Chapter 17 Structural Design of Main Port Facilities

17.1 Design Requirements and Conditions

17.1.1 Required Facilities of Short Term Development Plan

The following facilities are planned in the Short Term Development Plan of Takoradi Port:

Table 17.1.1 Facilities Required in Short Term Development Plan

Facilities	Requirement
1. Breakwater Extension	Extension of the Existing Main Breakwater to obtain necessary calmness for New Bulk Berth, L = 400m.
2. Wharf/ Berths	
- New Bulk Berth	- 13.0m, L = 260m; Extended from the existing Clinker Jetty.
- New container wharf	- 12.0m, L = 300m; Along with the reclaimed land area for new container yard
- Small Craft Wharf	- 5.0m, L = 150m; Replacing the exist. mooring facilities for port services crafts.
3. Exist wharf Improvement	
- Manganese Berth	- 12.0m, L = 200m (Exist. Berth No 1)
- Multi-purpose Berth	- 12.0m, L = 300m (Exist. Berth No 5 & 6)
4. Basin and Navigation	Dredge to - 12.0m for inside Exist. Port Basin Dredge to - 13.0m for New Bulk Berth Basin and Channel Navigation Aids.
5. Building & Utilities	Admi. Office & Gate for New Container Terminal, Lighting etc.
6. Others	Port Access Road improvement, Drainage, Container Yard paving etc.

17.1.2 Basic Design Conditions

(1) Design Vessels

Table 17.1.2 Design Vessels Specification

Vessel Type	Max .DWT (GT)	Length Overall (m)	Breadth (m)	Max. Draft (m)	Remarks
Bulk carrier	40, 000	200	29.9	11.8	Bulk berth
General cargo ship	30, 000	185	27.5	11.0	Multipurpose
Container ship	30, 000	220	30.2	11.1	Container wharf
Ro/Ro ship	28, 000	210	-	11.0	Multipurpose
Port service craft	(250)	30.5	10.3	4.1	Small craft wharf

(2) Marine Conditions

- Tidal Conditions :Design High Water Level (H.W.L);CD + 150
  Design Low Water Level (L.W.L); CD ± 0.00
- Design Waves (50 years return period waves)

Table 17.1.3 Design Waves

Wave Characteristics	Deep Water Wave Direction				
	SW	S	SE	E	All direction
Deep Water Wave Ho (m) To (sec)	 5.10 9~11	 5.40 9~11	 4.80 9~11	 4.40 5~9	 5.00 9~11
Lo (m)	126.4 - 188.8			39.0 – 126.4	126.4 – 188.8
Design Waves At-15.0 m water depth $H^1/_3$(m)	3.70	4.40	4.40	3.80	4.00
$T\ ^1/_3$ (sec)	9~11			5~9	9~11

- Design Max. Current Velocity : 1.0 m/sec

(3) Subsoil Conditions

Table 17.1.4 Subsoil Conditions

Location	Design Parameters of Subsoil
Southern part of the existing port basin	Sandstone Unit Weight : 24.5KN/m^3 Compressive Strength : 80 MPa
Other areas	Sandstone/siltstone Unit Weight : 24.5 KN/m^3 Compressive Strength : 10 to 50 MPa

(4) Seismic Force Coefficient : 0.15

(5) External Forces

- Tractive forces of ships Bulk Carrier (40,000 DWT) ; 2,000 KN
  Container / Ro.Ro / General
  Cargo Ships (30,000 DWT) ; 1,500 KN
- Crane Load and Surcharge

Load	Normal Condition	Seismic Condition
Crane Load	400 KN/Wheel	400 KN/Wheel
Surcharge	20 KN/m^2	10 KN/m^2

17.2 Breakwater Extension

In other to obtain the required calmness level for the planned new bulk berth, the existing main breakwater is extended at length 400m along the main breakwater alignment. A preliminary design has been carried out under the design conditions specified in 17.2.1, and the required rock sizes of seaward side armor layers have been examined.

The typical cross section of the breakwater extension is indicated in Figure17.2.1.

17.2.1 Design Conditions

(1) Design Wave : $H^1/_3$ = 4.4m (50 years return period)
: $T^1/_3$ = 9~11 sec.
: Lo = 1.56 T^2 = 126.4~188.8 m

(2) Structural Type : Rubble Mound Type

(3) Dimensions of Breakwater

- Crest Height : CD. + 5.0 m
- Crest Width : 10.0 m
- Slope

	Above CD - 6.0^m	Below CD - 6.0^m
Seaward Side	1 : 2	1 : 1.5
Lee Side	1 : 1.5	1 : 1.5

17.2.2 Armor Rock Sizes

The desirable size of seaward armor is determined using the following Hudson Formula;

$$W=\frac{W_r H^3}{K_D\,(S_r-1)^3 \cot\alpha}$$

Where;

W :Minimum weight of rock (tons)

Wr :Unit weight of rock in air (t/m^3).

Sr :Relative mass density of rock (relative to seawater)

α :Angle of the slope to horizontal plane

H :Significant wave height $H^1/_3$ at the water depth where the structure is constructed (m)

K_D :Stability coefficient

When, Wr = 2.60 tf/ m^3, cot α = 2, H = 4.4 m,
K_D = 2.4~4.0 (Under damage rate 0-5%) are used;

The desirable minimum rock weight is 8.0~13.0 tf/pcs.

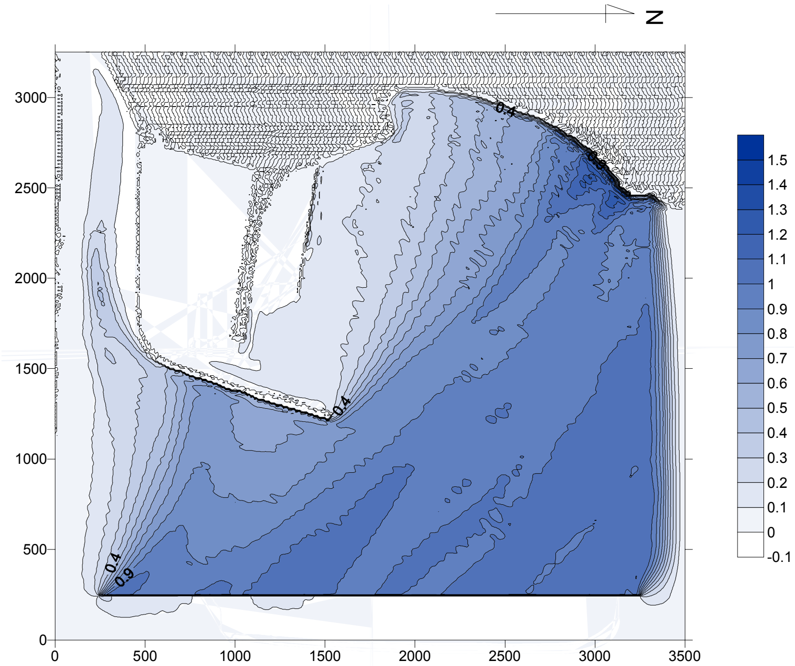
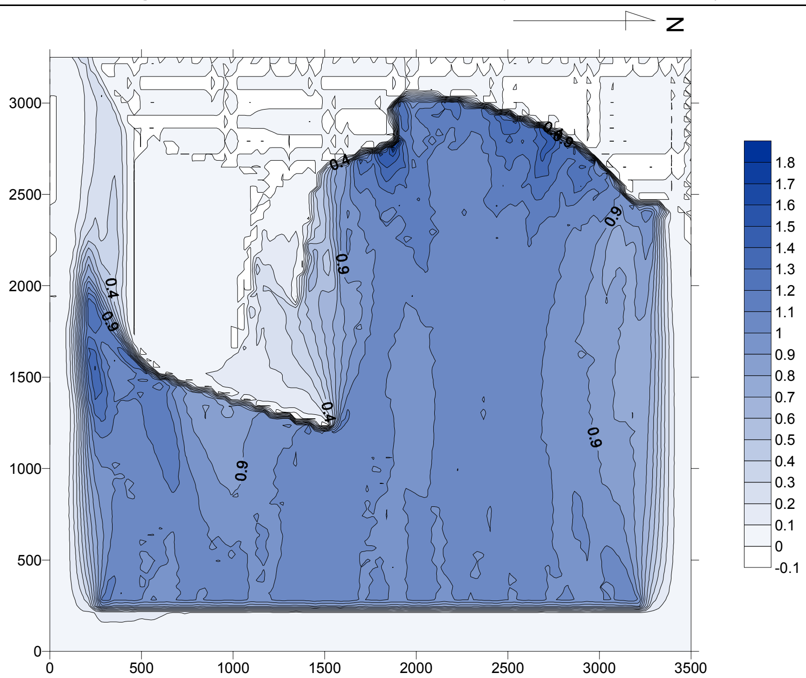
It is therefore recommended to use 10.0~15.0 tf/pcs size rock for the primary armor and the secondary armor rock size is to be 1/10 of the primary armor rock size (1.0 ~ 5.0t).

17.2.3 Calmness Ratio Analysis

A calmness ratio analysis has been carried out to examine the workability of the new bulk berth under the planned port layout. The calmness ratio estimated at Bulk Berth with the provision of 400m breakwater extension is 95.9 % under operative wave height limit at 0.7m, which is generally considered as acceptable for bulk cargoes handling.

The wave height ratio obtained from the analysis is indicated in Table 17.2.1.

Table 17.2.1 Wave Height Ratio at New Bulk Berth

Design Wave	Wave Height Rate
Wave Height : 4.40 m Direction : SE Period : 9 ~ 11sec Height Ratio : 0.126 ~ 0.132	 Wave Direction : South East, Period : 11.00 sec, Wave Height : 1.00m, Sea Level : 0.00m Wave Height Rate : Takoradi Port (Layout of F/S Study)
Wave Height : 3.80 m Direction : E Period : 5 ~ 9sec Height Ratio : 0.532 ~ 0.461	 Wave Direction : East, Period : 9.00 sec, Wave Height : 1.00m, Sea Level : 0.00m Wave Height Rate : Takoradi Port (Layout of F/S Study)

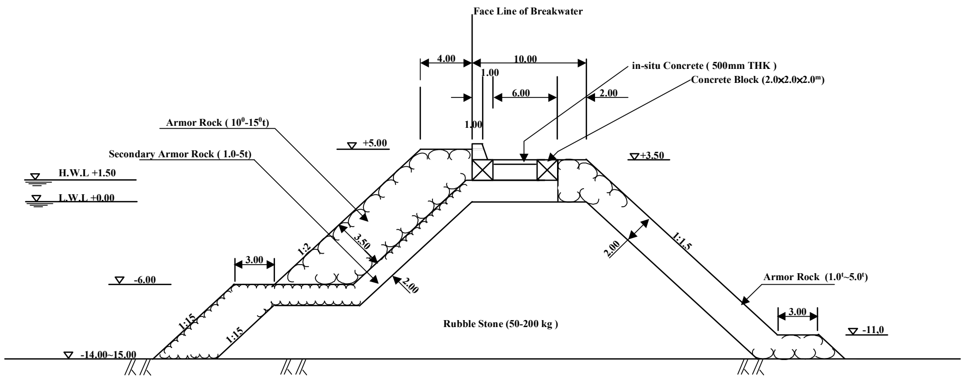


Figure 17.2.1 Typical Section of Breakwater Extension

17.3 New Wharf/Berth

17.3.1 Design Conditions

(1) Structural Type : R.C. Caisson

(2) Design Vessels and Sectional Dimensions

Table 17.3.1 Design Vessels and Sectional Dimensions

	Bulk Berth	Container Wharf
Design Vessel	Bulk Carrier 40,000 DWT	Container Ship 30,000 DWT
Water Depth	-13.0 ^{m}	- 12.0 ^{m}
Deck Elevation	C.D. + 3.50	C.D. + 3.00
Apron Width	30 m	50 m
Exist. Seabed Level	C.D. - 9.0 ^{m} (Average)	C.D. -5.0 m

(3) Subsoil Conditions

Seabed : Soft Rock (Compression Strength less than 50 MPA),
N - value is expectedly over 50
Back-fill : Quarry-run ; Unit weight 19.6 KN / m^3

(4) External Forces

The following external forces are considered in the design;

Table 17.3.2 Loading Conditions of External Forces

	Dead Load	Crane Load	Surcharge	Tractive force	Earth pressure	Seismic force
Normal Condition	O	O	O	O	O	N.A
Seismic Condition	O O	O X	O (1/2) X	N.A N.A	O O	O O

Note; O: to be considered, X: not considered, N.A: not applicable

17.3.2 Structural Design of New Wharf / Berth

Using the above design conditions, a preliminary design has been carried out and the following basic dimensions of the R.C. caisson units for New Bulk Berth (-13.0 m) and New Container Wharf are recommended taking constructional constraints also into consideration;

Location	Length(m)	Width (m)	Height (m)	Weight per Unit (tf)
Bulk Berth (-13.0 ^{m})	20.0	11.0 (12.0)	14.0	1,450
Container Berth (-12.0 ^{m})	20.0	10.0 (11.0)	13.0	1,290

Note; Figures in parenthesis indicate bottom widths.

The examination results on the stability are as shown in Table 17.3.3.

Table 17.3.3 Stability Examination Results

Item	Bulk Berth (-13.0 m)		Container Berth (-12.0 m)	
	Normal	Seismic	Normal	Seismic
Sliding	S.F=1.90	S.F=1.09	S.F=1.84	S.F=1.08
Over-turning	S.F=1.58	S.F=1.28	S.F=1.56	S.F=1.27
Bottom bearing Pressure	400 KN/m^2	670 KN/m^2	380 KN/m^2	650 KN/m^2

The examination conditions used in the design are as follows;

(1) Stability of Structure ;

(a) Safety factor for sliding, which expressed by the following equation is not less than 1.2 and 1.0 under normal condition and seismic case respectively.

$$S.F. = \frac{\mu (W-U)}{P}$$

(b) Safety factor for overturning is not less than 1.2 and 1.1 under normal condition and seismic condition respectively.

$$S.F. = \frac{W t - Mu}{Mp}$$

Where, P : Total Horizontal Force
W : Total vertical load of structure
U : Total up-lift force
μ : Coefficient of friction
t : Arm length of gravity center from the heel of the caisson.
Mu : Moment of up-lift pressure
Mp : Total moment of horizontal force

(2) Bearing Capacity of Foundation

Allowable bearing capacity of foundation used in the design is as follows:

- Normal condition : Not more than 500 KN / m^2
- Seismic condition : Not more than 700 KN / m^2

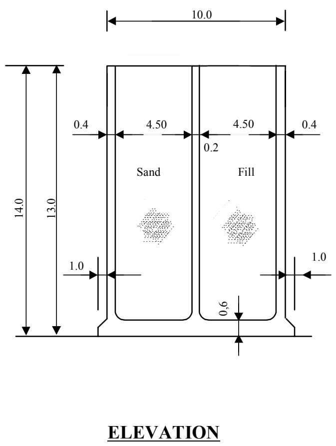
Based on the results of the preliminary design, the recommended structural sections are shown in Figure 17.3.1 and Figure 17.3.4.

17.3.3 Design of Access to New Bulk Berth.

An access way connecting the existing Clinker Jetty and New Bulk Berth is required. The width of the access way is recommended to be 15.0 m considering sufficient space for future belt conveyer line (s) and road way.

The structural type of the access way is recommended to be a reclaimed causeway type having a function of revetment seaward side when reclamation work takes place in future. The design wave height examined in the estimation of armor rock size is 2.5 m.

The typical section of the Access Way to New Bulk Berth is shown in Figure 17.3.3.



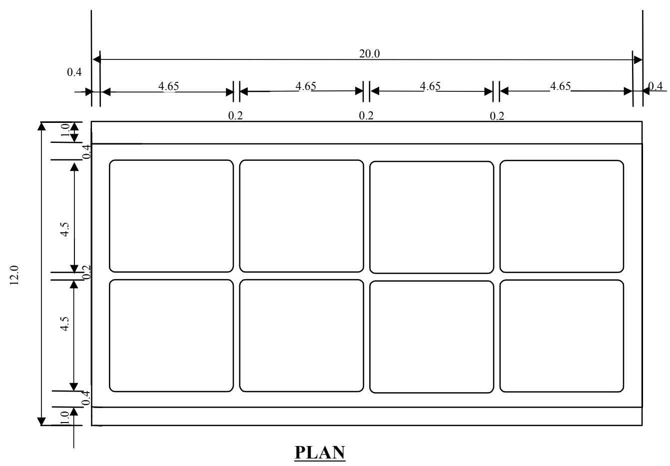


Figure 17.3.1 R.C. CAISSON STRUCTURE (Bulk Berth)

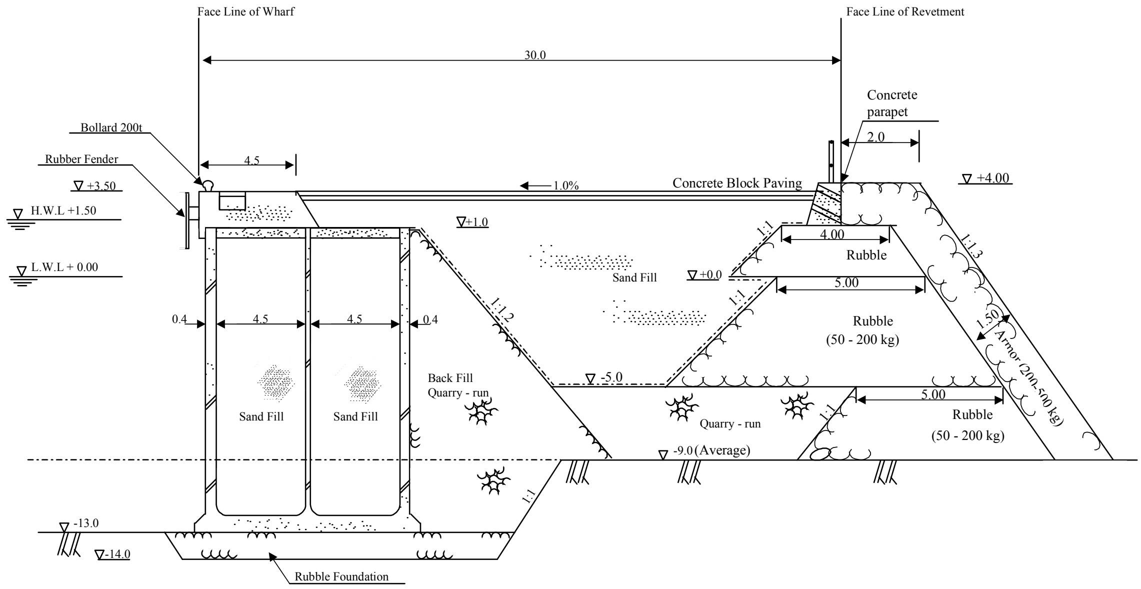


Figure 17.3.2 Typical Section of Bulk Berth

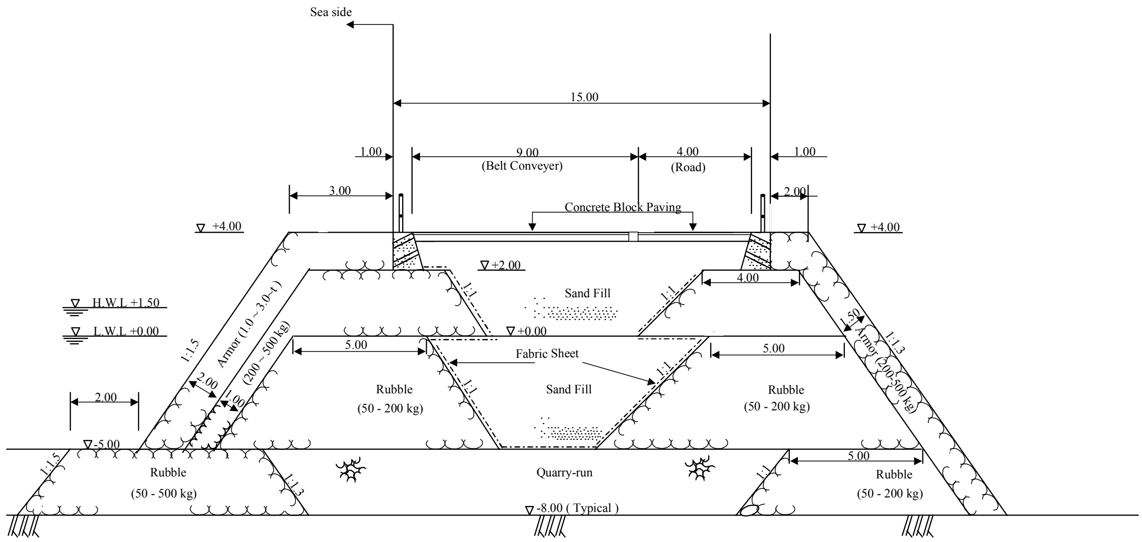
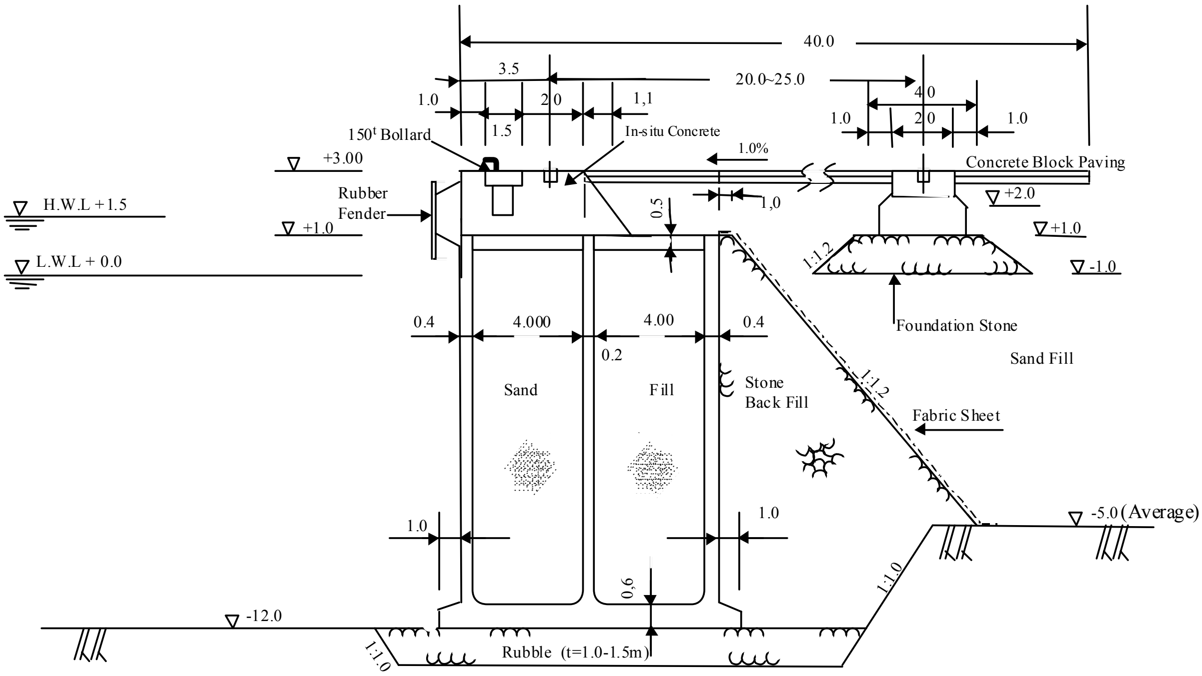
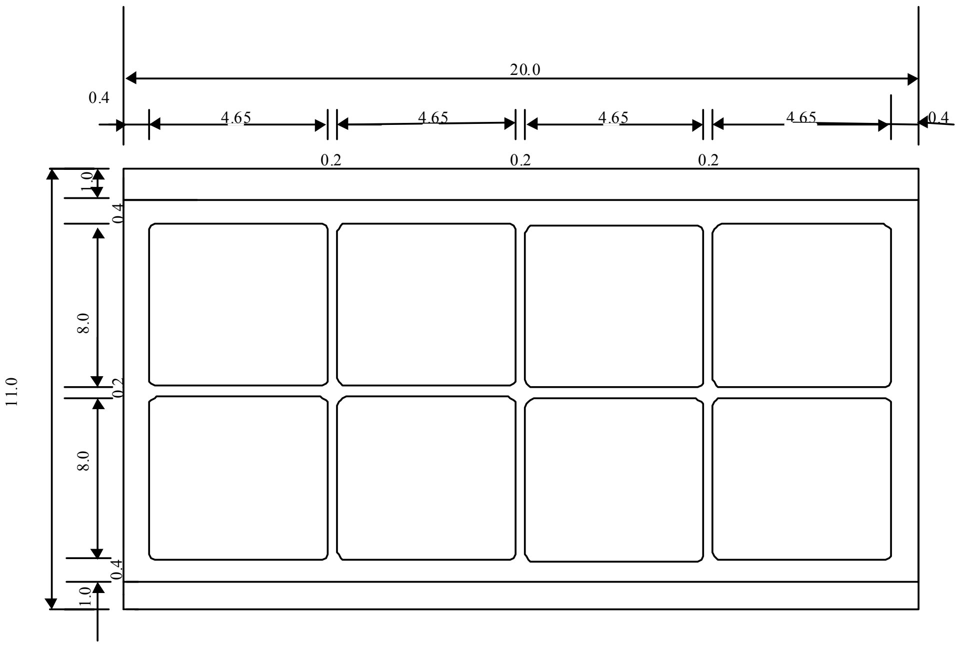


Figure 17.3.3 Typical Section of Access Way to Bulk Wharf



Elevation



Plan

Figure 17.3.4 Container Wharf

17.4 Existing Wharf Improvement

17.4.1 General Conditions

(1) In the Short Term Development Plan, the following parts of the existing wharf are suggested to be improved by deepening the berth front water depth to -12.0 m

- Berth No. 1 : Improvement length : 200^m as Manganese Berth
  Structural Type : R.C. pile supported open deck
  (Pile size 35 cm x 35 cm)
  Assumed pile toe elevation is -9.0^m

- Berth No. 5 & 6 : Improvement length : 300^m as Multi-purpose Berth.
  Structural Type : Concrete block gravity type.
  Assumed bottom elevation is -9.0^m.

(2) Structural design of the wharf improvement recommended in the Master Plan study is to provide new concrete block wall in front of the existing wharf structure in order to avoid any possible failure or adverse effect to the existing structure by the deepening.

(3) Cargo Handling Equipment loads considered at the improved berths are as follows;

- Manganese Berth : Ship loader (400KN/wheel)
- Multipurpose Berth : Multi-purpose Gantry Crane; 400/KN.

(4) It should be noted that in the Short Term Development Plan, about a half of the improvement work only (both ends of the existing wharf) is to be carried out leaving the other half of the wharf with recessed berth face line which may cause inefficient berth utilization of the wharf.

To this end, an alternative examination on the improvement plan that requires no berth alignment change (i.e. maintain the existing wharf face line) or prevent from such adverse effect to the berth utilization is to be discussed.

17.4.2 Structural Design

Based on the recommended structural type and dimensions, a preliminary design has been carried out.

As to the alternative improvement plans that maintain the existing wharf face line, a brief study has been carried out and the result shows that the new berth line with new concrete block walls is more economical and reliable.

It is therefore recommended in this Study to provide new concrete block wall structure, this however should be further examined in the implementation of the detailed design.

The design structural section of the wharf improvement is shown in Figure 17.4.1.

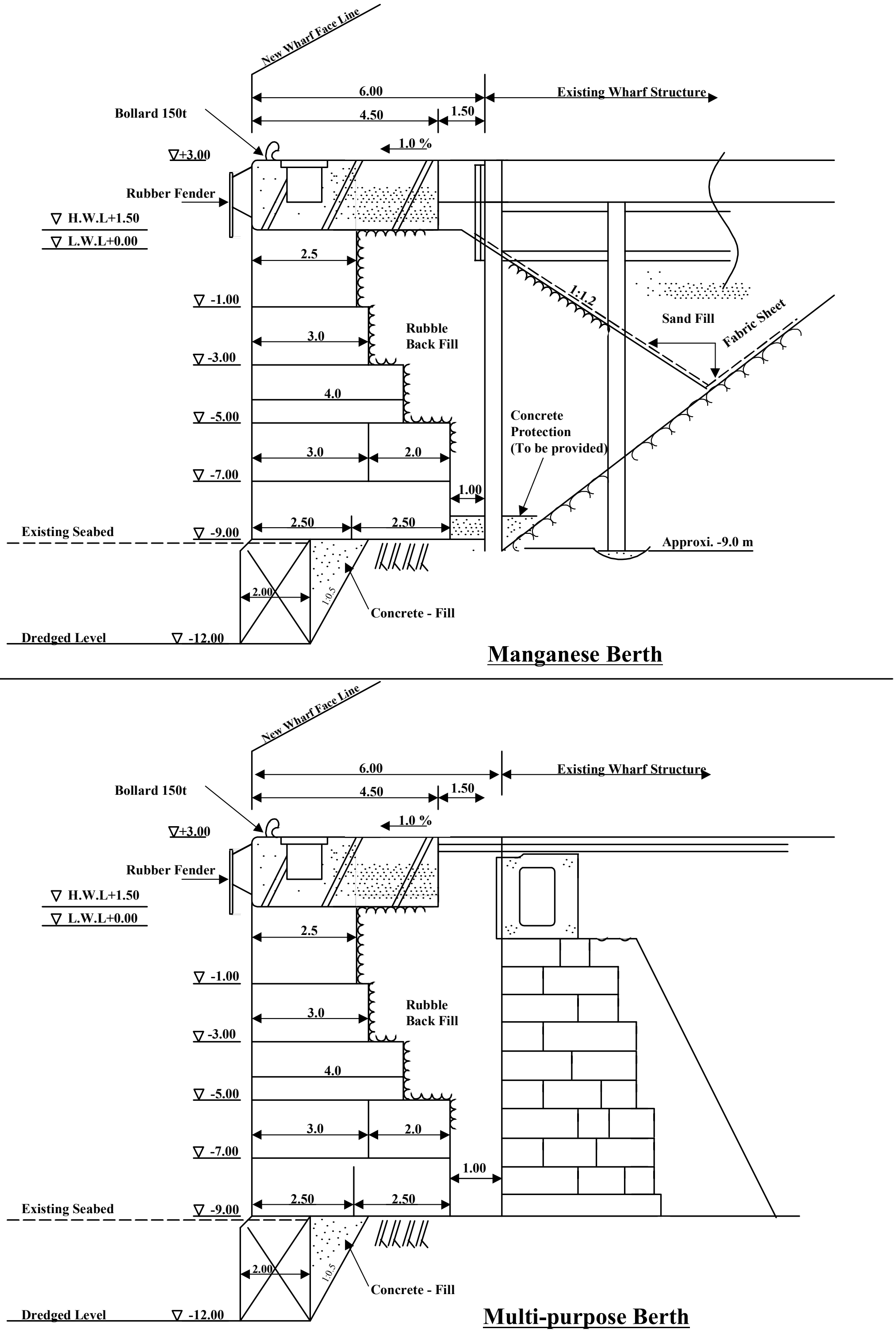


Figure 17.4.1 Typical Sections of Existing Wharf Improvement

17. 5 Small Craft Wharf

17.5.1 Design Conditions

Table 17.5.1 Design Conditions for Small Craft Wharf

Objective Vessels	Port services crafts ; Max. size : 250GT, L0A:30.5^{m}, Max. draft:4.1^{m}
Design Water Depth Deck Elevation	-5.0^{m} +2.50 above C.D.
Subsoil Conditions	Seabed : Sand, N-value 20 (assumed) Back-fill : Quarry-run, ϕ=35^{0}
Surcharge	10 KN/m^{2}
Structural Type	Concrete Block Type
Tractive Force	150 KN

17.5.2 Structural Design

The typical cross section of the Small Craft wharf is shown as recommended in Figure 17.5.1.

The examination conditions used in the design are as similar to the conditions described in 17.3.1 for R .C. Caisson Design.

17.6 Other Facilities

17.6.1 Revetment

Rubble mound type revetment is recommended as shown in Figure 17.6.1.

17.6.2 Paving

Concrete Block Paving is recommended to all the paving works as discussed in the Master Plan Design.

17.6.3 Drainage

At the planned location for the new container terminal area, the existing drainage (3 lines) is to be extended through the reclaimed land with appropriate out-falls preferably located at new revetment area.

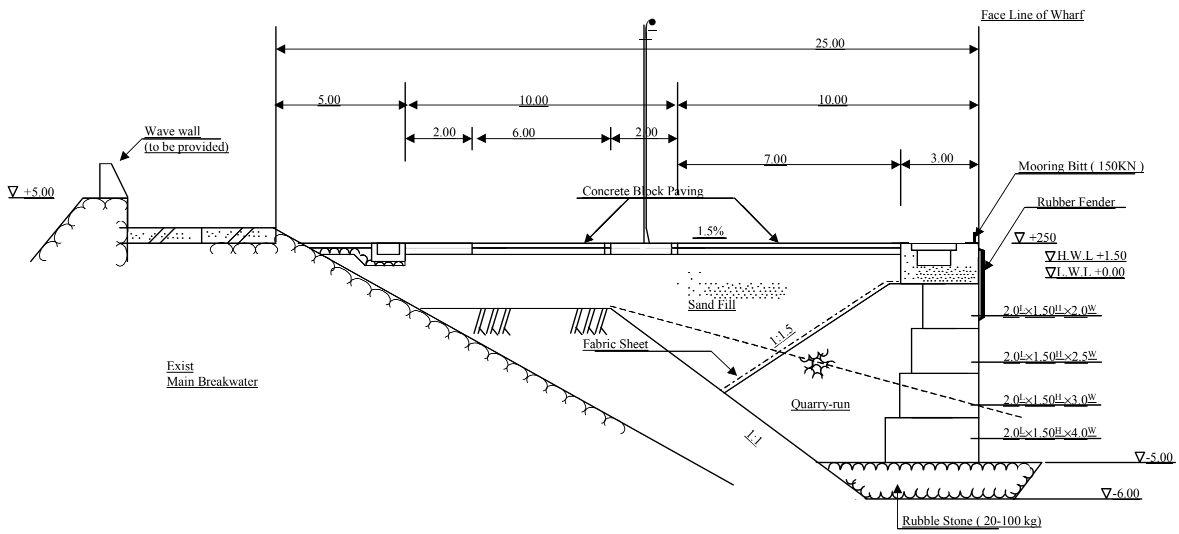


Figure 17.5.1 Typical Section of Small Craft Wharf

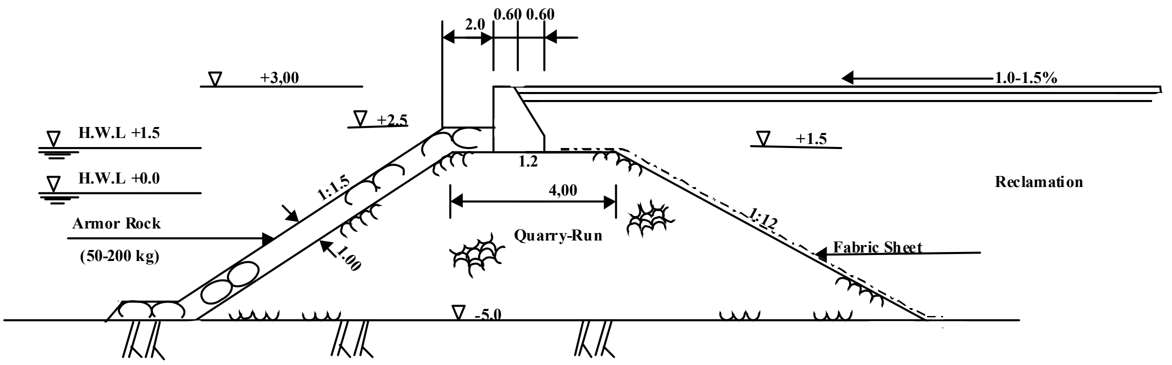


Figure 17.6.1 Revetment for Container Wharf

Chapter 18 Implementation Program

18.1 General Conditions

18.1.1 Construction Component of Short Term Development Plan

The following construction components are proposed in the Short Term Development Plan;

Table 18.1.1 Construction Component of Short Term Development Plan

Construction Component	Description	Quantity
1. Dredging and Reclamation		
1) Dredging	Hard rock	100,000 m^3
	Soft rock	1,199,200 m^3
	General soil	360,000 m^3
2) Reclamation	Dredged Material	1,143,000 m^3
2. Breakwater Extension (-14.0 m)	Rubble Mound	L = 400 m
3. New Wharf and Berth		
1) Bulk Berth (-13.0 m)	R.C. Caisson	L = 260 m
2) Container Wharf (-12.0 m)	R.C. Caisson	L = 300 m
3) Access to Bulk Berth	Rubble Mound	L = 110 m
4) Small Craft Berth (-5.0 m)	Concrete Block	L= 150 m
4. Existing Wharf Improvement		
1) Manganese Berth (-12.0 m)	Concrete Block	L = 200 m
2) Multi-purpose Berth (-12.0 m)	Concrete Block	L = 300 m
5. Building/ Utilities Works	(Container Terminal)	
1) Administration Office	2 stories, approxi. 500m^2	1 set
2) Gate	Gate booths	1 set
3) Electrical / Mechanical works		1 set
6. Other Construction Items		
1) Container Yard paving	Concrete block paving	120,000 m^2
2) Drainage	Including extension of Existing drainage lines	1 set
3) Navigation Aid	Lighted buoys, Lights beacons	1 set
4) Port Access Road improvement		1 set

18.1.2 Major Construction Materials

Major construction materials to be used in the development plan are shown in Table 18.1.2.

Table 18.1.2 Main Construction Materials

Material	Quantity	Supply Source
1. Rock Materials	(548,000 m^3)	
1.1 Armor rock (10-15 t)	35,000 m^3	Local quarry(s)
1.2 Armor rock (1-5 t)	75,000 m^3	Ditto
1.3 Rubble (50-500 kg)	317,000 m^3	Ditto
1.4 Rubble (foundation)	25,000 m^3	Ditto
1.5 Quarry-run	96,000 m^3	Ditto
2. Filling Sand	110,000 m^3	Dredged sand / Quarry dust
3. Concrete	(100,000 m^3)	Concrete batching plant
3.1 Characteristic strength > 20 MPa	36,000 m^3	Imported / Local cement
3.2 Ditto < 20 MPa	39,000 m^3	Local cement
3.3 Paving concrete block	138,000 m^2 (25,000 m^3)	Local cement/ products
4. Reinforcement Bars	2,200 t	Import
5. Other Materials		
5.1 Fabric sheet	34,000 m2	Import
5.2 Marine fittings	Rubber Fender, Bollards	Import

Note; The above quantities are for Civil Works only, and exclude Drainage/Port Access Road Works and aggregates/ crushed stones for concrete/ paving works.

18.1.3 Supply of Construction Materials

(1) Rock Materials

Approximately 550,000 m3 of rock materials are estimated to be required in the construction, of which more than 60% is to be used for Breakwater construction.

The rock materials are to be supplied from the existing quarries located at Essipon, about 13 km distant from Takoradi Port to the east. At Essipon three (3) quarries exist, at present however only one (1) quarry is commercially operating (another quarry is also operational but used exclusively for some road project). The supply capacity of the operating quarry is expected to be around 15,000~20,000 m^3/month depending on rock type and size, and is provided with max. 1,000 m^3/day capacity of crushing machine.

Since quite a large amount of rock materials is to be used in the construction, it is recommended that rocks be transported by sea instead of road transportation that may cause serious traffic congestion in the area between Secondi and Takoradi towns. To this end the existing small loading wharf at Secondi Fishing Harbour, which had been used as a temporary loading berth during its construction time. The loading wharf is located just beside the Secondi Fishing Port and the distance from the quarries is only 4~5 km.

(2) Concrete

Total concrete volume estimated for the construction is of the order of 100,000 m^3. Though concrete plants are available in Takoradi, it is recommended to arrange temporary concrete batching plant for own use as a stable and of high quality concrete supply is necessary in the construction particularly for R.C caisson works.

(3) Other Materials

(a) Cement: Cement is locally produced, therefore maximum utilization of local cement be considered. It is however suggested to use imported cement for a concrete of high quality and strength such as R.C. Caissons.

(b) Reinforcement Bars: No deformed bar is produced in Ghana, thus all the deformed bar be imported

(c) Sand for fills: No appropriate sand borrow pit exists in the vicinity of to Takoradi, however sand for fill may be obtained from sea close to the construction area or otherwise utilize quarry dust instead of sand.

18.2 Construction Plan for Major Works

18.2.1 Temporary Facilities

In the implementation of the Short Term Development Plan, the following temporary facilities/ measures should be thoroughly studied and appropriately arranged:

1) Materials Stock Yard: A sufficient space for materials stocking yards for rocks, fill sand, aggregates, cement, fabricated concrete products, etc. be considered. As for rock materials it is recommended to arrange close to the rock loading wharf at Secondi.

2) Temporary Jetty/Wharf for Caisson Fabrication: A Floating dock method is recommended for R.C. Caisson units fabrication. The possible location for docking the floating dock are; a) the reclaimed land adjacent to GHACEM, b) Seaward end of Clinker Jetty or c) Seaward side of Lee Breakwater. Among these three locations, Clinker Jetty site is recommendable as easier to obtain a sufficient water depth for docking the Floating Dock.

3) Concrete Block Fabrication Yard: Taking the required production rate (nrs/day) of concrete blocks to be used for the wharf improvement into consideration, the necessary space for block production, curing and stocking be considered. This area may possibly be obtained within the Port Boundary such as northern end of the reclaimed land area.

4) Other Items: The areas for construction office, construction equipment/materials, concrete batching plant etc is also preferably sought within Port Boundary.

18.2.2 Dredging and Reclamation

(1) Estimated Volume and Type of Material to be dredged

The total estimated volume of the dredging is 1.66 Million cubic meters of which over 70 % is so categorized soft rock represented by sandstone or silt stone as shown in Table 18.1.1.

(2) Selection of Dredger Type

As most of the materials to be dredged is soft rock, it is suggested to employ a grab type dredger of 18.0~20.0 m^3 grab capacity and being equipped with rock breaking hammer (drop hammer) which is generally applied for hard soil / soft rock dredging and for like this scale of dredging volume.

(3) Dredging Method

The following method are considered:

- Hard Rock : Blasting is to be adopted with drilling holes using Mini-SEP (self elevating pontoom), prior to dredging by Grab - Dredger.

- Soft Rock : Soft rock layers be broken by drop hammer and dredged by Grab Dredger.

After breaking rock layers, all the materials are grabbed by Dredger as well as general soil and disposed of at the reclamation area using barges.

(4) Reclamation : It is expected that all of the material for the reclamation work can be obtained from the dredged material.

Prior to the commencement of the reclamation work, the revetment be constructed providing an appropriate spill way to minimize water pollution.

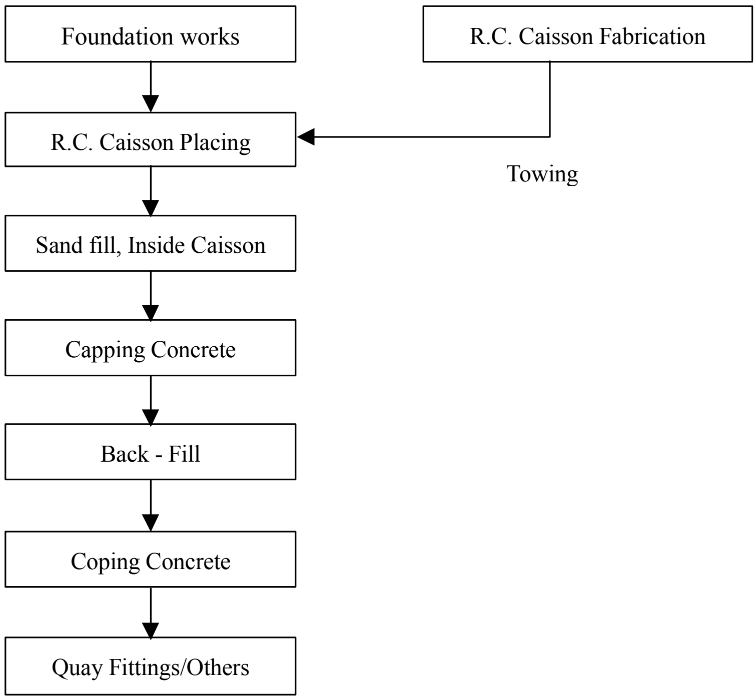
(5) Disposal of soft material : In the construction site, it is thought that very soft sediment which possibly contains contaminated materials exists though total amount of such soft soil is to be a small.

It is suggested to dispose of such material into the Dock No. 1 and No. 2 areas to be reclaimed in the construction as suitable to contain such materials.

18.2.3 R.C. Caisson Wharf / Berth Construction

(1) Construction Sequence

The construction of the R.C. Caisson Wharf / Berth will generally be made in accordance with the following work flow;



(2) R.C. Caisson Fabrication

Floating Dock method is recommended as no dry dock or slipway to fabricate the caisson units of the designed sizes are available in the vicinity of Takoradi Port.

The Floating Dock having its capacity 4000~6000 DWT class is recommended as this size is most popular and will be possible to produce 2~3 units of the designed caisson (1,300 ~ 1,450t/Unit) at same time.

In this design, the production rate of 2 Units / 45 days (1,33 units/month) is applied. Thus the required time for the caisson fabrication for Wharf / Berth are as follows;

- Bulk Berth (1,450t, 15 units) : 12 Months
- Container Wharf (1,290t, 16units) : 12 Months

18.2.4 Existing Wharf Improvement

As discussed in Chapter 17, a concrete block wall type structure is adopted as more reliable to withstand the increased loads and to protect the existing structures from a possible failure of foundation that might occur after deepening.

A careful execution in deepening the areas close to the existing structures is essentially required.

To this end, the following measures are recommended;

1) Employ a dipper dredger for the excavation of the area close to the existing structures.

2) Prior to the excavation, all of the front piles where pile supported type is adopted to the wharf structure be concreted using under water concrete to protect the piles from any possible movement during the construction

3) Soon after the placing of bottom block a new foundation will be prepared by use of under water concrete to receive new concrete blocks.

4) All the gap or void between the new and old wharf line or underneath of wharf deck be carefully backfilled with stones to reduce horizontal forces.

All the above said works can be done from the existing deck, by which more thorough execution will be possible.

18.2.5 Other Construction

(1) Breakwater

Breakwater construction is to be started as soon as possible since this work requires relatively long period being subjected to sea conditions.

Most of the works will be carried out as offshore work employing gutt barges, crane barge for placing armor rocks. Some works above water level can be done from land-side (i.e. existing breakwater) to expedite the construction.

Care should be taken that seaward side armor be placed immediately following the core materials placement to prevent from stormy wave actions.

(2) Small Craft Berth

Prior to the New Container Wharf construction, the small craft berth be provided as the replacement of the existing small craft docking areas

Most of the work can be done from land-side, except for dredging work thus no serious issue will be expected in the construction.

18.3 Implementation Schedule

1) Short Term Development of Takoradi Port will require approximately five (5) years for its implementation including 1.5 year for Engineering and Tendering before the commencement of the construction, and is to be completed by the end of year 2009.

2) In order to minimize interruption of the port operations, the following construction sequence of wharf/berth is proposed;

(a) Container wharf construction will at first be commenced, however the small craft berth be completed prior to its construction commencement.

(b) Bulk berth construction will follow the container wharf construction as this work is expected to cause a minimum affect to the existing port operations, and it is not critical.

(c) Manganese berth and Multi-purpose berth (improvement of exist. berths) construction be only commenced when the container wharf is completely constructed and become operational, and to be constructed one after another.

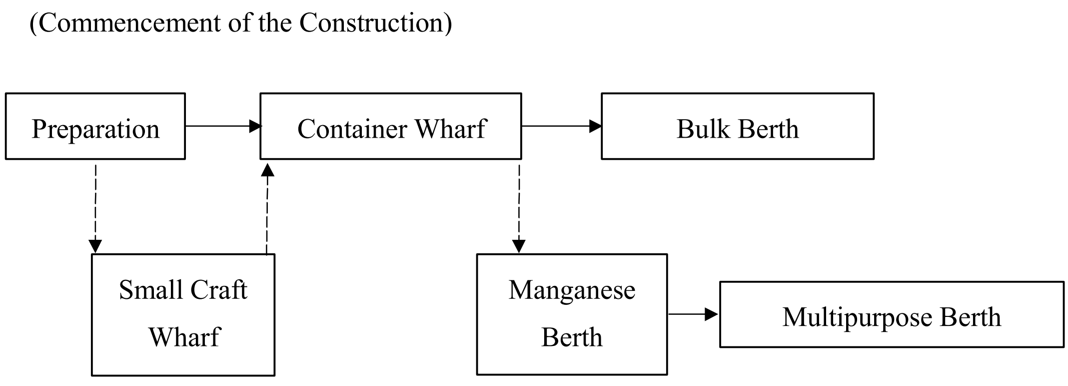


Figure 18.3.1 Wharf/Berth Construction Sequence

3) Based on the above considerations, the implementation schedule has been formulated and is shown in Figure 18.3.2.

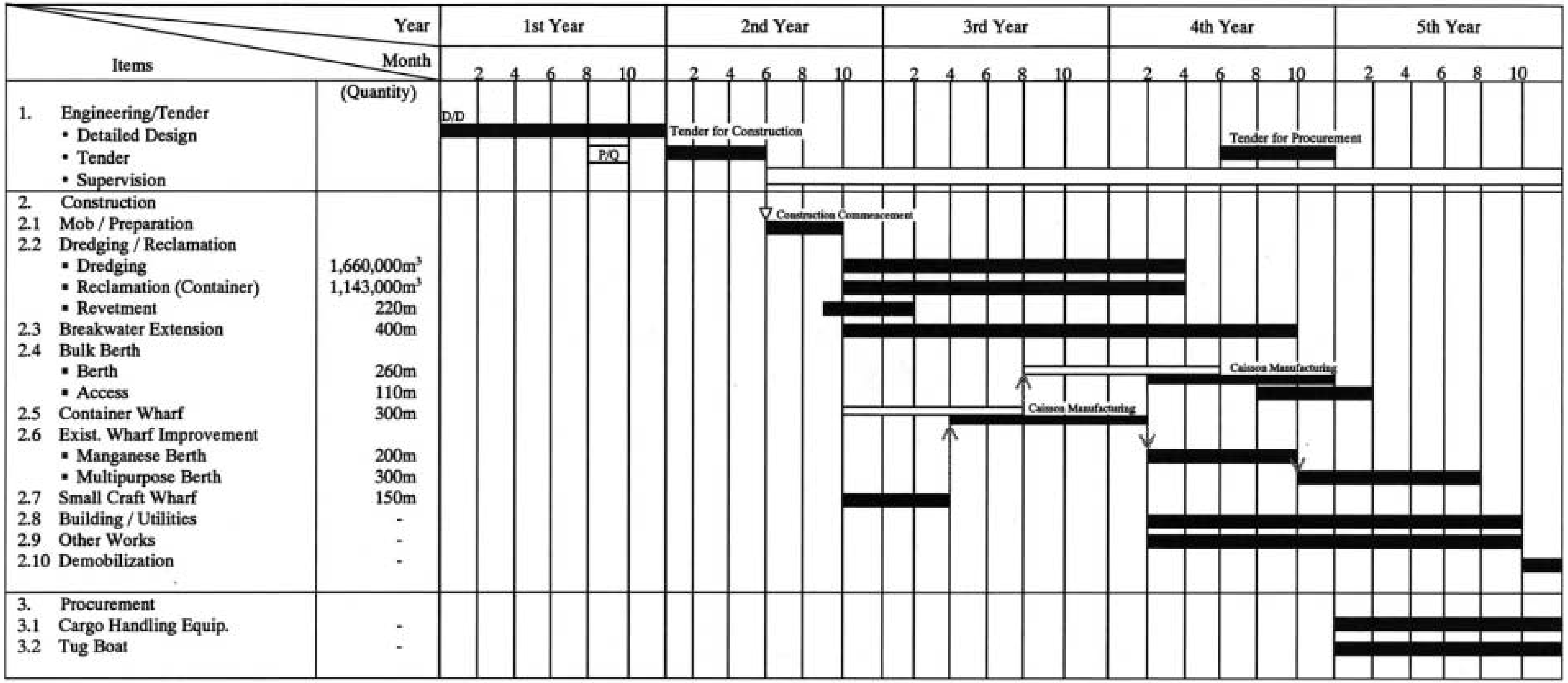


Figure 18.3.2 Implementation Schedule

Chapter 19 Cost Estimation

19.1 Estimation Conditions

The following conditions are adopted for the cost estimation:

1) Costs are estimated based on the recommended designs of the proposed facilities, works and equipments as necessary in the Short Term Development Plan, and the recommended or assumed construction methods described in Chapter 18.

2) Implementation period is 5 years including 1.5 year for Engineering and Tendering for the construction.

3) Costs are expressed in US dollars under the following exchange rates;

1 U.S. dollars   =   6,700 Cedis

4) Costs for land acquisitions or any compensations are not considered.

5) Tax / duties on the imported equipments/materials for the constructions/procurement and are exempted.

6) Foreign Currency Portion and Local Currency Portion

The following allocation of currency portions is applied;

Foreign Currency Portion	Local Currency Portion
• Costs for all of imported construction materials and equipments. • Expatriates Staff or foreign workers costs. • Construction equipment costs originally imported.	• Costs of construction materials and goods produced or manufactured locally. • Domestic transportation costs. • Local staff and workers salary and associated costs.

19.2 Construction Costs for Major Work Components

Unit costs for major construction components are estimated as shown in Table 19.2.1.

Table 19.2.1 Unit Costs of Major Work Components

Work Component	Unit	(USD) Foreign	(USD) Local	(USD) Total
	(Per)			
1. Dredging Work				
Hard Rock	m^3	64.6	3.4	68.0
Soft Rock	m^3	23.75	1.25	25.0
General Soil	m^3	5.7	0.3	6.0
2. Reclamation (Dredged material use)	m^3	1.8	0.2	2.0
3. Breakwater	m	16,225	13,275	29,500.0
4. Wharf and Berth				
Bulk Berth	m	29,070	5,130	34,200.0
Container Wharf	m	26,860	4,740	31,600.0
Small Craft Wharf	m	8,000	2,000	10.000.0
5. Exist. Wharf Improvement				
Manganese Berth	m	21,120	5,280	26,400
Multipurpose Berth	m	20,534	5,133	25,667
6. Revetment (-5.0 ^{m})	m	3,300	2,700	6,000.0
7. Concrete Block Paving	m^2	16.85	18.15	35.0

Note; The unit costs indicated above include indirect costs.

3) Allocation of Foreign/Local Currency Portions for buildings, utilities and miscellaneous works costs and equipments costs are assumed as follows :

Table 19.2.2 Currency Portion Allocation of Other Work Component

Work Item	Foreign	Local
1.Building, Utilities and Miscellaneous Works		
- Admin. Office	40%	60%
- Gate	60%	40%
- Electrical Works	90%	10%
- Drainage	40%	60%
- Navigation Aids	98%	2%
- Port Access Road Improvement	40%	60%
2.Equipment		
- Cargo Handling Equipment	100%	0
- Tug boat	100%	0

19.3 Implementation Cost

The total cost estimated for the implementation of Short Term Development Plan in Takoradi Port is 136.5 Million U.S. dollars including Physical Contingency (8.76 Million U.S. dollars) and Engineering cost (4.80 Million U.S. dollars) as indicated in Table 19.3.1. And the Implementation Cost disbursement estimated based on the implementation schedule is shown in Table 19.3.2

Table 19.3.1 Implementation Cost of Short Term Development Plan

Item	unit	Quantity	Unit Price (USD)	Foreign Cost (x1,000 USD)	Local Cost (x1,000 USD)	Total Cost (x1,000 USD)
1. Dredging						
1.1 Hard Rock	m^3	100,000	68.0	6,460	340	6,800
1.2 Soft Rock	m^3	1,199,200	25.0	28,481	1,499	29,980
1.3 General Soil	m^3	360,300	6.0	2,054	108	2,162
2. Reclamation (Dredged Material)	m^3	1,143,000	2.0	2,057	229	2,286
3. Breakwater Extension (-14.0 m Average)	m	400	29,500.0	6,490	5,310	11,800
4. Bulk Berth						
4.1 Berth (-13.0 m)	m	260	34,200.0	7,558	1,334	8,892
4.2 Access Way	m	110	10,000.0	660	440	1,100
5. Container Wharf						
5.1 Wharf (-12.0m)	m	300	31,600.0	8,058	1,422	9,480
5.2 Revetment (-5.0m)	m	220	6,000.0	726	594	1,320
5.3 Yard Paving	m^2	120,000	35.0	2,022	2,178	4,200
6. Existing Wharf Improvement						
6.1 Manganese Berth	m	200	26,400.0	4,224	1,056	5,280
6.2 Multi-purpose Berth	m	300	25,667.0	6,160	1,540	7,700
7. Small Craft Wharf	m	150	10,000.0	1,200	300	1,500
8. Other Items						
8.1 Administration Office	L.S.	1	500,000	200	300	500
8.2 Gate	L.S.	1	100,000	60	40	100
8.3 Lighting/ Electrical work	L.S.	1	1,000,000	900	100	1,000
8.4 Drainage	L.S.	1	250,000	100	150	250
8.5 Navigation Aids	L.S.	1	200,000	196	4	200
8.6 Port Access Road Improvement	L.S.	1	1,500,000	600	900	1,500
Total Construction Cost				**78,206**	**17,844**	**96,050**
9. Equipment						
9.1 Manganese Berth	L.S.	1	6,970,000	6,970	0	6,970
9.2 Container Wharf	L.S.	1	16,952,000	16,952	0	16,952
9.3 Tug Boat	L.S.	1	3,000,000	3,000	0	3,000
Total Equipment Cost				**26,922**	**0**	**26,922**
10. Physical Contingency	L.S.	1	8,760,872	7,334	1,427	8,761
11. Engineering Cost	L.S.	1	4,802,495	3,910	892	4,802
Grand Total				**116,372**	**20,163**	**136,535**

Table 19.3.2 Implementation Cost Disbursement

Item	1st Year		2nd Year		3rd Year		4th Year		5th Year	
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
A. Bulk Berths										
1. Dredging/Reclamation					9,897	520	3,300	174		
2. Breakwater extension			539	441	3,245	2,655	2,706	2,214		
3. Berths/Others					1,890	334	10,334	2,351	414	149
Sub-total	**0**	**0**	**539**	**441**	**15,032**	**3,509**	**16,340**	**4,739**	**414**	**149**
Contingency			43	35	1,203	281	1,307	281	33	12
Total	**0**	**0**	**582**	**476**	**16,235**	**3,790**	**17,647**	**5,020**	**447**	**161**
B. Container Terminal										
4. Dredging/ Reclamation			226	25	3,128	246	8,427	470		
5. Berths/Revetment			1,839	633	7,138	1,505	1,007	178		
6. Other Civil Works							1,061	1,164	1,661	2,064
7. Building/ Utility Works							580	220	580	220
Sub-total	**0**	**0**	**2,065**	**658**	**10,266**	**1,751**	**11,075**	**2,032**	**2,241**	**2,284**
Contingency			165	53	821	140	886	162	180	183
Equipment									19,952	0
Contingency									798	0
Total	**0**	**0**	**2,230**	**711**	**11,087**	**1,891**	**11,961**	**2,194**	**23,171**	**2,467**
C. Multipurpose Berth										
8. Dredging			6,052	319	8,022	422				
9. Berth							1,232	308	4,928	1,232
Sub-total	**0**	**0**	**6,052**	**319**	**8,022**	**422**	**1,232**	**308**	**4,928**	**1,232**
Contingency			484	25	642	34	99	25	394	98
Equipment									6,970	0
Contingency									279	0
Total	**0**	**0**	**6,536**	**344**	**8,664**	**456**	**1,331**	**333**	**12,571**	**1,330**
Total Construction	0	0	8,656	1,418	33,320	5,682	28,647	7,079	7,583	3,665
Total Equipment	0	0	0	0	0	0	0	0	26,922	0
Total Contingency	0	0	692	113	2,666	455	2,292	468	1,684	293
Engineering	1,174	268	684	156	684	156	684	156	684	156
Grand Total	**1,174**	**268**	**10,032**	**1,687**	**36,670**	**6,293**	**31,623**	**7,703**	**36,873**	**4,114**