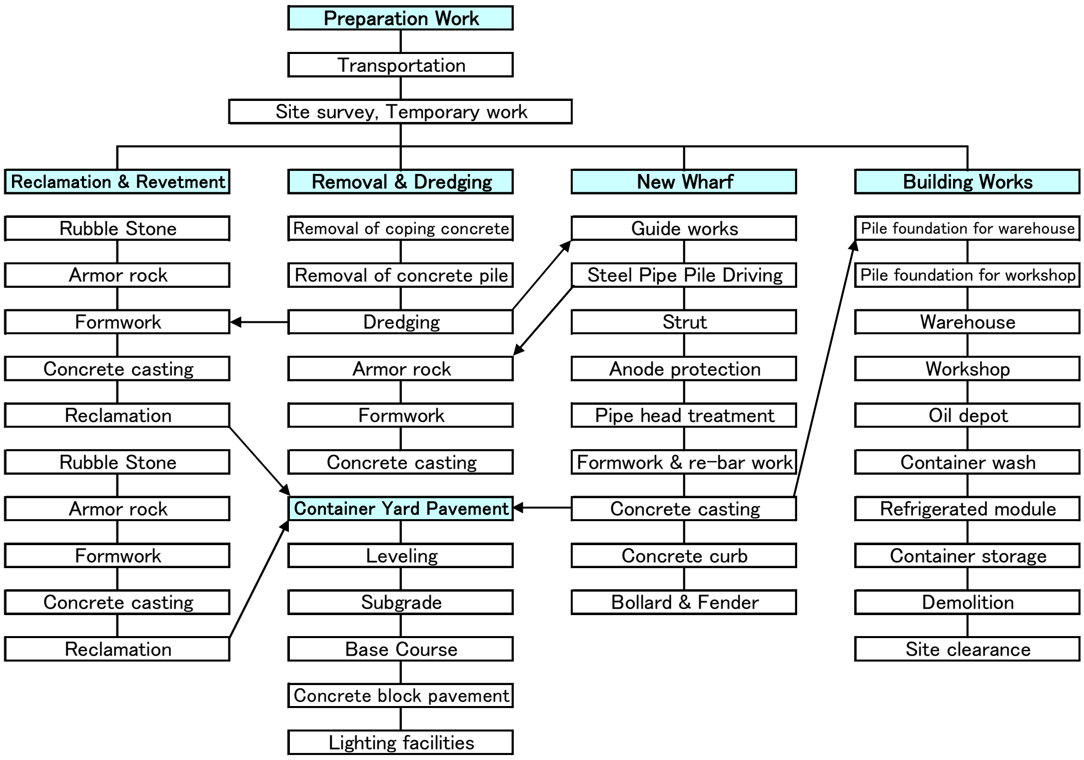
4. Construction Plan/Procurement Plan

4. Construction Plan/Procurement Plan

4.1 Construction Plan

4.1.1 Construction Work Flow

A flow of the construction works is described below.



4.1.2 Preparation Work

(1) Procurement preparation for material and equipment

Arrangement and preparation of material and equipment needed for the construction shall be made.

The order for manufacturing steel pipe piles in factories, maintenance of machinery, their transportation, etc. shall be made in Japan and or the third countries. Material and small construction machinery like excavators will be to procured locally. Since there is limitation to procure major construction machinery locally, it is necessary to procure them from Japan or the third countries. In order to save the transportation cost, construction machinery for various purposes shall be selected and minimization of machinery is required for the works. In respect of transportation, a chartered vessel with heavy lifting capacity shall be employed for transporting long and heavy cargoes from other foreign countries since the cost will become higher in transporting them with using liner ships.

Necessary material and equipment for construction works shall be procured from Japan where is cheaper than Australia or New Zealand for minimization of cargo volume.

(2) Site Survey

Before commencement of construction works, re-confirmation of BM(bench mark) and the installation of temporary BM, and basic surveys shall be executed to clarify boundaries of a project site and a temporary yard.

4.1.3 Direct Construction Works

4.1.3-1 Dredging and Removal of Existing Facilities

(1) Demolition of Existing Wharf and Removal

Existing concrete piles (made with two steel sheet piles joining together and filling concrete inside) , concrete beams and slabs shall be removed using a large breaker before driving steel pipe piles for the new wharf. Crushed concrete falling into water shall be recovered up by a clam shell bucket or an orange peel bucket equipped with a a crawler crane. The debris of the concrete is loaded onto dump trucks with backhoes and transported to dumping site designated by the Government where is about 10 km from the project site.

Machinery	Capacity	No.	Usage
Large Breaker	1,300 kg	1	Demolition of structures
Air Compressor	3.5～3.7 m^3/min	1	Demolition of structures
A crawler crane	150 ton (lifting)	1	Demolition of structures, Salvage debris
Clam Shell Bucket	$3m^3$	1	Demolition of structures, Salvage and loading debris
Orange Peel Bucket	$3m^3$	1	Demolition of structures, Salvage debris
Backhoe	$0.6m^3$	1	Demolition of structures, loading debris
Dump Truck	10t (loading)	5	Transporting debris

(2) Dredging

Dredging works is executed with marine crafts. A a crawler crane equipped on a flat barge with spuds will be employed for removal of the boulder stones with an orange peel bucket. Dredging works will be executed with a clam shell bucket and the dredged spoil shall be transported by transportation barges. The dredged spoil shall be aerated and transported by dump truck. Good quality of soil shall be re-used for reclamation and the other soil shall be dumped at the governmental disposal area as stated above.

Machinery	Capacity	No.	Usage
Flat barge with Spuds	1,000 ton	1	Dredging
A crawler crane	150 ton(lifting)	1	Dredging
Clam Shell Bucket	$3m^3$	1	Dredging
Orange Peel Bucket	$3m^3$	1	Dredging
Towing and Anchoring Boat	500 HP	1	Dredging(Flat barge transportation)
Sand Carrier	$500m^3$	1	Marine transportation of dredged soil
Backhoe	$0.6m^3$	1	Loading dredged soil
Dump Truck	10t (loading)	5	Land transportation of dredged soil

4.1.3-2 Reclamation and Revetment

(1) Construction of East Revetment

1) Rubble Stone

Rubble stone mounds under the concrete super structure will be constructed up to the crown height +1.6 m with the crown width of 3 m so as to make backhoe and dump truck be operated on them. It shall be used as temporary access road. The rubble stones (10 to 100 kg) shall be placed with employing a backhoe and dump trucks procurable locally.

Divers shall control and direct underwater rubble stone allocation. After placing rubble stone into water, a backhoe with assistance of divers shall be used for leveling underwater stones by diver. The stones on land shall be leveled by a backhoe.

Machinery	Capacity	No.	Usage
Backhoe	$0.6m^3$	1	Placement of rubble stone
Dump Truck	10t (loading)	1	Transportation of rubble stone
Boat for diver	70 HP	1	Leveling of rubble stone

2) Armor Stone

Transporting armor stones ranging from500 kg to 700kg by dump truck and the stones shall be placed by a backhoe from a land side. Divers shall control and direct underwater armor stone allocation. After placement of armor stone, a backhoe and a diving boat shall be used for leveling underwater stones by divers. Its leveling on land shall be executed by a backhoe and a rough-terrain crane.

Machinery	Capacity	No.	Usage
Backhoe	$0.6m^3$	1	Placement of armor stone
Damp Truck	10t (loading)	1	Transportation of armor stone
Boat for diver	70 HP	1	Leveling of armor stone (Underwater)
Rough-Terrain Crane	50 ton (lifting)	1	Leveling of armor stone (On land)
Orange Peel Bucket	$3m^3$	1	Placement of armor stone (Underwater), Leveling of armor stone (On land)

3) Formwork and Concrete Casting

Ready-mixed concrete that can be procured locally shall be used. The casting of ready-mixed concrete carried to the project site by concrete mixer shall be made by a rough-terrain crane, concrete bucket and vibrators for concrete. Transportation of material like forming frames and reinforcing bars shall be made by a truck with crane.

Machinery	Capacity	No.	Usage
Rough-Terrain Crane	25 ton (lifting)	1	Casting of concrete
Concrete Bucket	1.0m3	1	Casting of concrete
Vibrator for concrete	φ45 mm	3	Casting of concrete
Truck with crane	4 ton (loading), 2.9 ton (lifting)	1	Transportation of material

(2) Construction of West Revetment

1) Rubble Stone

After completion of dredging and piling of steel pipe piles, rubble stones (10 to 100 kg) shall be placed using a rough-terrain crane and a backhoe. Basically, the construction works shall be the same as the east revetment, however, as the water depth is deeper and already steel pipe piles were piled, precise care on the construction works shall be needed.

Machinery	Capacity	No.	Usage
Rough-Terrain Crane	50 ton (lifting)	1	Placement of rubble stone and leveling
Clam Shell Bucket	$3m^3$	1	Placement of rubble stone and leveling
Backhoe	$0.6m^3$	1	Placement of rubble stone and leveling
Dump Truck	10t(loading)	1	Transportation of rubble stone
Boat for diver	70 HP	1	Leveling of rubble stone (Underwater)

2) Armor Stone

Basically, construction works shall be the same as north and east revetment however, as the water depth is deeper and already steel pipe piles were piled, precise cares on the placement of armor stones and the leveling shall be needed. The armor stone works on land shall be executed by Backhoe and Rough-Terrain Crane.

Machinery	Capacity	No.	Usage
Dump Truck	10t(loading)	1	Transportation of armor stones
Boat for diver	70 HP	1	Placement and leveling of armor stone (Underwater)
Rough-Terrain Crane	50 ton (lifting)	1	Placement (underwater), Leveling(On land) of armor stone
Orange Peel Bucket	$3m^3$	1	Placement (underwater) and Leveling(On land) of armor stone
Backhoe	$0.6m^3$	1	Loading and placement and leveling of armor stone (On land)

3) Formwork and Concrete Casting

The same procedures will be applied as stated in description of the North and east revetments.

(3) Reclamation

After installing protection sheet against sand outflow at the land filling side by rubble stones in East revetment, leveling and compaction work shall be executed by a bulldozer. The thickness of spreading depth of one layer shall be 30 cm and the necessary height shall be obtained repeating leveling and compaction works.

Machinery	Capacity	No.	Usage
Bulldozer	21 ton	1	Leveling and compaction works
Road Sprinkler	5,000～6,000L	1	Leveling and compaction works

4.1.3-3 Wharf Construction

(1) Substructure Works

1) Installation of Guide Members and its Removal

Guide members shall be installed before piling steel pipes. Flat barge with spuds, a a crawler crane, vibration hammers and generators shall be used for the installation of guide piles executed from sea side. And, a flat barge and towing and anchorage boat for the marine transportation of guide piles and a rough-terrain crane and vibration hammer and trailer trucks for loading of guide piles shall be used. In addition, a crawler crane, vibration hammers and welding machine shall be used from sea side for the installation and removal of guide piles.

Machinery	Capacity	No.	Usage
Flat barge with spuds	1,000 ton	1	Installation of guide pile and beam and its removal
A crawler crane	150 ton (lifting)	1	Installation of guide pile and beam and its removal
Vibration Hammer	120 kW	1	Piling of guide piles
Generator	500 kVA	1	Piling of guide piles
Welding Machine	D300A	1	Installation of guide beams and its removal
Towing and anchoring Boat	500 HP	1	Piling of guide piles (transport by barge) and transportation of guide beams
Rough-Terrain Crane	50 ton (lifting)	1	Loading of guide beams (Project site), Piling support
Rough-Terrain Crane	25 ton (lifting)	1	Loading of guide beams (Stock yard)
Flat barge	500 ton	1	Marine transportation of guide beams
Semi Trailer	20 ton	1	Land transportation of guide beams

2) Steel Pipe Piling

A flat barge with spuds, a crawler crane, vibration hammers, hydro-hammers and generators shall be used from the sea side for the piling of steel pipes. And a flat barge and towing boat for the marine transportation of steel pipe piles and struts, and Rough-terrain cranes and trailer trucks for the loading shall be used. In addition, a crawler crane, welding machine and grouting equipment shall be used for the installation of struts.

Machinery	Capacity	No.	Usage
Flat barge with spuds	1,000 ton	1	Piling of Steel Pipe and installation of strut
A crawler crane	150 ton (lifting)	1	Piling of Steel Pipe and instillation of strut
Vibration Hammer	120 kW	1	Piling of Steel pipes
Hydro Hammer	7.1 ton	1	Piling of Steel pipes
Generator	500 kVA	1	Piling of Steel pipes
Welding Machine	D300A	1	Installation of strut, installation of anode protection, Pile head processing
Grouting Equipment		1	Fixing of strut
Towing and Anchoring Boat	500 HP	1	Piling steel pipes (transportation by barge), Transportation of strut
Rough-Terrain Crane	50 ton (lifting)	1	Loading of steel pipe piles and struts, and installation of anode protection
Rough-Terrain Crane	25 ton (lifting)	1	Loading of steel pipe piles and struts (Stock yard)
Flat Barge	500 ton	1	Marine transportation of steel pipe piles and struts
Semi Trailer	20 ton	1	Land transportation of steel pipe piles and struts
Boat for diver	70 HP	1	Installation of Anode protection

(2) Super Structure (concrete deck)

1) Formwork, Re-bar Works and Concrete Casting

Supports for concreting shall be installed using a rough-terrain crane. After completion of supports, installation of form frames and re-bar work shall be executed. A rough-terrain crane shall be used for concrete casting. In case that the approach from land side is not allowed, a crawler crane equipped to a flat barge shall be used for driving piles from a sea side. In addition, the transportation of form frames and re-bars shall be made by truck with crane and the same shall be applied to concrete curbs and corners.

Machinery	Capacity	No.	Usage
Rough-Terrain Crane	50ton(lifting)	1	Installation of scaffolding, Concrete casting
Concrete Bucket	1.0m3	1	Concrete casting
Vibrator	φ45mm	3	Concrete casting
Truck with crane	4ton(loading), 2.9ton(lifting)	1	Material Transportation
Welding machine	D300A	1	Re-bar work

2) Appurtenant work

Bollards and fenders shall be installed with a rough-terrain crane and a truck with crane shall be used for their transportation.

Machinery	Capacity	No.	Usage
Rough-Terrain Crane	50ton(lifting)	1	Installation of scaffolding, Concrete casting
Truck with crane	4ton(loading), 2.9ton(lifting)	1	Transportation of material and equipment
Welding Machine	D300A	1	Re-bar works

4.1.3-4 Pavement of Apron and Container Yard

(1) Land Grading (Leveling), Base-grade and Base-course

Land shall be graded by a mortar grader, a tire roller and a road roller shall be used for compaction of each layer.

Machinery	Capacity	No.	Usage
Motor Grader	3.1m class	1	Land grading
Tire Roller	8 to 20 ton	1	Compaction of Sub-grade and Base-course
Road Roller	Macadam 10 to 12 ton	1	Compaction of Sub-grade and Base-course
Dump Truck	10 ton	5	Transportation of material for Sub-grade and Base-course

(2) Inter-locking block pavement

After confirming design bearing capacity of base courses, pavement withinter-locking block shall be executed.

Machinery	Capacity	No.	Usage
Semi Trailer	20ton	1	Transportation of inter-locking block
Rough-Terrain Crane	25ton(lifting)	1	Loading inter-locking block
Truck with crane	4ton(loading), 2.9ton(lifting)	1	Conveyance of material

(3) Lighting Facilities

Lighting poles shall be installed by a rough-terrain crane.

Machinery	Capacity	No.	Usage
Semi Trailer	20ton	1	Transportation of matrial
Rough-Terrain Crane	25ton(lifting)	1	Loading of lighting tower(Stock yard)
Rough-Terrain Crane	50ton(lifting)	1	Installation of lighting tower

4.1.3-5 Architectural Works

(1) Building Works

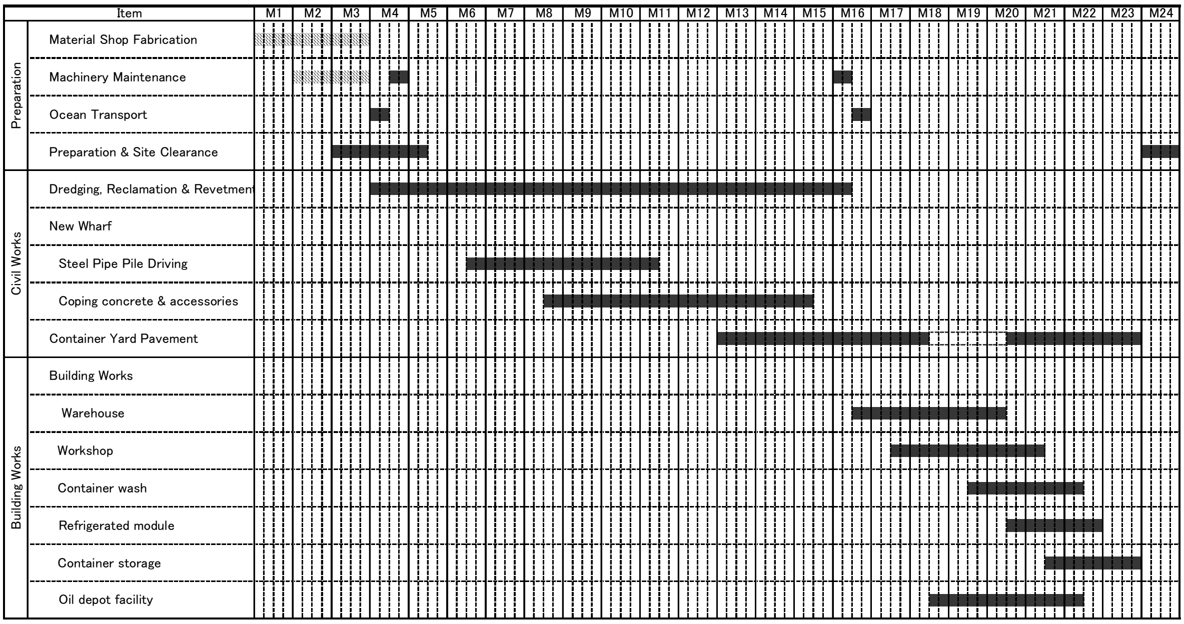
Machinery to be used for building works are as the list below.

Machinery	Capacity	No.	Usage
Backhoe	0.6m^3	1	Excavation, Backfilling
Dump Truck	10t(loading)	1	Transportation of surplus soil
Rough-Terrain Crane	50ton(lifting)	1	Piling for foundation
Hydro Hammer	7.1ton	1	Piling for foundation
Semi Trailer	20ton	1	Transportation of foundation pile
Rough-Terrain Crane	25ton(lifting)	1	Concrete Casting, Carrying material to altitude
Concrete Bucket	1.0m^3	1	Concrete Casting
Vibrator	φ45mm	3	Concrete Casting
Welding Machine	D300A	1	Re-bar works
Truck with crane	4ton(loading), 2.9ton(lifting)	1	Transportation of material

4.1.4 Construction Schedule

24 months will be required from commencement of construction to the completion as shown in the following work progress chart.

Construction Schedule



4.2 Procurement Plan of Material and Equipment

4.2.1 Construction Circumstance

(1) Construction Company

In Vanuatu there are a few construction companies of small scale with few capabilities to construct full-scale port facilities like this project. However, two companies named Fletcher Vanuatu and Pierre Brunet are possible to work as sub-contractors to construction companies of Japan, Australia, New Zealand and etc.

(2) Construction Machinery

The above two companies hold versatile civil construction machinery like a rough-terrain crane, etc. Such machinery and some materials for civil works to be able to use in this project shall be basically procured locally; however, it is necessary to procure large scale construction machinery of large scale cranes, dredger, working vessels for pile driving, etc. from Japan, Australia, New Zealand.

(3) Construction Materials

Fletcher Vanuatu and Pierre Brunet hold versatile materials for civil works like plant for ready mixed-concrete, quarry, steel reinforcing bars, stone materials (imported from New Zealand). Therefore, it is necessary to procure construction materials from Japan, Australia, New Zealand excluding concrete, stones and woods to be used in this project.

(4) Labor

In Vanuatu, skilled and unskilled laborers working for small scale civil and building works can be hired around Efate Island, however, there is few skilled laborers specialized for the size of the Star wharf Project. It is necessary to secure such special skilled laborers from other countries like foremen with special skills, operators for large size machinery and etc. in the special construction works like port construction. Therefore, it is necessary to procure special skilled labors from the third countries like Japan, Australia, New Zealand and etc.

4.2.2 Procurement Plan for Materials

(1) Local Market Conditions for main construction materials

It is possible to procure main materials locally except steel pipe pile, wide flange steel beams, inter-locking block and others. It is also possible to locally procure reinforcing bars imported from Australia and New Zealand. The prices are much expensive like 16,000 VT/ton. Recently, re-bars from China and Malaysia are imported, being sold at the price of 14,000 VT/ton. As no authorized quality of the material is confirmed, however, they should not be used for this project.

(2) Study on Material Importation

Concerning the import of materials, the comparison on the economic efficiency and the quality between the material from Japan and the third countries (Australia, New Zealand and Fiji) shall be studied.

The steel materials shall be imported from Japan from the economical and quality points of view in the cost estimate for this project because of the following reasons.

- Steel products meeting the ANZ specifications are expensive.
- Steel products sold in Fiji are expensive since they are imported from New Zealand.
- Protection system against rusting will be obtained from Japan.

Inter-locking blocks with ANZ specification are produced in Fiji and the price is cheaper than Japan, Australia and New Zealand and therefore, cheaper pavement method using inter-locking blocks will be selected, compared with concrete pavement constructed with local products.

As fenders, bollards and etc. are difficult to procure locally, these materials shall be purchased from Japan considering totally of specification, quality, price, delivery and construction method in the cost estimation for this project.

(3) Demarcation Table of Material Procurement

Demarcation of material procurement is shown below.

Classification	Item	Demarcation		
		Local	Japan	Third Countries
Steel material	Pipe pile, H-shape, Plate, Re-bar and etc.		○	
	Bolt, Nail, Binding wire	○		
Cement, Aggregate	Cement,	○	○(special one)	
	Sand	○		
	Aggregate	○		○
	Mixture material		○	
Stone material, Block	Rubble stone, Backfill stone, Armor stone	○		
	Quarry	○		
	Cobble stone	○		
	Inter-locking block			○
Lumber	Plywood for form and wood	○		
Fuel	Light oil	○		
	Gasoline	○		
	Bunker A	○		
	Lubricant oil	○		
Sand protection sheet	Sand protection sheet		○	
Ancillary facility	Joint sealing material		○	
	Fender		○	
	Bollard		○	
	Anode protection		○	
	Lighting pole		○	
	Grating		○	

4.2.3 Construction Machinery

(1) Procurement method of Construction Machinery

As a result of site surveys, it is found that there is few construction machinery possessed by construction company, lease company, transportation company and others to be able to rent in Vanuatu.

The procurement of machinery from Japan shall be the base for the cost estimate with consideration of the requirement for a long period of and that for special large scale machinery in this project.

(2) Demarcation Table for Procurement of Construction Machinery

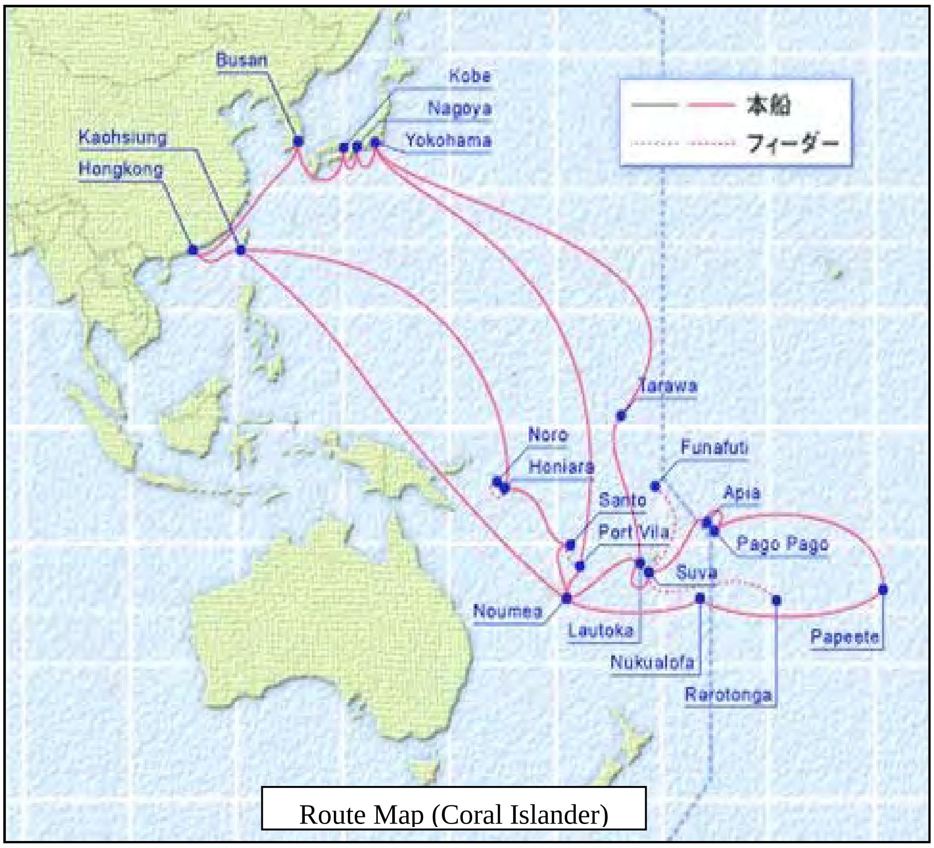
Construction machinery in the cost estimation are as follows.

Machinery	Capacity	No.	Usage	Demarcation	
				Local	Japan
Flat Barge with Spuds	1,000 ton	1	Dredging, Driving steel pipe piles		○
Generator	125 kVA	1	Driving steel pipe piles for spuds		○
Generator	500 kVA	1	Driving steel pipe piles for hammer		○
A crawler crane	150 ton (lifting)	1	Dredging, Driving steel pipe piles		○
Hydro Hammer	7.1 ton	1	Driving steel pipe piles		○
Vibration Hammer	120 kW	1	Driving steel pipe piles		○
Towing and anchoring boat	500 HP	1	Dredging and Driving steel pipe piles		○
Flat Barge	500 ton	1	Driving steel pipe piles		○
Orange Peel Bucket	$3m^3$	1	Dredging and armor stone		○
Clam Shell Bucket	$3m^3$	1	Dredging, excavation for foundation, rubble stone		○
Sand Carrier	$500m^3$	1	Dredging		○
Small boat for diver	70 ps	1	Armor stones (leveling under water) and under water welding		○
Bulldozer	21 ton	1	Reclamation leveling and compaction		○
Motor Grader	3.1m class	1	Land leveling, leveling of base course pavement		○
Tire Roller	8 to 20 ton	1	Surface compaction of base course pavement		○
Road Roller	Macadam 10 to 12 ton	1	Surface compaction of base course pavement		○
Sprinkler truck	5500-6000L	1	Reclamation and pavement		○
Rough-Terrain Crane	25 ton	1	Transportation of steel material, concrete casting and ancillary works	○	
Rough-Terrain Crane	50 ton	1	Support works for pipe pile driving		○
Trailer	20 ton	1	Transportation of steel materials	○	
Dump truck	10 ton	5	Foundation works and transportation	○	
Backhoe	$1.0m^3$	1	Reclamation and revetment		○
Backhoe	$0.6m^3$	1	Transportation and foundation	○	
Concrete Bucket	$1.0m^3$	1	Concrete casting	○	
Large Breaker	1,300 kg	1	Demolition of concrete		○
Air compressor	$3.5\sim3.7m^3$/min	1	Demolition of concrete	○	
Vibrator	φ45 mm	3	Concrete casting	○	
Welding Machine	D300A	1	Re-bar works, Butt welding for pipe piles	○	
Truck with crane	4t(loading), 2.9t crane	1	Transportation of materials	○	

4.3 Transportation Plan

(1) Transportation Cost from Japan

The marine transportation from Japan (Yokohama) to Port Vila use containers and load to container ship as much as possible. Only Kyowa Shipping has liner services to Vanuatu from Japan except chartered vessel. It may be necessary to hire a chartered vessel for the long and large measurement cargoes since these container vessels are calling many ports in the line of services.



Route Map (Coral Islander)

Liner

Feeder

(2) Procurement of Materials from Fiji

Inter-locking blocks shall be purchased from Fiji and 20ft containers shall be generally used when heavy products are transported for easier handling.

(3) Supplementary note on transportation plan

The transportation plan is very important under the influence to make or mar achievement of the project. A mature plan should be established since many kinds of material will not be transported by liner vessels like large construction machinery and long pipe piles. In addition, the procurement plan for the project refers to the cost estimate of the Project for Improvement of Port Vila Main Wharf that the consulting services were made by ECOH CORPORATION and the Project for Expansion of Betio Port in the South Pacific.

A chartered vessel with heavy lifting capacity shall be needed, in case that the delivery cargo volume is more than 5,000 F/T with the cargoes longer than 12 m and heavier than 30 ton.

(4) Supplementary Note for Transportation of Construction Materials, Equipment and Work Boats

- Chartered ship with Heavy Lifting Capacity (Outward)

Construction material, equipment and work boats that are not possible to be carried by liner ships due to the limitations of volume and weight shall be transported by a chartered ship with derrick cranes lifting capacity of 450 ton. Heavy cargoes like flat barge or long cargoes like steel pipe piles can be directly transported by a chartered ship. However, installation of hoisting attachment on such flat barge and steel pipe piles shall be necessary.

- Chartered ship with Heavy Lifting Capacity (Return)

As heavy and long material and equipment have less possibility to sell locally or re-sell to other construction companies, the return shipping cost to Japan has been added to the cost. For the return of these items, the same chartered ship as above shall be employed considering the economic efficiency and the completion period.

5. Summary of Project Cost

5. Summary of Project Cost

5.1 Total Capital Cost

(1) Conditions of Cost Estimation

1) Time of Cost Estimation: October, 2011

2) Exchange Rate: 1US$=82.43yen
: 1VT=0.91yen

3) Implementation Period: Detailed Design (approximately 12 months)
: Construction Period (approximately 24 months)

4) Others: The cost estimation is made based on the JICA guidelines for project cost estimation while prices of construction material in Japan and other countries are applied for estimation. The outline of the cost estimate is described below:

a) Direct Construction Cost

The construction cost is made in accordance with the Guidelines of JICA.

b) Indirect Construction Cost

Indirect construction cost is consisted of temporary works cost and site office expense and calculated using rates of temporary works cost and site office expense in “Guidelines for Cost Estimate of Contract Works for Ports and Harbours in Japan” (edited by Ministry of Land, Infrastructure, Transport and Tourism) In addition, overseas travel expenses including accommodations and daily allowances which are not included in the domestic construction works of Japan are allocated separately.

c) Engineering Fees

Engineering fees consist of the fees for detailed design and construction supervision. The detailed design includes the costs for topographic surveys, bathymetric surveys and soil investigation which are necessary for the detailed design.

The cost for tender assistance including pre-qualification and tender evaluation are included in the detailed design.

d) Contingency

A contingency amount consists of physical and price contingency. 5 % contingency is allocated as physical contingency on the construction cost and it covers unknown factors. And, the price contingency is calculated based on the price increase rate of 2.1% and 5.8% for imported and domestic construction items respectively.

As the local currency portion occupies about 33 % of the total construction cost in this project, the equivalent amount for the price contingency is included in the project cost.

e) Others

Operation management fee, Preparation fee, Tax, Interest and etc. shall be allocated.

(2) Summary of Project Cost

The project cost to be needed in case of this loan assistance is about 48.4 billion yen. But, this amount is not necessarily shown the maximum amount of Exchange of Notes.

	Item	Breakdown	Amount
〔1〕	Construction Cost		
		Direct Construction Cost	3,766,000,000
〔2〕	Design & Supervision		528,000,000
	(1)	Design Fee	238,000,000
	(2)	Supervision Fee	290,000,000
〔3〕	Contingency		543,000,000
	(1)	Price contingency	338,000,000
	(2)	Physical contingency	205,000,000
〔4〕	Operation Management		0
〔5〕	Preparation		0
	(1)	Eminent Domain cost	0
	(2)	Compensation cost	0
〔6〕	Tax		0
〔7〕	Total		4,837,000,000

(3) Maintenance and Management Cost for Facilities

Port facilities in this project are basically maintenance free facilities, however, maintenance and management cost for consumables shall be necessary. Depending upon the port cargo handling works, repair works on inter-locking pavement may be necessary.

Item	Replacement Time	Source of Country	Unit Price	Total
Fenders	Service life: 10 years or at the time of damage	Japan or Third countries	8 million yen/set	128 million yen in every 10 years
Grating	Service life: 10 years or at the time of damage	Japan or Third countries	70,000 yen /piece	20 million yen in every 10 years
Anode Protection	Service life: 50 years	Japan or Third countries	-	60 million yen in every 50 years
Inter-locking Pavement	At the time of damage	Third countries or Japan	20,000 yen /m^2	-

5.2 Procurement Package

The project is composed of the berthing facility, the container yard and the operation facilities in the container yard. All the proposed facilities should be provided in the project as one package since no modernized facilities are available in Star Wharf and they should be provided in one united function.

6 Information on Procurement

6. Information on Procurement

6.1 Procurement of Construction Firms for Port and Harbor Works in Vanuatu

(1) Port Construction by Japanese Assistance

Two projects were executed under the Japanese Grant Aid scheme related with the port sector and the details are shown below.

The port construction was implemented by Japanese major marine contractors, Penta Ocean Construction and TOA CORPORATION.

Past Record of Japanese Assistance (Port and Harbor Sector)

Year	Name of Project	Grant Amount (Million yen)	Summary of Project	Contractor (Consultant)
1998	Project for the wharf rehabilitation in Tanna Island	382	Rehabilitation of wharf and access road damaged by cyclone “Sala” at Tanna Island in 1994	TOA CORPORATION (Pacific Consultants International : Present Oriental Consultants)
2008 to 2010	Project for the Improvement of Port Vila Wharf	1,707	Improvement works for main wharf of port of Port Vila and procurement of Tug Boat and Pilot Boat	Penta Ocean Construction (facilities) and Kanagawa Dockyard (equipment) (JV between ECOH CORPORATION and Japan Marine Science Inc.)

(2) Port Construction by Other Donors

After independence of Vanuatu, two port construction projects were executed by ADB fund and others. The details are shown below. These two projects were done by Fletcher Construction Co., Ltd. in New Zealand.

The main office of Fletcher Construction in New Zealand made contracts of the projects and procured all necessary material and equipment from New Zealand. The firm has a Vanuatu branch office which has locally little construction machinery; they will be mobilized to the site from the main office upon needs.

Past Record of Other Donors’ Cooperation Fund (Port & Harbor Sector)

Year	Name of Project	Amount (Thousand US$)	Assistance	Donor	Summary of Project	Construction Company
1989 to 1991	Wharf Construction in Port of Luganville	10,290	Loan Assistance	ADB	Wharf Expansion of Port of Luganville	Fletcher Construction (NZ)
2000 ～ 2001	Rehabilitation of Port of Port Vila and fenders	2,000	Unknown	Unknown	Repairing Works for Wharf of Port of Port Vila	Fletcher Construction (NZ)

6.2 Employment of Consultants under Japan ODA Loan

Consultants under the scheme are normally employed following the "Guidelines for the Employment of Consultants under Japan ODA Loans in January 2005" (hereinafter refer to "Guidelines")

(1) Terms of Reference (TOR) for Consulting Services

A consultant will be employed for implementing a project under a Japan ODA loan. TOR will be drawn up in the course of the negotiations between the Borrower and JICA. The Guidelines indicates the contents of TOR as below:

- Project Information
- Other relevant Information
- General Terms of Reference including Environmental Consideration
- Specific Terms of Reference
- Estimated Time Required for Completion of Project and Consulting Services
- Methodological Details for Consulting Services
- Provision for the review of previous studies and possible additional studies

(2) Selection of Consultants

Two local consulting firms in Port Vila are operated with a small number of engineers and their contracts of consulting services are not solely involved in international consulting business in the port sector. International consultants fully experienced in the port sector will be required for implementation of the services.

The selection shall be made in accordance with the Guidelines.

(3) Contract

A contract between and the Client and the firm is made on the basis of the Guideline. The documents for the contract contains the terms of reference with the proposal by the consultant. General clauses of the contract are based on them indicated in "Sample Request for Proposals under Japanese ODA Loans: Selection of Consultants"

Lump-sum contract for the Star Wharf Project will be preferable since almost of the services will be clarified for the implementation.

6.3 Selection of Contractor under the Japanese ODA Loan

(1) Bidding Forms

Local competitive bidding will not be suited to the bidding of the Project because of the high bidding price, employment of larger marine crafts, procurement of material from the international market, etc. International bidding is preferable for the Project.

(2) Pre-qualification

Pre-qualification will be made to meet the requirements indicated in "SAMPLE PREQUALIFICATION DOCUMENTS UNDER JAPANESE ODA LOANS by JICA".

1) Eligibility

1.1 Nationality

1.2 No conflict of Interest

1.3 No JICA Ineligibility

2) History of Contract Non-Performance

2.1 History of Non-performing Contracts

*Non-performance of a contract within last two years

2.2 Pending Litigation

*Not more than 50% of an applicant's net worth

3) Financial Situation

3.1 Financial Performance

*Sound cash flow, Sound statement for last five years, Sound balance sheet

3.2 Average Annual Construction Turnover

*Not less than 10 billion Yen of estimated annual turnover in the contracts of marine works, etc.

4) Experience

4.1 General marine civil construction experience of prime contractors, etc. for last five years

4.2 Port construction experience of sole prime contractors for last five years

4.3 Port construction experience in the South Pacific Ocean region for last five years

4.4 Construction experience with application of the Submerged Strut Method

4.5 Construction experience of container wharves/container yards in Vanuatu