Appendix 6-3. Results of Investigations in the Project Site

Appendix 6-3-1. Results of Traffic Investigation in North Dock

An investigator was allotted and the quantity of persons and vessels and vehicles are counted and recorded around North dock (investigation had performed from 12th August to 31st August, 2005, 8:00 to 17:00 each hour).

Investigation results are shows in Table A.6.3.1-1 to A.6.3.1-5.

Table A.6.3.1-1 Average Number of Persons at North Dock

Hour	8	9	10	11	12	13	14	15	16	17
Visitor	1.9	4.2	4.8	3.1	1.8	2.5	3.0	4.1	1.4	4.2
Staff	1.8	3.1	2.4	2.8	2.9	3.8	2.6	2.4	2.1	3.1
Fishermen	0.2	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Others	8.5	9.0	11.1	9.3	5.9	7.7	9.2	10.2	6.7	9.0
Total	12.3	16.3	18.3	15.1	10.7	14.0	14.8	16.7	10.2	16.2

Table A.6.3.1-2 Average Number of Vehicles at North Dock

Hour	8	9	10	11	12	13	14	15	16	17
Truck	3.3	3.9	4.4	3.7	3.2	4.1	5.2	4.0	3.0	3.7
Sedan	3.7	3.3	3.1	3.0	2.6	3.5	4.6	3.4	2.2	2.9
Bus	1.4	1.9	2.6	2.3	1.9	2.2	2.1	1.9	1.2	1.5
Others	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Total	8.4	9.0	10.1	8.9	7.6	9.8	11.8	9.3	6.4	8.1

Table A.6.3.1-3 Average Number of Berthing Boats at North Dock and Beach

Hour	8	9	10	11	12	13	14	15	16	17
North and west side Quay	5.8	5.3	6.0	7.2	7.4	7.4	6.7	6.3	5.7	5.5
Eastside Quay	5.5	5.2	5.0	5.1	5.1	5.2	5.0	4.8	4.6	4.7
Total at North Dock	11.3	10.5	11.0	12.3	12.5	12.6	11.7	11.1	10.3	10.2
Beach	8.8	8.6	8.4	8.5	8.3	8.5	7.8	7.6	7.7	8.1
Total (North Dock and Beach)	20.1	19.1	19.3	20.8	20.8	21.0	19.4	18.7	18.0	18.3

Table A.6.3.1-4 Average Number of Boat Arrival and Departure per day at North Dock

Class of Boat	Fishing Boat	RoRo-Boat	Passenger Boat	Others	Total
Arrival	2.0	0.5	3.7	4.4	10.5
Departure	2.7	0.6	3.7	4.4	11.4
Total	4.7	1.0	7.4	8.8	21.9

Table A.6.3.1-5 Average Number of Embarkation and Disembarkation per day at North Dock

Items	Average Number of Person
Embarkation	82.9
Disembarkation	81.1
Total	164.0

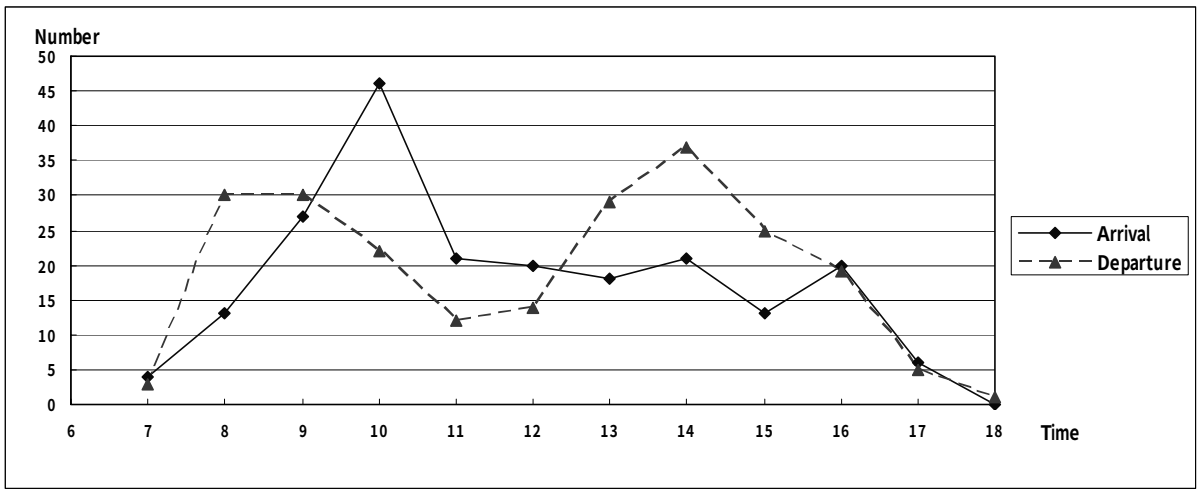


Figure A.6.3.1-1 Distribution of Arrival and Departure Time of Vessels at North Dock (20days Total from 12th August to 31st August)

Appendix 6-3-2. Results of Fishery Investigation in North Dock

(1) Fishermen

The number of residents of Peleliu is about 500. Labor force is about 200 persons. Members of fishing corporative (Beliliou Fishing Corporative (BFCA)) are 31 persons. Half of them are females. Much more persons can catch fishes and sell.

(2) Fishing boats

The study team confirmed 31 fishing boats in the area from 2 km west of North dock to 1km east of North dock in August 24th. The team also confirmed that fishing boats are landed in font of fishermen's home. It is supposed that there are approximate 50 fishing boats in Peleliu by above fact and the results of interviews for BFCA and fishermen.

(3) Fish catch, fishing method

Main fish catches are rabbit fish, parrotfish, grouper, snapper, mullet in Peleliu state. Fishing area is only around coral reef area. Gill netting, hand lining, spear fishing are dominant in Peleliu. Gill net is almost 30m wide and 1.5m height. Mesh size is about 10cm. small size mesh gill net is prohibited in Peleliu State. Fishermen go fishing about 12 hours in once time.

(4) Distribution of Fishes

Fishermen unloaded fishes in front of their home. Fishes to be caught by fishermen were mainly consumed within their family, and surplus fishes are sold to BFCA (Beliliou Fishing Cooperative) without rejection.

(5) Fish catch and fish price

BFCA buy fishes by fishermen (include non-member of BFCA) and sell in Peleliu and Koror. Fishes price to buy and to sell are fixed by fish pieces as Table A.6.3.2(5)-1.

Table A.6.3.2(5)-1 Fishes prices (unit: US$／lbs)

Pieces	To buy	To sell	Balance
Rabbit fish	0.85	1.1	0.25
Snapper	1.0	1.35	0.35
Parrotfish	1.15	1.4	0.25
Grouper, Mullet	1.2	1.5	0.3

In Peleliu State, average consumed volume of fishes per one family is about 40 lbs per month. Total consumed volume of fishes in one year in Peleliu State is calculated as below.

40 lbs/month/family * 160families * 12monthes = 34.5 (ton / year)

(6) Activity of BFCA

Number of member of BFCA is 31, half of the member is female. Member fee is not collected. BFCA buy fishes by fishermen (include non-member of BFCA) and sell in Peleliu and Koror.

Incomes of BFCA are balance of fish prices (as shown in Table A.6.3.2(4)-1), selling smoked fishes and ice cream and rental fee of crane truck. Business balance of BFCA is shown in Table A.6.3.2(6)-1.

Table A.6.3.2(6)-1 Business Balance of BFCA（unit：US$）

Calendar Year	Income	expenditure	Balance
2002	37,127	32,319	+4,808
2003	43,130	33,750	+9,381
2004	40,148	40,119	+29
2005 (Jan. to Jun.)	21,176	19,998	+1,178

BFCA intend to strengthen the organization and grow up fishermen's life through business of selling goods (ex ice cream, smoked fishes). He planes to held meeting of fishermen every two weeks or some (non member of BFCA will be welcomed). He also plans to buy and sell farmer products (ex taros, coconuts, papayas, bananas) to contribute for development of Peleliu State.

Appendix 6-3-3. Results of Structural Investigation in North Dock

Structural investigation in North Dock is performed by the team in August 2005. Results are described in below.

Although breakage of concrete at the tip of quay, severe damages are not recognized in north side of landing quay (constructed in 1999 by JICA project). Sinking of apron is not recognized also.

Bitts installed in 1999 (seven set) can use but the corrosion of metal portion is progressing.

Weathering of concrete is recognized in west side quay and east side seawall of the North dock

The stairs shapes are changing by weathering of concrete and a problem is in the safety .at west side. Mooring beams at east and west side are damaged and deformed.

In the west side of North dock apron concrete is damaged and base course are visible. In the east side of North dock apron concrete beneath the sign board of Peleliu is damaged and base course are visible. Because North Dock apron is not paved, there are many puddles after rain weather condition.

Gabions at west side of North Dock are damaged and filling stones are scattered.

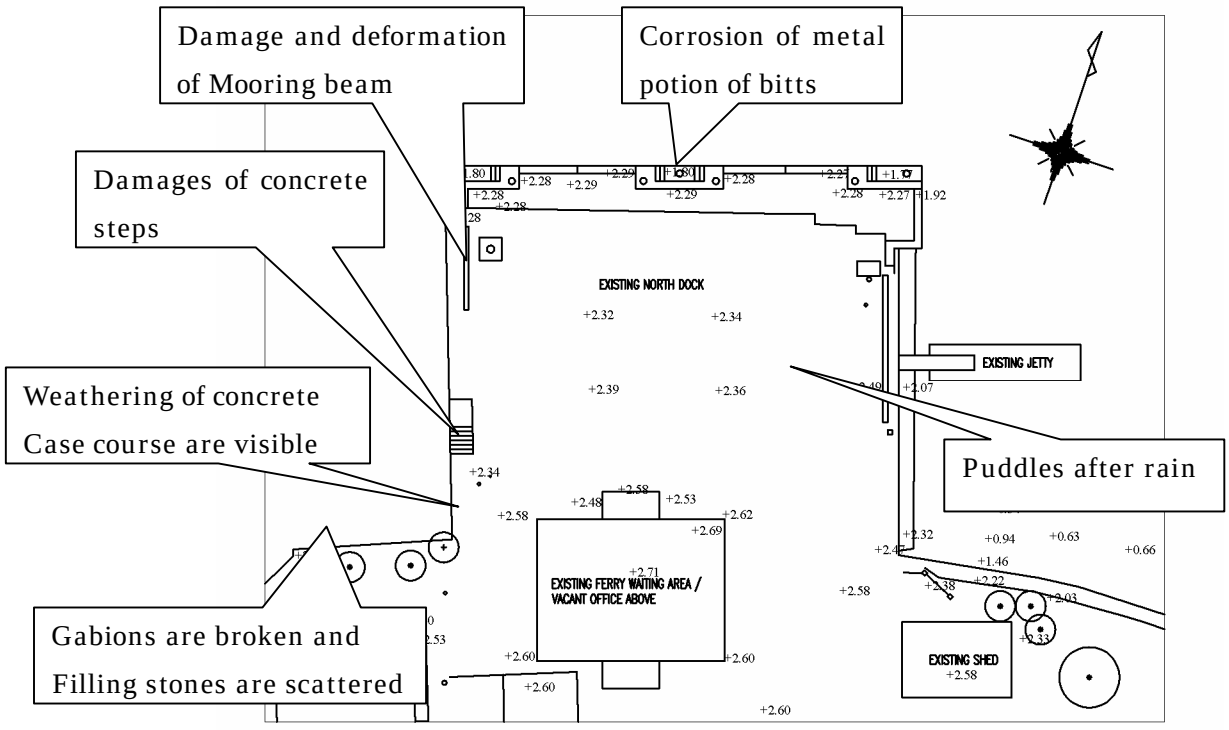


Figure A.6.3.3-1 Structural conditions in North Dock

Corrosion of metal portion of Bitts

Damages of concrete at west side pier

Damages of concrete at west side steps of pier

Damage and deformation of Mooring beam

Paddles at apron after raining

Gabions are broken and filling stones are scattered

Appendix 6-3-4. Results of Onboard Investigation of Peleliu State's Vessels

The study team performed onboard investigation on Peleliu State's vessel (ODESANGEL_DIL) on 22nd August 2005. Conditions of vessel movement and access channel and channel Navigation aids beacon are observed. Results are described as below.

22nd August

10:55	Engine start, Depart Malakal Port, Koror (25 passengers)
11:00～11:15	Turn half and down ramp
	Load 2 cars and cargoes
11:20	Depart again
11:23	Full speed at offshore of Malakal
11:35	Pass Malakal channel 24km/h
13:11	Passes channel mouth of Peleliu
	Passes Navigation Pole No.2（11km/h）
	Passes Navigation Pole No.6（6km/h）
	Passes Navigation Pole No.14（4km/h）
13:40	Passes Navigation Pole No.16（3km/h）,minimum speed
	Passes Navigation Pole No.20（7km/h）
13:50	Down ramp at natural ramp-way.
13:55	Unload 2 cars and cargoes.
14:05	Passes North Dock and turn anti-clockwise.
14:08	Arrived at North Dock
	Embarkation of passengers、unloading of cargoes (collection of tolls)
15:00 (approx.)	Finish unloading

Appendix 6-3-5. Results of Basic Information Survey in Peleliu State

(1) Working Forces and Life Goods

The number of residents of Peleliu is about 500. Working force are about 200 persons.

Working places are local government, fishing corporative, power plant, construction industry, forestry, a sight-seeing farm, markets etc. working rate is about 35 to 40%. Others earn by fishing and farming.

Resource of life goods are following.

Table A.6.3.5(1)-1 Resource of Life Goods

Item	Resource percentage from Koror	Resource percentage from Peleliu
Residence		
Lumber	90%	10%
Concrete block	100%	
Others	1) 100%	
Clothing	100%	
Food		
Rice	100%	
Bread	100%	
Taro		100%
Meat	2) 100%	
Eggs	100%	
Vegetables	50%	50%
Fruites	30%	70%
Processed food	Almost 100%	
Energy, water		
Water,electlicity		3) 100%
Gas forstove	100%（LPG）	
Kerosineforstove	100%	
Firewood, Husk of coconut		100%
Others (electrical appliance)	Almost100%	

1) construction of private home was done by own.
2) feeding pigs are done but not processing
3) kerosene for power plant are transferred form Koror in rate of 100%

(2) Traffic situation

1) Situation of ship trailers

Peleliu state government confirmed that there are 11 ship trailers in Peleliu. Consultant also confirmed those and these locations.

2) Vehicles

211 vehicles are registered in Peleliu as follows.

Sedan	110
Pickup	36
Van	35
Terano	14
Dump Truck	6
Jeep	4
Bus	5
Bike	10
Total	211

Vehicles are in down town of Peleliu.

Appendix 6-3-6. Records of Power cut in Peleliu State

Figure A.6.3.6-1 Power off records in Peleliu State

Year	Month/ date	Contents	Power off duration time
2003	3/6	Ground fault (3 phases lines fault)	1hour
	3/22	Ground fault	50minutes
	3/25	Ground fault	40minutes
	7/19	Ground fault	1hour 40minutes
	7/20	Leak of control box.	40minutes
	9/29	fault from line C only	1hour 30minutes
	9/30	fault from line C only	30minutes
	10/12	Ground fault	11hours 26minutes
2004	2/23	Ground fault	27minutes
	2/27	Ground fault	55minutes
	3/6	Ground fault	37minutes
	3/10	Ground fault	3minutes
	3/15	Ground fault	40minutes
	3/18	Pine trees fall down and cut lines.	7hours15minutes
	6/14	Ground fault	11hours22minutes
	9/17	Ground fault	3minutes
	12/31	Low voltage	1hour10minutes
2005	2/29	Lines fault	2hours
	3/5	Ground fault	15 minutes
	3/12	Ground fault	5minutes
	3/15	Ground fault	8hours
	3/17	Ground fault	8minutes
	3/23	Ground fault	55minutes
	5/11	Ground fault	22minutes
	5/23	Ground fault	5minutes
	5/25	Ground fault	3minutes
	5/30	Ground fault	4hours30minutes
	6/21	Ground fault	1 hour15minutes
	6/28	Ground fault	7minutes
	7/15	Ground fault	45minutes
	7/18	Ground fault	14hours

Appendix 6-3-7. Reports of Medical Conditions in Peleliu State

Super Dispensary is in north part of Peleliu Dr. Ishmael Togamae is only one person (no nurse) of this dispensary since March 2001. There are four beds but no hospitalization system. A nurse of Belau National Hospital comes to help him once a month.

In the dispensary doctor's fee is not charged. 10 days medicine fee is 1 US$ per 1 type medicine.

There are many electric treatment machines and pharmacy machines in dispensary. Backup generator is not setup.

Dr. Togamae treats 4 to 12 patients per day. Table a.6.3.7-1 shows the treatment condition in super dispensary. In case of urgent he transfers and attends patients to Koror (ones a month). He also transfer patient (no attend) once or twice a month

Transportation of patients from Peleliu to Koror is done by speed boat of Marine Enforcement Division in Peleliu State Government. Japanese Grant aid project of supply of ambulance boat is planned now.

Table A.6.3.7-1 Patients Consultation

Disease	2004											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ear, Nose, Throat	53	30	22	17	22	25	42	49	46	15	16	13
Eye	3	5	5	4	7	4	8	9	10	12	3	3
Resp	86	56	32	52	65	55	45	159	53	40	32	42
GIT	38	14	9	11	14	12	41	31	24	18	6	11
Cardiac & Vascular Surgery	0	0	2	2	0	2	6	0	0	0	0	0
GUT	5	5	3	0	5	5	5	5	4	3	1	1
Skeletal	14	16	9	13	11	12	14	19	17	10	8	8
Skin/SQ	25	12	24	20	41	43	55	20	26	9	18	13
CNS	6	7		7	7	2	8	5	4	2	2	3
Injury	10	8	6	6	6	16	12	9	7	3	8	2
Infect	0	0	0	0	0	0	0	2	0	0	3	0
Other problem	21	27	19	10	8	18	11	27	17	9	15	17
Diabetic High tension	3	1	0	0	0	2	1	0	0	0	1	1
Non Urgent ref	2	2	2	0	2	2	3	0	1	1	1	2
Urgent Ref*	31	31	29	21	21	57	60	63	42	2	41	9
Total	297	214	162	163	209	255	311	398	251	124	155	125

Resp:- Problems/Diagnosis associated with the respiratory system that includes viral Acute Upper respiratory infection, asthma, COPD, pneumonia and other ill defined symptoms.

GIT:- gastrointestinal system, including diarrhea, abdominal pains, gastritis, ulcers etc.

GUT:- Urinary system.

Skeletal:- Includes all joint problems

Skin:- includes skin infection, boils etc.

CNS:- The central nervous system, usually headaches only.

Injuries:- includes fractures, lacerations and soft tissue injury.

Chronic: DM(Diabetes Mellitus),HTN(Hipper Tension) and others

Referrals: Urgent cases, Non Urgent cases

Total pt:- Total Patients seen.

Patients usually present with more than one diagnosis.

** Of all Urgent referral cases 5 cases were injury related(Chest and Head injury)*

Appendix 6-4. Relevant Information of Planning and Designing of the Facility
Appendix 6-4-1. Relation between Tidal Change and Cross-section of Ramp-way

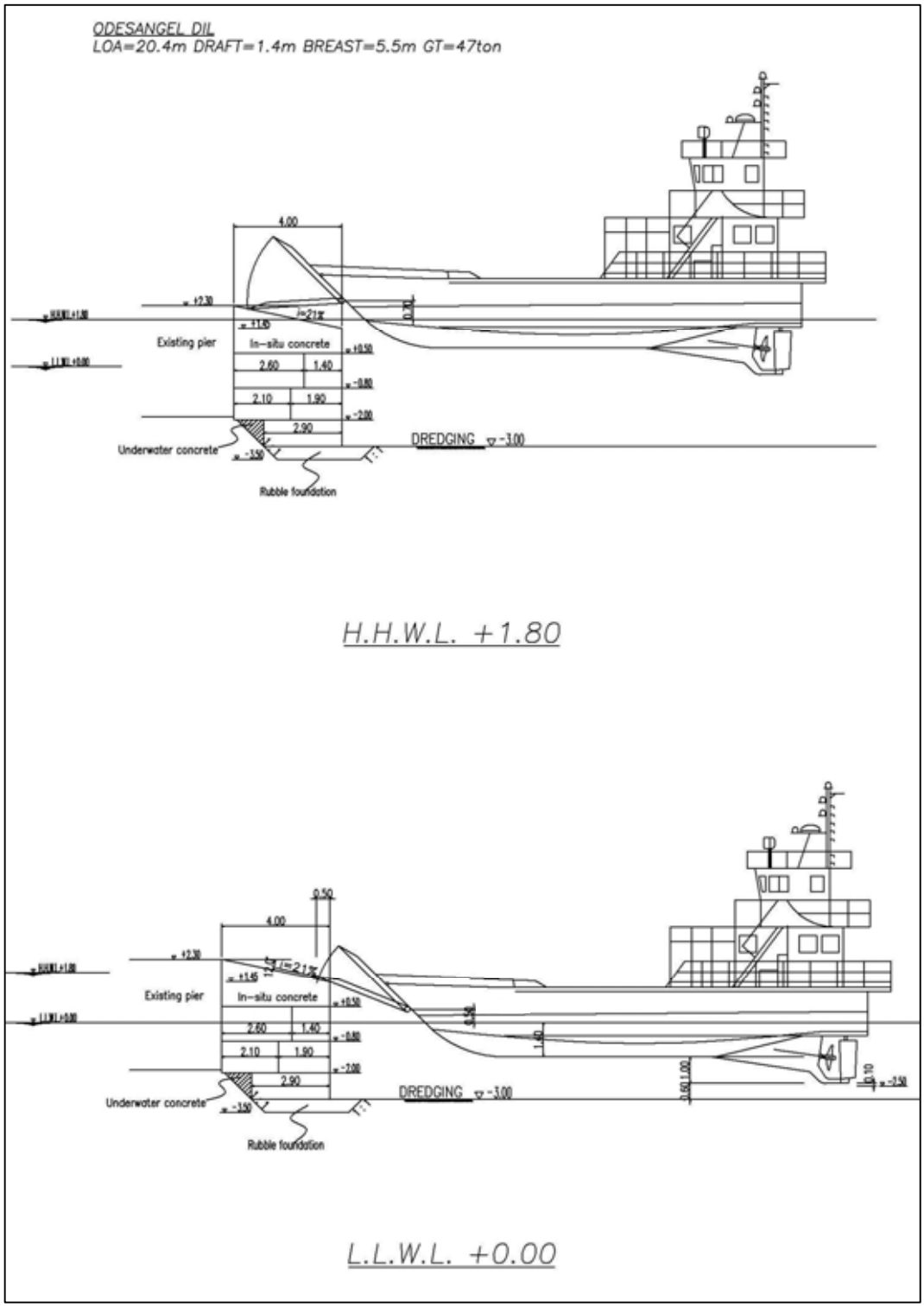


Figure A 6.4.1-1 Case Study of RoRo Ramp Operation in High and Low Tide

Points of the structural study of ramp-way are described below.
1. Length of ramp-way will be shorter as possible to keep whole reclaimed area within the boundary fences.
2. Angle of ramp-way will be designed to be able to load the vehicles by its drive even in low tide.
3. Avoid the design which make the steep bump to hit the vehicle bottom.
4. Mitigation slope on the top area of ramp-way will be installed to secure the smooth access of the self driven vehicle.
5.Surfacing of ramp-way will be anti-slip finishing which can be constructed at the site.

Appendix 6-4-2. Study of Depth in the Access Channel

(1) Calculation of run days by water depth

Navigable days of ODESANGEL_DIL (per month) are calculated by tide table in 2005.

Conditions of calculation are as follows.

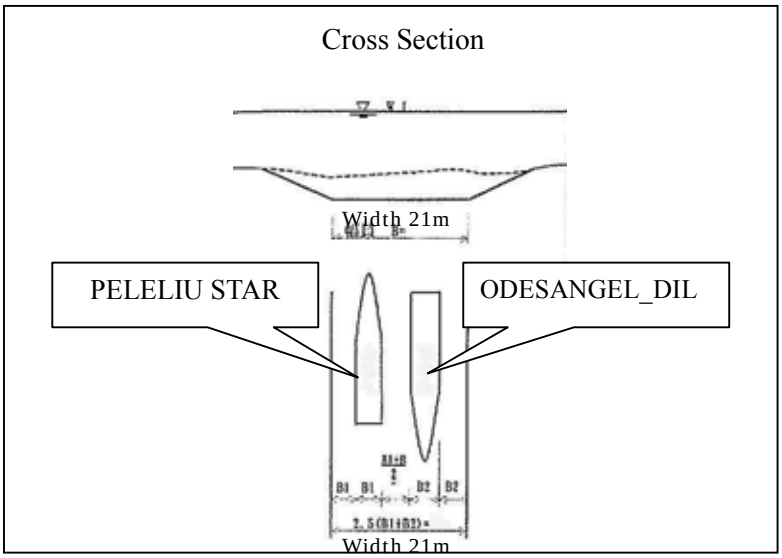
Design vessel : ODESABGEL_DIL

Draft : 1.4m

: Depth from bottom of vessel to tip of keel: 1.0m

: vertical dimension of vessel under water＝1.4＋1.0＝2.40m

Width of access channel: fixed by added width of ODESANGEL_DIL and PELELIU STAR, (5.5+3) × 2.5=21.25　21m



FigureA.6.4.2(1)-1 Setting of Width of Access Channel

At the point of access channel near Navigation Pole No.16R and No.20, the angular bend is to be loosened.

In Japanese standard for fisheries port in 2003, clearance of depth of access channel is fixed as 1m in stiff sea bed condition.

Relationship of water depth after dredging and navigable days of vessel is studied adopting above conditions. The results are described below.

Navigable days of vessel are increase sharply to 27 days in average at water depth of 2m and that is about 2 times at 1.5m.

Navigable days at less than 1.5m are about 7 days. Water depth of access channel is required over 2.0m in consideration of following results.

Table A.6.4.2(1)-1 Relationship between Navigable Days and Water Depth (2005)

depth	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Run days	%
-1.2m	0	0	0	5	1	2	5	5	11	11	4	0	44	12
-1.5	20	15	17	18	18	15	16	17	19	20	22	21	218	60
-2.0	29	28	31	27	29	24	24	24	24	26	27	30	323	88
-2.5	31	28	31	29	30	24	25	25	29	28	30	31	341	93
-3.0	31	28	31	30	31	29	29	31	30	31	30	31	362	99

(2) Calculation of Dredging Volume by Water Depth

Relationship between dredging depth and dredging volume is calculated as follows.

Table A.6.4.2(2)-1 Relationship between Dredging Water Depth and Dredging Volume

Depth	Width of Channel	Dredging Volume(m^3) (Design depth DL-1.5m)	Dredging Volume by Water Depth(m^3)*	Dredging Volume at Sand Trap (m^3)	Total(m^3)
- 1.5m	15m (Present Condition)	14,000			14,000
- 2.0m	21m	14,000	17,500		31,500
- 2.0m	21m	14,000	17,500	6,300	37,800
- 2.5m	21m	14,000	40,000		54,000
- 3.0m	21m	14,000	67,500		81,500

(*：Length of dredging area is assumed as 5,000m.)

Dredging volume at the water depth of -2.0m is 31,500 m^3 in total consist of depositing sand of 14,000m^3 and new dredging volume of 17,500 m^3.

In addition, it is planned to dredged up to 2.5m as sand traps to alleviate the future depositing in the vicinity of navigation poles No.10, 16, 20, 22 and 24 and North-Eastern cape of Peleliu State. Because depositing sand was found significantly in above areas. Total dredging volume will be 37,800m^3 as a whole.

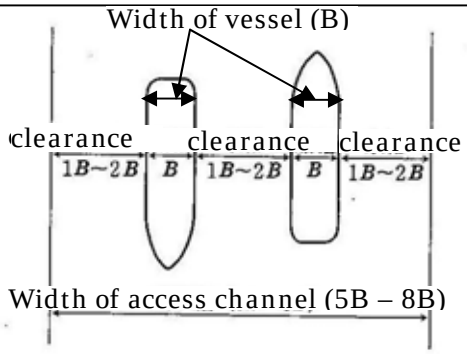
It is confirmed that some rocky seabed is located southern side of navigation Pole No.16 to No.18 and southern side of No.20. Rocky seabed is clearly found at depth of over 3m. It will be difficult to dredge the depth deeper than 2.5m since the dredging cost and period will become huge.

Temporary dumping yard is located at 50m south east of North Dock with 19,000 m^2 however, this area is covered with trees at present and there is a limitation of the usage as shown in following photo.

Area for Dredging Sand Depositing

Appendix 6-4-3. Study of Width in the Access Channel

(1) Design Method of width of Access Channel by “Design Standard for Fishing Port”.
1) Design method of width of access channel



Design method of width of access channel

(Reference: “Guidance for Fishing Port and Fishing Ground”)

FigureA.6.4.3(1)-1 Design Policy of Width of Access Channel

2) Study example by using maximum size vessel
In Kayangel Project, width of access channel is designed 20m (approximate 5B= 5*4.05m=20.5m) by using width of maximum size vessel (B=4.05m).

3) Study example by using maximum size and second largest size vessel
In Peleliu Project in 1998, width of access channel is designed 15m (2.5(B1+B2)=2.5(3.4+2.6)=15.0m) by using width of maximum size (B1=3.4m) and second largest vessel (B2=2.6m).

4) Study of this project
In this study, width of access channel is designed using width of maximum size vessel of ODESANGEL_DIL and second largest vessel of PELELIU STAR. Width is calculated 21m ((5.5+3)*2.5=21.25 =approximate 21m).

(2) Another condition
1) Design Method for Port and Harbor
In Japanese standard for port and harbor, design method width of access channel is described as below.

Table A.6.4.3(2)-1 Design Policy of Width of Access Channel

Length of access channel	Condition of Vessel Navigation	Width (L=LOA)
Longer channel	Frequency of intersection of vessel is high	2L
	Frequency of intersection of vessel is low	1.5L
Other channel	Frequency of intersection of vessel is high	1.5L
	Frequency of intersection of vessel is low	1L

(reference：”Design Standard for Port and Harbor”)

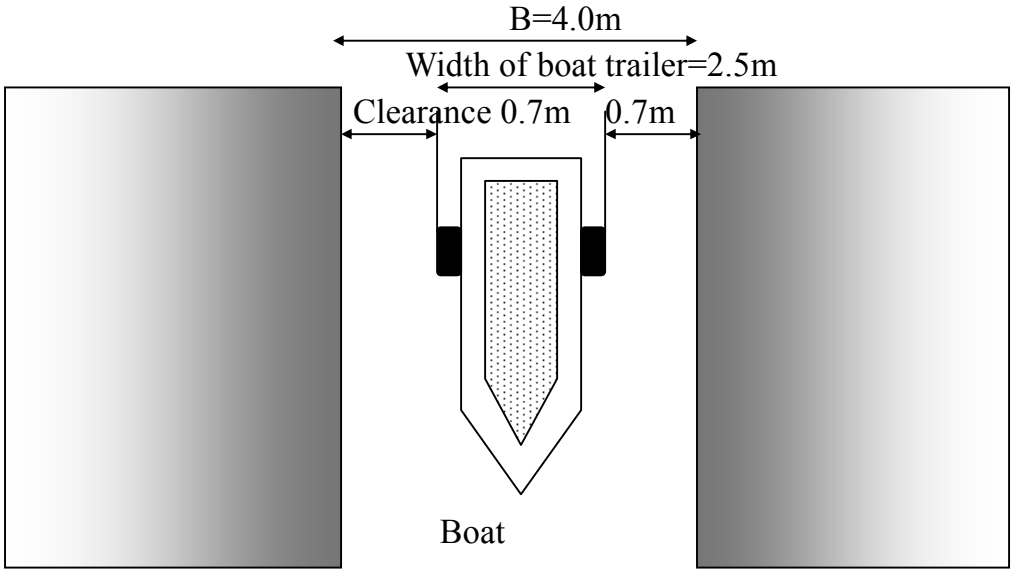
Width of access channel is calculated as approximate 20m (LOA of ODESANGEL_DIL is 20.4m).

2) Current across the Channel

In the site survey by using float, current across the channel with current speed of over 0.5m/s is observed. In this condition running vessel is dangerous to change her position as vertical to the channel. Therefore, the width of access channel is planned to exceed the length of vessel as 21 m.

Appendix 6-4-4. Study of Length and Width of Slipway
Width of slipway: width of slipway is designed based on the following conditions.

Maximum width of vessel ：7Ft (1Ft×0.305m　2.2m)---2.2m（vessel of Peleliu State）
* width of ship trailer (including wheel)：8Ft (1Ft×0.305m　2.5m)---2.5m
* clearance for operation : 0.7m for both sides ---1.4m
* width of slipway is calculated as below
Width of slipway =width of vessel + width of ship trailer + clearance for operation of both sides＝2.5m＋1.4m　4.0m.



FigureA.6.4.4-1 Design Layout of Slipway

Scale of extending pier is limited due to the limitation of public space in the vicinity of North Dock. Therefore, length of slipway including flat reclaimed area is 29m only.
Angle of slipway is planned as 1:6 according to Japan's Fisheries Standard.
Longitude of slipway is planned as 22.8m. Layout plan of slipway is shown in Figure A.6.4.4-2.

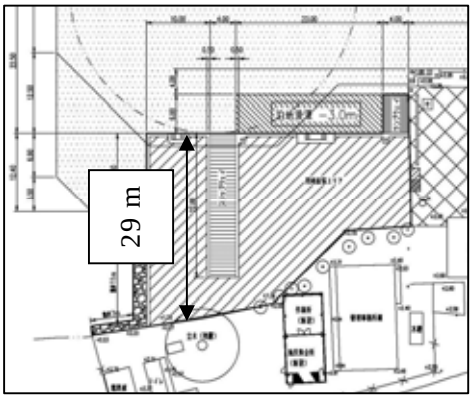


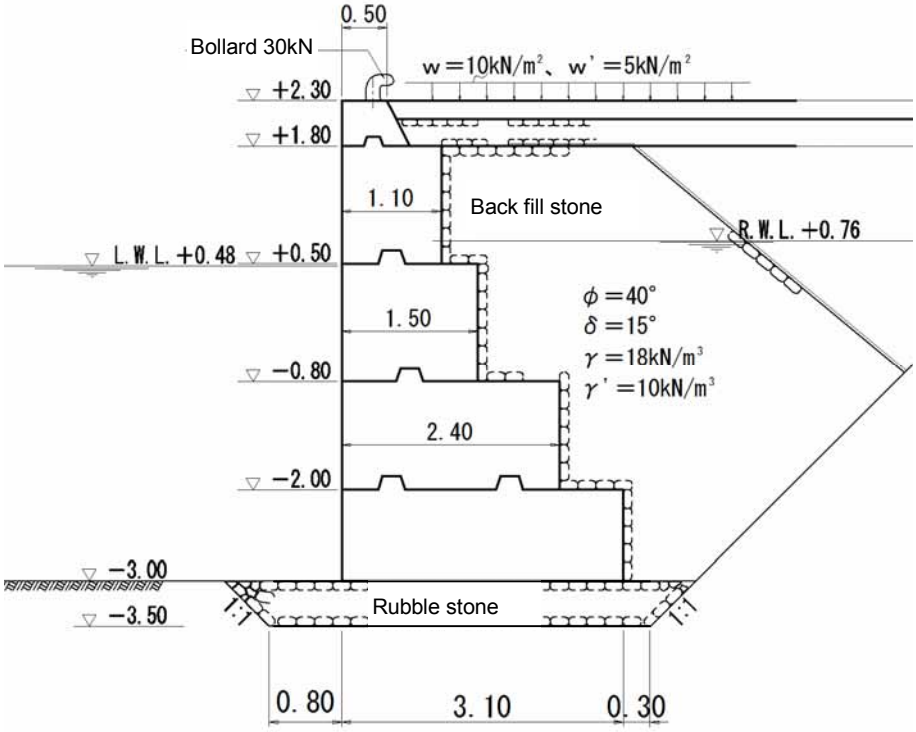
Figure A.6.4.4-2 Layout of Slipway

Boat sliding timbers and winches are not planned, because boats are hauled up by vehicle and boat trailer. There will be non-slip surfacing on the slipway. Angle of slope shoulder will be mitigated by easement slope, if necessary.

6-4-5 Structural Calculation Results of Berth

(1) -3.0m Berth

1) Cross section of the stability check



・Surcharge Load

Normal conditions 10kN/m^2 , Seismic Conditions 5kN/m^2

・Design Seismic Coefficient

Horizontal seismic coefficient Air k＝0.10

Underwater k'＝0.20

・Residual Water Level

R.W.L.＋0.76

・Check Level

Design calculation will be carried out following elevation

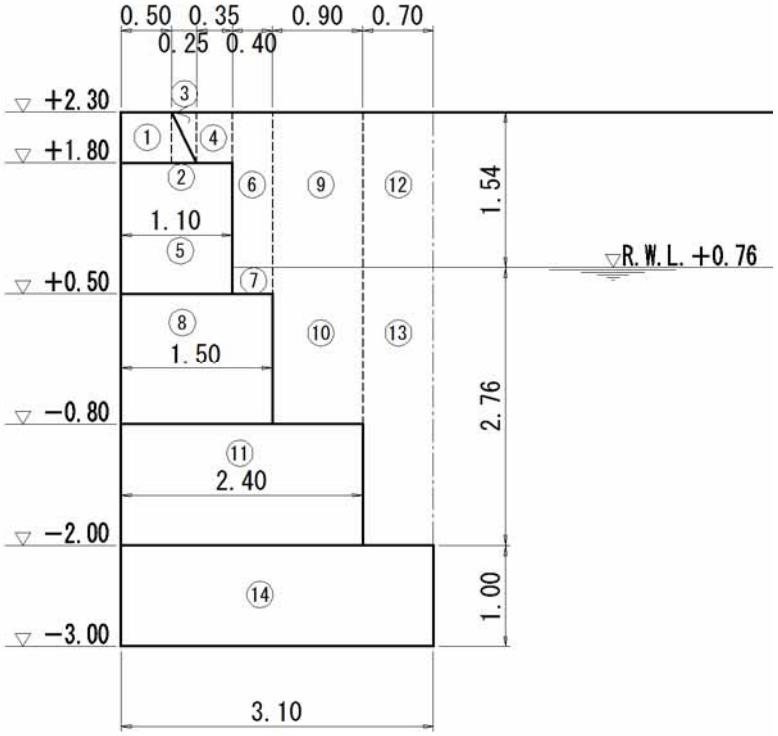
＋0.50m level

－0.80m level

－2.00m level

－3.00m level

2) Deadweight of the wall



・Self weight of block wall

	W (kN/m)		x (m)	y (m)	Wx (kN・m/m)	Wy (kN・m/m)
①	0.50 × 0.50 × 23.0	5.75	0.25	1.55	1.44	8.91
②	1/2 × 0.25 × 0.50 × 23.0	1.44	0.58	1.47	0.84	2.12
③	1/2 × 0.25 × 0.50 × 18.0	1.13	0.67	1.63	0.76	1.84
④	0.35 × 0.50 × 18.0	3.15	0.93	1.55	2.91	4.88
⑤	1.10 × 1.30 × 23.0	32.89	0.55	0.65	18.09	21.38
total	+0.50m	44.36	0.54193	0.88210	24.04	39.13
—		44.36	0.54193	2.18210	24.04	96.80
⑥	0.40 × 1.54 × 18.0	11.09	1.30	2.33	14.42	25.84
⑦	0.40 × 0.26 × 20.0	2.08	1.30	1.43	2.70	2.97
⑧	1.50 × 1.30 × 23.0	44.85	0.75	0.65	33.64	29.15
total	-0.80m	102.38	0.73061	1.51162	74.80	154.76
—		102.38	0.73061	2.71162	74.80	277.62
⑨	0.90 × 1.54 × 18.0	24.95	1.95	3.53	48.65	88.07
⑩	0.90 × 1.56 × 20.0	28.08	1.95	1.98	54.76	55.60
⑪	2.40 × 1.20 × 23.0	66.24	1.20	0.60	79.49	39.74
total	-2.00m	221.65	1.16264	2.07999	257.70	461.03
—		221.65	1.16264	3.07999	257.70	682.68
⑫	0.70 × 1.54 × 18.0	19.40	2.75	4.53	53.35	87.88
⑬	0.70 × 2.76 × 20.0	38.64	2.75	2.38	106.26	91.96
⑭	3.10 × 1.00 × 23.0	71.30	1.55	0.50	110.52	35.65
total	-3.00m	350.99	1.504	2.559	527.83	898.17

3) Buoyancy

Buoyancy will be considered below R.W.L.＋0.76m

・＋0.50m level

U＝1.10×0.26×10.1＝2.89kN/m

Ux＝2.89×1/2×1.10＝1.59kN・m/m

・－0.80m level

U＝1.50×1.56×10.1＝23.63kN/m

Ux＝23.63×1/2×1.50＝17.72kN・m/m

・－2.00m level

U＝2.40×2.76×10.1＝66.90kN/m

Ux＝66.90×1/2×2.40＝80.28kN・m/m

・－3.00m level

U＝3.10×3.76×10.1＝117.73kN/m

Ux＝117.73×1/2×3.10＝182.48kN・m/m

4) Earth Pressure

(a) Horizontal Earth Pressure

a) Normal conditions

$p_a = k a \cos\delta \cdot (\Sigma\gamma h + w)$, $w = 10 kN/m^2$

Elevation (m)	Soil Layer φ (°)	δ (°)	γ (kN/m³)	thickness h (m)	Σγh (kN/m²)	Σγh+q (kN/m²)	k or k'	ka·cosδ	p_a (kN/m²)
+2.30						10.00	0.00	0.1942	1.94
	40	15	18.0	1.54	27.72				
+0.76						37.72	0.00	0.1942	7.33
						37.72	0.00	0.1942	7.33
	40	15	10.0	0.26	2.60				
+0.50						40.32	0.00	0.1942	7.83
						40.32	0.00	0.1942	7.83
	40	15	10.0	1.30	13.00				
-0.80						53.32	0.00	0.1942	10.35
						53.32	0.00	0.1942	10.35
	40	15	10.0	1.20	12.00				
-2.00						65.32	0.00	0.1942	12.69
						65.32	0.00	0.1942	12.69
	40	15	10.0	1.00	10.00				
-3.00						75.32	0.00	0.1942	14.63

b) Seismic conditions

$p_a = k a \cos\delta \cdot (\Sigma\gamma h + w')$, $w' = 5 kN/m^2$

Elevation (m)	Soil Layer φ (°)	δ (°)	γ (kN/m³)	Thickness h (m)	Σγh 6	Σγh+q (kN/m²)	k or k'	ka·cosδ	p_a (kN/m²)
+2.30						5.00	0.10	0.2444	1.22
	40	15	18.0	1.54	27.72				
+0.76						32.72	0.10	0.2444	8.00
						32.72	0.20	0.3060	10.01
	40	15	10.0	0.26	2.60				
+0.50						35.32	0.20	0.3060	10.81
						35.32	0.20	0.3060	10.81
	40	15	10.0	1.30	13.00				
-0.80						48.32	0.20	0.3060	14.79
						48.32	0.20	0.3060	14.79
	40	15	10.0	1.20	12.00				
-2.00						60.32	0.20	0.3060	18.46
						60.32	0.20	0.3060	18.46
	40	15	10.0	1.00	10.00				
-3.00						70.32	0.20	0.3060	21.52

(b) Resultant earth pressure (Horizontal)

a) Normal conditions

Division	Pa (kN/m)		y (m)	Pa・y (kN・m/m)
①	1/2 × 1.94 × 1.54	1.49	1.29	1.92
②	1/2 × 7.33 × 1.54	5.64	0.77	4.34
③	1/2 × 7.33 × 0.26	0.95	0.17	0.16
④	1/2 × 7.83 × 0.26	1.02	0.09	0.09
total	+0.50 m	9.10	0.7154	6.51
		9.10	2.0154	18.34
⑤	1/2 × 7.83 × 1.30	5.09	0.87	4.43
⑥	1/2 × 10.35 × 1.30	6.73	0.43	2.89
total	-0.80 m	20.92	1.2266	25.66
		20.92	2.4266	50.76
⑦	1/2 × 10.35 × 1.20	6.21	0.80	4.97
⑧	1/2 × 12.69 × 1.20	7.61	0.40	3.04
total	-2.00 m	34.74	1.6917	58.77
		34.74	2.6917	93.51
⑨	1/2 × 12.69 × 1.00	6.35	0.67	4.25
⑩	1/2 × 14.63 × 1.00	7.32	0.33	2.42
total	-3.00 m	48.41		100.18

b) Seismic conditions

Division	Pa (kN/m)		y (m)	Pa・y (kN・m/m)
①	1/2 × 1.22 × 1.54	0.94	1.29	1.21
②	1/2 × 8.00 × 1.54	6.16	0.77	4.74
③	1/2 × 10.01 × 0.26	1.30	0.17	0.22
④	1/2 × 10.81 × 0.26	1.41	0.09	0.13
total	+0.50 m	9.81	0.6422	6.30
		9.81	1.9422	19.05
⑤	1/2 × 10.81 × 1.30	7.03	0.87	6.12
⑥	1/2 × 14.79 × 1.30	9.61	0.43	4.13
total	-0.80 m	26.45	1.1078	29.30
		26.45	2.3078	58.60
⑦	1/2 × 14.79 × 1.20	8.87	0.80	7.10
⑧	1/2 × 18.46 × 1.20	11.08	0.40	4.43
total	-2.00 m	46.40	1.5114	70.13
		46.40	2.5114	116.53
⑨	1/2 × 18.46 × 1.00	9.23	0.67	6.18
⑩	1/2 × 21.52 × 1.00	10.76	0.33	3.55
total	-3.00 m	66.39		126.26

(c) Resultant earth pressure (Vertical)

$P_v = P_a \cdot \tan\delta$ (kN/m)

$P_v \cdot X = P_v \cdot B$ (kN·m/m)

a) Normal conditions

Eleveation	Pa (kN/m)	Pv (kN/m)	B (m)	Pv·X (kN·m/m)
+0.50 m	9.10	2.44	1.10	2.68
-0.80 m	20.92	5.61	1.50	8.42
-2.00 m	34.74	9.31	2.40	22.34
-3.00 m	48.41	12.97	3.10	40.21

b) Seismic conditions

Eleveation	Pa (kN/m)	Pv (kN/m)	B (m)	Pv·X (kN·m/m)
+0.50 m	9.81	2.63	1.10	2.89
-0.80 m	26.45	7.09	1.50	10.64
-2.00 m	46.40	12.43	2.40	29.83
-3.00 m	66.39	17.79	3.10	55.15

(d) Resultant residual water pressure

a) ＋0.50m level

hw＝0.26m(R.W.L.＋0.76m～＋0.50m)

$p_w = \gamma w \cdot hw = 10.1 kN/m^3 \times 0.26m = 2.63 kN/m^2$

$P_w = 1/2 \times 2.63 \times 0.26 = 0.34 kN/m$

$M_{Pw} = 0.34 \times 1/3 \times 0.26 = 0.03 kN \cdot m/m$

b) －0.80m level

hw＝0.28m(R.W.L.＋0.76m～L.W.L.＋0.48m)

$p_w = \gamma w \cdot hw = 10.1 kN/m^3 \times 0.28m = 2.83 kN/m^2$

$P_w = 1/2 \times 2.83 \times 0.28 + 2.83 \times 1.28 = 0.40 + 3.62 = 4.02 kN/m$

$M_{Pw} = 0.40 \times (1/3 \times 0.28 + 1.28) + 3.62 \times 1/2 \times 1.28 = 2.87 kN \cdot m/m$

c) －2.00m level

$P_w = 1/2 \times 2.83 \times 0.28 + 2.83 \times 2.48 = 0.40 + 7.02 = 7.42 kN/m$

$M_{Pw} = 0.40 \times (1/3 \times 0.28 + 2.48) + 7.02 \times 1/2 \times 2.48 = 9.73 kN \cdot m/m$

d) -3.00m level

$P_w = 1/2 \times 2.83 \times 0.28 + 2.83 \times 3.48 = 0.40 + 9.85 = 10.25 kN/m$

$M_{Pw} = 0.40 \times (1/3 \times 0.28 + 3.48) + 9.85 \times 1/2 \times 3.48 = 18.57 kN \cdot m/m$

5) Surcharge load which acting wall body portion

· Surcharge Load Normal condition $10kN/m^2$, Seismic condition $5kN/m^2$

Checking Elevation	Load condition	q (kN/m)			x (m)	y (m)	qx (kN·m/m)	qy (kN·m/m)
+0.50m	Nomal	10.00 ×	1.10	11.00	0.55	1.80	6.05	19.80
	Seismic	5.00 ×	1.10	5.50	0.55	1.80	3.03	9.90
-0.80m	Nomal	10.00 ×	1.50	15.00	0.75	3.10	11.25	46.50
	Seismic	5.00 ×	1.50	7.50	0.75	3.10	5.63	23.25
-2.00m	Nomal	10.00 ×	2.40	24.00	1.20	4.30	28.80	103.20
	Seismic	5.00 ×	2.40	12.00	1.20	4.30	14.40	51.60
-3.00m	Nomal	10.00 ×	3.10	31.00	1.55	5.30	48.05	164.30
	Seismic	5.00 ×	3.10	15.50	1.55	5.30	24.03	82.15

6) Seismic Load

Design Seismic Coefficient $k = 0.10$

(a) Seismic Load

Checking Elevation	Weight of inertia W(kN/m)	Moment of inertia Wy(kN·m/m)	Seismic Coefficient k	Hw (kN·m/m)	Hwy (kN·m/m)
+0.50m	44.36	39.13	0.10	4.44	3.91
-0.80m	102.38	154.76	0.10	10.24	15.48
-2.00m	221.65	461.03	0.10	22.17	46.10
-3.00m	350.99	898.17	0.10	35.10	89.82

(b) Seismic Load for Surcharge Load

Checking Elevation	Weight of inertia W(kN/m)	Moment of inertia Wy(kN·m/m)	Seismic Coefficient k	Hw (kN·m/m)	Hwy (kN·m/m)
+0.50m	5.50	9.90	0.10	0.55	0.99
-0.80m	7.50	23.25	0.10	0.75	2.33
-2.00m	12.00	51.60	0.10	1.20	5.16
-3.00m	15.50	82.15	0.10	1.55	8.22

7) Mooring force

Mooring force will be considered based on the deployment of bollards at 5m interval

$H_o = 30kN/5.00m = 6.00kN/m$

Elevation	Mooring force Ho(kN/m)	y (m)	$H_o y$ (kN·m/m)
+0.50m	6.00	1.95	11.70
-0.80m	6.00	3.25	19.50
-2.00m	6.00	4.45	26.70
-3.00m	6.00	5.45	32.70

8) External forces and loads acting on the walls

(a) Normal conditions

			Normal conditions			
			Resultant force (kN/m)		Moment (kN･m/m)	
			Horizontal	Vertical	Overturning	Resisting
+0.50m	Active earth pressure		9.10	2.44	6.51	2.68
	Residual water pressure		0.34		0.03	
	Self weight of block wall			44.36		24.04
	Buoyancy			-2.89		-1.59
	Mooring force					
	Surcharge load			11.00		6.05
	Total	surcharge	9.44	54.91	6.54	31.18
		Unsurcharge	9.44	43.91	6.54	25.13
-0.80m	Active earth pressure		20.92	5.61	25.66	8.42
	Residual water pressure		4.02		2.87	
	Self weight of block wall			102.38		74.80
	Buoyancy			-23.63		-17.72
	Mooring force					
	Surcharge load			15.00		11.25
	Total	surcharge	24.94	99.36	28.53	76.75
		Unsurcharge	24.94	84.36	28.53	65.50
-2.00m	Active earth pressure		34.74	9.31	58.77	22.34
	Residual water pressure		7.42		9.73	
	Self weight of block wall			221.65		257.70
	Buoyancy			-66.90		-80.28
	Mooring force					
	Surcharge load			24.00		28.80
	Total	surcharge	42.16	188.06	68.50	228.56
		Unsurcharge	42.16	164.06	68.50	199.76
-3.00m	Active earth pressure		48.41	12.97	100.18	40.21
	Residual water pressure		10.25		18.57	
	Self weight of block wall			350.99		527.83
	Buoyancy			-117.73		-182.48
	Mooring force					
	Surcharge load			31.00		48.05
	Total	surcharge	58.66	277.23	118.75	433.61
		Unsurcharge	58.66	246.23	118.75	385.56

(b) Berthing conditions

			Berthing condition			
			Resultant force (kN/m)		Moment (kN･m/m)	
			Horizontal	Vertical	Overturning	Resisting
+0.50m	Active earth pressure		9.10	2.44	6.51	2.68
	Residual water pressure		0.34		0.03	
	Self weight of block wall			44.36		24.04
	Buoyancy			-2.89		-1.59
	Mooring force		6.00		11.70	
	Surcharge load			11.00		6.05
	Total	surcharge	15.44	54.91	18.24	31.18
		Unsurcharge	15.44	43.91	18.24	25.13
-0.80m	Active earth pressure		20.92	5.61	25.66	8.42
	Residual water pressure		4.02		2.87	
	Self weight of block wall			102.38		74.80
	Buoyancy			-23.63		-17.72
	Mooring force		6.00		19.50	
	Surcharge load			15.00		11.25
	Total	surcharge	30.94	99.36	48.03	76.75
		Unsurcharge	30.94	84.36	48.03	65.50
-2.00m	Active earth pressure		34.74	9.31	58.77	22.34
	Residual water pressure		7.42		9.73	
	Self weight of block wall			221.65		257.70
	Buoyancy			-66.90		-80.28
	Mooring force		6.00		26.70	
	Surcharge load			24.00		28.80
	Total	surcharge	48.16	188.06	95.20	228.56
		Unsurcharge	48.16	164.06	95.20	199.76
-3.00m	Active earth pressure		48.41	12.97	100.18	40.21
	Residual water pressure		10.25		18.57	
	Self weight of block wall			350.99		527.83
	Buoyancy			-117.73		-182.48
	Mooring force		6.00		32.70	
	Surcharge load			31.00		48.05
	Total	surcharge	64.66	277.23	151.45	433.61
		Unsurcharge	64.66	246.23	151.45	385.56

(c) Seismic conditions

			Seismic conditions			
			Resultant force (kN/m)		Moment (kN・m/m)	
			Horizontal	Vertical	Overturning	Resisting
+0.50m	Active earth pressure		9.81	2.63	6.30	2.89
	Residual water pressure		0.34		0.03	
	Self weight of block wall		4.44	44.36	3.91	24.04
	Buoyancy			-2.89		-1.59
	Mooring force					
	Surcharge load		0.55	5.50	0.99	3.03
	Total	surcharge	15.14	49.60	11.23	28.37
		Unsurcharge	14.59	44.10	10.24	25.34
-0.80m	Active earth pressure		26.45	7.09	29.30	10.64
	Residual water pressure		4.02		2.87	
	Self weight of block wall		10.24	102.38	15.48	74.80
	Buoyancy			-23.63		-17.72
	Mooring force					
	Surcharge load		0.75	7.50	2.33	5.63
	Total	surcharge	41.46	93.34	49.98	73.35
		Unsurcharge	40.71	85.84	47.65	67.72
-2.00m	Active earth pressure		46.40	12.43	70.13	29.83
	Residual water pressure		7.42		9.73	
	Self weight of block wall		22.17	221.65	46.10	257.70
	Buoyancy			-66.90		-80.28
	Mooring force					
	Surcharge load		1.20	12.00	5.16	14.40
	Total	surcharge	77.19	179.18	131.12	221.65
		Unsurcharge	75.99	167.18	125.96	207.25
-3.00m	Active earth pressure		66.39	17.79	126.26	55.15
	Residual water pressure		10.25		18.57	
	Self weight of block wall		35.10	350.99	89.82	527.83
	Buoyancy			-117.73		-182.48
	Mooring force					
	Surcharge load		1.55	15.50	8.22	24.03
	Total	surcharge	113.29	266.55	242.87	424.53
		Unsurcharge	111.74	251.05	234.65	400.50

9) Stability check

(a) Stability of Sliding

Safety factor against sliding;

$$F = \frac{\mu \cdot V}{H} \geqq Fa$$

V：total vertical force considering effect of buoyancy (kN/m)

H：total horizontal force applied to the structure (kN/m)

μ：friction coefficient (=0.5 for concrete vs. concrete)

(=0.6 for concrete vs. rock mound)

Allowable safety factor： Normal conditions, Berthing conditions

Fa＝1.2

Seismic conditions Fa＝1.0

a) Normal conditions

Checking Elevation	Load Condition	Normal conditions				
		Vertical load V(kN/m)	Horizontal load H(kN/m)	Coefficient of Friction μ	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	54.91	9.44	0.5	2.91	1.2
	Unsurcharge	43.91	9.44	0.5	2.33	1.2
-0.80m	Surcharge	99.36	24.94	0.5	1.99	1.2
	Unsurcharge	84.36	24.94	0.5	1.69	1.2
-2.00m	Surcharge	188.06	42.16	0.5	2.23	1.2
	Unsurcharge	164.06	42.16	0.5	1.95	1.2
-3.00m	Surcharge	277.23	58.66	0.6	2.84	1.2
	Unsurcharge	246.23	58.66	0.6	2.52	1.2

b) Berthing conditions

Checking Elevation	Load Condition	Berthing conditions				
		Vertical load V(kN/m)	Horizontal load H(kN/m)	Coefficient of Friction μ	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	54.91	15.44	0.5	1.78	1.2
	Unsurcharge	43.91	15.44	0.5	1.42	1.2
-0.80m	Surcharge	99.36	30.94	0.5	1.61	1.2
	Unsurcharge	84.36	30.94	0.5	1.36	1.2
-2.00m	Surcharge	188.06	48.16	0.5	1.95	1.2
	Unsurcharge	164.06	48.16	0.5	1.70	1.2
-3.00m	Surcharge	277.23	64.66	0.6	2.57	1.2
	Unsurcharge	246.23	64.66	0.6	2.28	1.2

c) Seismic conditions

Checking Elevation	Load Condition	Seismic conditions				
		Vertical load V(kN/m)	Horizontal load H(kN/m)	Coefficient of Friction μ	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	49.60	15.14	0.5	1.64	1.0
	Unsurcharge	44.10	14.59	0.5	1.51	1.0
-0.80m	Surcharge	93.34	41.46	0.5	1.13	1.0
	Unsurcharge	85.84	40.71	0.5	1.05	1.0
-2.00m	Surcharge	179.18	77.19	0.5	1.16	1.0
	Unsurcharge	167.18	75.99	0.5	1.10	1.0
-3.00m	Surcharge	266.55	113.29	0.6	1.41	1.0
	Unsurcharge	251.05	111.74	0.6	1.35	1.0

(b) Stability of Overturning

Safety factor against overturning;

$$F = \frac{Mr}{Ma} \geqq Fa$$

Ma: Overturning Moment (kN·m/m)

Mr: Resistance Moment (kN·m/m)

Allowable safety factor: Normal conditions,

Berthing conditions Fa=1.2

Seismic conditions Fa=1.1

a) Normal conditions

Checking Elevation	Load Condition	Normal conditions			
		Resisting Mr(kN·m/m)	Overturning Ma(kN·m/m)	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	31.18	6.54	4.77	1.2
	Unsurcharge	25.13	6.54	3.84	1.2
-0.80m	Surcharge	76.75	28.53	2.69	1.2
	Unsurcharge	65.50	28.53	2.30	1.2
-2.00m	Surcharge	228.56	68.50	3.34	1.2
	Unsurcharge	199.76	68.50	2.92	1.2
-3.00m	Surcharge	433.61	118.75	3.65	1.2
	Unsurcharge	385.56	118.75	3.25	1.2

b) Berthing conditions

Checking Elevation	Load Condition	Berthing conditions			
		Resisting Mr(kN·m/m)	Overturning Ma(kN·m/m)	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	31.18	18.24	1.71	1.2
	Unsurcharge	25.13	18.24	1.38	1.2
-0.80m	Surcharge	76.75	48.03	1.60	1.2
	Unsurcharge	65.50	48.03	1.36	1.2
-2.00m	Surcharge	228.56	95.20	2.40	1.2
	Unsurcharge	199.76	95.20	2.10	1.2
-3.00m	Surcharge	433.61	151.45	2.86	1.2
	Unsurcharge	385.56	151.45	2.55	1.2

c) Seismic conditions

Checking Elevation	Load Condition	Seismic conditions			
		Resisting Mr(kN·m/m)	Overturning Ma(kN·m/m)	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	28.37	11.23	2.53	1.1
	Unsurcharge	25.34	10.24	2.47	1.1
-0.80m	Surcharge	73.35	49.98	1.47	1.1
	Unsurcharge	67.72	47.65	1.42	1.1
-2.00m	Surcharge	221.65	131.12	1.69	1.1
	Unsurcharge	207.25	125.96	1.65	1.1
-3.00m	Surcharge	424.53	242.87	1.75	1.1
	Unsurcharge	400.50	234.65	1.71	1.1

(c) Bottom reaction

Bottom reaction is calculated by the following formula

・x： acting point of resultant force from front toe

$$x = \frac{Mr - Ma}{V}$$

・e： eccentricity of resultant force of V and H (m)

$$e = \frac{B}{2} - x$$

・Bottom reaction

【If $e > B/6$】……Triangular distribution

$$P_1 = \frac{2 \cdot V}{3 \cdot x} (kN/m^2)$$

distribution width of bottom $b = 3 \cdot x$(m)

【If $e \leqq B/6$】……Trapezoid distribution

$$P_1 = \left(1 + \frac{6 \cdot e}{B}\right) \cdot \frac{V}{B} \quad , \quad P_2 = \left(1 - \frac{6 \cdot e}{B}\right) \cdot \frac{V}{B}$$

Item	Load condition		Normal	Berthing	Seismic
x (m)	Surcharge		1.14	1.02	0.68
	Unsurcharge		1.08	0.95	0.66
e (m)	Surcharge		0.41	0.53	0.87
	Unsurcharge		0.47	0.60	0.89
$\frac{B}{6}$(m)	Surcharge		0.52	0.52	0.52
	Unsurcharge		0.52	0.52	0.52
distribution of reaction	Surcharge		Trapezoid	Triangular	Triangular
	Unsurcharge		Trapezoid	Triangular	Triangular
Bottom reaction (kN/m^2)	Surcharge	P_1	160.4	181.2	261.32
		P_2	18.46	—	—
		b	3.10m	3.06m	2.04m
	Unsurcharge	P_1	151.68	172.79	253.59
		P_2	7.17	—	—
		b	3.10m	2.85m	1.98m

(d) Bottom reaction of below the level of foundation bottom

Bottom reaction is calculated by the following formula

・inclined angle of resultant force

$$\theta = \tan^{-1}\frac{H}{V}(^{\circ})$$

・distribution width and reaction force

[If $e > B/6$] ……Triangular distribution

$$b' = b + D\cdot\{\tan(30^{\circ}+\theta)+\tan(30^{\circ}-\theta)\}$$

$$P_1' = \frac{b}{b'}\cdot P_1 + \gamma_2\cdot D\,(kN/m^2)$$

$$P_2' = \gamma_2\cdot D\,(kN/m^2)$$

[If $e \leqq B/6$] ……Trapezoid distribution

$$b' = B + D\cdot\{\tan(30^{\circ}+\theta)+\tan(30^{\circ}-\theta)\}$$

$$P_1' = \frac{B}{b'}\cdot P_1 + \gamma_2\cdot D\,(kN/m^2)$$

$$P_2' = \frac{B}{b'}\cdot P_2 + \gamma_2\cdot D\,(kN/m^2)$$

・Allowable bearing capacity

Allowable bearing capacity of the sandy ground is calculated by the following formula

$$q_a = \frac{1}{F}\cdot(\beta\cdot\gamma_1\cdot B\cdot Nr + \gamma_2\cdot D\cdot Nq) + \gamma_2\cdot D$$

where

q_a : allowable bearing capacity (kN/m^2)

γ_1 : unit weight of soil below the level of foundation bottom (kN/m^3)

γ_2 : unit weight of soil above the level of foundation bottom (kN/m^3)

B : smallest width of foundation b' (m)

D : embedded length of foundation (m)

β : shape factor of foundation $\beta = 0.5$,continuous

Nr, Nq : bearing capacity factors (Fig.1)

$\varphi = 35^{\circ} \rightarrow Nr = 27, Nq = 27$

F : safety factor $F = 2.5$

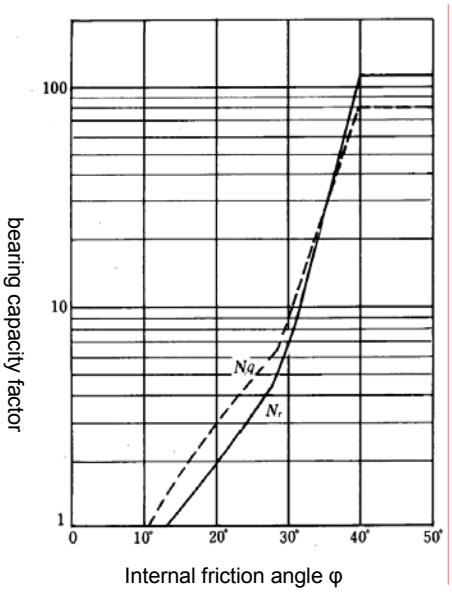


Fig.1

Item	Load condition		Normal	Berthing	Seismic
Vertical force	Surcharge		277.23	277.23	266.55
V(kN/m)	Unsurcharge		246.23	246.23	251.05
Horizontal force	Surcharge		58.66	64.66	113.29
H(kN/m)	Unsurcharge		58.66	64.66	111.74
Inclined angle	Surcharge		11.95	13.13	23.03
θ(°)	Unsurcharge		13.40	14.71	23.99
distribution of reaction	Surcharge		Trapezoid	Triangular	Triangular
	Unsurcharge		Trapezoid	Triangular	Triangular
D(m)	—		0.50	0.50	0.50
distribution width	Surcharge		3.71	3.68	2.77
b'(m)	Unsurcharge		3.72	3.48	2.72
Bottom reaction (foundation bottom)	Surcharge	P_1	139.03	155.67	197.45
		P_2	20.42	5.00	5.00
(kN/m^2)	Unsurcharge	P_1	131.40	146.51	189.60
		P_2	10.98	5.00	5.00
Allowable bearing capacity	Surcharge		259.34	257.72	208.58
qa(kN/m^2)	Unsurcharge		269.32	246.92	205.88
Judge.	Surcharge		OK	OK	OK
	Unsurcharge		OK	OK	OK

(e) Bearing Capacity for Eccentric and Inclined Load

Bearing capacity for eccentric and inclined load is calculated by the following formula

$$\tan^{-1}\theta = \frac{H}{V}(^{\circ})$$

$$\varepsilon = \frac{2 \cdot e}{B}$$

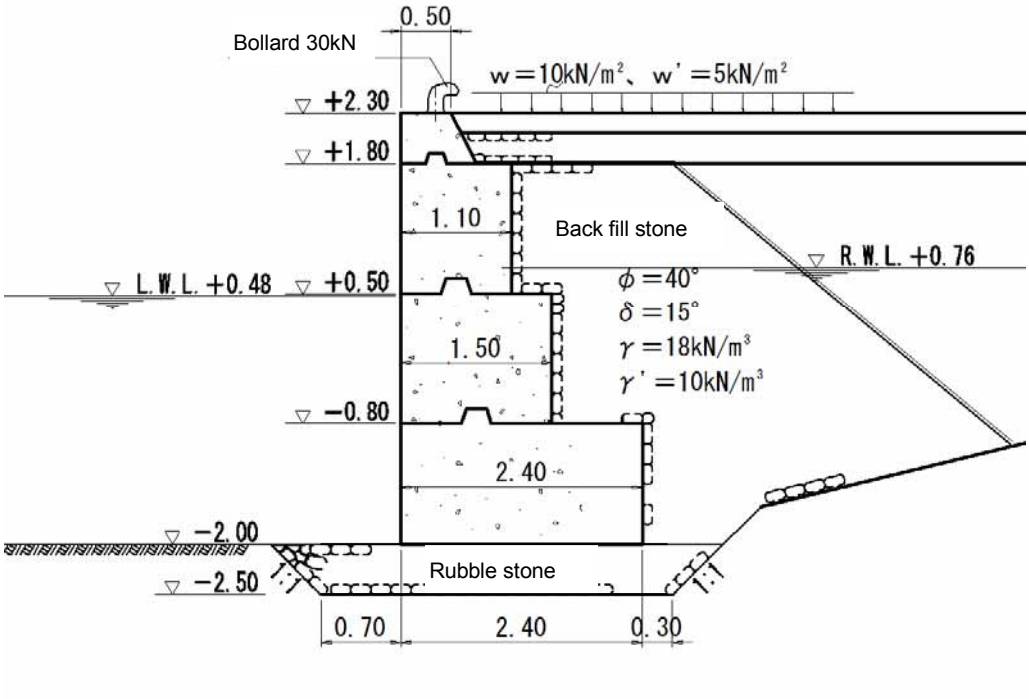
$$q_v = \frac{\gamma \cdot B}{2} \cdot N$$

$$F = \frac{q_v}{V/B} > 1.0$$

Item	Load condition	Normal	Berthing	Seismic
Vertical force V(kN/m)	Surcharge	277.23	277.23	266.55
	Unsurcharge	246.23	246.23	251.05
Horizontal force H(kN/m)	Surcharge	58.66	64.66	113.29
	Unsurcharge	58.66	64.66	111.74
e (m)	Surcharge	0.41	0.53	0.87
	Unsurcharge	0.47	0.60	0.89
ε	Surcharge	0.26	0.34	0.56
	Unsurcharge	0.30	0.39	0.57
tanθ	Surcharge	0.21	0.23	0.43
	Unsurcharge	0.24	0.26	0.45
N	Surcharge	45.0	28.0	7.8
	Unsurcharge	35.0	23.0	7.5
q_v (kN/m^2)	Surcharge	697.50	434.00	120.90
	Unsurcharge	542.50	356.50	116.25
F	Surcharge	7.80	4.85	1.41
	Unsurcharge	6.83	4.49	1.44

(2) -2.0m Berth

1) Cross section of the stability check



・Surcharge Load

Normal conditions 10kN/m^2 , Seismic conditions 5kN/m^2

・・Design Seismic Coefficient

Horizontal seismic coefficient Air k＝0.10

Underwater k'＝0.20

・Residual Water Level

R.W.L.＋0.76

・Check Level

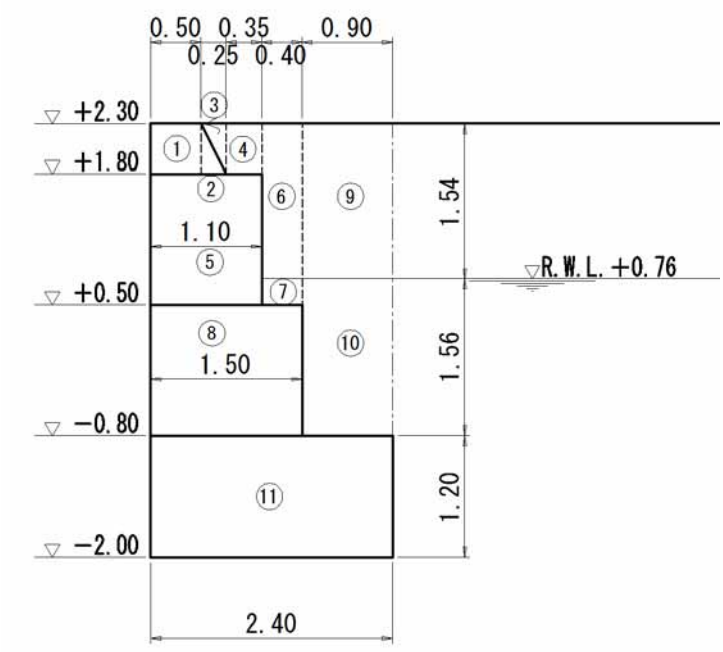
Design calculation will be carried out following elevation

＋0.50m level

－0.80m level

－2.00m level

2) Deadweight of the wall



	W (kN/m)			x (m)	y (m)	Wx (kN・m/m)	Wy (kN・m/m)
①	0.50 × 0.50 × 23.0	5.75		0.25	1.55	1.44	8.91
②	1/2 × 0.25 × 0.50 × 23.0	1.44		0.58	1.47	0.84	2.12
③	1/2 × 0.25 × 0.50 × 18.0	1.13		0.67	1.63	0.76	1.84
④	0.35 × 0.50 × 18.0	3.15		0.93	1.55	2.91	4.88
⑤	1.10 × 1.30 × 23.0	32.89		0.55	0.65	18.09	21.38
total	+0.50m	44.36		0.54193	0.88210	24.04	39.13
—		44.36		0.54193	2.18210	24.04	96.80
⑥	0.40 × 1.54 × 18.0	11.09		1.30	2.33	14.42	25.84
⑦	0.40 × 0.26 × 20.0	2.08		1.30	1.43	2.70	2.97
⑧	1.50 × 1.30 × 23.0	44.85		0.75	0.65	33.64	29.15
total	-0.80m	102.38		0.73061	1.51162	74.80	154.76
—		102.38		0.73061	2.71162	74.80	277.62
⑨	0.90 × 1.54 × 18.0	24.95		1.95	3.53	48.65	88.07
⑩	0.90 × 1.56 × 20.0	28.08		1.95	1.98	54.76	55.60
⑪	2.40 × 1.20 × 23.0	66.24		1.20	0.60	79.49	39.74
total	-2.00m	221.65		1.163	2.080	257.70	461.03

3) Buoyancy

Buoyancy will be considered below R.W.L.＋0.76m.

・＋0.50m level

U＝1.10×0.26×10.1＝2.89kN/m

Ux＝2.89×1/2×1.10＝1.59kN・m/m

・－0.80m level

U＝1.50×1.56×10.1＝23.63kN/m

Ux＝23.63×1/2×1.50＝17.72kN・m/m

・－2.00m level

U＝2.40×2.76×10.1＝66.90kN/m

Ux＝66.90×1/2×2.40＝80.28kN・m/m

4) Earth Pressure

(a) Horizontal Earth Pressure

a) Normal conditions

$p_a = k a \cos\delta \cdot (\Sigma\gamma h + w)$, $w = 10 kN/m^2$

Elevation (m)	Soil Layer φ (°)	δ (°)	γ (kN/m³)	thickness h (m)	Σγh (kN/m²)	Σγh+q (kN/m²)	k or k'	ka·cosδ	p_a (kN/m²)
+2.30						10.00	0.00	0.1942	1.94
	40	15	18.0	1.54	27.72				
+0.76						37.72	0.00	0.1942	7.33
						37.72	0.00	0.1942	7.33
	40	15	10.0	0.26	2.60				
+0.50						40.32	0.00	0.1942	7.83
						40.32	0.00	0.1942	7.83
	40	15	10.0	1.30	13.00				
-0.80						53.32	0.00	0.1942	10.35
						53.32	0.00	0.1942	10.35
	40	15	10.0	1.20	12.00				
-2.00						65.32	0.00	0.1942	12.69

b) Seismic conditions

$p_a = k a \cos\delta \cdot (\Sigma\gamma h + w')$, $w' = 5 kN/m^2$

Elevation (m)	Soil Layer φ (°)	δ (°)	γ (kN/m³)	thickness h (m)	Σγh (kN/m²)	Σγh+q (kN/m²)	k or k'	ka·cosδ	p_a (kN/m²)
+2.30						5.00	0.10	0.2444	1.22
	40	15	18.0	1.54	27.72				
+0.76						32.72	0.10	0.2444	8.00
						32.72	0.20	0.3060	10.01
	40	15	10.0	0.26	2.60				
+0.50						35.32	0.20	0.3060	10.81
						35.32	0.20	0.3060	10.81
	40	15	10.0	1.30	13.00				
-0.80						48.32	0.20	0.3060	14.79
						48.32	0.20	0.3060	14.79
	40	15	10.0	1.20	12.00				
-2.00						60.32	0.20	0.3060	18.46

(b) Resultant earth pressure (Horizontal)

a) Normal conditions

division	Pa (kN/m)		y (m)	Pa・y (kN・m/m)
①	1/2 × 1.94 × 1.54	1.49	1.29	1.92
②	1/2 × 7.33 × 1.54	5.64	0.77	4.34
③	1/2 × 7.33 × 0.26	0.95	0.17	0.16
④	1/2 × 7.83 × 0.26	1.02	0.09	0.09
Subtotal	+0.50 m	9.10	0.7154	6.51
		9.10	2.0154	18.34
⑤	1/2 × 7.83 × 1.30	5.09	0.87	4.43
⑥	1/2 × 10.35 × 1.30	6.73	0.43	2.89
Subtotal	-0.80 m	20.92	1.2266	25.66
		20.92	2.4266	50.76
⑦	1/2 × 10.35 × 1.20	6.21	0.80	4.97
⑧	1/2 × 12.69 × 1.20	7.61	0.40	3.04
total	-2.00 m	34.74		58.77

b) Seismic conditions

division	Pa (kN/m)		y (m)	Pa・y (kN・m/m)
①	1/2 × 1.22 × 1.54	0.94	1.29	1.21
②	1/2 × 8.00 × 1.54	6.16	0.77	4.74
③	1/2 × 10.01 × 0.26	1.30	0.17	0.22
④	1/2 × 10.81 × 0.26	1.41	0.09	0.13
Subtotal	+0.50 m	9.81	0.6422	6.30
		9.81	1.9422	19.05
⑤	1/2 × 10.81 × 1.30	7.03	0.87	6.12
⑥	1/2 × 14.79 × 1.30	9.61	0.43	4.13
Subtotal	-0.80 m	26.45	1.1078	29.30
		26.45	2.3078	61.04
⑦	1/2 × 14.79 × 1.20	8.87	0.80	7.10
⑧	1/2 × 18.46 × 1.20	11.08	0.40	4.43
total	-2.00 m	46.40		72.57

(c) Resultant earth pressure (Vertical)

$P_v = P_a \cdot \tan\delta$ (kN/m)

$P_v \cdot X = P_v \cdot B$ (kN·m/m)

a) Normal conditions

Eleveation	Pa (kN/m)	Pv (kN/m)	B (m)	Pv·X (kN·m/m)
+0.50 m	9.10	2.44	1.10	2.68
-0.80 m	20.92	5.61	1.50	8.42
-2.00 m	34.74	9.31	2.40	22.34

b) Seismic conditions

Eleveation	Pa (kN/m)	Pv (kN/m)	B (m)	Pv·X (kN·m/m)
+0.50 m	9.81	2.63	1.10	2.89
-0.80 m	26.45	7.09	1.50	10.64
-2.00 m	46.40	12.43	2.40	29.83

(d) Resultant residual water pressure

a) ＋0.50m level

hw＝0.26m(R.W.L.＋0.76m～＋0.50m)

$p_w = \gamma w \cdot hw = 10.1 kN/m^3 \times 0.26m = 2.63 kN/m^2$

$P_w = 1/2 \times 2.63 \times 0.26 = 0.34 kN/m$

$M_{Pw} = 0.34 \times 1/3 \times 0.26 = 0.03 kN \cdot m/m$

b) －0.80m level

hw＝0.28m(R.W.L.＋0.76m～L.W.L.＋0.48m)

$p_w = \gamma w \cdot hw = 10.1 kN/m^3 \times 0.28m = 2.83 kN/m^2$

$P_w = 1/2 \times 2.83 \times 0.28 + 2.83 \times 1.28 = 0.40 + 3.62 = 4.02 kN/m$

$M_{Pw} = 0.40 \times (1/3 \times 0.28 + 1.28) + 3.62 \times 1/2 \times 1.28 = 2.87 kN \cdot m/m$

c) －2.00m level

$P_w = 1/2 \times 2.83 \times 0.28 + 2.83 \times 2.48 = 0.40 + 7.02 = 7.42 kN/m$

$M_{Pw} = 0.40 \times (1/3 \times 0.28 + 2.48) + 7.02 \times 1/2 \times 2.48 = 9.73 kN \cdot m/m$

5) Surcharge load which acting wall body portion

・Surcharge Load Normal condition $10kN/m^2$, Seismic condition $5kN/m^2$

Checking Elevation	Load condition	q (kN/m)			x (m)	y (m)	qx (kN・m/m)	qy (kN・m/m)
+0.50m	Nomal	10.00 ×	1.10	11.00	0.55	1.80	6.05	19.80
	Seismic	5.00 ×	1.10	5.50	0.55	1.80	3.03	9.90
-0.80m	Nomal	10.00 ×	1.50	15.00	0.75	3.10	11.25	46.50
	Seismic	5.00 ×	1.50	7.50	0.75	3.10	5.63	23.25
-2.00m	Nomal	10.00 ×	2.40	24.00	1.20	4.30	28.80	103.20
	Seismic	5.00 ×	2.40	12.00	1.20	4.30	14.40	51.60

6) Seismic Load

Design Seismic Coefficient k＝0.10

(a) Seismic Load

Checking Elevation	Weight of inertia W(kN/m)	Moment of inertia Wy(kN・m/m)	Seismic Coefficient k	Hw (kN・m/m)	Hwy (kN・m/m)
+0.50m	44.36	39.13	0.10	4.44	3.91
-0.80m	102.38	154.76	0.10	10.24	15.48
-2.00m	221.65	461.03	0.10	22.17	46.10

(b) Seismic Load for Surcharge Load

Checking Elevation	Weight of inertia W(kN/m)	Moment of inertia Wy(kN・m/m)	Seismic k	Hw (kN・m/m)	Hwy (kN・m/m)
+0.50m	5.50	9.90	0.10	0.55	0.99
-0.80m	7.50	23.25	0.10	0.75	2.33
-2.00m	12.00	51.60	0.10	1.20	5.16

7) Mooring force

Mooring force will be considered based on the deployment of bollards at 5m interval

H_o = 30kN/5.00m = 6.00kN/m

Elevation	Mooring force Ho(kN/m)	y (m)	$H_o y$ (kN·m/m)
0.50m	6.00	1.95	11.70
-0.80m	6.00	3.25	19.50
-2.00m	6.00	4.45	26.70

8) External forces and loads acting on walls

(a) Normal conditions

			Normal conditions			
			Resultant force (kN/m)		Moment (kN・m/m)	
			Horizontal	Vertical	Overturning	Resisting
+0.50m	Active earth pressure		9.10	2.44	6.51	2.68
	Residual water pressure		0.34		0.03	
	Self weight of block wall			44.36		24.04
	Buoyancy			-2.89		-1.59
	Mooring force					
	Surcharge load			11.00		6.05
	Total	surcharge	9.44	54.91	6.54	31.18
		Unsurcharge	9.44	43.91	6.54	25.13
-0.80m	Active earth pressure		20.92	5.61	25.66	8.42
	Residual water pressure		4.02		2.87	
	Self weight of block wall			102.38		74.80
	Buoyancy			-23.63		-17.72
	Mooring force					
	Surcharge load			15.00		11.25
	Total	surcharge	24.94	99.36	28.53	76.75
		Unsurcharge	24.94	84.36	28.53	65.50
-2.00m	Active earth pressure		34.74	9.31	58.77	22.34
	Residual water pressure		7.42		9.73	
	Self weight of block wall			221.65		257.70
	Buoyancy			-66.90		-80.28
	Mooring force					
	Surcharge load			24.00		28.80
	Total	surcharge	42.16	188.06	68.50	228.56
		Unsurcharge	42.16	164.06	68.50	199.76

(b) Berthing conditions

			Berthing condition			
			Resultant force (kN/m)		Moment (kN・m/m)	
			Horizontal	Vertical	Overturning	Resisting
+0.50m	Active earth pressure		9.10	2.44	6.51	2.68
	Residual water pressure		0.34		0.03	
	Self weight of block wall			44.36		24.04
	Buoyancy			-2.89		-1.59
	Mooring force		6.00		11.70	
	Surcharge load			11.00		6.05
	Total	surcharge	15.44	54.91	18.24	31.18
		Unsurcharge	15.44	43.91	18.24	25.13
-0.80m	Active earth pressure		20.92	5.61	25.66	8.42
	Residual water pressure		4.02		2.87	
	Self weight of block wall			102.38		74.80
	Buoyancy			-23.63		-17.72
	Mooring force		6.00		19.50	
	Surcharge load			15.00		11.25
	Total	surcharge	30.94	99.36	48.03	76.75
		Unsurcharge	30.94	84.36	48.03	65.50
-2.00m	Active earth pressure		34.74	9.31	58.77	22.34
	Residual water pressure		7.42		9.73	
	Self weight of block wall			221.65		257.70
	Buoyancy			-66.90		-80.28
	Mooring force		6.00		26.70	
	Surcharge load			24.00		28.80
	Total	surcharge	48.16	188.06	95.20	228.56
		Unsurcharge	48.16	164.06	95.20	199.76

(c) Seismic conditions

			Seismic conditions			
			Resultant force (kN/m)		Moment (kN・m/m)	
			Horizontal	Vertical	Overturning	Resisting
+0.50m	Active earth pressure		9.81	2.63	6.30	2.89
	Residual water pressure		0.34		0.03	
	Self weight of block wall		4.44	44.36	3.91	24.04
	Buoyancy			-2.89		-1.59
	Mooring force					
	Surcharge load		0.55	5.50	0.99	3.03
	Total	surcharge	15.14	49.60	11.23	28.37
		Unsurcharge	14.59	44.10	10.24	25.34
-0.80m	Active earth pressure		26.45	7.09	29.30	10.64
	Residual water pressure		4.02		2.87	
	Self weight of block wall		10.24	102.38	15.48	74.80
	Buoyancy			-23.63		-17.72
	Mooring force					
	Surcharge load		0.75	7.50	2.33	5.63
	Total	surcharge	41.46	93.34	49.98	73.35
		Unsurcharge	40.71	85.84	47.65	67.72
-2.00m	Active earth pressure		46.40	12.43	72.57	29.83
	Residual water pressure		7.42		9.73	
	Self weight of block wall		22.17	221.65	46.10	257.70
	Buoyancy			-66.90		-80.28
	Mooring force					
	Surcharge load		1.20	12.00	5.16	14.40
	Total	surcharge	77.19	179.18	133.56	221.65
		Unsurcharge	75.99	167.18	128.40	207.25

9) Stability check

(a) Stability of Sliding

Safety factor against sliding;

$$F = \frac{\mu \cdot V}{H} \geqq Fa$$

V：total vertical force considering effect of buoyancy (kN/m)

H：total horizontal force applied to the structure (kN/m)

μ：friction coefficient (=0.5 for concrete vs. concrete)

(=0.6 for concrete vs. rock mound)

Allowable safety factor： Normal conditions, Berthing conditions

Fa＝1.2

Seismic conditions Fa＝1.0

a) Normal conditions

Checking Elevation	Load Condition	Normal conditions				
		Vertical load V(kN/m)	Horizontal load H(kN/m)	Coefficient of Friction μ	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	54.91	9.44	0.5	2.91	1.2
	Unsurcharge	43.91	9.44	0.5	2.33	1.2
-0.80m	Surcharge	99.36	24.94	0.5	1.99	1.2
	Unsurcharge	84.36	24.94	0.5	1.69	1.2
-2.00m	Surcharge	188.06	42.16	0.6	2.68	1.2
	Unsurcharge	164.06	42.16	0.6	2.33	1.2

b) Berthing conditions

Checking Elevation	Load Condition	Berthing conditions				
		Vertical load V(kN/m)	Horizontal load H(kN/m)	Coefficient of Friction μ	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	54.91	15.44	0.5	1.78	1.2
	Unsurcharge	43.91	15.44	0.5	1.42	1.2
-0.80m	Surcharge	99.36	30.94	0.5	1.61	1.2
	Unsurcharge	84.36	30.94	0.5	1.36	1.2
-2.00m	Surcharge	188.06	48.16	0.6	2.34	1.2
	Unsurcharge	164.06	48.16	0.6	2.04	1.2

c) Seismic conditions

Checking Elevation	Load Condition	Seismic conditions				
		Vertical load V(kN/m)	Horizontal load H(kN/m)	Coefficient of Friction μ	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	49.60	15.14	0.5	1.64	1.0
	Unsurcharge	44.10	14.59	0.5	1.51	1.0
-0.80m	Surcharge	93.34	41.46	0.5	1.13	1.0
	Unsurcharge	85.84	40.71	0.5	1.05	1.0
-2.00m	Surcharge	179.18	77.19	0.6	1.39	1.0
	Unsurcharge	167.18	75.99	0.6	1.32	1.0

(b) Stability of Overturning

Safety factor against overturning;

$$F = \frac{Mr}{Ma} \geqq Fa$$

Ma: Overturning Moment (kN·m/m)

Mr: Resistance Moment (kN·m/m)

Allowable safety factor: Normal conditions, Berthing conditions

Fa=1.2

Seismic conditions Fa=1.1

a) Normal conditions

Checking Elevation	Load Condition	Normal conditions			
		Resisting Mr(kN·m/m)	Overturning Ma(kN·m/m)	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	31.18	6.54	4.77	1.2
	Unsurcharge	25.13	6.54	3.84	1.2
-0.80m	Surcharge	76.75	28.53	2.69	1.2
	Unsurcharge	65.50	28.53	2.30	1.2
-2.00m	Surcharge	228.56	68.50	3.34	1.2
	Unsurcharge	199.76	68.50	2.92	1.2

b) Berthing conditions

Checking Elevation	Load Condition	Seismic conditions			
		Resisting Mr(kN·m/m)	Overturning Ma(kN·m/m)	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	31.18	18.24	1.71	1.2
	Un-surcharge	25.13	18.24	1.38	1.2
-0.80m	Surcharge	76.75	48.03	1.60	1.2
	Un-surcharge	65.50	48.03	1.36	1.2
-2.00m	Surcharge	228.56	95.20	2.40	1.2
	Un-surcharge	199.76	95.20	2.10	1.2

c) Seismic conditions

Checking Elevation	Load Condition	Seismic conditions			
		Resisting Mr(kN·m/m)	Overturning Ma(kN·m/m)	Safety factor F	Allowable Safety Factor Fa
+0.50m	Surcharge	28.37	11.23	2.53	1.1
	Un-surcharge	25.34	10.24	2.47	1.1
-0.80m	Surcharge	73.35	49.98	1.47	1.1
	Un-surcharge	67.72	47.65	1.42	1.1
-2.00m	Surcharge	221.65	133.56	1.66	1.1
	Un-surcharge	207.25	128.40	1.61	1.1

(c) Bottom reaction

Bottom reaction is calculated by the following formula

・x： acting point of resultant force from front toe

$$x = \frac{Mr - Ma}{V}$$

・e： eccentricity of resultant force of V and H (m)

$$e = \frac{B}{2} - x$$

・Bottom reaction

【If $e > B/6$】……Triangular distribution

$$P_1 = \frac{2 \cdot V}{3 \cdot x} (kN/m^2)$$

distribution width of bottom $b = 3 \cdot x$(m)

【If $e \leqq B/6$】……Trapezoid distribution

$$P_1 = \left(1 + \frac{6 \cdot e}{B}\right) \cdot \frac{V}{B} \quad , \quad P_2 = \left(1 - \frac{6 \cdot e}{B}\right) \cdot \frac{V}{B}$$

Item	Load condition		Normal	Berthing	Seismic
x (m)	Surcharge		0.85	0.71	0.49
	Unsurcharge		0.80	0.64	0.47
e (m)	Surcharge		0.35	0.49	0.71
	Unsurcharge		0.40	0.56	0.73
$\frac{B}{6}$ (m)	Surcharge		0.40	0.40	0.40
	Unsurcharge		0.40	0.40	0.40
distribution of reaction	Surcharge		Trapezoid	Triangular	Triangular
	Unsurcharge		Trapezoid	Triangular	Triangular
Bottom reaction (kN/m^2)	Surcharge	P_1	146.92	176.58	243.78
		P_2	9.79	—	—
		b	2.40m	2.13m	1.47m
	Unsurcharge	P_1	136.72	170.90	237.13
		P_2	0.00	—	—
		b	2.40m	1.92m	1.41m

(d) Bottom reaction of below the level of foundation bottom

Bottom reaction is calculated by the following formula

・inclined angle of resultant force

$$\theta = \tan^{-1} \frac{H}{V} (^\circ)$$

・distribution width and reaction force

【If $e > B/6$】……Triangular distribution

$$b' = b + D \cdot \{\tan(30^\circ + \theta) + \tan(30^\circ - \theta)\}$$

$$P_1' = \frac{b}{b'} \cdot P_1 + \gamma_2 \cdot D \, (kN/m^2)$$

$$P_2' = \gamma_2 \cdot D \, (kN/m^2)$$

【If $e \leqq B/6$】……Trapezoid distribution

$$b' = B + D \cdot \{\tan(30^\circ + \theta) + \tan(30^\circ - \theta)\}$$

$$P_1' = \frac{B}{b'} \cdot P_1 + \gamma_2 \cdot D \, (kN/m^2)$$

$$P_2' = \frac{B}{b'} \cdot P_2 + \gamma_2 \cdot D \, (kN/m^2)$$

・Allowable bearing capacity

Allowable bearing capacity of the sandy ground is calculated by the following formula

$$q_a = \frac{1}{F} \cdot (\beta \cdot \gamma_1 \cdot B \cdot Nr + \gamma_2 \cdot D \cdot Nq) + \gamma_2 \cdot D$$

where

q_a : allowable bearing capacity (kN/m^2)

γ_1 : unit weight of soil below the level of foundation bottom (kN/m^3)

γ_2 : unit weight of soil above the level of foundation bottom (kN/m^3)

B : smallest width of foundation b' (m)

D : embedded length of foundation (m)

β : shape factor of foundation β=0.5,continuous

Nr,Nq : bearing capacity factors (Fig.1)

φ=35° → Nr=27,Nq=27)

F : safety factor F=2.5

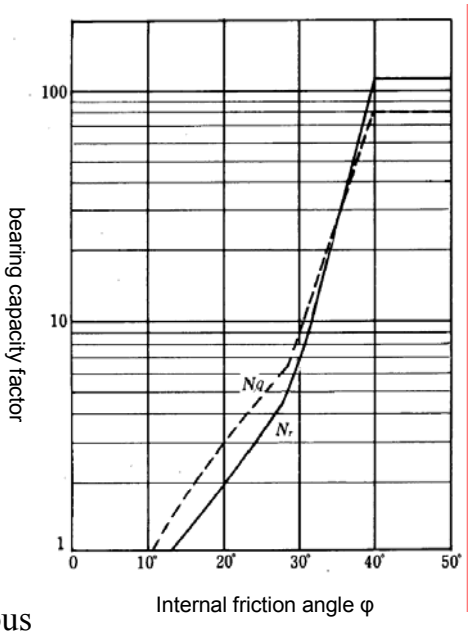


Fig.1

Item	Load condition		Normal	Berthing	Seismic
Vertical force V(kN/m)	Surcharge		188.06	188.06	179.18
	Unsurcharge		164.06	164.06	167.18
Horizontal force H(kN/m)	Surcharge		42.16	48.16	77.19
	Unsurcharge		42.16	48.16	75.99
Inclined angle θ(°)	Surcharge		12.64	14.36	23.31
	Unsurcharge		14.41	16.36	24.44
distribution of reaction	Surcharge		Trapezoid	Triangular	Triangular
	Unsurcharge		Trapezoid	Triangular	Triangular
D(m)	—		0.50	0.50	0.50
distribution width b'(m)	Surcharge		3.02	2.76	2.20
	Unsurcharge		3.03	2.57	2.16
Bottom reaction (foundation bottom) (kN/m^2)	Surcharge	P_1	121.76	141.27	167.89
		P_2	12.78	5.00	5.00
	Unsurcharge	P_1	113.29	132.68	159.79
		P_2	5.00	5.00	5.00
Allowable bearing capacity qa(kN/m^2)	Surcharge		222.08	208.04	177.80
	Unsurcharge		222.62	197.78	175.64
Judge.	Surcharge		OK	OK	OK
	Unsurcharge		OK	OK	OK

(e) Bearing Capacity for Eccentric and Inclined Load

Bearing capacity for eccentric and inclined load is calculated by the following formula

$$\tan^{-1}\theta = \frac{H}{V}(^{\circ})$$

$$\varepsilon = \frac{2 \cdot e}{B}$$

$$q_v = \frac{\gamma \cdot B}{2} \cdot N$$

$$F = \frac{q_v}{V/B} > 1.0$$

Item	Load condition	Normal	Berthing	Seismic
Vertical force V(kN/m)	Surcharge	188.06	188.06	179.18
	Unsurcharge	164.06	164.06	167.18
Horizontal force H(kN/m)	Surcharge	42.16	48.16	77.19
	Unsurcharge	42.16	48.16	75.99
e(m)	Surcharge	0.35	0.49	0.71
	Unsurcharge	0.40	0.56	0.73
ε	Surcharge	0.29	0.41	0.59
	Unsurcharge	0.33	0.47	0.61
tanθ	Surcharge	0.22	0.26	0.43
	Unsurcharge	0.26	0.29	0.45
N	Surcharge	45.0	26.0	7.5
	Unsurcharge	33.0	19.0	6.0
q_v (kN/m^2)	Surcharge	540.00	312.00	90.00
	Unsurcharge	396.00	228.00	72.00
F	Surcharge	6.89	3.98	1.21
	Unsurcharge	5.79	3.34	1.03

Appendix 6-5. Relevant Information of Construction Methodology
Appendix 6-5-1. Layout Plan and Aerial Photograph of Temporary Yard

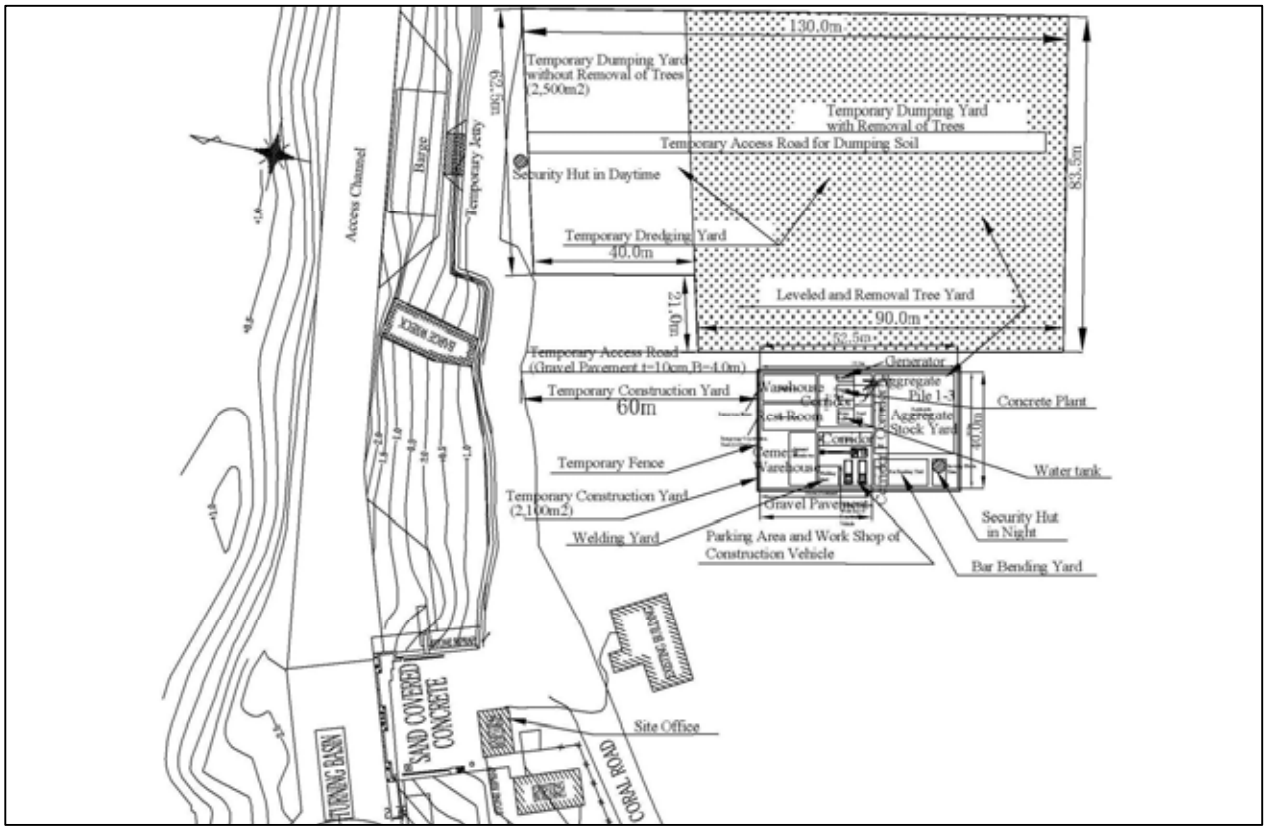


Figure A 6.5.1-1 Layout Plan of Temporary Yard

Aerial Photograph of Temporary Yard Site

Appendix 6-5-2. Location Map of Underwater Cable Line

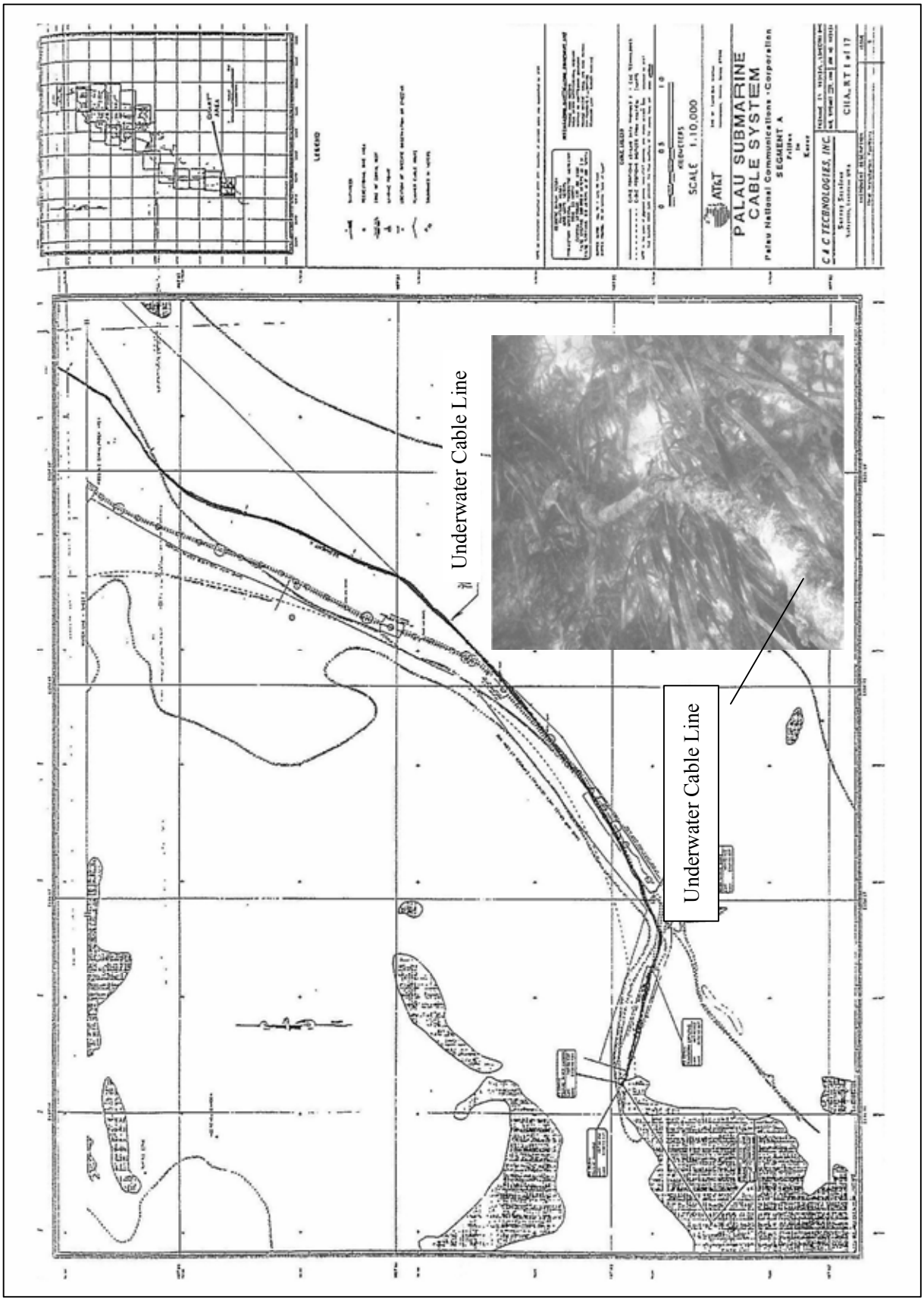
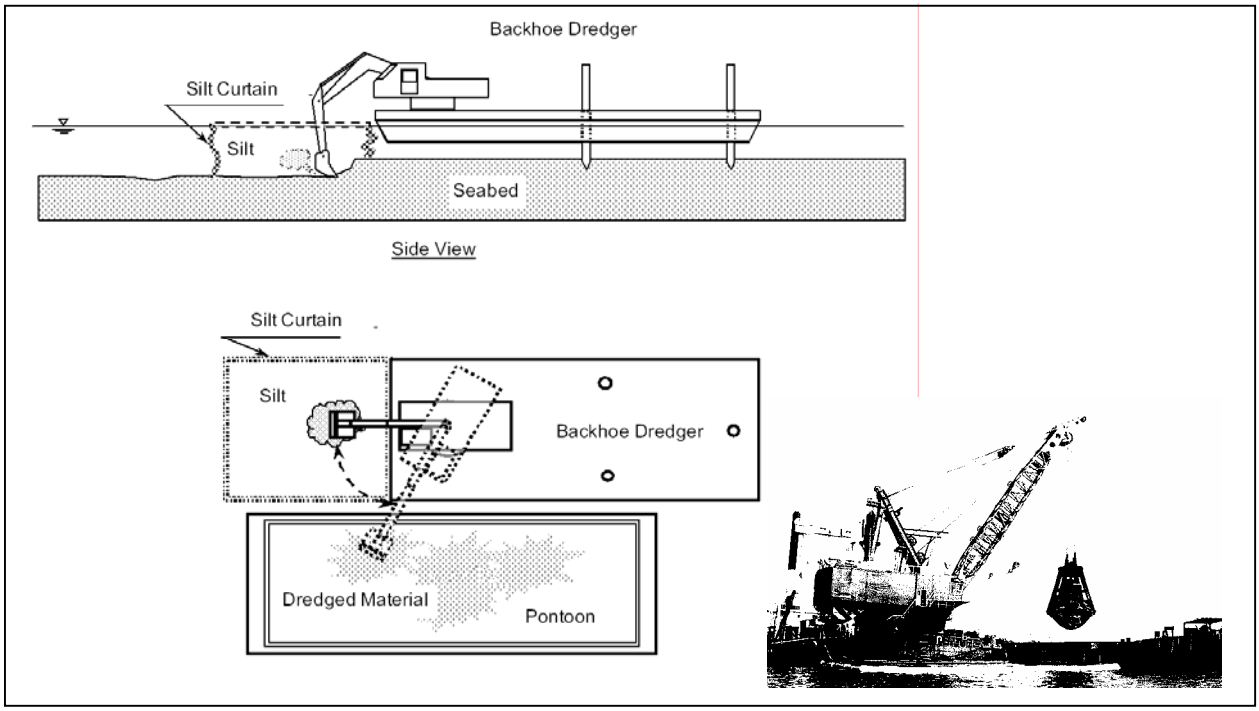
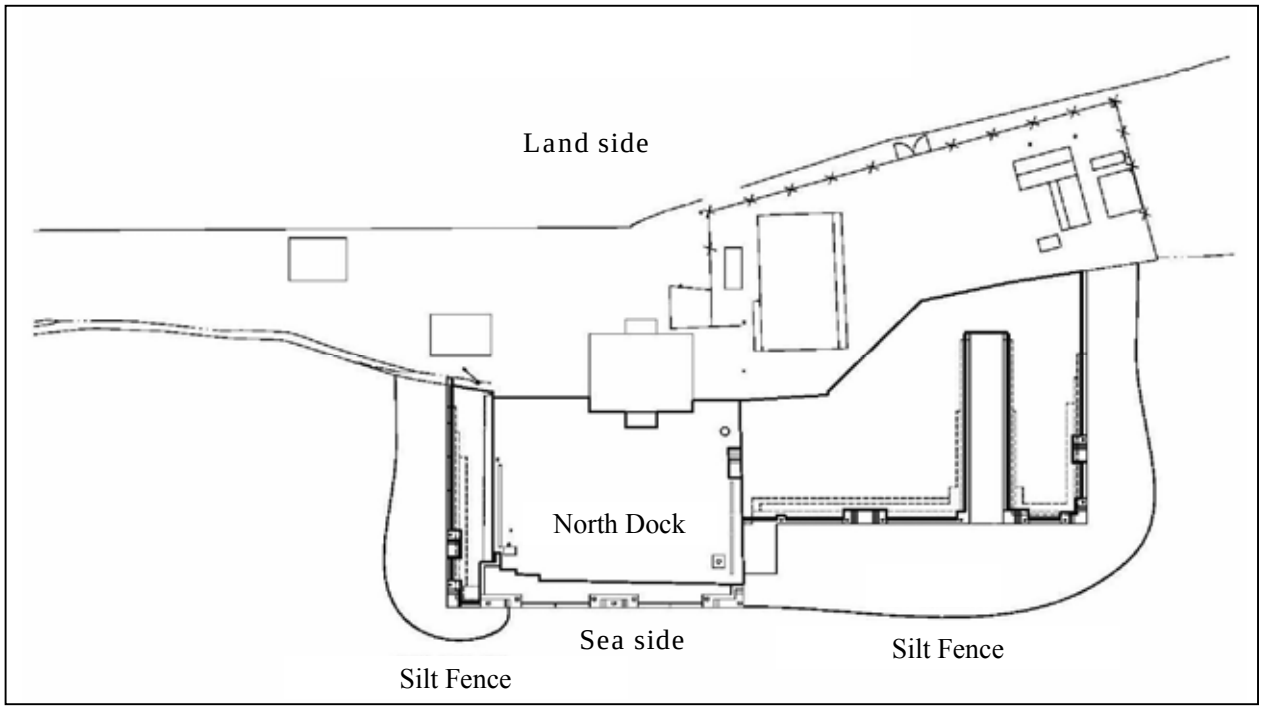


Figure A6.5.2-1 Location Map of Underwater Cable Line

Appendix 6-5-3. Expansion Plan of Silt Fence for Dredging Works



FigureA6.5.3-1 Installation Plan of Silt Fence for Channel Dredging



FigureA6.5.3-2 Installation Plan of Silt Fence for Basin Dredging

Appendix 6-5-4 State Authorization

Peleliu State Government
Office of the Governor

P.O. Box 6035 Peleliu, Republic of Palau 96940
Tel. No.: (680) 345-2967 • Fax/Tel.: (680) 488-1817

JACKSON R. NGIRAINGAS
GOVERNOR

November 8, 2005

ECO CORPORATION
Overseas Consultation Division
Ueno Takeuchi Bldg., 2-6-4, Kita-Ueno Taito-ku,
Tokyo 110-0014, Japan
Phone: +=81-3-5828-8412 Fax: -81-3-5828-8418
E-mail: m-muraoka@ecoh.co.jp

General Manager

Masakiyo MURAOKA Reg. PE
Environmental System Department
Senior Civil Engineer

Dear Muraoka:

On behalf of the people of Peleliu State and the Chiefs, I take this opportunity to acknowledge appreciation to the Government and people of Japan for their generous effort in the provision of the fisheries grant aid for the Development of the Southern Outlying State in the Republic of Palau particularly the Peleliu State in the pier extension, dredging of the channel and navigational lights. The community of Peleliu is looking forward to the materialization of this project to enhance the tourism and fishing industry as well as the overall socio-economic development in the State of Peleliu.

Once again, we thank the Government and the people of Japan for extending this project to the community of Peleliu and we affix our signatures hereunder as leaders representing and serving our community.

Jackson R. Ngiraingas
Governor, Peleliu State

Isao Singeo
Chief Obak, Peleliu State

Peleliu State Liaison Office
Koror, Republic of Palau 96940 • Tel. No.: (680) 488-1817

Appendix 6-5-5 Land Use Light

Peleliu State Government
Office of the Governor

P.O. Box 6035 Peleliu, Republic of Palau 96940
Tel. No.: (680) 345-2967 • Fax/Tel.: (680) 488-1817

JACKSON R. NGIRAINGAS
GOVERNOR

November 8, 2005

ECO CORPORATION
Overseas Consultation Division
Ueno Takeuchi Bldg., 2-6-4, Kita-Ueno Taito-ku,
Tokyo 110-0014, Japan
Phone: +=81-3-5828-8412 Fax: -81-3-5828-8418
E-mail: m-muraoka@ecoh.co.jp

General Manager

Masakiyo MURAOKA Reg. PE
Environmental System Department
Senior Civil Engineer

Dear Muraoka:

On behalf of the people of Peleliu State and the Chiefs, I take this opportunity to acknowledge appreciation to the Government and people of Japan for their generous effort in the provision of the fisheries grant aid for the Development of the Southern Outlying State in the Republic of Palau particularly the Peleliu State in the pier extension, dredging of the channel and navigational lights. The community of Peleliu is looking forward to the materialization of this project to enhance the tourism and fishing industry as well as the overall socio-economic development in the State of Peleliu.

With respect to the Minutes of Discussions provision 4-2 signed 7th November 2005, I am obliged to affix my signature hereunder as the Governor of Peleliu State to authorize use of the state land for Development of Southern Outlying State in the Republic of Palau particularly the Peleliu State including other dumping sites. The dumping site for stock pile and temporary construction yard adjacent to the project site have been secured during our meeting and a separate meeting with the land owner who concurred and agreed for the use of his land. The agreement is based on traditional confirmation for benefit of the community that is good as the law of the land.

I therefore as the Governor of Peleliu State affix my signature hereunder that the aforementioned are to the best of my assurance.

Jackson R. Ngiraingas
Governor, Peleliu State

Peleliu State Liaison Office
Koror, Republic of Palau 96940 • Tel. No.: (680) 488-1817

Appendix 6-5-6 Historic Preservation Office Clearance

Bureau of Arts and Culture
HISTORIC CLEARANCE REVIEW FINDINGS & CONCURRENCE

Historic Clearance Number:2000
Date:November 15, 2005

Step 1: Project Information

Applicant's Name: Palau/Japan Government
Project Name: Development of Southern Outlying State of Palau/ Peleliu Dock.
Location: (State) Peleliu **(Village)**Elochel
Project Summary:
The project is to dredge, excavate, fill, compacting of site for construction of building and pier.
Project Proposed Impact on the Landscape:
The project will involve dredging, filling and leveling the area that will alter the landscape

Step 2: Sufficiency of Data

We have examined the Bureau of Arts and Culture Archaeological Database and other sources for the proposed project area and find the following information.

We have reviewed the BAC database and archival materials and found that the project area is not an archaeological site. On previous visit to the site by BAC staff there was no feature in the vicinity of the proposed project. Historic posts are located at several meters away from the southwest side of the site. Based on the above information we have sufficient data to make a determination.

*A finding of **No Data or Insufficient Data** above shall require the applicant obtain an archaeological survey of the project area prior to proceeding with any site clearing or construction. Upon receipt of the survey report, Bureau of Arts and Culture can proceed with a Determination of Eligibility. A finding of sufficient data means that the Bureau of Arts and Culture can proceed with a Determination of Eligibility.*

Sufficiency of Available Data Summery

☐ **No Data:**.....The project is located in an area where *no previous surveys have been conducted* and where a reasonable probability exists that significant historical sites or tangible cultural properties occur. The project area must be surveyed by professional archaeologists.

☐ **Insufficient Data:**.....The project is located in an area where previous surveys have been conducted, but the *survey information is incomplete or insufficient* to evaluate the project area. The project area must be surveyed by professional archaeologist.

☒ **Sufficient Data:**.....The project is located in an area where previous survey have been conducted and *these data are sufficient to evaluate* the project area.

11/15/05

Erroflynn T. Kloulechad **Date**
Project Review & Compliance

Step 3: Determination of Eligibility

Once the project area has been surveyed adequately, then the next step is a formal Determination of Eligibility. Based upon the survey data, we hereby make the following determination:

The project area is not a site and not eligible for inclusion in the Palau Register of Historic Places.

Determination of Eligibility Summary

☒ **Not Eligible:**.....Within the project area, all sites are determined not eligible for inclusion in the Palau Register of Historic Places.

☐ **Eligible:**.....Within the project area, are located one or more sites determined eligible for inclusion in the Palau Register of Historic Places.

☐ **On Palau Register:**.....Within the project area, are located one or more sites listed on the Palau Register of Historic Places.

If sites are found within the project area and these sites are determined eligible for inclusion in the Palau Register, then the Criteria of effect is applied below.

Walter Metes — **Date** 11/15/2005

Palau Register

Step 4: Application of the Criteria of Effect

*The Criteria of Effect is applied to all sites determined eligible for inclusion in the Palau Register. If the determination is **No Effect**, then the project may proceed as planned. However, all significant modifications in design plans which might affect eligible properties or sites must be cleared through the Bureau of Arts and Culture. If the project is found to have an **Effect, Not Adverse** the project may proceed as planned. If the project is found to have **Adverse Effect**, then the applicant needs to meet with the Bureau of Arts and Culture to create a Memorandum of Agreement which details what will be done to protect the site(s) and the historical knowledge about the site.*

Based upon the above information provided we have applied the Criteria of Effect and make the following findings for the proposed project

The project will not effect an archaeological site.

Criteria of Effect Summery and Monitoring

☒	**No Effect:**	The project will have no effect on historic sites or tangible cultural properties, deemed eligible or potentially eligible for inclusion on the Palau Register of Historic Places or the U.S. Register of Historic Places.
☐	**Effect, Not Adverse:**	The project will have an effect on historic sites or tangible cultural properties deemed eligible or potentially eligible for nomination to the Palau Register of Historic Places or the U.S. Register of Historic Places. The effect, however, is not adverse.
☐	**Effect Adverse:**	The project will have an effect on historic sites or tangible cultural properties deemed eligible or potentially eligible for nomination to the Palau Register of Historic Places or the U.S. Register of Historic Places. The effect is adverse, execute MOA, MOU, PA.
☒	**Monitoring Required:**	Based on the probability of buried sites in the project area and the inability to survey the project area adequately given vegetation cover, soils, and later disturbances and/or historic features in close proximity to the project, the monitoring is required.
☒	**Reporting Required:**	During clearing or construction if any archaeological finds are encountered, the contractor is required to notify the Bureau of Arts and Culture immediately and halt construction in that area. Such finds include human burials, stone platforms and paths, and artifact deposits. These conditions shall be required if the following is checked.

Rita Olsudong — **Date**
Survey & Inventory

Step 5: Concurrence and Conditions

Based upon the review findings specified above, a concurrence to proceed with this project is granted dependent upon compliance with the following conditions:

The project must stay within the project area. Should an adveser effect occures to any archaeological site near the project, the applicant shall be responsible to carryout tasks deem necessary by BAC to mitigate the effect. It is required that any unusual find or human remain unearthed during the actual construction, the project must stop and BAC office must be notified. It is also required that any change of plan must be reported to BAC office for review. BAC staff will monitor the project on a systematic interval to ensure that the regulations are being followed.

This permit will expire after one year from the date of its issuance. If project for some reason, do not meet the expiration date, a written request for extension must be submitted to Bureau of Arts and Culture.

Vicky N. Kanai
Director/HPO
Bureau of Arts and Culture

11-16-05
Date

Cc:EQPB

REPUBLIC OF PALAU
PALAU ENVIRONMENTAL QUALITY PROTECTION BOARD

EARTHMOVING PERMIT

PEA-019-2006
Number

BUREAU OF MARINE RESOURCES OF KOROR STATE IS HEREBY GRANTED
NAME OF APPLICANT PLACE
PERMISSION TO CONSTRUCT EOCHEL PIER EXTENSION INCLUDING 6M WIDE X 4M LONG AT
DREDGE, LANDFIL, MOVE OR REMOVE
NGERBEKALL, PELELIU STATE SUBJECT TO THE REQUIREMENTS OF THE
HAMLET, STATE
PALAU NATIONAL CODE AND REGULATIONS OF THE PALAU ENVIRONMENTAL QUALITY PROTECTION BOARD AND SPECIAL CONDITIONS UNDER THIS PERMIT, AS LISTED ON THE ATTACHED LETTER (IF ANY).

THIS PERMIT MAY BE REVOKED AT ANY TIME BY A DULY AUTHORIZED REPRESENTATIVE OF THE BOARD, FOR NON-COMPLIANCE WITH THE PALAU NATIONAL CODE TITLE 24 AND REGULATIONS OF THE ENVIRONMENTAL QUALITY PROTECTION BOARD, AS PROMULGATED THEREUNDER.

11/25/05
DATE

JONATHAN KOSHIBA, CHAIRMAN, EQPB (BOARD)
PALAU ENVIRONMENTAL QUALITY PROTECTION BOARD
CHAIRMAN OR HIS AUTHORIZED REPRESENTATIVE

THIS PERMIT SHALL BE POSTED FOR PUBLIC DISPLAY
VALID FROM DATE OF ISSUE UNTIL: NOVEMBER 30, 2008

Republic Of Palau
Environmental Quality Protection Board
P.O. Box 8086
BUREAU OF PUBLIC WORKS BLDG.
KOROR, REPUBLIC OF PALAU 96940
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Mr. Theofanes Isamu
Director, Bureau of Marine Resources
Ministry of Resources & Development
P. O. Box 359, Koror
Republic of Palau 96940

November 25, 2005

Doc# 26-267

Re: **PEA-019-06 Peleliu Port Expansion & Channel Dredging Project (Amendment to PEA-082-00)**

Dear Director Isamu:

Your written request of November 3, 2005 for renewal of Earthmoving Permit PEA-082-00, which expired on December 31, 2001 has been considered and **APPROVED** by the Board subject to the following terms and conditions.

1. This permit renewal shall cover the following scope of work:

   a. Construction of Elochel Pier extension including 6m wide x 4m long rampway and 4m wide x 22.8m long slipway

   b. Dredging Works

      - Dredging of anchorage in front of new pier (DL – 3.0m)
      - Dredging of anchorage in front of existing pier (DL – 2.0m)
      - Dredging of shallow portion of channel (DL – 2.0m and – 2.5m for sandtraps)
      - Blasting of hard corals at 3 sites

   c. Erection of beacon and navigational pole
   d. Embankment/Slope protection
   e. Construction of temporary construction yard
   f. Construction of temporary workers' housing
   g. Temporary stockpile areas for coral materials

      - At temporary construction yard
      - At the Peleliu public water pump station site

   All works shall be in accordance with the EQPB Regulations, permit application and project design and plans attached herewith as Exhibit 1.

2. Permittee shall submit to EQPB for review and approval the final location and site plan for the temporary workers' housing.

3. Permittee shall submit to EQPB for review and approval the plan for temporary storage area for explosives to be used during blasting operation.

4. Prior to clearing of all areas that will be affected by the project, Permittee shall secure Historical Clearance from the Bureau of Arts and Culture (BAC); Permittee shall submit to EQPB copy of Historical Clearance to be issued by BAC.

5. Prior to clearing/earthmoving or dredging activities, Permittee shall install erosion control structures (silt curtains/fences, berm, lined ditch, etc.); Installed erosion control structures have to be inspected and approved by the EQPB Inspector prior to work commencement.

6. Prior to tree cutting, if any, Permittee and the EQPB shall inspect the work area to determine if the tree shall be designated for preservation; Permittee shall prevent removal of large trees within the work area when feasible.

7. Vegetation and other types of solid wastes to be removed from the site shall be properly disposed off at the Peleliu dumpsite. Permittee is required to coordinate with the Peleliu State Government prior to disposal.

8. Permittee shall be responsible for maintaining cleanliness, providing adequate sanitation facilities and potable drinking water for the workers during the entire duration of project construction; Disposal of solid waste and wastewater into the ocean is strictly prohibited.

9. Prior to blasting operation, Permittee shall secure clearance from the Bureau of Public Safety.

10. Permittee shall strictly adhere to the "Underwater Blasting Execution Plan" attached herewith as Exhibit 2; Safety and environmental measures shall be properly implemented prior to any blasting execution.

11. Blasting operation shall be undertaken only during low tide; Adequate air curtain system shall be installed prior to blasting operation; Installed air curtain system has to be inspected and approved by the EQPB Inspector prior to blasting operation.

12. Permittee shall notify the public at least 24 hours before the scheduled blasting operation via local radios and newspapers.

13. Prior to blasting operation, Permittee shall barricade the area at 300m radius from the blasting site; Permittee shall ensure that the area is cleared of protected/endangered marine species before the blasting operation.

14. Permittee shall submit to EQPB photographs of the under and above water blasting sites before and after blasting operation to assess the impact and/or extent of siltation.

15. Temporary workers' housing and construction yard connection to the public water supply system shall not be made without authorization from the Water Branch, Bureau of Public Works (BPW).

16. Temporary workers' housing and construction yard connection to the public electric power grid shall not be made without authorization from the Palau Public Utilities Corporation (PPUC).

17. Temporary workers' housing and construction yard connection to the public telephone line shall not be made without authorization from the Palau National Communication Corporation (PNCC); Permittee shall secure PNCC clearance prior to disturbance or relocation of PNCC underground/submarine cable, if any, due to dredging and blasting activities.

18. Disposal of unused concrete and concrete wastewater (wastewater from concrete trucks and mixers) into nearby natural or man-made drainage channels or surface waters of Palau is prohibited. Unused concrete and concrete wastewater shall be disposed of in a disposal pit and covered.

19. Engine oils, waste oils, hydraulic fluids, and other hazardous materials or wastes shall be stored in containers designed to contain any leakage or spillage, and chemicals shall be separated as needed for safety and compatibility.

20. All petroleum products and hazardous materials shall be provided with secondary containment (impermeable concrete pad and berm) and isolated from rainfall and storm water runoff (roofed storage).

21. Employees working on the site shall be instructed by the Permittee to comply with all conditions of the permit, and to immediately implement corrective measures if violations are observed.

22. Upon completion of the project, all areas disturbed by the construction shall be stabilized so that accelerated erosion and/or sedimentation will be prevented. All damaged adjoining properties and public infrastructure shall be repaired and restored to their original condition.

23. This permit renewal is valid until **November 30, 2008**.

Please note that all conditions of the original earthmoving permit PEA-082-00, herein attached as Exhibit 3, shall remain fully enforceable. EQPB would therefore request your cooperation to ensure compliance with all conditions of the permit.

If you have any questions regarding the regulatory or permitting requirements for this project, please contact Portia K. Franz, Executive Officer or Alex Apostol, Environmental Engineer at tel. no. 488-3600/1639.

Sincerely yours,

Jonathan Koshiba
Chairperson

AAA/Attachments (2): *Exhibit 1 – Project Plans (3 pages)*
Exhibit 2 – Underwater Blasting Execution Plan (5 pages)
Related Doc# *26-174, 26-119*
Related Permit# *082-00*

Xc: Permit File
ECOH Corporation
EQPB Compliance Section